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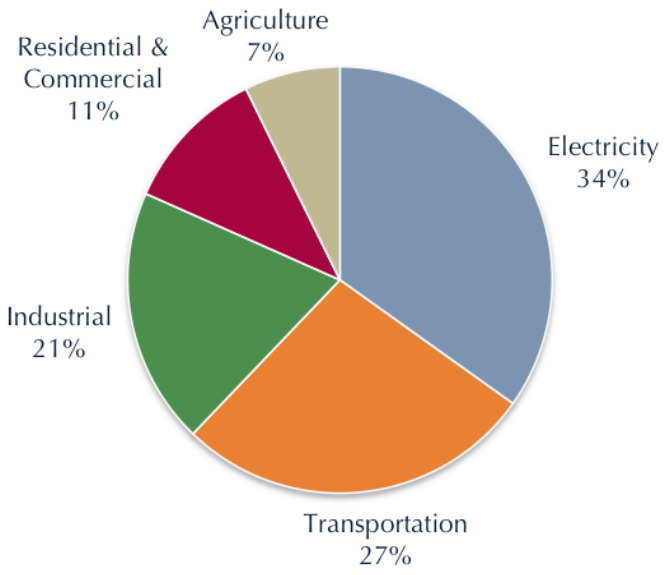
Transportation Overview

U.S. Emissions

More than one-quarter of total U.S. greenhouse gas emissions come from the transportation sector (see Figure 1), making transportation the second largest source of greenhouse gas emissions in the United States after the electric power sector.

Figure 1: U.S. Greenhouse Gas Emissions by Sector (2010)

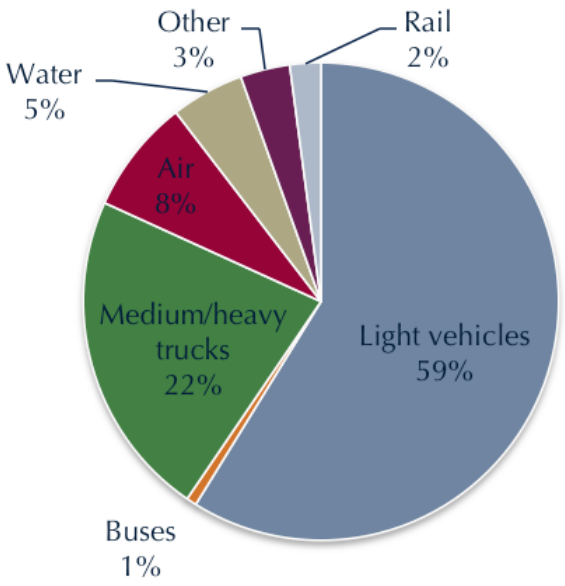


[1]

Source: U.S. Environmental Protection Agency (EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010*, Table ES-7, 2012. http://www.epa.gov/climatechange/emissions/usinventoryreport.html [2].

The transportation sector consists of passenger vehicles (a category including both passenger cars and light-duty trucks), 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). Greenhouse gas emissions mirror energy use by each mode, because all modes use petroleum fuels with similar carbon contents and thus greenhouse gas emissions.

Figure 2: Transportation Energy Use by Mode (2010).



[3]

Source: U.S. Department of Energy. *Transportation Energy Data Book*, Table 2.5, 2011. http://cta.ornl.gov/data/chapter2.shtml [4]

The vast 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 hydrocarbons (which are ozone precursors), 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]

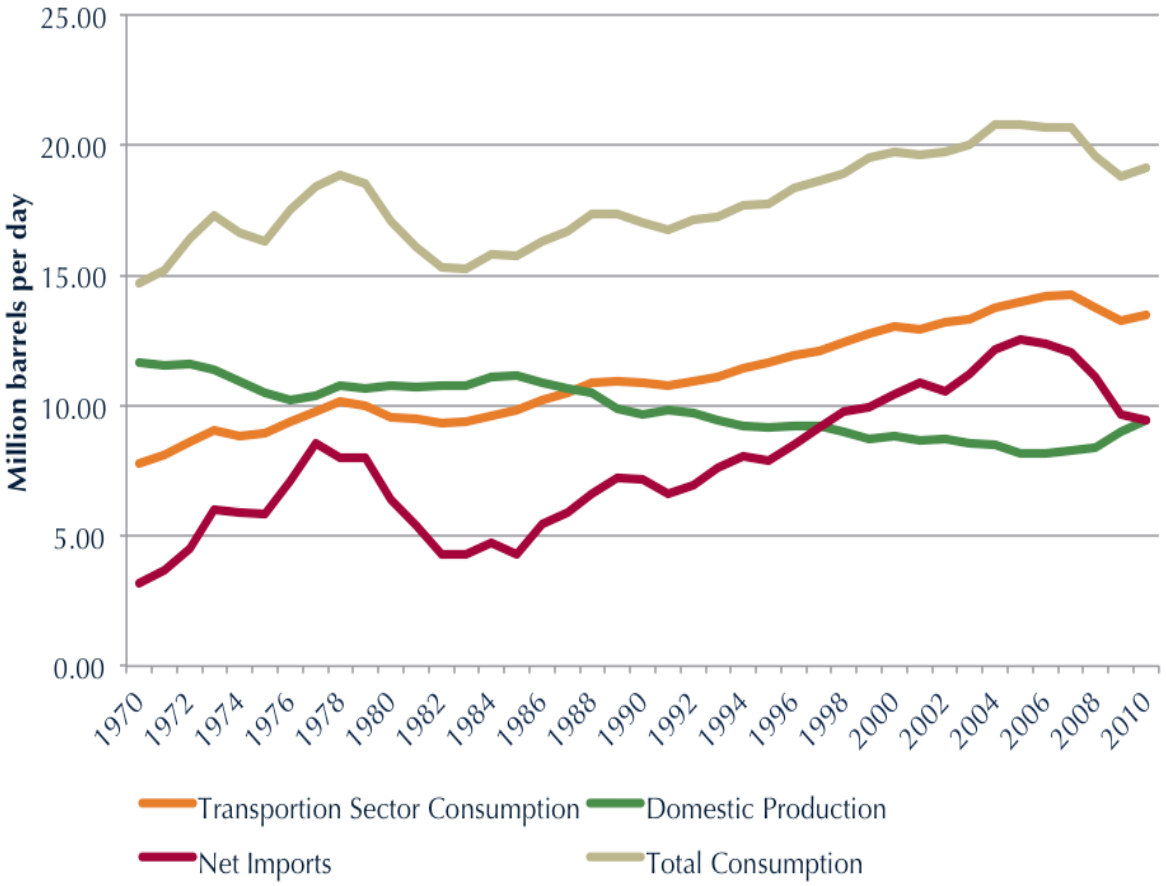
Factors Affecting Transportation Emissions

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. Importantly, transportation accounts for about 70 percent of U.S. oil consumption, which greatly affects U.S. energy security.

Figure 3: Petroleum and Other Liquids Production and Consumption, 1970–2010.



[5]

Source: U.S. Energy Information Agency (EIA), *Annual Energy Review 2011*, Table 5.1a, 5.13c, 2011. http://www.eia.gov/totalenergy/data/annual/index.cfm#petroleum [6]

Nearly all fossil fuel energy consumption in the transportation sector is from petroleum-based fuels (97.4 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 2010.

Table 1: Estimated U.S. Transportation Sector Petroleum Consumption (2010), Million Gallons.

Fuel Type	Consumption
Motor Gasoline	136,091.13
Distillate Fuel Oil (Diesel)	41,612.42

Jet Fuel	21,825.89
Residual Fuel Oil	6,042.41
Lubricants	971.59
Aviation Gasoline	225.12
Liquefied Petroleum Gases	314.75
Total	207,083.31

Source: U.S. Energy Information Administration (EIA), *Annual Energy Review*, Table 5.13c, 2011. http://www.eia.gov/totalenergy/data/annual/index.cfm#petroleum [6]

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.

The production and consumption of biofuels has increased significantly since 2005, due to the state and federal renewable fuel standards [7], which mandate minimum annual consumption levels of ethanol and biodiesel, the two renewable biofuels. Ethanol is an alcohol produced from crops such as corn, vegetable waste, wheat, and others; it is usually combined with gasoline to increase octane levels and more efficient fuel utilization.[3] Biodiesel is produced from natural oils like soybean oil and functions only in diesel engines.[4] In 2010, ethanol (3.9 percent) and biodiesel (0.1 percent) made up four percent of the total primary energy consumed in the transportation sector.[5]

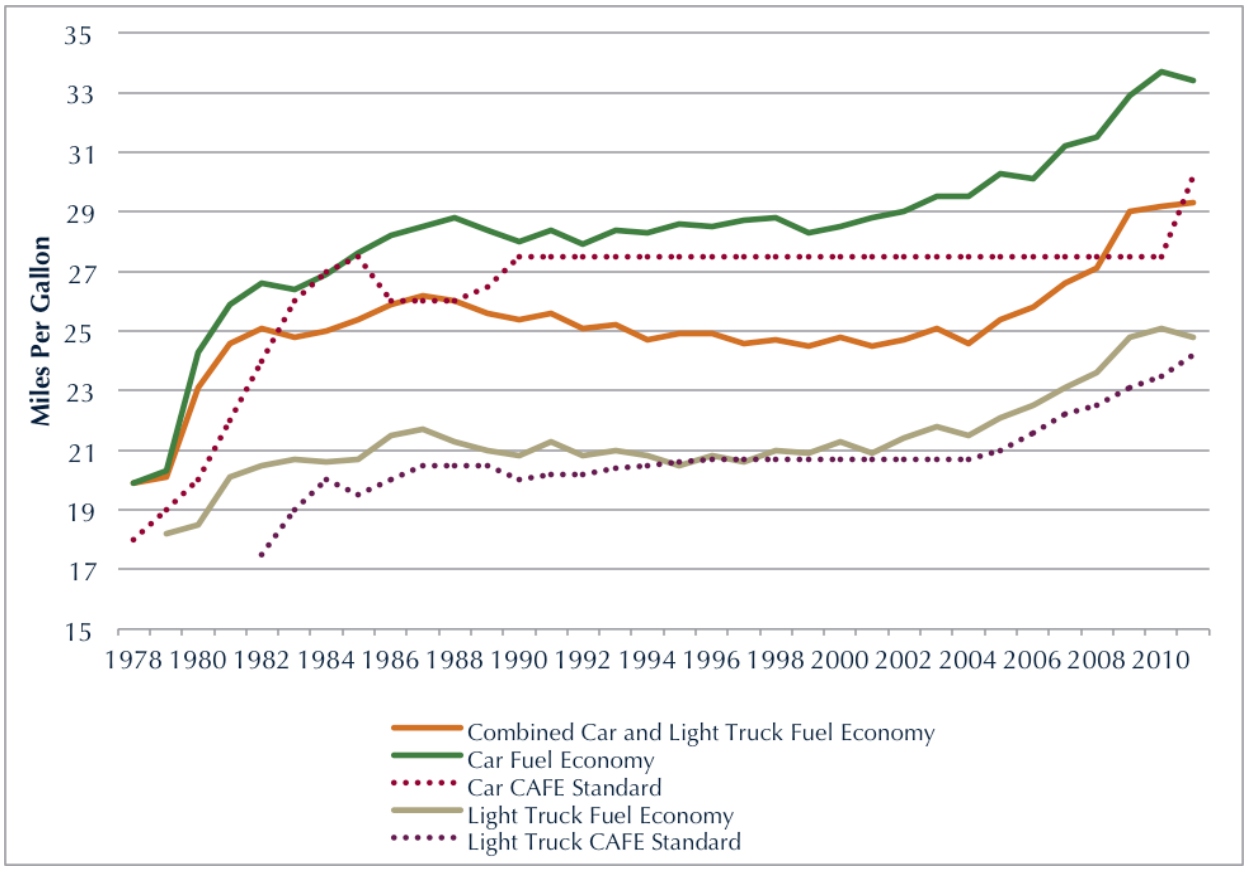
- **Vehicle Efficiency**

  Over the last 30 years, the fuel economy (miles per gallon, mpg) of new passenger vehicles in the United States has improved significantly, increasing by more than 30 percent. Until very recently, most of the gains occurred in the early years of fuel economy regulation under the Corporate Average Fuel Economy (CAFE) program. Fuel economy improvements were nearly stagnant from the late 1980s to the early 2000s. Over this 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. Fuel economy standard for light trucks were increased slightly in 2003, and recent federal vehicle standards [8] adopted in 2010 and 2012 are expected to raise average fuel economy as high as 54.5 mpg for model year 2025.

Transportation modes other than passenger vehicles also have efficiency improvement opportunities. For instance, aircraft energy intensity has historically improved at an average rate of 1.2-2.2 percent per year,[6] although aircraft energy intensity steadily plateaued through the 1990s and early 2000s due to both historically low fuel prices and a tripling in the average age of aircraft and engine production lines since 1989.[7] In addition, federal vehicle standards [8] for medium- and heavy-duty vehicles were adopted in 2011, and should improve fuel efficiency significantly.

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



[9]

Source: NHTSA, *Summary of Fuel Economy Performance*, 2012. http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/2011_Summary_Report... [10]

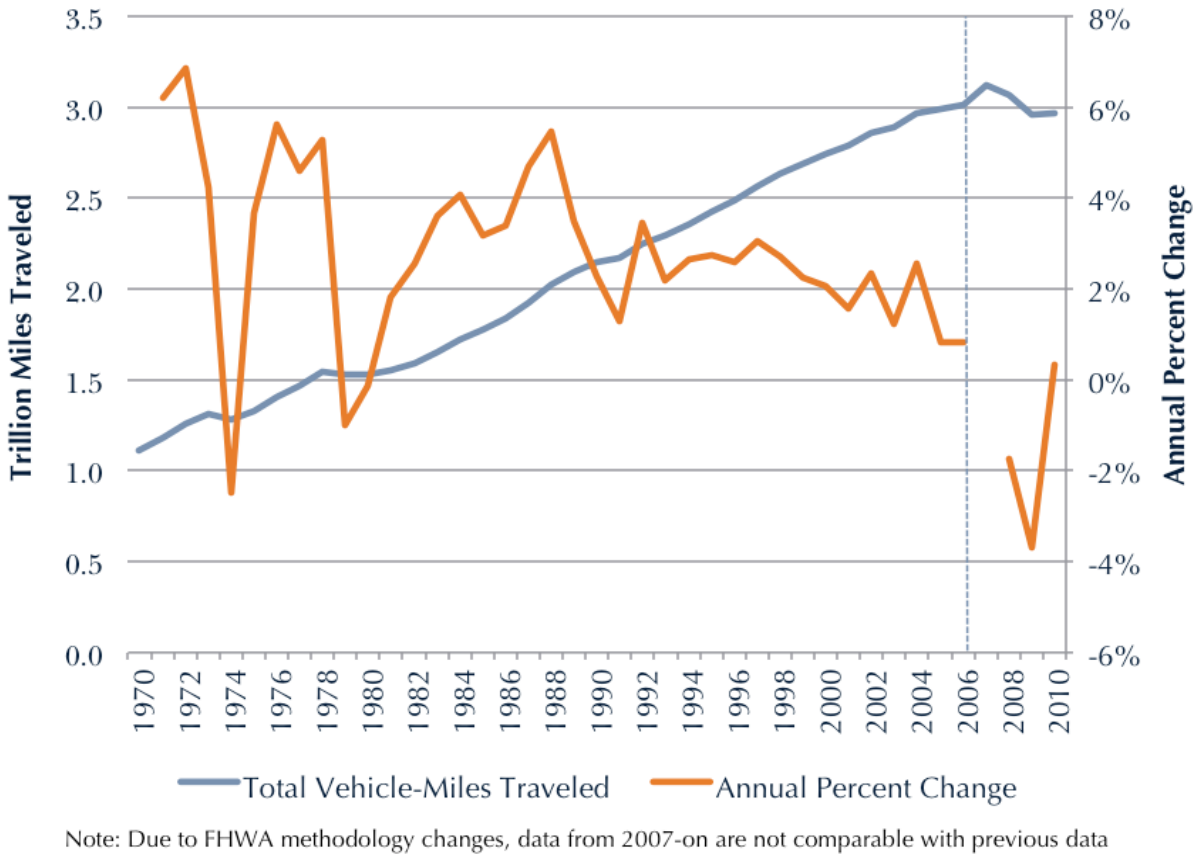
- **Vehicle Use and Distance Traveled**

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) [11] steadily increased until 2008, and has since declined slightly because of high fuel costs and slowing economic growth.

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).



[12]

Source: U.S. Department of Energy, *Transportation Energy Data Book*, Table 3.7, 2012. http://www-cta.ornl.gov/data/chapter3.shtml [13]

- **System Efficiency**

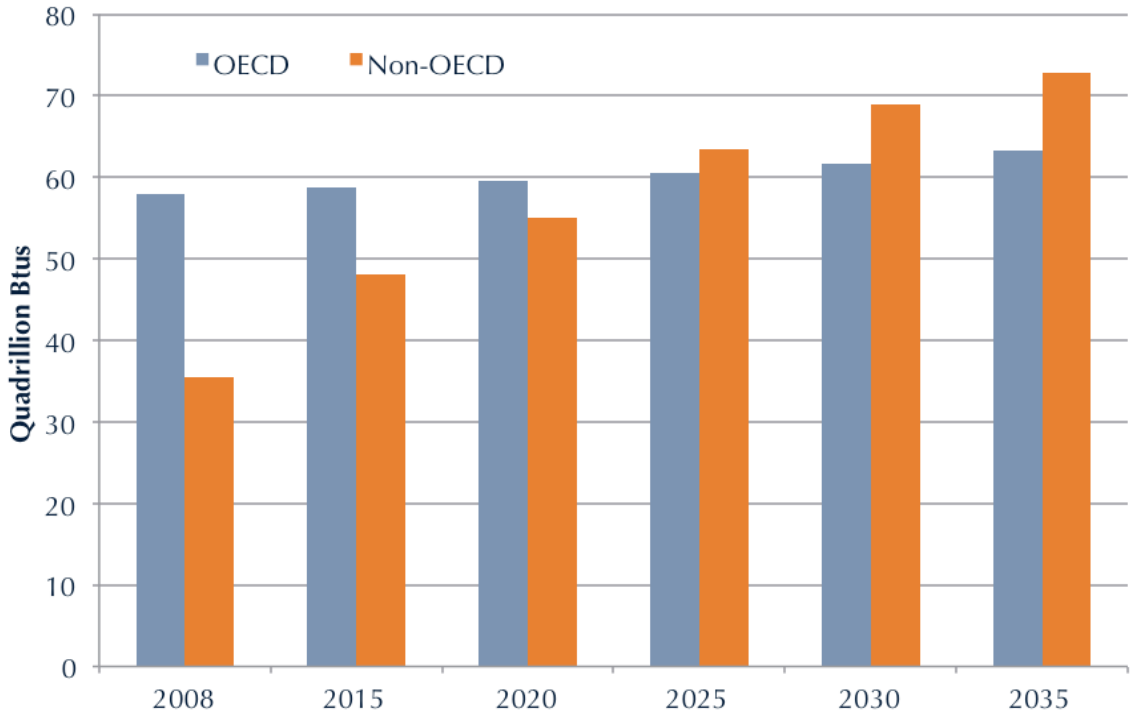
The overall operation of the transportation system also plays an important role in GHG emissions. For example, congestion results when transportation demand exceeds capacity and poses a challenge for almost all modes of transportation, from on-road and highway transport, air, and rail. Shifting travel 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 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 25 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 2008 to 2035, compared to an average increase of 0.3 percent per year for OECD countries.[8] Figure 6 shows projected worldwide energy consumption in the transportation sector.

Figure 6: Global Projections for Transportation Sector, Liquids Consumption, 2008-2035.



[14]

Source: U.S. Energy Information Agency, *International Energy Outlook 2011*. http://www.eia.gov/forecasts/ieo/transportation.cfm [15]

Transportation Sector GHG Mitigation Opportunities

Reducing GHG emissions from transportation will require a systematic approach to address the four interdependent yet distinct components 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* [16]. Prepared for the Center for Climate and Energy Solutions, 2011.
- Cambridge Systematics, Inc. (2009). *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions* [17]. Washington, D.C.: Urban Land Institute.
- Intergovernmental Panel on Climate Change (IPCC), "Transport and its infrastructure. [18]" In *Mitigation of Climate Change*, 2007.
- International Energy Agency (IEA), "Transport. [19]" In *Energy Technology Perspectives 2008: Scenarios and Strategies to 2050*, 2008.

C2ES Work on Transportation

Achieving emission reductions and oil savings from the transportation sector requires a multi-pronged approach that includes improving vehicle efficiency, lowering the carbon content of fuels, reducing vehicle miles traveled, and improving the efficiency of the overall transportation system.

At C2ES, we focus on all aspects of transportation from improving vehicle technology to the benefits of land-use planning. We produce cutting-edge research; track policy progress at the state, federal, and international level; blog on current transportation issues; and create and maintain an online resource of transportation technology.

Cutting-Edge Research - In our 2011 report titled *Reducing Greenhouse Emissions from U.S. Transportation* [16], we identify cost-effective solutions that will significantly reduce transportation's impact on our climate while improving our energy security. We also produce timely white papers on transportation such as two papers focused on surface

transportation reauthorization [20]. See all our transportation-related publications [21].

Policy Progress - We track action at the state, federal, and international level. Our state maps [22] provide useful overviews of action to promote alternative technologies. We also summarize action in Congress and in the Executive Branch, such as our summaries of the Renewable Fuel Standard [7] and Vehicle Fuel Economy and Emission Standards [8]. Lastly we track action at the international level, such as our comparison of international fuel economy standards [23].

Convening Stakeholders - We've undertaken a multi-year initiative on plug-in electric vehicles (PEV) focused on three key challenges (1) making sure PEV owners can conveniently plug in at home and on the road, (2) safeguarding the reliability of America's electrical grid; and (3) informing car buyers. Find out more about the PEV Dialogue Initiative [24].

Climate Compass Blog - On our blog, we provide C2ES's take on the latest news from the transportation sector. See our transportation blog postings [25]**.**

Climate Techbook - The transportation section of the Climate Techbook introduces different transportation modes and technologies along with policies to help mitigate GHG emissions and save oil. Below is a list of all the transportation-related factsheets within the Techbook.

Advanced Biohydrocarbons [26]

Aviation [28]

Biodiesel [30]

Biofuels [32]

Cellulosic Ethanol [34]

Ethanol [27]

Freight Transportation [29]

Hydrogen Fuel Cell Vehicles [31]

Marine Shipping [33]

Transportation Modes [35]

Recommended Resources

U.S. Department of Transportation (DOT)

- Research and Innovative Technology Administration (RITA) [36]
- National Household Travel Survey (NHTS) [37]

- Federal Highway Office of Planning, Environment and Realty (HEP) [38]

U.S. Department of Energy (DOE)

- Transportation Energy Data Book [39]
- Alternative Fuels & Advanced Vehicles Data Center [40]

U.S. Environmental Protection Agency (EPA)

- Renewable Fuel Standard [41]
- Office of Transportation and Air Quality [42]
- SmartWay Program [43]

Joint Federal Programs

- HUD-DOT-EPA Partnership for Sustainable Communities [44]
- Fueleconomy.gov [45]

Transportation Documents by the Natural Resources Defense Council [46]

The World Resources Institute Center for Sustainable Transport: EMBARQ [47]

AASHTO Transportation and Climate Change Resource Center [48]

Related Business Environmental Leadership Council (BELC) Companies

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Alcoa [49]

Alstom [51]

Air Products [53]

BP [55]

Cummins [57]

Daimler [59]

Dow Chemical Company [61]

DuPont [50]

GE [52]

Johnson Controls, Inc. [54]

Rio Tinto [56]

Royal Dutch/Shell [58]

Toyota [60]

Weyerhaeuser [62]

[1] Source: U.S. Environmental Protection Agency (EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010*, 2012. http://www.epa.gov/climatechange/emissions/usinventoryreport.html [2]

[2] EIA, *Annual Energy Review 2010*, Table 2.1e, 2011. http://www.eia.gov/totalenergy/data/annual/index.cfm#consumption [63]

[3] Renewable Fuels Association. “Ethanol Facts”. http://www.ethanolrfa.org/pages/ethanol-facts [64]. Accessed December 10, 2012

[4] National Biodiesel Board, “What is Biodiesel?”. http://www.biodiesel.org/what-is-biodiesel [65]. Accessed December 10, 2012.

[5] EIA, *Annual Energy Review 2010*, Table 10.2b, 2011. http://www.eia.gov/totalenergy/data/annual/index.cfm#renewable [66]

[6] McCollum, D., Gould, G. and Greene, D., *Aviation and Marine Transportation: GHG Mitigation Potential and Challenges*. Prepared for the Center for Climate and Energy Solutions, 2009. http://www.c2es.org/technology/report/aviation-and-marine [67]

[7] http://www.theicct.org/blogs/staff/overturning-conventional-wisdom-aircr... [68]

[8] EIA, *International Energy Outlook 2011*, Chapter 7, 2011. http://www.eia.gov/forecasts/ieo/table15.cfm [69]

A snapshot of U.S. greenhouse gas emissions, global context, and mitigation opportunities for the transportation sector

Teaser:

A snapshot of U.S. greenhouse gas emissions, global context, and mitigation opportunities for the transportation sector

Energy & Technology Transportation

Source URL: http://www.c2es.org/technology/overview/transportation

Links:
[1] http://www.c2es.org/docUploads/transp-1.png
[2] http://www.epa.gov/climatechange/emissions/usinventoryreport.html
[3] http://www.c2es.org/docUploads/transp-2.png
[4] http://cta.ornl.gov/data/chapter2.shtml
[5] http://www.c2es.org/docUploads/transp-3.png
[6] http://www.eia.gov/totalenergy/data/annual/index.cfm#petroleum
[7] http://www.c2es.org/federal/executive/renewable-fuel-standard
[8] http://www.c2es.org/federal/executive/vehicle-standards
[9] http://www.c2es.org/docUploads/transp-4.png
[10] http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/2011_Summary_Report.pdf
[11] http://www.fhwa.dot.gov/policyinformation/travel/tvt/history/
[12] http://www.c2es.org/docUploads/transp-5a.png
[13] http://www-cta.ornl.gov/data/chapter3.shtml
[14] http://www.c2es.org/docUploads/transp-6.png

[15] http://www.eia.gov/forecasts/ieo/transportation.cfm
[16] http://www.c2es.org/publications/reducing-ghg-emissions-from-transportation
[17] http://www.movingcooler.info/
[18] http://www.ipcc.ch/ipccreports/ar4-wg3.htm
[19] http://www.iea.org/Textbase/techno/etp/index.asp
[20] http://www.c2es.org/publications/federal-surface-transportation-authorization
[21] http://www.c2es.org/publications?body=&body_1=&date_filter[value][year]=&topic=All&keywords=Transportation&author=&field_is_article_value=&field_is_brief_value=&field_is_factsheet_value=&field_is_report_value=&field_is_whitepaper_value=&publication_type=0
[22] http://www.c2es.org/what_s_being_done/in_the_states/state_action_maps.cfm#TransportationSector
[23] http://www.c2es.org/federal/executive/vehicle-standards/fuel-economy-comparison
[24] http://www.c2es.org/initiatives/pev/action-plan-report
[25] http://www.c2es.org/blog/filtered_results?tid=2802&name_value=
[26] http://www.c2es.org/technology/factsheet/AdvancedBiohydrocarbons
[27] http://www.c2es.org/technology/factsheet/Ethanol
[28] http://www.c2es.org/technology/factsheet/Aviation
[29] http://www.c2es.org/technology/factsheet/FreightTransportation
[30] http://www.c2es.org/technology/factsheet/biodiesel
[31] http://www.c2es.org/technology/factsheet/HydrogenFuelCellVehicles
[32] http://www.c2es.org/technology/overview/biofuels
[33] http://www.c2es.org/technology/factsheet/MarineShipping
[34] http://www.c2es.org/technology/factsheet/CellulosicEthanol
[35] http://www.c2es.org/technology/factsheet/TransportationModes
[36] http://www.rita.dot.gov/
[37] http://nhts.ornl.gov/index.shtml
[38] http://www.fhwa.dot.gov/hep/index.htm
[39] http://cta.ornl.gov/data/index.shtml
[40] http://www.afdc.energy.gov/afdc/
[41] http://www.epa.gov/otaq/fuels/renewablefuels
[42] http://www.epa.gov/OMS
[43] http://www.epa.gov/smartwaylogistics/
[44] http://www.epa.gov/smartgrowth/partnership/index.html
[45] http://www.fueleconomy.gov/
[46] http://www.nrdc.org/documents.asp?topicid=0&tag=432
[47] http://www.wri.org/project/embarq
[48] http://climatechange.transportation.org/
[49] http://www.c2es.org/companies_leading_the_way_belc/company_profiles/alcoa
[50] http://www.c2es.org/companies_leading_the_way_belc/company_profiles/dupont
[51] http://www.c2es.org/companies_leading_the_way_belc/company_profiles/alstom
[52] http://www.c2es.org/companies_leading_the_way_belc/company_profiles/ge
[53] http://www.c2es.org/companies_leading_the_way_belc/company_profiles/airproducts
[54] http://www.c2es.org/companies_leading_the_way_belc/company_profiles/johnson_controls_inc
[55] http://www.c2es.org/companies_leading_the_way_belc/company_profiles/bp_amoco
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[58] http://www.c2es.org/companies_leading_the_way_belc/company_profiles/shell
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[61] http://www.c2es.org/companies_leading_the_way_belc/company_profiles/dow
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[63] http://www.eia.gov/totalenergy/data/annual/index.cfm#consumption
[64] http://www.ethanolrfa.org/pages/ethanol-facts
[65] http://www.biodiesel.org/what-is-biodiesel
[66] http://www.eia.gov/totalenergy/data/annual/index.cfm#renewable
[67] http://www.c2es.org/technology/report/aviation-and-marine
[68] http://www.theicct.org/blogs/staff/overturning-conventional-wisdom-aircraft-efficiency-trends
[69] http://www.eia.gov/forecasts/ieo/table15.cfm