Bay Area Consumption-Based Greenhouse Gas Emissions Inventory

Climate Protection Committee
November 19, 2015

David Burch
Principal Environmental Planner
Overview

- Description of consumption-based GHG inventory
- Methodology
- Results / Findings
- Potential uses
- Policy implications
What is a Consumption-Based Inventory?

- Conventional emissions inventory focuses on economic output: emissions from goods & services produced in a given area.
- Consumption-based emissions inventory (CBEI) estimates GHG emissions embedded in goods & services consumed by people residing within a given area.
- CBEI attributes all emissions to the end user/consumer.
  - Regardless of where goods & services are produced.
- CBEI includes full life-cycle emissions for each product or service:
  - Production: extraction, processing, production & shipping
  - Use
  - Disposal / recycling
- Deliverables: inventory tables & graphs at regional & city scale
  - Maps showing GHG footprint at fine-grained local scale
Why develop a CBEI?

• Production-based inventory does not tell the whole story
• Modern economy is highly integrated, national & global in scale
• Major portion of goods & services are imported to region
• Quantify and account for (indirect) emissions that we generate beyond our boundaries
• Provide a more complete analysis of our true GHG footprint
• Especially relevant in affluent areas (like Bay Area) where:
  - High consumption of goods & services
  - Economic output is dominated by service & information sectors
  - Limited production of heavy-duty goods with high GHG content
Potential Uses of CBEI

• Inform our Regional Climate Protection Strategy
• Identify potential GHG reduction policies
• Assist climate planning in local cities
• Help Bay Area residents reduce their GHG footprint
• Compare Bay Area GHG footprint to other areas
CBEI Methodology

• Collaboration with UC Berkeley Energy Resources Group:
  - Cool Climate Network - Chris Jones, PhD. http://coolclimate.berkeley.edu/

• Bottom-up approach: Start at household level & scale up

• Follow the money: Develop an expenditure profile for average household in each US Census Block Group in the Bay Area

• Apply appropriate emissions factor for each type of good or service:
  - $$ (by expenditure type) \times \text{GHG emission factor} = \text{GHG emissions}$$

• Emission factors include full life-cycle emissions for each product:
  - Key source: Comprehensive Environmental Data Archive
  - Used Bay Area-specific data & emissions factors whenever available
Major Expenditure Categories

**Transportation:**
- Motor vehicle production
- Vehicle maintenance
- Motor vehicle fuel consumption
- Public transportation
- Air travel

**Housing:**
- Construction
- Maintenance
- Residential energy use
- Water
- Waste

**Food:**
- Grains & cereals
- Fruits & vegetables
- Dairy
- Meat
- Other

**Goods:**
- Clothing
- Furniture & appliances
- Personal care products
- Books, newspapers, CDs

**Services:**
- Health care
- Education
- Financial services
- Communication
- Entertainment
Example for Automobile

Upstream

Individual Parts
Production, including upstream emissions for each part

Vehicle Assembly

Shipping to Dealer

In-Use

Fuel Consumption
• Fuel economy
• Fuel type
• Driving conditions

Vehicle Maintenance

Downstream

Landfill

Recycling / re-use (credit)

Upstream emissions from refining gasoline
Cool Climate Network model includes 30+ factors
But six factors account for 92% of variation in GHG footprint:

- household size (# people)
- size of home (square footage of dwelling unit)
- population density of neighborhood
- carbon intensity of electricity
- vehicle ownership rate
- household income
• Household income has strong influence on emissions related to transportation, goods, and services

• Lower income households spend larger portion of income on basics of food & shelter (housing)

• As income increases, people spend more on discretionary goods & services
US Average Household GHG Footprint

Average 49.8 metric tons CO₂e per household

Blue = direct emissions
Green = indirect emissions

Transportation  Housing  Food  Goods  Services

COMPOSTING
RECYCLING

-5  0  5  10  15  20
METRIC TONS CO2E PER HOUSEHOLD

Average Household Carbon Footprint

-5  0  5  10  15  20
METRIC TONS CO2E PER HOUSEHOLD
California Average Household GHG Footprint

Average 45.7 metric tons CO₂e per household

Blue = direct emissions
Green = indirect emissions

Transportation  Housing  Food  Goods  Services
SF Bay Area Average Household GHG Footprint

Average 44.3 metric tons CO₂e per household

Blue = direct emissions
Green = indirect emissions

Transportation | Housing | Food | Goods | Services

- AIRTRAVEL
- MOTOR VEHICLE MFG. & REPAIRS
- VEHICLE FUEL PRODUCTION
- VEHICLE FUEL DIRECT
  - CONSTRUCTION
  - WASTE
  - ENERGY-INDIRECT
  - ELECTRICITY
  - NATURAL GAS
- CEREALS
- FRUITS/VEGGIES
- OTHER FOOD
- DAIRY
- MEAT
- OTHER GOODS
  - HOME FURNISHING & LARGE APPLIANCES
  - CLOTHING
  - SMALL APPLIANCES & ENTERTAINMENT EQUIP.
- SERVICES
- COMPOSTING
- RECYCLING
Example: Transportation Emissions

• Motor vehicle travel accounts for the largest slice of GHG footprint

  Key Factors:
  - Residential location
  - Household size
  - Household income
  - Access to transit
  - Vehicle ownership rate
  - Trip length
  - Mode choice
  - Discretionary travel

• Need to reduce vehicle emissions, decarbonize transportation sector
• To reduce motor vehicle travel, residential density is necessary, but not sufficient. Housing must be well-served by transit & close to shopping & services
• Reducing motor vehicle travel will also reduce upstream emissions from oil refining
• Air travel is also a major contributor to transportation GHG - air travel is directly correlated with household income
Household GHG Emissions from Transportation by Block Group
Bay Area GHG Footprint

- CBEI is ~ 35% larger than production-based inventory
- GHG footprint is generally lower in urban core areas
  - smaller homes, lower vehicle ownership rate, better transit
- Variation between block groups: ratio of seven to one
- Variation between cities: ratio of three to one
- Less variation between counties:
  - average annual GHG footprint ranges from 39 to 49 metric tons per household
Average Carbon Footprint for Cities in Alameda & Contra Costa Counties
Key Points

- Consumption-based inventory complements production-based inventory; provides a more complete picture of our GHG impact.
- GHG inventory larger when analyzed from consumption perspective.
- CBEI can help to inform climate planning at regional & local scale - identify most promising opportunities for GHG reduction.
- Should consider local variation in size & composition of GHG footprint in designing GHG reduction strategies.
- CBEI findings may be most useful for public education.
Questions or Comments?
### ICLEI GHG Inventory Protocol: Appendix I: Consumption-Based Emissions (October 2012)

<table>
<thead>
<tr>
<th>Entity</th>
<th>Year</th>
<th>Scale / Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kings County, WA (Seattle)</td>
<td>2008</td>
<td>County-wide</td>
</tr>
<tr>
<td>State of Oregon, Dept of Environmental Quality</td>
<td>2010</td>
<td>Statewide</td>
</tr>
<tr>
<td>City &amp; County of San Francisco</td>
<td>2011</td>
<td>City-wide</td>
</tr>
<tr>
<td>New York City</td>
<td>2013</td>
<td>Zip code</td>
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</table>
California Air Resources Board Draft
Short-Lived Climate Pollutant Strategy

Climate Protection Committee
November 19, 2015

Abby Young
Manager, Climate Protection Program
The California Air Resources Board (ARB) is preparing a strategy to significantly reduce emissions of “short-lived climate pollutants” (SLCPs):

• One of Governor Brown’s five “Pillars” for achieving 80% reduction in greenhouse gas emissions (GHGs) by 2050
• SB 605 (Lara, 2014) directs ARB to develop a SLCP reduction strategy by the end of 2015
• Coordination with Air District’s own process to develop a strategy addressing SLCPs in the Regional Climate Protection Strategy
What Are Short-lived Climate Pollutants?

Characteristics:

• Remain in atmosphere much less time than other climate pollutants like $\text{CO}_2$
• Have high heat-trapping ability (global warming potential, or GWP)

Pollutants:

• Methane
• Black carbon
• Fluorinated gases
  – Human-made (no natural sources)
  – Some were introduced as substitutes for ozone-depleting substances
Why SLCPs are Important

According to the Air Resources Board, significantly reducing emissions of SLCPs by 2030 can:

• Cut global warming in half by 2050
• Reduce warming in the Arctic by two-thirds by 2040
• Slow the rate of sea level rise by 24 – 50%
• Increase the chances of keeping average warming below $2^\circ$C to greater than 90% by 2050

Reducing statewide emissions of SLCPs is one of Governor Brown’s five “Pillars” of climate action.
The Climate Warming Impact of SLCPs

From ARB’s *Draft Short-lived Climate Pollutant Strategy, 2015*:

Table 4: Global Warming Potential for SLCPs

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Lifetime (years)</th>
<th>20-year GWP*</th>
<th>100-year GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>~100</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Methane</td>
<td>12</td>
<td>72</td>
<td>34</td>
</tr>
<tr>
<td>Fluorinated Gases</td>
<td>1.4 – 52</td>
<td>437 – 6,350</td>
<td>124 – 3,500</td>
</tr>
<tr>
<td>Black Carbon</td>
<td>Days to weeks</td>
<td>3,200</td>
<td>900</td>
</tr>
</tbody>
</table>

*The use of a 20-year GWP time horizon better captures the importance of SLCPs and gives a better perspective on the speed at which SLCP emission controls will impact the atmosphere relative to CO₂ emission controls.*
SLCPs in the Bay Area
GHG Inventory

100 Year Timeframe

- High global warming potential (GWP) gases
  - 3.7% Nitrous oxide ($N_2O$)
  - 2.1% Carbon dioxide ($CO_2$)

- Methane ($CH_4$): 6.9%

20 Year Timeframe

- High global warming potential (GWP) gases
  - 6.6% Nitrous oxide ($N_2O$)
  - 1.7% Carbon dioxide ($CO_2$)

- Methane ($CH_4$): 15.1%

Carbon dioxide ($CO_2$): 76.6%
Sources in the Bay Area

Bay Area Methane Emissions by Source

- Transportation: 27%
- Electricity/Co-Generation: 16%
- Com/Res Fuel Use: 3%
- Industrial: 2%
- Recycling & Waste: 1%
- Agriculture: 1%

Bay Area HFC Emissions by Source

- Refrigerants/AC in commercial bldgs: 50%
- Refrigerants/AC in residential bldgs: 13%
- Refrigerants/AC in industry: 19%
- Refrigerants/AC in transportation: 10%
- Aerosol propellants: 7%

Bay Area Black Carbon Emissions by Source

- Transportation: 42%
- Electricity: 18%
- Residential fuel use: 12%
- Commerical fuel use: 9%
- Industry: 10%
- Agriculture: 7%
- Recycling/waste: 1%
Reducing Methane:
• California has strongest standards in the nation for limiting emissions from landfills; Air District assists ARB with enforcement
• Cap-and-Trade offset protocols to encourage methane reduction
• Rule-making underway to limit methane leaks from the natural gas pipeline system and oil & gas wells

Reducing Black Carbon:
• California human-caused emissions have been reduced 90% since 1960
• Regulations & incentives addressing diesel fuel and engines
• Air District wood smoke rule

Reducing Fluorinated Gases:
• Current ARB regulations will cut emissions 25% below projected levels by 2020
• Air District collaborating with ARB to enforce regulations on semi-conductor manufacturing and non-motor vehicle air-conditioning
ARB’s SLCP Reduction Targets

California SLCP Emissions & Proposed Reduction Targets

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Baseline</th>
<th>Forecast</th>
<th>Year 2030 Targets</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Year 2013</td>
<td>Year 2030</td>
<td>Tons</td>
</tr>
<tr>
<td>Black Carbon</td>
<td>38</td>
<td>26</td>
<td>19</td>
</tr>
<tr>
<td>Methane</td>
<td>118</td>
<td>117</td>
<td>71</td>
</tr>
<tr>
<td>F-gases</td>
<td>40</td>
<td>65</td>
<td>24</td>
</tr>
</tbody>
</table>

- In MMT CO$_2$e based on 20-year GWP
- “Forecast” includes anticipated reductions from implementation of current regulations

“The science unequivocally underscores the need to immediately reduce emissions of Short-lived Climate Pollutants (SLCPs)...cutting emissions of SLCPs can immediately slow global warming and reduce the impacts of climate change.”

-- ARB’s Draft Short-lived Climate Pollutant Reduction Strategy
ARB’s Reduction Strategy

Driving Principles:

• Prioritize actions with diverse benefits
• Put organic waste to beneficial use
• Identify practical solutions to overcome barriers
• Invest in SLCP emission reductions and communities
• Advance the science of SLCP sources and emissions
ARB’s Reduction Strategy

**METHANE (reduce 46 MMT CO2e)**

- **Dairy Manure 46%**
  - Monitor voluntary progress with additional regulation as backstop
  - Regulate new dairies (require best practices)
  - Build markets for soil amendment
  - Enable pipeline injection of dairy biogas
  - Explore incentives & regulation to capture and use methane at wastewater treatment facilities

- **Oil & Gas 17%**
  - Complete rule-making on oil & gas production, processing & storage

- **Wastewater, Industrial, other 15%**
  - Complete rule-making with CPUC to reduce leaks from natural gas pipelines
  - Enable pipeline injection of biogas

- **Landfill 11%**
  - Eliminate disposal of organics in landfills by 2025
  - Funding for buildout of 100+ new/expanded facilities to process and reuse organic waste
  - Facilitate permitting for new organics facilities

- **Enteric Fermentation 11%**
  - Increase milk production efficiency
  - Improve understanding of methane emissions in California

**Funding for buildout of 100+ new/expanded facilities to process and reuse organic waste**

**Enable pipeline injection of biogas**

**$500 million over 5 years needed in grants, loans, incentives**
ARB’s Reduction Strategy

- **Fireplace & Woodstove Conversion 43%**
- **Sustainable Freight Strategy 19%**
- **Clean Energy Goals 19%**
- **State Implementation Plans 19%**
- **Forest-related Sources ??%**

**State policies:**
- Low Carbon Fuel Standard
- Cap & Trade
- Renewable Portfolios Standard
- Federal Clean Power Plan

**Support development of zero and near-zero emission technologies**

**Provide incentives for woodstove replacements**

**Work with air districts to expand wood smoke policies**

**Statewide Forest Carbon Plan in development**

**Increase fuel reduction efforts:**
- prescribed burns, mechanical thinning, grazing
- Create markets for bioenergy and biofuels

**SIP for South Coast will reduce BC emission from on- and off-road vehicles**

**BLACK CARBON**
(reduce 7 MMT CO2e)
ARBG’s Reduction Strategy

- **HFC Supply Phasedown 56%**
  - Support international agreement to phase-down HFCs

- **FLOURINATED GASES**
  - (reduce 41 MMT CO2e)

- **Ban High-GWP Equipment 37%**
  - Prohibit the use of high-GWP refrigerants in new residential, commercial & industrial equipment

- **Low-GWP Refrigeration 5%**
  - Loan/grant incentive program to buy-down cost of converting to low-GWP refrigeration
  - Potentially partner with air districts on incentive program

- **Ban Sales of High GWP Refrigerants 2%**
  - Prohibit sale of refrigerants with very high GWP values (2,500+)

- **Require sale of only ARB-compliant equipment**
  (enforced through manufacturer, not end-user)
“Local Air Districts have a key role to play...”

• Continue collaboration with ARB in rule development and enforcement

• Work with local governments to include measurement, tracking and policies for reducing SLCPs in local climate action plans

• Include specific SLCP reduction measures in the 2016 Clean Air Plan / Regional Climate Protection Strategy

• Explore new source categories, approaches and partnerships for reducing SLCPs in the Bay Area
  - Soil carbon sequestration in rangelands