U.S. Transportation Sector Greenhouse Gas Emissions:
Trends, Uncertainties and Methodological Improvements

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ABSTRACT

The transportation sector accounted for almost 28 percent of total U.S. greenhouse gas (GHG) emissions in 2004, according to the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004 (published in 2006). Over the period 1990 to 2004, GHG emissions from the transportation sector increased at the fastest rate of any end-use economic sector in the U.S. and accounted for the largest absolute increase of any of these sectors. The largest sources of U.S. transportation GHG emissions continue to be light-duty vehicles, heavy-duty trucks and aircraft. While these three modes experienced increases in travel activity from 1990 to 2004, their GHG growth rates have differed considerably: GHGs from heavy-duty trucks increased by 62 percent, light-duty vehicles by 23 percent, and commercial aircraft by only about 10 percent. This paper 1) analyzes factors affecting transportation GHG emissions in the U.S., including the output from specific modes and travel purposes  2) examines sources of uncertainty in these estimates, and 3) describes methodological improvements used in the 1990-2004 Inventory and other planned improvements.
BACKGROUND

This paper was developed using the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004 as its primary foundation for data (EPA 2006a). The Inventory is prepared annually by the United States Environmental Protection Agency (EPA) and accounts for all national greenhouse gas (GHG) emissions within a framework specified by the United Nations Framework Convention on Climate Change (UNFCCC). Data are organized primarily around specific greenhouse gases such as carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and hydrofluorocarbons (HFCs). Many of these gases are further characterized by source categories specified by the UNFCCC, such as fossil fuel combustion or non-energy use of fuels. This method of presentation is most useful for climate specialists, but is not easily understood by analysts focused on specific economic sectors such as transportation. To improve the usefulness of GHG data for these professionals, the Inventory includes GHG emissions by economic sector. EPA also disaggregates transportation GHG emissions in the Inventory by mode, including passenger cars, light-duty trucks, heavy-duty vehicles, aircraft, boats and ships, etc.

EPA’s Office of Transportation and Air Quality (OTAQ) has recognized that further detail is necessary to identify significant trends and factors affecting transportation GHG output. In March 2006, OTAQ released Greenhouse Gas Emissions from the U.S. Transportation Sector 1990-2003, which provides complementary detail to the Inventory transportation estimates. The report contains analysis of historical trends, estimates of lifecycle GHG estimates and discussion of emerging issues (EPA 2006b). This paper highlights significant findings from the report, with updates to reflect data through 2004, including:

1) factors affecting GHGs from personal and freight transport;
2) sources of uncertainty in the Inventory estimates of transportation GHGs; and
3) methodological improvements developed for the 2006 Inventory (Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004) and possible improvements for the 2007 Inventory (addressing years 1990-2005).

TRANSPORTATION GHG EMISSIONS IN CONTEXT

The transportation sector accounts for a large and growing share of GHG emissions in the U.S. Transportation sources accounted for 27.6 percent of U.S. GHG emissions in 2004, up from 24.9 percent in 1990 (based on the global warming potential of all gasses). In absolute terms, transportation GHG emissions increased by a larger amount than any other end-use economic sector over this period, growing by 436.4 Teragrams (Tg) CO₂ Eq. – from 1,523.4 Tg CO₂ Eq. in 1990 to 1,959.8 Tg CO₂ Eq. in 2004. This nearly 29 percent increase in transportation GHG emissions represented the fastest growth rate of any end-use economic sector (EPA 2006a). (See Figure 1.) The transportation sector estimates primarily reflect “tailpipe” GHGs resulting from the combustion of energy in vehicle propulsion and idling. They do not include GHGs from non-transportation mobile sources, such as equipment used for construction and agriculture, which accounted for an additional 2.1 percent (151.3 Tg CO₂ Eq.) of total U.S. GHG emissions. They also do not include “lifecycle” emissions from processes such as the extraction of crude oil and the manufacture of vehicles.
Transportation GHG emissions are primarily in the form of CO₂ resulting from the combustion of fossil fuel, and almost all of the increase in transportation GHG emissions since 1990 has come in the form of CO₂. Since CO₂ is emitted in proportion to fuel consumption, with small differences based on the type of fuel used, the growth in transportation fuel consumption has been the major factor pushing the increase in transportation GHG emissions. Considering only CO₂, transportation sources emitted 1,870.4 Tg in 2004, an increase of 394.2 Tg (or 26.7 percent) from 1990. In contrast, the combined emissions of CH₄ and N₂O decreased by 2.9 Tg CO₂ Eq. (6.1 percent) over the same period, due largely to the introduction of control technologies designed to reduce criteria pollutant emissions, which also had the ancillary benefit of reducing these GHGs. Meanwhile, HFCs from mobile air conditioners and refrigerated transport increased from virtually no emissions in 1990 to 45.0 Tg CO₂ Eq. in 2004. HFCs were introduced as substitutes for ozone depleting substances (CFCs and HCFCs), which are being phased out under the Montreal Protocol and are not included in the official Inventory estimates.

**SOURCES OF TRANSPORTATION GREENHOUSE GAS EMISSIONS**

While there are many sources of emissions in the transportation sector, the vast majority of transportation GHG emissions in the U.S. come from “on road” vehicles. In 2004, about 81 percent of transportation GHG emissions came from on-road vehicles, including passenger cars, sport-utility vehicles (SUVs), vans, other light-duty trucks, motorcycles, and medium- and heavy-duty trucks and buses. “Light-duty” vehicles, which are used primarily for personal transport, accounted for 63 percent of total transportation emissions. This category consists of passenger cars, (33 percent of the transportation total), “light-duty trucks,” including SUVs, minivans and pickup trucks (28 percent), and motorcycles (less than one-tenth of one percent). Medium- and heavy-duty trucks accounted for 19 percent of transportation GHGs, and buses accounted for about 0.5 percent.

Non-road transportation sources produced 17 percent of all transportation GHG emissions in 2004. Aircraft were the largest non-road source, producing 9 percent of total transportation GHGs. Other non-road sources include boats and ships (3 percent), rail (3 percent), and pipelines (2 percent).

In addition, transportation sector GHG totals include emissions that are not classified as either on-road or non-road sources. Approximately 2 percent of total transportation emissions in 2004 consisted of HFCs released from vehicle air conditioning and refrigerated transport, which include refrigeration units on trucks and trailers, freight trains, and ships. Another 1 percent came from lubricants, consisting mainly of oil used in motor vehicle engine combustion.
FIGURE 2 U.S. Transportation GHG Emissions by Source, 2004


FACTORS AFFECTING TRANSPORTATION GHG EMISSIONS BY MODE

Transportation fuel consumption is broadly affected by travel activity and the amount of energy vehicles use to move people and goods. In the short-term, changes in transportation GHG emissions primarily reflect variation in travel activity that accompanies year-to-year economic fluctuations. Additional factors are influential over longer timeframes, especially the cost of fuel and vehicle purchase decisions, which in turn can influence travel patterns and vehicle energy efficiency.

From 1990 to 2004 there has been a significant increase in travel associated with three major categories of transportation: light-duty vehicles, heavy-duty trucks, and aircraft. Commercial aircraft passenger miles traveled (PMT) increased by 64 percent, heavy-duty truck vehicle miles traveled (VMT) increased by 53 percent and light-duty VMT grew by 37 percent. However, the change in energy efficiency has been substantially greater for aircraft than light-duty vehicles and heavy-duty trucks. These trends have resulted in significant differences in the GHG growth rate of major transportation sources. GHGs from heavy-duty trucks have increased by 62 percent, GHGs from light-duty vehicles have increased by 23 percent, and commercial aircraft GHG emissions have increased by only about 10 percent (see Figure 3).
FIGURE 3 GHG Emissions by Mode of Transportation, 1990–2004


Note: “Other Non-Road” includes boats and ships, rail, pipelines, and lubricants.

a Emissions of HFCs from refrigerated transport and mobile air conditioners are not included in this chart.

Light-Duty Vehicles

GHG emissions from light-duty vehicles (passenger cars and light-duty trucks) grew 23 percent from 1990 to 2004. Vehicle miles traveled (VMT) by light-duty vehicles increased by 37 percent over the period, over twice the rate of population growth. The increase in light-duty travel activity reflected the impact of several related factors including increases in personal income, automobile ownership, trip-making, and trip lengths, along with a decrease in the real cost of fuel and further decentralization of population and employment. The 37 percent increase in light-duty VMT outweighed a 4 percent improvement in the average fuel economy of the U.S. light-duty fleet, to yield increased motor vehicle fuel consumption. It is worth noting that the modest improvement in light-duty vehicle fuel economy that occurred over this period was due primarily to the replacement of less fuel-efficient vehicles from the 1970s and early-1980s. When looking at newly purchased vehicles, the sales-weighted fuel economy of new light-duty vehicles sold actually declined from a peak of 22.1 MPG in 1987 and 1988 to 20.8 MPG in 2004. This decline in new vehicle fuel economy reflected substantial growth in the market share of light-duty trucks, most notably SUVs, which tend to have lower fuel economy than passenger cars. As the composition of the vehicle fleet has changed, the use of light-duty trucks has increased dramatically. Between 1990 and 2004, VMT by light-duty trucks increased 77 percent, while VMT by passenger cars increased only 2 percent. Consequently, GHGs from light-duty trucks increased by 64 percent from 1990 to 2004, compared with a 2 percent increase from passenger cars.

Heavy-Duty Vehicles

GHG emissions from heavy-duty vehicles (predominantly freight trucks) grew by 62 percent from 1990 to 2004, the largest growth rate of any major transportation source and more than twice the growth rate of light-duty vehicles. This increase largely was the result of a rapid increase in freight movements by trucks, spurred by the growth of domestic consumption and global trade, along with changes in the economy that increased the share of freight being transported by trucks. These factors included a shift toward more high-value, low-weight products, which are more conducive to haulage by trucks than rail or ships; just-in-time inventory practices that strive to minimize on-site inventory and require smaller, more frequent shipments; and shifts in manufacturing and warehouse location patterns (BTS 2004). Heavy-duty truck VMT increased by 53 percent over this time period (FHWA 2005) and truck ton-miles transported increased even more rapidly.
Aircraft
Aircraft (including commercial, military, and general aviation aircraft) produced 181.5 Tg CO₂ in 2004, an increase of 1 percent from 1990. GHGs from military aircraft declined significantly over the period, while other sources of aviation GHGs increased moderately. Commercial aircraft GHG emissions actually increased by approximately 20 percent between 1990 and 2000, but then saw a substantial drop in 2001 and 2002 following the terrorist attacks of September 11, 2001, and then began to rise slowly in 2003 and 2004.

Commercial aircraft are the largest source of aviation GHGs, accounting for over 70 percent of total aircraft GHGs in 2004. (In the Inventory, aircraft emissions are based on domestic travel only, and exclude international travel to and from U.S. cities.) In total, commercial aircraft GHGs increased 10 percent between 1990 and 2004, significantly less than the 64 percent increase in air passenger miles travel over the same timeframe. As a result, emissions per passenger mile decreased by 33 percent from 1990 to 2004, representing the most significant improvement in emissions intensity of any major mode. This improvement reflected the increasing fuel efficiency of aircraft and increased numbers of occupied seats. The average passenger load factor (percent of available seats that are occupied) on certificated air carriers’ domestic operations increased from 60.4 percent in 1990 to 74.4 percent in 2004, continuing a longer term pattern of increasing passenger loads (BTS 2005). The reduced energy intensity of commercial aviation also reflects improvements in aircraft fuel efficiency, measured in fuel consumed per aircraft-mile traveled. For new production aircraft, the fuel economy improvements have averaged 1 to 2 percent per year since the 1950s (IPCC 1999).

Other Non-Road Sources
Among other non-road sources, GHG emissions from rail increased 32 percent from 1990 to 2004. Water-based transportation GHGs appear to have increased similarly (25 percent), although the data show much more fluctuation and have a higher degree of uncertainty. Pipeline emissions were virtually unchanged between 1990 and 2004.

Passenger and Freight GHG Emissions Trends
GHG emissions from freight sources increased at a much greater rate than passenger sources. Freight GHG emissions increased by 46 percent between 1990 to 2004, while GHGs from passenger modes increased by 20 percent (EPA 2006). Collectively, freight sources emitted 13 percent more GHGs per ton-mile in 2003 than in 1990. Most of the increase in GHG intensity of freight movement resulted from a shift to energy-intensive freight modes. Rail is typically the least energy-intensive freight mode. Measured in BTUs per ton-mile, rail used 90 percent less energy than trucks and 80 percent less than ships (DOE 2004). While the share of freight carried by rail has remained roughly constant, trucks’ share of freight ton-miles increased from 26 percent in 1993 to 32 percent in 2002, accounting for most of the overall increase in freight GHG output and intensity. (EPA does not explicitly calculate aircraft emissions associated with freight movement; these emissions are included in overall estimates for commercial aircraft, which are categorized as passenger transport. Air shipments required approximately 82 times more energy per ton-mile than rail in 2001, according to the DOE estimates referenced above. While air was the fastest-growing mode of freight transport, its share of total shipments remained below 1 percent.)

INVENTORY DEVELOPMENT PROCESS, UNCERTAINTIES, AND IMPROVEMENTS
U.S. CO₂ estimates are developed using a multi-stage “top-down” methodology. To summarize, this process starts with estimates of fuel consumption from the Energy Information Administration (EIA) of the U.S. Department of Energy (EIA 2004). EIA disaggregates these data by fuel type and economic sector. Transportation fuel consumption estimates are primarily representative of “tailpipe” GHGs that result from the use of energy to power vehicles, including energy used during vehicle idling. In developing estimates for the UNFCCC, EPA adjusts these values so that they correspond with the accounting framework specified by the UNFCCC reporting guidelines. EPA then estimates CO₂ by multiplying these fuel consumption estimates by carbon content of each fuel and adjusting for carbon that does not oxidize during combustion. Finally, EPA allocates the transportation-sector estimates to specific vehicles and modes using separate estimates of fuel consumption and activity data such as FHWA’s Highway Statistics, EIA’s Fuel Oil and Kerosene Sales Report, the American Association of Railroads, the Upper Great Plains Transportation Institute, and the Transportation Energy Data Book.

Unlike CO₂ emissions, which are proportional to vehicle fuel consumption, CH₄ and N₂O emissions are affected by a complex set of combustion dynamics that includes the type of emissions control system used. As a result, Inventory estimates of these gases require the use of laboratory-based emission factors that are specific to fuel type, vehicle type and vehicle control technology. Emission factors are expressed in grams per mile (for on-road vehicles) and grams per unit of fuel consumed (for non-road vehicles). CH₄ and N₂O are calculated multiplying emission factors by estimates VMT and fuel consumption. These activity data are also primarily from FHWA’s
Sources of Uncertainty Associated with Transportation GHG Estimates

**CO₂**

Since 96 percent of transportation GHG emissions are in the form of CO₂, uncertainty in CO₂ estimates is much more important than uncertainty associated with N₂O, CH₄, or HFC emissions. The largest source of uncertainty in sector-specific CO₂ estimates relates to fuel consumption statistics. The EIA estimates used in the *Inventory* are believed to be very accurate in accounting for the combined fuel consumption of all economic sectors. However, there is greater uncertainty in EIA’s apportionment of these values to specific economic sectors, which are also used to produce *Inventory* estimates. EPA apportions these fuel- and sector-specific estimates to specific sources such as transportation modes, resulting in further uncertainty. EPA uses “bottom-up” data from industry sources to allocate these estimates to specific transportation sources. These two data sources generally indicate different levels of transportation fuel consumption.

A second and related source of uncertainty involves estimates of international bunker fuels, which are associated with marine diesel fuel oil, marine distillate fuel oil and aviation jet fuel. According to the UNFCCC reporting guidelines, national totals of GHG emissions should reflect only domestic transport, including the domestic leg of shipments bound for foreign markets. International bunker fuel estimates are reported in the *Inventory*, but are not counted toward a national total. However, differentiating domestic and international fuel consumption is often difficult, resulting in significant year-to-year variations in the official estimates. For instance, estimated GHGs from marine and aviation international bunker fuel consumption in 2004 were 95.5 Tg CO₂ Eq., down from 115.7 Tg CO₂ Eq. in 1998. The disparity of these estimates largely reflects uncertainty in distinguishing the domestic and international components of this fuel consumption.

**CH₄ and N₂O**

Uncertainty in CH₄ and N₂O emissions from highway vehicles is a product of uncertainty in VMT estimates, the distribution of VMT to control technology types, and emission factors. The *Inventory* reports that the uncertainty range of on-road CH₄ and N₂O emissions is greater than that of CO₂ emissions (EPA 2005). This uncertainty range is considered to be of less significance given the smaller magnitude of CH₄ and N₂O produced. For non-road sources, CH₄ and N₂O are estimated by applying emission factors to estimates of the quantity of fuel consumed. Both the fuel economy estimates and emission factors for non-road sources are considered to be very uncertain. However, the estimated production of non-road CH₄ and N₂O is also relatively small and considered to be of low significance.

Transportation Fuel Consumption Estimates and Related Uncertainty (Through the 2005 *Inventory*)

EIA fuel consumption estimates have historically differed from those available in bottom-up data sources such as *Highway Statistics*. Given the significance of fuel consumption estimates in calculating CO₂ (96 percent of transportation GHG emissions) EPA and ICF International investigated the differences in these data sources.

- EIA’s estimates of transportation diesel fuel consumption, which were used in the 2005 *Inventory* (including years 1990-2003) and prior, were systematically 2.5 to 10.0 percent lower than estimates from various bottom-up sources for 1990 to 2003. Bottom-up sources include FHWA’s *Highway Statistics* for highway vehicles, EIA’s Fuel Oil and Kerosene Sales Report for ships and boats, AAR for Class I railroads, the Upper Great Plains Transportation Institute for Class II and III railroads, and the Transportation Energy Data Book for commuter rail and Amtrak.

- EIA’s estimates of transportation motor gasoline fuel consumption for 1990 to 2003 were systematically lower by a small amount (ranging from 0.6 to 2.4 percent) than estimates compiled by EPA using FHWA’s *Highway Statistics* for on-road vehicles and EPA’s NONROAD Model for recreational boats.

- EIA’s estimates of transportation jet fuel use were consistently higher (9.1 to 12.3 percent) than estimates compiled by EPA for 1990 to 2003. In the *Inventory*, EPA assigns the jet fuel to types of use (commercial aircraft, general aviation aircraft, military aircraft) based on primary data sources, and considers the
remainder use by “other aircraft.” As a result, EIA and EPA estimates of jet fuel consumption match up but there is uncertainty regarding where the other jet fuel is used.

Table 1 shows a comparison of transportation CO\(_2\) estimates in the 2005 Inventory (covering years 1990 to 2003), based on data from EIA, with estimates calculated directly from bottom-up data on fuel consumption from FHWA and other sources.

**TABLE 1 Comparison of 2005 U.S. GHG Inventory Estimates and Bottom-Up Estimates of CO\(_2\) for Selected Transportation Fuels and Sources**

<table>
<thead>
<tr>
<th>Fuel Type/Vehicle Type</th>
<th>1990</th>
<th>2003</th>
<th>Percent Difference</th>
<th>1990</th>
<th>2003</th>
<th>Percent Difference</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Inventory Estimate Based on EIA</td>
<td>Bottom-Up Estimate</td>
<td>Percent Difference</td>
<td>Inventory Estimate Based on EIA</td>
<td>Bottom-Up Estimate</td>
<td>Percent Difference</td>
</tr>
<tr>
<td>Gasoline</td>
<td>955.2</td>
<td>973.5</td>
<td>1.9</td>
<td>1,143.7</td>
<td>1,153.9</td>
<td>0.9</td>
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<td>Automobiles</td>
<td>605.1</td>
<td>616.7</td>
<td>1.9</td>
<td>630.2</td>
<td>635.8</td>
<td>0.9</td>
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<td>Light-Duty Trucks</td>
<td>301.0</td>
<td>306.7</td>
<td>1.9</td>
<td>460.9</td>
<td>465.0</td>
<td>0.9</td>
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<tr>
<td>Heavy-Duty Trucks</td>
<td>37.7</td>
<td>38.5</td>
<td>2.1</td>
<td>39.6</td>
<td>39.9</td>
<td>0.8</td>
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<tr>
<td>Buses</td>
<td>0.3</td>
<td>0.3</td>
<td>0.0</td>
<td>0.3</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Motorcycles</td>
<td>1.7</td>
<td>1.7</td>
<td>0.0</td>
<td>1.6</td>
<td>1.6</td>
<td>0.0</td>
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<tr>
<td>Boats (Recreational)</td>
<td>9.4</td>
<td>9.6</td>
<td>2.1</td>
<td>11.0</td>
<td>11.1</td>
<td>0.9</td>
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<tr>
<td>Diesel Fuel</td>
<td>253.7</td>
<td>264.1</td>
<td>4.1</td>
<td>386.6</td>
<td>417.0</td>
<td>7.9</td>
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<tr>
<td>Automobiles</td>
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<td>7.7</td>
<td>4.1</td>
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<td>4.7</td>
<td>17.6</td>
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<td>4.5</td>
<td>8.0</td>
<td>8.6</td>
<td>7.5</td>
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<tr>
<td>Locomotives</td>
<td>33.3</td>
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<td>4.0</td>
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<td>17.4</td>
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<td>6.7</td>
<td>3.2</td>
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<td>21.9</td>
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<td>Jet Fuel</td>
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<td>158.2</td>
<td>-9.2</td>
<td>169.0</td>
<td>152.7</td>
<td>-9.6</td>
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<tr>
<td>Commercial Aircraft</td>
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<td>0.0</td>
<td>122.8</td>
<td>122.8</td>
<td>0.0</td>
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<tr>
<td>Military Aircraft</td>
<td>34.8</td>
<td>34.8</td>
<td>0.0</td>
<td>20.5</td>
<td>20.5</td>
<td>0.0</td>
</tr>
<tr>
<td>General Aviation Aircraft</td>
<td>6.3</td>
<td>6.3</td>
<td>0.0</td>
<td>9.4</td>
<td>9.4</td>
<td>0.0</td>
</tr>
<tr>
<td>Other Aircraft</td>
<td>15.9</td>
<td>16.3</td>
<td>-</td>
<td>16.3</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

In January 2005, EPA Inventory staff met with fuel consumption specialists from EIA and FHWA to discuss differences in these fuel consumption estimates. It was agreed that FHWA’s figures represented the best source of highway fuel consumption, and that EIA uses these calculations in developing its own estimates of motor gasoline and diesel fuel consumption. However, the timing of EIA’s fuel consumption estimates requires the use of older FHWA data than are available to EPA in developing the Inventory. It was recognized that EPA should calculate transportation CO\(_2\) emissions directly from best available data sources, rather than relying on the EIA estimates for a particular sector or source.

**Updated Methodology for CO\(_2\) Estimates in the 2006 Inventory**

Given the wide discrepancies between EIA’s transportation diesel fuel consumption figures and estimates from “bottom up” data sources, starting with the 2006 Inventory, EPA adjusted the transportation diesel estimate provided by EIA upward to match the bottom-up estimate. Because EIA’s estimate of total diesel fuel consumption across all sectors is believed to be relatively accurate, the EIA diesel estimates for residential, commercial and industrial sectors were adjusted downward proportionally. This process was used to calculate both the most recent values presented in the 2006 Inventory (2004) as well as earlier estimates (1990-2003) that are also presented in the document. This adjustment represented the only substantive modification to EIA energy statistics used in the Inventory. A similar adjustment using bottom-up based gasoline estimates is being contemplated for future Inventories, but was considered beyond the scope of the 2006 Inventory effort.
A second methodological improvement involved the use of updated oxidation fraction for light-duty motor vehicle engines. A 2004 EPA study indicated that the fraction of fuel combusted for light-duty gasoline motor vehicles is 100 percent (EPA 2004a). This value was used to calculate both the most recent values presented in the 2006 Inventory (2004) as well as earlier estimates of CO₂ from gasoline engines. The revised estimate has been peer reviewed and may be incorporated into future IPCC guidance. It also is possible that diesel and gasoline vehicles burn virtually 100 percent of their fuel, and EPA may conduct further research to examine these estimates for transportation and non-transportation sources.

Planned Improvements
Several areas of potential improvement have been identified for consideration in the 2007 Inventory.

- **Continue to reconcile fuel consumption estimates used for calculating CO₂, N₂O and CH₄.** As noted earlier, the 2006 Inventory estimates reconciled EIA estimates of transportation diesel fuel consumption with those provided by FHWA and other sources that rely on direct accounting of transportation diesel fuel consumption. Potential future improvements include reconciling the EIA estimates of transportation gasoline consumption with estimates from FHWA.

- **Updating the estimation of jet fuel consumption by commercial aircraft.** The Federal Aviation Administration (FAA) has developed a model called the System for Assessing Aviation’s Global Emissions (SAGE), which is a high fidelity model used to estimate aircraft fuel burn and emissions for all commercial flights in a given year, based on data on aircraft flights by aircraft type, travel route, and operating characteristics, including delay at airports. These estimates are believed to be considerably more accurate than estimates that have historically been used to estimate commercial aircraft fuel consumption for the Inventory, and will help in reconciling EIA’s estimates of jet fuel consumption with bottom up estimates.

- **Improve estimates by vehicle / fuel category with improved VMT estimates.** The current Inventory process for estimating VMT by vehicle/fuel type category involves apportioning VMT by vehicle type to each fuel type in the basis of fuel consumption. While this is a reasonable simplification, it implicitly assumes the same average fuel economy for gasoline and diesel vehicles. A more accurate apportionment of VMT by fuel type for light-duty trucks and medium/heavy-duty trucks could potentially be developed using data on vehicle travel from the U.S. Census Vehicle Inventory and Use Survey and other publications, or using VMT breakdowns by vehicle/fuel type combinations from EPA’s MOBILE6 or MOVES models.

- **Updating CH₄ and N₂O emission factors for highway vehicles.** A number of recent efforts have focused on improving estimates of CH₄ and N₂O emission factors for alternative fuel vehicles. These studies are expected over the course of this year. In addition, it is recognized that existing emission factors may not characterize CH₄ and N₂O emissions from Tier 2 vehicles, which have entered the vehicle fleet.

- **Improve consideration of emissions from trucks used off-road.** Some light- and heavy-duty trucks travel for a portion of their mileage off-road. N₂O and CH₄ estimates for highway vehicles are developed based on vehicle mileage data from FHWA’s Highway Statistics, which, in turn, are drawn from the Highway Performance Monitoring System (HPMS). These emission estimates do not address travel by trucks off-road. Gasoline fuel consumed by trucks used off-road for construction, agriculture, and other industrial/commercial uses is reported in Highway Statistics, and is included as part of the Inventory non-road agriculture and construction categories. However, diesel fuel consumed by trucks used off-road is not addressed in the Inventory, and further work should be conducted to develop estimates of off-road truck use of diesel fuel.
ACKNOWLEDGEMENT

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REFERENCES


LIST OF TABLES AND FIGURES

TABLE 1  Comparison of U.S. GHG Inventory Estimates and Bottom-Up Estimates of CO$_2$ for Selected Transportation Fuels and Sources


FIGURE 2  2004 Transportation Greenhouse Gas Emissions, by Source

FIGURE 3  GHG Emissions by Mode of Transportation 1990–2004