Daily Travel and Carbon Dioxide Emissions from Passenger Transport
Comparison of Germany and the United States

Ralph Buehler

Federal, state, and local governments in the United States and Germany have the goal of reducing petroleum use and associated greenhouse gas emissions from passenger ground transport. This paper compares trends of carbon dioxide (CO2) emissions from passenger transport in Germany and the United States since 1990. Germany reduced CO2 emissions from passenger transport at a rate faster than that of the United States—even with controls applied for population growth, economic activity, and travel demand. Furthermore, for all indicators, CO2 emissions from transport were much higher in the United States than in Germany: 11.7 times greater for total CO2 emissions, 3.1 times greater per capita, 2.1 times greater per passenger kilometer, and 2.4 times greater per unit of gross domestic product. Also compared are U.S. and German policies that can help decrease CO2 emissions from passenger transport through improvements in technology, including fuel economy and CO2 tailpipe emission standards, vehicle registration fees and taxes, incentive programs for the purchase of fuel-efficient cars, and biofuel standards. Finally, policies in Germany and the United States that shape the relative attractiveness of driving, public transport, walking, and cycling are highlighted. The analysis concludes with policy lessons for the two countries.

Federal, state, and local governments in the United States and Germany have the goal of reducing petroleum use and associated greenhouse gas emissions (GHG) from transport. In 2010, the transport sector was responsible for 20% of GHG emissions in Germany, compared with 31% in the United States (1, 2). In both countries most (approximately 95%) of the energy for transport came from petroleum. Carbon dioxide (CO2) accounted for about 95% of GHG emissions from transport in Germany and the United States (1, 2).

Automobiles, light trucks, and public transport were responsible for roughly two-thirds of transport GHG emissions in each country. They accounted for 13.5% of total CO2 emissions in Germany and 22.7% in the United States (1, 2). In 2010, annual per capita CO2 emissions from passenger ground transport in the United States were three times greater than in Germany: 3,800 versus 1,200 kg (1, 2). The difference for passenger ground transport between the two countries is larger than for annual per capita CO2 emissions from fuel combustion for the countries as a whole (17,000 versus 9,200 kg) as well as for other sectors (electricity and heat, 7,100 versus 3,800 kg; industry, 2,600 versus 1,500 kg; residential, 1,000 versus 1,400 kg; other, 900 versus 700 kg). Even when economic activity is adjusted for, CO2 emissions from passenger transport per unit of gross domestic product (GDP) were 2.4 times greater in the United States than in Germany.

The problem of emissions from passenger ground transport has proved difficult, because improvements in technological efficiency of cars and fuels can be offset by heavier vehicles, more powerful engines, and longer travel distances (the so-called rebound effect) (3). Compared with other sectors of the economy, passenger transport emissions are difficult to regulate, because travel behavior depends on individual decisions about residential location, vehicle ownership, transport mode choice, number of trips, and travel distance (4, 5).

In this paper, trends of CO2 emissions from passenger transport in Germany and the United States since 1990 are compared first. Statistics reported refer to “CO2 equivalent” emissions—a measure that also accounts for other GHGs, such as methane and nitrous oxide. The paper then discusses policies that can help decrease CO2 emissions from passenger transport through technology and changes in travel demand. The analysis concludes with policy lessons for the two countries.

Germany and the United States present many similarities that make a comparison of CO2 emissions from transport and related policies meaningful (6). Both are Western democracies with market economies, a high standard of living, and federal systems of government in which the interaction between federal, state, and local governments shapes transport policies (6). The two countries have large networks of limited-access highways, a similar share of licensed drivers (70%) in the population, and an important automobile industry (7). In both countries most suburban development occurred after World War II during periods of rapid motorization. In Germany and the United States the automobile is an important status symbol (8, 9). Motorization rates in both countries are among the highest in the world. However, compared with Germans, Americans own 30% more vehicles: 766 versus 585 cars and light trucks per 1,000 inhabitants (10, 11).

TREND IN CO2 EMISSIONS FROM PASSENGER TRANSPORT:
GERMANY AND THE UNITED STATES

Germany was more successful than the United States in reducing CO2 emissions from passenger transport over the past two decades (see Table 1). Between 1990 and 2010, total passenger ground transport CO2 emissions in Germany declined by 15%, compared with a 12% increase in the United States. CO2 emissions in the United States increased sharply between 1990 and 2005 (by 21%) and then
fell between 2005 and 2010. The drop in CO₂ emissions between 2005 and 2010 is likely related to the greater severity of the economic crisis in the United States compared with Germany, higher volatility of fuel prices in the United States because of a lower share of taxes in the price of gasoline in that country, and a decrease in driving in the United States. For example, the U.S. Department of Transportation (11) reports a drop of 15% in passenger kilometers of car travel between 2006 and 2009. However, even in 2010, passenger transport CO₂ emissions in the United States were 11.7 times greater than in Germany—up from a ratio of 8.9 in 1990. This increase is partially explained by faster population growth in the United States than in Germany.

After adjustment for population size, per capita CO₂ emissions increased in the United States between 1990 and 2005 but declined between 2005 and 2010. The result was 9% lower CO₂ emissions per capita in 2010 than in 1990. In Germany, per capita CO₂ emissions declined by 17% between 1990 and 2010. In 1990, emissions per capita were 2.8 times greater in the United States than in Germany. By 2010, this ratio had increased to 3.1, a reflection of Germany’s stronger decrease in CO₂ emissions during that time frame.

Between 1990 and 2010, CO₂ emissions per passenger kilometer traveled declined by 20% in Germany but only by 3% in the United States, a reflection of larger gains in vehicle fuel efficiency as well as increases in public transport use and cycling in Germany during that period. Compared with economic activity, measured in inflation-adjusted dollars of constant GDP, between 1990 and 2010 Germany decreased its CO₂ emissions from passenger transport at a faster rate than did the United States (~36% versus ~31%).

In summary, between 1990 and 2010 Germany reduced CO₂ emissions from passenger transport at a faster rate than did the United States—even when population growth, economic activity, and travel demand are controlled for. Furthermore, for all indicators CO₂ emissions from transport were much higher in the United States than in Germany: 11.7 times for total CO₂ emissions, 3.1 times per capita, 2.1 times per passenger kilometer, and 2.4 times per unit of GDP.

### FEDERAL GHG REDUCTION GOALS FOR TRANSPORT

Since its ratification of the Kyoto protocol, Germany has set national targets for reducing GHG emissions. Between 1990 and 2010 Germany reduced its total GHG emissions by 22% and has the goal of achieving a 40% reduction relative to 1990 by 2020 (13). Between 1990 and 2010, emissions from transport declined at a lower rate than those for the industry and energy sectors. Achieving the overall 40% target by 2020 will require the transport sector to reduce its annual emissions by 20% to 25% between 2005 and 2020 (13).

There is no explicit federal policy for reducing GHGs in the United States. However, since 2009 the Environmental Protection Agency (EPA) has regulated GHG emissions as air pollutants that endanger public health and welfare (14). Furthermore, 23 states had GHG reduction targets, and 37 states had climate action plans in 2012. GHG reduction targets vary by state. For example, California’s target is to achieve 1990 emission levels by 2020 (15).

The federal governments of both countries have developed a number of policies that directly or indirectly reduce CO₂ emissions from automobile transport, including fuel economy and CO₂ tailpipe emission standards, vehicle registration fees and taxes, incentive programs for the purchase of fuel-efficient cars, biofuel standards, and gasoline taxes. The federal governments also support local and state policies aimed at changing travel demand by promoting public transport, walking, and cycling, as well as land use policies that keep trip distances short.

### TABLE 1 Trend in CO₂ Emissions from Passenger Ground Transport in Germany and the United States, 1990–2010 (1, 2, 12)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total CO₂ Equivalent (Tg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>117</td>
<td>119</td>
<td>115</td>
<td>107</td>
<td>100</td>
<td>−2</td>
<td>−8</td>
<td>−15</td>
</tr>
<tr>
<td>United States</td>
<td>1,039</td>
<td>1,116</td>
<td>1,216</td>
<td>1,259</td>
<td>1,165</td>
<td>17</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>Ratio United States/Germany</td>
<td>8.9</td>
<td>9.4</td>
<td>10.6</td>
<td>11.7</td>
<td>11.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ Equivalent per Capita (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>1.470</td>
<td>1.455</td>
<td>1.399</td>
<td>1.303</td>
<td>1.217</td>
<td>−5</td>
<td>−11</td>
<td>−17</td>
</tr>
<tr>
<td>Ratio United States/Germany</td>
<td>2.8</td>
<td>2.9</td>
<td>3.1</td>
<td>3.3</td>
<td>3.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ Equivalent per Passenger km (g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>134</td>
<td>121</td>
<td>119</td>
<td>113</td>
<td>107</td>
<td>−11</td>
<td>−16</td>
<td>−20</td>
</tr>
<tr>
<td>United States</td>
<td>214</td>
<td>228</td>
<td>217</td>
<td>214</td>
<td>208</td>
<td>1</td>
<td>0</td>
<td>−3</td>
</tr>
<tr>
<td>Ratio United States/Germany</td>
<td>1.6</td>
<td>1.9</td>
<td>1.8</td>
<td>1.9</td>
<td>1.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂ Equivalent per Constant $1,000 GDP (using PPP) (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>57.0</td>
<td>52.4</td>
<td>46.2</td>
<td>41.8</td>
<td>36.4</td>
<td>−19</td>
<td>−27</td>
<td>−36</td>
</tr>
<tr>
<td>United States</td>
<td>129.4</td>
<td>122.7</td>
<td>108.4</td>
<td>99.7</td>
<td>89.0</td>
<td>−16</td>
<td>−23</td>
<td>−31</td>
</tr>
<tr>
<td>Ratio United States/Germany</td>
<td>2.3</td>
<td>2.3</td>
<td>2.3</td>
<td>2.4</td>
<td>2.4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** CO₂ equivalent emissions are based on national fuel consumption estimates. PPP = purchasing power parity.
There are no fuel efficiency or CO$_2$ emission standards at the national level in Germany, but Germany is subject to European Union (EU) regulations. Both the EU and the United States attempt to reduce GHG emissions from transport through vehicle fuel efficiency and CO$_2$ emissions standards (14, 16). The two standards are treated interchangeably here, because the burning of fossil fuels is closely related to CO$_2$ emissions. In 2010, the German automobile and light truck vehicle fleet was 55% more fuel efficient than the U.S. light-duty vehicle fleet [35 versus 23 mi/gal (mpg) or 7.5 versus 11.2 L per 100 km of travel]. Fuel efficiency data presented in this paper rely on the International Council for Clean Transportation’s conversion tool to allow comparison of the U.S. corporate average fuel economy (CAFE) and the New European Driving Cycle (NEDC) testing cycles. Values expressed as mpg presented in this paper are based on the U.S. CAFE testing cycle. Liters per 100 km (L/100 km) values are based on the NEDC.

In 1975 the United States implemented the world’s first fuel economy standards for cars and light trucks, the CAFE standards (17). Between 1980 and 1991, the fuel efficiency of the U.S. light-duty vehicle fleet increased from 16 to 21 mpg (17 to 13 L/100 km). Progress has been slower since then, and a fleet average of 24 mpg (11 L/100 km) was reached in 2009. Decreasing gains in fuel efficiency are partially explained by the failure to raise CAFE standards for new passenger cars for nearly two decades after 27.5 mpg (9.7 L/100 km) was reached in 1985. Moreover, CAFE set lower fuel economy standards (20.7 mpg or 13.2 L/100 km) for increasingly popular light trucks (18). In the mid-1970s, when CAFE standards were developed, light trucks accounted for only a small share of the vehicle fleet and were mainly used by businesses or for agriculture. However, since then, minivans, SUVs, and pickup trucks, which are all classified under CAFE as light trucks, became increasingly popular as private vehicles. For example, in 2002 new retail vehicle sales for light trucks surpassed those of passenger cars (18). A greater share of light trucks with lower fuel economy depressed the overall fuel economy of the U.S. passenger vehicle fleet.

In response to the Energy Independence and Security Act of 2007, fuel economy standards were revised. The new standards apply to light-duty vehicles—including both passenger cars and light trucks (<8,500 lb) (19, 20). The standards vary by vehicle size, and a formula based on vehicle size requires smaller vehicles to achieve higher fuel efficiency than larger vehicles. In the U.S. system, vehicle size is assessed as the product of track width and wheelbase (i.e., distance between wheels on the same axle and distance between the front and rear axles). Thus, manufacturers of smaller cars face stricter standards, and producers of larger cars are subject to comparatively less strict standards. New light-duty vehicles are set to average 30 mpg by 2015 and 39 mpg by 2020 (8.8 L/100 km by 2015 and 6.6 L/100 km by 2020) (21).

Because of the close connection of fuel efficiency and CO$_2$ emissions, the new standards were developed in collaboration by NHTSA and the U.S. Environmental Protection Agency (EPA) (as well as the state of California and major car manufacturers). In 2007, EPA gained the authority to regulate GHG emissions under the Clean Air Act (Massachusetts v. EPA) and determined that GHGs endanger public health and welfare (20). The mpg standards for 2015 and 2020 translate to 181 and 144 g CO$_2$/km for new light-duty vehicles (on the basis of the NEDC).

Historically, there were no fuel efficiency standards at the national level in Germany. Higher fuel efficiency was mostly explained by higher taxes on fuel and the resulting increased demand for more fuel-efficient cars. However, in the late 1990s and early 2000s, car manufacturers entered into a voluntary agreement with the European Commission under which they promised to reduce average CO$_2$ emissions of new vehicles to 140 g CO$_2$/km over 10 years (22). There were no fines for not meeting the standard, but there was the looming threat of European Commission regulation. In the years after the agreement, most improvements in fuel efficiency in Germany were due to an increasing share of diesel vehicles in the vehicle fleet (a process termed dieselization). Diesel engines are more efficient than gasoline-powered engines, but diesel fuel has higher energy and carbon contents per unit. Overall, improvements in reductions of CO$_2$ emissions under this agreement were considered insufficient; emissions reached only 160 g CO$_2$/km in 2006.

As a result, since 2009, German passenger cars have become subject to EU CO$_2$ emission standards requiring manufacturers to achieve an average of 130 g CO$_2$/km by 2015 and 95 g CO$_2$/km (45.5 and 60.6 mpg) by 2020 (22, 23). Specifics about the standards are still under negotiation, partly because Germany has advocated the delay of the 95 g CO$_2$/km goal from 2020 to 2024 (24). Similar to the revised standards in the United States, EU standards will vary by vehicle size. In contrast to the United States, where vehicle size is determined by track width and wheelbase, the EU chose vehicle weight as a guide to distinguish between smaller or lighter and larger or heavier vehicles. The rate of differentiation between lighter and heavier vehicles, based on the slope of the so-called linear limit value curve, has been part of intense negotiations between producers of heavier cars (including many cars from Germany) and manufacturers of lighter cars. Manufacturers of heavier vehicles have argued for stricter standards for smaller vehicles and vice versa.

Under these rules, manufacturers must achieve the required standard for all cars sold per year or face a fine of €5 (US$7) for each vehicle sold during the year for the first gram above the standard, €15 (US$20) for the second gram, €25 (US$38) for the third gram, and €95 (US$124) for each additional gram. However, car manufacturers are allowed to join forces and have their vehicle fleets evaluated jointly. Thus, a manufacturer failing to meet the standard could partner with a manufacturer exceeding the standard. Jointly, the two manufacturers could then meet the standard. In addition, manufacturers can gain credits for low-emission vehicles with <50 g CO$_2$/km (16, 22). The EU sets different goals for light commercial vehicles, which account for about 12% of the European vehicle fleet, and their target rate is 175 g CO$_2$/km by 2020 (16, 23).

Compared with those of the United States, proposed EU standards for 2015 (130 versus 181 g) and 2020 (95 versus 144 g) are more stringent for passenger cars and noncommercial light trucks combined. However, the United States proposes to reduce CO$_2$ emissions per kilometer further to 107 g by 2025 (based on NEDC). U.S. goals for 2025 can be decomposed into standards for light trucks (137 g) and passenger cars (93 g). Thus, if Germany were successful in delaying future EU standards, U.S. standards for passenger cars in 2025 could be more stringent than standards in the EU (93 versus 95 g) (24).

Both EU and U.S. CO$_2$ standards differentiate by vehicle size. The design of U.S. standards may offer greater incentives to increase fuel efficiency. Under the EU standard, producers of more fuel-efficient and lighter vehicles are subject to stricter standards—even if the floor area of the car is the same as for a heavier vehicle. In the United States, a lighter vehicle (with the same floor area) can help improve a manufacturer’s overall fuel efficiency—CO$_2$ emissions
Incentives for Lowering Pollution from Cars

Governments in both countries provide incentives for cars and fuels that pollute less. For example, in 2009, Germany changed its formula for calculating annual vehicle registration fees for new cars to include CO₂ emissions in addition to engine size and fuel type (diesel or gasoline) of the vehicle. The CO₂ share of the annual registration fee is small and is calculated as €2 (US$2.60) for each gram of CO₂ emissions above a certain emissions threshold: 120 g, 110 g, and 95 g for cars built in 2009, 2012, and 2014, respectively. Electric vehicles are exempt from any annual registration fees for 5 years (25). However, studies suggest that the CO₂ element of the registration fee is too small to change customer preferences toward less polluting cars significantly (25).

Vehicle registration fees in the United States vary by state, and some local jurisdictions assess annual personal property taxes in addition (26). However, the federal government has offered periodic tax incentives for the purchase of alternative fuel vehicles, certain cars with diesel engines, hybrids, plug-in hybrids, and electric vehicles. Incentives and program structures vary but can be as high as $7,500 in federal tax credits for electric vehicles and plug-in hybrids. In 2012, all but 12 states offered additional incentive programs for hybrid-electric vehicles and plug-in hybrids (18).

During the economic crisis of 2008–2009, the federal governments of Germany and the United States sought to support their automobile industries through monetary incentives for new car purchases if buyers turned in their old vehicles (better known as “cash for clunkers”). In both countries, older, less fuel-efficient vehicles were replaced with more fuel-efficient newer vehicles with lower CO₂ emissions per kilometer. But the volume of new vehicle sales was too small to reduce CO₂ emissions from passenger transport significantly (27, 28).

By its design, the U.S. program provided more incentives to increase fuel efficiency than did the program in Germany. In 2009, Germany offered a €2,500 (US$3,300) incentive toward the purchase of a new car for individuals who scrapped vehicles that were a minimum of 9 years old. Even though the program was labeled as “environmental allowance” (Umweltprämie), there was no requirement concerning fuel efficiency or CO₂ emission standards for the new cars. An analysis found that newly purchased cars averaged 20% lower CO₂ emissions per kilometer than scrapped cars. Through this program, 1.9 million individuals received a total of about €5 billion (US$7.5 billion) in subsidies (28).

In July 2009, the United States implemented a similar program, called the car allowance rebate system, offering $3,500 to $4,500 if buyers of a new car scrapped an old vehicle. In contrast to the German program, which was based only on the age of scrapped vehicles, the U.S. program required old vehicles to have fuel economy lower than 18 mpg and new cars to achieve at least 22 mpg (27). The exact subsidy amount increased with the differential in fuel efficiency between the scrapped car and the new vehicle. Average fuel efficiency of newly purchased vehicles was 58% greater than for scrapped cars (24.9 versus 15.8 mpg). Through this program, 700,000 individuals received a total of about $3 billion in subsidies (27).

In both countries new vehicles purchased under these programs were more fuel efficient and had lower CO₂ emissions per kilometer than the vehicles traded in, but the volume of new vehicle sales under these programs was too small to reduce CO₂ emissions from passenger transport significantly (27, 28). Furthermore, critics argue that the programs may have resulted in negative environmental effects, if the full life-cycle cost and the higher levels of use of newer cars (e.g., miles driven per year) and not merely on-road fuel economy are considered.

Both countries support the development of alternative fuels and alternative fuel vehicles, including biodiesel, electricity, hydrogen, natural gas, and ethanol. The United States has a longer history of experimenting with and using alternative fuels (26). For example, a 10% share of ethanol in gasoline (E10) is common in the United States. In contrast, in 2011 the German federal government experienced a public relations disaster and public resistance when it attempted to increase the ethanol content of gasoline from 5% to 10%. Many Germans believed that E10 would destroy their vehicles. Mirroring a media campaign by the car industry in Germany against E10, the American Automobile Association issued a similar warning for new E15 standards in the United States (29).

Travel Behavior and Federal Policies

More CO₂ emissions from passenger transport in the United States can be explained partly by the lower fuel efficiency of the U.S. vehicle fleet discussed above. However, more trips by automobile and longer travel distances are important factors as well. The automobile accounts for a much higher share of trips in the United States than in Germany (86% versus 58% of daily trips). In contrast, compared with Americans, Germans make 4.5 times higher share of trips by public transport (9% versus 2% of trips), are 10 times more likely to ride a bicycle (10% versus 1% of trips), and are 2.2 times more likely to walk (24% versus 11% of trips) (30, 31).

A recent international comparison shows a correlation between CO₂ emissions from passenger ground transport and the share of daily trips made by walking, cycling, and public transport (32). Compared with Western European countries, the United States has the highest annual CO₂ emissions from passenger ground transport per capita and the lowest share of trips by foot, bicycle, and public transport (3,800 kg and 14% of trips, respectively). CO₂ emissions are lower and the share of trips by walking, cycling, and public transport are higher in Western European countries, such as the Netherlands (1,000 kg, 51%), Austria (1,100 kg, 42%), Germany (1,200 kg, 43%), Denmark (1,200 kg, 41%), Norway (1,300 kg, 36%), and the United Kingdom (1,300 kg, 34%) (2, 32, 33). There are no recent national travel surveys for all trip purposes for Australia and Canada. The only available travel data for those countries is the share of trips by walking, cycling, and public transport for the commute to work. Commutes account for only 15% to 20% of all trips. However, even when mode shares for the commute to work are compared, annual per capita CO₂ emissions from passenger ground transport show higher CO₂ emissions and less walking, cycling, and public transport use in the United States (3,800 kg, 8% of work commutes by foot, bicycle, and public transport) than in Australia (2,300 kg, 17%) and in Canada (2,900 kg, 18%) (32).

Americans not only make a higher share of trips by car but also drive longer distances. Compared with Germans, Americans drive almost twice as many miles per year: 13,500 versus 6,800 passenger miles of car travel (21,700 versus 11,000 passenger kilometers).
in Germany, car parking is more limited. This lack of high-speed highways in cities, combined with widespread traffic calming of residential neighborhoods, makes it slower in German cities. Most German cities, including large cities like Berlin and Munich, have traffic calmed more than 70% of their road network to speeds of 30 km/h (19 mph) and even to walking speed (7 km/h (4 mph)) for some residential streets (45).

Tolling passenger cars for stretches of highways, new lanes, bridges, and tunnels has been more common in the United States than in Germany. Trucks are tolled on the German Autobahn, but there is no charge for passenger cars (37). Furthermore, the German Autobahn network still has many stretches without speed limits, compared with speed limits between 65 and 75 mph on the U.S. Interstate system in most states (37).

Gasoline Taxes and Funding for Roads

In 2010, the cost of 1 L of unleaded gasoline (research octane number of 95) was €1.75 in Germany compared with $0.74 in the United States (39). Most of the difference was due to gasoline taxes, which were eight times higher in Germany than in the United States. In 2010, taxes accounted for 62% of the retail price of gasoline in Germany compared with only 18% in the United States (39).

The difference in gasoline retail price between Germany and the United States has been increasing. In 1986, gasoline cost about 80% more in Germany than in the United States. In 2010, the price of gasoline was 2.4 times higher in Germany. This divergence is partly explained by Germany’s environmental tax reform, which increased gasoline taxes annually by €0.03/L ($0.14/gal) between 1998 and 2003, for a total of €0.15/L ($0.71/gal) over 5 years (40). The tax was designed to curb energy use from transport and to encourage more fuel-efficient cars and less driving. The policy of annual increases expired in 2003, but the 5-year implementation of the environmental tax helped increase gasoline taxes and prices permanently. In contrast, federal gasoline taxes in the United States have not been raised since 1993.

Revenue from highway user taxes and fees in Germany was 2.2 times higher than government road spending in 2010. In contrast, highway users receive net subsidies in the United States. In 2009, highway user revenue collected by federal, state, and local governments in the United States covered only 58% of highway spending by all levels of government (41, Table VM 202). Furthermore, since 2008 the federal Highway Trust Fund, which receives the revenues from the federal gasoline tax, has been supplemented with general funds several times.

Higher gasoline taxes do not lead to higher household expenditures for transport in Germany. In fact, U.S. households spend about $2,500 more per year on transport—with transport accounting for 17% of household expenditures in the United States compared with less than 15% in Germany (32, 42).

At the local level, most German cities have increased the cost of or reduced car parking in city centers and many neighborhoods. In the United States, 95% of automobile trips are still subsidized with free car parking (43). Driving is also slower in German cities.

In contrast to the United States, limited-access highways in Germany rarely penetrate cities and city centers. In the United States, the federal government subsidized the construction of limited-access highways in most cities with as high as a 90% federal share (44). The lack of high-speed highways in cities, combined with widespread traffic calming of residential neighborhoods, restricts car travel and makes it slower in German cities. Most German cities, including large cities like Berlin and Munich, have traffic calmed more than 70% of their road network to speeds of 30 km/h (19 mph) and even to walking speed (7 km/h (4 mph)) for some residential streets (45).

Tolling passenger cars for stretches of highways, new lanes, bridges, and tunnels has been more common in the United States than in Germany. Trucks are tolled on the German Autobahn, but there is no charge for passenger cars (37). Furthermore, the German Autobahn network still has many stretches without speed limits, compared with speed limits between 65 and 75 mph on the U.S. Interstate system in most states (37).

Policies That Promote Public Transport, Cycling, and Walking as Viable Alternatives to Driving for Daily Travel

Higher costs for driving and more restrictions on car use in German cities help explain less car travel demand and lower CO₂ emissions from transport in Germany than in the United States. All levels of government in Germany have implemented policies that help make walking, cycling, and public transport attractive alternatives to driving (see Table 2 for details). For example, public transport is more attractive in Germany because of higher levels of public transport service and more ubiquitous access to public transport. In 2009, public transport service, measured as vehicle kilometers of service per person, was three times greater in Germany than in the United States (60 versus 20 vehicle kilometers per person per year). Furthermore, 88% of Germans lived within 1 km of a public transport stop, compared with only 43% of Americans (46).

Public transport use per capita is also higher. Germans make 6.5 times as many public transport trips per year as Americans (135 versus 21 trips per person per year) (36). As shown by a recent study (36), more attractive public transport in Germany can also be explained by regional integration of public transport services, coordination with other modes of transport, regionwide fare integration across operators, steeply discounted monthly and annual tickets, unified user information systems, real-time information at transit stations and on vehicles, and traffic priority for buses and light rail (36).

In the United States, most public transport trips are concentrated in large cities with subway systems and regional rail, such as New York City; Boston, Massachusetts; Philadelphia, Pennsylvania; Washington, D.C.; Chicago, Illinois; and San Francisco, California (47). Public transport service in suburban areas and many cities typically focuses on commute hours, with service going toward downtown in the morning and away from downtown in the late afternoon. Even though many public systems have made progress during recent decades, regional integration of timetables and ticketing, steeply discounted monthly tickets, and real-time passenger information are still rare or nonexistent in most of the United States (48).

The German federal government plays a minor role in promoting walking and cycling—mainly limited to federal traffic laws protecting cyclists and pedestrians and making their safety an integral part of the German driver’s license test (35). Most innovations, such as car-free pedestrian zones, areawide traffic calming, integrated...
TABLE 2  Comparison of Key Transport Policies in Germany and the United States That Restrict Car Use and Promote Walking, Cycling, and Public Transport for Daily Travel (35–37)

<table>
<thead>
<tr>
<th>Policies That Make Car Use Less Attractive in Germany Than in the United States</th>
</tr>
</thead>
</table>
| Sales tax for new cars | United States: State sales taxes for new car purchases range from 0% to 8.25%, with an average of 4.9%  
Germany: 19% in all states |
| Drivers license and cost | United States: Easy and cheap driver training and licensing, costing about $100 in most states  
Germany: Strict and expensive driver training and licensing, costing over $2,000 per license |
| Price of gasoline | United States: In 2010, $0.74/L (18% of price is tax)  
Germany: In 2010, $1.75/L (62% of price is tax) |
| Road revenues and expenditures | United States: Road user taxes and fees account for 58% of roadway expenditures by all levels of government  
Germany: Revenues from roadway user taxes and fees are 2.2 times higher than roadway expenditures by all levels of government |
| Traffic calming and speed limits | United States: Few cities have any traffic-calmed neighborhoods; speed limits on most city streets range from 35 to 45 mph (56 to 72 km/h)  
Germany: Most residential streets are traffic-calmed at 30 km/h or less, with speeds reduced to 7 km/h on some residential streets; general speed limit of 50 km/h (33 mph) in cities |
| Road and parking supply | United States: High-speed motorways and arterials criss-cross cities and suburbs; municipal zoning codes require high levels of minimum parking  
Germany: High-speed motorways rarely penetrate into city centers; most cities have reduced car parking in downtowns and increased parking fees since the 1960s |

<table>
<thead>
<tr>
<th>Policies That Make Public Transport More Attractive in Germany Than in the United States</th>
</tr>
</thead>
</table>
| Quantity of service | United States: 20 vehicle km of service per capita per year: regional rail and metro: 6 km; bus and light rail: 14 km  
Germany: 59 vehicle km of service per capita per year: regional rail and metro: 28 km; bus and light rail: 31 km |
| Quality of service | United States: Many systems have modernized their vehicles and stations; little coordination of services and ticketing across modes and operators  
Germany: All systems have modernized their vehicles and stations; full coordination of schedules and routes across modes and operators |
| User information | United States: Fragmented, incomplete, and often undependable information; real-time information rare even on trains, almost never on buses (except bus rapid transit)  
Germany: Online information about regional, statewide, and national routes, timetables, and fares; real-time information at most rail and some bus stops, and onboard most trains and buses |
| Discounts | United States: Public transport commuter tax benefits; discounts for seniors; slightly discounted monthly tickets for regular commuters; discounts for off-peak travel provided by some systems  
Germany: Tax benefit based on daily commute distance; discounts for children, university students, and seniors; deeply discounted monthly tickets available to all groups |
| Regionwide integration | United States: Fares and ticketing rarely integrated across operators and jurisdictions; regional transport planning authorities in most cities, but with less integration of services than in Germany  
Germany: Regional public transport authorities integrate fares, ticketing, operations, and financing across operators and jurisdictions; statewide coordination of schedules, fares, and tickets |

<table>
<thead>
<tr>
<th>Policies That Make Walking and Cycling More Attractive in Germany Than in the United States</th>
</tr>
</thead>
</table>
| Federal subsidies | United States: Federal transport funds eligible for walking and cycling projects; special federal funds for nonmotorized transport  
Germany: Earmarked federal funds for improvement of urban pedestrian and cycling facilities; federal funding for bike paths along highways |
| Car-free zones | United States: No areawide pedestrian zones; pedestrianized streets exist in some cities, such as Madison, Wisconsin; Minneapolis, Minnesota; or Denver, Colorado  
Germany: Most cities have pedestrianized large areas of their downtown that are off-limits for automobiles |
| Traffic calming | United States: Cities experiment with traffic calming; applications are not as systematic and comprehensive as in German cities  
Germany: Almost all cities have traffic calmed most residential streets to 19 mph (30 km/h); certain areas limit cars to walking speed (4 mph [7 km/h]) |
| Pedestrian facilities | United States: Lack of pedestrian facilities in many developments and along many urban roads; new complete streets policies in many cities consider the needs of all modes  
Germany: Universal provision of sidewalks in urban areas; priority for pedestrians in car-free zones in downtowns in almost all cities |
| Bikeway networks | United States: Only few cities have integrated network of bicycling facilities  
Germany: Majority of cities have comprehensive, regionwide integrated networks of separate facilities for cyclists |
| Traffic education | United States: Voluntary bicycling courses; rarely any education of drivers, pedestrians and cyclists about rights of pedestrians and cyclists; safe routes to school in all states with dedicated staff  
Germany: Safe and effective cycling training is part of school curriculum; rights of nonmotorized modes are part of driver’s training and testing |

<table>
<thead>
<tr>
<th>Planning and Policies That Facilitate More Dense and Mixed Land Uses to Encourage Walking, Cycling, and Public Transport Use</th>
</tr>
</thead>
</table>
| Coordination with public | United States: Little coordination of transport with land use planning, except for some transit-oriented developments  
Germany: Strict land use controls limit low density sprawl and encourage compact development around public transport stops |
| Planning process | United States: No federal land use planning; limited state land use planning; uncoordinated, and often conflicting land use planning by local jurisdictions  
Germany: Coordination of land use plans among levels of government and across jurisdictions; integration of land use, transport, and environmental planning at all levels of government |
citywide bicycling networks, bicycling training courses for schoolchildren, and pedestrian-activated traffic signals, were pioneered and implemented at the local and state level. The German federal government supported these efforts with technical guidance and flexible funding mechanisms, which allowed municipalities to use federal funds for nonmotorized modes (35).

Since the 1990s the U.S. federal government has made an increasing amount of federal funds eligible for walking and cycling projects at the local and metropolitan level (49, 50). Some U.S. cities have used this opportunity to promote walking and cycling. However, most U.S. cities still lack integrated networks of bicycle paths and lanes (50). Many suburban settlements in the United States do not have sidewalks or crosswalks for pedestrians. Drivers’ training in the United States does not emphasize the rights of pedestrians and cyclists. Even though some cities have made progress, the United States is still less bicycle- and pedestrian-friendly than Germany. For example, in 2010, cyclist and pedestrian fatality rates per kilometer cycled or walked were four to five times greater in the United States than in Germany (35).

Federal involvement in land use planning in Germany is limited to defining the legal framework for planning, ensuring consistency of planning techniques, and—in collaboration with the states—setting broad strategic goals for spatial development, such as sustainability (51). Municipal governments develop the actual land use plans and decide where different land uses are permitted. Local plans in Germany are restricted by regional and state plans, which are developed with the involvement of lower levels of government. In addition, land use plans must be coordinated with other sectors (e.g., transport) and neighboring jurisdictions (52).

In contrast, land use planning in the United States is typically in the domain of municipalities, rarely coordinated across jurisdictions, and typically not integrated with transport planning. In addition, mixed land use and dense development typically require changes in existing zoning codes in the United States (51). German land use planning is more flexible, because “residential zones” allow for doctors’ offices, small shops, restaurants, and multifamily housing. Furthermore, in the United States, areas zoned as “single-family residential” ban any mixed land uses or multifamily homes. German zoning typically applies to small areas (one block or a couple of blocks), while zones in the United States are typically much larger. Fine-grained zoning in Germany allows for a better mix of land uses that results in shorter trip distances (53).

**DISCUSSION OF RESULTS AND CONCLUSIONS**

CO₂ emissions from transport are much higher in the United States than in Germany, even when population, economic activity, and travel distance are controlled for. Between 1990 and 2010, Germany has reduced CO₂ emissions from passenger ground transport. Passenger transport CO₂ emissions per capita and per kilometer of travel also declined in the United States, but only between 2005 and 2010 during the economic crisis and in the face of volatile fuel prices. In both countries, regulations attempt to improve the fuel efficiency of the vehicle fleet by using CO₂ tailpipe emission standards and incentives for vehicles and fuels that pollute less.

The U.S. experience shows that fuel efficiency (and by extension CO₂ emission) standards can help increase the fuel efficiency of new vehicles, but it also highlights the difficulty of adapting the standards to changing technology, politics, and societal preferences. Between the mid- to late 1980s and the mid- to late 2000s, it was politically difficult to increase fuel efficiency standards significantly in the United States. During that time, policy makers also failed to adapt CAFE standards to the increasing use of light trucks as private vehicles. As a result, most progress in vehicle technology and fuel efficiency during that time was offset by heavier and larger vehicles.

New EU standards may run the same risks as CAFE standards in the United States. Germany’s government—likely reflecting the position of the country’s automobile industry—has already attempted to delay implementation of the stricter 95 g CO₂/km standard from 2020 to 2024. EU standards offer fewer incentives than U.S. standards to raise the fuel efficiency of increasingly popular larger vehicles. In the EU, more fuel-efficient lighter vehicles are subject to stricter standards. In the United States, a lighter vehicle (with the same floor area as a heavier vehicle) can help improve a manufacturer’s overall CO₂ emissions rating.

Government incentives for the purchase of more fuel-efficient cars with lower CO₂ emissions, such as special tax credits or no or lower annual registration fees, can help increase demand for those vehicles, but the overall volume of the programs is often too small or incentives are too little. For example, during the economic crisis in 2009, “cash for clunkers” programs in both countries were successful in replacing older, less fuel-efficient vehicles with newer, more efficient cars. However, despite the total cost of $7.5 billion (Germany) and $3 billion (United States), the volume of cars bought under the two programs was too small to have a significant impact on the overall fuel economy of the vehicle fleet. Similarly, the CO₂ component of Germany’s annual vehicle registration fee is too small to have a significant impact on the overall vehicle fleet.

The analysis also shows that Germany achieved higher fuel economy of its vehicle fleet and greater reductions in CO₂ emissions from transport than did the United States without fuel economy or CO₂ emission standards. This indicates that policies focusing on technological improvements can only be part of a policy package geared at reducing CO₂ emissions from transport. Technological improvements alone are prone to the potential rebound effect of heavier vehicles, larger engines, and greater car travel demand. Germany’s experience shows that public policies can also help reduce car travel demand while making walking, cycling, and public transport more attractive modes of transport.

Recent trends in travel demand and travel preferences among young adults may provide a window of opportunity for policies that promote walking, cycling, and public transport. Studies suggest that Western European countries experience a “peak car” phenomenon, under which overall car travel demand either increases slowly, stagnates, or declines (54–56). Young adults between 20 and 30 years old appear to lead this trend by driving less, owning fewer cars, and using other modes of transport more often than previous generations (57). Some studies report stagnating or declining overall travel demand in the United States (54). However, whether these trends continue once the U.S. economy and employment rebound from the 2009 crisis and gas prices decline again remains to be seen. In any case, more attractive public transport service and better infrastructure for walking and cycling may increase use of those modes in the United States, especially for individuals who reduced their driving and shifted to alternatives means of travel in response to the economic crisis and high gasoline prices.

Germany’s policies that promote walking, cycling, and public transport and restrict car use can provide lessons for the United States. However, policies from Germany cannot be imported wholesale; they
must be adapted to the U.S. context. The most important lesson from Germany is the combination of “push policies” restricting car use and making it more expensive with “pull policies” making alternatives to the car more attractive. Some U.S. cities, such as Portland, Oregon, and New York City, have adopted policies that promote public transport, walking, and cycling as viable alternatives to the car. However, the biggest difference between Germany and the United States is that U.S. cities rarely implement measures that restrict car use by making it more costly, slower, and less convenient. Incentives for public transport, walking, and cycling can make car restraint measures more feasible and successful. Once walking, cycling, and public transport are viable options for some trips, implementation of car restraint measures becomes easier politically.

ACKNOWLEDGMENTS

The author thanks Carole Cook and Venu Ghanta of EPA, Günter Hörmandinger of the European Commission, Andrea Hamre of the Boell Foundation, Dominika Kalinowska of the German Energy Agency, Uwe Kunert of DIW Berlin, Will Mallett of Congressional Research Service, Georg Maue and Helge Pohls of the German Embassy, Michael Mehlhing of Ecologic, Peter Mock of the International Council for Clean Transportation, Bob Noland of Rutgers University, Nadja Richter of the German Ministry of Environment, and three anonymous reviewers. This research has been supported by the American Institute of Contemporary German Studies (AICGS). A shortened blog version of this paper is available on the AICGS website. That version was not peer-reviewed.

REFERENCES

1. **CO₂ Emissions from Passenger Transport.** Umweltbundesamt, Dessau, Germany, 2012.

40. **Was bringt die Ökosteuer— Weniger Kraftstoffverbrauch oder Taktwirtschaft?** Umweltbundesamt, Dessau, Germany, 2005.

The Transportation Energy Committee peer-reviewed this paper.