Appendix I: Consumption-Based Emissions

U.S. Community Protocol
for Accounting and Reporting of Greenhouse Gas Emissions

Version 1.1

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Developed by
ICLEI – Local Governments for Sustainability USA

For the latest version of this Protocol, and other tools and resources that can help you report on community GHG emissions, visit www.icleiusa.org.

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Introduction

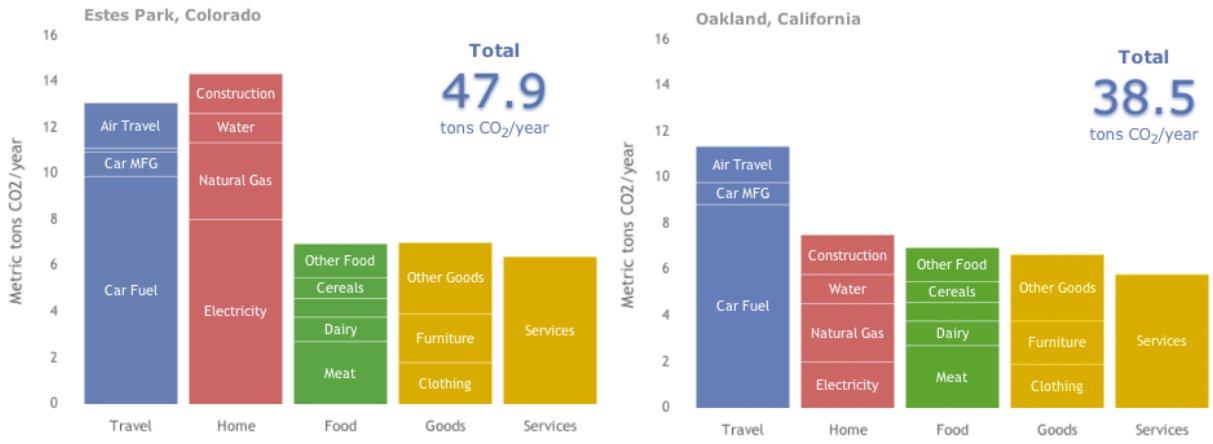
This appendix provides an introduction to consumption-based greenhouse gas accounting, describes several methods that have recently been developed to provide this accounting at the scale of local governments, and provides guidance on conducting consumption-based GHG inventories for communities in the United States. This appendix addresses consumption by households and consumption by governments. It also addresses the corollary activity in the private sector: the purchase of electricity, fuels, goods and services by businesses (included in this appendix but not called "consumption" for reasons described below).

Consumption-based inventories estimate the global emissions associated with satisfying the purchase and use of products and services – including fuels used in buildings and transportation, as well as food, other goods, and services. This method is typically applied at the household level, allowing individuals to answer the question, "what is my carbon footprint?" A household carbon footprint can be understood as the greenhouse gas emissions resulting from the production, use and disposal of everything the household consumes in a year, including household energy, transportation, food, goods and services.[1]

The size and composition of household carbon footprints has been shown to vary widely between communities. In some cases, household energy dominates, while in others transportation or food is more important. Goods and services – traditionally omitted from many footprint calculators – also contribute significant emissions. A household consumption inventory at the community scale is simply the sum of all of the carbon footprints for all households in the community. Practically speaking, a very simple and easy method of estimating the community's household consumption-based inventory involves using the CoolClimate Calculator to estimate the carbon footprint of the community's average household, and then multiplying this by the number of households in the community. Additional details on this and other methods are provided below. This information can help communities engage households in outreach programs that reduce greenhouse gas emissions related to household consumption by shifting from more carbon-intensive, to less carbon-intensive household activities. It can also focus policy and other attention on systemic drivers of emissions, such as transportation infrastructure, the built environment, and the emissions embedded in food and consumer goods.

[1] However, many (although not all) "household carbon footprint" calculators focus primarily on use of energy, and omit the significant emissions associated with household purchases of food, other goods, and services.

Just look it up!
Did you know you could get a quick estimate of the average household carbon footprint of your community just by looking it up at CoolClimate.Berkeley.edu?



Similarly, governments are also end users of a vast array of goods and services, such as office supplies, motor vehicles, and contracted services. Communities may elect to estimate and report consumption-based emissions for governments. This approach typically differs from an inventory performed under the local government operations protocol in several important regards:

- Consumption-based emissions for governments at the community scale could address *all* government facilities located in the community, including federal, state, county, municipal, and special districts (such as public schools).
- Consumption-based emissions for governments include all purchases, including food, other goods, and services, which in the past have typically not been included in inventories performed under the local government operations protocol.[2]
- Consumption-based emissions for governments at the community scale are not understood to be "owned" by the local government conducting the inventory, unlike the scope 1 emissions reported under the local government operations protocol.

Depending on how the household and government consumption-based inventories are performed, it may be possible to combine them into a full consumption-based emissions inventory for the community. Details on this approach are described below.

[2]Inventories developed under the local government operations protocol have tended to focus on emissions associated with direct energy use (electricity, heating, motor pool), and process emissions from municipal operations such as wastewater treatment and landfills.

Communities may also want to estimate the full GHG impacts of business activities in their communities, not limited to direct emissions and emissions associated with use of electricity, but also the life cycle emissions associated with the goods and services purchased by businesses in the community. This is analogous to the consumption-based approach for households and businesses, but these business-related emissions cannot be added together with household and government consumption-based emissions, due to double counting. Individual businesses are also increasingly interested in estimating their full life cycle GHG impact, including the GHG emissions used in the production of goods and services they purchase, either as inputs to their own production, or for their day-to-day operations. A new standard has been developed by WRI-WBCSD for individual businesses to calculate these emissions. Estimating these at the community-wide scale is more complex, but methods are currently under development. While municipal governments have little to no direct control over these emissions, they can give recognition to businesses that are taking steps to reduce their full life cycle GHG impact. It is also helpful for governments to understand the full scale of emissions from products entering and leaving their communities.

At the time this Protocol is being written, consumption-based accounting of greenhouse gas emissions at the community scale is a relatively young field. Methods are still being tested, evaluated and compared and "best practices" have not yet been identified. Additional new methods and variations on those methods may still be developed. As such, this Protocol does not recommend one method over another, but rather describes the existing approaches in their current state of development, and leaves it fully to Protocol users to determine which (if any) approaches to use. Future Protocol users are encouraged to check with ICLEI and subject-matter experts to see if accounting approaches for consumption-based emissions have changed.

Background

Historically, many community-wide GHG emissions inventories have focused primarily on GHG emissions released, or produced, from sources located within the geo-political boundary of the community. Inventories often also include some trans-boundary sources (located outside the community) associated with activities that occur in the community; emissions associated with generating electricity at a power plant outside of a community that is purchased for use in a community is a common example. One can think of a spectrum of approaches for inventorying emissions. At one end, a community could focus exclusively on emissions associated with production inside the geopolitical boundaries of the community even though some or many of the goods and services produced within the community will be used by those living outside the community. This method would be called a *production*-based approach. On the other end of the spectrum, a *consumption*-based approach counts emissions associated with all of the goods and services consumed (rather than produced) by the community – even if those emissions were released outside of the community in the course of making products, such as computers or food.

Another historically common approach is to focus on emissions that physically originate from sources within the community's borders. This method, sometimes called a *geographic*, or *in-boundary* approach, would be consistent with the practices of national governments. While geographic or source-based approaches offer the advantage of being fairly simple and easy to calculate and communicate (and are consistent with how other air pollutants are typically inventoried), they do not necessarily align well with the policies and measures available to a local community to reduce GHG emissions. For example, communities have a moderate to high degree of influence over efficiency in electricity use and sourcing electricity from renewable energy sources, which are measures that affect emissions at power plants that are often located outside the community boundary. In the geographic or source-based approach, communities would not get credit for reducing emissions outside their boundaries.

For this reason, this Protocol distinguishes between sources and activities, and requires that communities consider the full range of sources and activities (Section 1.3, Tables 2 and 3) for potential inclusion in their inventory report. Among the Basic Emissions Generating Activities[3] that must be included in a protocol-compliant inventory are the emissions associated with electricity use by the full community, a method that some call a "consumption-based" approach for electricity and which is now common for community-wide GHG inventories.[4] Some communities may be interested in extending this consumption-based approach far more widely: to all goods and services consumed in a community, including emissions associated with food, clothing, home furnishings, and other items.

Consumption-Based Emissions: How they Related to Trans-boundary Community-Wide Supply Chains (Appendix H)

Appendix H (Emissions Associated with the Community's Use of Materials and Services) and this appendix (Consumption-Based Emissions) have significant overlap but also significant differences. Table SC.1 in Appendix H summarizes the differences. Basically, Appendix H addresses the emissions associated with non-energy materials and services used by the entire community (households, governments, businesses), while this appendix addresses energy, materials, and services used by households and governments. Further, the methodologies included in Appendix H focus on estimating emissions for one material or service at a time, while the methodologies presented in this appendix tend to take a "market basket" approach to estimating emissions associated with all consumption.

[3] See section 2.2

[4] Please note that this Protocol does not refer to this approach as "consumption-based" for reasons that are explained later in this appendix.

Consumption-Based Emissions: How they Relate to "Life Cycle Emissions", Built Environment, and Transportation Emissions

This Protocol defines "life cycle emissions" as "GHG emissions associated with all stages of the life cycle of materials, energy, and services". Under this definition, all emissions are life cycle emissions. The methodologies used in consumption-based inventories inherently include all life cycle emissions, while the methodologies used elsewhere in this Protocol sometimes require that emissions associated with different life cycle stages be calculated separately. For example, the Built Environment and Transportation appendices both allow for upstream (fuel cycle) emissions to be calculated, as an optional, and additional, estimation activity. When estimating emissions associated with community-wide use of electricity, users have to estimate emissions at the point of power generation (including those lost in transmission and distribution) separately from the emissions associated with producing and providing the fuels that are used in power generation.

Again, built environment and transportation emissions as included in this Protocol are for community-wide use of energy in the built environment and transportation (households, government, and businesses), while consumption-based emissions focus on household and government consumption.

Why Consumption-Based Emissions?

Consumption is understood to be a "root cause" or "root driver" of both economic and environmental impacts. Consumption drives commercial and industrial activities, which in turn result in environmental impacts. Consumption-based emissions inventories help communities understand how consumption by their community contributes as a "root driver" of greenhouse gas emissions on a global scale.

Communities have also expressed interest in consumption-based emissions inventories because of the significant emissions associated with the cradle-to-consumer ("upstream") life cycle of goods and services. Many of these emissions go uncounted in traditional, territorial-based inventories. Accordingly, consumption-based reporting can be especially useful for communicating the GHG emissions impacts of households and government activities. Consumption-based reporting can also be useful for unveiling additional emissions reduction opportunities for community members, even as local governments themselves may have less direct influence over consumption of food, clothing, or home furnishings than they do over electricity.

Consumption-based emissions (for communities in the U.S.) are often – but not always – higher than in-boundary emissions. For example, San Francisco's consumption-based emissions (2008) are roughly four times larger than the emissions in its "conventional" inventory. Consumption-based emissions are also larger than geographic emissions for the nation as a whole, although communities with small residential populations, limited government presence, and large

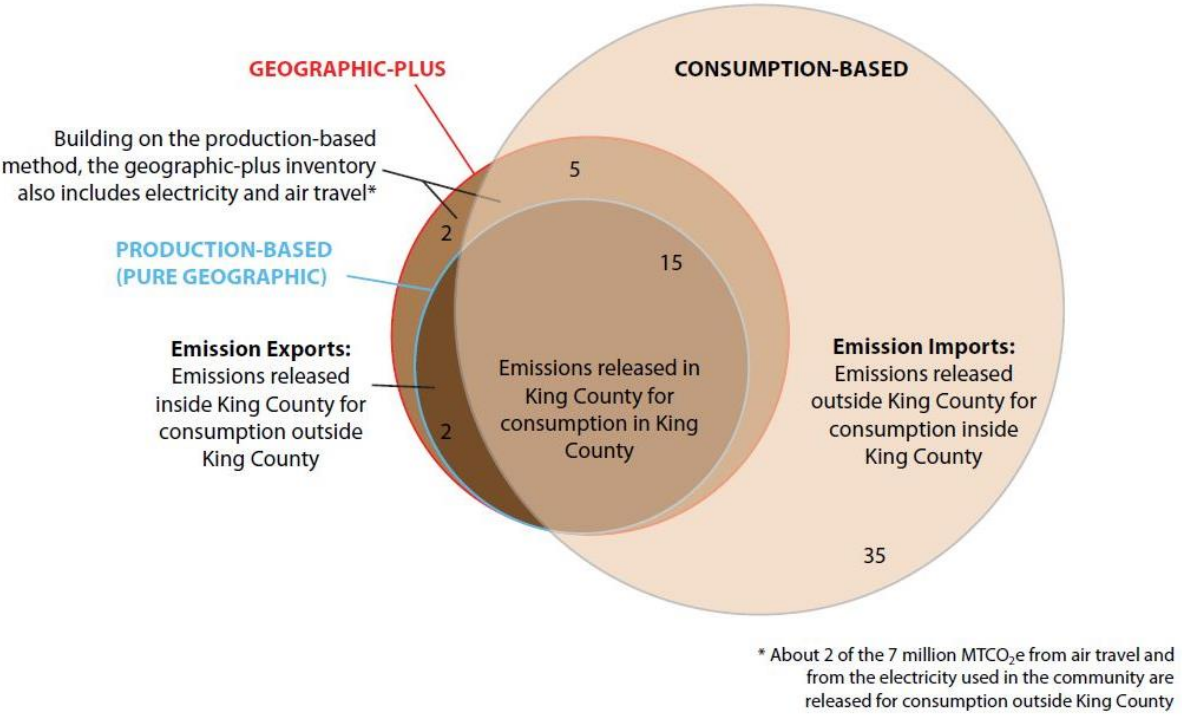
industrial or tourism activities (businesses serving non-resident customers) would find their consumption-based emissions to be relatively small. But regardless of whether consumption-based emissions are larger or smaller, some of the emissions are *different*, and they represent *additional ways in which the community contributes to climate change* and by extension, *additional opportunities for the community to reduce its contribution to climate change*.

Some communities have also indicated that conducting – or at least recognizing the existence of – consumption-based emissions helps to tell a more complete story of community GHG impacts. At a minimum, acknowledging the existence of these impacts (even if they go uncounted) is viewed by some as an important element of "truth in advertising" and maintaining credibility with the public.

The acknowledgment of consumption-based emissions also explicitly recognizes the potential for "leakage" – the transfer of emissions sources from one community to another as industries move. For example, a consumption-based inventory assigns to a community the emissions associated with cement used by that community, regardless of where it is made. This is different from source-based inventories that assign to the community all the emissions from cement plants inside their boundary (but none other). If these, or other industries, move operations elsewhere, taking their emissions with them, a territorial inventory reports that as an emissions reduction and represents it as a success towards achieving greenhouse gas reductions. Of course, simply moving emissions sources from one location to another does not truly reduce global climate change, a fact that is acknowledged explicitly in consumption-based accounting.

To be clear: communities contribute to greenhouse gas emissions both as a result of production within their communities and consumption activities by community members. And as discussed above, some greenhouse gas emissions resulting from consumption by a community occur from emissions sources located in other communities. Figure 1 illustrates this for King County, Washington's 2008 greenhouse gas inventories.

Figure 1. Comparison of King County, Washington GHG Inventories
(Numbers indicate approximately 2008 emissions, in million metric tons of CO2e. Areas are approximately proportional to emissions). Source: Stockholm Environment Institute for King County, Washington.



No single accounting framework, by itself, can tell a complete story of how a community contributes to emissions. This is also true of consumption-based accounting, by itself. However, consumption-based accounting, when performed alongside other lenses focusing on community-wide activities and sources, can help a community better understand the full scope of its contributions to global warming, and by extension, offers a more extensive view of opportunities to reach and reduce such emissions.

Consumption-Based Emissions: What Are They? What Aren't They?

Simply put, consumption-based accounting estimates the full life cycle "carbon footprint" of everything households (and sometimes other consumers, see below) consume. It is an internally consistent (e.g., not a hybrid) method of accounting for emissions since essentially all emissions can be traced to goods and services (including food, products, services, transportation, fuel, water and energy) consumed by households (and sometimes other members of the community, see below).

One common area of confusion is the meaning of the term "consumption". The words "consumption" and "use" are often used interchangeably, which has led to considerable confusion. This protocol distinguishes between them in the context of consumption-based accounting as follows: "use" refers to any and all use, by all potential users of a resource, while

"consumption" is a subset of "use", limited to the use of resources - typically purchased - by "consumers". Thus, for an act to count as "consumption" (and for its associated emissions to be included in consumption-based accounting), it has to involve a purchase by a consumer.[5] "Consumers", in turn, are usually limited to just households and governments, and not businesses, although a subcategory of business expenses (described below) are sometimes also included in "consumption". In the language of this Protocol, businesses, governments, and households all "use" electricity, but only governments and households "consume" electricity. (For households and governments, "consumption" and "use" of electricity are the same.) The reason for this distinction stems from the structure of the economic models typically used to estimate consumption-based emissions, described in more detail below.[6]

For example, the life cycle emissions associated with food purchased directly (e.g., at a grocery store) by households are included in a consumption-based inventory. In contrast, the life cycle emissions associated with food purchased by in-community businesses are not included in consumption-based inventories *except to the extent that the food was purchased to satisfy consumption by community members*.[7]

Many in-community businesses burn fuel, purchase electricity, and buy other materials and services in the course of satisfying goods and services that are "exported" – that is, consumed by members of other communities. Emissions associated with such activities are not included in consumption-based inventories.

One other consideration is that due to the nature of how data on consumption is normally estimated, the activity of consumption is normally defined as *consumption by community members* as opposed to *consumption inside the community's boundaries*. For example, when a household in community X travels to community Y to go shopping, their consumption activities in community Y are included in community X's consumption-based emissions. In contrast, when a household residing in community Y visits community X on vacation, their consumptive activities inside community X are not included in community X's consumption-based emissions.

[5] Goods and services that are used but not purchased by consumers (for example, gifts or telephone directories) are not normally counted as consumption, due to the use of economic modeling in consumption-based accounting.

[6] Readers of this Protocol should understand, however, that others may (and often do) use the terms "use" and "consumption" interchangeably. For example, the inclusion of emissions associated with off-site power plants burning coal to generate electricity that is used by businesses and households in a community is sometimes described as a "consumption-based approach for electricity". But when viewed through the framework of broader consumption-based accounting (and consistent with the language used by this Protocol), the consumption-related element of those emissions would be limited to those associated with electricity used by households and government.

[7] For example, the emissions associated with growing/producing food purchased by a hospital and fed to patients only counts as in-community "consumption" to the extent that some patients are residents of the community; the patients are purchasing a service ("medical service") and some fraction of the money paid for this service is spent by the hospital on the purchase of food.

Thus the consumption-based approach describes *consumption by the community* not *consumption in the community*.

Summary of Existing Methods

Household Consumption

Like most GHG accounting methods, consumption-based reporting relies heavily on assembling data on activities and the GHG-intensity of those activities, and calculating consumption-based emissions using the following relationship:

$$Emissions\ (CO_2e) = Consumption\ \text{X}\ Emissions\text{-}Intensity$$

The most fundamental question in assembling a consumption-based inventory is identifying sources of data for levels of consumption and the emissions-intensity of that consumption.

1. CoolClimate Calculator: instantaneous estimate of household carbon footprints

The CoolClimate Calculator (CoolClimate.Berkeley.edu) provides an instantaneous estimate of average household carbon footprints for essentially every populated zip code, city, county and state in the United States. Household consumption-based emissions for the whole community can be estimated by simply multiplying the average household footprint against the number of households in the community.

Since consumption data is not known at this level of geographic boundary, the model relies on other data available at the level of zip codes to estimate consumption levels.[8] For example, household energy is estimated based on size of homes, heating and cooling degree days, housing density, percentage of single family homes, household income, U.S. state, heating fuel and energy prices. Estimates of vehicles miles traveled by households (regardless of where they travel[9]) are based on vehicle ownership, access to public transit, average commute time, gasoline prices, income and housing density. The model assumes 22 miles per gallon per vehicle to estimate gallons. Food consumption is based on the number of people in households, assuming average U.S. diets. Consumption of goods and services is based on household size and income. The calculator then applies average emission factors for each type of consumption (see Jones and Kammen, 2011).

At the time this Protocol is being written, the CoolClimate Calculator is only populated with consumption data for calendar year 2008. Future improvements may allow users to select

[8] CoolClimate uses econometrics and is technically a linear multivariate regression model.

[9] Emissions from household transportation are not exactly comparable to those estimated from a regional travel demand model, in part because the consumption-based approach includes all miles traveled by residents, even for trips that both begin and end outside of the community.

multiple years, and thereby track changes in per-household emissions over time. Despite this limitation, the CoolClimate Calculator provides Protocol users with a free and very easy method of estimating their community's household consumption-based carbon footprint.

Cities should use their own data where available. For example, emissions associated with household use of electricity and fuels may be known from the Built Environment and Transportation appendices; however, full life cycle emissions should be used (including methods BE.4, BE.5 and TR.9) in the consumption-based inventory. If a community is able to estimate the life cycle emissions associated with household use of electricity, for example, it could run the CoolClimate Calculator to estimate consumption-based emissions, subtract out the "home/electricity" results, multiply the remaining emissions by the number of households in the community, and then add back in the electricity-related life cycle emissions, calculated using methods BE.2, BE.4, and BE.5 (for use of electricity by all households in the community).

2. Household Survey Data

A more accurate approach for estimating household carbon footprints would be to collect survey data from residents in the community to estimate annual household purchases of food, goods and services and then apply appropriate emission factors to each type of purchase. Jones and Kammen (2011), for example, compared the carbon footprints of 28 metropolitan regions using this method and using U.S. Consumer Expenditures Survey. While collecting survey data may be the most accurate estimate of household consumption, this method is extremely costly, requires significant technical expertise and, as a result, is likely not feasible for most local governments. Local governments may also decide to use other methods to estimate household consumption provided that these methods are clearly documented and developed by experts with sufficient knowledge to conduct these studies.

3. IMPLAN-based approach

A third option for estimating household-based emissions is to develop a customized model using macroeconomic data from a source such as the IMPLAN economic modeling software. This approach also requires a significant level of effort and expertise to develop, and as such, may be out of reach for many communities. However, it does offer a few advantages over the existing CoolClimate Calculator approach, specifically: higher resolution of types of consumption (e.g., a larger number of categories of goods and services), the option to evaluate emissions for multiple years, and the option to estimate emissions by different regions of the world.[10] The IMPLAN approach is also readily extended to estimate consumption-based emissions associated with government and business capital as well; together, all three

[10] The IMPLAN method can be represented in the model either as one region (e.g., U.S.) or multiple production regions (e.g., a "multi-regional input-output model"). Separating out different regions (e.g., own community, all other U.S., international) allows the model to more accurately reflect the GHG-intensity of production in each region. IMPLAN provides means to estimate what fraction of goods and services are produced in-region versus in other U.S. regions or internationally, but there is considerable uncertainty in these estimates.

(household, government, and business capital) can be summed into a full consumption-based emissions inventory, as described below.

Details of the IMPLAN-based approach are described in other documents, but the following provides a quick introduction.[11] IMPLAN is a widely used economic modeling software package that provides estimates of consumption by households, governments, and local businesses (limited to capital formation and net increases in inventory) at the geographic scale of a county or state. To use IMPLAN (or similar data) to estimate consumption-based emissions, a customized model must be created that uses other IMPLAN data to trace the dollar flows associated with this consumption through inter-industry supply chains, thereby estimating all of the production activities (denominated in dollars), by production sector, associated with satisfying the given quantity of consumption. Separately, conventional inventories of emissions sources are used to estimate emissions intensities (emission per dollar) for each production sector. Production estimates (in dollars) are then multiplied against emissions intensities (emissions per dollar) to estimate the upstream (supply chain) emissions associated with household (or other) consumption. Emissions associated with use and disposal are typically drawn from separate sources, such as activity-based estimates described elsewhere in this Protocol. Upstream, use, and disposal-related emissions are then summed together as an estimate of the full life cycle emissions associated with consumption.

Government Consumption

1. CoolClimate Calculator: instantaneous estimate of municipal carbon footprints

Researchers at U.C. Berkeley are currently developing a local government decision-support tool for the California Air Resources Board that quantifies greenhouse gas reduction opportunities for local governments in California communities. Initially, the tool will be made available via CoolCalifornia.org for California cities only, but will eventually be available for U.S. cities at CoolClimate.Berkeley.edu. The tool includes an instantaneous estimate of carbon footprints for municipal (city) government operations, including energy, transit, waste, goods and services procured by cities. Some of these activities are likely already counted elsewhere in your community's inventory (such as direct combustion of fuels) as well as some emissions that may not be counted (fuel cycle emissions for building and transportation fuels; upstream emissions associated with goods and services purchased). As currently configured, the calculator only addresses municipal activities (city departments, city colleges) and excludes county agencies, state universities and agencies, and federal agencies. The Calculator may be revised in the future to include these activities, so as to provide a more complete estimate of the carbon footprint of government consumption in the community. As with household consumption, users of this tool may wish to replace the Calculator's estimate of emissions for activities where

[11] For details, refer to technical reports for consumption-based greenhouse gas inventories prepared for the State of Oregon and/or King County, Washington.

the community inventory provides more detailed and locally-specific estimates, such as life cycle emissions associated with building energy use.

2. IMPLAN-based approach

The IMPLAN-based approach, also described above, easily lends itself to inclusion of all government consumption. It should be noted that IMPLAN estimates the consumption (purchasing) activities of government facilities located inside the community's boundaries, and not the emissions associated with household (or business) funding (via taxes, fees) of government operations. Thus, for example, the IMPLAN-based approach would include the emissions associated with purchasing by a federal agency with offices in a county (e.g., a regional office of the U.S. Forest Service), but not the global emissions associated with overseas diplomatic or military operations that are partially funded by income taxes paid by households located in the community.

Full Consumption-Based Emissions Inventories

To date, a few communities have conducted inventories of the greenhouse gas emissions associated with full consumption by the community. All to date have used the IMPLAN-based approach, although other, simpler approaches may yet be developed.

1. IMPLAN-based approach

Consistent with standards for national economic accounting, all consumption ("economic final demand") can be divided into three types of consumers: household consumption, government consumption, and business investment/capital formation (including net increases in inventory). The use of an IMPLAN-based model readily accommodates all three in a single model, allowing for the creation of a full community-scale consumption-based inventory, as have been recently developed for San Francisco, King County (Washington) and the State of Oregon. The cost and effort required to develop such a model at the community scale is significant.

2. Other approaches

Protocol users should periodically check with ICLEI and others to see if other approaches have been developed. One possible approach that may offer potential would be via the CoolClimate Calculator, which already provides for estimates of household and municipal (only) government consumption. Data exists that would allow the government model to be expanded to include other in-community government consumption. If this were to be built out, users could add the two (household and government) estimates and arrive at an estimate of emissions associated with full consumption.[12]

[12]The CoolClimate model uses the Comprehensive Environmental Data Archive (CEDA) emissions database, which treats business investment/capital formation as an input to household or government

Life Cycle Emissions of Community Businesses

Businesses are increasingly interested in estimating their full life cycle GHG impact. Large companies procure upwards of billions of dollars annually in goods and services and purchasing decisions can have significant influence over decisions by suppliers. For this reason, The World Resources Institute/World Business Council for Sustainable Development (WRI-WBCSD) recently developed a life cycle GHG standard for individual businesses to estimate their full life cycle emissions.

While local governments may have limited influence over these emissions, it may be important for cities to understand the full impact of the community activities, including businesses. Recent work by the University of Colorado Denver shows that some cities are "producer cities", with most emissions resulting from local businesses, while other cities are more "consumer cities" with most emissions resulting from household activities.

At the time of this writing methods for estimating full life cycle emissions from all businesses in a community are currently under development. Researchers at U.C. Berkeley are currently developing a local government decision-support tool for the California Air Resources Board that includes an estimate of life cycle GHG emissions from businesses in California communities. The same tool will eventually be available for U.S. cities at CoolClimate.Berkeley.edu.

Estimating the carbon footprints of businesses may help to highlight opportunities for local businesses to reduce emissions, and show the extent to which emissions are primarily driven by the activities of households or businesses within a community. These estimates will also illustrate the extent to which businesses contribute to emissions via direct use of energy vs. their procurement of goods and services. For many businesses, the emissions embedded in purchased goods and services will far exceed the emissions associated with direct use of electricity and fuels.

Emissions (both in-boundary and trans-boundary) associated with in-boundary business activities that do not support consumption by local households and governments are not part of consumption-based emissions. Clearly, combining life cycle emissions from in-boundary households/governments with life cycle emissions from businesses would result in double counting for goods and services that are both produced and consumed locally. Using the CoolClimate model only for household and government consumption will not result in double counting.

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consumption rather than as its own type of consumer. Under this approach, there is no need to separately estimate the emissions associated with capital formation/investment by in-community businesses and in fact, doing so would result in double counting with household and government-based consumption emissions.

Conclusion

As discussed at the beginning of this appendix, consumption-based accounting of greenhouse gas emissions is a relatively young field. No real standards exist, and "best practices" have not yet been identified. Two primary approaches are presented above. The first, developed by the CoolClimate Network offers a very easy and inexpensive "snapshot" estimate of consumption-based emissions for households and municipal governments. These estimates are currently only available for one calendar year (2008), although estimates for future years may be developed. In contrast, the IMPLAN method provides the potential for greater detail and customization, and includes a broader range of government activities as well as business capital/inventory formation (allowing for a full consumption-based emissions inventory), but this approach requires significantly higher effort and expense. Many communities may find it sufficient to use the CoolClimate approach as a rough estimate, and consider more detailed conclusions from existing, more-detailed studies, such as those produced by King County and Oregon.

Supplemental Information: Additional Methodology Considerations

This section is provided for Protocol users that have a strong interest in more deeply understanding consumption-based inventory methodologies.

Consumption-based reporting of GHGs associated with goods and services is relatively new and is rapidly developing. Like most GHG accounting methods, consumption-based reporting relies heavily on assembling data on activities and the GHG-intensity of those activities, and calculating consumption-based emissions using the following relationship:

$$Emissions\ (CO_2e) = Consumption \times Emissions\text{-}Intensity$$

The most fundamental question in assembling a consumption-based inventory is identifying sources of data for levels of consumption and the emissions-intensity of that consumption. In particular, practitioners face at least three key issues in defining what to count as *consumption*.

These issues are:

- **Categories of consumption to include.** A complete reporting of consumption-based emissions would include all categories of consumption (e.g., food, clothing, all other goods, services, and many subcategories therein). Several approaches developed to date build from economic data and models that divide the economy up into several hundred categories of consumption, from red meat to home furnishings. Other approaches may focus on a more limited set of categories, such as only concrete or food, and practical limitations may in some cases limit the number of categories addressed.

- **Types of "consumers" to include.** Uses of the terms *consumer* and *consumption* can vary depending on the context, and it is important to clearly state what types of consumers are included. As used in national economic accounts, *consumption* is comprised primarily of household expenditures, plus government spending and one type of business expenditures: investment (in capital equipment or in net, annual accumulations to inventory). This suggests three types of "consumers": households, governments, and businesses. Households are limited to those that reside in the community; purchases by out-of-community residents who may be visiting the community are typically not included in consumption. Further, in standard consumption-based accounting, business activities (if included at all) are limited to investment in capital equipment or net accumulations to inventory; emissions associated with other purchases, such as electricity, fuel or food, are only included to the extent that they support or are related to satisfying consumption by "consumers". Practitioners will need to decide which types of consumers they wish to include and if they wish to consider business investment as an input to household or government consumption rather than as its own type of consumer.[13] The CEDA input-output model that is used in the CoolClimate Calculator takes the former approach; the IMPLAN economic model used in consumption-based inventories for King County, San Francisco and Oregon took the latter approach. To date, one common approach has been to focus on household consumption, since it is the dominant driver and spending data is more readily available. A few communities have taken a broader view, consistent with national economic accounts, and included government and business capital.

- **Whether to use economic or physical units of consumption.** Most data on consumption of goods and services is available in economic, rather than physical, units, and so most consumption-based reporting approaches for GHGs rely on estimates of dollar-values of spending in different categories and also derive emissions-intensities on a per-dollar basis. However, GHG emissions may correlate more strongly with physical or "functional" units, such as kilograms (or calories) of food, number of pairs of blue jeans, kWh of electricity, or vehicle miles travelled. Accordingly, practitioners may wish to seek out means to use physical units to estimate consumption and emissions intensity where possible, especially if data on physical units is available specific to the community on a regular basis (to increase the ability of the community to track changes over time). At a minimum, consumption-based inventories should strive to use physical units for local vehicle travel and energy use, using the same activity and context data (e.g., vehicle miles traveled, kwh of electricity) as specified in Appendix C and Appendix D. In contrast, physical data for consumption of goods and services is (at this time) rarely available. Separate accounting can also be undertaken to estimate emissions associated with product end-of-life (disposal).

[13] The treatment of business spending presents additional challenges. From the perspective of national economic accounts, most business spending is not consumption, since it occurs in the process of fulfilling demand from other (household or government) consumers. Accordingly, most business emissions would be "embodied" in categories of household consumption, such as emissions from heating a retail store that sells clothing or food. Regardless, a consistent framework for defining what types of consumers are included (and how) is very important in conducting consumption-based accounting.

Decisions on the issues above may also inform (and be informed by) sources of data on emissions-intensity. In general, two broad methods are available to calculate emissions intensity of goods and services, and both are types of life cycle assessments (LCA).

1. Input-output LCA relies on (usually) national-level averages of how expenditures on certain economic commodities flow through the economy and result in production activities in a variety of economic sectors (e.g., how money consumers spend on fresh fruits and vegetables result in production activities in sectors such as farming, fertilizer production, and packaging production). The estimates of production activities (in dollars) associated with satisfying consumption are combined with estimates of emissions intensity for each of those producing sectors, typically expressed in CO_2e *per dollar*. While national-level averages are commonly used, some communities have gone further and created multi-regional models that trace consumption dollars through various regions of the world and use different estimates of emissions intensity for different geographic regions.

2. Process LCAs take a different approach and instead assemble data on specific production practices and inputs for a particular product (e.g., a tomato) and usually yield estimates of emissions intensity in CO_2e *per kilogram* or other functional unit (e.g., a pair of blue jeans or liter of juice). In general, input-output LCAs offer greater breadth of coverage (enabling inclusion of a greater array of goods and services) while process-based LCAs allow for more specific definition of products.

To be most complete, consumption-based reporting would include all emissions, including imports, required to satisfy consumption activities by community members. Because of the huge array of goods and services consumed in a community, relatively complete consumption-based methods typically involve the use of input-output life cycle analysis to estimate patterns of consumption activity and the emissions intensity of that consumption. Due to the complexity of these methods, however, few communities in the U.S. have attempted such calculations and reporting to date. However, other, simplified methods are emerging.

Emissions occurring during the disposal of products and recovered during the recycling of products are also sometimes considered in consumption-based approaches and allocated (partially or fully) to households. Again, there are several different methods of addressing these emissions.