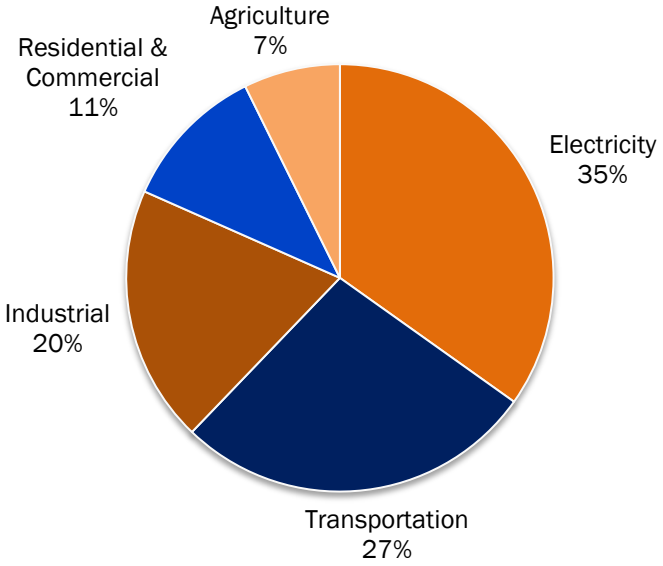
Transportation Emissions in the United States

Over 25 percent of total U.S. greenhouse gas (GHG) emissions come from the transportation sector (see Figure 1), making transportation the second largest source of GHG emissions in the United States after the electric power sector.

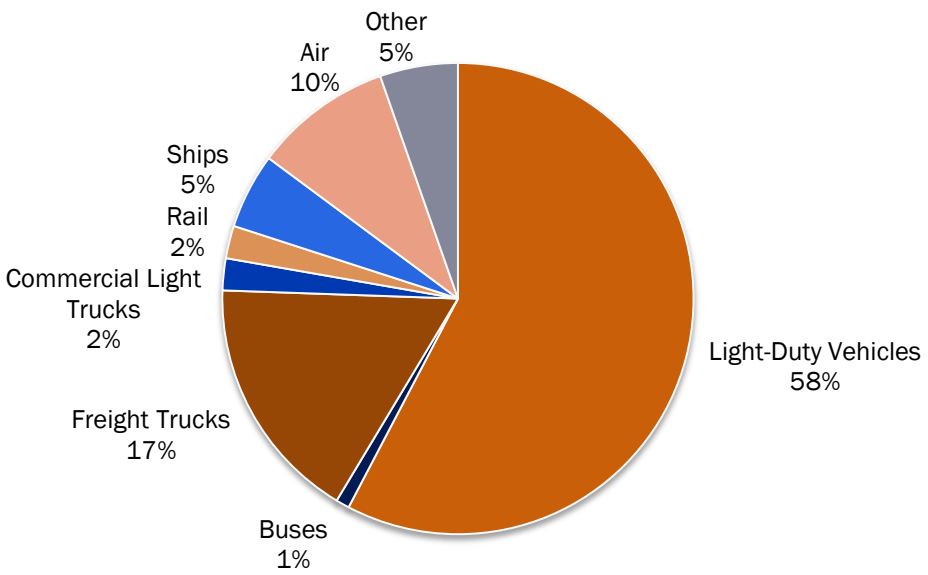
Figure 1: U.S. Greenhouse Gas Emissions by Sector (2008)



Source: U.S. Environmental Protection Agency (EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, Table ES-7, 2010. http://www.epa.gov/climatechange/emissions/usinventoryreport.html

The transportation sector consists of passenger cars and light-duty trucks (also referred to as passenger vehicles), medium- and heavy-duty trucks, buses, and rail, marine, and air transport. Of the various transportation modes, passenger vehicles consume the most energy (see Figure 2). GHG emissions mirror energy use by each mode, because all modes use petroleum fuels with similar carbon contents and thus GHG emissions.

Figure 2: Transportation Energy Use by Mode (2008).



Source: EIA. *Annual Energy Outlook 2010*. Washington, D.C.: U.S. EIA. http://www.eia.gov/oiaf/archive/aeo10

The majority of transportation emissions (95 percent) are composed of carbon dioxide (CO_2), which is released during fossil fuel combustion. An additional one percent of total transportation GHG emissions come from methane (CH_4) and nitrous oxides (N_2O), emissions also associated with fossil fuel combustion. The leakage of hydrofluorocarbons (HFCs) from vehicle air conditioning systems is responsible for the remaining three percent of transportation GHG emissions. Transportation sources also emit ozone, carbon monoxide (CO), and aerosols. These substances are not counted as greenhouse gases in transportation emissions inventories but are believed to have an indirect effect on global warming, although their impact has not been quantified with certainty.[1]

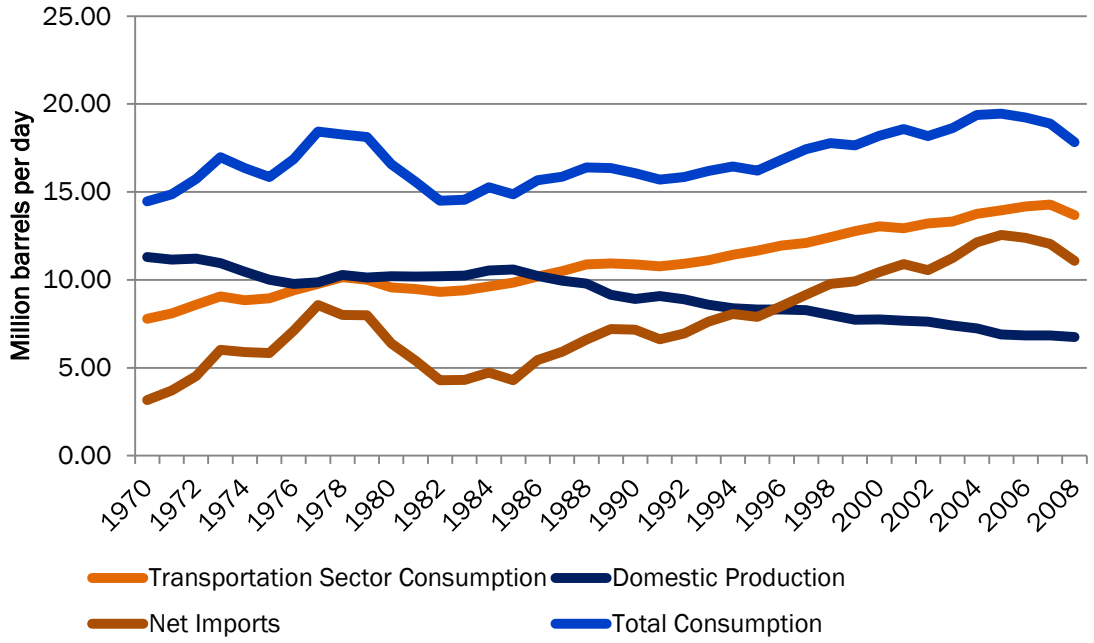
Factors Affecting Transportation Emissions

Transportation energy use and emissions are determined by four interrelated but distinct factors: the type of fuels or energy sources, the vehicles, the distance traveled, and the overall system infrastructure.

- Fuel Types and Energy Sources

  The transportation sector is the largest consumer of petroleum-based fuels in the United States.

Figure 3: Petroleum Production and Consumption, 1970–2008.



Source: U.S. Department of Energy (DOE), *Annual Energy Outlook 2010*, Table 45, 2010.
http://www.eia.gov/oiaf/archive/aeo10

Nearly all fossil fuel energy consumption in the transportation sector is from petroleum-based fuels (97.6 percent), with a small amount from natural gas.[2] There are several types of petroleum fuels used for transportation. Table 1 lists the major petroleum-based transportation fuels and the volume consumed in the United States in 2008.

Table 1: Estimated U.S. Transportation Sector Petroleum Consumption (2008), Million Gallons.

Fuel Type	Consumption
Motor Gasoline	134,939.15
Distillate Fuel Oil (Diesel)	43,888.24
Jet Fuel	23,333.35
Residual Fuel Oil	6,244.77
Lubricants	970.41
Aviation	236.80
Liquefied Petroleum Gases	224.62
Total	209,837.38

Source: Energy Information Administration (EIA), *Annual Energy Review*, Table 5.13c, 2009.
http://www.eia.doe.gov/aer/contents.html

Petroleum fuels are supported by an extensive and well-functioning infrastructure and have the benefit of high energy density, low cost, and a demonstrated ability to adapt to a range of operating conditions.

To date, the use of non-fossil based energy sources for transportation has been limited. The production and consumption of biofuels has increased significantly since 2005, due to the state and federal renewable fuel standards, which mandate minimum annual consumption levels of ethanol and biodiesel.

Table 2: Estimated U.S. Consumption of Alternative Fuels (2008), Million Gasoline-Equivalent Gallons.

Fuel Type	Consumption
Ethanol	6495.50
Biodiesel	324.33
Electricity	5.05
Hydrogen	0.12

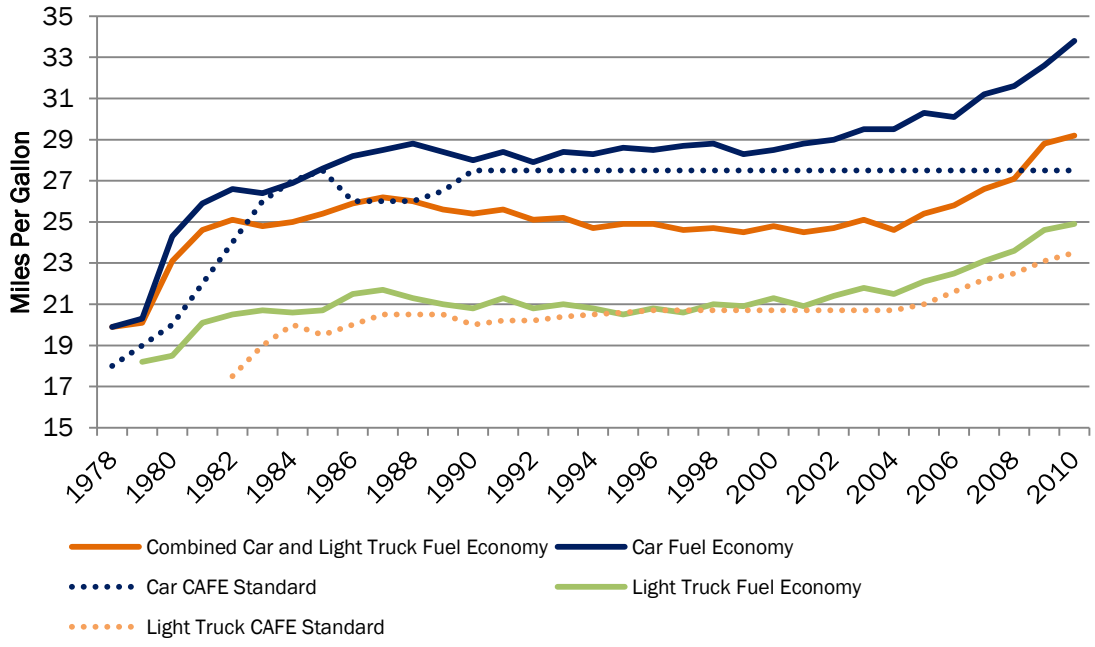
Source: EIA, *Alternatives to Traditional Transportation Fuels*, Table C1, 2010. http://www.eia.doe.gov/cneaf/alternate/page/atftables/afv_atf.html

- Vehicle Efficiency

Over the last 30 years, the fuel economy (miles per gallon) of new passenger vehicles in the United States has improved significantly, increasing by more than 30 percent. Yet most of the gains occurred in the early years of fuel economy regulation under the Corporate Average Fuel Economy (CAFE) program, peaking in 1987. Fuel economy improvements were nearly stagnant throughout the 1990s. Over this time period, the technical efficiency (amount of energy needed to move a given vehicle mass) of light-duty vehicles improved, although fuel economy (the amount of gasoline consumed per mile traveled) remained unchanged, as consumer preferences shifted to larger, heavier, and more powerful vehicles.

Improvements for other modes of transportation besides passenger vehicles are mixed. Some have experienced steady continuous increases in efficiency; for example, aircraft energy intensity has improved at an average rate of 1-2 percent per year.[3] Efficiency in truck and waterborne freight movement, on the other hand, does not appear to have improved significantly, although data on the subject are inconclusive.[4]

Figure 4: Corporate Average Fuel Economy (CAFE) Standards vs. Sales-Weighted Fuel Economy Estimates.



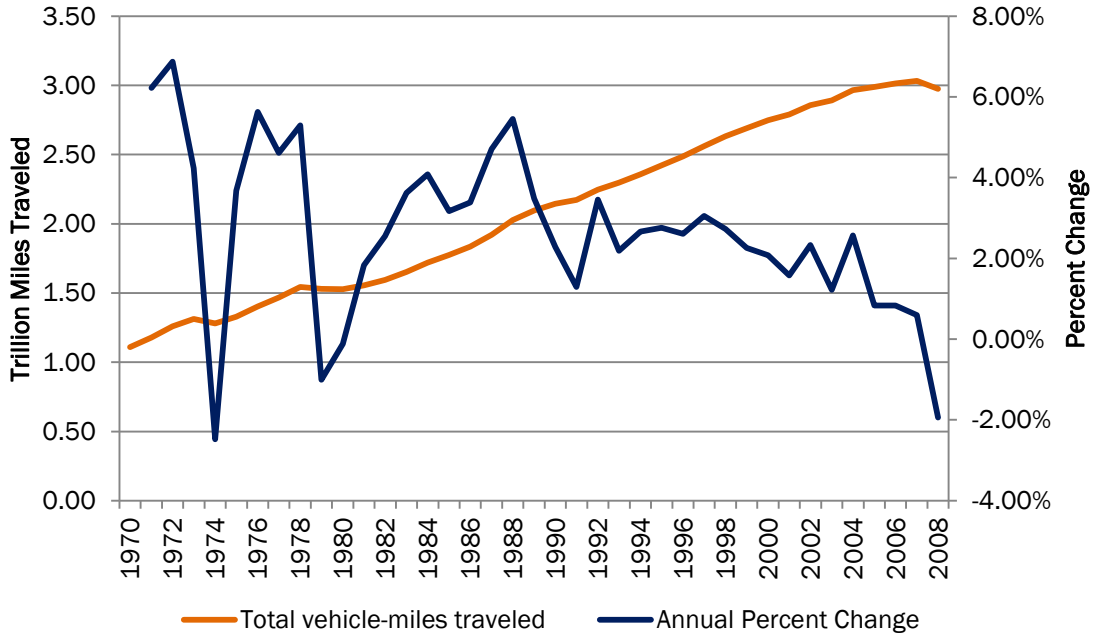
Source: DOE, *Transportation Energy Data Book*, Tables 4.21 and 4.22, 2010. http://www-cta.ornl.gov/data/index.shtml

- Vehicle Use and Distance Traveled

  The third factor that affects transportation emissions is the amount of vehicle use and distance traveled. Transportation demand is influenced by the geographic distribution of people and places, especially the density of development and zoning. Over the past 50 years, on-road vehicle miles traveled (VMT) has increased steadily, although the annual growth rate in miles traveled has generally decreased over time. Because of high fuel costs and slowing economic growth, absolute VMT decreased for the first time in 2008.

  The absolute growth in distance traveled for modes has been similar. The use of all transportation modes (particularly freight transport and air travel) is still projected to grow rapidly in the future.

Figure 5: Annual On-Road Vehicle Miles Traveled (VMT).



Source: DOE, *Transportation Energy Data Book*, Table 3.6, 2010. http://www-cta.ornl.gov/data/index.shtml

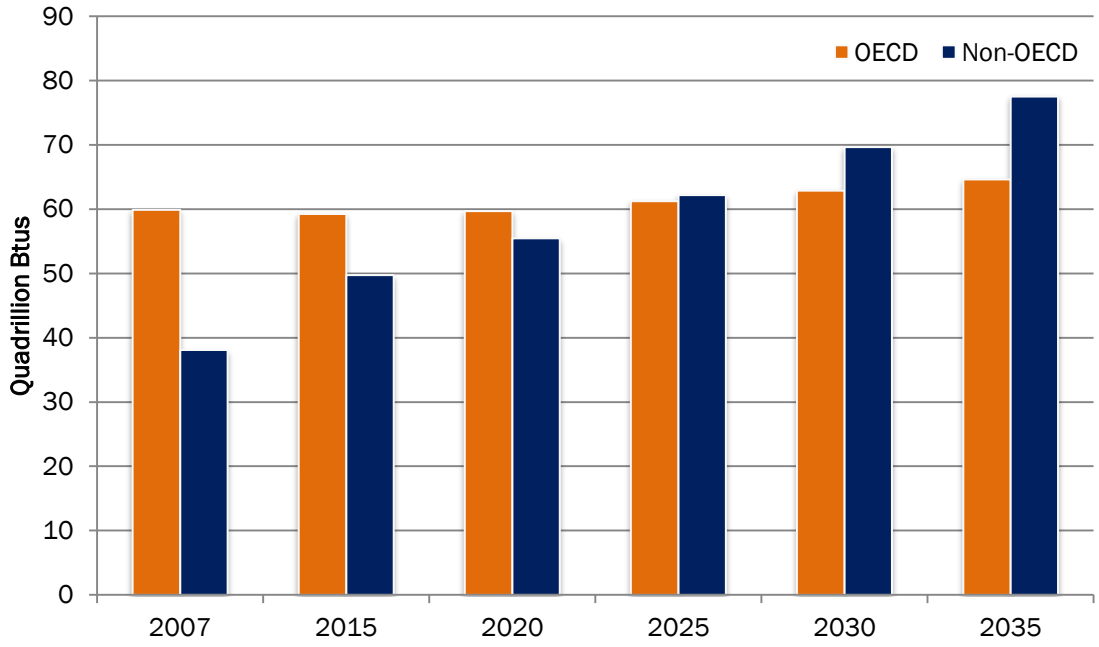
- System Efficiency

  The overall operation of the transportation system also plays an important role in GHG emissions. For example, congestion results when transportation demand exceeds capacity and poses a challenge for almost all modes of transportation, from on-road and highway transport, air, and rail. Shifting travel to other modes can reduce congestion, as can electronic signaling and other measures to smooth traffic flows. Reducing congestion has the benefit of lowering fuel consumption and GHG emissions by decreasing the time and spent idling. For freight (via rail, truck, and ship) and air traffic, system improvements that allow vehicles to take more direct routes from origin to destination can reduce energy use and emissions.

Global Context

Transportation activity is expected to grow significantly in all countries of the next 50 years. Over the next two decades, vehicle ownership is expected to double worldwide, with most of the increase occurring in non-OECD countries. The U.S. Department of Energy projects that non-OECD transportation energy use will increase by an average of 2.6 percent per year from 2007 to 2030, compared to an average increase of 0.3 percent per year for OECD countries.[5] Figure 6 shows projected worldwide energy consumption in the transportation sector.

Figure 6: Global Projections for Transportation Energy Use, 2007-2035.



Source: EIA, International Energy Outlook 2010, Chapter 7, 2010. http://www.eia.doe.gov/oiaf/ieo

Transportation Sector Mitigation Opportunities

Reducing greenhouse gas emissions from transportation will require a systematic approach to address the four interdependent yet distinct elements of the sector.

- On the fuels side, transitioning to low-carbon energy sources, such as advanced biofuels or electricity produced from renewable sources, can directly reduce the carbon emissions from fuel consumption.
- Significantly more efficient transportation equipment is needed to complement the transition to low-carbon fuel sources. Alternative vehicle designs include flexible fuel vehicles that can run on a mix of biofuels and petroleum-based fuels or are powered by electricity and stored on-board in batteries or by hydrogen fuel cells.
- Vehicle travel demand is affected by a number of factors. Changing land use patterns and increasing alternative travel options, such as biking, walking or rail, can reduce the use of more energy-intensive modes of transportation.
- Increasing the efficiency of the transportation system would require both improving accessibility to and performance of the various modes of transportation and using more efficient ones. Advanced traffic monitoring and signaling can reduce congestion and improve the overall efficiency of the transportation system.

A strategy to reduce GHG emissions from the transportation sector will need to take into account the potential efficiency improvements for each mode of transportation and determine the appropriate reduction strategy for each. Policies that facilitate the adoption of low-carbon technologies and align infrastructure development and land use planning with GHG reduction goals can lead to further GHG reductions in these areas.

Several studies have analyzed the most cost-effective approach to emission reductions in transportation. Some of these studies include:

- Greene, D. and S. Plotkin, *Reducing Greenhouse Gas Emissions from U.S. Transportation*. Prepared for the Pew Center on Global Climate Change, 2011. http://www.pewclimate.org/publications/reducing-ghg-emissions-from-transportation
- Cambridge Systematics, Inc. (2009). Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions. Washington, D.C.: Urban Land Institute. http://www.movingcooler.info/
- Intergovernmental Panel on Climate Change (IPCC), "Transport and its infrastructure." In *Mitigation of Climate Change*, 2007. http://www.ipcc.ch/ipccreports/ar4-wg3.htm
- International Energy Agency (IEA), "Transport." In *Energy Technology Perspectives 2008: Scenarios and Strategies to 2050*, 2008. http://www.iea.org/Textbase/techno/etp/index.asp

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[1] Source: U.S. Environmental Protection Agency (EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008*, 2010. http://www.epa.gov/climatechange/emissions/usinventoryreport.html

[2] EIA, *Annual Energy Review 2009*, Table 2.1e, 2010. http://www.eia.doe.gov/aer/consump.html

[3] IPCC, *Aviation and the Global Atmosphere.* A Special Report by Working Groups I and III. Cambridge: Cambridge University Press, 1999. http://www.grida.no/publications/other/ipcc_sr/?src=/Climate/ipcc/aviation/index.htm

[4] Greene, D. and S. Plotkin, Reducing Greenhouse Gas Emissions from U.S. Transportation. Prepared for the Pew Center on Global Climate Change, 2011. http://www.pewclimate.org/publications/reducing-ghg-emissions-from-transportation

[5] EIA, *International Energy Outlook 2010*, Chapter 7, 2010. http://www.eia.doe.gov/oiaf/ieo/