Consumption-Based Emissions Inventory For San Francisco

Estimates of the Greenhouse Gases Released to Produce, Transport, Sell, Use, and Dispose of Goods and Services Consumed in San Francisco

Technical Report - May 2011

Stockholm Environment Institute – U.S. Center for City of San Francisco, California

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TECHNICAL MODEL DESCRIPTION

1. OVERVIEW

The Consumption-Based Emissions Inventory[1] (CBEI) provides a different vantage point on greenhouse gas emission responsibility. Conventional inventories assign emissions to geographic regions based on the location of their release: Making a loaf of bread in San Francisco results in (for illustrative purposes) 1 metric ton of carbon dioxide equivalent (CO2-e) emissions, and San Francisco is assigned that 1 metric ton CO2-e in its geographic emissions inventory. These geographic-based inventories show how much CO2-e is emitted where – an essential first step in implementing mitigation policies.

The geographic basis is an important way of viewing emissions responsibility, but not the only way. There is increasing interest in attributing emissions not only to the jurisdiction where they are released (for example, local bakeries using energy), but also to the end users of goods and services (the consumers that buy bread from those bakeries, locally or elsewhere). Both of these views are legitimate in that every ton of CO2-e results from both the supply and demand side of the economic systems: it "belongs" to its location of production, and it "belongs" to its location of consumption.

A consumption-based analysis notes that the bread was produced in San Francisco, but then considers a series of follow-up questions: Who purchased the bread? And furthermore, if someone in San Francisco purchases bread: Where was it produced, and how much emissions were released in its production? What emissions were generated by production of the materials that went into that bread? What materials went into those materials? And so on.

CBEI's consumption-based methodology tracks financial flows and attributes greenhouse gas emissions to the "consumption" (the end use or final purchase, not as an input to production or for resale) of goods and services. Every purchase that we make is "embedded" with greenhouse gases; CBEI makes the consumers of goods and services accountable for the emission of greenhouse gases in those commodities' production and distribution. Every region is assigned the emissions embedded in the goods and services used by its households (and a few other kinds of "final consumers" discussed below), and no region is assigned emissions for goods produced in-region but purchased elsewhere. The result is a shift in emission attribution from producers to consumers. For regions that import more embedded emissions than they export (such as most urban areas and many higher-income areas), consumption-based emissions will be higher than in a geographic inventory accounting. For regions that export more embedded emissions (such as areas with a lot of industrial production or petroleum extraction), consumption-based emissions will be lower than in a geographic inventory.

CBEI can be used to model consumption-based emissions for any sub-national jurisdiction in the United States. For this project, two CBEI inventories were constructed: one for the City of San Francisco, and one for the State of California. Part 2 of this technical report presents results of the CBEI inventory for San Francisco. Part 3 presents results of the CBEI inventory for California, and compares these results to those of San Francisco. Part 4 presents a detailed technical

[1] Stanton, E.A., Bueno, R. and Munitz, C. (2011). *Consumption-Based Inventory (CBEI)*. Version 2.0 (March 2011). Somerville, MA: Stockholm Environment Institute-U.S. Center. http://sei-us.org/projects/id/199.

methodology for the CBEI model, including data sources for both inventories. For ease of exposition, this overview (Part 1) will focus solely on the CBEI for San Francisco.
The CBEI model begins with San Francisco's 2008 "Community Wide GHG Inventory"[2] data on: 1) the emissions released by the use of fuel and electricity in (and waste disposal from) residential and government buildings in the area, and 2) emissions released by industrial and commercial activities in the area. The industrial and commercial inventory data are combined with San-Francisco-specific IMPLAN[3] input-output economic data that tracks supply chains from raw materials, to "intermediate goods" (materials, including fuels and electricity, used to produce other goods and services), to the final goods and services sold to consumers. IMPLAN economic data are widely used by jurisdictions throughout the United States to create economic forecasts, inform budget projections, and analyze the expected impact of economic development projects.

Using IMPLAN data, CBEI tracks supply chains both within and outside the San Francisco borders and classifies emissions as occurring in one of three areas: inside San Francisco, outside San Francisco but inside the United States, and outside the United States. CBEI uses inventory data from the San Francisco Community Wide inventory, the U.S. Environmental Protection Agency, and a detailed study of U.S. international trade in embedded emissions to create emissions coefficients (tons of CO2-e per dollar spent) for each area and for each of 440 different kinds of goods and services. Consumption-based emissions are calculated by multiplying San Francisco's consumption (in dollars) of goods and services from each area by that area's emissions coefficients (see Figure 1). Then CBEI adds end-use emissions from fuels burned and wastes disposed of by households and government entities within San Francisco as calculated in the Community Wide inventory.

Figure1: CBEI Calculation Summary

San Francisco Consumption (in dollars)	x	Emissions Coefficients (tons CO_2-e/$)	=	San Francisco Embedded Emissions (tons CO_2-e)
of San-Francisco-made goods and services	x	San Francisco	=	from San Francisco
of U.S. (outside of San Francisco) made goods and services	x	United States	=	from rest of the United States
of foreign goods and services	x	Imports to the U.S.	=	from other countries
			SUB-TOTAL	**San Francisco Embedded Emissions (tons CO_2-e)**
			+	San Francisco End-Use Emissions (tons CO_2-e)
			TOTAL	**Total San Francisco Consumption-Based Emissions (tons CO_2-e)**

[2] San Francisco (California). *City and County of San Francisco, 2008 Community Wide GHG Inventory* Department of the Environment, City and County of San Francisco (2011).
[3] Minnesota IMPLAN Group Inc. (2010). *IMPLAN Economic Modeling.* Version 3.0. Hudson, WI. http://implan.com.

This consumption-based methodology is not meant to replace geographic greenhouse gas inventories, but rather to complement them. Both viewpoints – geographic and consumption-based accounting – are valid ways to approach emissions accountability, and both are useful for different types of decision-making – by residents, governments and businesses.

The following sections provide a non-technical description of the CBEI model.

KEY TERMS

Commodities – goods and services

Consuming Sector – the final good or service purchased (for example, bread)

Consumption – final (end use) purchase of goods and services. Consumption excludes business purchases of inputs to production or products for resale.

Consumption-Based Inventory – emissions inventory based on consumer responsibility: emissions released as a result of consumer purchases from an area are attributed to that area

Direct Emissions – those emitted in producing the final good or service (for example, emissions released at an electric power plant)

Embedded Emissions – emissions from industrial and commercial activities necessary to produce and distribute goods and services. Sometimes called "embodied" or "upstream" emissions.

Emissions Coefficients – the amounts of greenhouse gases released per dollar of economic activity in a particular industrial or commercial sector and a particular geographic area. Also called emissions intensities.

Emitting Sector – the type of production occurring at the time of emission (for example, wheat farming)

End-Use Emissions – emissions from households and government entities use of fuel, electricity, and waste disposal services

Final Consumers – purchasers of goods and services for end use: households, government entities, and (for investment purposes only) businesses. Business purchases of inputs to production or products for resale are not part of consumption.

Final Demand – the purchase of goods and services by households and government, and businesses' investment in capital goods and net inventory

Geographic Inventory – emissions inventory based on geographic responsibility: emissions released from an area are attributed to that area

Goods – material products for market purchase (bread, steel, automobiles)

Gross Demand – final demand plus intermediate demand

Hybrid Inventory – an emissions inventory that includes elements of both geographic and consumer-based responsibility

Indirect Emissions – those emitted further upstream in the production process (for example, emissions from refining and distributing the petroleum products used to generate electricity)

Intermediate Demand – the upstream inputs needed to produce final demand

Intermediate Goods – materials used in production, including fuels and electricity

Services – activities for market purchase (haircuts, tax preparation, restaurant dining)

1.1. Consumption versus Geographic-Based Emissions Inventories

Greenhouse gas emissions can be viewed either in terms of geographic responsibility or consumer responsibility. Geographic responsibility attributes emissions strictly by the location of their emission: all emissions physically released in San Francisco belong to San Francisco. Consumer responsibility takes a different view: all emissions caused by consumer purchases in San Francisco belong to San Francisco, regardless of where they were physically emitted. For the world as a whole (or for any economy that does not trade outside its borders), total emissions by geographic responsibility must equal total emissions by consumer responsibility.

Emissions inventories often mix and match between geographic and consumer perspectives. San Francisco's 2008 Community Wide Inventory, for example, is a hybrid, containing both geographic and consumption-based elements in its "Community Wide Emissions Factor," which uses a weighted average of the carbon intensities for power produced in San Francisco and consumed by its residents. Figure 2 reports responsibility assignments used for each of three kinds of emissions inventories. GEO is an archetypal geographic inventory; HYBRID is an example of a geographic inventory that includes some consumer responsibility elements; and CBEI is the SEI-US Consumption-Based Emissions Inventory.[4]

Figure 2: Emissions Responsibility Assignments

		Geographic Responsibility	Consumer Responsibility
End Use:	**Fuels, Buildings**	GEO, HYBRID, CBEI	
	Fuels, Transportation	GEO	HYBRID, CBEI
	Electricity	GEO	HYBRID, CBEI
	Waste Disposal	GEO	HYBRID, CBEI
Industrial/Commercial		GEO, HYBRID	CBEI
LULUCF		GEO, HYBRID	

Figure 2 breaks greenhouse gas emissions into several types that, together, are comprehensive and exhaustive; that is, all greenhouse gas emissions fall into one, and only one, of these types.

- *End Use*, including:
  - Fuels for burned for heating and appliances in buildings
  - Fuels burned for transportation
  - Electricity
  - Waste disposal

[4] Responsibility assignments in the geographic (GEO) and hybrid (HYBRID) inventories have been generalized across many similar inventory methods, quite a few of which vary from these examples. The Consumption-Based Emissions Inventory (CBEI) refers only to the responsibility assignments in the SEI-US model; other models of the emissions embedded in consumption may differ.

- *Industrial/Commercial*, energy and non-energy greenhouse gas emissions from the production and sale of consumer products
- *LULUCF*, or land use, land-use change, and forestry

For end-use emissions from fuels used in buildings, geographic and consumer responsibility amount to the same thing – the end purchaser of the fuel always is present at the location of emission. All types of inventories estimate the same value for these emissions. The use and disposal phases of the San Francisco CBEI model include these end-use emissions, as estimated in the San Francisco Community Wide inventory, plus the upstream emissions associated with producing the fuels burned for these end uses.

End-use emissions from transportation fuels, electricity and waste disposal are assigned strictly to their physical location of emission in a geographic inventory, but there is a recent trend towards hybrid inventory methodologies, like San Francisco's Community Wide inventory, that approach some of these end-use emission types from the point of view of consumer responsibility. A strict geographic inventory would include emissions from the electricity produced in San Francisco, the transportation fuels burned in San Francisco, and the wastes disposed of in San Francisco. The Community Wide inventory instead includes emissions from electricity used by San Francisco consumers, regardless of where the electricity was produced. The Community Wide inventory also departs from a pure geographic perspective for ground transportation and waste emissions. For ground transportation, the inventory counts half of the emissions associated with all vehicle trips that cross the city border and all the emissions associated with vehicle trips that occur entirely within San Francisco. For waste emissions, supplemental materials to the Community Wide inventory count all emissions associated with waste disposal by San Francisco consumers in 2008, even if those emissions occur outside San Francisco (and in future years, as materials, such as food waste, decompose in the landfill).

Geographic inventories, San Francisco's Community Wide inventory, and other hybrid inventories include *industrial/commercial emissions* based on geographic responsibility: emissions from industrial production and commercial establishments located in San Francisco are assigned to San Francisco, regardless of whether the goods produced are purchased in San Francisco or exported. CBEI instead assigns industrial/commercial emissions based on consumer responsibility as discussed below.

The final emission type, *land use, land-use change, and forestry*, is approached almost exclusively from a position of geographic responsibility: LULUCF emissions, positive or negative, that take place in San Francisco are assigned to San Francisco. Many geographic and hybrid inventories leave this category out all together, or include net sequestration as an addendum to the main inventory. The San Francisco Community Wide Inventory includes the net emissions sink generated by the San Francisco Urban Forest. CBEI excludes any LULUCF.

1.2. Emissions Responsibility in CBEI

The CBEI model estimates the total emissions accountability of a given area in a given year based on the viewpoint that emissions are the responsibility of the consumers that use fuel, electricity, goods and services. This "consumer responsibility" logic turns conventional inventories' "geographic responsibility" on its head, making it possible to look at the relationship between trade in goods that have emissions embedded in them (that is, greenhouse gases were emitted in the production of the traded goods) and local, national, and global greenhouse gas mitigation efforts.

San Francisco's CBEI estimates the greenhouse gas emissions resulting from the purchase of goods and services by San Francisco consumers. The terms "consumer" and "consumption" are critical to understanding the meaning of consumption-based results and relating these results to those of other emission inventories. **Consumption** refers to the final use of commodities – in economics, "final demand" – where goods and services are purchased solely for their use and not for resale or as inputs into the production of other goods and services. **Consumers** may be households, government entities, or, in some special cases, businesses. The vast majority of a business' purchases, however, is not consumption – a topic we return to below.

CBEI approaches emissions responsibility exclusively from a consumer perspective, as shown in Figure 3. In assigning emissions responsibility, CBEI differs from the Community Wide inventory in its treatment of industrial/commercial emissions. In fact, CBEI is really the combination of two inventory methods (a consumption-based accounting of industrial and commercial emissions and the Community Wide inventory's accounting of end-use emissions), with some adjustment made for double-counting between them. CBEI brings together San Francisco's existing Community Wide inventory with a newly developed inventory of "embedded" emissions.

Figure 3: Comparing Inventory Methods

<table>
<tr><th colspan="2"></th><th>Geographic</th><th>Hybrid</th><th>SEI-US' CBEI</th></tr>
<tr><td rowspan="4">Consumer End Use:</td><td>Fuels, Buildings</td><td colspan="3">geographic responsibility = consumer responsibility</td></tr>
<tr><td>Fuels, Transportation</td><td rowspan="3">geographic responsibility</td><td colspan="2" rowspan="3">consumer responsibility</td></tr>
<tr><td>Electricity</td></tr>
<tr><td>Waste Disposal</td></tr>
<tr><td colspan="2">Industrial/Commercial</td><td colspan="2">geographic responsibility (except for electricity)</td><td>consumer responsibility</td></tr>
</table>

Embedded emissions are industrial/commercial emissions approached from a consumer responsibility perspective. Using input-output economic data, each consumer purchase can

be traced backward through its production process all the way to its raw materials, making it possible to estimate the total "embedded" emissions caused by the purchase and distribution of that commodity. Embedded emissions exclude end-use emissions from the use and disposal of goods after the consumer purchase. For example, the embedded emissions in purchasing a car are the emissions from its construction and sale, not from its end use: burning gasoline in its engine.a

The estimation of embedded emissions combines economic data with "emission intensities" that are calculated using the Community Wide inventory's industrial/commercial emissions. For each type of commodity, emissions released in San Francisco are divided by the monetary value of production in San Francisco (that is, the dollars spent to produce that product or service). Each sector's emissions intensity is presented in tons of CO2-equivalent per dollar. CBEI calculates separate emissions intensities for goods produced in San Francisco, in the United States but outside of San Francisco, and in foreign countries for import into the United States.

In the CBEI consumption-based results, the embedded emissions from San Francisco's purchases of consumer goods and services are divided into three pre-purchase phases: production, pre-purchase transportation, and retail/wholesale. Two additional phases report end-use emissions: use, and post-consumer disposal (see Figure 4).

Figure 4: Five Phases of the SEI-US CBEI Model

Emission Type	Life-Cycle Phase	Inventory Sources
Embedded Emissions	Production	**From** CBEI Embedded Pre-Purchase model **minus deleted** emissions from electricity and waste disposal and **minus transferred** indirect emissions for fuel and electricity (to use phase) and waste disposal (to post-consumer disposal phase)
	Pre-Purchase Transportation	
	Retail/Wholesale	
End-Use Emissions	Use	**From** Community Wide inventory end-use fuel and electricity **plus transferred** indirect emissions for fuel and electricity
	Post-Consumer Disposal	**From** Community Wide inventory end-use waste disposal **plus transferred** indirect emissions for waste disposal

CBEI's methodology for estimating embedded emissions overlaps with the Community Wide inventory's estimation of end-use emissions for two types of purchases: electricity and waste disposal services. To avoid double counting, CBEI deletes its *direct* emissions estimates for these two sectors (direct emissions are those emitted at the electrical generator, landfill, or incinerator) but retains important information about *indirect* emissions further upstream in the production

process (for example, emissions from refining and distributing the petroleum products used to generate electricity). In the end, CBEI's use and disposal emissions are the end-use emissions estimated in San Francisco's Community Wide inventory, plus indirect emissions from the production and distribution of fuels and electricity, and disposal of wastes, that are calculated in the model's embedded pre-purchase phases and then transferred to the use and disposal phases.

1.3. Model Organization

Emissions are organized by type of consumer, commodity type, life-cycle phase, and location of emission. Before reporting more detailed information about CBEI calculations, this section presents a primer on the model's organization.

Type of Consumer

CBEI's consumption-based emissions are attributed to three types of consumers:

- San Francisco ***households*** purchase commodities for their final use, including goods (such as food, electronics, household furnishings, and cars), services (such as haircuts or tax preparation), fuel for vehicles and home heating, and electricity for household lights, electronics, and appliances. In 2008, 71 percent of San Francisco's final demand came from households (see Part 4, Table 1).

- San Francisco-based local, state and federal ***government*** entities purchase commodities for final use, including goods (like office supplies or food consumed in a prison), fuel, and electricity used in government facilities. San Francisco-based federal government activities were responsible for 4 percent of final demand, while local and state government activities accounted for 14 percent.[5] CBEI does not estimate San Francisco residents' "share" of or "contribution" to (via taxes or voting) out-of-city emissions resulting from federal government activities (e.g. foreign affairs, military, etc.).

- The vast majority of businesses' purchases is not direct consumption, but rather support for the production of goods and services for household or government consumption. ***Business investment*** purchases, or the equipment or inventory that businesses purchase but do not sell in a given year, are treated as direct consumption by businesses. Business investment accounted for 11 percent of San Francisco's final demand in 2008. (For comparison, U.S. investment was 15 percent of total final demand.) In CBEI, emissions associated with construction of nonresidential buildings are included under business investment consumption, while emissions associated with construction of residential buildings are reported under household consumption.

Most business purchases are of "intermediate" goods and services that are combined to produce new goods and services for sale. In input-output economic data (and in the CBEI model) these intermediate purchases can be linked together into a supply chain from raw materials to intermediate goods to final goods.

But a few kinds of business purchases do not easily conform to classification by supply chain. Wheat, yeast, water, and electricity are combined to make bread – these intermediate goods become the bread. The mixers, ovens and bakery building are also essential to making bread, but they don't become the bread. These durable goods – equipment and infrastructure – are used to make products year in and year out. They depreciate; they receive maintenance or

[5] Transfer payments (government payments made directly to households, for example, social security) are not included in San Francisco-based federal government activities (except to the extent that San Francisco state/local governments or households use the transfer payments to engage in consumption).

retro-fitting; and over a machine or a building's lifetime it may be utilized in the production of many different products. Because of these complexities, in CBEI durable goods are treated, not as a part of the supply chain that becomes the final good, but rather as a special kind of final consumption called business investment. Net inventory (inventory at the end of this year less inventory at the end of last year) is included in business investment for a similar reason – it has not yet become part of a final purchased good, so there is no supply chain to which to attach it.

In CBEI, emissions from San Francisco businesses' purchase of equipment, construction of buildings, and net inventory are attributed to San Francisco.[6] Just like households and government entities, businesses can consume final goods that are not accountable to whoever buys the businesses' products. This logic may seem incongruous at first but consider two points. First, this approach is used throughout the field of economics, and is central to the standard methodology for calculating gross domestic product used in every country around the world. Second, businesses investing in equipment and buildings cannot know how much (or even what) goods will be produced as a result. They may go out of business this year or in 50 years; they may decide to sell these investments, or the equipment may break down or become obsolete. There is no reasonable set of assumptions with which to tie business investments to all of the future products they might produce. Emissions from business investments, then, are attributed as consumption in the jurisdictions in which these purchases are made, and can be part of these jurisdictions long-term emission abatement strategies.

Commodity Type

Commodities are classified in 440 sectors. These sectors are aggregated to 62 subcategories and 16 categories (see Figure 5).

- ***Sectors***: CBEI data are calculated and reported in 440 types of industries (or, equivalently, 440 types of commodities produced by these industries). About one-tenth of these commodity sectors have little or no "final demand" in San Francisco – that is, San Francisco's consumers do not buy these products. Instead, they are purchased by businesses to make intermediate products for sale to other businesses, or goods and services for final consumption. (See the Appendix for a full mapping of sectors, sub-categories and categories.)

- ***Subcategories***: The 440 commodity sectors are grouped into 62 subcategories.[7]

- ***Categories***: The 62 sub-categories are grouped into 16 categories: Appliances, heating, ventilation and air conditioning (HVAC); Appliances, other; Clothing; Concrete, cement and lime; Construction; Electronics; Food and beverages; Forest products; Fuel, utilities, waste; Healthcare; Home, yard, office; Retailer and wholesale; Services; Transportation services; Vehicles and parts; and Other.

[6] Note that the CBEI model treats residential construction, normally part of the "investment" category in National Income and Product Accounting, as a type of household consumption.
[7] Categories that are not further subdivided are counted as both categories and subcategories. For example, clothing is both a category and a subcategory.

The change in emissions responsibility from geographic-based industrial/commercial emissions to consumer-based embedded emissions is one of two main differences between CBEI and San Francisco's Community Wide inventory. A second critical difference is that hybrid inventories such as the Community Wide sort emissions by the emitting sector, while CBEI sorts emissions by the consuming sector. The emitting sector refers to the type of production occurring at the time of emission – wheat farming, yeast manufacture, water and natural gas utilities. The consuming sector refers to the final purchased good or service responsible for the embedded emissions – bread.

In Figure 6, all of the emitting sectors have counterparts as consuming sectors. Bread consumed in San Francisco includes emissions from numerous emitting sectors, just a few of which are shown here.

Figure 5: CBEI's Categories and Subcategories

Appliances, HVAC	**Healthcare**
Appliances, other	Healthcare services
Lighting fixtures and bulbs	Medicines and other healthcare supplies
Ranges and microwaves	**Home, yard, office**
Refrigerators and freezers	Home furnishings
Washers and dryers	Household supplies
Other appliances	Lawn and garden
Clothing	Media and office supplies (except paper)
Concrete, cement and lime	**Retailer and wholesale**
Construction	Retailers
Non-residential construction	Wholesale
Prefabricated buildings	**Services**
Residential construction and remodeling	Banks, financial, legal, real estate, insurance
Electronics	Building services
Computer service and equipment	Education and day care
Other electronics	Hotels, motels, entertainment, media
Food and beverages	Other services
Beverages	**Transportation services**
Condiments, oils and sweeteners	Car rental, repair and wash
Dairy	Transportation services, air
Fresh fruit, nuts and vegetables	Transportation services, mass transit
Frozen food	Transportation services, rail
Grains, baked goods, cereals, roasted nuts, nut butters	Transportation services, truck
Poultry and eggs	Transportation services, water
Processed fruit, nuts and vegetables	Transportation services, other
Red meat	**Vehicles and vehicle parts**
Restaurants	Aircraft
Seafood	Cars and light trucks
Other food and agriculture	Heavy duty trucks
Forest products	Other road vehicles
Paper and cardboard	Railroad rolling stock
Other processed forest products	Ships and boats
Unprocessed forest products	Vehicle parts
Fuel, utilities, waste	**Other**
Gasoline, heating fuels, other petroleum products	
Natural gas distribution	
Oil and gas extraction	
Power generation and supply	
Waste management	
Water- sewage and other systems	

Figure 6: Emissions Embedded in Bread and Light Bulbs

		Consuming Sector										
		Bread	Electricity	Filaments	Glass	Light bulbs	Natural gas	Silica	Tungsten	Water	Wheat	Yeast
Emitting Sector	Bread manufacturers	X										
	Electric utilities	X				X						
	Filament manufacturers					X						
	Glass manufacturers					X						
	Light bulb manufacturers	X				X						
	Natural gas utilities	X										
	Silica mining					X						
	Tungsten mining					X						
	Water utilities	X				X						
	Wheat farmers	X										
	Yeast manufacturers	X										

In geographic and hybrid inventories industrial/commercial emissions are commonly classified by the type of process that releases emissions. CBEI first calculates emissions according to a similar classification logic, disaggregated into 440 emitting sectors (for example, light bulb manufacturers, tungsten and silica mining, filament and glass manufacture, and water and electric utilities in Figure 6). But before combining its results with the Community Wide inventory's end-use emissions, CBEI reclassifies both embedded and end-use emissions by consuming sector. Embedded pre-purchase emissions are sorted by the final good or service that is consumed (in this example, light bulbs), and end-use emissions are sorted by the type of vehicle or appliance using the energy (end-use electricity to power light bulbs), or the type of good that is disposed of (waste emitted from landfilling or incinerating light bulbs).

Location of Emission

The emissions embedded in final goods and services may occur within San Francisco, inside the United States but outside of San Francisco, or outside of the United States:

- ***San Francisco*** emissions are from San Francisco production for San Francisco consumption. They include upstream requirements of production for San Francisco consumption only when the intermediate products are made in San Francisco.

- ***Inside-US-Outside-SF*** emissions are from United States (other than San Francisco) production for San Francisco consumption. They include U.S.-made upstream requirements of production for San Francisco consumption.

- ***Foreign*** emissions are from foreign production for San Francisco consumption. They include foreign-made upstream requirements of production for San Francisco consumption.

Both material goods and services can be imported. San Francisco consumers "import" foreign services whenever they make an overseas financial transaction, use overseas technical support for a computer problem, or receive the results of an X-ray analyzed by an overseas radiologist – all common practices. Services are also "imported" into San Francisco from the rest of the United States whenever San Francisco residents purchase a service from outside the city (for example, by going out to dinner in Berkeley).

Life-Cycle Phases

Finally, CBEI's consumption-based emissions are divided into five life-cycle phases: production, pre-purchase transportation, wholesale and retail, use, and post-consumer disposal.

Embedded pre-purchase emissions:

- ***Production phase***: Emissions from the manufacture of consumer goods are classified as production-phase emissions. For example, in the case of a cookie, this phase includes not only emissions released by the cookie factory, but also the emissions that resulted from production of all of the supplies purchased by the manufacturer: flour, chocolate, water, and electricity. Final consumer products also can be services, such as a haircut or tax preparation. Emissions that result from the operation of a hair salon, and all of the emissions from the products purchased for use in the salon, are also production-phase emissions.

- ***Pre-purchase transportation phase***: Consumer products, and the supplies necessary to manufacture them, often make several stops on their way from factory to retail store. Transportation emissions from intermediate producer (the makers of the flour and chocolate in the example of cookie manufacture) to final producer (the cookie factory) to wholesale warehouse to retail store are classified as pre-purchase transportation. To be clear, this life-cycle phase does not include post-purchase transportation (bringing the cookies home from the store – these emissions are captured in the vehicles and parts category of the "use phase").

- ***Wholesale and retail phase***: Wholesale warehouses and retail stores cause greenhouse gas emissions primarily from lighting, electronics and temperature control. This phase includes the direct emissions of wholesalers and retailers, and upstream emissions from goods and services purchased by wholesale and retail businesses (including electricity and fuel).

End-use emissions:

- ***Use phase***: Some products cause emissions in their use by the final consumer. For

example, heating fuel causes emissions when burned in the consumer's furnace and gasoline causes emissions when burned in the consumer's car engine. Electricity emissions are also classified as a part of the use phase – the use of a computer or a light causes emissions from electricity generation. The use phase includes emissions at the point of combustion, as well as supply-chain emissions associated with the fuels that are combusted (e.g., emissions from petroleum refineries and coal mines).

- ***Post-consumer disposal phase***: The final life-cycle phase is disposal. This phase includes only the emissions that result from the post-consumer landfilling or incineration of products. This phase does not include emissions that result from industrial or commercial waste, which are instead classified as production emissions. This phase does not include any "credits" for emissions reductions resulting from recycling or composting, except to the extent that recycling and composting reduce emissions from landfilling and combustion.

Geographic, hybrid, and consumption-based inventories share a common scope of analysis: the emissions related to (by location of emission or by location of consumption) a particular geographic area in a particular year. Embedded emissions (production, pre-purchase transportation, retail/wholesale) result from products purchased by San Francisco in 2008, and end-use emissions (use and post-consumer disposal) result from fuels burned and waste disposed of by San Francisco in 2008. The focus of the CBEI analysis is on the activities of San Francisco as a whole, and not on individual households, or purchases of single goods. The life-cycle phases in CBEI are subdivisions of the total San Francisco emissions in 2008, from a consumer responsibility perspective. In contrast, a true life-cycle analysis follows a single good from cradle to grave. CBEI embraces the idea of cradle-to-grave responsibility by dividing its emissions into activities that relate to each phase of the single-year "life cycle."

For example, a true life-cycle emissions analysis of a car would follow that car from the raw materials that went into its production, through the production process, through pre-purchase transportation, retail and wholesale activities, to its purchase, use in combination with gasoline, and eventual disposal. CBEI does not estimate the emissions of a single car; it estimates the emissions related to San Francisco residents' purchasing and driving cars in 2008. For the production, pre-purchase transportation, and retail/wholesale phases, car emissions result from all car purchases made in San Francisco in 2008. For the use phase, car emissions result from San Francisco residents' driving cars in 2008. For the post-consumer disposal phase, car emissions result from San Francisco residents' disposal of cars in 2008.

CBEI results are best viewed from the vantage point of the planner or policymaker considering what can be done to reduce their jurisdiction's aggregate annual emissions responsibility. These results are not directed towards helping individual households make decisions about when it is best to invest in a new car or household appliance in order to reduce lifetime greenhouse gas emissions. This being said, the CBEI apparatus does include an additional "demand modeler" tool for detailed analysis. Using this tool, an analyst can explore the embedded emissions implications of customized consumption profiles. The CBEI demand modeler results, however, only include embedded pre-purchase emissions, and not end-use (use and disposal phase) emissions.

1.4. Understanding CBEI

CBEI results include the complete impacts of San Francisco 2008 consumption, divided into three embedded pre-purchase phases (production, pre-purchase transportation, and wholesale-and-retail distribution) and two end-use phases (use and post-consumer disposal). CBEI's first three "pre-purchase" phases estimate the embedded emissions from the purchase of commodities; that is, they include both the direct emissions from the production of goods and services purchased by San Francisco consumers, and the indirect emissions from the production of inputs into those consumer goods. The use and post-consumer disposal phases estimate end-use emissions that occur after goods and services are purchased by consumers. The use phase includes the direct and indirect emissions from fuel used by the area's households and government entities, and the direct and indirect emissions from the generation of electricity used by households and governments.[8] The post-consumer disposal phase includes the direct and indirect emissions from households' and governments' waste disposal, both from landfilling and (where applicable) the incineration of solid wastes.

CBEI models consumption-based greenhouse gas emissions for a given locality and a single year. San Francisco 2008 CBEI follows four steps to model the consumption-based emissions of goods and services purchased for final use in San Francisco. The first step constructs emission coefficients – kg CO2-e per dollar – for San Francisco, the United States, and foreign imports into the United States for 440 types of goods and services. The second step models emissions from the production, wholesale, retail and transportation of goods and services up to the point of sale; this intensive, input-output analysis represents the bulk of CBEI calculations. The third step reorganizes these results from emitting sector to consuming sector. The final step adds two post-purchase end-use phases and adjusts the pre-purchase phases for double-counting.

San Francisco's pre-purchase emissions are calculated by multiplying emissions intensities in kilograms of CO2-e per dollar by the gross demand (final plus intermediate) for the 440 sectors. Final demand is the purchase of goods and services by households and government, and firms' investment in capital goods and net inventory. The intermediate demand included in CBEI is the upstream inputs needed to produce final demand. This type of methodology is often referred to as "input-output life-cycle analysis," for its use of input-output matrices that track the flow of money (as a measure of production activity) through the supply chain for various commodities. Unlike true life-cycle analyses, which typically trace materials through the life-cycle, the elementary flows in input-output life-cycle analysis are in dollars.

Consumption, or final demand, is the purchase of goods and services by households and government, and businesses' investment in capital goods or net inventory. All economic data used in CBEI are taken from IMPLAN (MIG 2010) databases. IMPLAN is a leading economic modeling software product that includes national, state, and county income and production accounts data, as well as input-output models of the U.S. and San Francisco economies developed using data from the U.S. Commerce Department's Bureau of Economic Analysis, the U.S. Bureau of Labor Statistics, the U.S. Census Bureau, and other sources. IMPLAN's input-output matrices estimate the indirect (intermediate or upstream materials and equipment)

[8] CBEI follows the convention of treating electricity emissions as "use" emissions, as if they occurred after the electricity was purchased. Alternatively, electricity could be viewed as a service that contains embedded emissions. For consistency with all other goods and services, CBEI first calculates electricity emissions as embedded in the purchased service, then discards the direct end-use results of this calculation and replaces them with the end-use electricity emissions estimated in the Community Wide inventory to which are added CBEI's calculation of the indirect emissions from end-use electricity generation.

requirements of production, from all sectors, that are needed to produce a unit of any one industry's output for both the United States and San Francisco; IMPLAN data also include estimates of foreign imports and imports from the rest of the United States to San Francisco. This input-output analysis makes it possible for CBEI to model upstream emissions impacts.

The following sections describe each step of CBEI model calculations in turn:

- Step 1: Emissions coefficients
- Step 2: Intermediate pre-purchase emissions by emitting sector
- Step 3: Reorganizing results from emitting sector to consuming sector
- Step 4: Final results, adding use and disposal emissions

Step 1: Emissions Coefficients

"Emissions coefficients" (or emissions intensities) are the amounts of greenhouse gases released per dollar of economic activity in a particular industrial or commercial sector and a particular geographic area. The first step in CBEI model calculations is the construction of three sets of 440 emissions coefficients (for each of the 440 sectors in IMPLAN data), each for a different area: San Francisco, the United States, and foreign imports to the United States.[9] Each coefficient estimates the greenhouse gas emissions intensity of producing a particular type of good or service in a particular location.

For the San Francisco coefficients, industrial/commercial emissions from the Community Wide inventory for 2008 are allocated to the 440 sectors. In some cases, the Community Wide inventory includes details about particular industries or commercial enterprises, and these emissions are assigned accordingly. Where less detail is available, emissions are assigned to groups of sectors in proportion to the San Francisco economic output of each sector. Emissions from the Community Wide inventory are the numerators of these emissions coefficient ratios; the denominators are the San Francisco economic output of each sector.

For the United States emissions coefficients, the CBEI model uses 2008 industrial/commercial emissions from the U.S. Environmental Protection Agency's Greenhouse Gas Inventory Report (EPA 2010). Again, where sufficient details are provided, emissions are assigned to specific sectors; where there is less detail, emissions are assigned to groups of sectors in proportion to their U.S. economic output. To supplement the level of industrial detail available in this inventory, we use shares taken from a 2006 U.S. Energy Information Agency report on greenhouse gas emissions from U.S. manufacturing (Schipper 2006). These are the most up-to-date industrial emissions data available, and their use was recommended to us by the EIA.[10] The denominators for the U.S. emissions coefficient ratio are the U.S. economic outputs of each sector.

For emissions coefficients for foreign imports to the United States, we rely on greenhouse gas emissions intensity data from the Multi-Regional Input-Output (MRIO) International Emissions Data

[9] For technical reasons, CBEI calculations require the construction of two additional sets of emissions coefficients (for a total of five), as discussed in detail in Part 4 of this technical report.
[10] Personal communication with Stephanie Battles, U.S. Energy Information Administration, October 2010.

2004 project (Peters 2010). The MRIO research effort has constructed emission intensity factors for trade between 87 countries or regions in 2004 – the most recent data year available. CBEI maps the MRIO emissions intensities for imports into the United States onto its 440 IMPLAN sectors.

There is one exception to this framework for constructing emissions coefficients in CBEI. The model only allows for three locations of emissions for every type of production, but for electricity there are four location possibilities with corresponding emission intensities: (1) generated within San Francisco, (2) the power pool used within San Francisco, (3) the rest of the United States, and (4) imports to the United States. While the electricity coefficients for the United States and U.S. imports are constructed as described above, the San Francisco electricity coefficient represents the intensity of electricity purchased in city (the power pool as a whole), and not the electricity made in city in a strict geographic accounting. The denominator for the San Francisco electricity coefficient is the full electricity emissions (residential, commercial, and industrial) used in San Francisco from the Community Wide inventory. The numerator is the electricity output (or economic activity) in dollars for San Francisco.

This method gives the best estimation of the embedded emissions in commodities made and purchased in San Francisco. It does, however, muddy the distinction between electricity consumption emissions released in the San Francisco and Inside-U.S.-Outside-San Francisco locations of emissions. In CBEI results, all San Francisco electricity end-use emissions – direct and indirect – are classified as having been released Inside-U.S.-Outside-San Francisco. All other end-use emissions – direct fuel use and waste disposal – are classified as having been released from the San Francisco geographic area.

Step 2: Intermediate Pre-Purchase Emissions by Emitting Sector

Emissions calculations take the dollar value of San Francisco's consumer purchases (called final demand) – classified into 440 types of commodities – and use "input-output" analysis to calculate the upstream (supply chain) production requirements of these purchases, also called "intermediate" or "indirect" demand. For example, the purchase of a washing machine by a household (final demand) requires an upstream chain of business-to-business purchases: the washing machine factory purchases steel, plastic, wiring, and electricity; the steel foundry purchases iron and coal; and so on. Final demand for each commodity creates intermediate demand for other commodities. The sum of final demand and intermediate demand for any given commodity is called "gross demand." Gross demand is organized by the emitting sector. The gross demand of clothing would be the final demand of clothing (direct purchases of clothing by consumers), plus the intermediate demand for clothing resulting from final demand for all commodities (such as the purchase of uniforms by hotels and the purchase of scrubs by hospitals). Demand is measured in dollars.

In CBEI, the gross (final plus intermediate) demand for all commodities purchased by San Francisco consumers is multiplied by the appropriate emissions coefficient (emissions per dollar) for each commodity to calculate the resultant emissions. Gross demand is divided into production in three regions: San Francisco, inside the United States but outside San Francisco, and imports from other countries. Gross demand for products made in San Francisco is

multiplied by San Francisco's emissions intensities; gross demand for products made in the rest of the United States is multiplied by U.S. emissions intensities; and demand for products made in other countries is multiplied by the emissions intensities for foreign imports into the United States.[11]

In this intermediary step, embedded pre-purchase emissions in the clothing category, for example, are not the full embedded emissions of clothing purchases; if a consumer's purchase of clothing results in upstream emissions from the clothing industry's purchase of appliances, electronics, or fuel, these emissions are classified as appliances, electronics or fuel, and are not readily observable as having resulted from the purchase of clothing. Similarly, if a consumer's purchase of hotel stays, doctor's visits, or computers results in upstream emissions from the clothing industry (associated with the manufacture of clothing for housekeeping staff or medical scrubs, or clean-room "bunny suits"), these emissions are classified as clothing, and are not readily observable as having resulted from the purchase of hotel stays, doctor's visits, or computers.

The intermediate emissions calculated in this manner are classified as production, pre-purchase transportation, or wholesale/retail, and are reported on an industry and location basis. For example, in order to produce cars sold in San Francisco, auto companies must purchase steel and other inputs. The emissions from production of the steel used to make these cars are included in the CBEI intermediate calculation of production emissions, since they are part of the embedded emissions of cars sold in San Francisco. Those emissions, however, are reported as steel industry emissions. In this intermediate step, a similar principle of classification applies to all other emissions from production of inputs or intermediate goods: All emissions are assigned to the industries that produce them (e.g. steel), even when the emissions are embedded in a final good in another industry (e.g. cars).

Step 3: Reorganizing Results from Emitting Sector to Consuming Sector

The CBEI model estimates the consumption-based emissions of San Francisco's final demand for goods and services. Emissions "upstream" of the consumer (embedded pre-purchase emissions) are first classified according to emitting industry (in Step 2 above), allowing users to observe the share of emissions originating in each of 440 industries.

Running CBEI in its "life-cycle analysis" mode reorganizes the pre-purchase results according to commodities consumed. Both classification systems (by emitting sector and by consuming sector) result in the same grand total of emissions for the San Francisco pre-purchase emissions, but very different allocations of emissions among sectors. CBEI's pre-purchase results by consuming sector are the embedded emissions of each and every sector of San Francisco consumption separately. Emissions are assigned to the sector of the good or service consumed. For example, emissions from the production of any good or service that are associated with the consumption of clothing (cotton growing, dye manufacture, and advertising) are assigned to clothing.

[11] The CBEI methodology for calculating the emissions embodied in San Francisco's foreign imports is slightly different than for San Francisco's domestic imports and San Francisco production for in-city consumption. These differences are explained in more detail in the Part 4 of this technical report.

Imagine an economy with just three production sectors and three types of final goods: bread, electricity, and steel. CBEI first calculates the total consumption-based emissions for this economy using the Community Wide emissions inventory (to establish in-region emission coefficients) along with economic data. The emissions are organized by emitting sector; that is, the purchase of final goods in the San Francisco results in emissions from the production of bread, electricity, and steel. Emissions that result from the *production* of bread are assigned to the bread sector, from electricity to the electricity sector, and from steel to the steel sector. These are the embedded pre-purchase emissions of San Francisco's total consumption by emitting sector.

In Step 3 of the CBEI model, emissions are reorganized by the sector of consumption: the purchase of bread in San Francisco results in emissions from producing bread, but also in upstream emissions from producing electricity and steel used for bakery operations. All emissions that result from the end-use consumption of bread are assigned to the bread sector, regardless of how and where they were produced. All emissions resulting from the end-use consumption of electricity are assigned to the electricity sector, and all emissions resulting from the end-use consumption of steel are assigned to the steel sector. This is a single-year "life-cycle analysis" of each sector of San Francisco's consumption, where the results sum to total 2008 San Francisco consumption-based pre-purchase emissions.

Because of the way the IMPLAN economic data are organized, the CBEI pre-purchase results for a given commodity category do not include emissions from wholesalers, retailers, or the transportation of a final commodity from factory to wholesaler to retailer; rather, these results are broken out in the pre-purchase transportation and wholesale/retail phases. Wholesale, retail and pre-purchase transportation are treated as services purchased by consumers. When particular categories of consumption are shown to have pre-purchase transportation or wholesale/retail phase emissions in final consumption-based emissions, these emissions result from producer's purchases of these services (such as, transporting wheat from farm to factory). In buying a cookie, for example, the consumer buys – separately – the cookie; the transportation that was necessary to move the cookie and its raw materials from field, to factory, to wholesaler, to retailer; the storage services of the wholesaler; and the retail services of the store. All of these emissions are included in the pre-purchase total, but cookie pre-purchase transportation emissions, for example, are not linked to cookie production emissions.

Step 4: Final Results, Adding Use and Disposal Emissions

In a final step, emissions from two additional life-cycle phases are added to the pre-purchase results organized by consuming sector, after adjustments to avoid double counting. The calculation of CBEI's use and post-consumer disposal phases includes additional emissions from direct fuel use not included in the pre-purchase model, and a transfer of some emissions from the pre-purchase model to the use and disposal phases. Fuels are an important category of San Francisco's consumer purchases, but the pre-purchase model only includes the upstream impacts of refining and distributing fuels, and of businesses' burning fuels to make and transport products; it does not include the use phase impacts of consumers burning fuels in their cars and furnaces.

Use-phase calculations take the Community Wide inventory's emissions from households and governments end-use of fuel and electricity and add to them the indirect emissions from refining and distributing fuels (for direct use and to generate electricity). These emissions are then allocated to the sectors representing the appliance and vehicles that use fuels and electricity. Indirect emissions from end-use fuel and electricity purchases, and direct emissions from end-use electricity purchases, are subtracted from the pre-purchase results in order to avoid double-counting.

Post-consumer disposal phase emissions calculations are taken from supplemental materials to the Community Wide inventory. CBEI's direct pre-purchase emissions embedded in waste disposal are deleted to avoid double counting. End-use disposal emissions are combined with indirect waste disposal emissions from the pre-purchase model, and are allocated to various commodities in proportion to the types of items found in San Francisco's municipal waste. Again, post-consumer disposal phase emissions are not classified according to the service purchased (waste disposal), but instead according to the types of commodities that San Francisco consumers throw away.

Limitations and Uncertainties

CBEI's embedded pre-purchase emission results are not measurements; they are the best possible estimates given the availability of data. The economic data underlying CBEI's pre-purchase model are IMPLAN data, including input-output and other production data for San Francisco and for the United States as whole; domestic and foreign import shares for each type of good purchased in San Francisco; and consumption data for households, government entities, and business investment in San Francisco. All IMPLAN data are estimated, as are all economic data used by governments and reported in the media: gross domestic product, the inflation rate, the unemployment rate – these are all estimates.

CBEI emission results are estimates, but, of course, many of the emissions totals presented in geographic and hybrid greenhouse gas inventories are also estimates, based on calculations of the average emission intensities of fuels, industry self-reporting on emissions from production, or elaborate systems for approximating the number of vehicle miles traveled and the average fuel efficiency of those vehicles. When measurement is not possible – as is the case for most economic and much physical data – the practice of using good estimates is commonplace.

IMPLAN estimates the consumption of households in every ZIP code, county and state of the United States based on annual data from the national Consumer Expenditure Survey,[12] a relatively small-scale survey that excludes several states each year, disguises the origins of surveys from several other states, and samples fewer than 100 households in each of the smaller states and up to (roughly) 2,000 households in each of the largest states. The Consumer Expenditure Survey does not have enough respondents to give an accurate picture of consumption in any county or in most states. In order to customize these national data so they apply to each smaller area, IMPLAN divides the respondents into nine income groups.

[12] Bureau of Labor Statistics (n.d.). *Consumer Expenditure Survey.* Washington, DC: U.S. Department of Labor. Available at http://www.bls.gov/cex/.

Using consumption profiles for each income group and income distribution data from the very large-scale American Community Survey and the U.S. Census, IMPLAN estimates each area's household expenditures.[13]

Given the availability of data, this is the most accurate method for estimating local area consumption. Indeed, detailed analysis of Consumer Expenditure Survey data by region shows that, after controlling for income, there are only very small differences in consumption patterns across regions, with the exception of a few categories of goods: transportation fuels, heating fuels, and electricity (see Stanton and Ackerman 2010). Fuel and electricity consumption do vary by income, but they also vary by climate and population density (Stanton et al. 2010). IMPLAN household consumption estimates for fuel and electricity, then, are likely to be inaccurate. Note, however, that for fuel and electricity, CBEI uses its pre-purchase emissions analysis only to estimate the indirect emissions from refining and distributing fuels. For the direct emissions from burning fuels and generating the electricity used by consumers, CBEI uses the end-use emissions calculated by the Community Wide inventory.

The CBEI model is a work in progress, designed to utilize the best data available today and the best assumptions about the relationships between those data in order to estimate consumption-based emissions for regions of the United States. An important part of the model still under development is the translation of "producer prices" from IMPLAN data (the price paid for something at the factory door) to the more intuitive "consumer prices" (the price paid at a store). This organization of IMPLAN data makes it necessary for CBEI to treat the services of the retailer as a separate purchase – the dollars spent to buy bread are not readily connected to the retail "margin" (the mark-up that the retailer charges). In a future version of CBEI, we hope to use IMPLAN's margin data to make this connection and present emissions for purchases made at the store, not the factory.

A final limitation of CBEI is its transferability to another region or year. In principle, creating a San Francisco CBEI for 2009 would be fairly straightforward; the more similar the categories of emissions given in the 2009 Community Wide inventory, the simpler this process would be. Introducing San Francisco IMPLAN data for 2009, and updating the various emissions coefficients and the mapping of use and disposal emissions to end-use sectors, however, is labor-intensive. Transferring CBEI to another jurisdiction is still more complicated, both technically and legally. Inventories vary greatly in their categorization of emissions – in CBEI development, we construct new mappings for each jurisdiction from scratch. It is also the case that IMPLAN data for San Francisco and for the United States are embedded in the CBEI model, and these data cannot be transferred according to the terms of the IMPLAN licensing agreement. (When a CBEI project is complete, we transfer our license for IMPLAN data used in the project to the client.) Our long-range plan is to build a version of CBEI that would be generic and publically accessible, along with instructions for purchasing and importing IMPLAN data, constructing emissions coefficients, etc.

[13] U.S. Census Bureau, *American Community Survey* (annual), http://www.census.gov/acs/www/, and 2000 U.S. Census, http://www.census.gov/main/www/cen2000.html.

Using CBEI to Measure Policy Impacts

Greenhouse gas emissions inventories are often intended to inform a policy debate regarding local-area mitigation efforts. Abatement policies could affect emissions in a number of ways that can be tracked by observing changes in annual inventories. For the emissions embedded in consumer products, some of the most likely observable policy effects include:

- Local policies could affect local emission intensities (lowering emissions per dollar of production value). In CBEI, this impact would be recorded in annual changes to San Francisco's emissions coefficients. (Returning to the example of bread, if local policies required bakeries to use solar ovens, the change in commercial emissions would be reflected in San Francisco's Community Wide Inventory and, therefore, in the emissions intensities for San Francisco used in CBEI.)

- National policy could affect national emissions intensities. In CBEI, this impact would be recorded in annual changes to U.S. emission coefficients. (Similarly, if a U.S. regulation required bakeries nationwide to use solar ovens, the change in commercial emissions would be reflected in the U.S. EPA emissions inventory and in the emission intensities for inside the United States, outside San Francisco used in CBEI.)

- Global policies or policies elsewhere in the world could affect the emissions intensities of imports to the United States. In CBEI, this impact would be recorded in changes to the foreign emission coefficients, although there would be some lag, as these data are not annual. The most recent available data are for 2004. (Given a relevant global agreement, reductions to emissions embedded in foreign-made bread would be reflected in CBEI's emissions intensities for foreign-made goods.)

- Local policies could affect local fuel and electricity consumption and waste disposal patterns. In CBEI this impact would be recorded in the Use and Post-consumer disposal phases, which take their data from the Community Wide inventory. (This policy would not affect the emissions embedded in bread; it would only affect emissions from end-use energy consumption and waste disposal.)

- Local policies could affect local non-energy consumption patterns such that local consumption (by income group) became atypical for the United States. For CBEI to record this impact, IMPLAN data must be supplemented by additional data sources. (The example here would be a policy to reduce San Francisco's bread consumption with the goal of reducing greenhouse gas emissions. Clearly, this would not be a very effective policy. A more likely policy in this category would be to induce a reduction in the consumption of especially high emissions-intensity goods or services. For within-San-Francisco production, the highest emissions per dollar commodities (excluding fuel and electricity) are transportation services: buses, ferries, light-rail, taxis, and trains. If such a policy were undertaken, IMPLAN data used in CBEI would have to be supplemented by local data in order to observe the effect on emissions.)

Options for supplementing CBEI's non-energy consumption data to monitor changes in local consumption patterns can take a few different forms. To observe the impact of policies aimed at reducing overall consumption, year-to-year changes in the jurisdiction's sales tax receipts (adjusting for any variation in rates) could be used to scale IMPLAN consumption data. One scaling factor could be applied to all non-energy consumption, or – if some disaggregation of sales tax sources exists – different scaling factors could be applied to a few different categories of emissions.

To observe the impacts of policies aimed at reducing the consumption of particular products, an annual survey of selected retail establishments could reveal changes in consumption patterns for specific, targeted items. With this information, scaling factors could be constructed for IMPLAN's consumption data for the targeted products. This survey of retailers could be as large or as small as time and budget allows. For many products, requesting multi-year sales data from the largest retailers could provide a very rich data source.

2. SAN FRANCISCO 2008 CONSUMPTION-BASED EMISSIONS, RESULTS AND ANALYSIS

2.1. Relationship to the Community Wide Inventory

Calculation of the CBEI 2008 consumption-based inventory for San Francisco begins with San Francisco's 2008 "Community Wide GHG Inventory"[1]. Emissions from the Community Wide inventory are used in two ways in CBEI calculations: first, Community Wide industrial and commercial emissions are used to construct emission intensities for San Francisco-based production; and second, Community Wide end-use emissions are the basis for the use and disposal phases.

Table 1 shows the allocation of Community Wide emissions towards these two purposes. (Note that end-use electricity and waste disposal emissions are needed to calculate the correct emissions intensities for San Francisco production, but estimates of the emissions embedded in San Francisco's purchase of electricity and waste disposal services are replaced with more accurate data on end-use emissions provided by the Community Wide inventory.) The consumption-based inventory results presented below have been adjusted to remove any double counting.

Table 1: San Francisco's Community Wide Inventory by Emission Type, 2008

(million m T CO2-e)	Industrial/Commercial Emissions	End-Use Emissions
San Francisco's Community Wide Inventory	**2.64**	**3.24**
Transportation	**0.89**	**1.35**
Residential		1.32
Government		0.03
Industrial/Commercial	0.89	
Electricity	**0.95**	**0.67**
Residential		0.42
Government		0.26
Commercial	0.61	
Industrial	0.34	
Direct Fuel Use	**0.80**	**0.90**
Residential		0.79
Government		0.11
Commercial	0.74	
Industrial	0.07	
Waste		**0.31**

Source: Authors' calculations based on San Francisco 2008 Community Wide GHG Inventory

[1] San Francisco (California). *City and County of San Francisco, 2008 Community Wide GHG Inventory* Department of the Environment, City and County of San Francisco (2011).

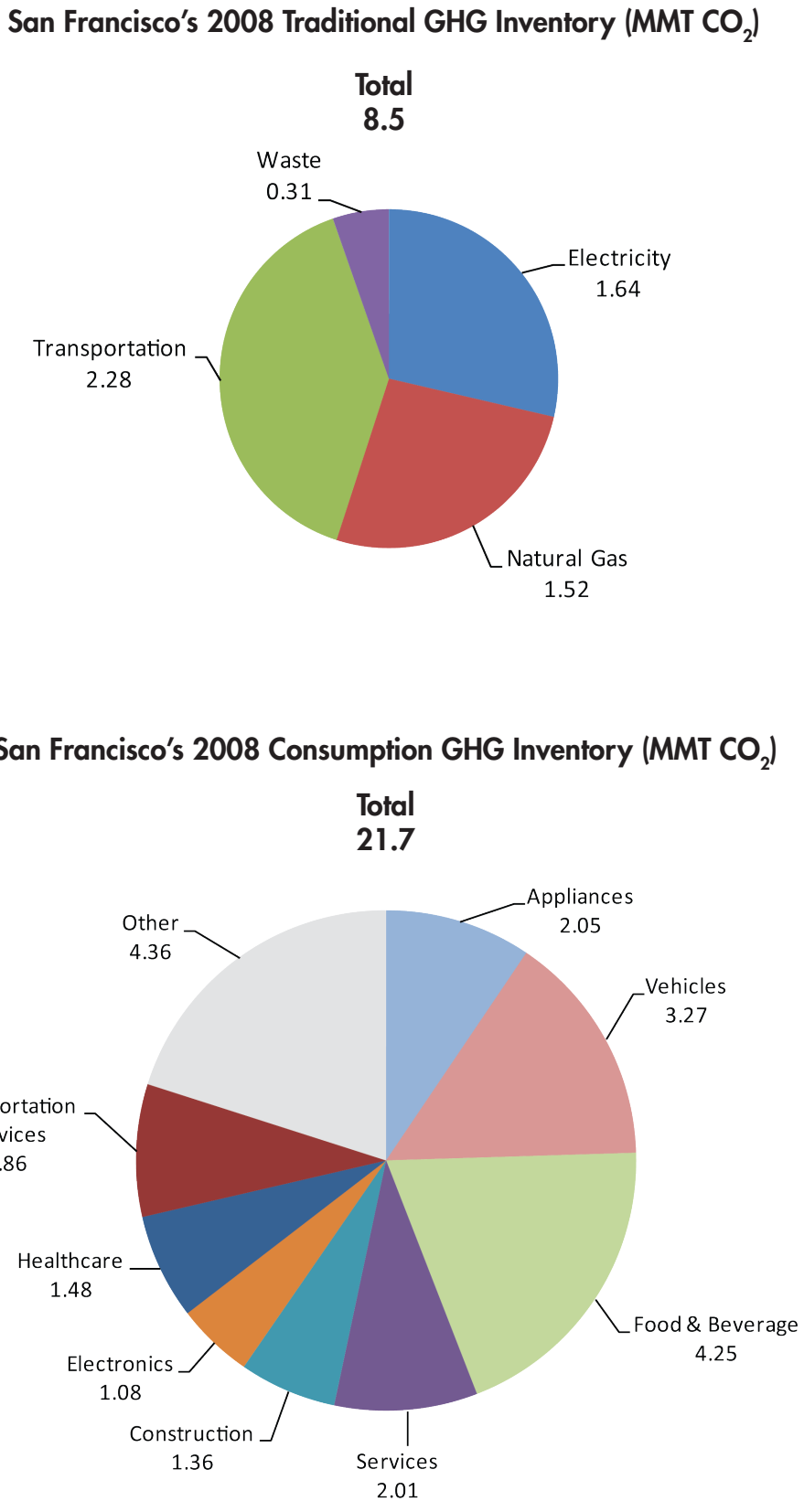
CBEI calculations result in 18.58 million metric tons CO2-e in embedded pre-purchase emissions (see Table 2). To this, the Community Wide end-use emissions are added (5.88 million metric tons CO2-e) and adjustments are made for double-counting (-2.74 million metric tons CO2-e). Final consumption-based emissions for San Francisco in 2008 are 21.73 million metric tons CO2-e. In the context of the United States, San Francisco is an urban and, on average, affluent area where most of what is consumed is imported from outside the city, and few industrial goods are produced within the city. San Francisco's consumption-based emissions are more than three and a half times higher than those estimated in San Francisco's 2008 Community Wide inventory (see Figure 1).

Table 2: Final Consumption-Based Emissions, San Francisco 2008

	(million mT CO2-e)
Embedded Pre-Purchase Emissions	18.58
Community Wide End-Use Emissions	5.88
Correction for Double-Counting Direct Emissions from Electricity and Waste	-2.74
Final Consumption-Based Emissions for San Francisco	**21.73**

Source: CBEI Version 2.0 (Stanton et al. 2011) for San Francisco 2008.

Figure 1: Total Traditional GHG Inventory and Total Consumption Inventory for San Francisco



2.2. San Francisco's Consumption-Based Inventory

Table 3 reports San Francisco's 2008 total consumption-based emissions by life-cycle phase totaling 21.73 million metric tons CO2-e. Production-phase emissions account for 63 percent of the total; pre-purchase transportation, 13 percent; wholesale and retail, less than 2 percent; use 20 percent; and post-consumer disposal, 2 percent. In interpreting these results it is important to recall two points discussed in detail in Section 1:

- Vehicles and vehicle parts production emissions are the emissions embedded in cars purchased in San Francisco in 2008, while this category's use emissions are the end-use emissions from San Francisco driving in 2008. Production emissions relate only to the cars purchased in 2008; use emissions relate to all cars driven in 2008.

- Pre-purchase emissions for each category include only the emissions embedded in a product when it leaves the factory. Emissions wholesale and retail activities (such as the electricity from running a freezer at a retail store), and from transportation to wholesalers and retailers, are included in the consumption-based emissions results but are not connected to the purchase of specific goods and services. Instead these emissions are embedded in wholesale, retail, and pre-purchase transportation services (as if the consumer made separate purchases of, for example, (1) a bag of frozen corn, and (2) the service provided by the supermarket that sold the corn).

Table 3: San Francisco's 2008 Total Consumption-Based Emissions by Life-Cycle Phase

(million mT CO2-e)	GHG Emissions by Phase					
	Production	Pre-Purchase Transportation	Wholesale/ Retail	Use	Post-Consumer Disposal	Total
San Francisco Total Emissions	**13.585**	**2.920**	**0.392**	**4.342**	**0.490**	**21.728**
Appliances, HVAC	0.013	0.001	0.000	1.314	0.000	1.327
Appliances, other	0.144	0.006	0.000	0.575	0.001	0.727
Clothing	0.736	0.008	0.000	0.000	0.001	0.745
Concrete, cement and lime	0.003	0.000	0.000	0.000	0.000	0.003
Construction	1.141	0.198	0.006	0.000	0.018	1.364
Electronics	0.879	0.047	0.003	0.145	0.003	1.077
Food and beverages	3.640	0.342	0.007	0.000	0.263	4.253
Forest products	0.179	0.014	0.000	0.000	0.119	0.312
Fuel, utilities, waste	0.038	0.003	0.000	0.000	0.001	0.042
Healthcare	1.333	0.129	0.005	0.000	0.008	1.476
Home, yard, office	0.955	0.060	0.002	0.000	0.020	1.037
Retailer and wholesale	0.465	0.140	0.357	0.000	0.006	0.968
Services	1.783	0.190	0.004	0.000	0.035	2.011
Transportation services	0.224	1.633	0.001	0.000	0.001	1.860
Vehicles and vehicle parts	0.897	0.058	0.002	2.307	0.006	3.271
Other	1.156	0.090	0.003	0.000	0.008	1.256

Source: CBEI Version 2.0 (Stanton et al. 2011) for San Francisco 2008.

San Francisco's consumption-based emissions amount to 26.9 metric tons per person (see Table 4);[2] further discussion of San Francisco's per capita emissions, and a comparison to California's per capita emissions is presented in Part 3 of this report.

Table 4: San Francisco's 2008 Per Capita Consumption-Based Emissions by Life-Cycle Phase

(m T CO2-e)	GHG Emissions by Phase					
	Production	Pre-Purchase Transportation	Wholesale/ Retail	Use	Post-Consumer Disposal	Total
San Francisco Per Capita Emissions	**16.793**	**3.610**	**0.484**	**5.367**	**0.605**	**26.859**
Appliances, HVAC	0.016	0.001	0.000	1.624	0.000	1.641
Appliances, other	0.179	0.008	0.000	0.711	0.001	0.899
Clothing	0.910	0.010	0.000	0.000	0.001	0.921
Concrete, cement and lime	0.003	0.000	0.000	0.000	0.000	0.003
Construction	1.410	0.245	0.008	0.000	0.023	1.686
Electronics	1.086	0.058	0.003	0.180	0.004	1.331
Food and beverages	4.500	0.423	0.009	0.000	0.325	5.257
Forest products	0.221	0.017	0.000	0.000	0.147	0.386
Fuel, utilities, waste	0.047	0.004	0.000	0.000	0.001	0.052
Healthcare	1.648	0.160	0.007	0.000	0.010	1.824
Home, yard, office	1.181	0.074	0.002	0.000	0.025	1.281
Retailer and wholesale	0.574	0.173	0.442	0.000	0.007	1.196
Services	2.204	0.235	0.005	0.000	0.043	2.486
Transportation services	0.277	2.019	0.002	0.000	0.001	2.299
Vehicles and vehicle parts	1.109	0.072	0.003	2.852	0.007	4.043
Other	1.429	0.111	0.004	0.000	0.010	1.553

Source: CBEI Version 2.0 (Stanton et al. 2011) for San Francisco 2008.

Table 5 reports San Francisco's 2008 consumption-based emissions by type of consumer. Household emissions account for 82 percent of the total; government, 11 percent; and business investment, 7 percent. Recall that business investment refers only to emissions embedded in businesses purchase of capital goods and net inventory, which cannot be associated with final purchases by households and governments (see discussion in Section 1).

As shown in Table 6, the largest categories are Food and beverages (20 percent) and Vehicles and vehicle parts (15 percent). These are also the largest categories of emissions from household consumption: Vehicles and vehicles parts (23 percent), and Food and beverages (16 percent).

Table 7 reports consumption-based emissions by subcategory. Cars and light trucks is the subcategory with the greatest emissions (14 percent), followed Appliances, HVAC (6.1 percent), and Other (5.8 percent). No other subcategories exceed 5 percent of consumption-based emissions.

[2] Per capita calculations for Table 4 use a San Francisco 2008 population of 808,976 (2008 American Community Survey 1-Year Estimates, Table B01003, Total Population. Universe: Total Population. http://www.census.gov/acs/).

Table 5: San Francisco's 2008 Consumption-Based Emissions by Consumer Type

(million mT CO2-e)	GHG Emissions by Type of Consumer			
	Household	Government	Investment	Total
San Francisco Total Emissions	**17.833**	**2.293**	**1.602**	**21.728**
Appliances, HVAC	1.077	0.251	0.000	1.327
Appliances, other	0.512	0.214	0.001	0.727
Clothing	0.737	0.009	0.000	0.745
Concrete, cement and lime	0.001	0.002	0.000	0.003
Construction	0.134	0.381	0.849	1.364
Electronics	0.455	0.147	0.475	1.077
Food and beverages	4.128	0.124	0.000	4.253
Forest products	0.205	0.107	0.000	0.312
Fuel, utilities, waste	0.029	0.011	0.002	0.042
Healthcare	1.421	0.048	0.007	1.476
Home, yard, office	0.928	0.046	0.062	1.037
Retailer and wholesale	0.914	0.013	0.041	0.968
Services	1.782	0.192	0.038	2.011
Transportation services	1.687	0.148	0.024	1.860
Vehicles and vehicle parts	2.911	0.326	0.034	3.271
Other	0.912	0.276	0.069	1.256

Source: CBEI Version 2.0 (Stanton et al. 2011) for San Francisco 2008.

Table 6: San Francisco's 2008 Consumption-Based Emissions, Share by Category

(million mT CO2-e)	GHG Emissions by Type of Consumer			
	Household	Government	Investment	Total
San Francisco Total Emissions	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Food and beverages	23.2%	5.4%	0.0%	19.6%
Vehicles and vehicle parts	16.3%	14.2%	2.1%	15.1%
Services	10.0%	8.4%	2.4%	9.3%
Transportation services	9.5%	6.4%	1.5%	8.6%
Healthcare	8.0%	2.1%	0.4%	6.8%
Construction	0.7%	16.6%	53.0%	6.3%
Appliances, HVAC	6.0%	10.9%	0.0%	6.1%
Other	5.1%	12.0%	4.3%	5.8%
Electronics	2.5%	6.4%	29.6%	5.0%
Home, yard, office	5.2%	2.0%	3.9%	4.8%
Retailer and wholesale	5.1%	0.6%	2.5%	4.5%
Clothing	4.1%	0.4%	0.0%	3.4%
Appliances, other	2.9%	9.3%	0.1%	3.3%
Forest products	1.2%	4.7%	0.0%	1.4%
Fuel, utilities, waste	0.2%	0.5%	0.1%	0.2%
Concrete, cement and lime	0.0%	0.1%	0.0%	0.0%

Source: CBEI Version 2.0 (Stanton et al. 2011) for San Francisco 2008.

Table 7: San Francisco's 2008 Consumption-Based Emissions by Subcategory

(million mT CO2-e)	GHG Emissions by Type of Consumer			
	Household	Government	Investment	Total
San Francisco Total Emissions	**17.833**	**2.293**	**1.602**	**21.728**
Appliances, HVAC	**1.077**	**0.251**	**0.000**	**1.327**
Appliances, other	**0.512**	**0.214**	**0.001**	**0.727**
Lighting fixtures and bulbs	0.154	0.162	0.000	0.316
Ranges and microwaves	0.095	0.003	0.000	0.098
Refrigerators and freezers	0.083	0.044	0.000	0.127
Washers and dryers	0.110	0.000	0.000	0.110
Other appliances	0.071	0.005	0.000	0.076
Clothing	**0.737**	**0.009**	**0.000**	**0.745**
Concrete, cement and lime	**0.001**	**0.002**	**0.000**	**0.003**
Construction	**0.134**	**0.381**	**0.849**	**1.364**
Non-residential construction	0.000	0.361	0.550	0.911
Prefabricated buildings	0.000	0.001	0.000	0.001
Residential construction and remodeling	0.133	0.019	0.300	0.452
Electronics	**0.455**	**0.147**	**0.475**	**1.077**
Computer service and equipment	0.167	0.074	0.391	0.632
Other electronics	0.288	0.073	0.084	0.445
Food and beverages	**4.128**	**0.124**	**0.000**	**4.253**
Beverages	0.484	0.002	0.000	0.486
Condiments, oils and sweeteners	0.085	0.002	0.000	0.087
Dairy	0.457	0.025	0.000	0.482
Fresh fruit, nuts and vegetables	0.214	0.002	0.000	0.215
Frozen food	0.115	0.001	0.000	0.116
Grains, baked goods, cereals, roasted nuts, nut butters	0.444	0.008	0.000	0.452
Poultry and eggs	0.255	0.002	0.000	0.257
Processed fruit, nuts and vegetables	0.129	0.007	0.000	0.135
Red meat	0.700	0.038	0.000	0.738
Restaurants	0.849	0.029	0.000	0.878
Seafood	0.036	0.002	0.000	0.038
Other food and agriculture	0.361	0.006	0.000	0.368
Forest products	**0.205**	**0.107**	**0.000**	**0.312**
Paper and cardboard	0.194	0.098	0.000	0.292
Other processed forest products	0.011	0.008	0.000	0.020
Unprocessed forest products	0.000	0.000	0.000	0.000
Fuel, utilities, waste	**0.029**	**0.011**	**0.002**	**0.042**
Gasoline, heating fuels, other petroleum products	0.000	0.000	0.000	0.000
Natural gas distribution	0.000	0.000	0.000	0.000
Oil and gas extraction	0.004	0.008	0.002	0.013
Power generation and supply	0.000	0.000	0.000	0.000
Waste management	0.000	0.000	0.000	0.000
Water-sewage and other systems	0.025	0.003	0.000	0.028

Table 7 (continued): San Francisco's 2008 Consumption-Based Emissions by Subcategory

(million mT CO2-e)	GHG Emissions by Type of Consumer			
	Household	Government	Investment	Total
San Francisco Total Emissions	**17.833**	**2.293**	**1.602**	**21.728**
Healthcare	**1.421**	**0.048**	**0.007**	**1.476**
Healthcare services	1.113	0.002	0.000	1.116
Medicines and other healthcare supplies	0.308	0.045	0.007	0.360
Home, yard, office	**0.928**	**0.046**	**0.062**	**1.037**
Home furnishings	0.262	0.003	0.004	0.270
Household supplies	0.482	0.019	0.000	0.502
Lawn and garden	0.097	0.014	0.000	0.111
Media and office supplies (except paper)	0.087	0.010	0.058	0.154
Retailer and wholesale	**0.914**	**0.013**	**0.041**	**0.968**
Retailers	0.748	0.000	0.019	0.768
Wholesale	0.166	0.013	0.022	0.200
Services	**1.782**	**0.192**	**0.038**	**2.011**
Banks, financial, legal, real estate, insurance	0.472	0.026	0.000	0.499
Building services	0.006	0.003	0.000	0.010
Education and day care	0.307	0.020	0.000	0.327
Hotels, motels, entertainment, media	0.591	0.037	0.003	0.632
Other services	0.405	0.105	0.034	0.545
Transportation services	**1.687**	**0.148**	**0.024**	**1.860**
Car rental, repair and wash	0.129	0.004	0.000	0.132
Transportation services, air	0.607	0.041	0.002	0.649
Transportation services, mass transit	0.022	0.005	0.000	0.026
Transportation services, rail	0.033	0.008	0.001	0.042
Transportation services, truck	0.871	0.086	0.021	0.978
Transportation services, water	0.021	0.003	0.000	0.024
Transportation services, other	0.006	0.001	0.000	0.007
Vehicles and vehicle parts	**2.911**	**0.326**	**0.034**	**3.271**
Aircraft	0.002	0.029	0.000	0.032
Cars and light trucks	2.694	0.216	0.033	2.943
Heavy duty trucks	0.000	0.011	0.000	0.011
Other road vehicles	0.085	0.001	0.000	0.086
Railroad rolling stock	0.000	0.001	0.000	0.001
Ships and boats	0.025	0.024	0.001	0.050
Vehicle parts	0.105	0.043	0.000	0.148
Other	**0.912**	**0.276**	**0.069**	**1.256**

Source: CBEI Version 2.0 (Stanton et al. 2011) for San Francisco 2008.

Table 8 reports San Francisco's 2008 consumption-based emissions by location of emissions. Note that a large fraction of emissions associated with services were released outside San Francisco. Consumers frequently purchase services from outside of San Francisco (by using an electronic service, or by taking a trip outside of the city). In addition, services providers located within San Francisco purchase intermediate goods and services from outs ide of San Francisco; for example, a San Francisco hair dresser will purchase shampoo and styling gel made outside of San Francisco.

Table 8: San Francisco's 2008 Consumption-Based Emissions by Location

(million mT CO2-e)	GHG Emissions by Location of Emission			
	San Francisco	Inside-US-Outside-SF	Foreign	Total
San Francisco Total Emissions	**4.541**	**10.685**	**6.502**	**21.728**
Appliances, HVAC	0.881	0.439	0.007	1.327
Appliances, other	0.082	0.539	0.106	0.727
Clothing	0.003	0.035	0.708	0.745
Concrete, cement and lime	0.000	0.001	0.001	0.003
Construction	0.042	0.900	0.422	1.364
Electronics	0.072	0.444	0.560	1.077
Food and beverages	0.330	2.947	0.976	4.253
Forest products	0.119	0.126	0.066	0.312
Fuel, utilities, waste	0.002	0.021	0.019	0.042
Healthcare	0.095	1.009	0.371	1.476
Home, yard, office	0.029	0.450	0.558	1.037
Retailer and wholesale	0.144	0.578	0.246	0.968
Services	0.317	1.050	0.644	2.011
Transportation services	0.038	1.248	0.575	1.860
Vehicles and vehicle parts	2.313	0.379	0.579	3.271
Other	0.075	0.517	0.665	1.256

Source: CBEI Version 2.0 (Stanton et al. 2011) for San Francisco 2008. Results adjusted from standard CBEI output: San Francisco area electricity emissions have been reallocated to Inside-US-Outside-SF.

2.3. Emissions Intensity Comparison

San Francisco consumers purchase commodities that are made in San Francisco, made in the rest of the United States, and made in foreign countries. Because emissions intensities (emissions per dollar) differ in each of these production locations, if San Francisco residents were to change their purchasing habits – buy more foreign-made products, for example – San Francisco's consumption-based emissions inventory would change. Table 9 compares San Francisco's consumption-based emissions with the estimated emissions if San Francisco consumers continued to buy the same dollar-value of items, but chose to buy them from the rest of California, the rest of the United States, or from foreign countries; these comparisons are made for pre-purchase emissions only (not for use and disposal phase emissions[3]) and are organized by consuming sector.

Table 9: Comparison of Emissions Results with Adjusted Emissions Intensities

	(millions of mT CO2-e)						
	SF Pre-Purchase Emissions (SF)	In-City Final Demand at CA Intensities (SF at CA)	In-City Final Demand at US Intensities (SF at US)	In-U.S. Final Demand at US-Import Intensities (SF&US at Foreign)	Ratio of SF-at-CA to SF	Ratio of SF-at-US to SF	Ratio of SF&US-at-Foreign to SF
San Francisco Emissions	18.583	22.519	27.276	40.892	1.212	1.468	2.201
Appliances, HVAC	0.014	0.014	0.014	0.018	1.000	1.000	1.357
Appliances, other	0.151	0.151	0.151	0.187	1.001	1.001	1.239
Clothing	0.744	0.747	0.753	0.843	1.004	1.012	1.133
Concrete, cement and lime	0.003	0.003	0.003	0.002	1.052	1.160	0.779
Construction	1.346	1.576	1.812	3.343	1.171	1.347	2.484
Electronics	0.928	1.127	1.252	1.901	1.214	1.349	2.048
Food and beverages	3.990	4.260	4.382	5.567	1.068	1.098	1.395
Forest products	0.193	0.194	0.197	0.240	1.006	1.020	1.241
Fuel, utilities, waste	1.727	2.956	6.542	6.995	1.712	3.788	4.050
Healthcare	1.468	1.746	1.776	5.209	1.189	1.210	3.549
Home, yard, office	1.017	1.040	1.044	1.728	1.023	1.027	1.700
Retailer and wholesale	0.962	1.378	1.588	4.420	1.433	1.652	4.596
Services	1.976	2.824	3.167	5.664	1.429	1.603	2.866
Transportation services	1.859	1.973	2.268	2.385	1.061	1.220	1.283
Vehicles and vehicle parts	0.958	0.958	0.959	1.018	1.000	1.001	1.063
Other	1.249	1.572	1.367	1.371	1.259	1.095	1.098

Source: CBEI Version 2.0 (Stanton et al. 2011) for San Francisco 2008.

Table 9 does not compare emissions intensities. Instead, it compares actual 2008 emissions with emissions in three "what-if" scenarios: (1) what if everything purchased in San Francisco that is made in San Francisco were instead made in the rest of California (at California average emission intensities); (2) what if everything purchased in San Francisco that is made in San Francisco were instead made in the rest of the United States (at U.S. average emission

[3] Pre-purchase emissions are reported before adjustment for double-counting.

intensities); and (3) what if everything purchased in San Francisco that is made in the U.S. (including in San Francisco) were instead made in another country (at the average emissions intensities of current U.S. imports). Purchasing San Francisco-made commodities from the rest of California would increase 2008 emissions by 21 percent. Purchasing San Francisco-made commodities from the rest of the United States would increase 2008 emissions by 47 percent. Purchasing U.S.-made commodities from other countries would increase 2008 emissions by 120 percent.

2.4. San Francisco's Emissions from Waste

San Francisco's 2008 consumption-based greenhouse gas emissions from waste account for 2.3 percent of its total consumption-based emissions (see Table 3 above). Table 10 compares these 2008 results with the results of three "what if" scenarios for San Francisco waste disposal: In Scenario A, San Francisco's waste levels return to their 1990 levels;[4] in Scenario B, there are no organic wastes (food scraps and yard waste) whatsoever; and in Scenario C, mixed paper waste is reduced to half of its 2008 level.

At 1990 waste levels, San Francisco's waste emissions rise to 2.5 percent of total consumption-based emissions, compared to 2.3 percent in the base CBEI results for 2008. When organic waste is eliminated, waste emissions account for just 1.5 percent of total consumption-based emissions, and when mixed paper is reduced to half, waste emissions make up 2.0 percent of the total.

Table 10: Comparison of Emissions Results with Adjusted Waste Disposal Emissions

	(millions of m T CO2-e)						
	SF Waste Disposal Emissions (SF)	Scenario A: At 1990 waste levels (A)	Scenario B: Zero Organics (B)	Scenario C: 50% of 2008 Mixed Paper (C)	Ratio of A to SF	Ratio of B to SF	Ratio of C to SF
San Francisco Emissions	**0.490**	**0.550**	**0.334**	**0.444**	**1.122**	**0.682**	**0.907**
Appliances, HVAC	0.000	0.000	0.000	0.000	1.122	1.349	0.799
Appliances, other	0.001	0.001	0.001	0.001	1.122	1.349	0.799
Clothing	0.001	0.001	0.001	0.001	1.122	1.349	0.799
Concrete, cement and lime	0.000	0.000	0.000	0.000	1.122	1.349	0.945
Construction	0.018	0.021	0.025	0.017	1.122	1.349	0.933
Electronics	0.003	0.003	0.004	0.002	1.122	1.349	0.799
Food and beverages	0.263	0.295	0.039	0.257	1.122	0.147	0.978
Forest products	0.119	0.133	0.160	0.091	1.122	1.349	0.768
Fuel, utilities, waste	0.001	0.001	0.001	0.000	1.122	1.349	0.799
Healthcare	0.008	0.009	0.011	0.006	1.122	1.349	0.799
Home, yard, office	0.020	0.023	0.017	0.018	1.122	0.830	0.877
Retailer and wholesale	0.006	0.007	0.008	0.005	1.122	1.349	0.799
Services	0.035	0.039	0.047	0.033	1.122	1.349	0.947
Transportation services	0.001	0.001	0.001	0.001	1.122	1.349	0.799
Vehicles and vehicle parts	0.006	0.006	0.007	0.004	1.122	1.349	0.799
Other	0.008	0.009	0.011	0.006	1.122	1.349	0.799

Source: CBEI Version 2.0 (Stanton et al. 2011) for San Francisco 2008.

[4] 1990 data from "Calculations of GHG Emissions from the Waste Sector in the City of San Francisco for the baseline year of 1990," memorandum from Amruta Sudhalkar, of ICLEI, to Calla Rose Ostrander, City and County of San Francisco Department of Environment, April 25, 2011.

3. CALIFORNIA 2008 CONSUMPTION-BASED EMISSIONS, RESULTS AND ANALYSIS

3.1. Relationship to California State Traditional Inventory

Calculation of the CBEI 2008 consumption-based inventory for San Francisco begins with San Francisco's 2008 "Community Wide GHG Inventory" . Emissions from the Community Wide inventory are used in two ways in CBEI calculations: first, Community Wide industrial and commercial emissions are used to construct emission intensities for San Francisco-based production; and second, Community Wide end-use emissions are the basis for the use and disposal phases.

Table 1 shows the allocation of Community Wide emissions towards these two purposes. (Note that end-use electricity and waste disposal emissions are needed to calculate the correct emissions intensities for San Francisco production, but estimates of the emissions embedded in San Francisco's purchase of electricity and waste disposal services are replaced with more accurate data on end-use emissions provided by the Community Wide inventory.) The consumption-based inventory results presented below have been adjusted to remove any double counting.

Table 1: California's Traditional Inventory by Emission Type, 2008

(million m T CO2-e)	Industrial/Commercial Emissions	End-Use Emissions
California 2008 Traditional Inventory	**250.75**	**223.02**
Transportation	**79.12**	**95.87**
Residential		92.81
Government		3.06
Industrial/Commercial	79.12	
Electricity	**65.70**	**51.62**
Residential		39.91
Government		11.71
Commercial	42.99	
Industrial	22.71	
Direct Fuel Use	**105.93**	**30.53**
Residential		28.45
Government		2.09
Commercial	12.60	
Industrial	93.33	
Waste		**6.71**
Agriculture		**24.27**
Not Specified		**14.02**

Source: Authors' calculations based on California Environmental Protection Agency Air Resources Board (2010).

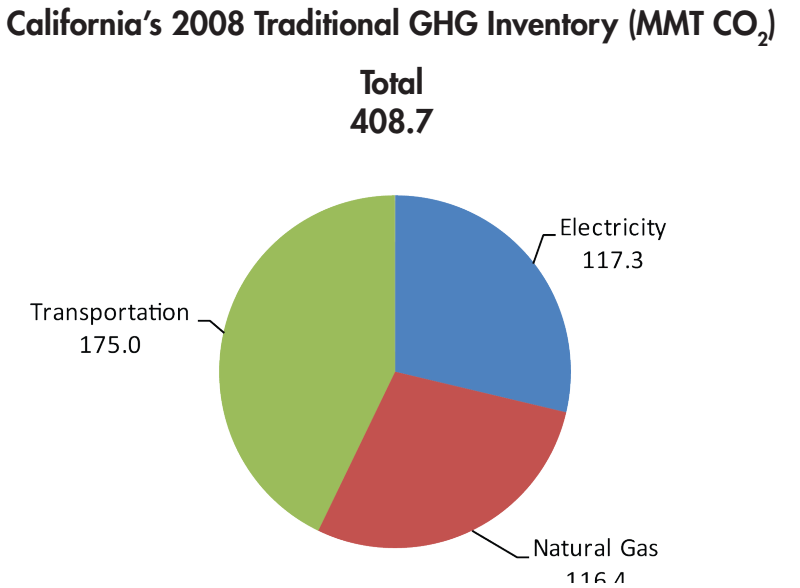
CBEI calculations result in 648 million metric tons CO2-e in embedded pre-purchase emissions (see Table 2). To this, the California traditional end-use emissions are added (474 million metric tons CO2-e) and adjustments are made for double-counting (-288 million metric tons CO2-e). Final consumption-based emissions for California in 2008 are 834 million metric tons CO2-e. California's consumption-based emissions are almost double (176 percent) the emissions estimated in California's 2008 traditional inventory (see Figure 1).

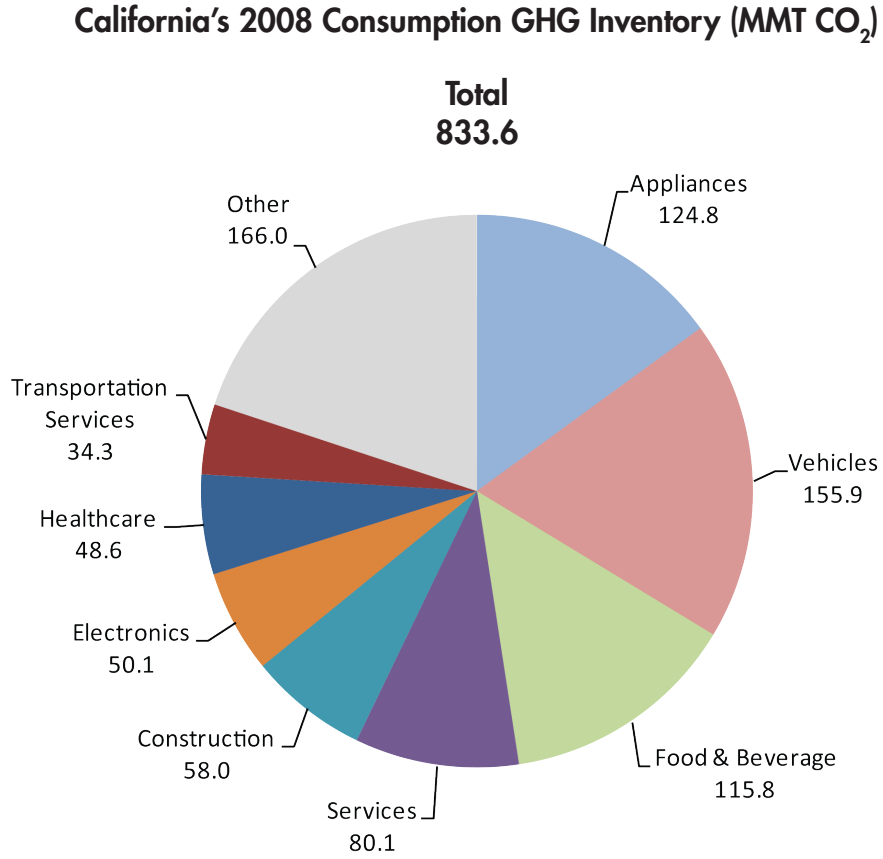
Table 2: Final Consumption-Based Emissions, California 2008

	(million mT CO2-e)
Embedded Pre-Purchase Emissions	647.79
Traditional Inventory End-Use Emissions	473.77
Correction for Double-Counting Direct Emissions from Electricity and Waste	-287.92
Final Consumption-Based Emissions for California	**833.64**

Source: CBEI Version 2.0 (Stanton et al. 2011) for California 2008.

Figure 1: Total Traditional GHG Inventory and Total Consumption Inventory for California





3.2. California's Consumption-Based Inventory

Table 3 reports California's 2008 consumption-based emissions by life-cycle phase totaling 834 million metric tons CO2-e. Production-phase emissions account for 56 percent of the total; pre-purchase transportation, 6 percent; wholesale and retail, 2 percent; use, 31 percent; and post-consumer disposal less than 5 percent.

Table 4 reports California's 2008 consumption-based emissions by type of consumer. Household emissions account for 76 percent of the total; business investment and government, 12 percent each.

As shown in Table 5, the largest categories are Vehicles and vehicle parts (19 percent) and Food and beverages (14 percent). These are also the largest categories of emissions from household consumption: Vehicles and vehicles parts (21 percent), and Food and beverages (18 percent).

Table 6 reports consumption-based emissions by subcategory. Cars and light trucks is the subcategory with the greatest emissions (16 percent), followed by Appliances, HVAC (8.8 percent), and Other (7 percent). No other subcategories exceed 5 percent of consumption-based emissions.

Table 7 reports California's 2008 consumption-based emissions by location of emissions.

Table 3: California's 2008 Consumption-Based Emissions by Life-Cycle Phase

(million MT CO2-e)	GHG Emissions by Phase					
	Production	Pre-Purchase Transportation	Wholesale/ Retail	Use	Post-Consumer Disposal	Total
California Total Emissions	467.891	50.988	17.958	257.917	38.886	833.639
Appliances, HVAC	0.454	0.030	0.002	72.673	0.004	73.163
Appliances, other	3.930	0.149	0.009	47.532	0.065	51.685
Clothing	18.995	0.097	0.013	0.000	0.065	19.171
Concrete, cement and lime	0.050	0.001	0.000	0.000	0.003	0.054
Construction	48.060	3.944	0.579	0.000	5.368	57.952
Electronics	36.331	1.141	0.256	12.222	0.190	50.140
Food and beverages	96.465	6.022	0.372	0.000	12.913	115.772
Forest products	4.560	0.308	0.012	0.000	11.002	15.883
Fuel, utilities, waste	2.127	0.152	0.011	0.000	0.035	2.325
Healthcare	45.578	2.272	0.298	0.000	0.484	48.632
Home, yard, office	23.923	1.123	0.078	0.000	3.567	28.691
Retailer and wholesale	19.688	1.730	15.690	0.000	0.374	37.482
Services	72.693	3.222	0.219	0.000	3.936	80.070
Transportation services	7.376	26.756	0.069	0.000	0.052	34.252
Vehicles and vehicle parts	28.268	1.745	0.103	125.490	0.340	155.945
Other	59.394	2.295	0.246	0.000	0.487	62.423

Source: CBEI Version 2.0 (Stanton et al. 2011) for California 2008.

Table 4: California's 2008 Consumption-Based Emissions by Consumer Type

(million mT CO2-e)	GHG Emissions by Type of Consumer			
	Household	Government	Investment	Total
California Total Emissions	**636.810**	**98.200**	**98.628**	**833.639**
Appliances, HVAC	62.631	10.388	0.144	73.163
Appliances, other	39.914	11.500	0.271	51.685
Clothing	18.818	0.351	0.001	19.171
Concrete, cement and lime	0.022	0.032	0.000	0.054
Construction	5.998	17.188	34.765	57.952
Electronics	18.171	6.834	25.135	50.140
Food and beverages	111.678	3.821	0.272	115.772
Forest products	10.121	5.760	0.002	15.883
Fuel, utilities, waste	1.075	0.337	0.913	2.325
Healthcare	44.619	1.354	2.659	48.632
Home, yard, office	24.866	1.643	2.182	28.691
Retailer and wholesale	34.466	0.663	2.354	37.482
Services	69.714	9.604	0.751	80.070
Transportation services	28.686	4.170	1.397	34.252
Vehicles and vehicle parts	136.215	15.260	4.470	155.945
Other	29.817	9.294	23.311	62.423

Source: CBEI Version 2.0 (Stanton et al. 2011) for California 2008.

Table 5: California's 2008 Consumption-Based Emissions, Share by Category

(million mT CO2-e)	GHG Emissions by Type of Consumer			
	Household	Government	Investment	Total
California Total Emissions	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Vehicles and vehicle parts	21.4%	15.5%	4.5%	18.7%
Food and beverages	17.5%	3.9%	0.3%	13.9%
Services	10.9%	9.8%	0.8%	9.6%
Appliances, HVAC	9.8%	10.6%	0.1%	8.8%
Other	4.7%	9.5%	23.6%	7.5%
Construction	0.9%	17.5%	35.2%	7.0%
Appliances, other	6.3%	11.7%	0.3%	6.2%
Electronics	2.9%	7.0%	25.5%	6.0%
Healthcare	7.0%	1.4%	2.7%	5.8%
Retailer and wholesale	5.4%	0.7%	2.4%	4.5%
Transportation services	4.5%	4.2%	1.4%	4.1%
Home, yard, office	3.9%	1.7%	2.2%	3.4%
Clothing	3.0%	0.4%	0.0%	2.3%
Forest products	1.6%	5.9%	0.0%	1.9%
Fuel, utilities, waste	0.2%	0.3%	0.9%	0.3%
Concrete, cement and lime	0.0%	0.0%	0.0%	0.0%

Source: CBEI Version 2.0 (Stanton et al. 2011) for California 2008.

Table 6: California 2008 Consumption-Based Emissions by Subcategory

(million mT CO2-e)	GHG Emissions by Type of Consumer			
	Household	Government	Investment	Total
CaliforniaTotal Emissions	**636.810**	**98.200**	**98.628**	**833.639**
Appliances, HVAC	**62.631**	**10.388**	**0.144**	**73.163**
Appliances, other	**39.914**	**11.500**	**0.271**	**51.685**
Lighting fixtures and bulbs	16.529	8.592	0.084	25.205
Ranges and microwaves	5.626	0.327	0.159	6.112
Refrigerators and freezers	6.822	2.398	0.020	9.240
Washers and dryers	7.671	0.173	0.001	7.845
Other appliances	3.265	0.011	0.007	3.283
Clothing	**18.818**	**0.351**	**0.001**	**19.171**
Concrete, cement and lime	**0.022**	**0.032**	**0.000**	**0.054**
Construction	**5.998**	**17.188**	**34.765**	**57.952**
Non-residential construction	0.000	16.273	23.152	39.425
Prefabricated buildings	0.008	0.032	0.226	0.265
Residential construction and remodeling	5.990	0.884	11.388	18.261
Electronics	**18.171**	**6.834**	**25.135**	**50.140**
Computer service and equipment	6.095	3.181	18.173	27.448
Other electronics	12.076	3.653	6.962	22.692
Food and beverages	**111.678**	**3.821**	**0.272**	**115.772**
Beverages	12.410	0.064	0.011	12.485
Condiments, oils and sweeteners	2.151	0.053	0.000	2.204
Dairy	10.502	0.589	0.033	11.125
Fresh fruit, nuts and vegetables	4.046	0.029	0.216	4.291
Frozen food	2.770	0.030	0.000	2.799
Grains, baked goods, cereals, roasted nuts, nut butters	11.227	0.237	0.000	11.463
Poultry and eggs	6.205	0.061	0.003	6.269
Processed fruit, nuts and vegetables	3.101	0.178	0.000	3.279
Red meat	18.487	1.147	0.000	19.634
Restaurants	29.869	1.210	0.000	31.079
Seafood	1.136	0.075	0.004	1.216
Other food and agriculture	9.775	0.149	0.004	9.928
Forest products	**10.121**	**5.760**	**0.002**	**15.883**
Paper and cardboard	9.856	5.519	0.000	15.376
Other processed forest products	0.264	0.232	0.000	0.497
Unprocessed forest products	0.000	0.008	0.002	0.010
Fuel, utilities, waste	**1.075**	**0.337**	**0.913**	**2.325**
Gasoline, heating fuels, other petroleum products	0.012	0.003	0.000	0.015
Natural gas distribution	0.002	0.000	0.000	0.002
Oil and gas extraction	0.088	0.194	0.913	1.195
Power generation and supply	0.005	0.000	0.000	0.006
Waste management	0.004	0.004	0.000	0.007
Water- sewage and other systems	0.965	0.135	0.000	1.100

Table 6 (continued): California 2008 Consumption-Based Emissions by Subcategory

(million m T CO2-e)	GHG Emissions by Type of Consumer			
	Household	Government	Investment	Total
CaliforniaTotal Emissions	**636.810**	**98.200**	**98.628**	**833.639**
Healthcare	**44.619**	**1.354**	**2.659**	**48.632**
Healthcare services	37.055	0.073	0.000	37.128
Medicines and other healthcare supplies	7.565	1.280	2.659	11.504
Home, yard, office	**24.866**	**1.643**	**2.182**	**28.691**
Home furnishings	6.355	0.084	0.479	6.918
Household supplies	11.696	0.494	0.023	12.214
Lawn and garden	3.946	0.691	0.028	4.666
Media and office supplies (except paper)	2.869	0.374	1.651	4.894
Retailer and wholesale	**34.466**	**0.663**	**2.354**	**37.482**
Retailers	27.418	0.003	0.893	28.315
Wholesale	7.048	0.659	1.460	9.168
Services	**69.714**	**9.604**	**0.751**	**80.070**
Banks, financial, legal, real estate, insurance	23.214	1.408	0.000	24.621
Building services	0.209	0.160	0.000	0.368
Education and day care	12.898	0.748	0.000	13.646
Hotels, motels, entertainment, media	19.036	1.515	0.105	20.657
Other services	14.357	5.774	0.646	20.777
Transportation services	**28.686**	**4.170**	**1.397**	**34.252**
Car rental, repair and wash	3.803	0.126	0.000	3.929
Transportation services, air	11.344	1.207	0.147	12.699
Transportation services, mass transit	0.542	0.131	0.000	0.672
Transportation services, rail	0.848	0.253	0.132	1.233
Transportation services, truck	10.209	1.745	1.116	13.070
Transportation services, water	1.321	0.587	0.001	1.909
Transportation services, other	0.619	0.121	0.000	0.740
Vehicles and vehicle parts	**136.215**	**15.260**	**4.470**	**155.945**
Aircraft	0.464	2.094	1.206	3.764
Cars and light trucks	126.009	7.028	2.091	135.128
Heavy duty trucks	0.031	2.725	0.427	3.183
Other road vehicles	6.514	0.022	0.094	6.631
Railroad rolling stock	0.000	0.033	0.068	0.101
Ships and boats	0.619	0.803	0.071	1.493
Vehicle parts	2.577	2.556	0.512	5.645
Other	**29.817**	**9.294**	**23.311**	**62.423**

Source: CBEI Version 2.0 (Stanton et al. 2011) for California 2008.

Table 7: California's 2008 Consumption-Based Emissions by Location

(million mT CO2-e)	GHG Emissions by Location of Emission			
	California	Inside-US-Outside-CA	Foreign	Total
California Total Emissions	**378.808**	**251.424**	**203.407**	**833.639**
Appliances, HVAC	50.869	22.028	0.266	73.163
Appliances, other	24.205	24.536	2.944	51.685
Clothing	0.321	0.566	18.283	19.171
Concrete, cement and lime	0.019	0.010	0.026	0.054
Construction	22.602	20.077	15.273	57.952
Electronics	11.531	16.218	22.391	50.140
Food and beverages	36.219	53.179	26.375	115.772
Forest products	11.232	2.868	1.782	15.883
Fuel, utilities, waste	0.805	0.962	0.558	2.325
Healthcare	16.091	20.710	11.832	48.632
Home, yard, office	6.479	8.062	14.150	28.691
Retailer and wholesale	17.130	14.005	6.348	37.482
Services	33.250	30.037	16.783	80.070
Transportation services	7.774	10.991	15.487	34.252
Vehicles and vehicle parts	126.795	10.935	18.215	155.945
Other	13.487	16.242	32.694	62.423

Source: CBEI Version 2.0 (Stanton et al. 2011) for California 2008. Results adjusted from standard CBEI output: 52.5 percent of California area electricity emissions have been reallocated to Inside-US-Outside-SF. This electricity import share was derived from California Environmental Protection Agency Air Resources Board (2010).

3.3. Comparing California to San Francisco

Table 8 reports per capita consumption-based emissions for California of 22.6 metric tons CO2-e, as compared to San Francisco's 26.9 metric tons CO2-e.[1] In the traditional inventories, California's per capita emissions are 77 percent higher than San Francisco's, but in CBEI San Francisco's per capita emissions are 18 percent higher than California's (see Table 9). The root cause of San Francisco's comparatively high per capita consumption-based emissions is its high income as compared to the rest of the state. San Francisco's 2008 per capita income was $47,420 while the California average was $29,388.[2]

Table 8: California's 2008 Per Capita Consumption-Based Emissions by Life-Cycle Phase

(m T CO2-e)	GHG Emissions by Phase					
	Production	Pre-Purchase Transportation	Wholesale/ Retail	Use	Post-Consumer Disposal	Total
California Per Capita Emissions	**12.729**	**1.387**	**0.489**	**7.017**	**1.058**	**22.680**
Appliances, HVAC	0.012	0.001	0.000	1.977	0.000	1.990
Appliances, other	0.107	0.004	0.000	1.293	0.002	1.406
Clothing	0.517	0.003	0.000	0.000	0.002	0.522
Concrete, cement and lime	0.001	0.000	0.000	0.000	0.000	0.001
Construction	1.308	0.107	0.016	0.000	0.146	1.577
Electronics	0.988	0.031	0.007	0.332	0.005	1.364
Food and beverages	2.624	0.164	0.010	0.000	0.351	3.150
Forest products	0.124	0.008	0.000	0.000	0.299	0.432
Fuel, utilities, waste	0.058	0.004	0.000	0.000	0.001	0.063
Healthcare	1.240	0.062	0.008	0.000	0.013	1.323
Home, yard, office	0.651	0.031	0.002	0.000	0.097	0.781
Retailer and wholesale	0.536	0.047	0.427	0.000	0.010	1.020
Services	1.978	0.088	0.006	0.000	0.107	2.178
Transportation services	0.201	0.728	0.002	0.000	0.001	0.932
Vehicles and vehicle parts	0.769	0.047	0.003	3.414	0.009	4.243
Other	1.616	0.062	0.007	0.000	0.013	1.698

Source: CBEI Version 2.0 (Stanton et al. 2011) for California 2008.

[1] Per capita calculations for Table 4 use a California 2008 population of 36,756,666 (2008 American Community Survey 1-Year Estimates, Table B01003, Total Population. Universe: Total Population. http://www.census.gov/acs/).
[2] 2008 American Community Survey 1-Year Estimates, Table B19301, Per Capita Income in the Past 12 months (in 2008 inflation-adjusted dollars) . Universe: Total Population. http://www.census.gov/acs/.

Table 9 reports the ratio of San Francisco to California per capita consumption-based emissions by commodity category. For most categories, San Francisco's per capita emissions exceed those of the California average; the highest of these ratios is that of Transportation services, where San Franciscans' use of public transportation and taxis dwarfs that of average Californian. There are however, several categories in which California's per capita emissions are higher than those of San Francisco: Appliances, HVAC; Appliances, other; Electronics; Forest products; Fuel, utilities and waste; Vehicles and vehicle parts; and Other.

Table 9: Comparing San Francisco and California 2008 Per Capita Consumption-Based Emissions

(mT CO2-e)	San Francisco	California	Ratio of SF to CA
Per Capita Emissions	**26.859**	**22.680**	**1.18**
Appliances, HVAC	1.641	1.990	0.82
Appliances, other	0.899	1.406	0.64
Clothing	0.921	0.522	1.77
Concrete, cement and lime	0.003	0.001	2.24
Construction	1.686	1.577	1.07
Electronics	1.331	1.364	0.98
Food and beverages	5.257	3.150	1.67
Forest products	0.386	0.432	0.89
Fuel, utilities, waste	0.052	0.063	0.82
Healthcare	1.824	1.323	1.38
Home, yard, office	1.281	0.781	1.64
Retailer and wholesale	1.196	1.020	1.17
Services	2.486	2.178	1.14
Transportation services	2.299	0.932	2.47
Vehicles and vehicle parts	4.043	4.243	0.95
Other	1.553	1.698	0.91

Source: CBEI Version 2.0 (Stanton et al. 2011) for San Francisco and California 2008.

4. TECHNICAL MODEL DESCRIPTION

The CBEI model estimates the consumption-based greenhouse gas emissions of a particular area in a particular year. Part 4 of this Technical Report discusses the CBEI technical methodology in detail. For this project, we conducted two, separate CBEI analyses for two different "study areas": one for the City of San Francisco, and one for the State of California.

Abbreviations:

San Francisco or California = Study Area = SA
Inside-U.S.-Outside-SA = UX
United States including SA = US
Outside of the United States = Foreign = FR

4.1. Step 1: Emissions Coefficients

In the CBEI model, greenhouse gas coefficients represent the quantity of emissions released per dollar of activity in each IMPLAN sector. CBEI calculates direct coefficients (the emissions intensity of a production process, not including upstream effects) for the Study Area and the United States, and uses existing data for direct plus indirect coefficients (including upstream effects) for foreign imports to the United States. (The original data for foreign emissions intensities are available only in the direct+indirect form.)

CBEI's direct coefficients are the per dollar emissions, by sector, that result only from activities in the originating production sector; direct coefficients do not include indirect, or upstream, emissions. Production sectors are based on industrial and commercial IMPLAN codes (1 to 427), which correspond to NAICS codes 11 to 81. Sectors 428 to 440 do not have direct emissions,[1] although they might have direct+indirect emissions if their indirect emissions are positive.

Direct coefficients are presented in CBEI in kg CO2-e per dollar of industrial and commercial output for 2008. Separate direct coefficients are calculated for Study Area and the United States based on Study Area and U.S. emissions inventories and economic output, respectively.

Direct coefficients:
Dcoef_SA Study Area direct coefficients
Dcoef_US U.S. direct coefficients

[1] IMPLAN sectors 361 and 428 to 440 have no direct greenhouse gas emissions, although they may purchase inputs that required emissions for their production. Most of these sectors are purely labor. A few (scrap, used goods) are trade in second-hand materials; all greenhouse gas emissions from the production of these materials are assigned to their first use. Owner-occupied dwellings refers to the "service" of owning or renting a home; the manufacturing and transport of construction materials, emissions associated with construction activities, and fuel and electricity emissions of owning or renting a home are counted elsewhere in the model.

San Francisco Direct Coefficients

Data:

San Francisco's 2008 "Community Wide GHG" Inventory[2]

Emission allocations:

See 2008_SF_Community_GHG_Emissions CBEI mapping.xlsx for a full mapping of the Community Wide inventory to San Francisco direct coefficients.

- Transportation: Several data sources are used to allocate transportation emissions household, government, and commercial uses and relevant IMPLAN sectors; see "CBEI Transportation Allocation.xlsx" in the "San Francisco" folder for calculations and detailed methodology.
- Electricity: All end-use electricity emissions are allocated to Sector 31, "Electricity, and distribution services."
- Commercial building emissions from direct fuel: These emissions are allocated to all commercial sectors (319-427) in proportion to their gross output (GO_SA).
- Industry direct fuel, process, and fugitive gases: Allocated to the appropriate IMPLAN sectors using supplemental data on NAICS and SIC codes.[3] Where no information was available to assign emissions to particular IMPLAN sectors, these emissions are allocated to all industrial sectors (41-318), or to all industrial sectors not otherwise accounted for with specific emission assignments, in proportion to their gross output (GO_SA).
- Waste, landfills: Waste disposal emissions are based on a "waste commitment" methodology, and are taken from supplement materials to the Community Wide inventory.[4]
- Waste, wastewater treatment: Allocated to Sector 33, "Water, sewage treatment, and other utility services."

California Direct Coefficients

Data:

California Greenhouse Gas Inventory by Sector & Activity, 2008 data (California Environmental Protection Agency Air Resources Board 2010).

[2] San Francisco (California). 2008 City and County of San Francisco Community Wide GHG Inventory. Department of the Environment. City andCounty of San Francisco (2011).
[3] Data obtained from EDGAR (SEC n.d.) and the "Bridge between NAICS and SIC" in the 1997 Economic Census (U.S. Census Bureau 1997).
[4] "Calculations of GHG Emissions from the Waste Sector in the City of San Francisco for the baseline year of 1990," memorandum from Amruta Sudhalkar, of ICLEI, to Calla Rose Ostrander, City and County of San Francisco Department of Environment, April 25, 2011.

Emission allocations:

See CA ghg_inventory_by_sector_00-08_2010-05-12 CBEI Mapping.xlsx for a full mapping of the Community Wide inventory to California direct coefficients.

- Transportation: Several data sources are used to allocate transportation emissions household, government, and commercial uses and relevant IMPLAN sectors; see "CBEI Transportation Allocation.xlsx" in the "California" folder for calculations and detailed methodology.
- Electricity: All end-use electricity emissions are allocated to Sector 31, "Electricity, and distribution services."
- Commercial building emissions from direct fuel: After removing government from total commercial (based on the government share of commercial heating and cooling emissions[5]), these emissions are allocated to all commercial sectors (319-427) in proportion to their gross output (GO_SA).
- Industry direct fuel, process, and fugitive gases: Allocated to the appropriate IMPLAN sectors using supplemental data on NAICS and SIC codes.[6] Where no information was available to assign emissions to particular IMPLAN sectors, these emissions are allocated to all industrial sectors (41-318), or to all industrial sectors not otherwise accounted for with specific emission assignments, in proportion to their gross output (GO_SA).
- Waste, landfills: Waste disposal emissions are taken from the California State inventory.
- Waste, wastewater treatment: Allocated to Sector 33, "Water, sewage treatment, and other utility services."
- Agriculture: Enteric emissions from livestock and manure management are allocated to Sectors 11-14; soil management is allocated to sectors 1-10.

Study Area direct coefficients:

$$\text{Dcoef\_SA} = \frac{\text{(SA total production emissions)}}{\text{(GO\_SA)}}$$

where GO_SA (defined below) is SA economic output by sector

Note that here, and throughout this methodology, calculations are for each of 440 sectors, unless otherwise noted. For simplicity sake, we omit the subscript indicating the sector number throughout.

U.S. Direct Coefficients

Data:

Emission of Greenhouse Gases in the United States 2008 (U.S. Energy Information Administration 2009)

[5] U.S. Energy Information Administration (2008), Table B18, Table A1, see "KC2008 CBEI Sources for Direct Coefficients.xlsx."

[6] Data obtained from EDGAR (SEC n.d.) and the "Bridge between NAICS and SIC" in the 1997 Economic Census (U.S. Census Bureau 1997).

Emission allocations:

- Transportation: Several data sources are used to allocate transportation emissions household, government, and commercial uses and relevant IMPLAN sectors; see "CBEI Transportation Allocation.xlsx" for calculations and detailed methodology.
- Electricity: Allocated to Sector 31, "Electricity, and distribution services".
- Industry energy: Allocated to specific IMPLAN sectors in proportion to U.S. EIA 2001 data (Schipper 2006).
- Industry non-energy: Allocated to specific sectors or groups of sectors based on U.S. EIA 2008 data (EIA 2009 Table 15, "U.S. Carbon Dioxide Emissions from Other Sources, 1990-2008"), and allocated to sectors within these groups in proportion to their gross output (GO_US).
- Commercial: Allocated to all commercial sectors (319-427) in proportion to their gross output (GO_SA).
- Other gases: Allocated to specific sectors or groups of sectors based on U.S. EIA 2008 data (EIA 2009) and allocated to sectors within these groups in proportion to their gross output (GO_US).

U.S. direct coefficients:

Dcoef_US = (US total production emissions)/(GO_US)

where GO_US (defined below) is U.S. economic output by sector

Foreign Direct+Indirect Coefficients

Data:

Multi-Regional Input-Output (MRIO) International Emissions Data 2004 (Peters 2010)

Direct+indirect coefficient calculations from CBEI direct coefficients:

DIcoef_CBEI_US U.S. direct+indirect coefficients (generated by CBEI model)

1. Transpose Dcoef_US from column to row vector.
2. DIcoef_CBEI_US_Transpose=Dcoef_US_Transpose×TypeI_Matrix_US
3. Transpose DIcoef_CBEI_US_Transpose from row to column vector.

Direct+indirect coefficients from Peters data:

DIcoef_IM_US U.S. "imports" direct+indirect coefficients (for foreign final and intermediate goods used in foreign final products imported to the United States)

DIcoef_GL_US U.S. "global" direct+indirect coefficients (for foreign intermediate goods used in U.S. final products)

U.S. Import Coefficients: DIcoef_IM_US

1. Calculate values using Peters international data set by sector (i):
    a. Emissions coefficient for final imports into the U.S. in i sectors:

$$\text{PetersDIcoef\_Imports\_US} = \frac{(\text{US total emissions} - \text{US global emissions})}{(\text{US total output} - \text{US global output})}$$

    b. Value of final imports into the U.S. in i sectors:

PetersImports_US = US total output - US global output

2. Peters international GHG coefficient data (2001 dollars) in sectors (i) are converted to 2008 dollars using the U.S. CPI-U.

3. Each IMPLAN sector (j) is mapped to 1 to 3 Peters (2008 dollars) sectors (i). In some cases several GTAP sectors fall under a single IMPLAN sector, and vice versa. Groupings of GTAP sectors into IMPLAN sectors are unique such that 57 GTAP sectors (i) become 51 GTAP-sector groups (m):

    i=57 GTAP sectors

    j = 440 IMPLAN sectors

    k=1st/2nd/3rd GTAP sector per IMPLAN sector

    i(j,k) maps IMPLAN to GTAP

    m(j)=i(j,1) - in practice, there are 51 unique values of m

    n = a GTAP sector or group of 2 or 3 sectors, all mapped to the same IMPLAN sector (i.e., a value taken on by m(j))

4. $\text{DIcoef\_IM\_US\_unweighted}_i = \frac{(\sum_k(\text{PetersDIcoef\_Imports\_US}_{(j,k)} * \text{PetersImports\_US}_{(j,k)})}{(\sum_k \text{PetersImports\_US}_{(j,k)})}$

5. $\text{US\_TCO}_n = \sum_i \text{US\_TCO}_i$, summed over all j for which m(j)=n

6. $\text{US\_TCOxDIcoef\_CBEI\_USn} = \sum_i(\text{DIcoef\_CBEI\_US}_i * \text{US\_TCO}_i)$, summed over all j for which m(j)=n

7. $\text{PetersWeight}_i = \frac{\text{US\_TCOxDIcoef\_CBEI\_US}_{(m(j))}}{\text{US\_TCO}_{m(j)}}$

8. $\text{DIcoef\_IM\_US}_i = \text{DIcoef\_IM\_US\_unweighted}_i * \left(\frac{\text{DIcoef\_CBEI\_US}_i}{\text{PetersWeight}_i}\right)^{0.5}$

U.S. Global Coefficients: DIcoef_GL_US

1. Calculate values using Peters international data set by sector (i):

    a. U.S. global emission coefficients (for U.S. final production including domestic and imported intermediate goods – direct+indirect):

    PetersDIcoef_Global_US = (US global emissions)/(US global output)

    b. U.S. domestic-only emissions (for U.S. final production including only domestic intermediate goods – direct+indirect):

    PetersDIcoef_DomesticOnly_US = US domestic only

    c. Ratio of Peters U.S. global to Peters U.S. domestic-only emissions:

$$\text{PetersCoefRatio} = \frac{(\text{PetersDIcoef\_Global\_US})}{\text{PetersDIcoef\_DomesticOnly\_US})}$$

    d. Value of production in the U.S. by sector:

    PetersGlobal_US = US global output

2. Each IMPLAN sector (j) is mapped to 1 to 3 Peters (2008 dollars) sectors (i). In some cases several GTAP sectors fall under a single IMPLAN sector, and vice versa. Groupings of GTAP sectors into IMPLAN sectors are unique such that 57 GTAP sectors (i) become 51 GTAP-sector groups (m):

    i=57 GTAP sectors

    j = 509 IMPLAN sectors

    k=1st/2nd/3rd GTAP sector per IMPLAN sector

    i(j,k) maps IMPLAN to GTAP

3. $$\text{CoefRatio\_j} = \frac{(\sum_k(\text{PetersCoefRatio}_{(j,k)} * \text{PetersGlobal\_US}_{(j,k)})}{(\sum_k\text{PetersGlobal\_US}_{(j,k)}}$$

4. $\text{DIcoef\_GL\_US}_i = \text{CoefRatio}_i * \text{DIcoef\_CBEI\_US}_i$

4.2. Step 2: Intermediary Pre-Purchase Emissions by Emitting Sector

Final Demand

Final demand data are extracted from IMPLAN databases as "regional institutional demand"[7] for the Study Area and for the United States in producer prices and terms. IMPLAN reports final demand for four types of institutions responsible for expenditures: personal or household consumption; Study-Area-based federal government; state and local government entities; and business investment expenditures in capital formation and net inventory replacement (see Table 1). Final business investment demand does not include other business-to-business transactions. (Note that, as is standard in economic analysis, these data include the "service" provided by government salaries and benefits, and government purchases, but exclude transfer payments such as Social Security or unemployment compensation.[8])

San Francisco's final demand in 2008 was 0.5 percent of total U.S. final demand; California's final demand was 12.6 percent of U.S. final demand:

Table 1: Final Demand for San Francisco, California, and the United States, 2008 (millions $)

	Households	State and Local Government	Federal Government	Business Investment	Total
San Francisco					
million $	$51,556	$10,488	$3,170	$7,807	$73,021
percent	70.6%	14.4%	4.3%	10.7%	100.0%
California					
million $	$1,330,734	$270,207	$112,939	$299,218	$2,013,097
percent	66.1%	13.4%	5.6%	14.9%	100.0%
United States					
million $	$10,299,248	$2,147,637	$1,114,883	$2,377,205	$15,938,973
percent	64.6%	13.5%	7.0%	14.9%	100.0%

Source: IMPLAN 2008 data for San Francisco, California, and the United States (MIG 2010).

CBEI multiplies final demand by IMPLAN input-output matrices to calculate gross (or direct plus indirect) demand. Gross demand is calculated for the Study Area (including the Study Area's final and intermediate purchases of commodities produced in the Study Area); and Inside-US-Outside-SA (including the Study Area's final and intermediate purchase of commodities produced Inside-US-Outside-SA, and intermediate purchases used to produce final products consumed in Study Area produced Inside-US-Outside-SA). Gross demand for each location of

[7] "Regional institutional demand" is IMPLAN's term for final demand for commodities by households and government, plus firms' investment in equipment or inventory.

[8] Government expenditures on employment (just like other pure-labor sectors such as household domestic work) have direct emissions coefficients of zero; labor by itself does not cause greenhouse gas emissions. Any emissions associated with government employees spending their salaries (as consumers) are accounted for as part of "household" final demand, so there is no double-counting of emissions.

production is then multiplied by the appropriate emissions coefficients (Study Area or U.S.). (Note that final and intermediate demand for foreign commodities – including the Study Area's final and intermediate purchase of commodities produced in foreign countries – are calculated somewhat differently because of data constraints as described below.)

"Producer prices and terms" indicates that IMPLAN's reported final demand in a given commodity sector reflects payments to that commodity's production sector, not the retail price paid by the ultimate purchasers of the commodity. Few purchases are made directly from industrial sectors. Instead, finished products typically pass through several hands before reaching the customer, and a portion of each consumer dollar spent on any product is retained by wholesale, retail, and transportation firms. For example, for a $1 cookie purchase, 25 cents is estimated, on average, to be retained by the retailer, 9 cents is paid to the wholesaler, 3 cents goes to pre-purchase transportation, and 63 cents is paid to the manufacturer. The portions retained by businesses other than the producer are the margin or mark up.

CBEI does not include any calculation of final demand from margining activities that would associate a particular good's emissions with the share of each consumer dollar spent on retail, wholesale, and transportation of a good before purchase. Instead, CBEI takes the dollars spent by Study Area consumers on margining activities (retail, wholesale, and transportation) to be separate purchases of these services – the convention followed in IMPLAN demand data.

IMPLAN data (where xx is the data year):

SAxx_CD_10000	Study Area 20xx Commodity Demand by 10000 (Household) Institution
SAxx_CD_11000	Study Area 20xx Commodity Demand by 11000 (Federal Government Institution
SAxx_CD_12000	Study Area 20xx Commodity Demand by 12000 (State and Local Government) Institution
SAxx_CD_14000	Study Area 20xx Commodity Demand by 14000 (Investment) Institution
SAxx_CD_Intm	Study Area 20xx Commodity Demand, Intermediate
SAxx_IM_10000	Study Area 20xx Imports by 10000 (Household) Institution
SAxx_IM_11000	Study Area 20xx Imports by 11000 (Federal Government) Institution
SAxx_IM_12000	Study Area 20xx Imports by 12000 (State and Local Government) Institution
SAxx_IM_14000	Study Area 20xx Imports by 14000 (Business Investment) Institution
SAxx_TCO	Study Area 20xx Total Commodity Output
SAxx_EX_Frn	Study Area 20xx Exports, Foreign
SAxx_EX_Dom	Study Area 20xx Exports, Domestic
TypeI_Matrix_SA	Study Area 20xx Type I Multiplier Matrix
USxx_CD_Inst	United States 20xx Commodity Demand by All Institutions

USxx_CD_Intm	United States 20xx Commodity Demand, Intermediate
USxx_IM_Inst	United States 20xx Imports by All Institutions
USxx_IM_Intm	United States 20xx Imports, Intermediate
USxx_TCO	United States 20xx Total Commodity Output
TypeI_Matrix_US	United States 20xx Type I Multiplier Matrix

Data year adjustment (where yy is year under study):

SAxx_GDP	GDP for study area in IMPLAN data year xx (in xx year dollars)
SAyy_GDP	GDP for study area in emissions data year yy (in xx year dollars)
USxx_GDP	GDP for United States in IMPLAN data year xx (in xx year dollars)
USyy_GDP	GDP for United States in emissions data year yy (in xx year dollars)

$$SAxxtoyy\_GDPratio = \frac{(SAyy\_GDP)}{(SAxx\_GDP)}$$

$$USxxtoyy\_GDPratio = \frac{(USyy\_GDP)}{(USxx\_GDP)}$$

If IMPLAN data year and emissions data year are the same, both ratios are set equal to 1. If IMPLAN data year and emissions data year differ, then all dollar-denominated data are multiplied by Study Area or U.S. ratios, as appropriate. After these ratios area applied, the variables are renamed removing "SAxx_" for study area variables and "xx" (but leaving "US_") for U.S. variables.

Foreign import rate:

FIR_10000 =

…if CD_10000 = 0 or IM_10000 = 0, then 0

…otherwise (CD_10000 and IM_10000 not equal to 0):

Minimum of:

$$\frac{(IM\_10000)}{(CD\_10000)} \quad \text{or} \quad \frac{(US\_IM\_INST)}{(US\_CD\_INST)}$$

Identical calculations for 10000, 11000, 12000, 14000

Final demand by production geography:

Study Area Final Demand for Study Area products:

FD_10000_SA=CD_10000-IM_10000

Study Area Final Demand for U.S. products:

FD_10000_US=CD_10000× (1-FIR_10000)

Study Area Final Demand for foreign products:

FD_10000_FR=CD_10000×FIR_10000

Identical calculations for all institutions: 10000, 11000, 12000, 14000

Gross demand by production geography:

Study Area Gross Demand for Study Area final products and Study Area intermediate production used in Study Area final production:

GD_10000_SA=TypeI_Matrix_SA×FD_10000_SA

Study Area Gross Demand for Inside-US-Outside-SA final products and Inside-US-Outside-SA intermediate goods used in final products purchased in Study Area:

GD_10000_UX=GD_10000_US-GD_10000_SA

Note: GD_10000_UX is restricted to non-negative numbers.

where:

Study Area Gross Demand for U.S. final products and U.S. intermediate goods used in final products purchased in Study Area:

GD_10000_US=TypeI_Matrix_US×FD_10000_US

Note: GD_10000_US is restricted to be equal to or greater than FD_10000_US.

Identical calculations and restrictions for 10000, 11000, 12000, 14000

Total Gross Output (an input to direct coefficient development):

GO_SA=SA_TCO

GO_US=US_TCO

Greenhouse Gas Emissions

Greenhouse gas emissions are reported in CBEI in thousands of metric tons of CO2-e and are calculated as follows (see Figure 1):

- Emissions from Study Area consumption of Study-Area-made final commodities are the product of the Study Area's in-area gross demand and the Study Area direct coefficients for each of the 440 IMPLAN sectors.
- All other emissions from the Study Area's consumption of U.S.-made final commodities (including Inside-US-Outside-SA indirect emissions from the Study Area's consumption of U.S.-made final commodities) are the product of the Study Area's U.S. gross demand and the U.S. direct coefficients less the product of the Study Area's in-area gross demand and the Study Area direct coefficients.
- Foreign emissions results from the Study Area's consumption of final products are calculated in two pieces:
    - The Study Area's final demand for foreign-made goods is multiplied by the MRIO direct+indirect coefficients for "U.S. imports."
    - Emissions from the production of foreign-made intermediate goods used in the Study Area and Inside-US-Outside-SA production for the Study Area's final consumption are the product of the Study Area's U.S. final demand and the "U.S. global" direct+indirect coefficients less CBEI's U.S. direct+indirect coefficients.

<table>
<tr><th>Final production locale:
Stage of production by locale:</th><th>Study Area (SA)</th><th>Inside-US-Outside-SA (UX)</th><th>Foreign (FR)</th></tr>
<tr><td>Final Production</td><td colspan="2" rowspan="3">SA direct+indirect demand * SA direct coefficient + UX direct+indirect demand + US coefficient</td><td rowspan="3">FR1 = FR direct demand * "Import" direct+indirect coefficient</td></tr>
<tr><td>Intermediate production: SA (used in final production by column)</td></tr>
<tr><td>Intermediate production: UX (used in final production by column)</td></tr>
<tr><td>Intermediate production: FR (used in final production by column)</td><td colspan="2">FR2 = US direct demand * "Global - US" direct+indirect coefficient</td></tr>
</table>

Note: FR = FR1 + FR2
Source: CBEI Version 2.0 (Stanton et al. 2011).

Figure 1: CBEI Emission Calculation Schematic
Emissions coefficients:

- SA production of final and intermediate goods (direct)
- U.S. production of final and intermediate goods (direct)
- "U.S. Imports": FR production of final goods sold to United States (direct+indirect)
- "U.S. Global": FR production of intermediate goods sold to United States (direct+indirect)
- U.S. production of final and intermediate goods (direct+indirect)

Two ways to calculate emissions (depending on emissions coefficient data availability):

Emissions = Direct demand * direct+indirect coefficient

where, Direct coefficient * I/O matrix = direct+indirect coefficient

Emissions = Direct+indirect demand * direct coefficient

where, I/O matrix * Direct demand = direct+indirect (gross) demand

Emissions calculations:

Emissions released in the Study Area from Study Area consumption:

EM_10000_SA=GD_10000_SA×Dcoef_SA

Emissions released Inside-US-Outside-SA from Study Area consumption:

EM_10000_UX=GD_10000_UX×Dcoef_US

Emissions released outside of the United States from Study Area consumption:

EM_10000_FR=(FD_10000_FR×DIcoef_IM_US)+

(FD_10000_US×(DIcoef_GL_US-DIcoef_CBEI_US))

Identical calculations for 10000, 11000, 12000, 14000

Pre-purchase emissions correction:

For transparency in presentation, the 14000 emissions results for sectors 37 and 38 (residential construction and remodeling) are added to the 10000 results for sectors 37 and 38. This change is made for all locations of emission (SA, UX, and FR) and all phases. That is, all emissions related to residential construction that would otherwise be classified as business investment consumption (a convention in economics) are instead classified as household consumption.

Greenhouse Gas Emissions by Phase

Designating emission phases:

- Each sector's emissions belong to one and only one life-cycle phase.
- Unless otherwise specified, all sectors' emissions belong to the "production" phase.
- The following sectors' emissions belong to the "pre-purchase transportation" phase:
  - 332-338 transportation sectors
- The following sectors' emissions belong to the "wholesale+retail" phase:
  - 319 wholesale trade
  - 320-331 retail sectors

EM_10000_SA_Prd	Household, study-area, production-phase emissions
EM_10000_SA_Trn	Household, study-area, pre-purchase-transportation-phase emissions
E M_10000_SA_WhR	Household, study-area, wholesale-retail-phase emissions

Identical calculations for 10000, 11000, 12000, 14000 and SA, UX, FR

4.3. Step 3: Reorganizing Results From Emitting Sector To Consuming Sector

To reclassify pre-purchase emissions from their emitting sectors to their consuming sectors, CBEI is run in its "Life-Cycle-Analysis" mode:

- Standard CBEI results are the pre-purchase consumption-based emissions of the Study Area as a whole.
- To calculate the pre-purchase emissions for each sector of final demand separately requires re-running CBEI 440 times using the appropriately circumscribed demand vector (i.e., demand for each sector is run separately).
- Study Area consumption-based emissions are reorganized on this principle by running CBEI for each of the Study Area's 440 sectors of demand individually and recording the total emissions generated by that run as that sector's emissions.
- This method results in the same total CBEI emissions for the SA as a normal run, but a different distribution of emissions across sectors.

4.4. Step 4: Final Results, Adding Use and Disposal Emissions

Final CBEI results add use and post-consumer disposal emissions to the pre-purchase emissions, organized by consuming sector, and adjust for double counting.

Use and Disposal results:

- Use and post-consumer disposal phase emissions (and, therefore, final CBEI results) are calculated at the sub-category level and cannot be presented by sector.

- Use and disposal emissions (and final results) are reported for three institutions only: households, and a combined "government" institution (local and state government plus federal government), and investment.

EM_10000_SA_Use	Household, study-area, use-phase emissions
EM_10000_SA_Dsp	Household, study-area, post-consumer disposal-phase emissions
EM_11000+12000_SA_Use	Government, study-area, use-phase emissions
EM_11000+12000_SA_Dsp	Government, study-area, post-consumer disposal-phase emissions

Use Phase

The use life-cycle phase includes all post-purchase emissions, with the exception of disposal emissions. Specifically, the use phase consists of emissions from direct fuel use by households and government (for heating or other appliances), household and government transportation from the San Francisco Community Wide and California State inventories (as appropriate by Study Area), households and governments direct electricity emissions from the from the San Francisco Community Wide and California State inventories, and the indirect emissions for household and government fuel and electricity purchases as calculated in the pre-purchase model. Indirect emissions in the use phase are sector-specific ratio of indirect to direct emissions from the pre-purchase results multiplied by the end-use emissions from the San Francisco Community Wide and California State inventories.

Use phase calculations disaggregate fuel and electricity emissions into the categories and sub-categories of commodities that utilize fuel and electricity – cars, furnaces, appliances, electronics, lighting, etc. (Double-counting is corrected by subtracting from the pre-purchase results the indirect fuel and direct+indirect electricity emissions included in the use phase, as described below.) For calculations, see CBEI Use and Disposal.xlsx in the "San Francisco" and "California" folders; for data sources see 2008_SF_Community_GHG_Emissions (new VMT) CBEI mapping.xlsx, CA ghg_inventory_by_sector_00-08_2010-05-12 CBEI Mapping.xlsx, and CBEI Use and Disposal Sources.xlsx.

Post-Consumer Disposal Phase

The post-consumer disposal life-cycle phase consists of emissions from post-consumer waste in landfills and waste combustion.[9] Emissions from household and government purchase of waste disposal services are calculated in supplemental materials to San Francisco's Community Wide

[9] Landfill emissions here are calculated on the basis of future lifetime emissions from each year's disposal (sometimes called "methane commitment").

inventory[10] and the California State inventory[11], and disaggregated into the categories and sub-categories of commodities that become waste products. (Double-counting is corrected as described below.) For calculations see CBEI Use and Disposal.xlsx in the "San Francisco" and "California" folders; for data sources see 2008_SF_Community_GHG_Emissions (new VMT) CBEI mapping.xlsx, CA ghg_inventory_by_sector_00-08_2010-05-12 CBEI Mapping.xlsx, and CBEI Use and Disposal Sources.xlsx.

Final Consumption-Based Emissions Results

Final consumption emissions for the production, pre-purchase transportation, and wholesale+retail phases are the pre-purchase emissions by consuming sector for these phases, summed across sub-categories (i.e., there are no sector results) and summed across the 11000 and 12000 institutions (for a single "government consumer"), with a few adjustments (below), and renamed as, for example, 5P_EM_10000_SA_Prd (where 5P refers to "five-phase" results).

There is some double counting between the pre-purchase model and the use and post-consumer disposal phases. In order to correct for this double counting it is necessary to zero out the following emissions in the five-phase results from the production, pre-purchase transportation, and wholesale/retail phases:

5P_EM_10000, sub-category "Gasoline, heating fuels, other petroleum"
5P_EM_11000+12000, sub-category "Gasoline, heating fuels, other petroleum"
5P_EM_10000, sub-category "Natural gas distribution"
5P_EM_11000+12000, sub-category "Natural gas distribution"
5P_EM_10000, sub-category "Power generation and supply"
5P_EM_11000+12000, sub-category "Power generation and supply"
5P_EM_10000_SA, sub-category "Waste management"
5P_EM_11000+12000_SA, sub-category "Waste management"

4.5. CBEI Demand Modeler

CBEI "Demand Modeler" is a separate tool used to calculate emissions for a user-determined subset of Study Area final demand (that is, dollar values of Study Area demand defined by economic sector and by type of consumer – households, federal government, local and state government, and investment). The "Modeler" can be used to view the consumption-based emissions of the demand for a single IMPLAN category, subcategory or sector, where emission results are disaggregated by emitting industry, type of consumer, life-cycle phase, and location of emission. Emission results for a single sector of demand can be viewed in the intermediary CBEI pre-purchase results by consuming sector emissions, but to see emissions by contributing emitting sectors or to do analysis based on custom demand profiles, it is necessary to do a sector-specific analysis using the Modeler.

[10] See 2008 data on emission shares by type of product disposed in "Calculations of GHG Emissions from the Waste Sector in the City of San Francisco for the baseline year of 1990," memorandum from Amruta Sudhalkar, of ICLEI, to Calla Rose Ostrander, City and County of San Francisco Department of Environment, April 25, 2011.
[11] See 2003 data on emission shares by type of product disposed in Cascadia Consulting Group Inc. (2004), Statewide Waste Characterization Study. Publication #340-04-005. Sacramento, CA: Report to the California Integrated Waste Management Board. Available at http://www.calrecycle.ca.gov/WasteChar/WasteStudies.htm.

This method can be used to determine the (emitting) sector-by-sector emissions associated with that actual or speculative demand for a single commodity sector. For example, if the user enters a demand profile representing the Study Area's consumption of cheese, the CBEI "Modeler" would return sector-by-sector emissions from all of the direct and upstream purchases associated with the Study Area's consumption of cheese.

4.6. CBEI in Access and Excel

System Overview
The controller program for the CBEI system, written in Microsoft Access, is CBEI.accdb. The main back-end database files for the system are in CBEI_Data.accdb, another Access database file.

Accessory functions are provided in other Access databases, including:

- *CBEI_Mapping_Data.accdb*
- *CBEI_Foreign_yyyy.accdb*
- *CBEI_SA_Direct_Coefficients_yyyy.accdb*
- *CBEI_US_Direct_Coefficients_yyyy.accdb*

Accessory functions are provided, as well, by the following Excel workbook, which receives intermediate results from queries made available in CBEI_Data.accdb:

- *SAyyyy CBEI Use and Disposal.xlsx*

Output from the system is provided by a series of queries made available in CBEI_Data.accdb and which feed into the following Excel workbooks:

- *SAyyyy CBEI Results.xlsx*
- *SAyyyy CBEI Modeler Results.xlsx*

System Structure
The components of the system listed above must reside in the same subdirectory for the system to operate correctly.

A subdirectory of this directory, named CBEI *UserReports*, must be present as well. It serves as a repository for snapshots of the Excel browser files which receive their data from the queries in *CBEI_Data.accdb*.

Parameterization
System parameters are maintained in Table: *tblParam* (in *CBEI.accdb*), in order to make the system as flexible as possible.

System Linkage
In order for the system to work correctly, it must have its various components relinked whenever the system is installed, moved or copied. This process is invoked by the first button on the *Main Menu* in the controller program, labeled *Refresh Data Connections*. The macro invoked by this button is *Init_Relink*, which performs the following sequence of actions:

- Relinking all Access databases
    - *m_Initialize_RelinkAllDBsToLocalDirectory*: Relinks all tables in all Access databases in the system to the set of files in the current system directory, i.e. the same directory in which CBEI.accdb resides.
- Resetting data connections in all Excel workbooks in the system to Access queries in current system directory
    - *XL_ResetDataConnectionToAccess*: This function resets the target of Access Data Connections within Excel workbooks to the relevant Access database in the current system directory, and does this, in Macro: Init_Relink, for the following:
        - The Use and Disposal workbook, designated above as SAyyyy CBEI Use and Disposal.xls, (and, more specifically, in the parameter table)
    - *m_XLBrowser_ResetConnections*: This macro resets all the data connections from the Complete Emissions Browser (in Excel) to their sources in CBEI_Data.accdb (Access)
    - *m_XLBrowser_ResetConnections*: This macro resets all the data connections from the Complete Emissions Browser (in Excel) to their source in CBEI_Data.accdb (Access)
    - *m_XLModelerBrowser_ResetConnections*: This macro resets all the data connections from the Demand Modeler Browser (in Excel) to their sources in CBEI_Data.accdb (Access)

Enabling Macros
If the directory, or directory tree, within which the system resides is not designated as a Secure Location (via the Trust Center in Access), it will be necessary to enable macros manually each time one starts the system. If this is the case, the system will prompt the user to press, at startup, the required button to enable macros. This is necessary to do for proper functioning of the CBEI system.

Startup
At startup, once macros have been enabled, the rest of Macro: *autoexec* runs and it displays the Main Menu (Form: *frmMainMenu*).

Main Menu
The form, frmMainMenu, is the hub of the user-interface for the system.

Button: "Perform Emissions Calculations" invokes Form: *frmEmissionsCalculations*, which provides methods for performing the main calculation streams.

Emissions Processing
The system does Emissions Processing in two basic modes:

- Complete Emissions Processing
- Demand Modeler Processing

In order for each of these to take place, two preliminary operations are performed, invoked when the *Perform Emissions Calculations* button on the *Main Menu* is pressed and before the *Emissions Processing Menu* is displayed:

- Initialization of Matrix Arrays
- Standard Emissions Processing

Initialization of Matrix Arrays

Two large matrices are used repeatedly in calculations and are loaded preliminarily into memory from their static storage in Access tables in order to optimize processing time.

Macro: *m_Initialize_Matrix_Arrays* carries out this process and does it in three steps:

- Function: *initializeMatrixArrays*
  - Creates the variable *numSectors* from the *NumberOfSectors* value in the parameter table
  - Dimensions the array *Type_I_SAxx_Matrix* to *numSectors x numSectors*
  - Dimensions the array *Type_I_USxx_Matrix* to *numSectors x numSectors*
- Function: *initialize_Matrix* loads Table: *tbl_Type_I_SAxx*, which stores the Study Area matrix, into the memory array named *Type_I_SAxx_Matrix*
- Function: initialize_Matrix loads Table: *tbl_Type_I_USxx*, which stores the US matrix, into the memory array named *Type_I_USxx_Matrix*

Standard Emissions Processing: Overview

Standard Emissions Processing performs several calculations that are required for Complete Emissions and Demand Modeler processing. Notably, these are:

- Setting up the phase tables
- Calculating the GDP ratios which are multiplicative factors used to calculate demand values for an Emissions Study year which may be different from an EmissionsData year
- Calculating values for and storing them in Table: *tblIMPLAN_Adjusted*, which represents the values stored in Table: *tblIMPLAN_Raw* multiplied times the GDP ratios.
- Calculating and storing the values for emissions Coefficients in Table: *tblCoefficients_Standard*.

As well, Standard Emissions Processing produces results in Table: *tblFinalDemand_Standard* and Table: *tblEmissions_Standard*, which represent aggregate calculations based on the input data.

Standard Emissions Processing: Details

Main driver: Macro *m_AllCalculatedResults_Standard_Update*. This routine calls all the necessary steps in sequence:

- Macro *m_tblPhase_*_Update* sets up the phase tables, which contain lists of sectors corresponding to each of the three phases that form part of standard processing.
- Macro *m_tblCBEIParam_Calc_Update* initializes various system variables, notably the GDP ratio between the study year and the data year.

- Macro *m_tblIMPLAN_Adjusted_Standard_Update* creates, from the raw IMPLAN data, a secondary "adjusted" table which represents a calculation based on the GDP ratios.
- Macro *m_tblFinalDemand_Standard_Update* is the first major piece of Standard processing, and the one that takes the longest time to execute. It involves loading tblFinalDemand_Standard, which is derived from a series of calculations which load the work table, tblFinalDemand. Multiple of the resultant vectors in tblFinalDemand are generated by a matrix multiplication that loads Leontieff matrices, stored in the tables *tbl_Type_I_SAxx* and *tbl_Type_I_USxx*, and derives a product from them and a series of demand vectors stored in tblFinalDemand. That series of calculations is executed by the Macro *m_tblFinalDemand_Update*, which, as an example calls Macro m_ *tblFinalDemand_GD_10000_SA_Update* which performs the species of matrix multiplication in question by invoking the VBA function *arrayMMult_Store*, which one can find in Module: *Main*.
- Macro *m_tblCoefficients_Update* updates tblCoefficients, through a series of subsidiary macros and queries, and, to this end, uses vectors derived from CBEI_SA_ Direct_Coefficients_2008.accdb and CBEI_US_Direct_Coefficients_2008.accdb. To retrieve those vectors – delivered as queries from those databases, this macro makes use of a series of routines, evident, for example, in Macro *m_tblCoefficients_Dcoef_SA_ Update*, which constructs a query to the relevant target database depending on the current path of the system. (See, for example, the function, also in Module: *Main, qryCoefficients_Dcoef_SA_Construct*) which creates the appropriate query code for this retrieval function and uses it, in the context of the macro, to load a vector array in tblCoefficients, which is then used in subsequent calculations.
- Macro *m_tblEmissions_Standard_Update* calls Macro *m_tblEmissions_Update* and performs the final calculations of the first three phases of emissions based on the results thus far calculated and stored in *tblFinalDemand* and *tblCoefficients*. These results are stored in the work table *tblEmssions*, and finally stored in *tblEmissions_Standard*.

Complete Emissions Processing
Complete Emissions Processing involves a similar set of routines to Standard Processing, with the following exceptions:

- Calculations for each sector of *tblEmissions_LCA_Complete* (which is the final result of the process) is derived by isolating each row of the original IMPLAN data (found in *tblIMPLAN_Adjusted*) and running , iteratively, the entire series of calculations for tblFinalDemand and tblEmissions.

This process is driven by the Macro *m_tblEmissions_LCA_Complete_Update* , which invokes the VBA function *LCAComplete_CalcAndStore_AllSector*) (in Module: *Main*) which, in turn, commands the process which isolates each row of *tblIMPLAN_Adjusted* and stores the final results, ultimately, in *tblEmissions_LCA_Complete*.

The Complete Emissions Process is very execution intensive (running a sequence of about a million different calculations) and are best run on a local (not a networked) directory on a fast machine.

- The last two phases, for emissions related to use and disposal, are calculated as follows. Macro *m_tblUseAndDisposal_Update* creates vectors that go into tblUseAndDisposal, and which are retrieved by the Excel program *CBEI Use and Disposal.xlsx*.
- In order that the Excel program is updated with the values from Access, Macro: *m_tblUseAndDisposal_Update* then executes a VBA function (found in Module: *Main*) *XL_RefreshLocalWorkbook* which does this through an automation interface between Access and Excel.
- Macro: *m_tblEmissions_5Phase_Update* performs a series of routines that use results derived from the calculations in the Excel workbook in combination with subtotals (corresponding to sector subcategories) to produce the results for the use and disposal phases, which are stored in the table *tblEmissions_5Phase*. A routine which tailors specialized instances, Macro: *m_tblEmissions_5Phase_Tailor* ,is run subsequently to modify the results in *tblEmissions_5Phase*.
- Output to the Excel reporting module is summarized through a series of queries, among them *qry__OUTPUT_Emissions_3Phase_Standard* and *qry__OUTPUT_Emissions_5Phase_Standard*.

Demand Modeler

The Demand Modeler process is very similar to the Complete Emissions process, with the provision for enabling the user to fill in sample data for final demand. That process of filling in can be done through the form *frmLCAModeler* which calls the form *frmLCAModeler_Input*.

Macro *m_tblEmissions_LCA_Modeler_Update* is the main routine for the Demand Modeler. It runs through a very similar set of steps to the routine which runs the Complete Emissions process, except that, instead of running the processes based on each line of the *tblIMPLAN_Adjusted*, it uses instead, each line of the final demand data input by the user, in *tblDemand_LCAModeler*. The main macro calls a VBA function, *LCAModeler_CalcAndStore_AllSector)* which, akin to the version for the Complete Emissions process, runs through the full calculation process iteratively. Results are stored in *tblEmissions_LCAModeler*.

Modeler results are transmitted to the Excel reporting interface through the queries *qry__OUTPUT_Emissions_3Phase_LCA_Complete* and *qry__OUTPUT_Emissions_3Phase_LCA_Modeler.*
Again, the Demand Modeler processes do not generate 5-phase output.

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Category	Subcategory	#	Sector Name
Appliances, HVAC	Heating and cooling appliances	215	Heating equipment (except warm air furnaces)
Appliances, HVAC	Heating and cooling appliances	216	Air conditioning, refrigeration, and warm air heating equipment
Appliances, other	Lighting fixtures and bulbs	259	Electric lamp bulbs and parts
Appliances, other	Lighting fixtures and bulbs	260	Lighting fixtures
Appliances, other	Ranges and microwaves	262	Household cooking appliances
Appliances, other	Refrigerators and freezers	263	Household refrigerators and home freezers
Appliances, other	Washers and dryers	264	Household laundry equipment
Appliances, other	Other appliances	261	Small electrical appliances
Appliances, other	Other appliances	265	Other major household appliances
Clothing	Clothing	86	Knit apparel
Clothing	Clothing	87	Cut and sewn apparel from contractors
Clothing	Clothing	88	Mens and boys cut and sewn apparel
Clothing	Clothing	89	Womens and girls cut and sewn apparel
Clothing	Clothing	90	Other cut and sew apparel
Clothing	Clothing	91	Apparel accessories and other apparel
Clothing	Clothing	93	Footwear
Concrete, cement and lime	Concrete, cement and lime	160	Cement
Concrete, cement and lime	Concrete, cement and lime	161	Ready-mix concrete
Concrete, cement and lime	Concrete, cement and lime	162	Concrete pipes, bricks, and blocks
Concrete, cement and lime	Concrete, cement and lime	163	Other concrete products
Concrete, cement and lime	Concrete, cement and lime	164	Lime and gypsum products
Construction	Non-residential construction	34	Newly constructed nonresidential commercial and health care structures
Construction	Non-residential construction	35	Newly constructed nonresidential manufacturing structures
Construction	Non-residential construction	36	Other newly constructed nonresidential structures
Construction	Non-residential construction	39	Maintained and repaired nonresidential structures
Construction	Prefabricated buildings	101	Manufactured homes (mobile homes)
Construction	Prefabricated buildings	102	Prefabricated wood buildings
Construction	Prefabricated buildings	186	Plates and fabricated structural products
Construction	Residential construction and remodeling	37	Newly constructed residential permanent site single- and multi-family structures
Construction	Residential construction and remodeling	38	Other newly constructed residential structures
Construction	Residential construction and remodeling	40	Maintained and repaired residential structures
Electronics	Computer service and equipment	234	Electronic computers
Electronics	Computer service and equipment	235	Computer storage devices
Electronics	Computer service and equipment	236	Computer terminals and other computer peripheral equipment
Electronics	Computer service and equipment	257	Software, blank audio and video media, mass reproduction
Electronics	Computer service and equipment	352	Data processing- hosting- ISP- web search portals
Electronics	Computer service and equipment	371	Custom computer programming services
Electronics	Computer service and equipment	372	Computer systems design services
Electronics	Computer service and equipment	373	Other computer related services, including facilities management
Electronics	Other electronics	212	Photographic and photocopying equipment
Electronics	Other electronics	237	Telephone apparatus
Electronics	Other electronics	238	Broadcast and wireless communications equipment
Electronics	Other electronics	239	Other communications equipment
Electronics	Other electronics	240	Audio and video equipment
Food and beverages	Beverages	66	Coffee and tea
Food and beverages	Beverages	70	Soft drinks and manufactured ice
Food and beverages	Beverages	71	Beer, ale, malt liquor and nonalcoholic beer
Food and beverages	Beverages	72	Wine and brandies
Food and beverages	Beverages	73	Distilled liquors except brandies
Food and beverages	Condiments, oils and sweeteners	1	Oilseeds
Food and beverages	Condiments, oils and sweeteners	44	Corn sweeteners, corn oils, and corn starches
Food and beverages	Condiments, oils and sweeteners	45	Soybean oil and cakes and other oilseed products
Food and beverages	Condiments, oils and sweeteners	46	Shortening and margarine and other fats and oils products

Category	Subcategory	#	Sector Name
Food and beverages	Condiments, oils and sweeteners	48	Raw and refined sugar from sugar cane
Food and beverages	Condiments, oils and sweeteners	49	Refined sugar from sugar beets
Food and beverages	Condiments, oils and sweeteners	67	Flavoring syrups and concentrates
Food and beverages	Condiments, oils and sweeteners	68	Seasonings and dressings
Food and beverages	Dairy	12	Dairy cattle and milk products
Food and beverages	Dairy	55	Fluid milk and butter
Food and beverages	Dairy	56	Cheese
Food and beverages	Dairy	57	Dry, condensed, and evaporated dairy products
Food and beverages	Dairy	58	Ice cream and frozen desserts
Food and beverages	Fresh fruit, nuts and vegetables	3	Vegetables and melons
Food and beverages	Fresh fruit, nuts and vegetables	4	Fruit
Food and beverages	Fresh fruit, nuts and vegetables	5	Tree nuts
Food and beverages	Frozen food	53	Frozen foods
Food and beverages	Grains, baked goods, cereals, roasted nuts, nut butters	2	Grains
Food and beverages	Grains, baked goods, cereals, roasted nuts, nut butters	43	Flour and malt
Food and beverages	Grains, baked goods, cereals, roasted nuts, nut butters	47	Breakfast cereal products
Food and beverages	Grains, baked goods, cereals, roasted nuts, nut butters	51	Chocolate confectioneries from purchased chocolate
Food and beverages	Grains, baked goods, cereals, roasted nuts, nut butters	52	Nonchocolate confectioneries
Food and beverages	Grains, baked goods, cereals, roasted nuts, nut butters	62	Bread and bakery products
Food and beverages	Grains, baked goods, cereals, roasted nuts, nut butters	63	Cookies, crackers, and pasta
Food and beverages	Grains, baked goods, cereals, roasted nuts, nut butters	64	Tortillas
Food and beverages	Grains, baked goods, cereals, roasted nuts, nut butters	65	Snack foods including nuts, seeds and grains, and chips
Food and beverages	Poultry and eggs	13	Poultry and egg products
Food and beverages	Poultry and eggs	60	Processed poultry meat products
Food and beverages	Processed fruit, nuts and vegetables	54	Canned, pickled and dried fruits and vegetables
Food and beverages	Red meat	11	Cattle from ranches and farms
Food and beverages	Red meat	59	Processed animal (except poultry) meat and rendered byproducts
Food and beverages	Restaurants	413	Restaurant, bar, and drinking place services
Food and beverages	Seafood	17	Fish
Food and beverages	Seafood	61	Seafood products
Food and beverages	Other food and agriculture	7	Tobacco
Food and beverages	Other food and agriculture	8	Cotton
Food and beverages	Other food and agriculture	9	Sugarcane and sugar beets
Food and beverages	Other food and agriculture	10	All other crop farming products
Food and beverages	Other food and agriculture	14	Animal products, except cattle, poultry and eggs
Food and beverages	Other food and agriculture	18	Wild game products, pelts, and furs
Food and beverages	Other food and agriculture	19	Agriculture and forestry support services
Food and beverages	Other food and agriculture	41	Dog and cat food
Food and beverages	Other food and agriculture	42	Other animal food
Food and beverages	Other food and agriculture	50	Chocolate cacao products and chocolate confectioneries
Food and beverages	Other food and agriculture	69	All other manufactured food products
Food and beverages	Other food and agriculture	74	Cigarettes, cigars, smoking and chewing tobacco, and reconstituted tobacco
Forest products	Paper and cardboard	105	Paper from pulp
Forest products	Paper and cardboard	106	Paperboard from pulp
Forest products	Paper and cardboard	107	Paperboard containers
Forest products	Paper and cardboard	108	Coated and laminated paper, packaging paper and plastics film
Forest products	Paper and cardboard	109	All other paper bag and coated and treated paper

Category	Subcategory	#	Sector Name
Forest products	Paper and cardboard	110	Paper and paperboard stationary products
Forest products	Paper and cardboard	112	All other converted paper products
Forest products	Other processed forest products	97	Engineered wood members and trusses
Forest products	Other processed forest products	98	Reconstituted wood products
Forest products	Other processed forest products	99	Wood windows and doors and millwork
Forest products	Other processed forest products	100	Wood containers and pallets
Forest products	Other processed forest products	103	All other miscellaneous wood products
Forest products	Other processed forest products	104	Wood pulp
Forest products	Unprocessed forest products	15	Forest, timber, and forest nursery products
Forest products	Unprocessed forest products	16	Logs and roundwood
Forest products	Unprocessed forest products	95	Dimension lumber and preserved wood products
Forest products	Unprocessed forest products	96	Veneer and plywood
Fuel, utilities, waste	Gasoline, heating fuels, other petroleum products	115	Refined petroleum products
Fuel, utilities, waste	Natural gas distribution	32	Natural gas, and distribution services
Fuel, utilities, waste	Oil and gas extraction	20	Oil and natural gas
Fuel, utilities, waste	Oil and gas extraction	28	Oil and gas wells
Fuel, utilities, waste	Oil and gas extraction	29	Support services for oil and gas operations
Fuel, utilities, waste	Oil and gas extraction	119	All other petroleum and coal products
Fuel, utilities, waste	Oil and gas extraction	120	Petrochemicals
Fuel, utilities, waste	Oil and gas extraction	121	Industrial gas
Fuel, utilities, waste	Power generation and supply	31	Electricity, and distribution services
Fuel, utilities, waste	Waste management	390	Waste management and remediation services
Fuel, utilities, waste	Water- sewage and other systems	33	Water, sewage treatment, and other utility services
Healthcare	Healthcare services	394	Offices of physicians, dentists, and other health practitioners
Healthcare	Healthcare services	395	Home health care services
Healthcare	Healthcare services	396	Medical and diagnostic labs and outpatient and other ambulatory care services
Healthcare	Healthcare services	397	Private hospital services
Healthcare	Healthcare services	398	Nursing and residential care services
Healthcare	Medicines and other healthcare supplies	132	Medicines and botanicals
Healthcare	Medicines and other healthcare supplies	133	Pharmaceutical preparations
Healthcare	Medicines and other healthcare supplies	134	In-vitro diagnostic substances
Healthcare	Medicines and other healthcare supplies	135	Biological products (except diagnostic)
Healthcare	Medicines and other healthcare supplies	305	Surgical and medical instrument, laboratory and medical instruments
Healthcare	Medicines and other healthcare supplies	306	Surgical appliances and supplies
Healthcare	Medicines and other healthcare supplies	307	Dental equipment and supplies
Healthcare	Medicines and other healthcare supplies	308	Ophthalmic goods
Healthcare	Medicines and other healthcare supplies	309	Dental laboratories
Home, yard, office	Home furnishings	82	Carpets and rugs
Home, yard, office	Home furnishings	83	Curtains and linens
Home, yard, office	Home furnishings	295	Wood kitchen cabinets and countertops
Home, yard, office	Home furnishings	296	Upholstered household furniture
Home, yard, office	Home furnishings	297	Nonupholstered wood household furniture
Home, yard, office	Home furnishings	298	Metal and other household furniture
Home, yard, office	Home furnishings	303	Mattresses
Home, yard, office	Home furnishings	304	Blinds and shades
Home, yard, office	Household supplies	111	Sanitary paper products
Home, yard, office	Household supplies	138	Soaps and cleaning compounds

Category	Subcategory	#	Sector Name
Home, yard, office	Household supplies	139	Toilet preparations
Home, yard, office	Household supplies	142	Plastics packaging materials and unlaminated films and sheets
Home, yard, office	Household supplies	153	Pottery, ceramics, and plumbing fixtures
Home, yard, office	Household supplies	156	Flat glass
Home, yard, office	Household supplies	157	Other pressed and blown glass and glassware
Home, yard, office	Household supplies	159	Glass products made of purchased glass
Home, yard, office	Household supplies	184	Cutlery, utensils, pots, and pans
Home, yard, office	Household supplies	270	Storage batteries
Home, yard, office	Household supplies	271	Primary batteries
Home, yard, office	Household supplies	310	Jewelry and silverware
Home, yard, office	Household supplies	318	Brooms, brushes, and mops
Home, yard, office	Lawn and garden	6	Greenhouse, nursery, and floriculture products
Home, yard, office	Lawn and garden	130	Fertilizer
Home, yard, office	Lawn and garden	131	Pesticides and other agricultural chemicals
Home, yard, office	Lawn and garden	204	Lawn and garden equipment
Home, yard, office	Media and office supplies (except paper)	313	Office supplies (except paper)
Home, yard, office	Media and office supplies (except paper)	341	Newspapers
Home, yard, office	Media and office supplies (except paper)	342	Periodicals
Home, yard, office	Media and office supplies (except paper)	343	Books
Home, yard, office	Media and office supplies (except paper)	344	Directories and mailing lists
Home, yard, office	Media and office supplies (except paper)	345	Software
Home, yard, office	Media and office supplies (except paper)	346	Motion pictures and videos
Home, yard, office	Media and office supplies (except paper)	347	Sound recordings
Retailer and wholesale	Retailers	320	Retail Services - Motor vehicle and parts
Retailer and wholesale	Retailers	321	Retail Services - Furniture and home furnishings
Retailer and wholesale	Retailers	322	Retail Services - Electronics and appliances
Retailer and wholesale	Retailers	323	Retail Services - Building material and garden supply
Retailer and wholesale	Retailers	324	Retail Services - Food and beverage
Retailer and wholesale	Retailers	325	Retail Services - Health and personal care
Retailer and wholesale	Retailers	326	Retail Services - Gasoline stations
Retailer and wholesale	Retailers	327	Retail Services - Clothing and clothing accessories
Retailer and wholesale	Retailers	328	Retail Services - Sporting goods, hobby, book and music
Retailer and wholesale	Retailers	329	Retail Services - General merchandise
Retailer and wholesale	Retailers	330	Retail Services - Miscellaneous
Retailer and wholesale	Retailers	331	Retail Services - Nonstore, direct and electronic sales
Retailer and wholesale	Wholesale	319	Wholesale trade distribution services
Services	Banks, financial, legal, real estate, insurance	354	Monetary authorities and depository credit intermediation services
Services	Banks, financial, legal, real estate, insurance	355	Nondepository credit intermediation and related services
Services	Banks, financial, legal, real estate, insurance	356	Securities, commodity contracts, investments, and related services
Services	Banks, financial, legal, real estate, insurance	357	Insurance
Services	Banks, financial, legal, real estate, insurance	358	Insurance agencies, brokerages, and related services
Services	Banks, financial, legal, real estate, insurance	359	Funds, trusts, and other financial services
Services	Banks, financial, legal, real estate, insurance	360	Real estate buying and selling, leasing, managing, and related services

Category	Subcategory	#	Sector Name
Services	Banks, financial, legal, real estate, insurance	367	Legal services
Services	Banks, financial, legal, real estate, insurance	368	Accounting, tax preparation, bookkeeping, and payroll services
Services	Building services	388	Services to buildings and dwellings
Services	Education and day care	391	Elementary and secondary education from private schools
Services	Education and day care	392	Education from private junior colleges, colleges, universities, and professional schools
Services	Education and day care	393	Other private educational services
Services	Education and day care	399	Child day care services
Services	Hotels, motels, entertainment, media	348	Radio and television entertainment
Services	Hotels, motels, entertainment, media	349	Cable and other subscription services
Services	Hotels, motels, entertainment, media	350	Internet publishing and broadcasting services
Services	Hotels, motels, entertainment, media	351	Telecommunications
Services	Hotels, motels, entertainment, media	364	Video tape and disc rental services
Services	Hotels, motels, entertainment, media	402	Performing arts
Services	Hotels, motels, entertainment, media	403	Spectator sports
Services	Hotels, motels, entertainment, media	404	Promotional services for performing arts and sports and public figures
Services	Hotels, motels, entertainment, media	405	Independent artists, writers, and performers
Services	Hotels, motels, entertainment, media	406	Museum, heritage, zoo, and recreational services
Services	Hotels, motels, entertainment, media	408	Bowling activities
Services	Hotels, motels, entertainment, media	409	Amusement parks, arcades, and gambling recreation
Services	Hotels, motels, entertainment, media	410	Other amusements and recreation
Services	Hotels, motels, entertainment, media	411	Hotels and motel services, including casino hotels
Services	Hotels, motels, entertainment, media	412	Other accommodation services
Services	Other services	114	Printing support services
Services	Other services	339	Couriers and messengers services
Services	Other services	340	Warehousing and storage services
Services	Other services	353	Other information services
Services	Other services	363	General and consumer goods rental services except video tapes and discs
Services	Other services	365	Commercial and industrial machinery and equipment rental and leasing services
Services	Other services	366	Leasing of nonfinancial intangible assets
Services	Other services	369	Architectural, engineering, and related services
Services	Other services	370	Specialized design services
Services	Other services	374	Management, scientific, and technical consulting services
Services	Other services	375	Environmental and other technical consulting services
Services	Other services	376	Scientific research and development services
Services	Other services	377	Advertising and related services
Services	Other services	378	Photographic services
Services	Other services	379	Veterinary services
Services	Other services	380	All other miscellaneous professional, scientific, and technical services
Services	Other services	381	Management of companies and enterprises
Services	Other services	382	Employment services
Services	Other services	383	Travel arrangement and reservation services
Services	Other services	384	Office administrative services
Services	Other services	385	Facilities support services
Services	Other services	386	Business support services
Services	Other services	387	Investigation and security services
Services	Other services	389	Other support services
Services	Other services	400	Individual and family services
Services	Other services	401	Community food, housing, and other relief services, including rehabilitation services
Services	Other services	407	Fitness and recreational sports center services
Services	Other services	416	Electronic and precision equipment repairs and maintenance
Services	Other services	418	Personal and household goods repairs and maintenance

Category	Subcategory	#	Sector Name
Services	Other services	419	Personal care services
Services	Other services	420	Death care services
Services	Other services	421	Dry-cleaning and laundry services
Services	Other services	422	Other personal services
Services	Other services	423	Services from religious organizations
Services	Other services	424	Grantmaking, giving, and social advocacy services
Services	Other services	425	Civic, social, and professional services
Services	Other services	426	Cooking, housecleaning, gardening, and other services to private households
Services	Other services	427	US Postal delivery services
Transportation services	Car rental, repair and wash	362	Automotive equipment rental and leasing services
Transportation services	Car rental, repair and wash	414	Automotive repair and maintenance services, except car washes
Transportation services	Car rental, repair and wash	415	Car wash services
Transportation services	Transportation services, air	332	Air transportation services
Transportation services	Transportation services, mass transit	336	Mass transit
Transportation services	Transportation services, rail	333	Rail transportation services
Transportation services	Transportation services, truck	335	Truck transportation services
Transportation services	Transportation services, water	334	Water transportation services
Transportation services	Transportation services, other	337	Pipeline transportation services
Transportation services	Transportation services, other	338	Scenic and sightseeing transportation services and support activities for transportation
Vehicles and vehicle parts	Aircraft	284	Aircraft
Vehicles and vehicle parts	Cars and light trucks	276	Automobiles
Vehicles and vehicle parts	Cars and light trucks	277	Light trucks and utility vehicles
Vehicles and vehicle parts	Heavy duty trucks	278	Heavy duty trucks
Vehicles and vehicle parts	Other road vehicles	281	Motor homes
Vehicles and vehicle parts	Other road vehicles	282	Travel trailers and campers
Vehicles and vehicle parts	Other road vehicles	292	Motorcycles, bicycles, and parts
Vehicles and vehicle parts	Railroad rolling stock	289	Railroad rolling stock
Vehicles and vehicle parts	Ships and boats	290	Ships
Vehicles and vehicle parts	Ships and boats	291	Boats
Vehicles and vehicle parts	Vehicle parts	118	Petroleum lubricating oils and greases
Vehicles and vehicle parts	Vehicle parts	150	Tires
Vehicles and vehicle parts	Vehicle parts	279	Motor vehicle bodies
Vehicles and vehicle parts	Vehicle parts	280	Truck trailers
Vehicles and vehicle parts	Vehicle parts	283	Motor vehicle parts
Vehicles and vehicle parts	Vehicle parts	285	Aircraft engines and engine parts
Vehicles and vehicle parts	Vehicle parts	286	Other aircraft parts and auxiliary equipment
Vehicles and vehicle parts	Vehicle parts	288	Propulsion units and parts for space vehicles and guided missiles
Vehicles and vehicle parts	Vehicle parts	294	All other transportation equipment
Other	Other	21	Coal
Other	Other	22	Iron ore
Other	Other	23	Copper, nickel, lead, and zinc
Other	Other	24	Gold, silver, and other metal ore
Other	Other	25	Natural stone
Other	Other	26	Sand, gravel, clay, and ceramic and refractory minerals
Other	Other	27	Other nonmetallic minerals
Other	Other	30	Support services for other mining
Other	Other	75	Fiber filaments, yarn, and thread
Other	Other	76	Broadwoven fabrics and felts
Other	Other	77	Woven and embroidered fabrics
Other	Other	78	Nonwoven fabrics and felts
Other	Other	79	Knitted fabrics
Other	Other	80	Finished textiles and fabrics
Other	Other	81	Coated fabric coating
Other	Other	84	Textile bags and canvas
Other	Other	85	All other textile products

Category	Subcategory	#	Sector Name
Other	Other	92	Tanned and finished leather and hides
Other	Other	94	Other leather and allied products
Other	Other	113	Printed materials
Other	Other	116	Asphalt paving mixtures and blocks
Other	Other	117	Asphalt shingles and coating materials
Other	Other	122	Synthetic dyes and pigments
Other	Other	123	Alkalies and chlorine
Other	Other	124	Carbon black
Other	Other	125	All other basic inorganic chemicals
Other	Other	126	Other basic organic chemicals
Other	Other	127	Plastics materials and resins
Other	Other	128	Synthetic rubber
Other	Other	129	Artificial and synthetic fibers and filaments
Other	Other	136	Paints and coatings
Other	Other	137	Adhesives
Other	Other	140	Printing inks
Other	Other	141	All other chemical products and preparations
Other	Other	143	Unlaminated plastics profile shapes
Other	Other	144	Plastics pipes and pipe fittings
Other	Other	145	Laminated plastics plates, sheets (except packaging), and shapes
Other	Other	146	Polystyrene foam products
Other	Other	147	Urethane and other foam products (except polystyrene)
Other	Other	148	Plastics bottles
Other	Other	149	Other plastics products
Other	Other	151	Rubber and plastics hoses and belts
Other	Other	152	Other rubber products
Other	Other	154	Bricks, tiles, and other structural clay products
Other	Other	155	Clay and nonclay refractory products
Other	Other	158	Glass containers
Other	Other	165	Abrasive products
Other	Other	166	Cut stone and stone products
Other	Other	167	Ground or treated mineral and earth products
Other	Other	168	Mineral wool
Other	Other	169	Miscellaneous nonmetallic mineral products
Other	Other	170	Iron and steel and ferroalloy products
Other	Other	171	Steel products from purchased steel
Other	Other	172	Aluminum products
Other	Other	173	Aluminum alloys
Other	Other	174	Aluminum products from purchased aluminum
Other	Other	175	Copper
Other	Other	176	Nonferrous metals (except copper and aluminum)
Other	Other	177	Rolled, drawn, extruded and alloyed copper
Other	Other	178	Rolled, drawn, extruded and alloyed nonferrous metals (except copper and aluminum)
Other	Other	179	Ferrous metals
Other	Other	180	Nonferrous metals
Other	Other	181	All other forged, stamped, and sintered metals
Other	Other	182	Custom roll formed metals
Other	Other	183	Crowned and stamped metals
Other	Other	185	Handtools
Other	Other	187	Ornamental and architectural metal products
Other	Other	188	Power boilers and heat exchangers
Other	Other	189	Metal tanks (heavy gauge)
Other	Other	190	Metal cans, boxes, and other metal containers (light gauge)
Other	Other	191	Ammunition
Other	Other	192	Arms, ordnance, and accessories
Other	Other	193	Hardware
Other	Other	194	Spring and wire products

Category	Subcategory	#	Sector Name
Other	Other	195	Machined products
Other	Other	196	Turned products and screws, nuts, and bolts
Other	Other	197	Coated, engraved, heat treated products
Other	Other	198	Valves and fittings other than plumbing
Other	Other	199	Plumbing fixture fittings and trims
Other	Other	200	Balls and roller bearings
Other	Other	201	Fabricated pipes and pipe fittings
Other	Other	202	Other fabricated metals
Other	Other	203	Farm machinery and equipment
Other	Other	205	Construction machinery
Other	Other	206	Mining and oil and gas field machinery
Other	Other	207	Other industrial machinery
Other	Other	208	Plastics and rubber industry machinery
Other	Other	209	Semiconductor machinery
Other	Other	210	Vending, commercial, industrial, and office machinery
Other	Other	211	Optical instruments and lens
Other	Other	213	Other commercial and service industry machinery
Other	Other	214	Air purification and ventilation equipment
Other	Other	217	Industrial molds
Other	Other	218	Metal cutting and forming machine tools
Other	Other	219	Special tools, dies, jigs, and fixtures
Other	Other	220	Cutting tools and machine tool accessories
Other	Other	221	Rolling mills and other metalworking machinery
Other	Other	222	Turbines and turbine generator set units
Other	Other	223	Speed changers, industrial high-speed drives, and gears
Other	Other	224	Mechanical power transmission equipment
Other	Other	225	Other engine equipment
Other	Other	226	Pumps and pumping equipment
Other	Other	227	Air and gas compressors
Other	Other	228	Material handling equipment
Other	Other	229	Power-driven handtools
Other	Other	230	Other general purpose machinery
Other	Other	231	Packaging machinery
Other	Other	232	Industrial process furnaces and ovens
Other	Other	233	Fluid power process machinery
Other	Other	241	Electron tubes
Other	Other	242	Bare printed circuit boards
Other	Other	243	Semiconductor and related devices
Other	Other	244	Electronic capacitors, resistors, coils, transformers, and other inductors
Other	Other	245	Electronic connectors
Other	Other	246	Printed circuit assemblies (electronic assemblies)
Other	Other	247	Other electronic components
Other	Other	248	Electromedical and electrotherapeutic apparatus
Other	Other	249	Search, detection, and navigation instruments
Other	Other	250	Automatic environmental controls
Other	Other	251	Industrial process variable instruments
Other	Other	252	Totalizing fluid meters and counting devices
Other	Other	253	Electricity and signal testing instruments
Other	Other	254	Analytical laboratory instruments
Other	Other	255	Irradiation apparatus
Other	Other	256	Watches, clocks, and other measuring and controlling devices
Other	Other	258	Magnetic and optical recording media
Other	Other	266	Power, distribution, and specialty transformers
Other	Other	267	Motor and generators
Other	Other	268	Switchgear and switchboard apparatus
Other	Other	269	Relay and industrial controls
Other	Other	272	Communication and energy wires and cables

Category	Subcategory	#	Sector Name
Other	Other	273	Wiring devices
Other	Other	274	Carbon and graphite products
Other	Other	275	All other miscellaneous electrical equipment and components
Other	Other	287	Guided missiles and space vehicles
Other	Other	293	Military armored vehicles, tanks, and tank components
Other	Other	299	Institutional furniture
Other	Other	300	Office Furniture
Other	Other	301	Custom architectural woodwork and millwork
Other	Other	302	Showcases, partitions, shelving, and lockers
Other	Other	311	Sporting and athletic goods
Other	Other	312	Dolls, toys, and games
Other	Other	314	Signs
Other	Other	315	Gaskets, packing and sealing devices
Other	Other	316	Musical instruments
Other	Other	317	All other miscellaneous manufactured products
Other	Other	361	Imputed rental services of owner-occupied dwellings
Other	Other	417	Commercial and industrial machinery and equipment repairs and maintenance
Other	Other	428	* Not a unique commodity (electricity from fed govt utilities)
Other	Other	429	Products and services of Fed Govt enterprises (except electric utilities)
Other	Other	430	* Not a unique commodity (passenger transit by state & local govt)
Other	Other	431	* Not a unique commodity (electricity from state & local govt utilities)
Other	Other	432	Products and services of State & Local Govt enterprises (except electric utilities)
Other	Other	433	Used and secondhand goods
Other	Other	434	Scrap
Other	Other	435	Rest of the world adjustment
Other	Other	436	Noncomparable foreign imports
Other	Other	437	* Employment and payroll only (state & local govt, non-education)
Other	Other	438	* Employment and payroll only (state & local govt, education)
Other	Other	439	* Employment and payroll only (federal govt, non-military)
Other	Other	440	* Employment and payroll only (federal govt, military)