Bay Area Air Quality Management District
Consumption-based Regional GHG Emissions Inventory

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Agenda

1. Project Overview
2. Methods
3. Results
4. Maps Demonstration
5. Discussion
1. Project Overview

Goals

• Develop a regional consumption-based GHG inventory to help inform development of Air District’s Regional Climate Protection Strategy.

• Provide guidance to Bay Area cities and counties on the size, composition and driving factors of household carbon footprints at neighborhood scale.

• Use local data whenever possible

• Compare consumption-based to conventional approach

• Create results for every city and county

Output

- Excel spreadsheet model
- Maps
- Excel lookup tool
- Technical paper
- Summary report
Consumption-based GHG Inventories

- Allocate all global GHG emissions to end users, regardless of where emissions were produced

- End users includes households and government

- Include emissions from all forms of consumption: transportation, energy, home construction, water, waste, food, goods, and services.

- Follow money to show how households allocate their spending among the universe of goods & services
Six factors account for 93% of variation in carbon footprints

**Table 3. Summary statistics of model results for all zip codes in the full dataset, principal cities (cores) and suburbs**

<table>
<thead>
<tr>
<th></th>
<th>all</th>
<th>cores</th>
<th>suburbs</th>
</tr>
</thead>
<tbody>
<tr>
<td># vehicles</td>
<td>0.338</td>
<td>0.183</td>
<td>0.310</td>
</tr>
<tr>
<td>annual hh income</td>
<td>0.499</td>
<td>0.476</td>
<td>0.500</td>
</tr>
<tr>
<td>gCO2/kWh</td>
<td>0.271</td>
<td>0.255</td>
<td>0.288</td>
</tr>
<tr>
<td># rooms</td>
<td>0.202</td>
<td>0.242</td>
<td>0.221</td>
</tr>
<tr>
<td>ln persons per hh</td>
<td>0.179</td>
<td>0.255</td>
<td>0.154</td>
</tr>
<tr>
<td>log pop. density</td>
<td>-0.126</td>
<td>-0.084</td>
<td>-0.123</td>
</tr>
<tr>
<td>adj. R-sq</td>
<td>0.925</td>
<td>0.962</td>
<td>0.946</td>
</tr>
</tbody>
</table>

Source: Jones and Kammen 2014
Carbon footprint of average U.S. household
50 metric tons carbon dioxide equivalents (CO₂e) per year

source: coolclimate.berkeley.edu
Carbon footprint of average California household
47 metric tons CO$_2$e per year
source: coolclimate.berkeley.edu
Methods
Transportation: motor vehicles

Motor Vehicles
- SF Bay Area respondents in National Household Travel Survey
  - Key variables: Vehicle ownership, household size, income, commute time, commute mode...
- Fuel Economy by County
- Vehicle production: 56 kg CO2e/mile
- Vehicle maintenance

Air Travel
- Estimate miles based on household size and income
- GHG emission factors for fuel and atmospheric effects

Public transit
- Allocate all emissions from transit systems evenly to household in counties served
Methods
Electricity, Natural Gas, Other Fuel

1. Utility data by zip code

2. Modified or each census block group by key factors: income, home size, home type, heating degree days, etc.

3. GHG emission factors from each electric utility
Methods: Goods & Services

1. Estimate consumption of ~25 categories of goods and services based on income and household size

2. GHG emission factors (CEDA database)

Table 7. Goods and Services categories and weighted GHG-intensity from CEDA Version 4

<table>
<thead>
<tr>
<th>Consumption Category</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clothing</td>
<td>750</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Furnishings, appliances, other household items</td>
<td>614</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Other goods (sum of below)</td>
<td>971</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Healthcare products</td>
<td>696</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Electronics &amp; entertainment equipment</td>
<td>1,279</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Paper products</td>
<td>2,100</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Personal care &amp; cleaning</td>
<td>954</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Auto parts</td>
<td>558</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Services (sum of below)</td>
<td>507</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Vehicle repair</td>
<td>433</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Household maintenance and repair</td>
<td>134</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Education</td>
<td>1,065</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Health care</td>
<td>1,151</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Personal business and finances</td>
<td>197</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Entertainment &amp; recreation</td>
<td>711</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Information and communication</td>
<td>291</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Organizations and charity</td>
<td>122</td>
<td>gCO2e/$(2005)</td>
</tr>
<tr>
<td>Miscellaneous services</td>
<td>720</td>
<td>gCO2e/$(2005)</td>
</tr>
</tbody>
</table>
3. Results
CITY OF ATHERTON

85.2 tCO2e / household × 2,281 Households = 194,438 Metric tons CO2e

Average Household Carbon Footprint

- Transportation
  - Air Travel
  - Motor Vehicle MFG. & Repairs
  - Vehicle Fuel
  - Natural Gas
  - Construction
- Housing
  - Waste
  - Energy-Indirect
  - Electricity
- Food
  - Cereals
  - Small Appliances & Entertainment Equip.
  - Other Food
  - Dairy
  - Meat
- Goods
  - Other Goods
  - Home Furnishing & Large Appliances
  - Clothing
  - Small Appliances & Entertainment Equip.
- Services
  - Other Goods
  - Home Furnishing & Large Appliances
  - Clothing
  - Small Appliances & Entertainment Equip.
  - Services
- Composting
- Recycling
Average Household Carbon Footprint

CITY OF EMERYVILLE

30.5 tCO2e / household ÷ 15,010 Households = 458,288 Metric tons CO2e
### Comparison of Territorial and Consumption-Based GHG Inventories

<table>
<thead>
<tr>
<th>Sector</th>
<th>% of total</th>
<th>MMTCO2e</th>
<th>Sector</th>
<th>% of total</th>
<th>MMTCO2e</th>
<th>B / A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation &amp; off-road equipment</td>
<td>39%</td>
<td>34.8</td>
<td>Transportation</td>
<td>33%</td>
<td>37.1</td>
<td>1.07</td>
</tr>
<tr>
<td>Residential fuel usage</td>
<td>8%</td>
<td>6.7</td>
<td>Natural Gas &amp; other heating fuels</td>
<td>5%</td>
<td>5.4</td>
<td>0.80</td>
</tr>
<tr>
<td>Electricity / Co-generation</td>
<td>15%</td>
<td>13.0</td>
<td>Electricity</td>
<td>2%</td>
<td>2.5</td>
<td>0.19</td>
</tr>
<tr>
<td>Industrial / Commercial</td>
<td>35%</td>
<td>30.9</td>
<td>Goods, Services, water, construction, indirect energy</td>
<td>40%</td>
<td>45.2</td>
<td>1.46</td>
</tr>
<tr>
<td>Agriculture</td>
<td>1%</td>
<td>1.3</td>
<td>Food</td>
<td>19%</td>
<td>21.7</td>
<td>17.07</td>
</tr>
<tr>
<td>Recycling &amp; Waste</td>
<td>2%</td>
<td>1.5</td>
<td>Waste &amp; Composting</td>
<td>1%</td>
<td>0.7</td>
<td>0.46</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>88.2</strong></td>
<td><strong>Total tCO2e/HH</strong></td>
<td><strong>100%</strong></td>
<td><strong>112.6</strong></td>
<td><strong>1.28</strong></td>
</tr>
</tbody>
</table>
Potential policy implications

1. Focus more on vehicles, food and consumption, and less on electricity

2. Electrification: need local and state policies to support electrification of vehicles and heating (including phasing out gas heating)

3. Urban infill: Maps should help identify locations for priority infill development

4. Social marketing: community-based programs should target specific population segments within cities
Future potential research

2. Updates every five years
3. Identify high priority locations for infill development
1. Online tools
Contacts

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Supporting Information
Methods
Transportation: Public Transit

1. Collect fuel consumption from transit authorities

2. Allocate emissions evenly to residents of counties served by each system
Methods: Water

Water

– 10-region California GHG-intensity model
– 70 gallons per person per day for indoor purposes
– 130 gallons per person per day for outdoor purposes (20% less than CA avg.)
– 66 kgCO2e per person per year
Methods: Waste

1. CalRecycle waste characterization study for each county

2. GHG emission factors from ARB and EPA
Methods: Food

1. Caloric consumption (by ~10 food groups) for average American adult and child
2. Reduce by 10% to account for SF diet
3. Apply GHG emission factors per calorie (CEDA database)
4. Apply to census block groups based on household size
CITY OF OAKLAND

Average Household Carbon Footprint

METRIC TONS CO2e PER HOUSEHOLD

Transportation

- AIRTRAVEL
- MOTOR VEHICLE
- MFG. & REPAIRS
  - VEHICLE FUEL
    - NATURAL GAS
    - ELECTRICITY
    - ENERGY INDIRECT
    - WASTE

Housing

- CONSTRUCTION

Food

- CEREALS
- FRUITS/VEGGIES
- OTHER FOOD
  - DAIRY
  - MEAT
  - MEAT

Goods

- OTHER GOODS
  - HOME FURNISHING
  - LARGE APPLIANCES
  - CLOTHING
  - SMALL APPLIANCES
  - ENTERTAINMENT EQUIP.

Services

- SERVICES

Other

- COMPOSTING
- RECYCLING

METRIC TONS CO2e

37.0 tCO2e / household × 147,986 Households = 5,473,084 Metric tons CO2e
38.5 tCO2e / household \times 345,344 Households = 13,282,997 Metric tons CO2e
CITY OF SAN JOSE

The average household carbon footprint is 46.6 tCO2e. This is calculated by multiplying the metric tons CO2e per household by the number of households. In this case, it is 46.6 tCO2e/household \times 314,615 households = 14,662,199 metric tons CO2e.