innovative policy solutions TO GLOBAL CLIMATE CHANGE

In Brief, Number 6

Taking Climate Change into Account in U.S. Transportation

U.S. transportation is responsible for more than a quarter of U.S. greenhouse gas (GHG) emissions. This *In Brief* describes options for reducing this contribution to global climate change. There are three fundamental ways to curb these emissions:

- **Improve vehicle efficiency.** Major gains in fuel efficiency are technically feasible for cars, trucks, and airplanes. There is evidence, however, that consumers undervalue fuel savings when purchasing new vehicles. In addition, the environmental and security benefits of fuel efficiency are external—i.e., dispersed throughout society rather than to the individual consumer. Because fuel efficiency is thus undervalued in the market place, policies are essential to pull efficiency improvements into the market. The current system for setting vehicle efficiency standards could be made more effective by providing longer lead times for tougher standards. Another option would be to require light trucks to meet standards as stringent as those for cars. Because it takes time for the vehicle fleet to turn over, programs must be initiated now and sustained over decades to realize this technological potential.
- **Substitute low-carbon fuels for carbon-intensive fuels.** Many alternative fuels produce less carbon dioxide (CO_2) per unit of energy than petroleum. Petroleum, however, has many advantages and is supported by an extensive and well-functioning infrastructure, so policy intervention would be required to spur a transition to alternative fuels. Requiring the use of ethanol as a gasoline additive could yield a 3 percent net reduction in GHG emissions in the near term and a 10 percent reduction in the long term, while maintaining the current fueling system.[1] Work should also start now to lay the groundwork for longer-term solutions, such as a hydrogen-based transportation system.
- **Increase transportation system efficiency.** Numerous transportation modes—such as air, water, rail, car, bus, and bicycling—exist to move people and goods. Increasing the efficiency of the transportation system would require both improving accessibility to the various modes of transportation and using more efficient ones. Which mode is most efficient depends on the distance traveled as well as population density. In the United States, the evolution over decades of automobile dependence and land use patterns has resulted in an energy-intensive transportation system. Policy options for increasing system efficiency include funding public transportation, building infrastructure that eases the transfer of freight and passengers between modes, supporting "intelligent transportation" technologies, and promoting "smart growth."

Greenhouse gas emissions consequences are now unaccounted for in public as well as private transportation decisions. *Taking climate change into account* in these decisions would provide a major impetus to improve vehicle efficiency, substitute low-carbon fuels, and increase transportation system efficiency. Policy options include building institutional capacity at all levels of government to address the climate consequences of transportation, incorporating climate change as a consideration in disbursing monies from the federal Highway Trust Fund, and developing a greenhouse gas cap and trade program to constrain emissions at the lowest possible cost.

No single policy approach will be sufficient. Reducing GHG emissions from transportation calls for a balanced combination of cost-effective measures. Many of the policy measures discussed in this brief do much more than reduce CO_2 emissions. For example, since U.S. transportation is almost entirely fueled by petroleum, decreasing GHG emissions from this sector would also decrease dependence on foreign oil.

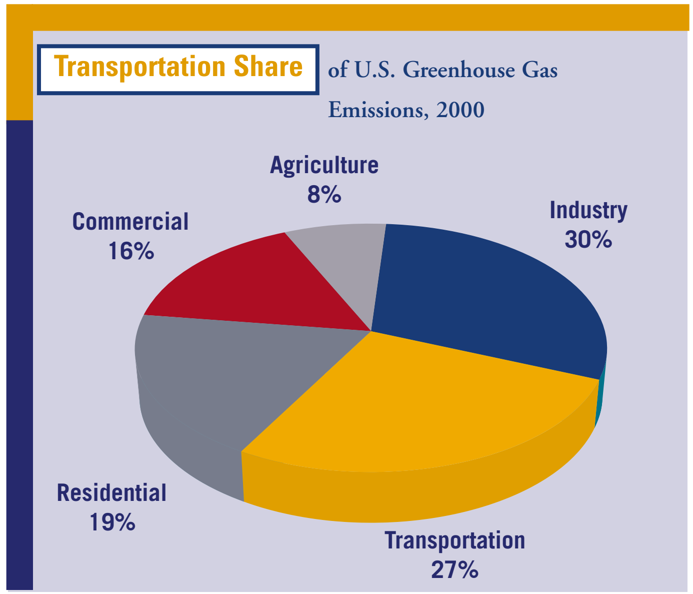
Introduction

The U.S. transportation system is the world's largest and provides the American economy and society with the greatest mobility on earth. However, the transportation sector also generates 27 percent of U.S. GHG emissions (see Figure 1). The U.S. transportation sector alone emits more CO_2 than the entire economy of any other country except China, which has four times the U.S. population. The U.S. transportation system is also primarily responsible for U.S. oil dependence.

The transportation sector's energy use and GHG emissions are rising. Cars and light trucks are not only being driven more, but also their fuel economy—unimproved since 1988—has actually begun to decline. For other modes, efficiency is improving, but growth in travel demand is exceeding the rate of improvement. Use of low-carbon fuels for all modes is increasing only slightly. Decisions made in the next several years could determine whether the U.S. transportation system continues to follow "business as usual" or takes an alternative path toward more aggressive efficiency improvements and more diverse, low-carbon energy sources.

> *Cars and light trucks are not only being driven more, but also their fuel economy—unimproved since 1988—has actually begun to decline.*

Figure 1



Source: U.S. EPA, (2002), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000,* ES-5.

Increasing the energy efficiency of vehicles

In the next fifteen years, the most significant reductions in GHG emissions from U.S. transportation can be achieved by increasing the energy efficiency of vehicles. This would preserve both the desirable characteristics of conventional vehicles and the enormous investment in the infrastructure for producing, distributing, and retailing conventional petroleum fuels.

Passenger cars, light trucks, heavy-duty trucks, and commercial aircraft account for over 80 percent of U.S. transportation energy use and GHG emissions. Though not discussed here, buses, rail, marine, and pipeline modes also offer GHG emissions reduction opportunities (see Figure 2).

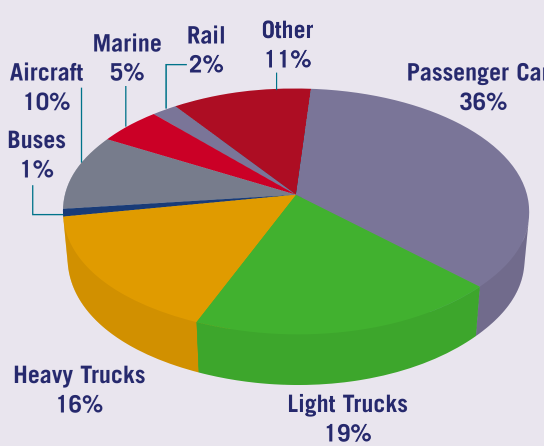
Light-Duty Vehicles. Light-duty vehicles (automobiles and light trucks) account for more than half of GHG emissions from the U.S. transportation sector, with emissions growing steadily. The Energy Policy and Conservation Act of 1975 mandated Corporate Average Fuel Economy (CAFE) standards for light duty vehicles. The initial round of standards in the late 1970s doubled fuel economy, but these standards have not been increased for passenger cars in over twenty years and have increased only slightly for light trucks. Because light truck standards are weaker than those for passenger cars, the shift from passenger cars to light truck purchases has led to an overall decrease in the fuel economy of new light-duty vehicles.

This trend could be reversed. Light-duty vehicle fuel economy could be increased by one-fourth to one-third at less than the cost of the fuel saved over the vehicle's lifetime. Depending on technological progress, fuel economy could be increased by 50 to 100 percent by 2030. In the near term, improvements in engines and transmissions and in the reduction of aerodynamic drag, rolling resistance, and vehicle weight could be implemented without compromising safety, handling, or comfort. In the long term, advanced diesel engines, gasoline or diesel hybrids,[2] and hydrogen powered fuel cell vehicles can yield more dramatic improvements.

Heavy-duty vehicles. Virtually every new large truck and bus in the United States is already equipped with the most energy-efficient internal combustion engine available, since fuel costs are typically the largest expenditure item for commercial operators after the cost of the vehicle itself. Even so, in the near term, fuel efficiency could be improved by approximately 25 percent for long-distance transport and by 50 percent for short-haul stop-and-go transport. For long-distance transport, reducing tractor-trailer idling at truck stops by installing auxiliary power units could yield fuel savings on the order of 10 percent. Reducing driving resistance[3] may offer even greater potential. For stop-and-go truck transport, hybrid drive trains are a promising technology. In the long term, according to the U.S. government's 21st Century Truck program, a 140 percent improvement for medium-sized trucks, a 60 percent improvement for over-the-road tractor trailers, and a 160 percent fuel economy increase for transit buses can be achieved through a combination of engine, aerodynamic, rolling resistance, and materials technologies.[4]

Figure 2

Transportation GHG Emissions by Mode 2000



Source: U.S. EPA, (2002), Table 1.14.

Light-duty vehicle fuel economy could be increased by one-fourth to one-third at less than the cost of the fuel saved over the vehicle's lifetime.

Commercial aircraft. Major technological and operational efficiency improvements significantly reduced the energy intensity of commercial air travel in the U.S. from 1971-1998, but these gains were more than offset by the increase in air travel over the same period. Opportunities for further improvements remain, especially from improved engines and aerodynamics. Considering the time required for technology implementation and stock turnover, potential reductions in energy intensity are roughly 15 to 25 percent by 2015 and 25 to 40 percent by 2030.

Consumers, and even trucking companies, heavily discount the lifetime fuel savings of increased fuel economy. Thus, manufacturers will not produce vehicles with economically efficient fuel economy[5] levels, even if fuel prices increase. Governmental policies, including market based and mandatory instruments, can help overcome such behavioral factors and bring more fuel-efficient technologies into the market.

Policy options for increasing the energy efficiency of vehicles include:

- **Fuel economy and GHG emissions standards and credits.** Strengthening fuel economy standards or establishing GHG emissions standards would increase efficiency. Requiring light trucks such as SUVs to meet standards of equal stringency as automobiles would stop the decline in light-duty fuel economy. CAFE could also be reformed, for example, by establishing tougher standards with longer lead times, to make the program more rational and more effective. A single rulemaking with a longer lead time would result in much greater improvement than a succession of rulemakings, each with a short lead time. Vehicle manufacturers that significantly exceeded efficiency standards could be granted marketable GHG emission credits under a "cap-and-trade" law limiting GHG emissions. Another approach is to establish GHG emission standards, as is being done in California and the European Union. GHG standards would not only encourage use of low-carbon fuels, but would have the added benefits of providing automotive manufacturers more flexibility in finding least-cost means of achieving the reductions. Tire efficiency standards, especially for replacement tires, could also increase efficiency.
- **Tax incentives or "feebates" for highly efficient light duty vehicles.** Purchasers of highly efficient vehicles could be given tax breaks. A revenue-neutral fee and rebate ("feebate") system could be established in which fees would be paid on the purchase of inefficient vehicles and rebates provided towards the purchase of highly efficient vehicles.
- **Incentives for auxiliary power units and electrical hookups at truck stops.** Alternatives to truck idling could be encouraged. Several U.S. states are experimenting with an Advanced Travel Center Electrification (ATE) program,[6] using state funds to provide energy-efficient heating, ventilation, and cooling systems (HVAC) for use by truckers at travel centers and other areas where drivers stop and idle their vehicles. The ATE systems reduce idling and the associated fuel consumption and emissions.
- **Research and development.** Technology would be advanced through continuing and expanding public-private research partnerships on topics such as improving vehicle drive trains and reducing aerodynamic drag, rolling resistance, and vehicle weight. Examples include DOE's FreedomCAR and 21st Century Truck programs, and NASA's Ultra-Efficient Engine Technology program for aircraft.

- **Information programs.** Providing drivers with better information about the GHG implications of their driving choices could influence those choices. Options include driver training, more dissemination of information from sources like www.fueleconomy.gov, GHG emissions labels on new and used cars, and efficiency labeling for replacement tires.

Substituting low-carbon fuels for carbon-intensive fuels

Alternative and replacement fuels can lower GHG emissions. Alternative fuels are those that are used as a complete substitute for petroleum and require specifically designed engines and fueling structure. Replacement fuels are those that are blended with gasoline in proportions that do not require specialized technology. Declining conventional oil reserves may motivate a shift to such low-carbon fuels. The other option would be to shift to unconventional petroleum, but its production involves significantly more GHG emissions than conventional petroleum.

Alternative fuels are promising long-term solutions, but economic and technological hurdles must first be overcome. Alternative fuels—such as liquefied petroleum gas (LPG), compressed natural gas (CNG), hydrogen (H2), solar and electricity—offer reductions in GHG emissions from 10 to 100 percent over the full fuel cycle depending on how they are produced and used. These fuels, however, often suffer from higher costs, limited driving range, a lack of fuel supply and refueling infrastructure, and the need for specifically designed engines. Largely unaffected by these constraints, replacement fuels, particularly biofuels, can reduce GHG emissions by up to 20 percent. Ethanol and other fuels that can be blended with petroleum fuels offer the greatest promise for reducing transportation GHG emissions during the next 15 years.

Biofuels. About 1.76 billion gallons of ethanol were produced in 2001, almost all from the fermentation of corn. At present, corn-based ethanol reduces full fuel-cycle GHG emissions by slightly more than 30 percent in comparison with gasoline. In the long term, ethanol production may come mainly from cellulosic feedstocks, such as switch grass, hardwoods and softwoods, agricultural residues, and municipal waste. Production of ethanol from cellulose requires much less energy and fertilizer than production from corn and allows for co-production of electricity, resulting in approximately zero net GHG emissions. Other advantages of ethanol and methanol include the ability of the gasoline infrastructure to convert to handling alcohol fuels and the hundreds of thousands of flexible-fuel vehicles already on U.S. roads that are capable of running on any blend of gasoline with up to 85 percent ethanol. An important limitation of these fuels is that land available to grow biofuel feedstock is limited.

Liquefied Petroleum Gas (LPG) and Compressed Natural Gas (CNG). LPG vehicles can reduce GHG emissions by almost 20 percent compared to gasoline vehicles. However, LPG's potential as a large-scale transportation fuel is limited because reserves are much smaller than those of crude oil and natural gas. CNG can reduce CO_2 emissions by about 30 percent, and although a complete network of refueling stations is lacking, a nearly ubiquitous natural gas supply infrastructure exists.

Hydrogen and electricity. Among the alternative fuels, only hydrogen and electricity could be produced on a sufficiently large scale to fuel the entire U.S. transportation system. Hydrogen and electricity can be produced from a variety of sources, including carbon-free renewables. If fossil fuels are used, CO_2 emissions can be nearly eliminated if the CO_2 can be captured and permanently sequestered. Hydrogen can be burned in internal combustion engines or oxidized in fuel cells. The most efficient hydrogen-fueled internal combustion engines reduce energy use by roughly 15 percent compared to gasoline engines.[7] Fuel cells are a more promising long-term option for using hydrogen because they have potential for a two-fold efficiency increase. High-temperature fuel cells may be a promising longer-term option for marine and rail transport.

Electric vehicles consume significantly less energy per mile than internal combustion engine vehicles. An even lower rate can be achieved by recovering kinetic energy during braking and by shutting off the motor during vehicle stops, approaches that are already being used in hybrid electric cars on the market today. Obstacles to commercializing hydrogen and electric vehicles include their higher cost, the lack of associated infrastructure, and technological barriers such as fuel storage.

Ethanol and other fuels that can be blended with petroleum fuels offer the greatest promise for reducing transportation GHG emissions during the next 15 years.

Policies for substituting low-carbon fuels for carbon-intensive fuels include:

- **Incentives for ethanol use.** Continuing the federal highway tax exemption for ethanol would promote ethanol use and reduce GHG emissions. A renewable fuel content standard—a requirement that gasoline contain a specified volume of renewable fuel—would also be an incentive to use ethanol.
- **Incentives for alternative fuels and vehicles.** These could take the form of tax breaks to private and institutional owners of low-carbon alternative fueling facilities, as well as to purchasers of low-carbon alternative fuel vehicles.
- **Laying the groundwork for a hydrogen-based transportation system.** The Bush Administration's proposed hydrogen research initiative is an important first step. There are opportunities through the reauthorization of the Transportation Equity Act and through energy legislation to fund research and pilot demonstrations of hydrogen production, storage and delivery systems, and vehicles. Also, the U.S. Department of Transportation could evaluate hydrogen safety issues and develop codes and standards for pipelines, vehicles, and refueling facilities.

Increasing transportation system efficiency

System efficiency can be improved by increasing the use of energy-efficient modes of transportation. Increasing the efficiency of particular modes, and increasing accessibility through denser land use patterns that facilitate alternative modes such as walking, biking, and transit, would both decrease GHG emissions.

Despite very large differences in the energy intensities of freight modes, attempts to shift to more energy-efficient modes, such as from truck to rail or from rail to water, run counter to increasing requirements for speed and reliability. The greatest opportunity for improving freight efficiency may lie in providing infrastructure that allows freight to be quickly, efficiently, and inexpensively transferred among modes.

For passenger travel within the United States, energy use per passenger is similar across modes in large part because transit occupancy rates are low. A suite of policies could promote the use of transit and ease inter-modal transfers.

Transportation demand is influenced by the geographic distribution of people and places, especially the density of development and zoning. Studies have shown that a combination of land use and transit policies might succeed in reducing vehicle miles in large urban areas by 5 to 10 percent over thirty years, if combined with policies to charge for parking and for use of congested roads. Vehicle travel might be reduced by 10 to 25 percent by changing the design of subdivision development to accommodate walking and cycling and mixed land uses to reduce the need for motorized trips.

Land use and transportation infrastructure policies will have little immediate impact on GHG emissions, but could be among the most important policies in the long run. Investments in transit infrastructure and land use policies favoring transit-oriented development not only reduce automobile trips, but also increase transit occupancy rates and density of development. Moreover, there are other benefits from more efficient land use, including reducing traffic congestion, protecting habitats, and improving air quality.

Policy options for increasing transportation system efficiency include:

- **Investment and incentives for more efficient transportation modes.** For instance, funding could be increased for highly efficient rail systems or Bus Rapid Transit (BRT). Another way to encourage more efficient modes would be to increase the amount employers are allowed to provide to their employees for transit fare on a tax-free basis, and to extend the benefit to commuters who walk or bike. This would balance the untaxed parking benefits many employers provide. It would also save the employers money since they do not have to pay payroll taxes on the amount of employee income excluded under such benefit plans.
- **Investment in intermodal infrastructure.** This would provide funding for infrastructure that facilitates the transfer of freight and passengers between modes of transportation, such as rail lines to ports, transit lines to airports, and better parking facilities and car-sharing services at transit stations. Providing alternative revenue sources for airports might be especially important, given that many airports now derive half of their revenue from their parking garages.
- **Allowing highly efficient vehicles on HOV lanes.** Highly efficient vehicles could be granted special access to High Occupancy Vehicle lanes.
- **"Smart growth" policies.** Integrating land-use and transportation planning would help to minimize sprawl and promote easy access to public transit.
- **Intelligent Transportation Systems.** Computers and global positioning satellites are already being used to route long-haul trucks more efficiently. Intelligent transportation systems may save both time and energy by finding the most efficient routes for auto and transit users as well.

Transportation Law and Funding Context

Federal policy has long helped shape the U.S. transportation system. Most recently, the annual transportation appropriations bills and the Transportation Equity Act for the 21st Century (TEA-21, which must be reauthorized or extended by September 2003) have been major federal instruments for influencing road transportation. TEA-21 amended Title 23 and Title 49 of the U.S. Code. Title 23 apportions federal funds to the states for the National Highway system, the Surface Transportation, and the Congestion Mitigation and Air Quality Improvement (CMAQ) programs, as well as providing for research. Title 49 covers mass and intermodal transportation, motor vehicle safety, information and standards, and pipeline safety. Much of the recent federal influence has come in the form of conditions placed on uses of the apportioned funds and requirements for state and metropolitan planning.

Highway user fees of all kinds amounted to $99 billion in 2000, a third of which was collected by the federal government and distributed mostly to states. At present, most federal funds for highways and transit come from federal gasoline taxes, which are placed into the Highway Trust Fund. In 2000, the federal government funded 22 percent of total highway expenditures and 17 percent of total expenditures on transit. The rest of the funding came from state and local governments.

In the year 2000, U.S. federal, state, and local governments spent $130 billion providing and maintaining highways for public use (see Table 1).[8] Nearly all of the money was spent by state and local governments. The federal government owns only 3 percent of highway miles, while local governments control about 77 percent and states about 20 percent.

Table 1

Transportation Expenditures by U.S. Federal, State, and Local Governments

Year 2000 Expenditures	
Total government expenditure for highways	$130 billion
Total government spending on airports	$21 billion
Total government expenditure on transit	$32 billion
Total government spending on water transport	$8 billion
Total government spending on rail projects	$1 billion

- **Use of climate-friendly materials.** Using recycled materials in road-beds or for road surfacing could reduce GHG emissions. For example, substituting coal fly ash for cement can significantly reduce greenhouse gas emissions. Every ton of coal flyash substituted for cement reduces life-cycle GHG emissions by almost a ton.[9] The adoption of performance measures for pavement, for example under the Interstate Maintenance and Bridge program, would be one policy option. Requiring the use of longer-lasting pavement could also reduce congestion caused by work zones for repaving roads and filling potholes.

Taking climate change into account

Greenhouse gas emissions consequences are now unaccounted for in public as well as private transportation decisions. In order to affect private decisions, travelers and transporters would need to see climate damages reflected in the cost of transportation services. In order to affect public decisions, the relevant policies—including statutes, regulations, funding mechanisms, disbursement formulas, and transportation plans—would need to be changed to take GHG emissions into account.

Greenhouse gas emissions consequences are now unaccounted for in public as well as private transportation decisions.

At present, some external costs of transportation, such as toxic air pollution and congestion, are addressed by non-price policies such as emissions and fuel economy standards and traffic controls. Since the current $0.45 per gallon motor fuel tax discourages travel by increasing travel cost, it could be argued that the tax already internalizes some of the environmental impacts of motor fuel use, but much remains unaddressed. A 10 percent increase in fuel price could result in a 5 to 6 percent reduction in fuel consumption and emissions in the long run.

Policy options for internalizing the environmental cost of greenhouse gas emissions include:

- **A greenhouse gas cap-and-trade program.** Such a program would set an absolute limit on the amount of greenhouse gas emissions. GHG "allowances" would be issued or auctioned to entities such as oil refiners and importers to correspond to allowable emissions under the cap. These allowances could be traded so that those who could more cost-effectively reduce emissions—for example, by blending ethanol in gasoline—could sell allowances to those with higher emission reduction costs.
- **Shifting costs of driving from "fixed" to "per gallon of gasoline."** Shifting fixed costs to variable costs would discourage some driving, leading to lower GHG emissions from transportation, without increasing the overall cost of driving. For example, if a minimum amount of insurance were paid through a surcharge at the pump, insurance would be more closely tied to miles traveled, and motorists would have an incentive to use less fuel. Motorists would still sign up with an insurance carrier and would pay additional insurance premiums for increased liability, collision, or if their risk classification required it.

Policy options for institutionalizing consideration of GHG impacts include:

- **Incorporating climate change as a consideration in federal transportation project funding.** Climate change considerations could be incorporated throughout existing grant programs, including the Surface Transportation, National Highway, and Congestion Mitigation and Air Quality (CMAQ) programs, or through new funding mechanisms focused on energy and climate change benefits.
- **Building state and local capacity to address climate change.** Options include providing federal funds to states to promote integration of energy, environmental and transportation planning at the state and metropolitan levels; developing methodology[10] and evaluating the GHG and energy impacts of transportation plans and projects; and allowing states greater flexibility to use federal, state and local funds to address these issues.
- **Incorporating climate change considerations into federal transportation research and development.** One option is to increase funding for climate-friendly technology development and demonstration through DOE's, DOD's, NASA's and DOT's R&D programs. In addition, it is important for DOT to increase climate-relevant evaluation of transportation programs and projects.

...improving fuel efficiency of the U.S. transportation system would reduce dependence on foreign oil imports and spur technological advances...

Conclusion

No single approach for reducing the greenhouse gas emissions of the U.S. transportation sector will be sufficient. The key is to begin to take climate change into account in private and public decisions through a combination of measures addressing vehicle efficiency, alternative fuels, and system efficiency. It is important that all components be addressed by meaningful measures that are both cost-effective and successful in reducing emissions. Experience with higher oil prices and fuel economy standards has shown that it is possible to slow the growth of transportation petroleum use and GHG emissions.

The total potential reduction in CO_2 emissions from one illustrative and moderate combination of these measures appears to be about 20 percent by 2015 and almost 50 percent by 2030, compared to what the emissions would otherwise have been. This would hold absolute U.S. transportation GHG emissions constant at today's levels. Greater reductions are possible with more aggressive carbon constraints or policies that slow the growth in travel.

Many of the policy measures discussed in this brief would do much more than reduce CO_2 emissions. For example, improving fuel efficiency of the U.S. transportation system would reduce dependence on foreign oil imports and spur technological advances, increasing the global competitiveness of the U.S. vehicle industry. It also would reduce emissions of conventional pollutants. Similarly, more efficient land-use patterns would increase the ridership potential of public transportation and relieve traffic congestion. Taking these multiple benefits into account would spread the costs of controlling CO_2 emissions and add incentive for taking action.

A significant amount of time would be needed to increase the fuel efficiency of the vehicle fleet, substitute low-carbon fuels for carbon-intensive ones, and improve the efficiency with which transportation systems provide mobility. Because these changes take time, they must be initiated now. The knowledge, experience, and policy tools needed to reduce GHG emissions growth from the U.S. transportation sector are at hand. The United States must act now to make the changes needed to make U.S. transportation more climate-friendly.

For a more complete discussion of this subject, see *Reducing Greenhouse Gas Emissions From U.S. Transportation* by David Greene and Andreas Schaefer, published by the Pew Center on Global Climate Change.

[1]This assumes a blend of 90% gasoline and 10% ethanol by energy content. Ethanol derived from corn generates 30% less GHG emissions than the gasoline it replaces, when one considers the full fuel cycle. In the long term, ethanol may be derived from cellulosic feedstocks, resulting in approximately zero net GHG emissions over the full fuel cycle. (Greene & Schafer)

[2]Hybrid drive trains recover braking energy and shut off engines during idling time; they are already used in some Honda and Toyota vehicles.

[3]Driving resistance is the sum of forces opposing the motion of a vehicle, including inertia, aerodynamic drag and rolling resistance.

[4]U.S. Department of Energy (USDOE/OSTI), 2000. *Technology Roadmap for the 21st Century Truck Program*, 21CT-01, available at http://www.osti.gov/hvt/21stcenturytruck.pdf, Washington, DC.

[5]Greene and Schafer, 2003.

[6]Tennessee, Georgia, Arkansas, and New York are involved in the program.

[7]This comparison assumes gasoline engines with high air-fuel ratios producing the same power.

[8]Statistics on highway user revenues and their disposition are from the U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, table HF-10.Revenue and expenditure estimates for non-highway modes are from the U.S. Department of Transportation, Bureau of Transportation Statistics, *Pocket Guide to Transportation 2003*, tables 26 and 27, available at www.bts.gov.

[9]National Recycling Coalition and Buy Recycled Business Alliance.

[10]See www.travelmatters.org *Combatting Global Warming through Sustainable Surface Transportation Policy,* prepared for the Transit Cooperative Research Program, Transportation Research Board, National Research Council, by the Center for Neighborhood Technology, Chicago, IL

References

Greene, David L. and Andreas Schafer, 2003. *Reducing Greenhouse Gas Emissions from U.S. Transportation.* Pew Center on Global Climate Change, Arlington, VA.

Shapouri, H., J.A. Duffield and M. Wang, 2002. The Energy Balance of Corn Ethanol: An Update, Agricultural Economic Report No. 813, U.S. Department of Agriculture, Office of the Chief Economist, Office of Energy Policy and New Uses, Washington, D.C.

Wang, M.S., 2002. *GREET Web Site,* http://www.transportation.anl.gov/ttrde/greet/, Argonne National Laboratory, Argonne, IL.

Wang, M.Q., 1999. GREET 1.5 - *Transportation Fuel Cycle Model, Volume 1: Methodology, Development, Use and Results*, ANL/ESD-39, vol. 1, Argonne National Laboratory, Argonne, IL

Dedicated to providing credible information, straight answers, and innovative solutions in the effort to address global climate change.

Pew Center on Global Climate Change
2101 Wilson Blvd., Suite 550
Arlington, VA 22201
Phone: 703/ 516.4146
Fax: 703/ 841.1422
www.pewclimate.org