



A Smaller Carbon Footprint

Research suggests combining strategies to meet legislative goals in the transportation sector



A Summary of the Study:
Reducing Greenhouse Gas Emissions From Transportation Sources in Minnesota

June 2008

This study was conducted by the University of Minnesota's Center for Transportation Studies through funding from the Minnesota Legislature.

A Smaller Carbon Footprint

Research suggests combining strategies to meet legislative goals in the transportation sector

A Summary of the Study:

Reducing Greenhouse Gas Emissions From Transportation Sources in Minnesota

The full report—CTS 08-10—is available at:
www.cts.umn.edu/Research/GreenhouseGas.

Report authors:

- Adam Boies, David Kittelson, and Winthrop Watts,
Department of Mechanical Engineering
- Jan Lucke and Laurie McGinnis, Center for
Transportation Studies
- Julian Marshall and Tyler Patterson, Department of Civil
Engineering
- Peter Nussbaum and Elizabeth Wilson, Hubert H.
Humphrey Institute of Public Affairs

Contact:

Laurie McGinnis
Associate Director
Center for Transportation Studies
University of Minnesota
612-625-3019
mcgin001@cts.umn.edu

Inside

Executive Summary.....	1
About the Study.....	2
Reduction Strategies.....	3
Conclusions	7

Credits

Editing: Pamela Snopl
Design: Cadie Adhikary

The University of Minnesota is an equal opportunity educator and employer. This publication is available in alternative formats upon request. Recycled paper with 30 percent postconsumer waste.

Executive Summary

The 2007 Minnesota Next Generation Energy Act established greenhouse gas (GHG) reduction goals of 15 percent by 2015, 30 percent by 2025, and 80 percent by 2050 compared with 2005. The legislature also funded a study to evaluate potential strategies for the transportation sector to help the state meet the legislated goals.

This document summarizes the findings from that study, which was coordinated by the University of Minnesota's Center for Transportation Studies.

Key Findings

- The transportation sector can nearly meet its share of Minnesota's GHG emissions goals in 2015 and can exceed them in 2025 using a combination of strategies targeted to reduce fuel consumption, vehicle-miles traveled, and fuel carbon content.
- Comprehensive action is needed sooner, not later.
- Vehicle and fuel policies are most effective when implemented across a broad base that includes other states.
- Mileage standards considerably higher than those being considered in this country are possible with today's technology.
- The *quality* of low-carbon fuel—in other words, the carbon emitted over its entire life cycle—has a bigger impact on GHG emissions than the *quantity* blended with gasoline. Some biofuels have higher total GHG emissions than gas or diesel.
- The savings from buying a more fuel-efficient vehicle offset the cost of the added technology. Greater fuel efficiency benefits the economy and helps insulate consumers from rising gas prices.
- The amount of travel has a huge effect on the success of the state's GHG goals, but it is the area with greatest uncertainty, particularly with rising gas prices.
- Further research and innovation—perhaps technologies that don't even exist today—can help Minnesota meet the goals.
- An important step in meeting the 2050 target is to develop infrastructure to shift the long-distance transport of freight and passengers to more efficient modes, such as rail.

About the Study

Americans drove 11 billion fewer miles in March 2008 than in March 2007, the largest drop since 1942. Whether this is a blip or a harbinger of the future is too soon to tell.

Context

The transportation sector produces about 24 percent of Minnesota's total GHG emissions. The light-duty vehicle (LDV) fleet—passenger vehicles such as cars and SUVs—accounts for nearly two-thirds of this. Commercial vehicles powered by diesel engines create about 16 percent, with the remainder coming from aviation, rail, marine, and off-road vehicles.

Unlike conventional pollutants, GHG emissions are not limited by federal emission standards. Technology is not commercially available to remove carbon dioxide (CO_2) at the tailpipe.

Parameters

The following parameters shaped the study:

- The reduction goals were established by state legislation.
- Reductions are relative to 2005.
- Transportation's share of the overall GHG reduction is proportional to its share of total emissions—at least 24 percent.
- Vehicle-miles traveled increases annually at a rate of 0.9 percent (the projected value used by the Minnesota Department of Transportation).

Approach

GHG emissions are determined by three factors:

1. Fuel consumption per mile
2. Fuel carbon content
3. Vehicle-miles traveled (VMT)

Each factor contributes equally in determining emissions, and reductions in one parameter may be offset by an increase in another.

The emphasis of the study was on the light-duty vehicle fleet, because it produces most of the transportation-related GHG emissions. The study did not address aviation, rail, or marine.

The analysis quantified the reductions that could occur in the short term (2015) and medium term (2025), but did not quantify reductions past 2030.

Uncertainties

The best available information was used in the study, but many things are changing rapidly—even daily. Here are the major uncertainties affecting the projections:

- Fuel prices
- Future VMT growth
- Future federal regulations and international agreements
- Estimates of carbon emissions from current and future fuels
- Timeframes for phasing in standards
- Land use development patterns
- Economic impact of changing fuel, food, and crop prices
- Consumer response to regulations, price increases, and lifestyle changes
- New vehicle and fuel technology

The study provides a framework to understand the impacts of these changing numbers and adjust the mix of strategies over time.

Reduction Strategies

The strategies fall into three broad categories:

1. Reduce vehicle fuel consumption per mile. These strategies typically rely on technology that improves the fuel economy of the vehicle fleet or on regulations or pricing incentives that cause consumers to purchase more fuel-efficient vehicles.
2. Reduce fuel carbon content. These strategies include mandates, technology shifts, and economic incentives.
3. Reduce VMT. These strategies—such as incentives for high-density urban housing—increase the use of public transit and alter land use patterns.

Reduce Vehicle Fuel Consumption Per Mile

Reducing fuel consumption per mile offers much of the potential for GHG reduction. Improving mileage burns less fuel, so GHG emissions fall per mile.

Passenger Vehicle Standards

The analysis looked at two regulatory approaches: the “California standards” and the federal Corporate Average Fuel Economy (CAFE) standards (see Figure 1).

In 2004, California proposed average GHG emissions standards for manufacturer fleets as part of the California Low Emission Vehicle (LEV) II rules. The U.S. EPA declined to grant a waiver for California’s standards, but 17 states including Minnesota are challenging the EPA decision in court.

In late 2007, the U.S. Congress enacted the Energy Independence and Security Act, which requires CAFE standards for manufacturers’ fleets to reach 35 miles per gallon (MPG) by 2020.

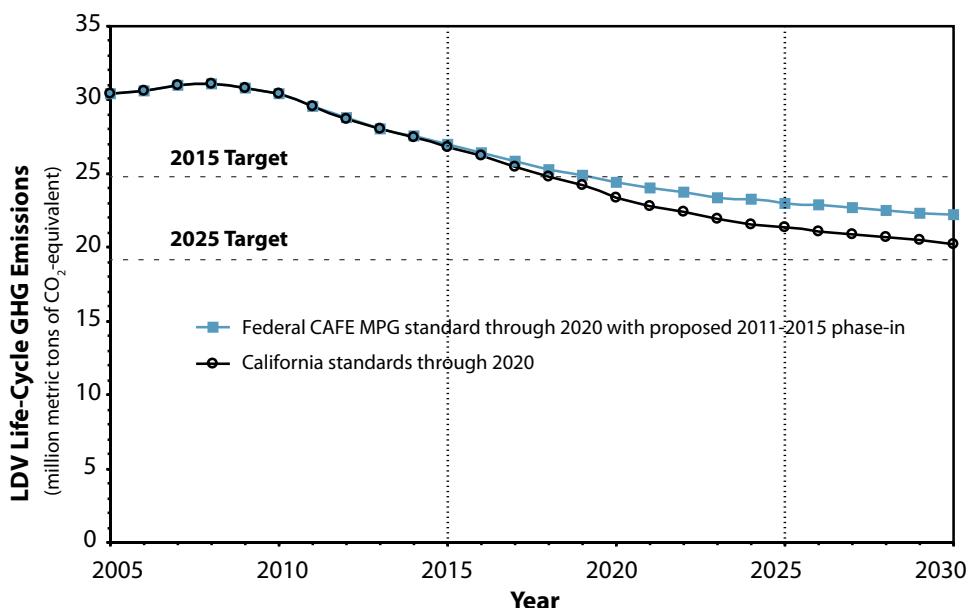


Figure 1. Life-cycle emissions projections for the Minnesota light-duty vehicle fleet resulting from the proposed phase-in for the federal CAFE standards and the California standards

THE STUDY ESTIMATES that the federal CAFE standards or the California standards could contribute between 61 percent and 64 percent of the target emissions reductions

The savings from buying a more fuel-efficient vehicle offset the added cost of technology—in some cases, in less than a year.

Technologies to achieve the CAFE standard are readily available. Other industrialized countries and China already have standards in place that are tougher than the *goals* established by CAFE or California standards.

for the transportation sector in 2015. In 2025, assuming no further efficiency improvements past 2020 (the final year for each standard), CAFE standards could contribute about 66 percent and California standards about 80 percent of the transportation reduction goal.

Feebates

Feebates are financial incentives for the production and purchase of vehicles with reduced carbon emissions. In a full feebate program, a rebate is offered for vehicles with emissions below a selected level—a pivot point—and a fee is added to vehicles rated above that level. Rebates and fees have been used separately at the federal level, but no state has implemented a vehicle feebate policy.

THE STUDY FOUND that a feebate policy in Minnesota, if enacted with other Midwest states so that the fleet size would be comparable to California's, could cut emissions significantly. For example, a \$180 feebate based on a 30-MPG pivot point—\$180 for each MPG increment above or below 30 MPG—gives these results:

- A \$180 feebate would reduce LDV fleet-wide emissions by about 17 percent in 2016 (compared with 2002). This could contribute a third to half of Minnesota's transportation reduction goal.
- Doubling the feebate to \$360 produces the same reduction as the California standards.
- The combination of the \$180 feebate program with the California standards cuts emissions 25 percent more than implementing the California standards alone—showing the benefit of combined policies.

Heavy-Duty Vehicles

Reducing idling and improving fuel economy are the main ways to cut emissions from the heavy-duty fleet. The study found that the best way to do this may be with a state-level policy to encourage further participation in SmartWay, an existing U.S. EPA program. The Minnesota Pollution Control Agency has been proactive in promoting SmartWay, and Minnesota's commercial fleet participation is strong.

A policy could, for example, offer low-interest loans to Minnesota-based truckers to help implement GHG reduction strategies such as these:

- Reduce idling: electrification of truck stops or the use of auxiliary units to power heating and air conditioning; automatic engine start-stop systems; anti-idling laws; driver education
- Improve efficiency: better aerodynamics; lower rolling-resistance tires; properly inflated tires ensured through automatic inflation systems; low-friction lubricants; reduced vehicle weight; reduced speed; driver training

THE STUDY ESTIMATES that heavy-duty vehicle efficiency improvements available today could contribute approximately 13 percent of the transportation sector's reduction goal in both 2015 and 2025.

Reduce Fuel Carbon Content

Reducing the fuel carbon content is the second broad strategy for reducing GHG emissions. The analysis found that the *quality* of the biofuel—in other words, the carbon emitted over its entire life cycle—has a greater impact than the *quantity* blended with gasoline. The life cycle includes emissions from fuel extraction, production, distribution, and storage as well as any land use changes that may affect climate change, such as

Reducing total long-term emissions from biofuels in Minnesota would require using feedstocks other than corn and processing the feedstocks with more efficient technologies.

converting virgin soil to feedstock. Some biofuels have higher total emissions than gas or diesel.

Three factors drive the potential for reducing carbon emissions from fuel: the type of feedstock, the processing technology, and the blend of low-carbon fuel with gasoline. In Minnesota, 10 percent ethanol (known as E10) is already being blended in gasoline, and 2 percent biodiesel is blended in diesel fuel. The state has established future goals of a 20 percent ethanol blend—with 5 percent of the ethanol coming from cellulosic materials—and a 5 percent biodiesel blend by 2013.

The study compared three scenarios:

- Scenario A: E20 mandate, corn used as the feedstock, natural gas used to generate heat
- Scenario B: E20 mandate, corn used as the feedstock, corn stover (leaves and stalks) burned in the dry-mill refining process to generate heat
- Scenario C: E10 mandate, ethanol produced from 100 percent cellulosic feedstock

Figure 2 shows the results. Scenario C, in which 10 percent ethanol was produced from 100 percent cellulosic feedstock, gives the best results. It outperforms both Scenarios A and B, which use 20 percent ethanol.

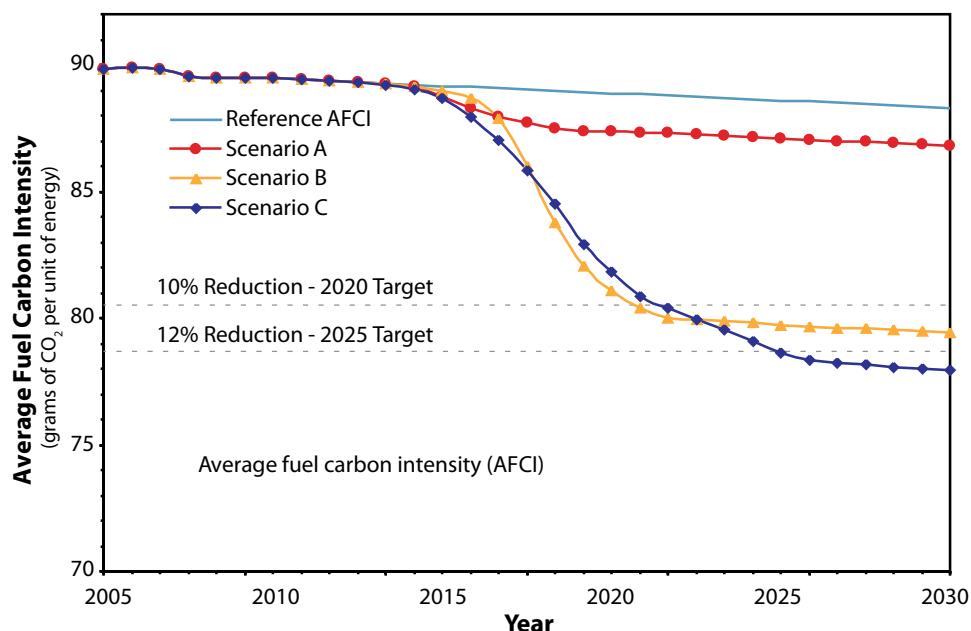


Figure 2. Average fuel carbon intensity (AFCI) for the light-duty vehicle fleet. Results are compared to the AFCI without a low-carbon fuel standard.

IF MINNESOTA ADOPTS a low-carbon fuel standard requiring low-carbon biofuels and alternative fuels, the study projects that carbon emissions would fall 10 percent by 2020 and 12 percent by 2025. This policy could contribute 27 percent of Minnesota's transportation reduction goals in 2015 and 40 percent in 2025.

Reduce Vehicle-Miles Traveled

Reducing the vehicle-miles traveled (VMT) is the third strategy policymakers can consider for reducing GHG emissions. VMT has a major effect on the state's success in achieving the GHG reduction goals, but it is arguably the area with greatest uncer-

tainty, largely because of the need to assume a future rate of VMT increase. The study used the current annual rate projected by the Minnesota Department of Transportation—0.9 percent. Historically, Minnesota's VMT growth trend has been close to 2.3 percent, but growth has been flat over the past several years.

The research team studied a range of policies that reduce VMT, such as alternative travel modes, improved urban form and mixed land-use, population densification, pricing, telecommuting, pay-as-you-drive insurance, improved freight efficiency, and process alteration (for example, creating an office of sustainability in Mn/DOT).

Depending on which policies are chosen, VMT could range widely. Each 1 percent reduction in VMT would contribute a 0.8 percent reduction in the transportation sector's GHG emissions, holding all other factors constant (see Figure 3).

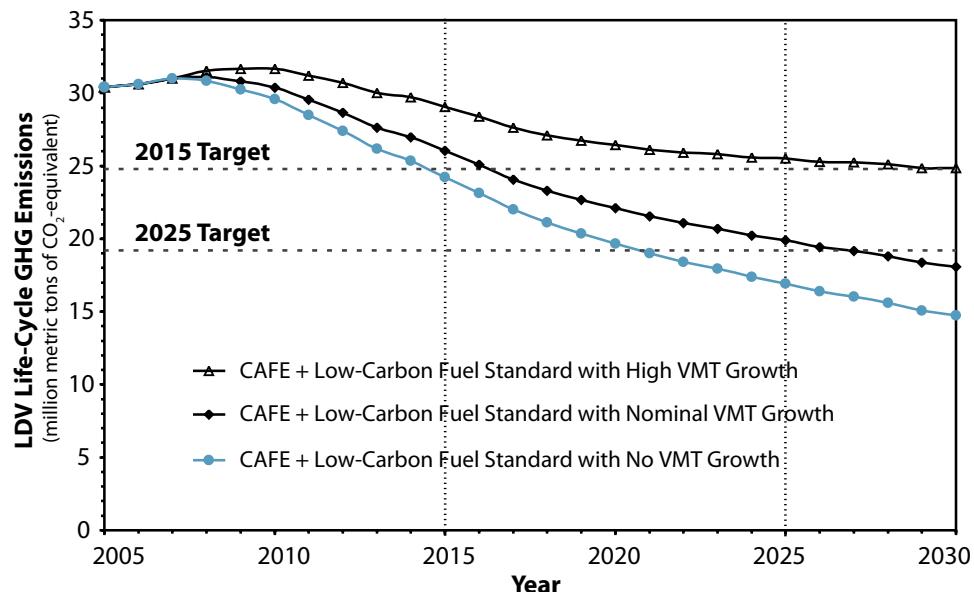


Figure 3. Sensitivity of reduction strategy estimates to changes in the baseline VMT forecast

AS SHOWN in Table 1, each reduction policy reduces total VMT between 0.1 percent and 5.3 percent in 2025. Combined, they would represent up to 14 percent of the transportation sector's reduction goal for that year.

Table 1. Estimated statewide VMT impacts of selected strategies between 2005 and 2025

Strategy	Percent statewide VMT reduction relative to "do-nothing" alternative
Do-nothing alternative (no reduction strategies applied; 0.9 percent projected annual increase)	0.0
Smart Growth	
Aggressive	5.3
Comprehensive	3.4
Limited	1.5
Construction of light-rail transit network	2.2
Construction of bus rapid transit network	2.2
Pay-as-you-drive insurance	1.0
General transit improvements	0.3
Employer / municipal parking-pricing plans	0.3
Construction of commuter rail	0.1

Conclusions

Short and Medium Terms—2015 and 2025

The study shows that by using a combination of strategies, Minnesota can nearly meet its GHG reduction goals for the transportation sector in 2015 and can exceed them in 2025. Figure 4 compares five scenarios:

1. California standards
2. Federal CAFE with proposed phase-in
3. Comprehensive transportation and land-use planning (TLUP) plus CAFE with proposed phase-in
4. Low-carbon fuel standard (LCFS) plus CAFE with proposed phase-in
5. California standards plus LCFS plus TLUP

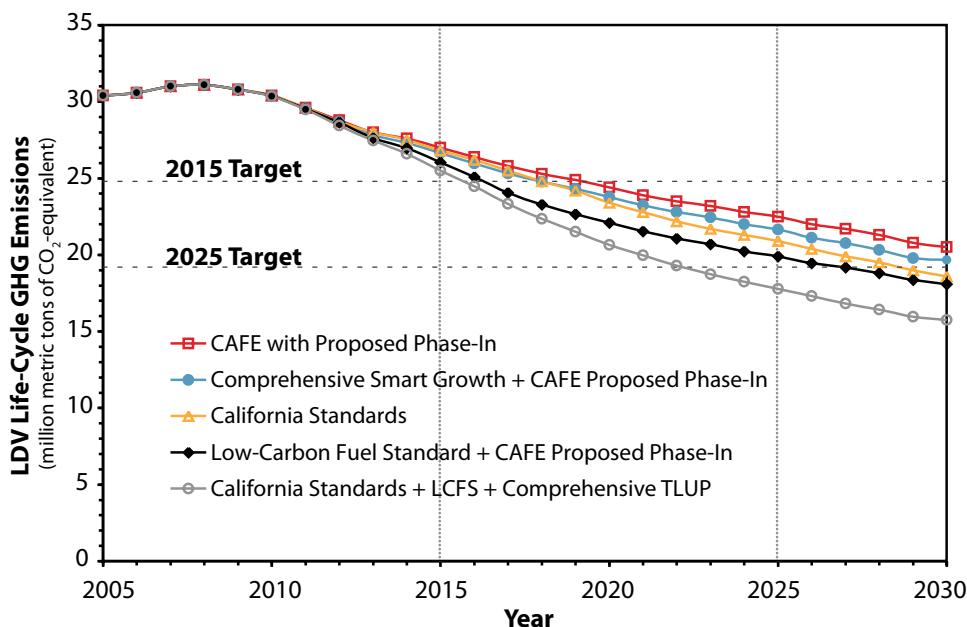


Figure 4. Impact of selected strategies and strategy combinations. (The final year for both the California and CAFE standards is 2020. The study assumed continued mileage improvements in the light-duty vehicle fleet when modeling these scenarios.)

Of this set, only the fifth option—California standards plus low-carbon fuel standard and comprehensive transportation and land use planning—meets the goals.

This is one snapshot of the possibilities. Policymakers can choose among these strategies, combine them differently, modify elements of them, and so on. And many variables will shape the ultimate reductions, including gas prices and driver behavior. What is clear is that the transportation sector can meet Minnesota's goals—if strong action is taken on all three fronts, and soon.

TO SUMMARIZE, the top contributors to the 2015 and 2025 reduction goals for transportation as shown in Figure 4 are:

1. Emissions standards for light-duty vehicles: depending on year and standard, approximately 60 to 80 percent of the goal.
2. Low-carbon fuel standards: approximately 27 percent of the goal in 2015 and 40 percent in 2025.

3. Feebates for light-duty vehicles on a multistate level: in 2015, approximately 15 percent of the goal when implemented with vehicle emissions standards. (The study did not estimate 2025 reductions for feebates.)
4. Decreased vehicle-miles traveled: in 2025, up to approximately 14 percent of the goal.
5. Heavy-duty vehicle efficiencies: in both 2015 and 2025, approximately 13 percent of the goal.

Long Term—2050

The final target set by the legislature—2050—is too distant for meaningful quantitative modeling. As an alternative, the research team investigated ways to position the state for the aggressive 2050 targets. For the most part, these technologies and strategies are already well along in the pipeline, but some issues remain.

Infrastructure

An important step toward meeting the 2050 targets is to develop infrastructure to shift the long-distance transport of freight and passengers to more fuel-efficient modes such as rail. This mode shift requires a substantial commitment by policymakers to invest in infrastructure improvements over the long term. However, the GHG reduction benefits are substantial. Trains, for instance, consume fuel at a much lower rate per ton-mile than trucks and cut GHG emissions per ton-mile fourfold.

To take advantage of plug-in hybrid technology, Minnesota must produce more of its electricity from low-carbon forms of energy.

Hybrid Vehicles

A potentially significant GHG-reducing technology already in many garages is the hybrid electric vehicle (HEV). HEVs such as the Toyota Prius combine a conventional gasoline or diesel propulsion system with an on-board, rechargeable energy storage system to achieve better fuel economy without loss of vehicle range.

In the pipeline is the plug-in hybrid electric vehicle (PHEV). The PHEV is a hybrid vehicle with batteries that can be recharged by connecting a plug to an electric power source. Per vehicle, fuel reduction from a PHEV could be 45 percent or more compared to a non-hybrid.

The infrastructure technology for charging the PHEV is crucial. Powering vehicles with electricity as it is currently generated in Minnesota would actually *increase* life-cycle GHG emissions associated with PHEVs. If the electrical sector reduces its GHG emissions proportionately to the Next Generation Energy Act mandates, life-cycle emissions from PHEVs would begin to be lower than those from using gasoline—but not until 2025.

Fuels

For travel beyond the range of electric vehicles but not within the network of railways, liquid fuel options must be developed to deliver higher energy density with lower associated emissions. The creation of cellulosic ethanol from prairie grasses for use in conventional vehicles is a strategy that shows potential in this area. A diesel fuel technology that shows promise is dimethyl ether (DME).

Land Use and Other Modes

Land use and system shifts of passenger and vehicle miles to other modes of transportation provide short and mid-term GHG reductions while also providing a framework for future reductions.

Recent data provide evidence. On average, buses produce 16 percent less GHG per passenger-mile than personal vehicles (see Figure 5). Commuter and light rail can yield GHG reductions of 40 percent and 75 percent, respectively, while choosing rail rather than air for long-range passenger travel reduces emissions up to 28 percent. Even stronger benefits have been found for long-distance freight transport.

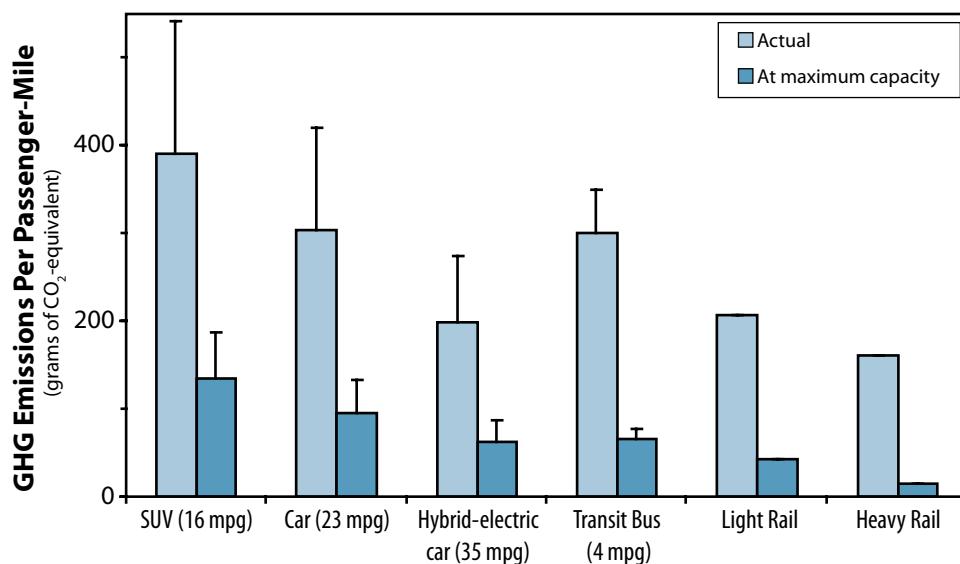


Figure 5. U.S. average GHG emissions per passenger-mile

The Path to a Smaller Footprint

This study suggests that the transportation sector can nearly meet its share of Minnesota's GHG emissions goals in 2015 and can exceed them in 2025 using a combination of strategies targeted to reduce fuel consumption per mile, vehicle-miles traveled, and fuel carbon content. The final target set by the legislature—2050—is too distant for meaningful modeling, so the research team investigated ways to position the state for the aggressive 2050 targets.

Policymakers may use the study as a framework to choose a mix of strategies and adjust them over time. Many combinations are possible, and future research and innovation will surely lead to more options for making the transportation sector greener. What is important is to take comprehensive action—sooner, not later.

For More Information

Read the full report—CTS 08-10—on the study's Web site:
www.cts.umn.edu/Research/GreenhouseGas.



Center for Transportation Studies
University of Minnesota
200 Transportation and Safety Building
511 Washington Avenue S.E.
Minneapolis, MN 55455
Phone: 612-624-8398
E-mail: cts@umn.edu