

# **Consumption-Based Emissions Inventory (CBEI):**

## **Modeling Emissions Embodied in Trade for U.S. States and Counties**

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# Comparing Inventory Methods

		Geographic	Hybrid	SEI-US' CBEI
Consumer End Use:	Fuels, Buildings	geographic responsibility = consumer responsibility		
	Fuels, Transportation	geographic responsibility	consumer responsibility	
	Electricity			
	Waste Disposal			
Industrial/Commercial		geographic responsibility (except for electricity)		consumer responsibility

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- “ Post-consumer emissions the same as +hybrid+geographic inventories (although organized by consumer good)
- “ Pre-consumer emissions (industrial and commercial) modeled as the emissions embodied in goods and services

# 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										

# Embodied Emissions Literature

- “ Peters and Hertwich 2008, 2009; Peters 2008; Peters et al. 2011
- “ Wilting and Vringer 2009; Davis and Caldeira 2010
- “ Numerous country comparison studies
- “ EIO-LCA; Hendrickson et al. 2006; Weber and Matthews 2007

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- “ 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 Calculation Summary

<b>Study Area Consumption (in dollars)</b>	<b>x</b>	<b>Emissions Coefficients (tons CO<sub>2</sub>-e/\$)</b>	<b>=</b>	<b>Study Area Embedded Emissions (tons CO<sub>2</sub>-e)</b>
of Study-Area-made goods and services	x	Study Area	=	from Study Area
of U.S. (outside of Study Area) 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
		<b>SUB-TOTAL</b>		<b>Study Area Embedded Emissions (tons CO<sub>2</sub>-e)</b>
			<b>+</b>	Study Area End-Use Emissions (tons CO <sub>2</sub> -e)
		<b>TOTAL</b>		<b>Total Study Area Consumption-Based Emissions (tons CO<sub>2</sub>-e)</b>

# Five Phases of the CBEI Model

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

# Upstream (Indirect) Emissions

Final production locale:	Study Area (SA)	Inside-US-Outside-SA (UX)	Foreign (FR)
Stage of production by locale:			
Final Production	$\text{SA direct+indirect demand} * \text{SA direct coefficient} + \text{UX direct+indirect demand} * \text{US coefficient}$		$\text{FR1} = \text{FR direct demand} * \text{"Import" direct+indirect coefficient}$
Intermediate production: SA (used in final production by column)			
Intermediate production: UX (used in final production by column)			
Intermediate production: FR (used in final production by column)	$\text{FR2} = \text{US direct demand} * \text{"Global - US" direct+indirect coefficient}$		

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- “ Type of Consumer: households, government, business investment
- “ Commodity Type: 440 commodity sectors, 62 subcategories, 16 categories

# CBEI Categories and Subcategories

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

# CBEI Projects To Date:

- ” State of Oregon (v.1.0)
- ” King County, Washington (v.2.1)
- ” City of San Francisco (v.2.1):
  - . San Francisco
  - . State of California

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