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Overview

- Characterize the magnitude of growth in transportation GHG emissions, based on data from EPA *Inventory of U.S. Greenhouse Gas Emissions and Sinks*
- Discuss factors affecting the rise in transportation GHGs
- Sources of uncertainty in the *Inventory* transportation estimates
- Recent methodological improvements
Inventory of U.S. GHG Emissions and Sinks – Institutional Responsibilities

- Prepared annually by EPA under United Nations Framework Convention on Climate Change (UNFCCC)
- Coordinated by EPA Office of Atmospheric Programs (OAP)
- Includes transportation estimates developed by EPA Office of Transportation and Air Quality (OTAQ)
- Relies extensively on data provided by the Energy Information Administration (EIA) of the U.S. Department of Energy
Inventory of GHG Emissions and Sinks – Document Organization

- GHG data are oriented around specific gases (CO$_2$, CH$_4$, N$_2$O, HFCs)
  - UNFCCC guidelines also require presentation of GHG data by broad categories (fossil fuel combustion, non-energy use of fuel, etc.)
  - Primary value to climate specialists
- EPA disaggregates estimates by economic sector, relying heavily on EIA estimates for CO2 emissions
- OTAQ further disaggregates transportation GHG estimates by mode (passenger cars, light-duty trucks, heavy-duty trucks, aircraft, rail, ships/boats)
- OTAQ also generates bottom-up estimates of CH$_4$ and N$_2$O
Inventory estimates of Transportation GHGs

Includes
- Tailpipe emissions (from use of energy to power vehicles)
- HFCs from mobile air conditioners

Does not include
- Ozone-depleting substances, which are not counted in national totals
- Agriculture and construction equipment (generally represented in the industrial sector)
- International bunker fuels
- Lifecycle GHGs
U.S. GHG Emissions by Gas (Weighted by Global Warming Potential)

Transportation

- CO₂: 95.4%
- CH₄: 2.2%
- N₂O: 0.1%
- HFCs: 2.3%

All Sources

- CO₂: 93%
- CH₄: 1%
- N₂O: 2%
- HFCs: 2%
Stand-alone OTAQ Transportation GHG Report

- Released by OTAQ in March 2006 as a complement to the GHG Inventory
- Provides context for transportation GHGs
  - Lifecycle GHG estimates
  - Factors affecting emissions
  - Emerging issues

Available at http://www.epa.gov/otaq/greenhousegases.htm
Change in U.S. GHG Emissions by End-Use Economic Sector, 1990-2003

- Industry
- Agriculture
- Commercial
- Residential
- Transportation

Tg CO₂ Equiv.
Transportation GHGs up 24 percent
Non-transportation sectors cumulatively up 9.5 percent
Transportation accounted for over 27 percent of U.S. GHG emissions in 2003
Sources of U.S. Transportation GHG Emissions

- **Car**: 35% (61.7% of Light-Duty Vehicles)
- **Light-Duty Trucks**: 27%
- **Heavy-Duty Vehicles**: 18.4%
- **Aircraft**: 9.3%
- **Boats and Ships**: 3.1%
- **Rail**: 2.3%
- **Pipelines, Lubricants, and Refrigerants**: 3.1%
- **Motorcycles, Mobile AC**: 0.1%
- **Buses**: 0.5%
- **Aircraft**: 9.3%
- **Light-Duty Vehicles**: 61.7%

Light-Duty Vehicles account for 35% of total transportation emissions.
## Growth in Transportation GHGs by Source, 1990-2003

<table>
<thead>
<tr>
<th>Source</th>
<th>Change in GHGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light-Duty Vehicles</td>
<td>+19%</td>
</tr>
<tr>
<td>Passenger Cars</td>
<td>+2%</td>
</tr>
<tr>
<td>Light-Duty Trucks</td>
<td>+51%</td>
</tr>
<tr>
<td>Heavy-Duty Vehicles</td>
<td>+57%</td>
</tr>
<tr>
<td>Aircraft</td>
<td>-3%</td>
</tr>
<tr>
<td>Commercial Aircraft</td>
<td>+4.8%</td>
</tr>
</tbody>
</table>
Transportation GHG Emissions by Source, 1990-2003
## GHG Growth by Source: Impact of Activity and Vehicle Energy Efficiency

<table>
<thead>
<tr>
<th>Source</th>
<th>Change in Activity</th>
<th>Change in Energy Efficiency</th>
<th>Change in GHGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light-Duty Vehicles</td>
<td>+34%</td>
<td>Small increase in overall fuel economy- but <em>new</em> vehicle fuel economy has been declining</td>
<td>+19 %</td>
</tr>
<tr>
<td>Heavy-Duty Vehicles</td>
<td>+48%</td>
<td>Virtually unchanged</td>
<td>+57%</td>
</tr>
<tr>
<td>Commercial Aircraft</td>
<td>+48%</td>
<td>Significant improvement: aircraft becoming more fuel efficient, and greater passenger loads</td>
<td>4.8%</td>
</tr>
</tbody>
</table>
## Passenger versus Freight GHGs, 1990-2003

<table>
<thead>
<tr>
<th>Source</th>
<th>Change in Activity</th>
<th>Change in GHGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger</td>
<td>~36 % increase</td>
<td>+20 %</td>
</tr>
<tr>
<td>Freight</td>
<td>~42 % increase</td>
<td>+46%</td>
</tr>
</tbody>
</table>
Freight GHGs by Source, 1990 and 2003
Estimating CO$_2$
Traditional Approach and Uncertainty

- Have traditionally used EIA’s “top-down” estimates of fuel consumption by economic sector.
- Multiply by carbon content of fuel and adjusting for carbon that does not oxidize during combustion (UNFCCC values).
- OTAQ allocates CO$_2$ to specific modes using “bottom-up” fuel consumption and activity:
  - FHWA *Highway Statistics*
  - Oak Ridge National Laboratories *Transportation Energy Data Book*
- Inconsistencies between the top-down and bottom-up data.
## Comparison of EIA and Bottom-Up Fuel Consumption Estimates

<table>
<thead>
<tr>
<th>Fuel Type/Vehicle Type</th>
<th>2003 Inventory Est.</th>
<th>2003 Bottom-Up Est.</th>
<th>Difference</th>
<th>Percent Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gasoline</strong></td>
<td>1,143.70</td>
<td>1,153.90</td>
<td>10.2</td>
<td>0.89%</td>
</tr>
<tr>
<td>Automobiles</td>
<td>630.2</td>
<td>635.8</td>
<td>5.6</td>
<td>0.89%</td>
</tr>
<tr>
<td>Light-Duty Trucks</td>
<td>460.9</td>
<td>465</td>
<td>4.1</td>
<td>0.89%</td>
</tr>
<tr>
<td>Heavy-Duty Trucks</td>
<td>39.6</td>
<td>39.9</td>
<td>0.3</td>
<td>0.76%</td>
</tr>
<tr>
<td>Buses</td>
<td>0.3</td>
<td>0.3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Motorcycles</td>
<td>1.6</td>
<td>1.6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Boats (Recreational)</td>
<td>11</td>
<td>11.1</td>
<td>0.1</td>
<td>0.91%</td>
</tr>
<tr>
<td><strong>Diesel Fuel</strong></td>
<td>386.6</td>
<td>417</td>
<td>30.4</td>
<td>7.86%</td>
</tr>
<tr>
<td>Automobiles</td>
<td>3.4</td>
<td>3.7</td>
<td>0.3</td>
<td>8.82%</td>
</tr>
<tr>
<td>Light-Duty Trucks</td>
<td>17.6</td>
<td>19</td>
<td>1.4</td>
<td>7.95%</td>
</tr>
<tr>
<td>Heavy-Duty Trucks</td>
<td>301.1</td>
<td>325.5</td>
<td>24.4</td>
<td>8.10%</td>
</tr>
<tr>
<td>Buses</td>
<td>8</td>
<td>8.6</td>
<td>0.6</td>
<td>7.50%</td>
</tr>
<tr>
<td>Locomotives</td>
<td>39.6</td>
<td>42.8</td>
<td>3.2</td>
<td>8.08%</td>
</tr>
<tr>
<td>Ships and Boats</td>
<td>17</td>
<td>17.4</td>
<td>0.4</td>
<td>2.35%</td>
</tr>
<tr>
<td><strong>Electricity</strong></td>
<td>3.2</td>
<td>3.9</td>
<td>0.7</td>
<td>21.88%</td>
</tr>
<tr>
<td><strong>Jet Fuel</strong></td>
<td>169</td>
<td>152.7</td>
<td>-16.3</td>
<td>-9.64%</td>
</tr>
<tr>
<td>Commercial Aircraft</td>
<td>122.8</td>
<td>122.8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Military Aircraft</td>
<td>20.5</td>
<td>20.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>General Aviation Aircraft</td>
<td>9.4</td>
<td>9.4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other Aircraft</td>
<td>16.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Comparison of EIA and Bottom-Up Fuel Consumption Estimates

- Interagency Discussion with EIA and FHWA
- Determined that EIA was using older FHWA data in its fuel consumption estimates
- Recognized that EPA should calculate CO$_2$ using best available data sources, which include bottom-up data
Improvements in the 2006 Inventory

- Implemented bottom-up calculation of transportation diesel
  - Held constant EIA estimate of total diesel consumption across all sectors
  - Non-transportations sectors adjusted downward
- Use of an updated oxidation fraction estimate
  - 2004 EPA study indicated that light-duty gasoline vehicles combust 100 percent of fuel (default assumption was 99 percent)
  - Study has been peer reviewed and may be incorporated into IPCC reporting guidelines
Planned Improvements for future *Inventory* estimates

- Continue reconciling bottom-up and top-down data used to estimate CO$_2$, CH$_4$ and N$_2$O
- Investigation of bunker fuel data
- Use better VMT data to improve estimates by vehicle / fuel category
- Updating CH$_4$ and N$_2$O emissions factors for Tier-2 vehicles
- Improve consideration of off-road vehicle use