U.S. Department of Transportation
Federal Transit Administration

Public Transportation's Role in Responding to Climate Change

UPDATED JANUARY 2010

The Federal Transit Administration (FTA) collects and analyzes data from across the country on public transportation fuel use, vehicles deployed, rides taken, and other key metrics. These data, taken from the National Transit Database and combined with information from the U.S. Department of Energy and the U.S. Environmental Protection Agency, provides valuable insight into the impacts of automobile, truck, SUV, and public transportation travel on the production of greenhouse gas emissions. National level data show significant greenhouse gas emission savings by use of public transportation, which offers a low emissions alternative to driving. This paper presents an analysis of the data and frames it in a broader context. It concludes with a description of FTA actions that address climate change.

Based on an examination of FTA's data and other academic, government, and industry sources, public transportation can reduce greenhouse gas emissions by:

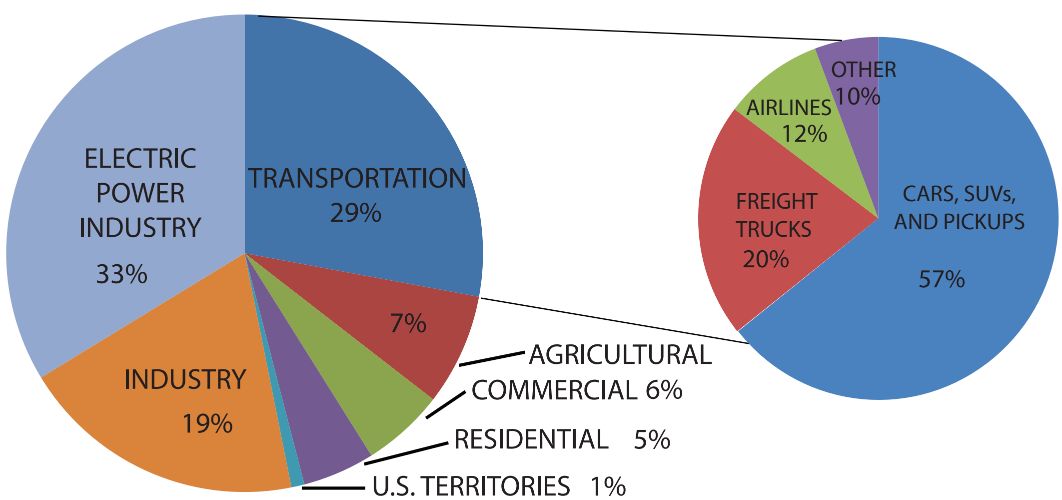
- Providing a low emissions alternative to driving.
- Facilitating compact land use, reducing the need to travel long distances.
- Minimizing the carbon footprint of transit operations and construction.

Greenhouse Gas Sources: Vehicles and Carbon Dioxide

Carbon dioxide makes up 95% of all transportation-related greenhouse gas emissions. Cars, SUVs, and pickup trucks running on conventional gasoline, diesel, and other fuels emit carbon dioxide. Combined, these vehicles account for roughly two-thirds of transportation-related emissions, (see fig. 1) ranking transportation as the second largest source of total U.S. greenhouse gas emissions.

FIGURE 1
Transportation Accounts For 29% of U.S. Greenhouse Gas Emissions.

Source:
U.S. Environmental Protection Agency, *Inventory of Greenhouse Gas Emissions and Sinks: 1990-2007*, April 2009.



The Nobel Prize winning 2007 Intergovernmental Panel on Climate Change report concluded that greenhouse gas emissions must be reduced by 50% to 85% by 2050 in order to limit global warming to four degrees Fahrenheit, thereby avoiding many of the worst impacts of climate change.

Reducing greenhouse gas emissions from transportation will likely require a broad range of strategies, including increasing vehicle efficiency, lowering the carbon content of fuels, and reducing vehicle miles of travel. Public transportation can be one part of the solution.

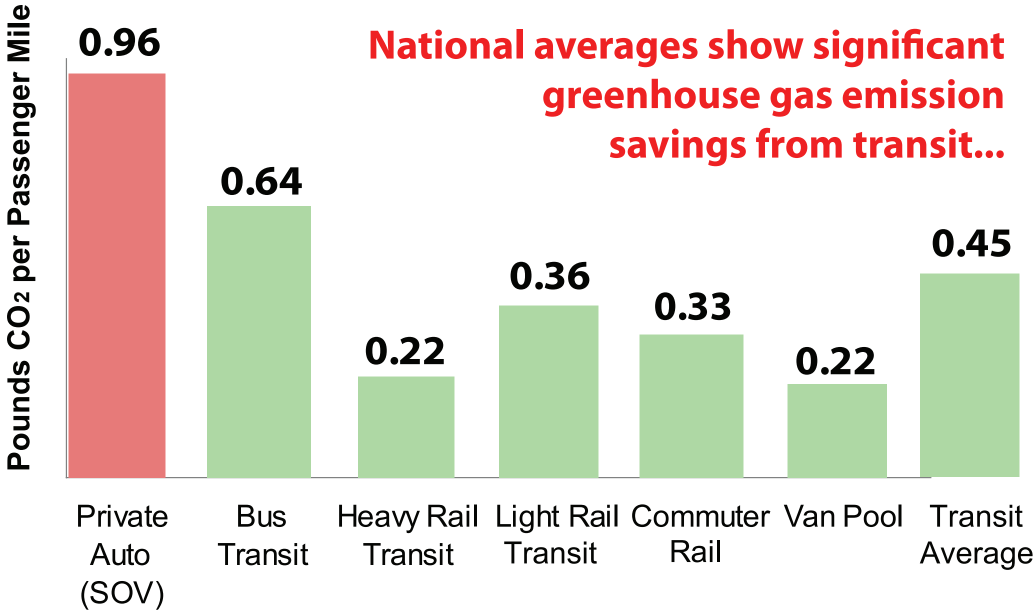


FIGURE 2
Estimated CO_2 Emissions per Passenger Mile for Transit and Private Autos

Source:
See Appendix II for data sources and methodology.

The average passenger car in the United States produces just under one pound of carbon dioxide per mile traveled.

Public Transportation Produces Lower Greenhouse Gas Emissions than Autos

National averages demonstrate that public transportation produces significantly lower greenhouse gas emissions per passenger mile than private vehicles (see Figure 2).[1] Leading the way is heavy rail transit, such as subways and metros, which produce 76% less in greenhouse gas emissions per passenger mile than an average single-occupancy vehicle (SOV). Light rail systems produce 62% less and bus transit produces 33% less.[2]

Estimates are calculated from fuel usage and passenger mile data in the 2008 National Transit Database, standard emissions factors for different fuels are from the U.S. Department of Energy, and sub-regional electricity emissions factors are from the U.S. Environmental Protection Agency (see Appendix II: Methodology).

The environmental benefits of public transportation vary based on the number of passengers per vehicle, the efficiency of the bus or train, and the type of fuel used (see Appendix I for estimates for transit agencies across the country).

The number of riders greatly impacts transit's emissions savings.

The more passengers that are riding a bus or train, the lower the emissions per passenger mile. For instance, U.S. bus transit, which has about a quarter (28%) of its seats occupied on average, emits an estimated 33% lower greenhouse gas emissions per passenger mile than the average U.S. single occupancy vehicle. The savings increases to 82% for a typical diesel transit bus when it is full with 40 passengers (see Figure 3).

What Individuals Can Do to Reduce their Carbon Footprint

Switching to riding public transportation is one of the most effective actions individuals can take to reduce their carbon footprint.

Car transportation alone accounts for 47% of the carbon footprint of a typical American family with two cars—by far the largest source of household emissions and, as such, the largest target for potential reductions. (a) The average passenger car in the U.S. produces just under 1 pound of carbon dioxide per mile traveled.

If just one driver per household switched to taking public transportation for a daily commute of 10 miles each way, this would save 4,627 pounds of carbon dioxide per household per year—equivalent to an 8.1% reduction in the annual carbon footprint of a typical American household. This benefit has a greater impact than other actions, such as replacing light bulbs with compact fluorescents (a 1.6% reduction based on 20 out of 25 light bulbs change) or adding R-40 insulation to a home attic (a 1.2% reduction). (b)

Visit FTA's carbon calculator at www.fta.dot.gov/sustainability to estimate how much you can reduce your carbon footprint by switching to public transportation.

(a) Godo Stoyke, The Carbon Buster's Home Energy Handbook, 2007, pp22-23.
(b) The Carbon Buster's Home Energy Handbook, 2007, pp22-23

With these data in mind, when expanding transit service as a greenhouse gas reduction strategy, communities would likely want to ensure that passenger loads are sufficient to achieve efficiencies over the alternative of driving.[3] For example, the average 40-passenger diesel bus must carry a minimum of 7 passengers on board to be more efficient than the average single-occupancy vehicle. Similarly, the average heavy rail car would need to have at least 19% of seats full to exceed the efficiency of an automobile carrying an average passenger load.

Power sources and vehicle efficiency also impact transit's emissions.

Most rail transit systems are powered by electricity. Those relying on electricity from a low emissions source, such as hydroelectric, not surprisingly, have much lower emissions than those relying on electricity from coal power plants. (See Appendix I for emissions factors). Rail vehicles also vary in terms of energy efficiency due to weight and engineering factors.

Emissions from bus systems vary due to the use of low carbon fuels, more energy efficient vehicles, and different operating environments (such as frequent stops in denser urban areas). In terms of vehicle efficiency for instance, many transit agencies are replacing older diesel buses with new hybrid-electric buses, which consume 15% to 40% less fuel, and consequently produce 15% to 40% fewer carbon dioxide emissions.

Taking lifecycle emissions into account also shows emissions savings from transit.

Transit-based greenhouse gas emissions per passenger mile are significantly lower than those from driving, even taking into account emissions from construction, manufacture, and maintenance.

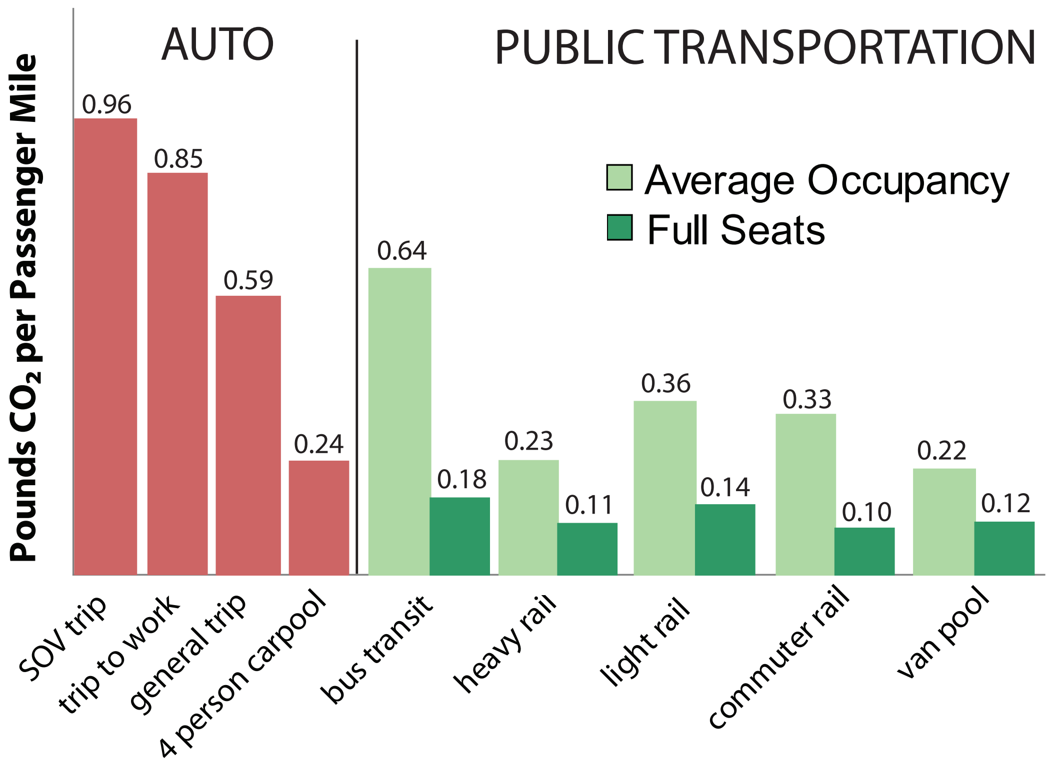


FIGURE 3

Estimated CO_2 Emissions per Passenger Mile for Average and Full Occupancy

Sources:
See Appendix II for data sources and methodology.

Notes: The average number of passengers for private auto trips is 1.14 for work trips and 1.63 for general trips.

Life cycle emissions include a full accounting of all emissions generated over the full life of a transportation system. This includes emissions from building the highway or rail system, manufacturing the vehicles, maintaining the infrastructure and vehicles, producing and using the fuel, and eventually disposing of the vehicles and infrastructure. The previous graphs only showed tailpipe emissions, or solely the emissions from burning fuel or generating electricity to move a vehicle.

Researchers at the University of California at Berkeley have developed a methodology for measuring life cycle greenhouse gas emissions from cars and public transportation (see Figure 4).[4] As transit systems vary greatly, the researchers chose a handful of systems, including the San Francisco Bay Area's heavy rail BART system and light rail Muni system, California's commuter rail system Caltrain, and Boston's light rail Green Line. In a second study, they added analysis of New York City's subway, the PATH system serving New York and New Jersey, and Chicago's "L" and commuter rail. The researchers found that including full life cycle greenhouse gas emissions increased estimates by as much as 70% for autos, 40% for buses, 150% for light rail, and 120% for heavy rail.

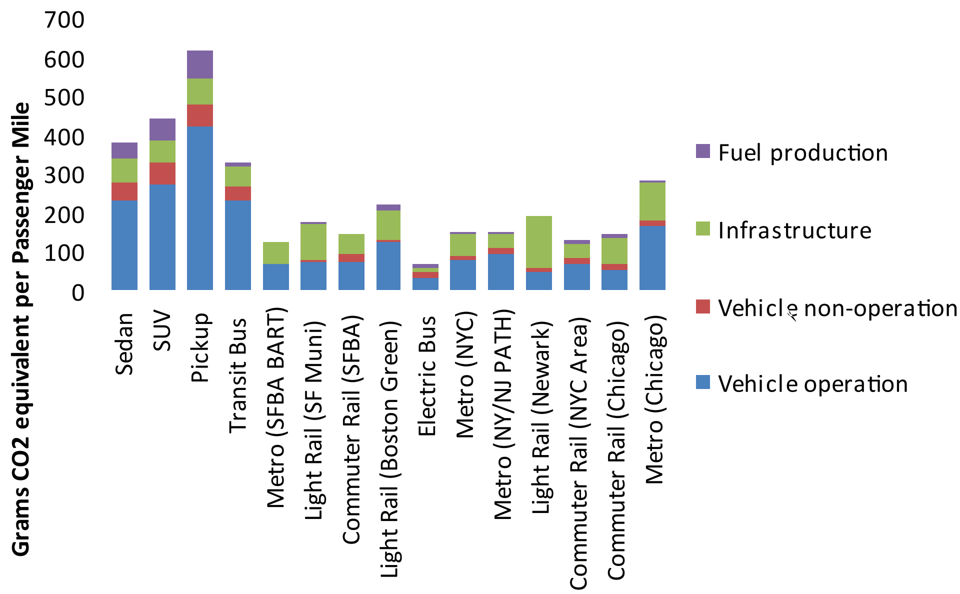
While including emissions from construction of infrastructure has a larger impact on rail transit than on automobiles, the results still show significant emissions savings from average occupancy rail and bus transit over average occupancy sedans, SUVs, and pickups.[5] The researchers found that including greenhouse gas emissions from construction and maintenance of the BART heavy rail transit system increases estimated greenhouse gas emissions per passenger mile from 64 grams to 140 grams, but that this still represents a 63% and 69% savings over travel by sedan and SUV, respectively. Similarly, emissions per passenger mile on Boston's light rail Green Line increase from 120 to 230 grams, still offering a 55% and 62% savings over sedan and SUV travel, respectively.

FIGURE 4
Life Cycle Greenhouse Gas Emissions

Source:

Mikhail Chester and Arpad Horvath. *Life-cycle Energy and Emissions Inventories for Motorcycles, Diesel Automobiles, School Buses, Electric Buses, Chicago Rail, and New York City Rail*, 2009. http://escholarship.org/uc/item/6z37f2jr

Note: The study uses average occupancies for these vehicles and systems.



...transit greenhouse gas emissions per passenger mile are still significantly lower than those from driving, even taking into account emissions from construction, manufacturing, and maintenance.

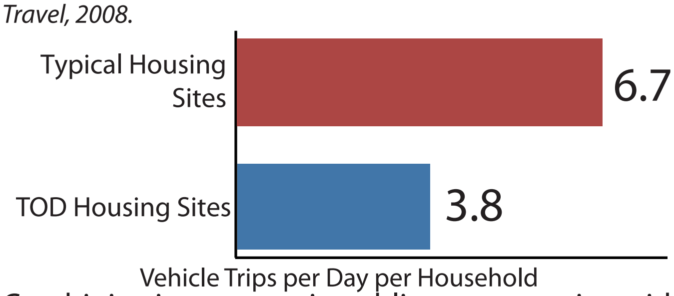
Public Transportation Facilitates Compact Land Use, Which Plays a Role in Greenhouse Gas Reductions

Public transportation reduces emissions by facilitating higher density development, which conserves land and decreases the distances people need to travel to reach destinations. In many cases, higher density development would be more difficult without the existence of public transportation because more land would need to be devoted to parking and travel lanes. By facilitating higher density development, public transportation can shrink the footprint of an urban area and reduce overall trip lengths. In addition, public transportation supports increased foot traffic, street-level retail, and mixed land uses that enable a shift from driving to walking and biking. Public transportation can also facilitate trip chaining, such as combining dry-cleaning pick-up, shopping, and other errands on the way home from a station. Finally, households living close to public transportation tend to own fewer cars on average, as they may not need a car for commuting and other trips. A reduced number of cars per household tends to lead to reduced car use, and driving may cease to be the habitual choice for every trip.[6]

Multiple studies have quantified this relationship between public transportation, land use, and reduction in travel. Studies show that for every additional passenger mile traveled on public transportation, auto travel declines by 1.4 to 9 miles.[7] In other words, in areas served by public transportation, even non-transit users drive less because destinations are closer together. One study used modeling to isolate the effect of public transportation on driving patterns (rather than that effect combined with denser land use creating a need for improved public transportation). That study, conducted by consulting firm ICF and funded through the Transit Cooperative Research Program (TCRP), found that each mile traveled on U.S. public transportation reduced driving by 1.9 miles. It concluded that public transportation reduces U.S. travel by an estimated 102.2 billion vehicle miles traveled (VMT) each year, or 3.4% of annual U.S. VMT.[8] Moreover, the report argued, by reducing congestion, transit lowers emissions from cars stuck in traffic. The Texas Transportation Institute's 2007 Mobility Report estimates that by reducing congestion, transit saved an estimated 340 million gallons of fuel in 2005.[9] Combining the emissions savings from passengers taking transit rather than driving, with VMT reduction due to transit's impact on the built environment, and savings from reduced congestion due to transit, the ICF report finds that public transportation reduces carbon dioxide emissions by 37 million metric tons annually.[10]

FIGURE 5
Vehicle Trips per Day of Transit Oriented Development (TOD) Housing Sites versus Typical Housing Sites

Source: *TCRP 128: Effects of TOD on Housing, Parking and Travel, 2008.*



Combining investment in public transportation with compact, mixed-use development around transit stations has a synergistic effect that amplifies the greenhouse gas reductions of each strategy. TCRP Report 128, "Effects of TOD on Housing, Parking and Travel," surveyed 17 transit-oriented development (TOD) housing projects and found that these projects averaged 44% fewer vehicle trips for a typical weekday period than that estimated by the Institute of Transportation Engineers (ITE) manual for a typical housing development.[11] The weighted average differentials were even larger during peak periods – 49% lower rates during the A.M. peak and 48% lower rates during the P.M. peak.[12] A study by the Center for Transit Oriented Development (CTOD) compared CO_2 emissions per household based on location efficiency, as defined by access to rail transit and neighborhood land use characteristics. The study found that, compared to the average metropolitan area household, households in transit zones that fell into the two middle categories of location efficiency produced 10% and 31% lower transportation emissions, and households in the highest location efficient category produced 78% lower transportation emissions than the average metropolitan area household.[13] A study published by the Urban Land Institute found that within areas of compact development, driving is reduced 20% to 40% compared to average U.S. development patterns.[14]

On a national scale, a recent Transportation Research Board report estimated that the reduction in vehicle miles traveled (VMT), energy use, and CO_2 emissions resulting from more compact, mixed-use development would be in the range of less than 1% to 11% by 2050.[15] A report by Cambridge Systematics found that pursuing a combined land use, transit, and non-motorized transportation strategy bundle could reduce U.S. transportation greenhouse gas emissions by 9% at an aggressive level or 15% at a maximum deployment level. The study found that savings from reduced driving costs would outweigh implementation costs. (The study did not quantify other benefits and costs such as changes in environmental quality, public health, travel time, safety, and user fees.)[16] Adding a strong price signal such as a VMT fee and varying car insurance rates by the number of miles driven would almost double the emission reductions.[17]

There are several examples in the United States of communities that are planning integrated public transportation and land use strategies in order to enhance quality of life, reduce congerstion, lower household transportation expenses, and reduce greenhouse gas emissions as well. Salt Lake City is one example. Through a participatory pro-

The left photo shows an intersection near Central Pointe Station in Salt Lake City. The right photo shows the same intersection with proposed transit oriented development.
Photo Credit: Reproduced from Envision Utah, Wasatch Front Transit Oriented Development Guidelines, 2002.

cess called "Envision Utah" residents of Salt Lake City chose between four alternative growth scenarios. In the end, residents chose the scenario with growth focused into walkable, transit-oriented communities. Under this scenario, daily household VMT is ten miles lower than under the business as usual case, resulting in a significant drop in emissions. Salt Lake City is now building new light rail transit lines and clustering housing, jobs, and recreation around these lines in order to make the community's preferred scenario a reality.[18]

Denver, Portland, the Twin Cities, Washington, DC, and Dallas also provide examples of metropolitan areas aggressively pursuing transit-oriented development, yielding transportation, environmental, and economic benefits. California's experience with a new state law, SB375, requiring integrated transportation and land use planning to reduce greenhouse gas emissions, will provide lessons for other states.

Public Transportation Providers Use Energy Conservation and Technology to Reduce Emissions from Operations

Public transportation agencies across the country are taking actions to reduce the greenhouse gas intensity of their operations. Some agencies are building new administrative and maintenance facilities to Leadership in Energy and Environmental Design (LEED) standards or higher. For instance, New York City Transit built a LEED certified maintenance facility that has fuel cell units, rooftop solar panels, natural lighting, and rain water storage to wash buses and cars. The agency is also reducing emissions from construction by using recycled content in construction materials. Many agencies are replacing older buses with new hybrid buses. In fact, 35% of buses on order by U.S. transit agencies are hybrid electric.[19]

Agencies are also using alternative fuels such as biodiesel and piloting hydrogen fuel cell buses, which produce zero emissions when the hydrogen is produced from a zero emission power source such as solar.

Most rail transit is powered by electricity, which offers efficiency improvements over internal combustion engines. Rail agencies are looking to further reduce energy consumption by lowering the amount of electricity used in powering vehicles. In Phoenix, for example, the new light rail system uses regenerative braking to lower electricity consumption.

As the electric power industry shifts to more renewable sources of energy, as being mandated in several states, electric public transportation systems provide even more emissions reduction benefits. When the electricity is generated from a zero emissions source, such as wind, hydroelectric, nuclear, or solar, the public transportation systems that use these power sources are also zero emission.

Several transit agencies are installing on-site renewable energy generation to power parts of their systems. Boston's transit agency is installing wind turbines, New York City Transit plans to harvest power from the tides by installing turbines in tidal waters, and Los Angeles Metro is installing solar panels on its properties.

FTA Actions to Address Climate Change

The Federal Transit Administration (FTA) works with public transportation providers and other key stakeholders to implement strategies that reduce greenhouse gas emissions from the transportation sector. FTA's grants, technical assistance, research, and policy leadership all play a role in the agency's efforts to address climate change.

Portland Streetcar (TriMet), Portland, Oregon

FTA grows and sustains public transportation as a low-emission alternative to automobiles through the agency's $10 billion a year grant programs. Over 1,500 transit agencies representing every state in the country benefit from FTA grants. Agencies received an additional $8.4 billion infusion of support from the American Recovery and Reinvestment Act (ARRA) of 2009, which provided funding for public transportation, among other job creating strategies.

In its grants, FTA seeks to give local communities flexibility to implement the type of projects that maximize transit's potential to reduce greenhouse gas emissions. For instance, combining investment in public transportation with compact, mixed-use development around transit stations has a synergistic effect that amplifies the greenhouse gas reductions of each strategy. To encourage these synergies, FTA's grants can be used for "joint development," or common use of property for both transit and non-transit purposes.[20] This enables clustered development around transit. FTA's grants can also fund bicycle paths and sidewalks, helping residents better access transit and get around emissions free.[21]

Combating climate change is a key goal of the Secretary of Transportation's signature livability initiative, of which FTA programs are a central element. According to Secretary LaHood, "livable communities are mixed-use neighborhoods with highly-connected streets promoting mobility for all users, whether they are children walking or biking to school or commuters riding transit or driving motor vehicles. Benefits include improved traffic flow, shorter trip lengths, safer streets for pedestrians and cyclists, lower greenhouse gas emissions, reduced dependence on fossil fuels, increased trip-chaining, and independence for those who prefer not to or are unable to drive. In addition, investing in a "complete street" concept stimulates private-sector economic activity by increasing the viability of street-level retail small businesses and professional services, creating housing opportunities and extending the usefulness of school and transit facilities."[22]

U.S. DOT, the U.S. Department of Housing and Urban Development (HUD) and the U.S. Environmental Protection Agency (EPA) created a high-level interagency partnership to support these goals. The initiative is based on six principles:

- providing more transportation choices,
- promoting equitable, affordable housing,
- enhancing economic competitiveness,
- supporting existing communities,
- coordinating policies and leveraging investment,
- valuing the uniqueness of communities and neighborhoods.

As part of the first batch of funding for the livability initiative, the Secretary announced $280 million in FTA bus and urban circulator grants targeted to projects that meet livability and sustainability criteria, including greenhouse gas reduction.[23]

In addition to FTA's grant programs, FTA's technical assistance is another key part of the agency's efforts to respond to climate change. FTA's technical assistance gives local communities the tools they need to improve planning practices, engage stakeholders, and build transit-oriented development. FTA provides Environmental Management Systems (EMS) training that helps transit agencies continually assess and reduce the energy and environmental impact of their operations. For instance, in Kentucky, the Transit Authority of River City reduced its carbon dioxide emissions by 907,000 lbs per year and saved $15,000 annually through energy efficiency measures.

Transit-Oriented Development in Boulder, Colorado

FTA research on alternative fuels and high fuel efficiency vehicles has yielded the introduction of low emission technologies such as hybrid-electric buses, compressed natural gas vehicles, and biodiesel. FTA's new Electric Drive Strategic Plan and the National Fuel Cell Bus Program are intended to introduce the next generation of low emission vehicles. FTA encourages adoption of clean technologies by supporting a higher share of the cost of purchasing clean vehicles. In addition, FTA's Clean Fuel Bus Program targets investment in clean transit vehicles.

And a new FTA program under ARRA, Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER), supports transit agencies in pursuing cutting-edge environmental technologies to help reduce global warming and create green jobs. Among the 43 projects funded under the competitive bidding in 2009, Alabama will replace gasoline and diesel buses with electric hybrids, Massachusetts will construct wind energy generation turbines, and Vancouver, Washington will install solar panels at transit facilities. Transit agencies submitted $2 billion in applications for this $100 million program, indicating pent-up demand. As such, Congress included funding for the program in the 2010 appropriations.

FTA conducts policy research, produces outreach materials, and engages stakeholders in addressing the challenge of climate change. For instance, FTA partnered with the American Public Transportation Association (APTA) to develop a standard methodology for measuring greenhouse gas emissions produced by public transportation, so agencies can track and reduce their emissions.

Finally, FTA contributes to research and policy development on climate change mitigation and adaptation in the transportation sector through the U.S. Department of Transportation Climate Change Center. The Center has produced key studies on the impacts of climate change on transportation infrastructure, reports on integrating climate change considerations into transportation planning, and evaluations of strategies for reducing greenhouse gas emissions from transportation. The Center also maintains a web-based clearinghouse (See www.climate.dot.gov).

A view of Arlington, VA shows clustered development around the transit corridor. Office, retail, restaurants, multi-family housing, and single family housing are all within walking distance to Metrorail stops

FOOTNOTES

1. Passenger miles = vehicle miles x average number of passengers on vehicle. Normalizing by passenger miles allows for comparison between vehicles carrying different numbers of passengers.

2. Comparison is with single occupancy vehicles as policy typically focuses on shifting single occupancy trips to transit rather than shifting high occupancy trips. Comparisons with average occupancy private vehicles and carpools are found in figure 3.

3. Communities may still wish to expand transit for benefits other than environmental ones, such as providing access to jobs, spurring economic development, and providing mobility for people who cannot afford to drive or who cannot drive because of age or disability.

4. Mikhail Chester, *Life-cycle Environmental Inventory of Passenger Transportation Modes in the United States*, University of California, Berkeley, August 2008.

5. Average bus occupancy is 9 passengers, according to the National Transit Database. Authors of the Berkeley study assume peak buses have 40 passengers, off-peak buses have 5 passengers, sedans have 1.58 passengers, SUVs 1.74, and pick-ups 1.46.

6. American Public Transportation Association, Climate Change Standards Working Group, Discussion Paper, July 2008.

7. Newman, P. and J. R. Kenworthy (1999). *Sustainability and Cities: Overcoming Automobile Dependence*. Washington, D.C., Island Press. Studied 32 major cities worldwide. Showed a reduction of 5 to 7 miles.

Neff, J. W. (1996). *Substitution Rates Between Transit and Automobile Travel*. Association of American Geographers Annual Meeting. Charlotte, NC. Studied U.S. urbanized areas. Showed a reduction of 5.4 to 7.5 miles.

Pushkarev, B. S., J. M. Zupan, et al. (1982). *Urban Rail in America: An Exploration of Criteria for Fixed-Guideway Transit*, Indiana University Press.

Holtzclaw, J. (2000). *Does A Mile In A Car Equal A Mile On A Train? Exploring Public Transit's Effectiveness In Reducing Driving*. Studied three cities in the San Francisco Bay Area. Showed a reduction of 1.4 to 9 miles.

8. T*he Broader Connection between Public Transportation, Energy Conservation and Greenhouse Gas Reduction*, ICF International, TCRP Project J-11/Task 3, February 2008. http://www.apta.com/research/info/online/land_use.cfm

9. Texas Transportation Institute, 2007 Mobility Report, http://mobility.tamu.edu/ums/

10. *The Broader Connection between Public Transportation, Energy Conservation and Greenhouse Gas Reduction*, ICF International, funded through Transit Cooperative Research Program (TCRP) Project J-11/Task 3, February 2008. http://www.apta.com/research/info/online/land_use.cfm

11. 3.754 versus 6.715 daily trips per unit
G.B. Arrington and Robert Cervero, *TCRP Report 128: Effects of TOD on Housing, Parking and Travel*. Transportation Research Board: Washington, DC, 2008.

12. Ibid.

13. Center for Transit Oriented Development and Center for Neighborhood Technology. *Transit Oriented Development and the Potential for VMT-related Greenhouse Gas Emissions Reduction*. 2009.

14. *Growing Cooler: The Evidence on Urban Development and Climate Change*, Urban Land Institute, Smart Growth America, National Center for Smart Growth, Center for Clean Air Policy, September 2007. http://www.smartgrowthamerica.org/gcindex.html

15. Transportation Research Board. *Special Report 298: Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions*. 2009.

16. The strategies in this bundle are parking pricing, congestion pricing, smart growth land use strategies, pedestrian and bicycle improvements, public transportation and intercity rail investment, HOV lanes, car-sharing, commuting and carpool measures, urban non-motorized zones, parking restrictions, signal management, traveler information, and urban consolidation centers.

17. Cambridge Systematics. *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. Urban Land Institute: Washington, DC, 2009.

18. For more information, see http://www.envisionutah.org/.

19. American Public Transportation Association. *2009 Public Transportation Vehicle Database*. June 2009.

20. For more information, please see http://www.fta.dot.gov/documents/Joint_Development_-_State_Public_Transit_Partnerships_Conference_2007-08-09.ppt#291,1,2007 State Public Transit Partnerships Conference ----- FTA State Programs Meeting.

21. For more information, please see http://edocket.ac2cess.gpo.gov/2009/pdf/E9-27240.pdf.

22. Statement of Ray LaHood, Secretary of Transportation, before the U.S. Senate Committee on Banking, Housing, and Urban Affairs, June 16, 2009

23. For more information on this funding, officially called, "Section 5309 Bus and Bus Facilities Livability Initiative Program Grants" and "Exempt Discretionary Program Grants (Section 5309) for Urban Circulator Systems," please see http://edocket.access.gpo.gov/2009/pdf/E9-29242.pdf and http://edocket.access.gpo.gov/2009/pdf/E9-29245.pdf.

Appendix I

Estimated Carbon Dioxide Emissions per Passenger Mile for U.S. Transit Systems, 2008

Listed by system type in order of total passenger miles. See Appendix II for data sources and methodology.

Average U.S. Single Occupany Vehicle: 0.964 pounds CO_2/passenger mile

Heavy Rail Systems

State	Heavy Rail Common Name	Pounds CO2 / passenger mile	% of total heavy rail passenger miles traveled in the U.S.	KWH/ seat mile (Efficiency of Vehicle)	Average % of seats full (Ridership)	Pounds CO2/MWH for eGRID subregion (carbon content)
NY	New York City Subway	**0.147**	59.3%	0.107	59%	815
DC	Washington Metro	**0.347**	9.7%	0.101	33%	1,139
CA	San Francisco BART	**0.085**	8.6%	0.069	32%	399*
IL	Chicago "L"	**0.573**	7.0%	0.133	36%	1,538
GA	Atlanta MARTA	**0.245**	3.5%	0.064	39%	1,490
MA	Boston "T"	**0.336**	3.3%	0.167	46%	928
PA	Philadelphia SEPTA	**0.374**	2.5%	0.151	46%	1,139
NJ	New Jersey PATH	**0.302**	2.1%	0.249	94%	1,139
CA	Los Angeles Metro	**0.282**	1.3%	0.248	64%	724
FL	Miami-Dade Transit	**0.656**	0.8%	0.137	28%	1,319
NJ	New Jersey PATCO	**0.519**	0.6%	0.128	28%	1,139
MD	Baltimore Metro	**0.919**	0.4%	0.137	17%	1,139
OH	Cleveland Rapid	**0.805**	0.3%	0.168	32%	1,538
NY	Staten Island Railway	**0.346**	0.3%	0.110	26%	815
National Average Weighted by Passenger Miles		**0.224**	**99.7%**	**0.109**	**47%**	

Source: Calculated from Federal Transit Administration 2008 National Transit Database (NTD), U.S. Department of Energy carbon dioxide conversion factors, U.S. Environmental Protection Agency eGRID.

Note: Energy data not available for the privately operated Tren Urbano system in Puerto Rico.
Note: This paper uses the Climate Registry General Reporting Protocol method for determining the emissions factors for purchased electricity. That method is to use the eGRID subregion data published by the U.S. Environmental Protection Agency unless electricity is purchased directly from a generation source with a known emissions factor. The calculations for all of the transit systems in this paper use the eGRID subregion emissions factors with the exception of the BART system. The BART system purchases electricity directly rather than through the general subregion grid. As such, BART was able to provide an emissions factor specific to the electricity it purchases, 399 pounds per megawatt hour, which was used in the calculations rather than the eGRID factor for its subregion of 724 pounds per megawatt hour. The system specific factor yields .085 pounds CO2 per passenger mile for the BART system while the subregion eGRID factor yields 0.155 pounds CO2 per passenger mile. This changes the national average only slightly, from 0.230 to 0.224 pounds CO2 per passenger mile.

Light Rail Systems

State	Transit Authority	Pounds CO2 / passenger mile	% of total light rail passenger miles traveled in the U.S.	KWH/ seat mile (Efficiency of Vehicle)	Average % of seats full (Ridership)	Pounds CO2/MWH for eGRID subregion (carbon content)
CA	Los Angeles County Metropolitan Transportation Authority	**0.219**	14.7%	0.138	46%	724.12
CA	San Diego Metropolitan Transit System	**0.146**	9.9%	0.081	40%	724.12
OR	Tri-County Metropolitan Transportation District of Oregon	**0.213**	9.3%	0.106	45%	902.24
MA	Massachusetts Bay Transportation Authority	**0.266**	9.0%	0.208	73%	927.68
TX	Dallas Area Rapid Transit	**0.534**	7.3%	0.162	40%	1324.35
MO	Bi-State Development Agency	**0.284**	6.9%	0.083	30%	1019.74
CO	Denver Regional Transportation District	**0.683**	6.4%	0.081	22%	1883.08
CA	San Francisco Municipal Railway	**0.299**	6.4%	0.166	40%	724.12
CA	Sacramento Regional Transit District	**0.338**	4.1%	0.146	31%	724.12
NJ	New Jersey Transit Corporation (privately operated)	**0.560**	4.0%	N/A*	33%	1139.07
PA	Southeastern Pennsylvania Transportation Authority	**0.557**	3.5%	0.184	38%	1139.07
UT	Utah Transit Authority	**0.260**	3.4%	0.111	38%	902.24
MN	Metro Transit	**0.422**	2.9%	0.109	47%	1821.84
CA	Santa Clara Valley Transportation Authority	**0.381**	2.6%	0.123	23%	724.12
MD	Maryland Transit Administration	**0.627**	2.6%	0.126	23%	1139.07
PA	Port Authority of Allegheny County	**1.371**	1.6%	0.259	29%	1537.82
TX	Metropolitan Transit Authority of Harris County, Texas	**0.312**	1.4%	0.110	47%	1324.35
OH	The Greater Cleveland Regional Transit Authority	**0.912**	0.9%	0.188	32%	1537.82
NY	Niagara Frontier Transportation Authority	**0.390**	0.7%	0.192	35%	720.8
NJ	New Jersey Transit Corporation (directly operated)	**0.635**	0.7%	0.172	31%	1139.07
NC	Charlotte Area Transit System	**0.394**	0.6%	0.156	45%	1134.88
LA	New Orleans Regional Transit Authority	**0.325**	0.4%	0.067	21%	1019.74
CA	North County Transit District	**0.474**	0.4%	N/A*	36%	
WA	Central Puget Sound Regional Transit Authority	**0.411**	<0.1%	0.148	33%	902.24
TN	Memphis Area Transit Authority	**3.209**	<0.1%	0.103	5%	1510.44
FL	Hillsborough Area Regional Transit Authority	**1.241**	<0.1%	0.177	19%	1318.57
WA	King County Department of Transportation - Metro Transit Division	**1.301**	<0.1%	0.357	25%	902.24
AR	Central Arkansas Transit Authority	**1.837**	<0.1%	0.160	9%	1019.74
WI	Kenosha Transit	**4.266**	<0.1%	0.228	8%	1537.82
	National	**0.365**	100.0%	0.126	**37%**	

Source: Calculated from Federal Transit Administration 2008 National Transit Database (NTD), U.S. Department of Energy carbon dioxide conversion factors, U.S. Environmental Protection Agency eGRID.

*New Jersey Transit Corporation in Newark, NJ and North County Transit District in Oceanside, CA do not have values listed for kilowatt hours per seat mile because the former uses both electricity and diesel and the latter uses diesel.

Note: There are two separate entries for New Jersey Transit Corporation as one entry contains the data for the directly operated portion of the system and the other contains the data for the privately operated portion of the system.

Note: Six of the twenty-nine light rail systems, representing less than two percent of all U.S. light rail passenger travel, have carbon dioxide emissions per passenger mile greater than single occupancy cars.

50 Largest Directly Operated Bus Systems

State	Transit Authority	Pounds CO2 / passenger mile	% of total transit bus passenger miles traveled in the U.S.	Average % of Seats Full (Ridership)	Pounds CO2/ Seat mile (CO2 Efficiency of Vehicle)
NY	MTA New York City Transit	**0.564**	8.78%	41%	0.229
CA	Los Angeles County Metropolitan Transportation Authority	**0.494**	6.68%	38%	0.189
NJ	New Jersey Transit Corporation	**0.515**	4.66%	30%	0.153
IL	Chicago Transit Authority	**0.690**	3.68%	27%	0.186
PA	Southeastern Pennsylvania Transportation Authority	**0.643**	2.59%	32%	0.207
WA	King County Department of Transportation - Metro Transit Division	**0.452**	2.38%	33%	0.150
DC	Washington Metropolitan Area Transit Authority	**0.718**	2.10%	28%	0.199
FL	Miami-Dade Transit	**0.658**	2.01%	33%	0.220
TX	Metropolitan Transit Authority of Harris County, Texas	**0.536**	1.97%	30%	0.161
MN	Metro Transit	**0.512**	1.51%	30%	0.153
HI	City and County of Honolulu Department of Transportation Services	**0.458**	1.42%	37%	0.169
NY	MTA Bus Company	**0.956**	1.40%	24%	0.225
MD	Maryland Transit Administration	**0.682**	1.30%	34%	0.231
CA	Orange County Transportation Authority	**0.570**	1.24%	30%	0.169
MA	Massachusetts Bay Transportation Authority	**0.732**	1.22%	27%	0.195
PA	Port Authority of Allegheny County	**0.718**	1.20%	27%	0.197
CO	Denver Regional Transportation District	**0.582**	1.16%	25%	0.147
NJ	Academy Lines, Inc.	**0.177**	1.15%	58%	0.104
OR	Tri-County Metropolitan Transportation District of Oregon	**0.557**	1.05%	25%	0.139
NV	Regional Transportation Commission of Southern Nevada	**0.127**	1.03%	24%	0.031
IL	Pace - Suburban Bus Division	**0.565**	1.02%	35%	0.200
GA	Metropolitan Atlanta Rapid Transit Authority	**0.782**	1.01%	21%	0.160
CA	Alameda-Contra Costa Transit District	**0.750**	0.93%	22%	0.165
TX	VIA Metropolitan Transit	**0.733**	0.92%	27%	0.198
NJ	Hudson Transit Lines, Inc.	**0.239**	0.92%	43%	0.103
TX	Dallas Area Rapid Transit	**1.211**	0.88%	15%	0.182
MI	City of Detroit Department of Transportation	**0.654**	0.87%	30%	0.196
CA	San Francisco Municipal Railway	**0.658**	0.86%	34%	0.221
FL	Broward County Transportation Department	**0.620**	0.84%	32%	0.199
UT	Utah Transit Authority	**0.582**	0.83%	27%	0.156
OH	The Greater Cleveland Regional Transit Authority	**0.706**	0.82%	24%	0.171
NY	MTA Long Island Bus	**0.555**	0.75%	34%	0.187
WI	Milwaukee County Transit System	**0.615**	0.72%	25%	0.152
FL	Central Florida Regional Transportation Authority	**0.638**	0.72%	25%	0.159
WA	Central Puget Sound Regional Transit Authority	**0.327**	0.71%	39%	0.126
NY	Westchester County Bee-Line System	**0.544**	0.70%	35%	0.189
CO	Denver Regional Transportation District	**0.760**	0.69%	24%	0.180
CA	Santa Clara Valley Transportation Authority	**0.731**	0.68%	22%	0.163
MO	Bi-State Development Agency	**0.763**	0.64%	20%	0.152
OH	Southwest Ohio Regional Transit Authority	**0.570**	0.60%	27%	0.156
NJ	Suburban Transit Corporation	**0.288**	0.57%	38%	0.109
CA	Foothill Transit	**0.872**	0.54%	23%	0.205
TX	Capital Metropolitan Transportation Authority	**0.669**	0.52%	34%	0.226
VA	Hampton Roads Transit	**0.646**	0.48%	25%	0.164
CA	San Diego Metropolitan Transit System	**0.845**	0.47%	25%	0.212
NC	Charlotte Area Transit System	**0.796**	0.46%	23%	0.182
PA	Trans-Bridge Lines, Inc.	**0.202**	0.46%	46%	0.093
MI	Suburban Mobility Authority for Regional Transportation	**0.760**	0.42%	26%	0.198
MD	Ride-On Montgomery County Transit	**0.738**	0.41%	24%	0.178
CA	Long Beach Transit	**0.611**	0.39%	31%	0.187
National Average Weighted by Passenger Miles (includes the 50 systems above as well as the other 412 systems with fuel data in the NTD)		**0.643**		**28%**	**0.177**

Source: Calculated from Federal Transit Administration 2008 National Transit Database (NTD) and U.S. Department of Energy carbon dioxide conversion factors.

Note: Seven percent of bus passenger miles are on systems that did not report fuel data to the NTD (fuel reporting is optional for privately operated systems). The list above is of the 50 largest bus systems with fuel data in the NTD by passenger miles, which account for 69 percent of all transit bus passenger miles traveled in the United States and reported in the NTD. Data for the entire list of 462 bus systems with fuel data is available from FTA but is not listed here due to space constraints. The national averages shown at the bottom of the table as well as earlier in the graphs include all 412 bus systems reporting fuel data.

Commuter Rail

State	Transit Authority	Pounds CO2 / passenger mile	% of total commuter rail passenger miles traveled in U.S.	Average % of seats full (Ridership)	Pounds CO2/ seat mile (CO2 efficiency of train)
NJ	New Jersey Transit Corporation	**0.325**	21.2%	32%	0.103
NY	MTA Metro-North Railroad	**0.072**	19.8%	32%	0.023
NY	MTA Long Island Rail Road	**0.518**	17.0%	26%	0.134
IL	Northeast Illinois Regional Commuter Railroad Corporation	**0.414**	15.9%	31%	0.130
MA	Massachusetts Bay Transportation Authority	**0.358**	7.2%	29%	0.105
PA	Southeastern Pennsylvania Transportation Authority	**0.459**	4.4%	24%	0.112
CA	Southern California Regional Rail Authority	**0.311**	4.0%	29%	0.090
CA	Peninsula Corridor Joint Powers Board	**0.365**	2.5%	37%	0.135
MD	Maryland Transit Administration	**0.013**	2.2%	38%	0.005
FL	South Florida Regional Transportation Authority	**0.454**	1.1%	30%	0.135
IN	Northern Indiana Commuter Transportation District	**0.256**	1.1%	33%	0.085
VA	Virginia Railway Express	**0.359**	1.0%	51%	0.182
WA	Central Puget Sound Regional Transit Authority	**0.369**	0.6%	52%	0.191
CA	North County Transit District	**0.403**	0.4%	33%	0.132
CA	Altamont Commuter Express	**0.283**	0.3%	43%	0.120
UT	Utah Transit Authority	**0.239**	0.3%	17%	0.041
TX	Fort Worth Transportation Authority	**0.616**	0.2%	21%	0.129
TN	Regional Transportation Authority	**1.524**	0.0%	13%	0.197
National Average Weighted by Passenger Miles		**0.326**	**99.1%**	**30%**	**0.098**

Source: Calculated from Federal Transit Administration 2008 National Transit Database (NTD), U.S. Department of Energy carbon dioxide conversion factors, U.S. Environmental Protection Agency eGRID.

Note: Less than 1 percent of commuter rail passenger miles reported to the NTD lack fuel data.

Van Pool

State	Transit Authority	Pounds CO2 / passenger mile	% of total van pool passenger miles traveled in U.S.	Average % of seats full (Ridership)	Pounds CO2/ seat mile (CO2 efficiency of vehicle)
UT	Utah Transit Authority	0.149	7.2%	52%	0.077
WA	King County Department of Transportation - Metro Transit Division	0.246	6.2%	59%	0.144
IL	Pace - Suburban Bus Division	0.345	4.8%	48%	0.166
WA	Ben Franklin Transit	0.155	4.5%	75%	0.116
AZ	Phoenix - VPSI, Inc.	0.216	3.5%	55%	0.120
CT	Greater Hartford Ridesharing Corporation - The Rideshare Company	0.280	3.3%	54%	0.151
TX	Dallas Area Rapid Transit	0.174	2.9%	79%	0.137
GA	Marietta - VPSI, Inc.	0.195	2.9%	40%	0.078
WA	Pierce County Transportation Benefit Area Authority	0.228	2.8%	52%	0.119
TX	Dallas - VPSI, Inc.	0.218	2.6%	60%	0.131
WA	Intercity Transit	0.157	2.5%	76%	0.119
WA	Snohomish County Public Transportation Benefit Area Corporation	0.239	2.4%	53%	0.126
CA	Kings County Area Public Transit Agency	0.267	2.3%	40%	0.108
VA	Greater Richmond Transit Company	0.174	1.8%	62%	0.108
HI	Honolulu - VPSI, Inc.	0.276	1.6%	55%	0.152
NC	Charlotte Area Transit System	0.199	1.4%	57%	0.113
NC	Research Triangle Regional Public Transportation Authority	0.128	1.4%	88%	0.113
CO	Denver Regional Transportation District	0.214	1.4%	48%	0.103
FL	Miami Lakes - VPSI, Inc.	0.200	1.3%	60%	0.119
IA	Des Moines Area Regional Transit Authority	0.209	1.2%	56%	0.117
AK	VPSI, Anchorage	0.220	0.8%	53%	0.117
VA	Hampton Roads Transit	0.187	0.8%	74%	0.139
FL	Space Coast Area Transit	0.646	0.7%	62%	0.403
WA	Kitsap Transit	0.283	0.7%	49%	0.138
GA	Georgia Regional Transportation Authority	0.238	0.7%	51%	0.120
TX	Capital Metropolitan Transportation Authority	0.385	0.6%	39%	0.150
GA	Douglas County Rideshare	0.271	0.6%	39%	0.105
WA	Spokane Transit Authority	0.270	0.5%	45%	0.120
WA	Skagit Transit	0.177	0.5%	63%	0.112
WA	Yakima Transit	0.152	0.5%	67%	0.102
TN	Regional Transportation Authority	0.099	0.4%	83%	0.082
FL	County of Volusia, VOTRAN	0.203	0.4%	83%	0.167
CT	2Plus Partners in Transportation, Inc	0.575	0.3%	74%	0.428
MO	Kansas City Area Transportation Authority	0.268	0.3%	60%	0.161
MI	Interurban Transit Partnership	0.262	0.2%	63%	0.164
FL	Lee County Transit	0.103	0.1%	58%	0.059
WI	Milwaukee County Transit System	0.190	0.1%	66%	0.125
PA	Centre Area Transportation Authority	0.155	0.1%	71%	0.111
VT	Chittenden County Transportation Authority	0.135	0.1%	65%	0.087
TX	Corpus Christi Regional Transportation Authority	0.141	0.0%	79%	0.112
SC	Santee Wateree Regional Transportation Authority	0.191	0.0%	46%	0.087
PA	York County Transportation Authority	0.179	0.0%	94%	0.169
WA	Link Transit	0.299	0.0%	120%	0.359
MI	Kalamazoo Metro Transit System	0.288	0.0%	20%	0.056
National Average Weighted by Passenger Miles		**0.223**	**66.5%**	**56%**	**0.124**

Source: Calculated from Federal Transit Administration 2008 National Transit Database (NTD) and U.S. Department of Energy carbon dioxide conversion factors.

Note: 43 percent of van pool passenger miles reported to the NTD lack fuel data.

Other Modes

The transit modes below represent less than 3 percent of U.S. transit passenger miles, and other than demand response, are generally specific to limited geographic areas.

State	Name	Pounds CO2 / passenger mile	% of total U.S. transit passenger miles	Average % of seats full (Ridership)	Pounds CO2/ MWH for subregion (Carbon content)	lbs CO2/ Seat mile (CO2 efficiency of vehicle)
	Automated Guideway					
FL	Miami-Dade Transit	1.088	0.02%	55%	1319	0.596
FL	Jacksonville Transportation Authority	6.093	<0.01%	6%	1319	0.336
MI	Detroit Transportation Corporation	2.025	0.01%	18%	1563	0.362
	Alaska Railroad					
AK	Alaska Railroad Corporation	1.124	<0.01%	30%		0.342
	Cable Car					
CA	San Francisco Municipal Railway	0.314	0.02%	61%	724	0.192
	Ferry Boat					
WA	Kitsap Transit	1.252	<0.01%	19%		0.235
WA	Pierce County Ferry Operations	1.746	<0.01%	17%		0.294
WA	Washington State Ferries	2.123	0.34%	30%		0.629
ME	Casco Bay Island Transit District	3.073	<0.01%	13%		0.392
NY	MTA Metro-North Railroad	4.896	<0.01%	21%		1.007
NY	New York City Department of Transportation	0.864	0.19%	24%		0.210
NJ	Port Authority Trans-Hudson Corporation	3.989	0.01%	12%		0.488
NY	BillyBey Ferry Company, LLC	4.248	0.01%	13%		0.533
NJ	Port Imperial Ferry Corporation, NY Waterway	2.295	0.03%	18%		0.406
VA	Hampton Roads Transit	3.061	<0.01%	15%		0.471
GA	Chatham Area Transit Authority	4.660	<0.01%	11%		0.525
PR	Maritime Transportation Authority of Puerto Rico	2.214	0.03%	36%		0.790
LA	Crescent City Connection Division - Louisiana Department of Transportation	8.567	<0.01%	11%		0.971
TX	Corpus Christi Regional Transportation Authority	2.775	<0.01%	16%		0.437
HI	City and County of Honolulu Department of Transportation Services	3.099	<0.01%	15%		0.462
CA	Golden Gate Bridge, Highway and Transportation District	1.599	0.04%	27%		0.427
CA	City of Alameda Ferry Services	2.325	0.01%	21%		0.492
	Inclined Plane					
PA	Cambria County Transit Authority	8.934	<0.01%	35%	1139	3.147
PA	Port Authority of Allegheny County (directly operated)	3.220	<0.01%	20%	1538	0.632
PA	Port Authority of Allegheny County (privately operated)	4.166	<0.01%	18%	1538	0.745
TN	Chattanooga Area Regional Transportation Authority	0.380	<0.01%	51%	1510	0.195
	Monorail					
WA	City of Seattle - Seattle Center Monorail Transit	0.190	0.00%	24%	902	0.046
	Publico					
PR	Department of Transportation and Public Works	0.318	0.26%	34%		0.109
	Trolley Bus					
WA	King County Department of Transportation - Metro	0.388	0.07%	29%	902	0.111
MA	Massachusetts Bay Transportation Authority	0.778	0.01%	33%	928	0.256
PA	Southeastern Pennsylvania Transportation	0.709	<0.01%	37%	1139	0.259
OH	Greater Dayton Regional Transit Authority	0.882	0.02%	18%	1538	0.162
CA	San Francisco Municipal Railway	0.234	0.20%	32%	724	0.074
	Demand Response National Average	3.100	1.57%	12%		0.364

Note: Ferry boats are particularly challenging to compare directly to emissions from an equivalent number of miles in an automobile as ferries often carry automobiles as well as passengers and often allow for a much shorter route across a body of water rather than a circuitous route by land. Demand response consists largely of paratransit services for persons with disabilities, and is not typically conducted for environmental purposes, but rather for social and equity purposes. Trolley bus may be instructive for systems considering electrifying their buses. Note the large range in carbon efficiency, depending on carbon content of the electricity, ridership, and efficiency of the vehicle.

Definitions of Transit Modes

Bus: A transit mode comprised of rubber-tired passenger vehicles operating on fixed routes and schedules over roadways. Vehicles are powered by diesel, gasoline, battery, or alternative fuel engines contained within the vehicle.

Heavy Rail: A transit mode that is an electric railway with the capacity for a heavy volume of traffic. It is characterized by high speed and rapid acceleration passenger rail cars operating singly or in multi-car trains on fixed rails, separate rights-of-way from which all other vehicular and foot traffic are excluded, sophisticated signaling, and high platform loading.

Light Rail: A transit mode that typically is an electric railway with a light volume traffic capacity compared to heavy rail. It is characterized by passenger rail cars operating singly (or in short, usually two car, trains) on fixed rails in shared or exclusive right-of-way, low or high platform loading, and vehicle power drawn from an overhead electric line via a trolley or a pantograph.

Commuter Rail: A transit mode that is an electric or diesel propelled railway for urban passenger train service consisting of local short distance travel operating between a central city and adjacent suburbs.

Vanpool: A transit mode comprised of vans, small buses and other vehicles operating as a ride sharing arrangement, providing transportation to a group of individuals traveling directly between their homes and a regular destination within the same geographical area.

Alaska Railroad: In recognition of the special Federal relationship with the Alaska railroad (AR), a segment of the passenger service portion of the Alaska railroad (AR) is considered to be eligible for certain FTA funding under the Fixed Guideway Modernization program. The service encompasses only those lines operating within the Anchorage, Alaska, urbanized area (UZA) where passenger service is provided and only includes car miles for passenger cars; car miles for freight cars are specifically excluded.

Automated Guideway: A transit mode that is an electric railway (single or multi-car trains) of guided transit vehicles operating without vehicle operators or other crew onboard the vehicle. Service may be on a fixed schedule or in response to a passenger activated call button. Automated Guideway (AG) transit includes personal rapid transit, group rapid transit, and people mover systems.

Cable Car: A transit mode that is an electric railway with individually controlled transit vehicles attached to a moving cable located below the street surface and powered by engines or motors at a central location, not onboard the vehicle.

Ferryboat: A transit mode comprised of vessels carrying passengers and / or vehicles over a body of water that are generally steam or diesel powered.

Inclined Plane: A transit mode that is a railway operating over exclusive right-of-way (ROW) on steep grades (slopes) with powerless vehicles propelled by moving cables attached to the vehicles and powered by engines or motors at a central location not onboard the vehicle. The special tramway type of vehicles have passenger seats that remain horizontal while the undercarriage (truck) is angled parallel to the slope.

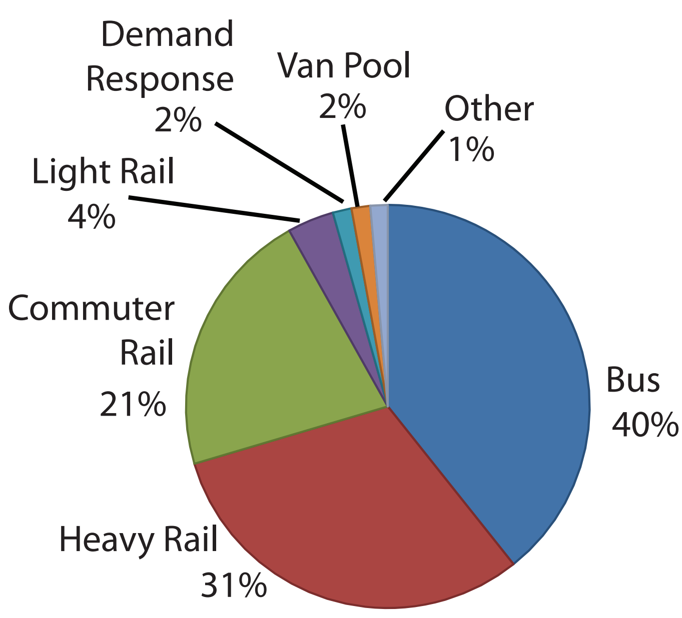
Monorail: A transit mode that is an electric railway of guided transit vehicles operating singly or in multi-car trains. The vehicles are suspended from or straddle a guideway formed by a single beam, rail or tube.

Publico: A transit mode comprised of passenger vans or small buses operating with fixed routes but no fixed schedules. Publicos (PB) are a privately owned and operated public transit service which is market oriented and unsubsidized, but regulated through a public service commission, state or local government. Publicos (PB) are operated under franchise agreements, fares are regulated by route and there are special insurance requirements. Vehicle capacity varies from eight to 24, and the vehicles may be owned or leased by the operator.

Trolleybus: A transit mode comprised of electric rubber-tired passenger vehicles, manually steered and operating singly on city streets. Vehicles are propelled by a motor drawing current through overhead wires via trolleys, from a central power source not onboard the vehicle.

Demand Response: A transit mode comprised of passenger cars, vans or small buses operating in response to calls from passengers or their agents to the transit operator, who then dispatches a vehicle to pick up the passengers and transport them to their destinations.

Distribution of Public Transportation Passenger Miles, 2008



Total 2008 public transportation passenger miles: 54 billion.
Other: ferryboat, publico, trolleybus, automated guideway, cable car, Alaska Railroad, inclined plane, monorail.
Source: National Transit Database, 2008

Appendix II: Data Sources and Methodology

Pounds of carbon dioxide emissions per passenger mile is calculated using the following formula:
lbs CO2 / passenger mile = units of fuel used x (lbs CO2 / unit of fuel) / passenger miles

Transit energy and passenger mile data
The Federal Transit Administration's National Transit Database (NTD) provides data on fuel and electricity used in powering transit vehicles such as buses and trains, number of people riding, and distances traveled for each transit system. The analysis uses passenger mile data, vehicle capacity data, and energy data in Tables 17 and 19, as well as their associated database files, of the most recent full set of annual data available, the 2008 National Transit Database, http://www.ntdprogram.gov/ntdprogram/data.htm.

Energy data is available for 96% of passenger miles reported in the NTD. Transit agencies are not required to report energy usage from privately operated services, though some do so voluntarily.

Seat miles traveled is calculated by multiplying vehicle revenue miles by average seating capacity, as reported in the 2008 National Transit Database. Average percent of seats full is calculated by dividing seat miles by passenger miles.

Conversion factors
For fuels such as diesel, gasoline, and compressed natural gas, the total quantity of each fuel type was multiplied by the standard CO_2 emissions factor provided by the Department of Energy to obtain pounds of CO_2 produced.

Almost all heavy and light rail transit systems, such as subways and streetcars, are powered by electricity. For these systems, the level of carbon dioxide emissions depends on the types of power plants supplying the electricity (coal, gas, nuclear, hydroelectric, wind, etc.). The calculations in this publication use the carbon dioxide emissions per megawatt hour for the power supplied to the electrical grid in the particular subregion in which the transit agency operates. The data is from the U.S. Environmental Protection Agency's Emissions & Generation Resource Integrated Database (eGRID) 2007 v1.1, published in April 2009 and available at http://cfpub.epa.gov/egridweb/ghg.cfm. Sub-region emission factors are used rather than state level emission factors as regional power grids do not correspond with state lines. In addition, using the eGRID sub-region data rather than the state level data is recommended by the Climate Registry General Reporting Protocol, Chapter 14, http://www.theclimateregistry.org/downloads/GRP.pdf.

Private car
The average fuel economy for the in-use fleet of all light-duty vehicles (cars, SUVs, and pick-up trucks) is 20.3 miles per gallon according to EPA data. See "Emission Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle, EPA420-F-05-004, February 2005, http://www.epa.gov/OMS/climate/420f05004.htm. Gasoline releases 19.564 pounds of carbon dioxide per gallon burned according to the U.S. Department of Energy, Energy Information Administration, Voluntary Reporting of Greenhouse Gases Program, Fuel and Energy Source Codes and Emission Coefficients, http://www.eia.doe.gov/oiaf/1605/coefficients.html. Therefore, for each mile traveled driving alone, 0.964 pounds of carbon dioxide (19.564/20.3), or about 1 pound, is released into the atmosphere.

According to the 2001 National Household Transportation Survey, the average private auto work and general purpose trips have 1.14 and 1.63 passengers, respectively. These load factors are used for calculating greenhouse gas emissions per passenger mile for private auto work and general trips.

FOR MORE INFORMATION, PLEASE SEE:
http://www.fta.dot.gov/sustainability

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