CONSUMPTION-BASED GREENHOUSE GAS INVENTORIES:

LESSONS LEARNED AND NEXT STEPS

April 26, 2012

A Webinar for the West Coast Forum on Climate and Materials Management

Today's Outline

- Background and motivation for consumption-based inventories
- Methodologies
  - Common elements
  - Variations
- Break for Q&A
- Roundtable: results and next steps
  - King County/Seattle
  - City and County of San Francisco
  - Cool California
  - State of Oregon
  - State of Washington
- More Q&A, discussion

Today's Panel

Matt Kuharic,
King County

David Allaway,
Oregon Department of
Environmental Quality

Calla Ostrander,
City and County of
San Francisco

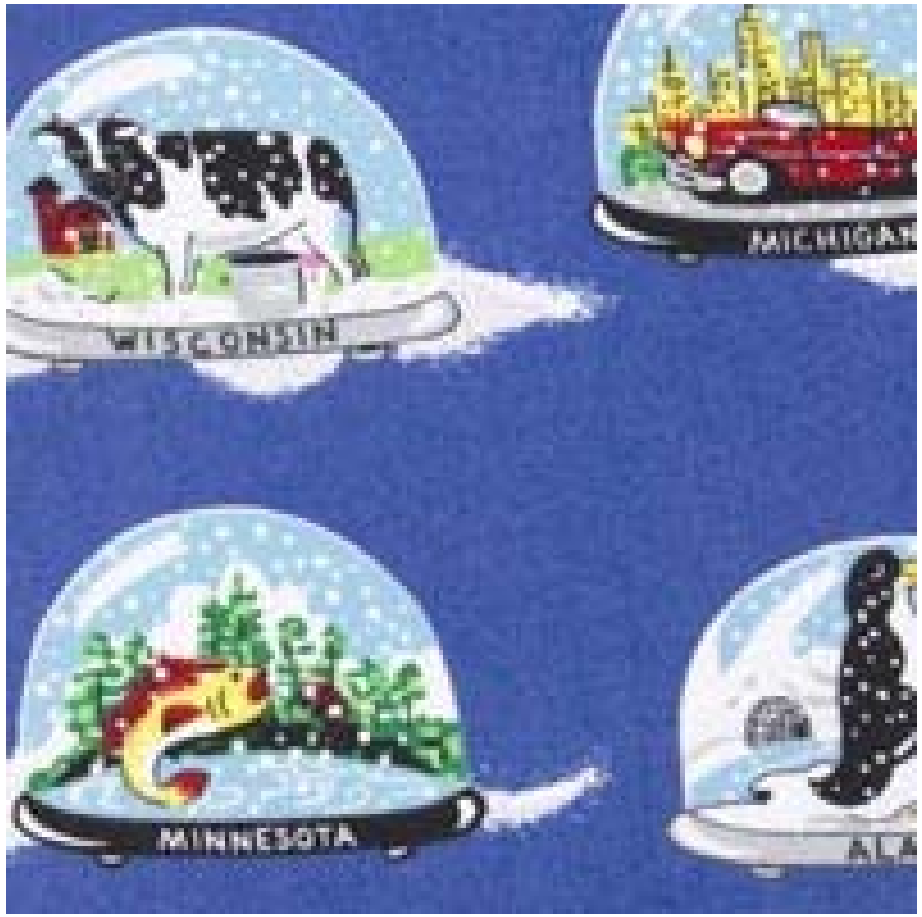
Cristiana Figueroa,
Washington Department
of Ecology

Chris Jones,
CoolClimate Network,
UC Berkeley

Common Uses of Community-Scale Greenhouse Gas (GHG) Inventories

- Establish a baseline and measure progress towards climate change goals
- Identify sources of emissions that the community can influence, identify trends in those emissions, and inform related efforts
  - Support climate related projects, programs, planning efforts
  - Provide data and tools to community partners (e.g. cities, community groups, businesses, individuals)
  - Inform development of emissions reduction policy and targets
  - Consumption based inventory broadens opportunities for climate solutions
- Communicate all of the above to policy-makers and the public

GHG inventories: the traditional, "snow globe" approach



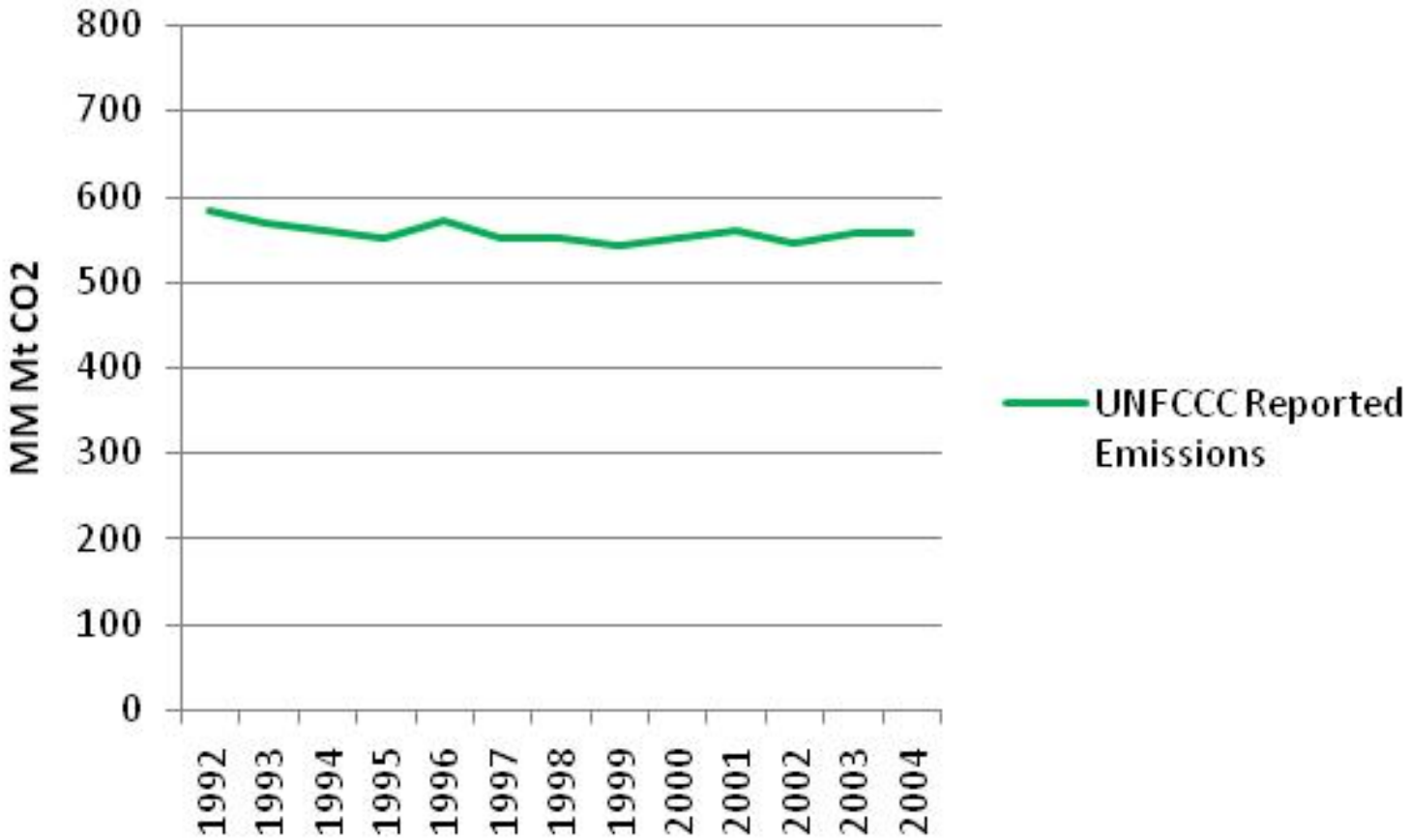
Common adjustments to the "snow globe" approach

- Electricity used, not generated
  - To incent electricity conservation, "green power" purchases
- Motor vehicles (and airline travel)
  - "Trip origination" vs. in-region vehicle miles
- Exported/imported solid waste
  - Emissions at landfills, incinerators

Limitations of the (modified) "snow globe"

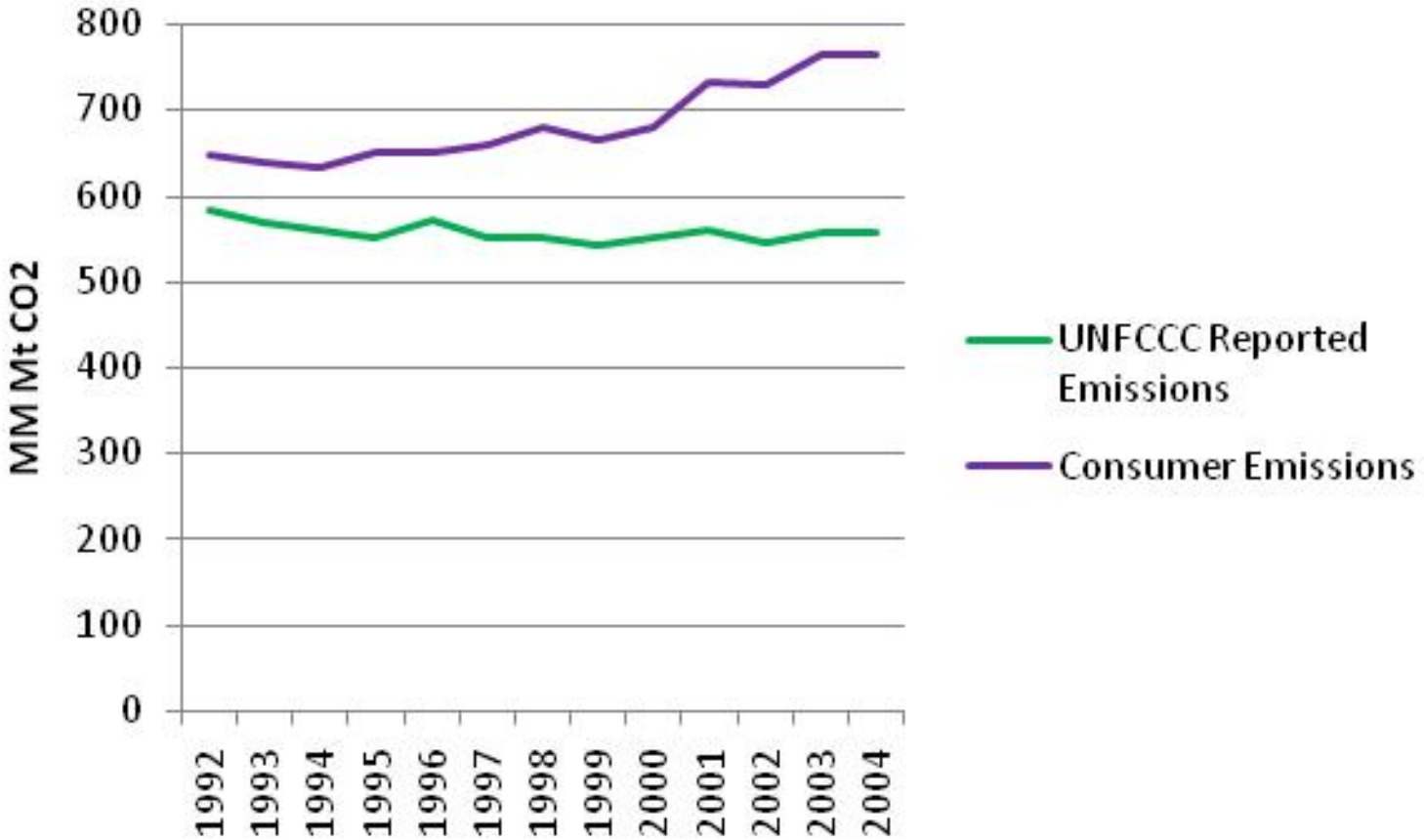
- Provides an incomplete perspective of how communities contribute to emissions . . .
  - . . . and by extension, opportunities to reduce emissions
  - Particularly acute for materials!
- Appears to penalize local production, reward outsourcing ("leakage")
- May lead to sub-optimal decisions (e.g., discontinue recycling)
- May provide misleading signals of change over time

United Kingdom Greenhouse Gas Emissions – Conventional Accounting



Source: DEFRA, 2008

United Kingdom Greenhouse Gas Emissions – A More Complete Picture



Source: DEFRA, 2008

Consumption-Based Emissions Inventories

- An inventory of the GHG emissions associated with *consumption*
  - "Consumption" is typically defined in economic terms (purchases by "consumers" = households, sometimes others)
  - Consumption = a "root driver" of environmental impacts
  - Emissions are life-cycle emissions and globally distributed
    - "Life-cycle" = Supply chain/Production + Use + Disposal
    - Not all in-community emissions are included (not the snow globe)
  - Includes, but not limited to, materials
    - Includes all materials "consumed" by the community
    - Excludes materials that aren't purchased by consumers (e.g., phone books), or that are purchased by non-consumers (e.g., business supplies)

Local Consumption, Global Production

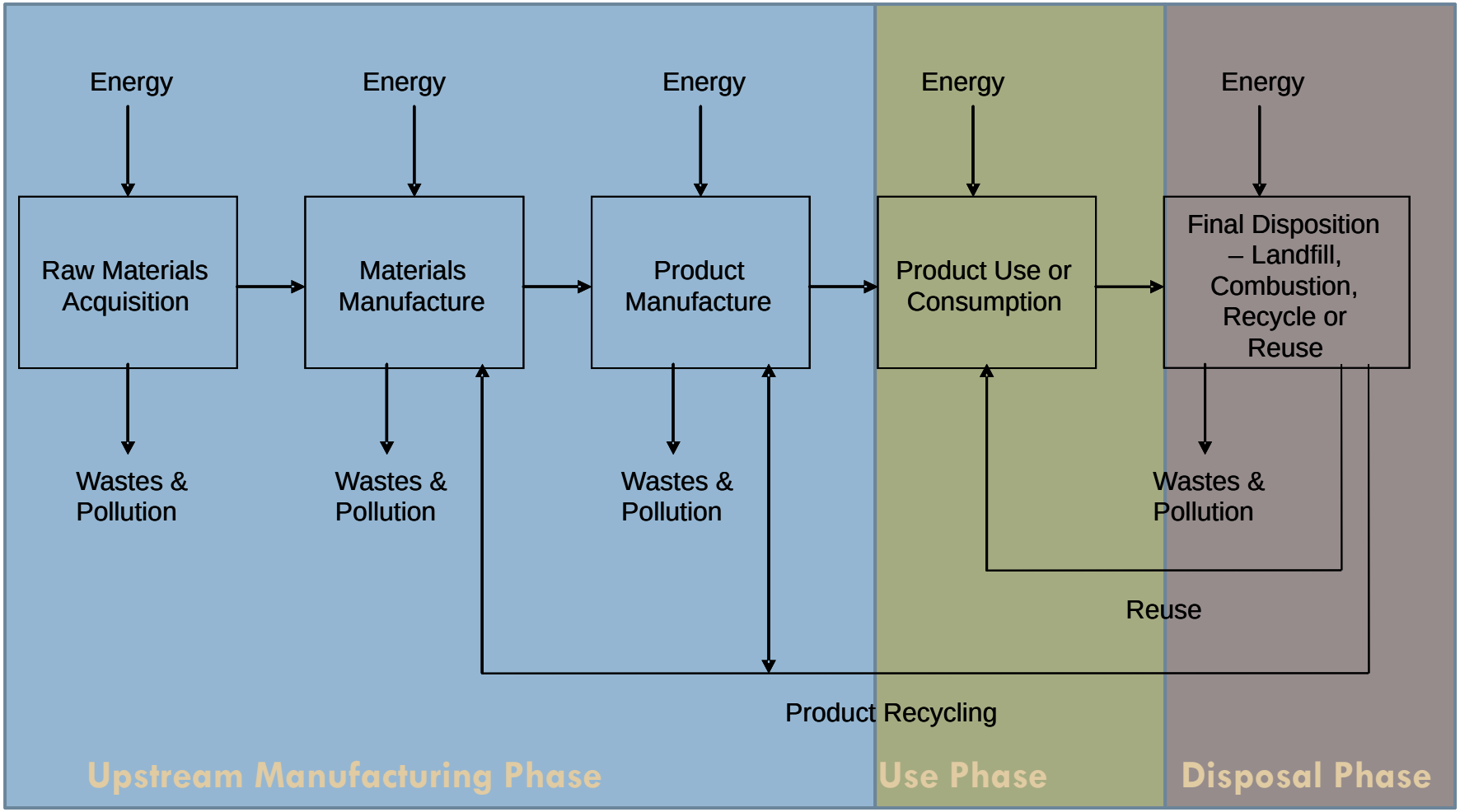
Der Spiegel, The Global Toothbrush, 01/31/2006

http://www.spiegel.de/international/spiegel/0,1518,398229,00.html

Common Basic Methodology

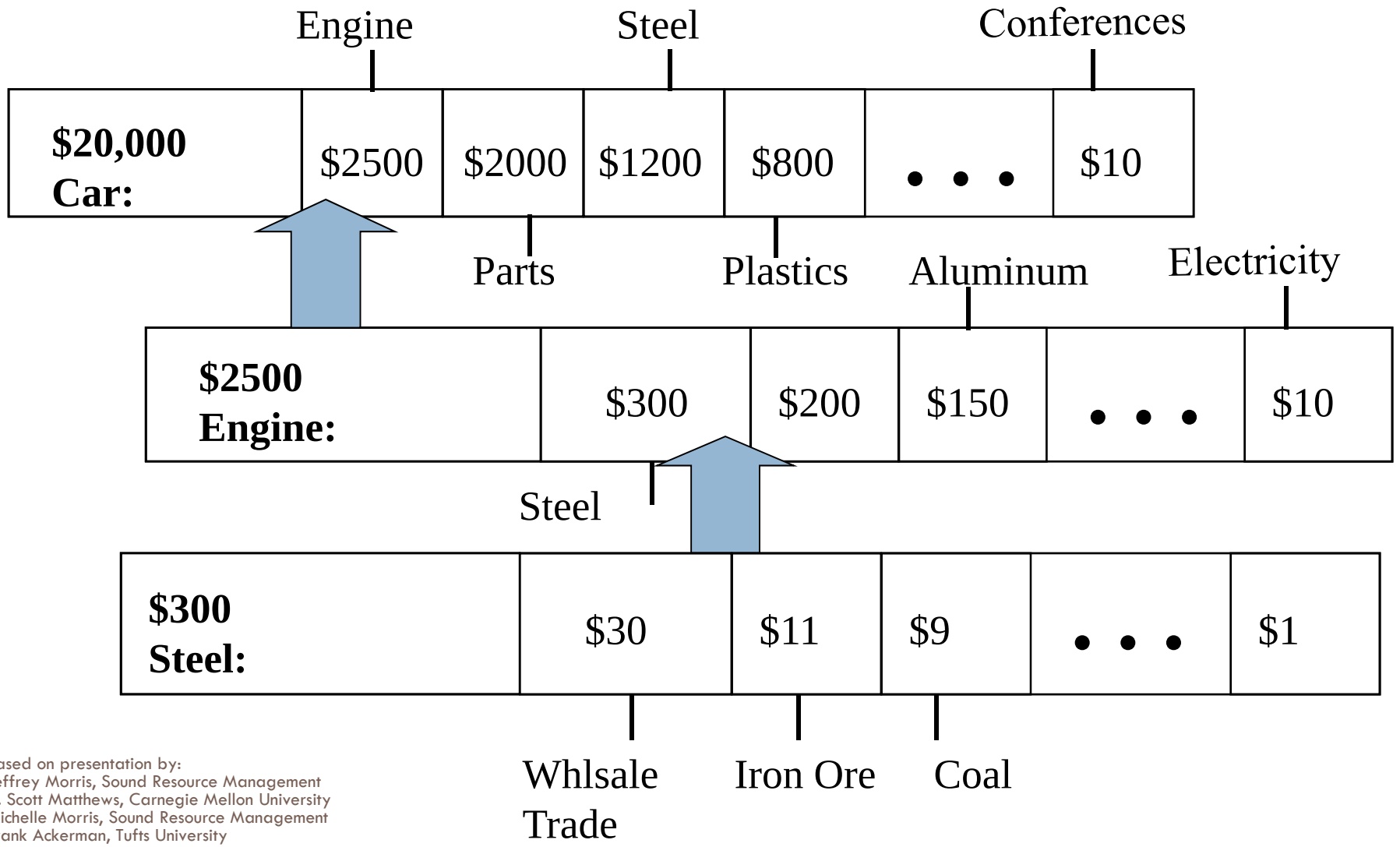
- There is no “standard” yet
- Life Cycle Approach
  - Upstream phase: Using Input-Output Economic models
  - Use phase
  - Disposal phase

LCA: Basis for Consumption-Based Inventories



Based on presentation by:
Jeffrey Morris, Sound Resource Management
H. Scott Matthews, Carnegie Mellon University
Michelle Morris, Sound Resource Management
Frank Ackerman, Tufts University

Upstream Phase Based on Benchmark Input-Output Tables of US Economy, Bureau of Economic Analysis



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Upstream Models using Input-Output LCA

- Typically make use of U.S. Department of Commerce data:
  - 483 sectors (BEA-1997)
  - 428 sectors (BEA-2002)
  - Links economic transaction data with public data on energy, environmental flows
    - e.g., if $100 B of chicken/fish/eggs *production* emits 100 billion kg of CO2, then $1M of chicken/fish/eggs emits 1 million kg of CO2, or 1kg CO2 per $

An example of input-output models: Carnegie-Mellon's EIO-LCA

- Uses US Department of Commerce published IO (input-output) tables
  - Benchmarks available: 1997 and 2002
- Long-term project: 15+ years in the making
  - www.eiolca.net
- Widely used in the US
  - More than 100 peer-reviewed papers on development and application
  - More than 1 million uses of the model

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Emissions associated with "use"

- Typically denominated in physical units (e.g., gallons of gas, kWh of electricity) rather than dollars
- Models include emissions at the point of fuel combustion plus life-cycle (e.g., "well to pump") emissions

Introduction to the Methodologies

- Oregon/King County/San Francisco – detailed model, designed primarily as a GHG inventory
- Washington – detailed model, designed to inform a "consumer environmental index"
- Cool Climate – quick "snapshot" of community-scale emissions (under development)

Methodological Variables

1. Definition of "consumers": households, government, business capital?
2. Source(s) of consumption data
3. Which impacts to track? Greenhouse gases only, or GHG + other impacts?
4. Single-region or multi-region modeling
5. Custom analysis vs. on-line screening tool

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Which consumers are included in Oregon's, King County's, and San Francisco's consumption-based inventories?

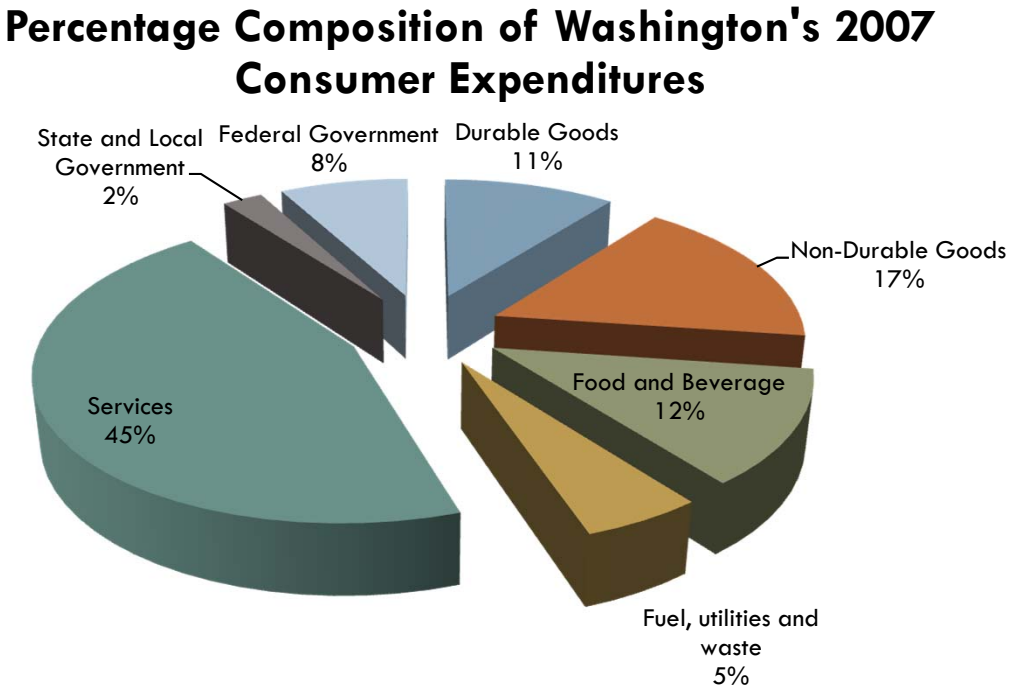
- Generally consistent methodology (developed by Stockholm Environment Institute, US Center)
  - Households
  - In-boundary local, state, and federal government entities
  - Business investment purchases (capital formation)
    - Including construction
    - Most business expenditures not included directly
- Commonly referred to by economists as "final demand"
- Consumption from these three sectors is evaluated in parallel
- Other local business purchases/activities are not included in consumption
  - But emissions are included to extent these purchases/activities support or satisfy "final demand" (consumption) by local consumers

Which consumers are included in the Cool Climate model?

- Households and government
  - Business inventory/capital associated with household and government purchases treated the same as other business expenditures:
    - Included (regardless of location) to the extent these purchases support or satisfy "final demand" (consumption) by local consumers (household, government)
  - All local business expenditures
    - Inventory/capital and other expenditures (e.g., supplies)
    - A "business footprint" – some double-counting with households and governments, and not "pure" consumption

Which consumers are included in Washington's Consumer Environmental Index (WA CEI)?

WA CEI is **household**-based. It does not include business or government *capital* investments. It does include certain payments consumers make to governments such as property tax or social security contributions, but not income tax.



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Where does the WA CEI's consumption data come?

- Consumer expenditure surveys (Bureau of Labor Statistics -www.bls.gov/cex/)
- Based on metropolitan statistical areas
- Also used to compute the consumer price index

Item	All consumer units in the West	Los Angeles	San Francisco	San Diego	Seattle	Phoenix
Other food at home	$1,428	$1,455	$1,448	$1,147	$1,641	$1,465
Sugar and other sweets	139	128	157	73	171	120
Fats and oils	105	110	112	71	111	102
Miscellaneous foods	748	745	751	611	832	822
Nonalcoholic beverages	373	421	350	350	428	368
Food prepared by consumer unit on out-of-town trips	64	52	77	41	99	54
Food away from home	2,942	3,343	4,070	2,468	2,983	2,685
Alcoholic beverages	503	515	774	482	600	472
Housing	19,784	22,645	26,111	22,562	21,515	19,492
Shelter	12,725	15,521	18,800	15,761	13,890	11,711
Owned dwellings	8,114	9,077	11,238	8,903	8,883	7,806
Mortgage interest and charges	5,342	6,068	6,581	6,128	5,554	5,298
Property taxes	1,540	1,837	2,565	2,080	1,948	1,080
Maintenance, repairs, insurance, other expenses	1,232	1,173	2,091	695	1,381	1,428
Rented dwellings	3,845	5,857	6,208	6,432	3,950	3,201
Other lodging	766	587	1,355	426	1,057	705

Where does Oregon's, King County's, and San Francisco's consumption data come?

- Estimates in IMPLAN database
- Combination of Bureau of Economic Analysis personal consumption expenditures data, Bureau of Labor Statistics consumer expenditure survey data, and U.S. Census data on population and incomes
- 9 household income categories
  - Assumption that individuals in any given income category have similar consumption patterns throughout the U.S.

Where does the Cool Climate consumption data come?

- Econometric model – still under development by UC Berkeley
- Variables include:
  - Vehicles per household
  - Population density
  - Commute time
  - Presence of public transit
  - Gasoline, electricity, fuel prices
  - Demographics (income, population)
  - Access to shopping
  - Types of heating fuels
  - Heating and cooling degree days
  - Home size
  - Household size
  - Others

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Which Impacts to track?

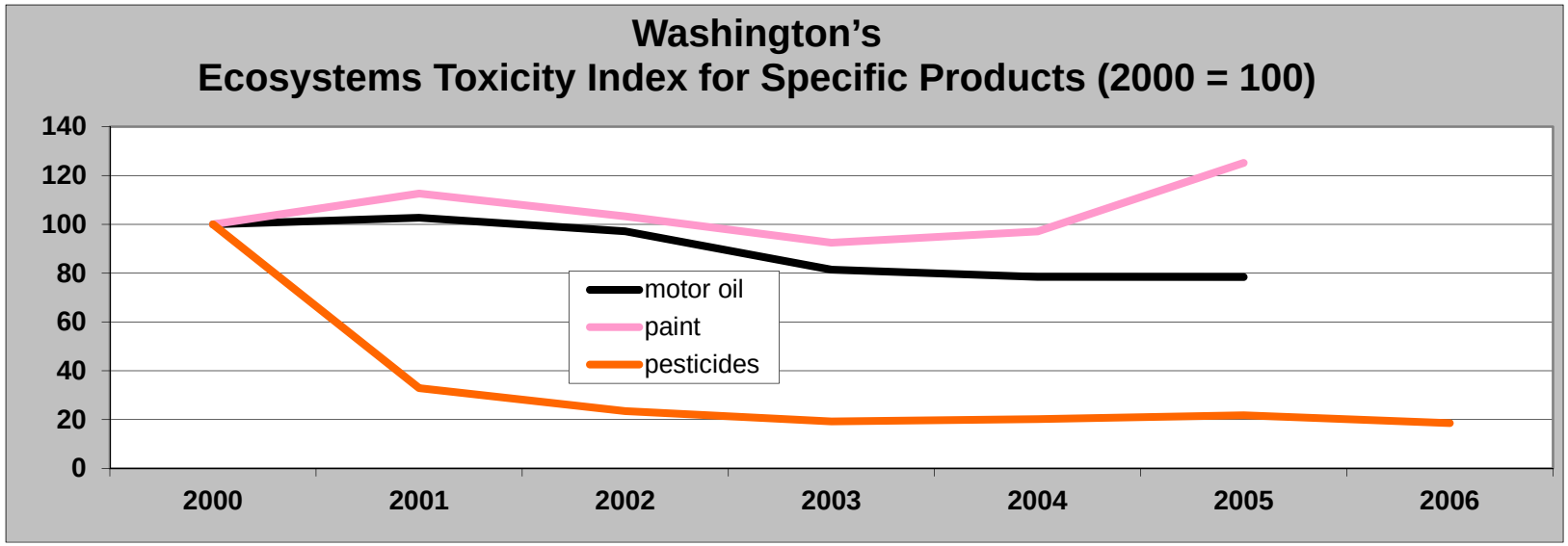
- Global warming – Most commonly tracked
- Degree of complexity increases when tracking other impacts
- Could also track:
  - Ozone depletion
  - Acidification
  - Eutrophication
  - Human Health (cancer and non-cancer impacts)
  - Ecosystem toxicity

Benefits and Challenges of tracking other impacts

- Can produce a multi-dimensional analysis of materials management
- Complexity is increased
- Data availability is often not adequate, but improving
  - In 2006, characterization factors available for 960 chemicals
  - Now factors available for 3927 chemicals.
- Environmental data for other impacts may be less accurate than for GHG impacts.

WA Consumer Environmental Index (WA CEI)

- Currently tracking the trends of two impacts:
  - Global warming
  - Ecosystem toxicity
  - Developed to track human health impacts also
  - Example:



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Single-Region vs. Multi-Region Modeling

- Single-region modeling usually uses US-average emissions factors as a proxy for global production
- SEI's models (for Oregon, King County and San Francisco) used a 3-region approach:
  - Community (Oregon, King County, San Francisco)
  - Rest of US
  - Rest of world
- Trade data allocates production between regions
- Use of different emissions factors (emissions/$) for different regions
  - "Rest of world" emissions factors have higher uncertainty . . .
  - . . . but are also generally higher

Methodological Variables

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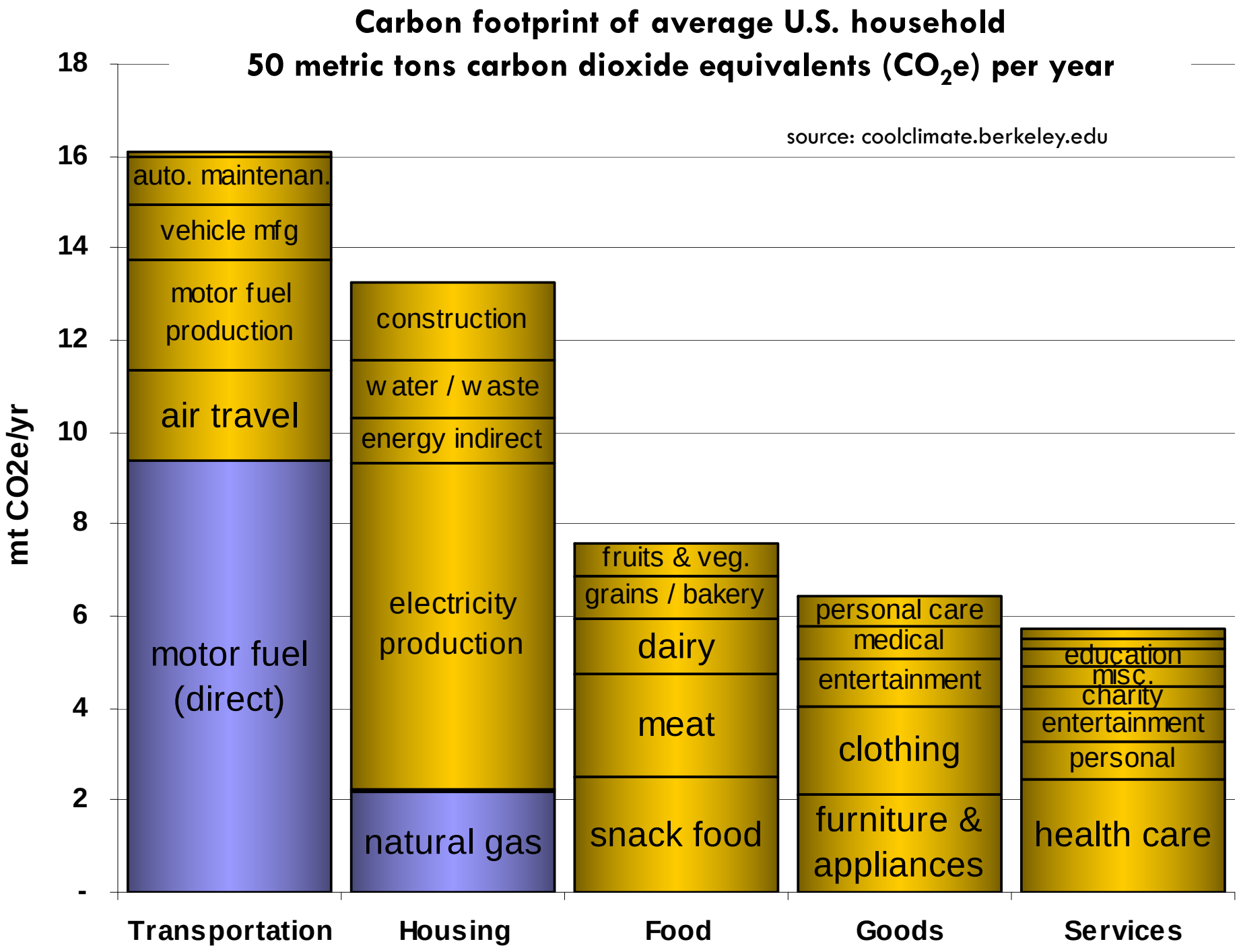
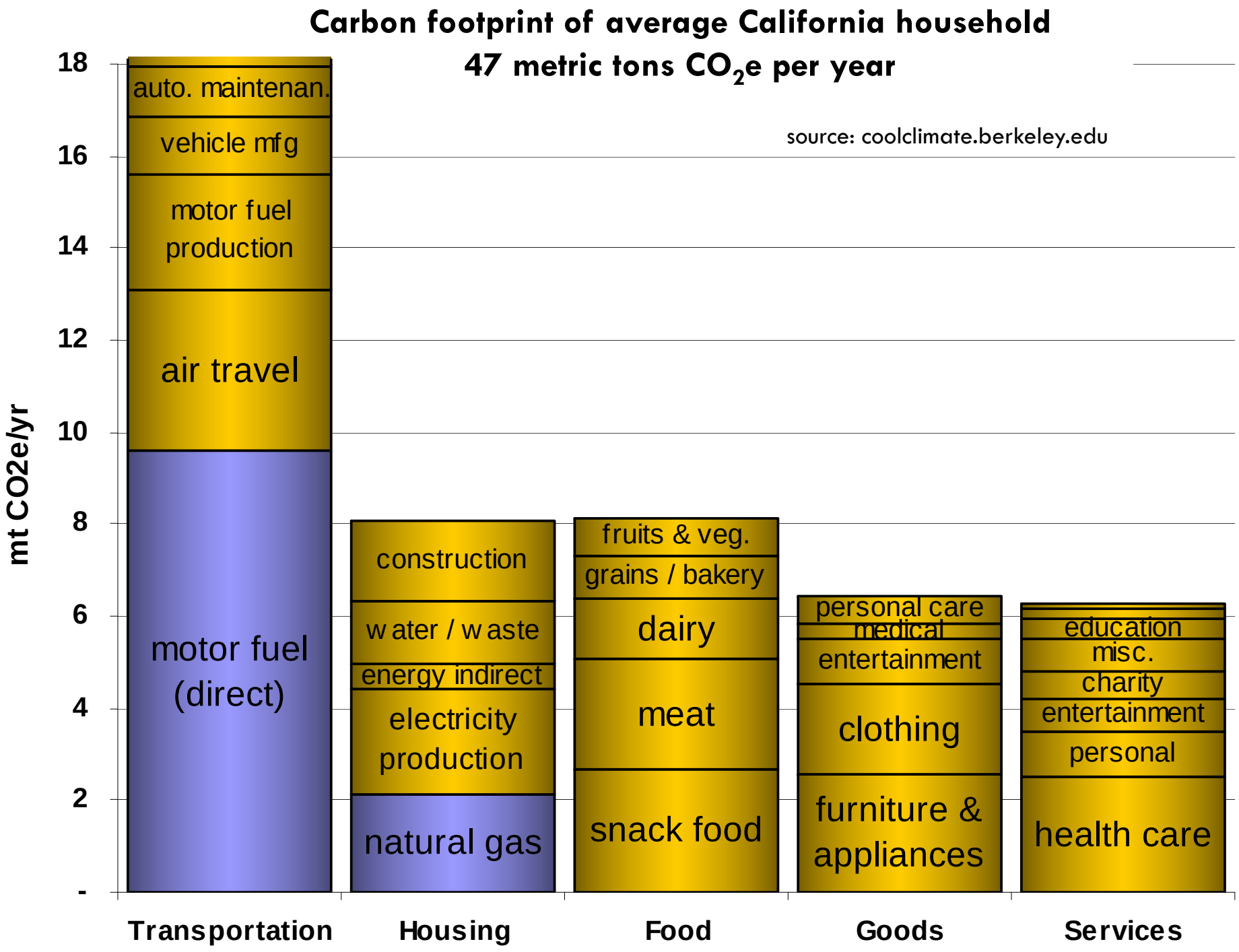

Carbon footprint of average U.S. household
50 metric tons carbon dioxide equivalents (CO_2e) per year
source: coolclimate.berkeley.edu
mt CO2e/yr
18
16
14
12
10
8
6
4
2
-
auto. maintenan.
vehicle mfg
motor fuel production
air travel
motor fuel (direct)
construction
water / waste
energy indirect
electricity production
natural gas
fruits & veg.
grains / bakery
dairy
meat
snack food
personal care
medical
entertainment
clothing
furniture & appliances
education
misc.
charity
entertainment
personal
health care
Transportation
Housing
Food
Goods
Services


Carbon footprint of average California household
47 metric tons CO_2e per year
source: coolclimate.berkeley.edu
mt CO2e/yr
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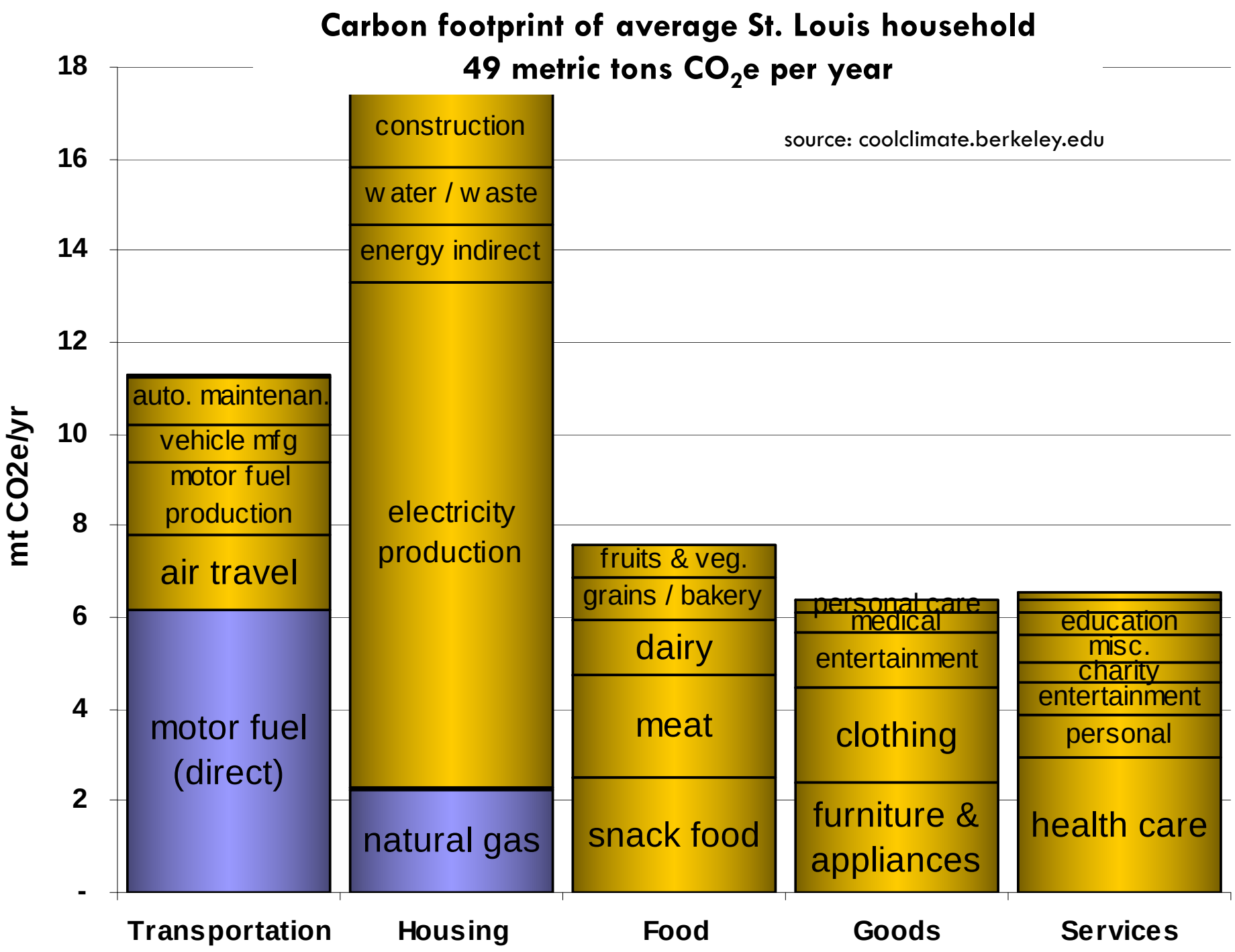
auto. maintenan.
vehicle mfg
motor fuel production
air travel
motor fuel (direct)
construction
water / waste
energy indirect
electricity production
natural gas
fruits & veg.
grains / bakery
dairy
meat
snack food
personal care
medical
entertainment
clothing
furniture & appliances
education
misc.
charity
entertainment
personal
health care
Transportation
Housing
Food
Goods
Services


Carbon footprint of average St. Louis household
49 metric tons CO_2e per year
source: coolclimate.berkeley.edu
mt CO2e/yr
18
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auto. maintenan.
vehicle mfg
motor fuel production
air travel
motor fuel (direct)
construction
water / waste
energy indirect
electricity production
natural gas
fruits & veg.
grains / bakery
dairy
meat
snack food
personal care
medical
entertainment
clothing
furniture & appliances
education
misc.
charity
entertainment
personal
health care
Transportation
Housing
Food
Goods
Services

Intro | Travel | Housing | Food | Goods & Services | Take Action

Start with a quick footprint estimate

Select State: California

Select City/Area: San Diego Area

How Many people live in your household?

Three

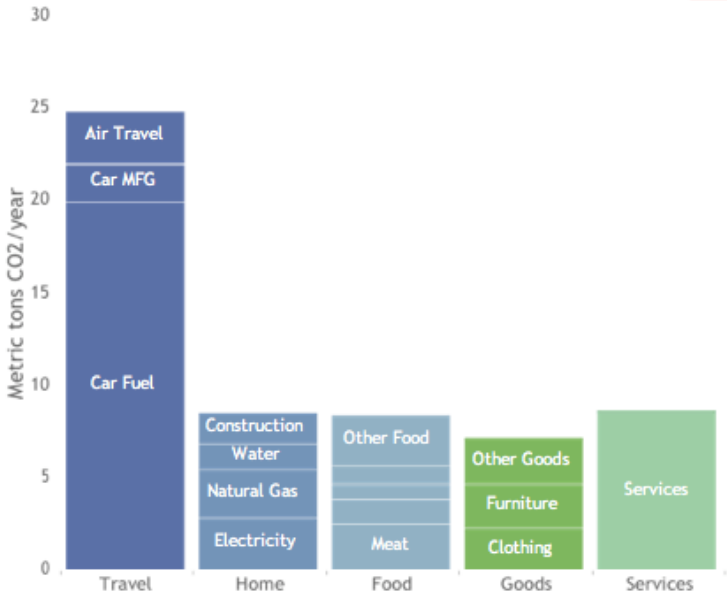
Adults: 2

Children: 1

What is your gross annual household income?

$60,000 to $79,999

Next: Travel



Total

57

Tons

The footprint of the average CA household with 3 people and similar income

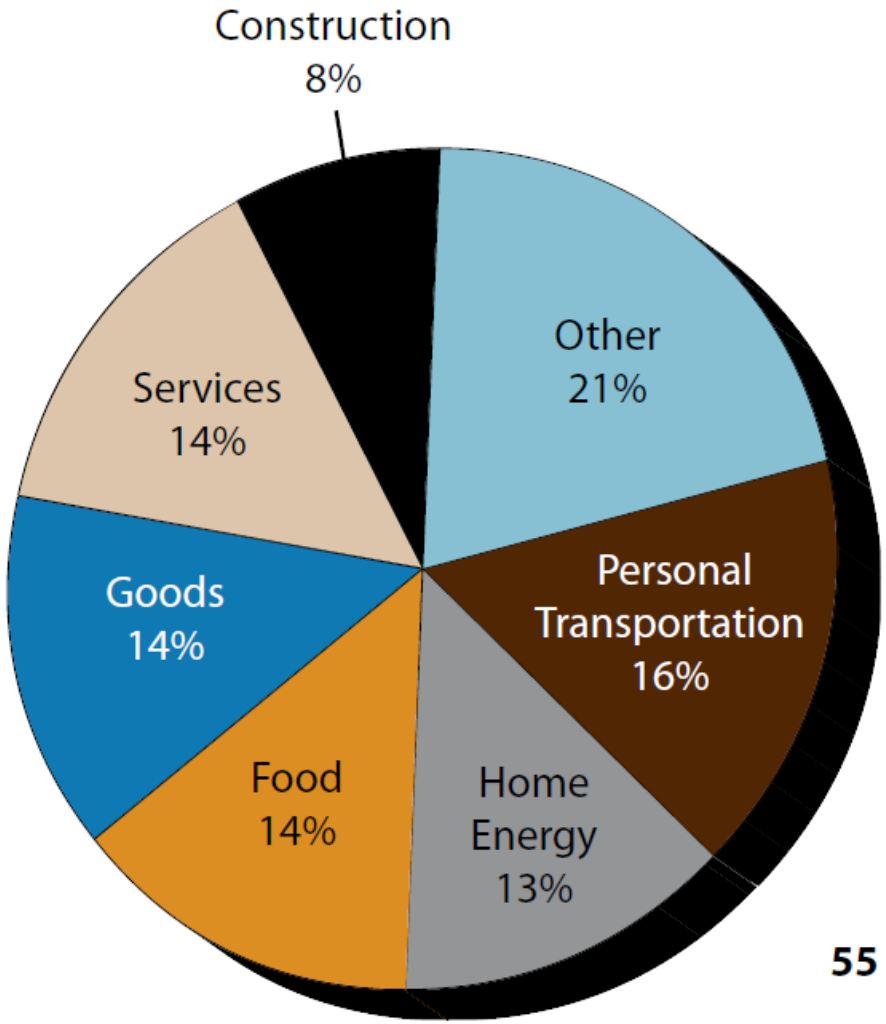
Questions?

King County Consumption-Based Greenhouse Gas Emissions Inventory

Project Deliverables

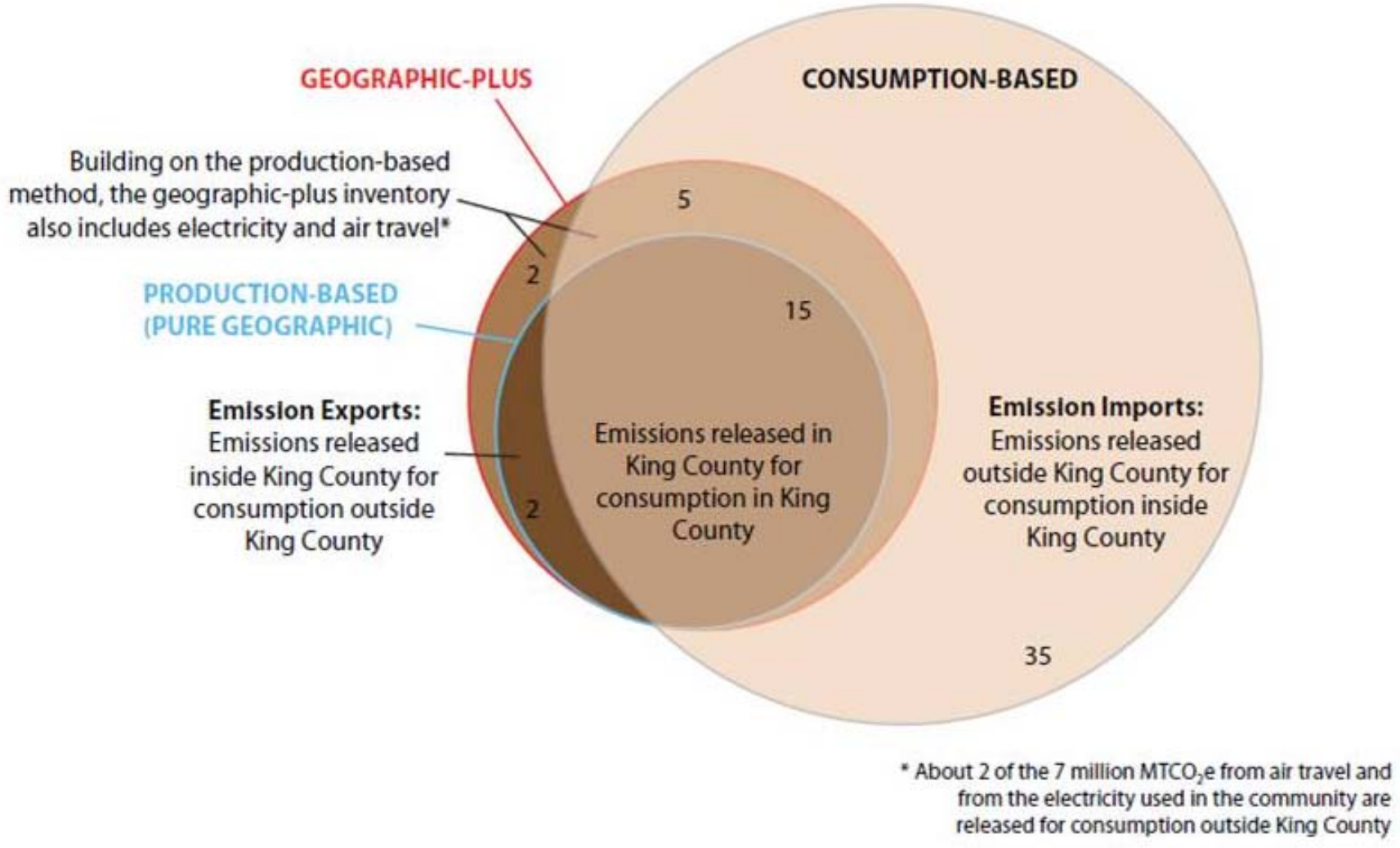
- **"Geographic Plus" GHG Inventory**
  - "Standard" inventory; similar to other communities'
- **Consumption GHG Inventory**
  - Innovative method
- **GHG measurement framework**
  - Annual tracking of most important sources
- **Additional products:**
  - High-priority household actions
  - GHGs associated with food
  - GHGs associated with government purchasing

Consumption-based Inventory: Results by Category



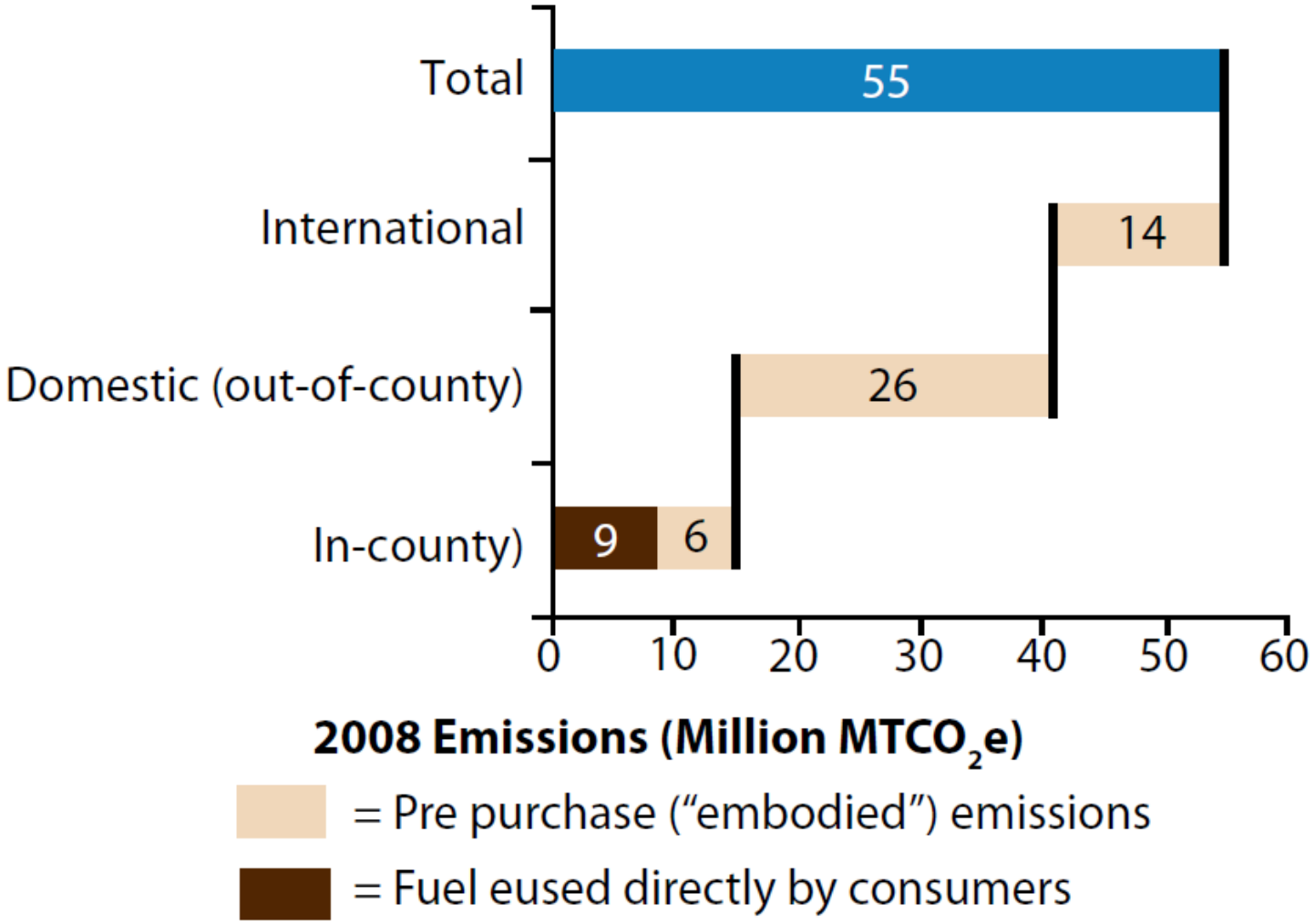
Total:
55 Million $MTCO_2e$

Inventories Compared

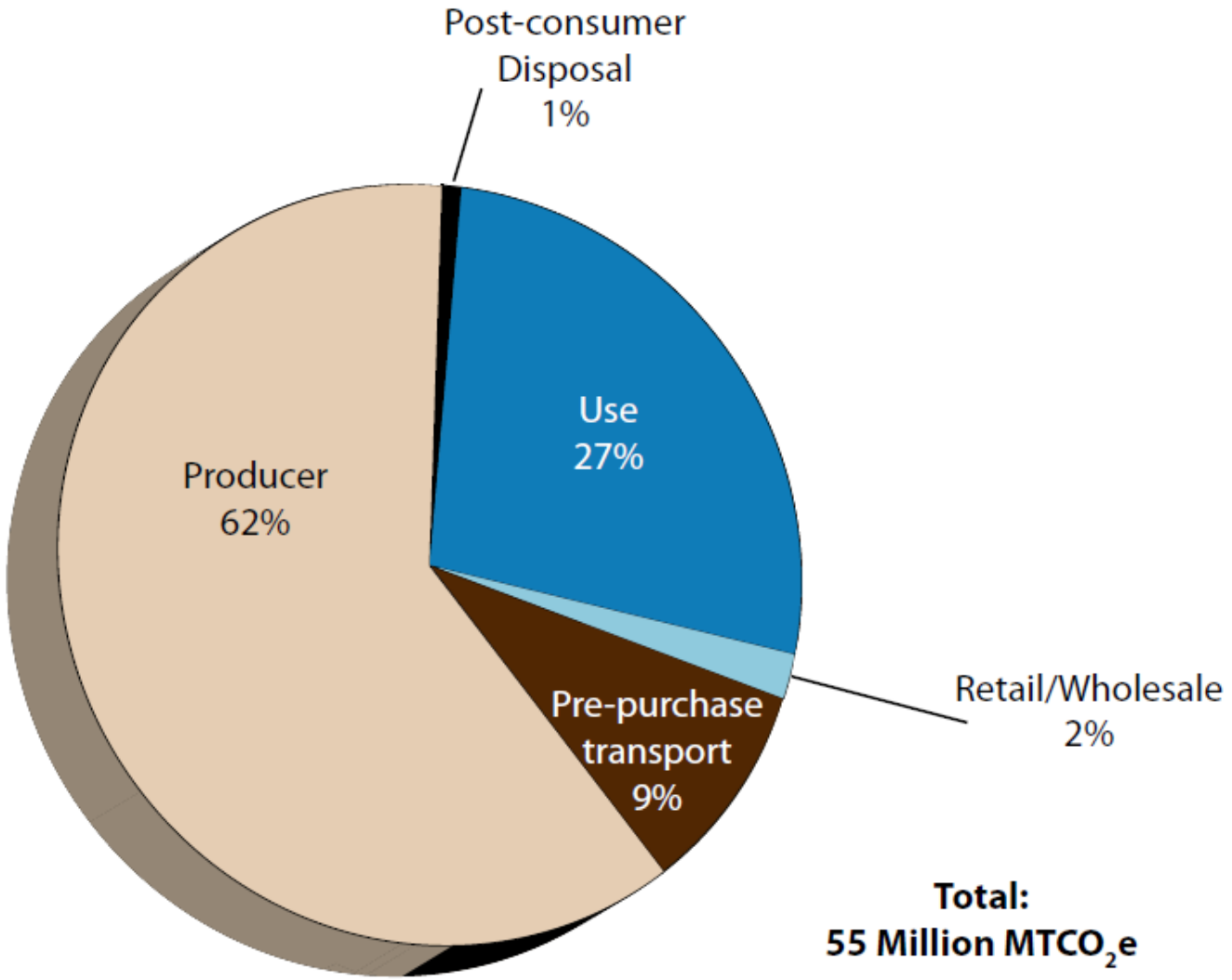


* About 2 of the 7 million $MTCO_2e$ from air travel and from the electricity used in the community are released for consumption outside King County

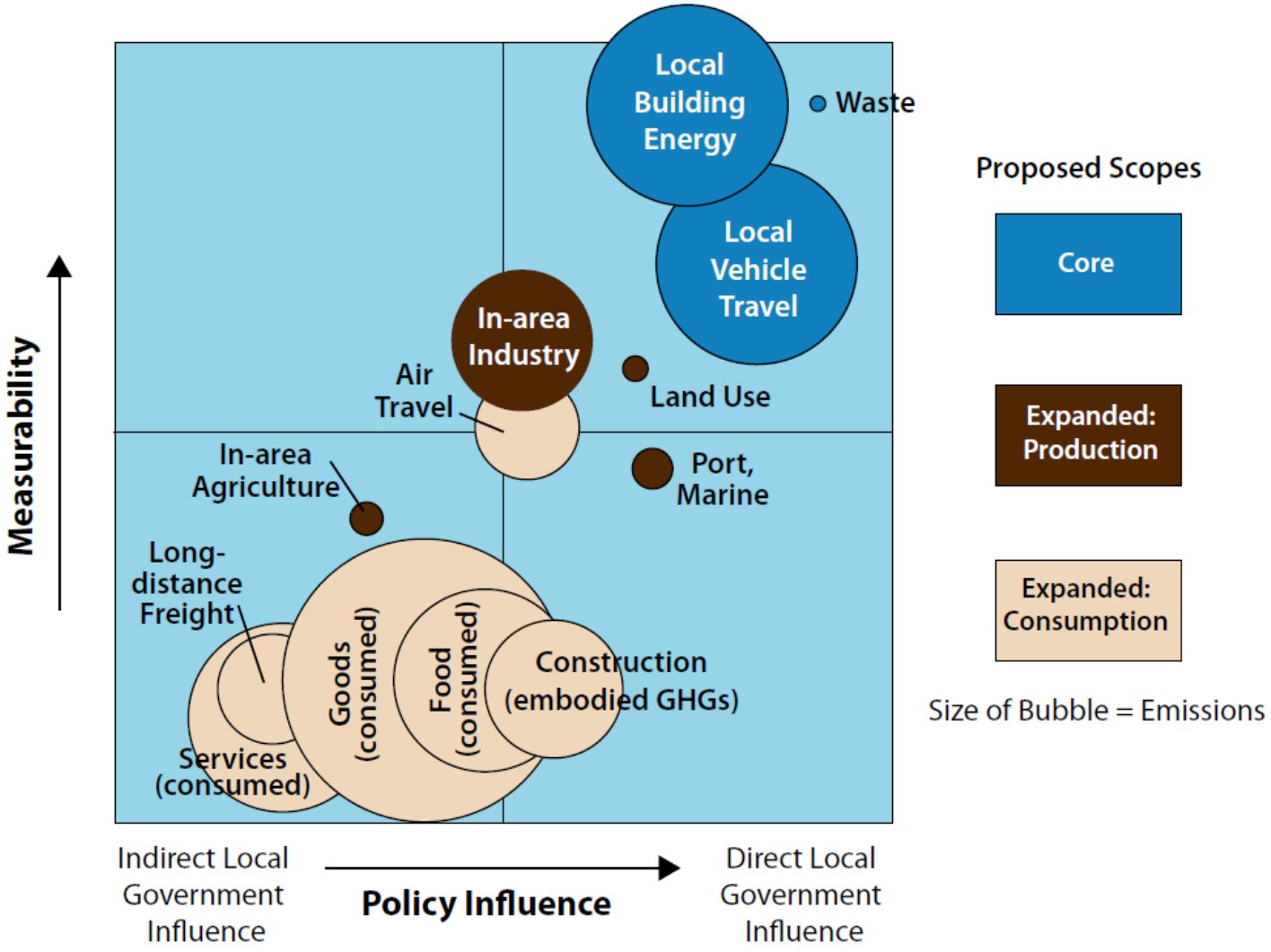
Consumption-based Inventory: Results by Geography



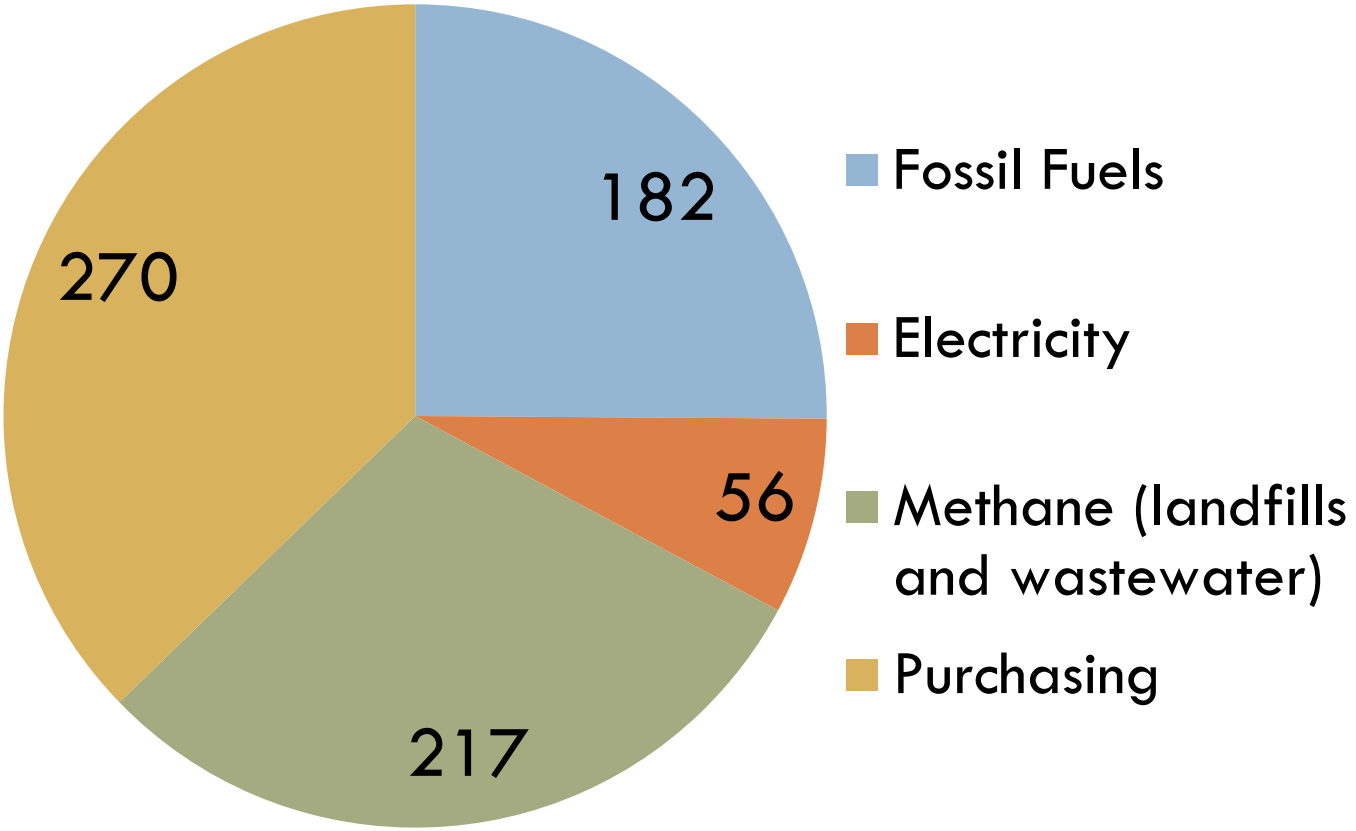
Consumption-based Inventory: Results by Life-cycle Phase



From inventories to a measurement framework

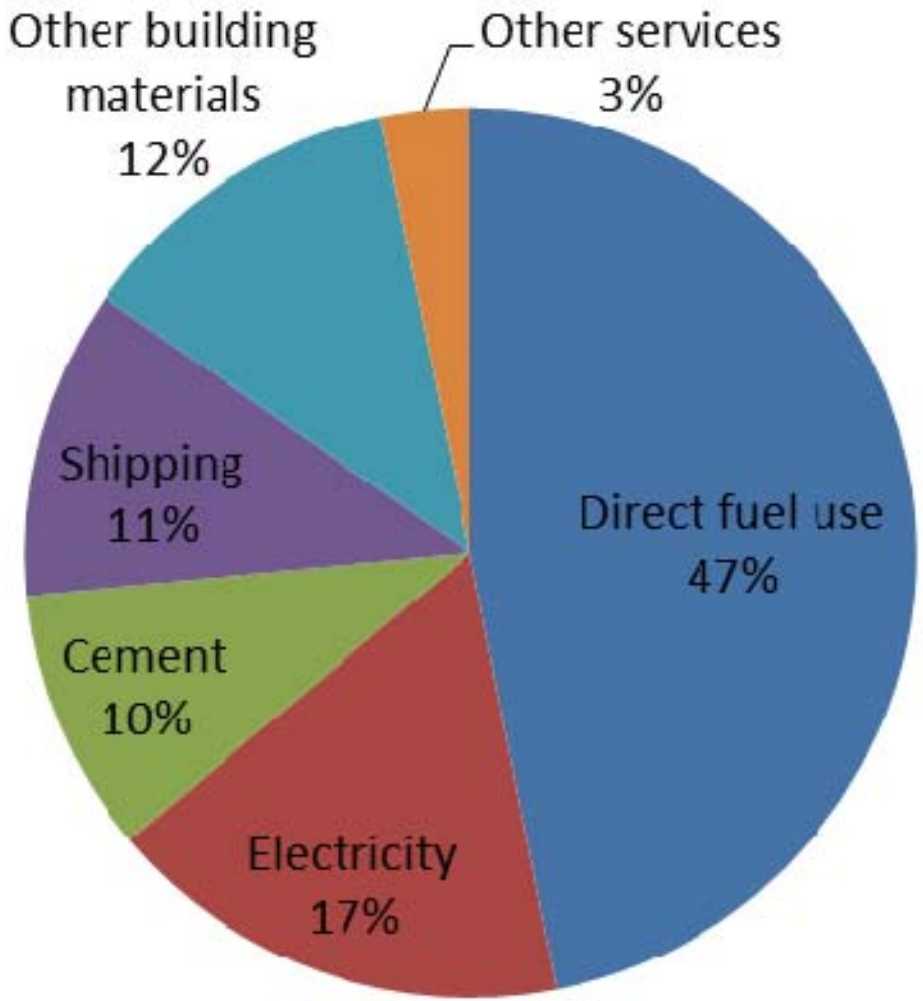


GHGs and King County Government Purchasing



GHGs and King County Government Purchasing

Estimated Sources of Construction related GHG Emissions



Recent and Next Steps

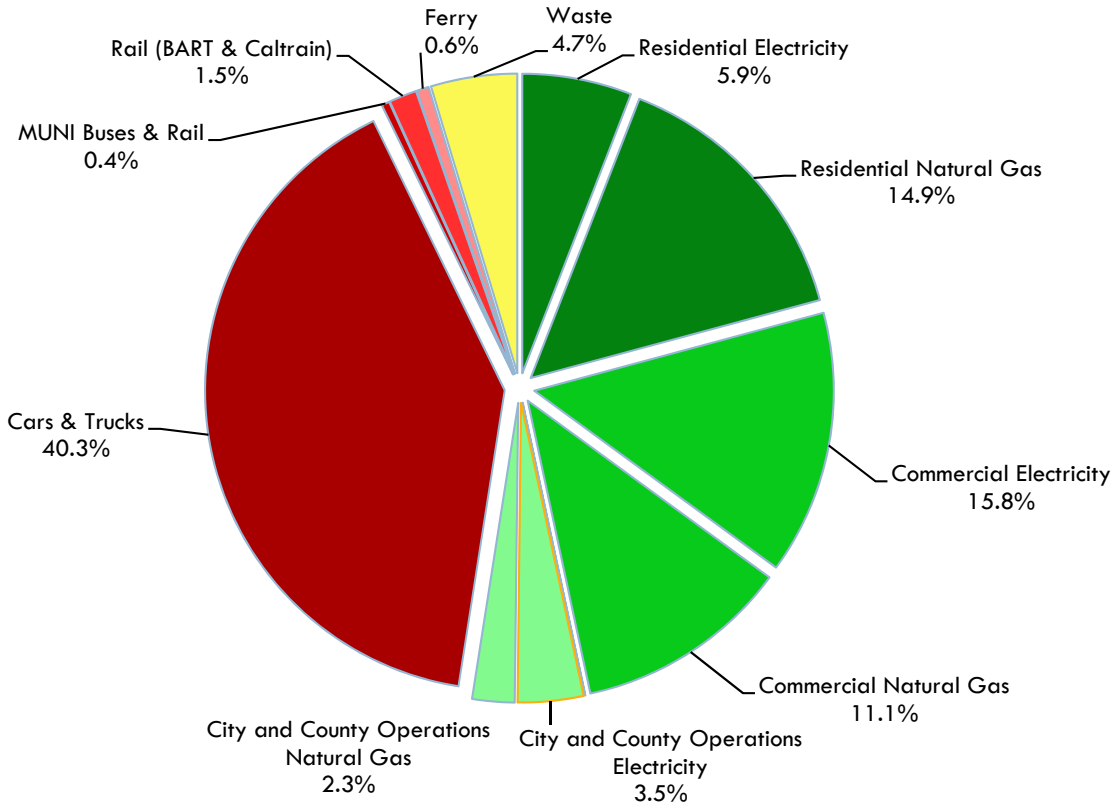
- Published reports and got press coverage (KUOW, Grist, several local newspapers)
- Working to develop additional in depth reporting

- Integrate new info into ongoing County efforts (e.g. ongoing outreach)
- Using the findings of this study to inform work with King County cities to develop a countywide greenhouse gas emissions reduction target and monitoring framework

- Take next steps to address key highlighted emissions sources
  - e.g. “reducing wasted food” pilot project
  - exploring food and purchasing related next steps
- **Suggestions?**

San Francisco Greenhouse Gas Emissions Inventories

San Francisco Traditional Community GHG Emissions Inventory 5.4MMT



SF Environment
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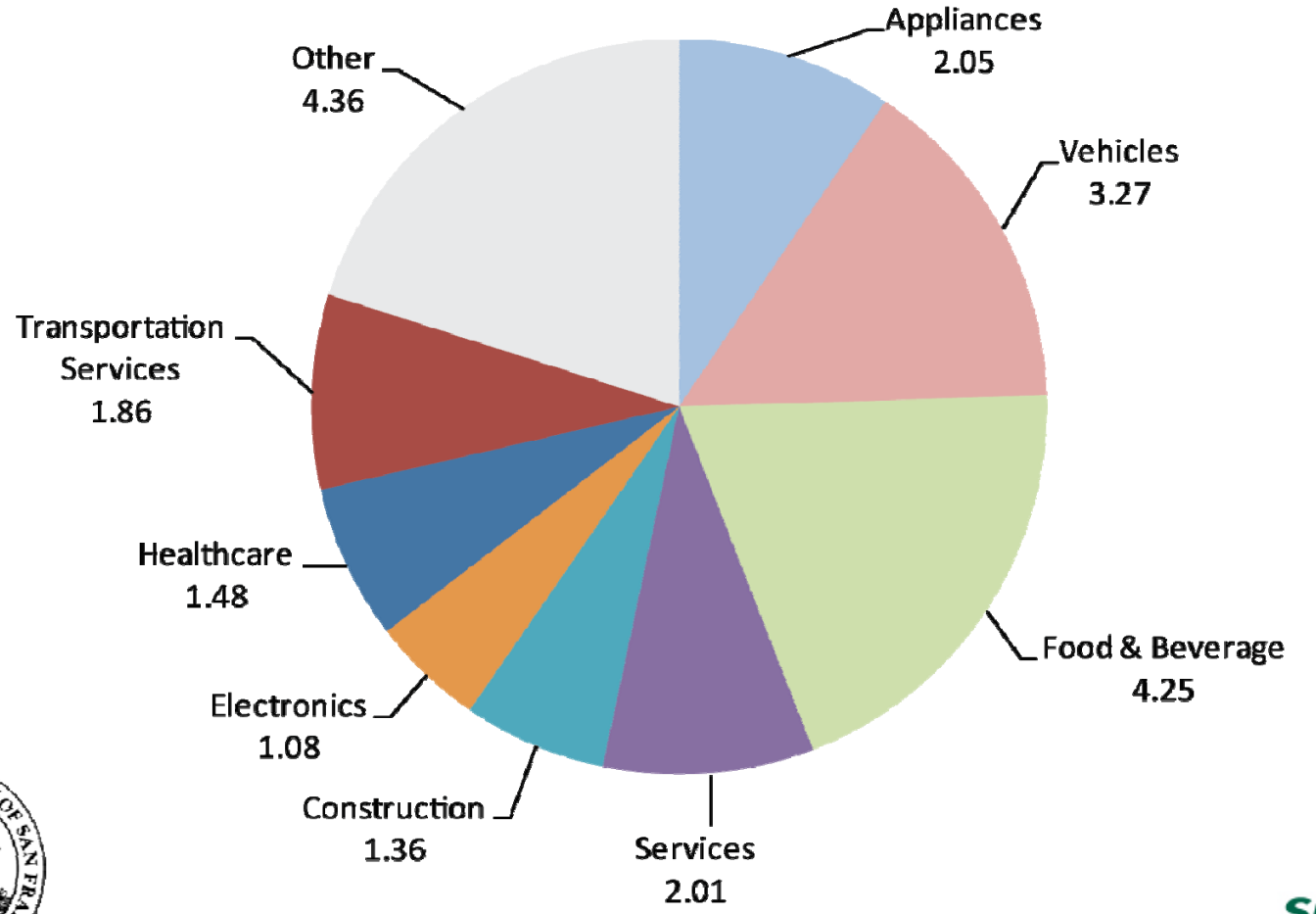
San Francisco's Consumption Based Emissions Inventory 21.7 MMT



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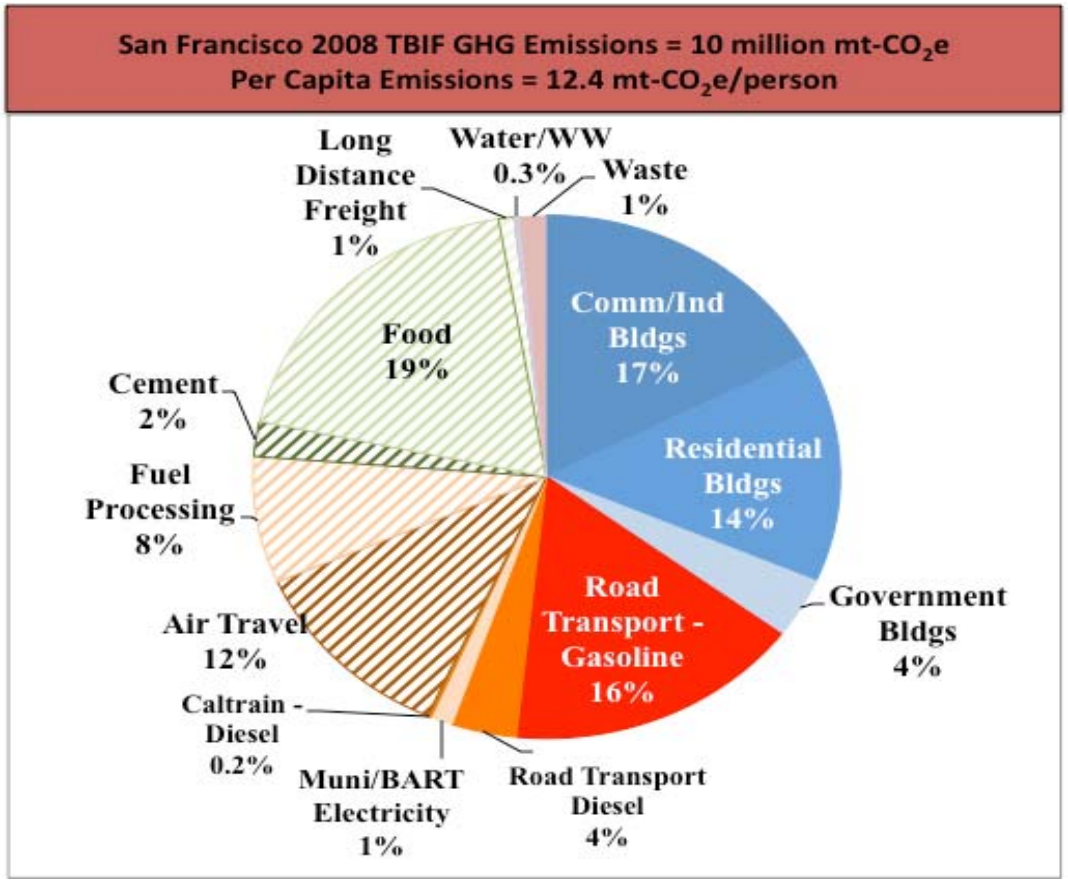
Trans-Boundary Infrastructure Footprint 10 MMT



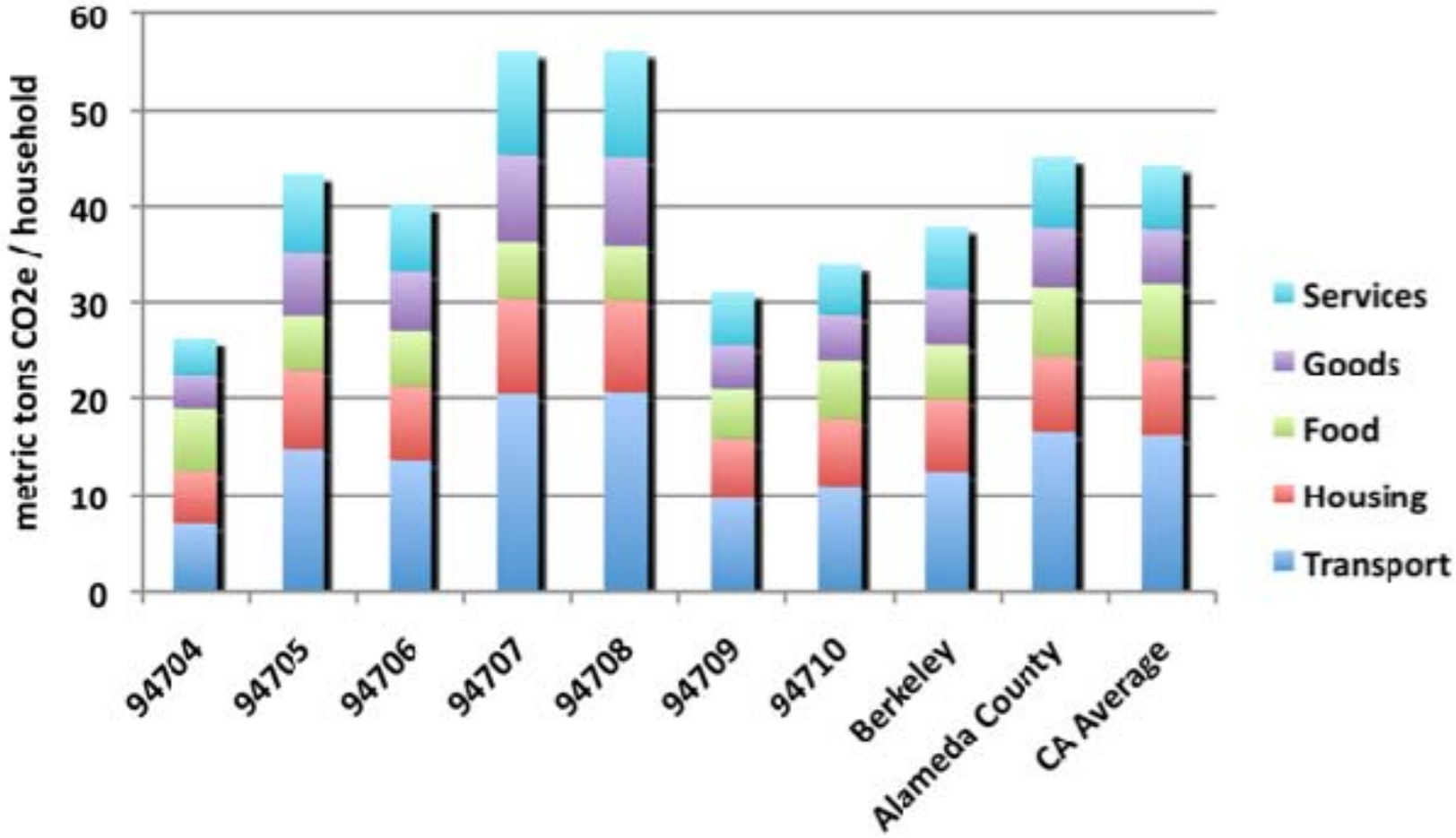
SF Environment
Our home. Our city. Our planet.

How can this inform action? (policy relevance)

- What are the take away's from these three carbon footprints?
  - There is no "one ring"
  - Main areas of focus need to be . . .
- How can they be used?
- What are San Francisco's next steps?

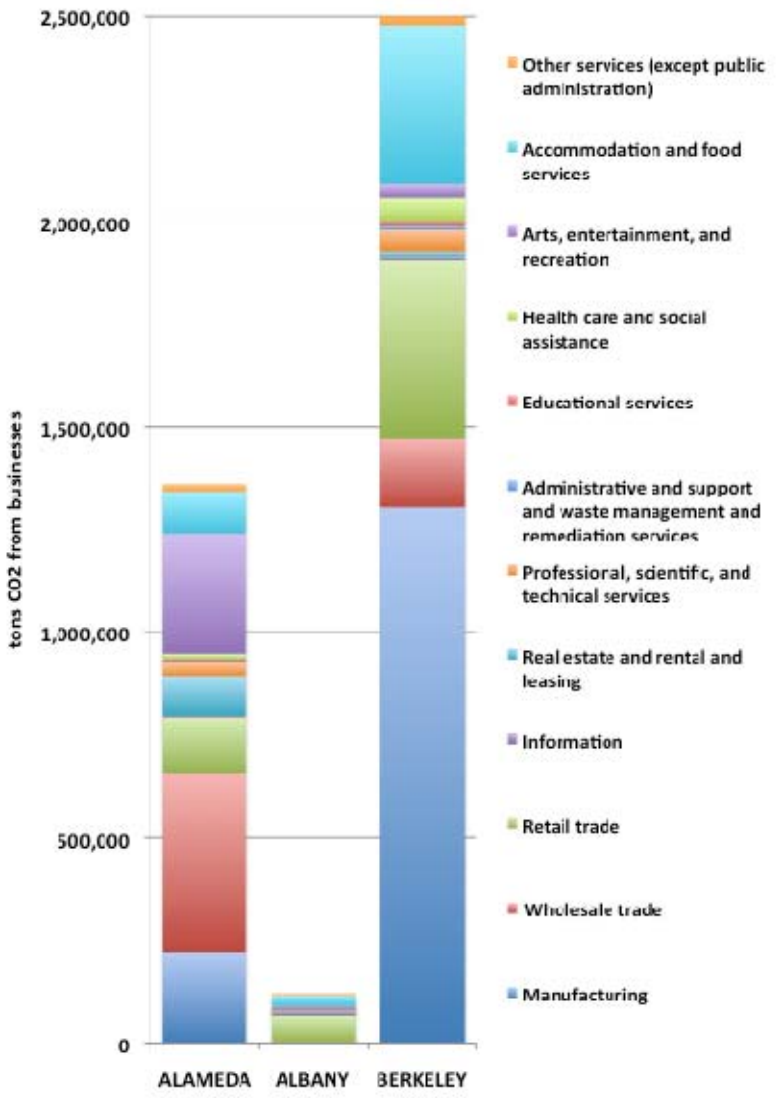
Cool Climate Model

Household Carbon Footprints
Berkeley, CA



Source: CoolClimate Network
coolclimate.berkeley.edu

Carbon footprint of businesses in 3 Bay Area cities



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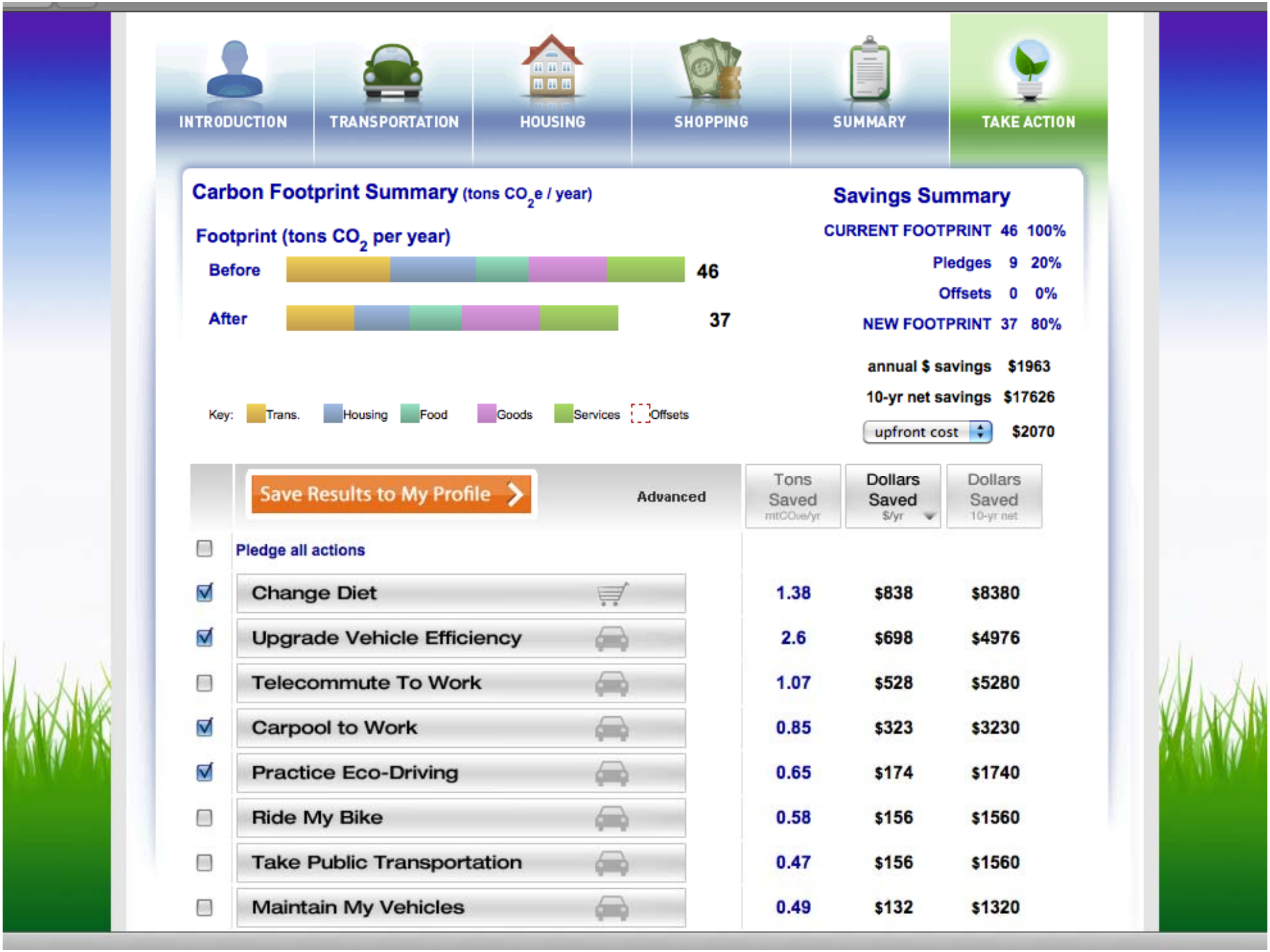
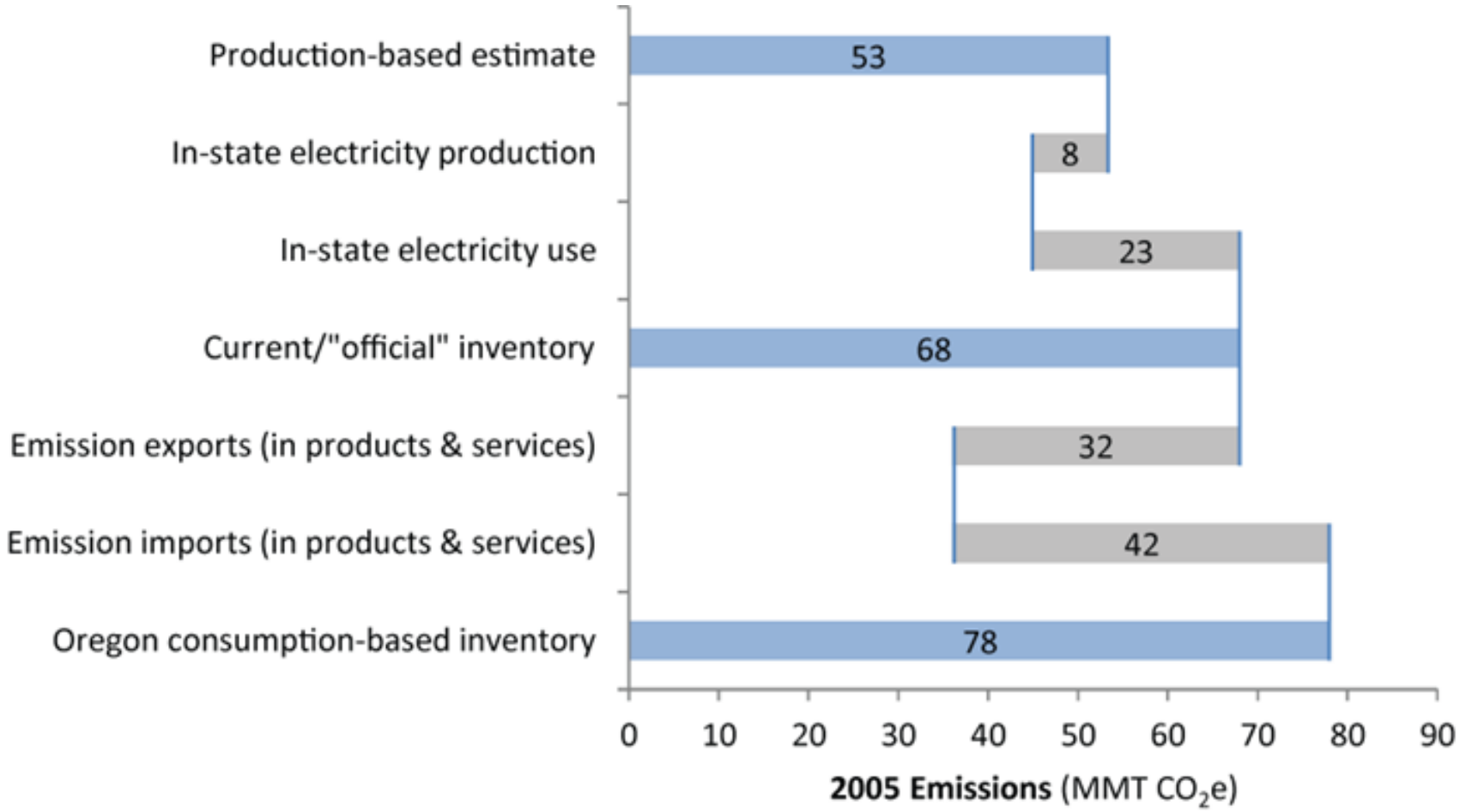
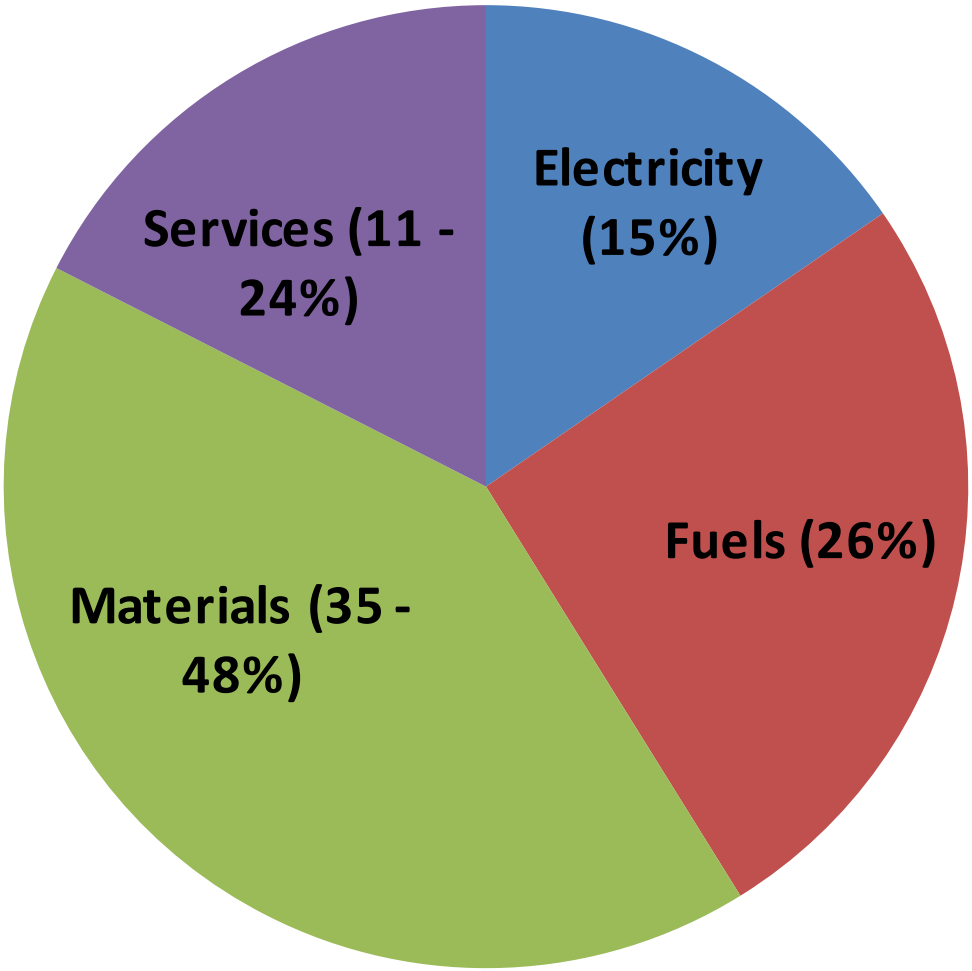

INTRODUCTION
TRANSPORTATION
HOUSING
SHOPPING
SUMMARY
TAKE ACTION
Carbon Footprint Summary (tons CO2e / year)
Footprint (tons CO2 per year)
Before
46
After
37
Key: Trans. Housing Food Goods Services Offsets
Savings Summary
CURRENT FOOTPRINT 46 100%
Pledges 9 20%
Offsets 0 0%
NEW FOOTPRINT 37 80%
annual $ savings $1963
10-yr net savings $17626
upfront cost $2070
Save Results to My Profile
Advanced
Tons Saved mtCO2e/yr
Dollars Saved $/yr
Dollars Saved 10-yr net
Pledge all actions
Change Diet 1.38 $838 $8380
Upgrade Vehicle Efficiency 2.6 $698 $4976
Telecommute To Work 1.07 $528 $5280
Carpool to Work 0.85 $323 $3230
Practice Eco-Driving 0.65 $174 $1740
Ride My Bike 0.58 $156 $1560
Take Public Transportation 0.47 $156 $1560
Maintain My Vehicles 0.49 $132 $1320

Oregon Consumption-Based Greenhouse Gas Emissions Inventory

The Big Picture: Oregon's Consumption-Based GHG Emissions (2005)



Emissions by Major Category of Consumption ("Final Demand")



Emissions Intensities and Rebound Effects

- Emissions intensity: emissions per dollar spent.
- Rebound effect: response to financial savings resulting from resource conservation . . . money is still spent, albeit it possibly someplace else.
- Understanding *emissions intensities* leads to better understanding potential *rebound effects*.

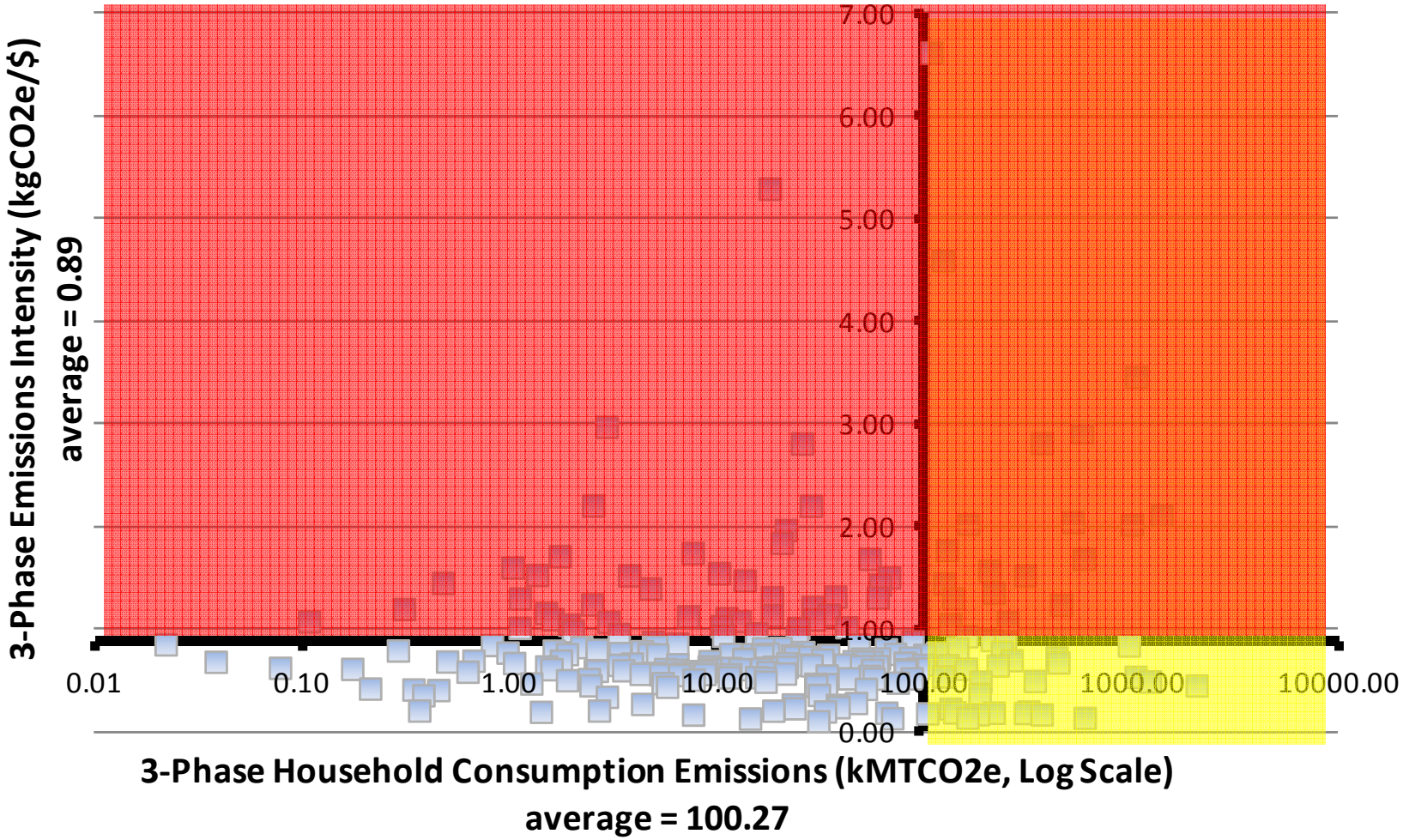
Emissions Intensities

Final Demand	LCA Emissions Intensities (kg CO2e/2005$)
Materials	0.5 – 0.6
Electricity	6.9
Fuel	5.8
Services	0.1 - 0.2

More Emissions Intensities

Categories	LCA Pre-purchase Emissions Intensities (kg CO2e/2006$)
Transportation services	1.6
Clothing	1.1
Food and beverages	0.9
Appliances	0.7
Electronics	0.6
Furnishings and supplies	0.5
Construction	0.4
Services	0.2

Emissions vs. Emissions Intensities, Selected Household Commodities

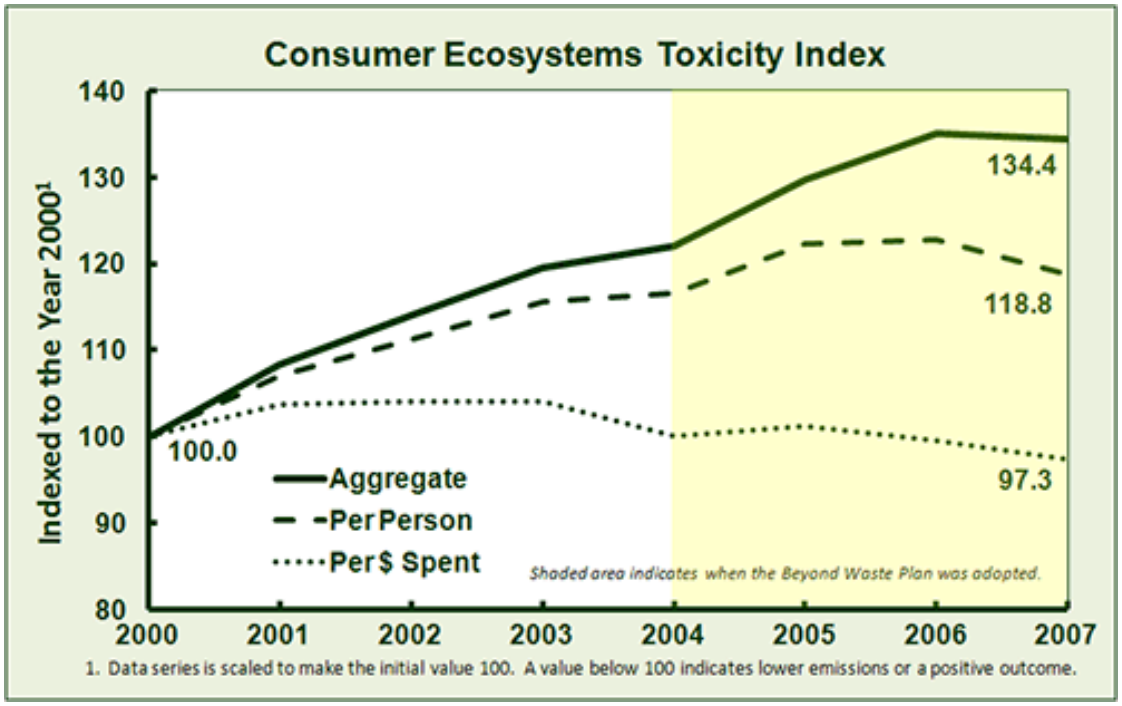


Recent and Next Steps

- Published reports
- Informing DEQ's 2050 Materials Management Vision project
- Developing screening tool to identify "high-carbon" categories of government purchasing
- Update emissions estimate every 5 years?
- Co-publish with conventional inventory?
- Evaluate expanding to other impact categories (like Washington CEI).

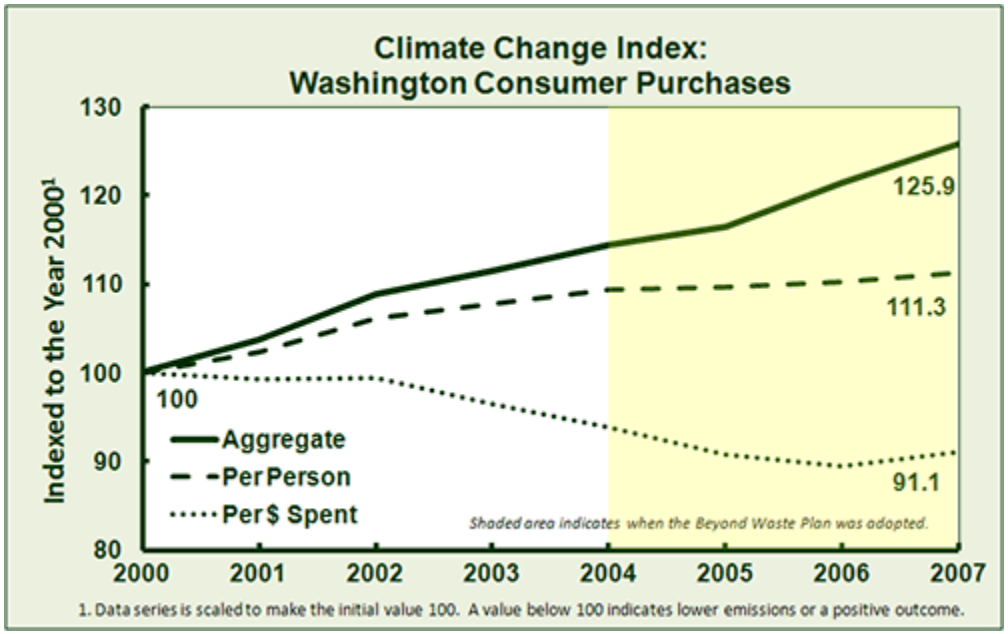
Washington Department of Ecology Consumer Environmental Index (CEI)

WA CEI Results: Consumer Impacts
Ecosystem toxicity trends over time



www.ecy.wa.gov/beyondwaste/bwprogMRW.html

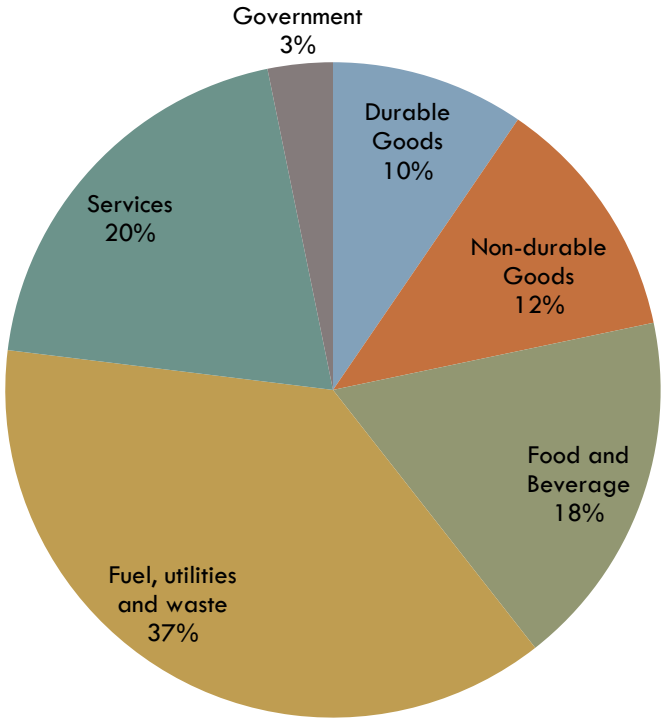
WA CEI Results: Consumer Impacts GHG trends over time



www.ecy.wa.gov/beyondwaste/bwprogMeasure.html

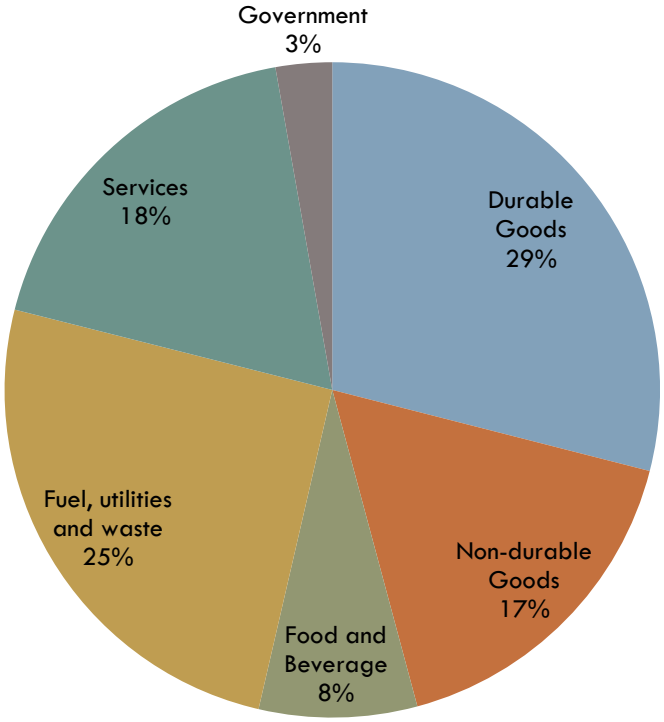
Breakdown of 2007 WA CEI Inventory

Upstream GHG Impacts per category



2007 Total metric tons of CO2 equivalents
Upstream Phase: 96,730,000 (78.3%)
Use Phase: 26,702,000 (21.6%)
Disposal Phase: 141,000 (0.11%)
Total Life Cycle: 123,600,000

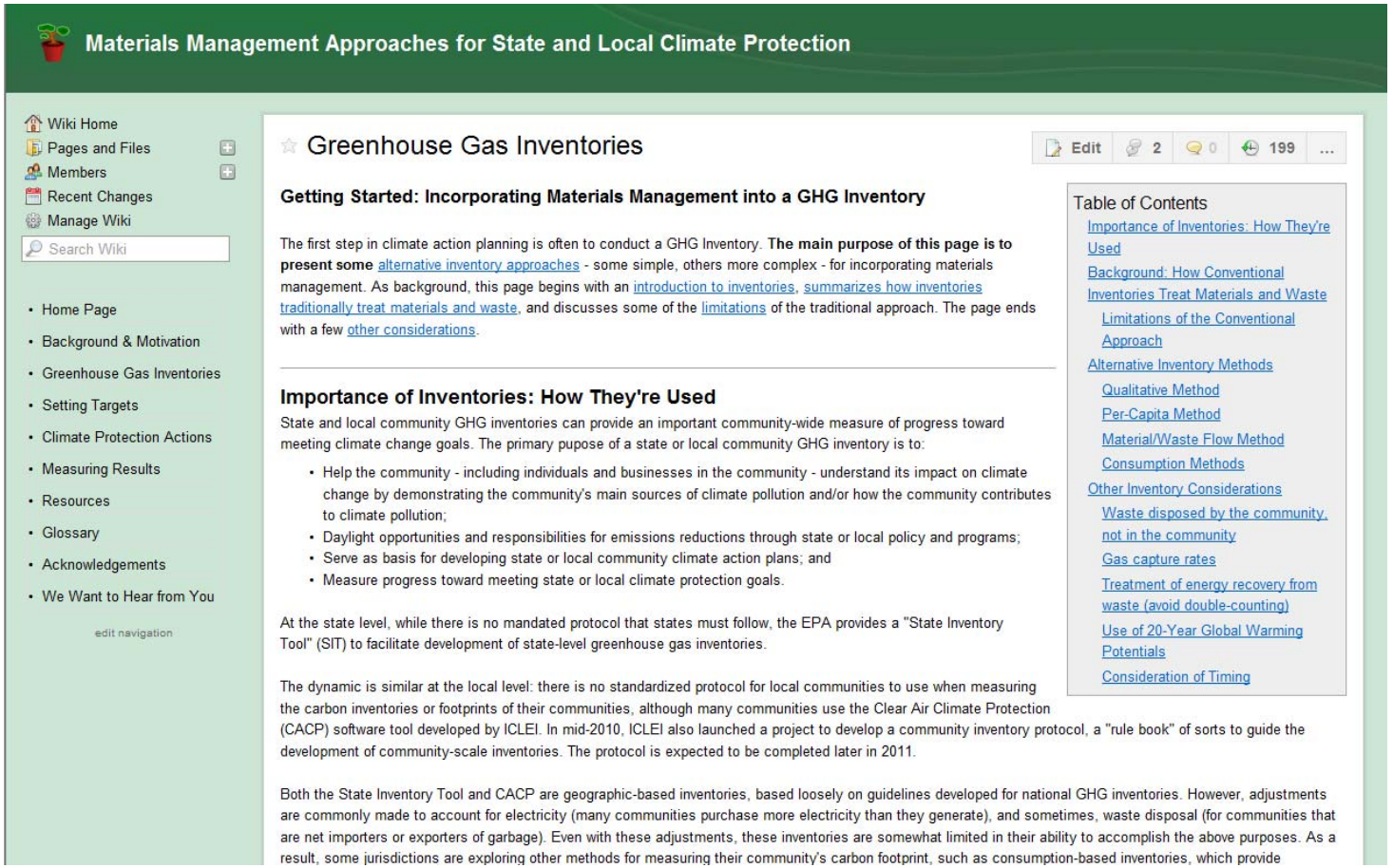
Upstream Ecosystems Toxicity Impacts per category



2007 Total metric tons of 2,4-D equivalents
Upstream Phase:1,492,000 (97.8%)
Use Phase: 30,900 (2.02%)
Disposal Phase: 3,300 (0.28%)
Total Life Cycle: 1,526,000

Additional Resources

- West Coast Forum's Materials Management Toolkit: Inventory Page: http://captoolkit.wikispaces.com/Greenhouse+Gas+Inventories



Materials Management Approaches for State and Local Climate Protection

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Greenhouse Gas Inventories

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Getting Started: Incorporating Materials Management into a GHG Inventory

The first step in climate action planning is often to conduct a GHG Inventory. **The main purpose of this page is to present some** alternative inventory approaches - some simple, others more complex - for incorporating materials management. As background, this page begins with an introduction to inventories, summarizes how inventories traditionally treat materials and waste, and discusses some of the limitations of the traditional approach. The page ends with a few other considerations.

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Importance of Inventories: How They're Used

State and local community GHG inventories can provide an important community-wide measure of progress toward meeting climate change goals. The primary pupose of a state or local community GHG inventory is to:

- Help the community - including individuals and businesses in the community - understand its impact on climate change by demonstrating the community's main sources of climate pollution and/or how the community contributes to climate pollution;
- Daylight opportunities and responsibilities for emissions reductions through state or local policy and programs;
- Serve as basis for developing state or local community climate action plans; and
- Measure progress toward meeting state or local climate protection goals.

At the state level, while there is no mandated protocol that states must follow, the EPA provides a "State Inventory Tool" (SIT) to facilitate development of state-level greenhouse gas inventories.

The dynamic is similar at the local level: there is no standardized protocol for local communities to use when measuring the carbon inventories or footprints of their communities, although many communities use the Clear Air Climate Protection (CACP) software tool developed by ICLEI. In mid-2010, ICLEI also launched a project to develop a community inventory protocol, a "rule book" of sorts to guide the development of community-scale inventories. The protocol is expected to be completed later in 2011.

Both the State Inventory Tool and CACP are geographic-based inventories, based loosely on guidelines developed for national GHG inventories. However, adjustments are commonly made to account for electricity (many communities purchase more electricity than they generate), and sometimes, waste disposal (for communities that are net importers or exporters of garbage). Even with these adjustments, these inventories are somewhat limited in their ability to accomplish the above purposes. As a result, some jurisdictions are exploring other methods for measuring their community's carbon footprint, such as consumption-based inventories, which provide

Questions and Discussion