

# Primer on Transportation and Climate Change

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AMERICAN ASSOCIATION OF  
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**AASHTO**  
THE VOICE OF TRANSPORTATION

# Climate Change, VMT, and the Economy:

## The AASHTO Perspective

In its July 2007 publication, *A New Vision for the 21st Century*, AASHTO noted that “global climate change has become a political, environmental, and economic fact of life.” That report identified bold but achievable goals for reducing Greenhouse gas (GHG) emissions from road transportation:

- Support the President’s goal to reduce oil consumption 20 percent in 10 years. Double the fuel efficiency of passenger cars and light trucks.
- Double transit ridership by 2030, and significantly expand the market share of passengers and freight moved by rail.
- Reduce the growth in vehicle miles traveled (VMT)—from three trillion in 2006 to five trillion, rather than the projected seven trillion, by 2055.
- Increase the percentage of those who car pool, walk, bike, or work at home.

Achieving these goals will require major efforts to develop next-generation technologies in vehicles and fuels. Current government forecasts assume only incremental advances in vehicles and fuels between now and 2020, with few additional gains beyond that year. Much greater improvements will be needed in order to achieve major reductions in GHG emissions.

In addition to improving vehicles and fuels, it also will be important to reduce the growth in VMT as compared to recent trends. Between 1982 and 2007, VMT grew at approximate 2.5 percent annually—closely tracking growth in the economy and personal income, and exceeding the growth in population. Going forward, some growth in VMT will be needed to accommodate a growing population and a growing economy, including truck freight shipments. Therefore, rather than seeking to cut VMT in real terms, AASHTO has proposed a goal of reducing the *rate of growth* in VMT to approximately the rate of population growth—about 1 percent per year.

It was interesting to note how the United Kingdom addressed this issue in its October 2007 report *Toward a Sustainable Transport System*. The report found that for transport, supporting economic growth and tackling carbon emissions, “does not have to be an either/or choice.” Likewise, AASHTO believes U.S. policies must be balanced in ways which help reduce transportation’s impact on global climate change, but which also sustain VMT growth at the level needed to support a healthy National economy.



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Executive Director



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Cover photo courtesy of FIGG, engineer of record for the Natchez Trace Parkway Arches.



# Introduction



**T**his primer is an introduction to the issue of climate change and its implications for transportation policy in the United States. The paper is organized in five parts:

***Part I summarizes the current state of scientific knowledge concerning the causes and impacts of climate change.*** This section reviews the data that shows climate change is occurring; summarizes the impacts of climate change, including impacts on the transportation system; and explains how greenhouse gas emissions contribute to climate change.

***Part II provides an introduction to climate change policy issues.*** This section briefly outlines the main goals of climate change policies, and provides an overview of the major strategies that are being considered and/or adopted to achieve those goals. This section includes a discussion of “cap and trade” proposals, a carbon tax, energy efficiency standards, and other economy-wide proposals that could be adopted to address climate change.

***Part III discusses trends in GHG emissions from road transportation.*** This section reviews historical trends and current government projections for fuel economy, vehicle miles traveled (VMT), and greenhouse gas emissions from road transportation. It also presents four alternate scenarios showing that faster improvements in fuel economy and somewhat slower growth in VMT could result in steep reductions in greenhouse gas emissions by 2050.

***Part IV reviews potential measures to reduce GHG emissions from road transportation.*** This section discusses potential improvements in vehicles and fuels;

potential ways to reduce the growth of VMT; and potential operational strategies for reducing GHG emissions. This section then provides an overview of policy tools that could help promote these changes, including measures such as increasing fuel economy standards; requiring greater use of renewable fuels; expanding funding for research and development; and establishing a “carbon price” through a cap-and-trade system or other measures.

***Part V identifies issues for further research.*** This section lists a series of issues that warrant additional research by AASHTO or others. For example, one important issue is the underlying growth trend in VMT. There is some evidence that growth in VMT is slowing due to economic and demographic factors. Additional research is needed to ensure that policymakers have a solid basis for setting policies on transportation and climate change.

The Reference Materials section, which follows Part V, includes a list of major studies and other published reports on climate change and transportation. A literature review summarizing these reports has been posted on the AASHTO web site along with this primer at [bookstore.transportation.org](http://bookstore.transportation.org).

This primer is based on the most recent research in the field. Its purpose is to outline the current thinking of governmental agencies, researchers, and advocacy groups on the issue of climate change and transportation. The conclusions stated in those reports do not necessarily reflect the views of AASHTO or its members. AASHTO will be sponsoring additional research and will be providing the results of that research in subsequent reports.



# Executive Summary



**A**uthoritative sources tell us the global climate is becoming warmer. Global warming is caused in large part by human activities. If allowed to continue unchecked, it will cause severe and lasting impacts. What is the role of transportation in mitigating global climate change and adjusting for its impacts?

## Anticipated Impacts Affecting Transportation

Research studies have identified the serious impacts climate change poses for transportation. Increases in very hot days will increase the frequency of wildfires, compromise pavement integrity, and deform rail lines; increased flooding of coastal areas will inundate roads, bridges, and rail lines; increases in Arctic temperatures will cause subsidence of permafrost, disrupting roads, rail lines, and airports. Heavier rainfall in many parts of the country will require redesign and replacement of drainage structures; and more frequent and more severe hurricanes will disrupt service in affected areas and require devoting more resources to evacuations.

### Recent Reports Say Climate Change Poses a Big Problem for Transportation

Recent authoritative reports have confirmed the challenges that global climate change will pose for the transportation sector. These studies include the *2007 Report of the Intergovernmental Panel on Climate Change* and TRB's Report 290: *Potential Impacts of Climate Change on U.S. Transportation*, 2008.

## Emission of Greenhouse Gases Is Causing Temperatures to Rise

The strategy to stop the continuing rise in temperatures is to slow down the rate of greenhouse gas (GHG) emissions and ultimately stabilize GHG concentrations in the atmosphere.

The goals of climate change policy are to stabilize global average temperatures and prepare for the impacts of climate change.

## U.S. Goals for Greenhouse Gas Emission Reduction

To date, the U.S. government has not adopted a specific GHG reduction goal. The U.S. Climate Action Partnership (U.S. CAP)—a broad coalition of industry and environmental groups—has set a goal to reduce U.S. GHG emissions below 2005 levels by 60–80 percent by 2050. Many states have adopted even more aggressive goals.

## Cap-and-Trade or Carbon Tax

Many economists have agreed that the most cost-effective way to reduce GHG emissions is to establish a *carbon price*. Carbon pricing would give businesses and individuals an incentive to use less carbon. A carbon price could be set by establishing a cap-and-trade program or a carbon tax. Under a cap-and-trade program, allowances for emissions would be allocated by the government, possibly through an auction. The price of emitting carbon and other greenhouse gases would be increased. The price of

given industry would reduce them directly or by purchasing allowances from others. Imposing a carbon tax would have a similar effect. Cap-and-trade appears to be the solution which stands the best chance of near-term enactment in Congress.

## Climate Change and Transportation

It is estimated that approximately 33 percent of GHG emissions in the United States come from transportation. Seventy-two percent of the transportation sector's emissions are generated by road use.

## Factors Affecting Road-Related GHG Emissions

There are several factors that affect the GHG emissions from road transportation. These include: 1) fuel economy, 2) the type of fuel used, and 3) the number of vehicle miles traveled. A fourth is traffic operations, including traffic-flow management by transportation agencies and individual driving behavior.

## Fuel Economy

In 2007, Congress enacted fuel economy standards that will require that the average of all new vehicles in the light-duty automotive fleet, which includes cars, light trucks, and sports utility vehicles, achieve a standard of 35 miles per gallon by 2020. The average today for both new and existing vehicles is approximately 20 mpg, so this will bring about a major change in the vehicles produced and sold by the auto industry.

## Alternative Fuels and Hybrid Vehicles

It is hoped that alternative fuels, such as ethanol and biodiesel, will help reduce GHG emissions because they emit less CO<sub>2</sub> for each unit of energy produced. There is also interest in the contribution that hybrids, plug-in electric, and hydrogen-fueled vehicles can make in the future. Alternative fuels represent less than two percent of the fuel supply in 2006, and DOE projects that they will rise to only eight percent by 2030.

- **Gas-Electric Hybrids.** A good example of the potential of hybrid vehicles is the Prius, which is rated at 46 mpg in average fuel efficiency, as compared to a standard Toyota vehicle, the Corolla, which is rated at 27 mpg city and 35 mpg highway.

- **Plug-In Electric Hybrids.** Plug-in electric hybrid vehicles are being developed. Many of them are expected to achieve fuel efficiency rates of 100 mpg. According to DOE, their commercial deployment is not expected to occur until around 2015.

- **Biofuels.** Federal and state laws have promoted increased use of ethanol and other biofuels as an energy supply for transportation vehicles. For example, in 2007 Congress enacted energy legislation mandating the production of 36 billion gallons of biofuels by 2020. While most current biofuels come from corn, there is great interest in the development of cellulosic ethanol, which is expected to represent a more clear-cut reduction in GHG emissions.

- **Zero-Emission Vehicles, Like Hydrogen.** Also under development are hydrogen fuel-cell powered vehicles which produce zero GHG emissions from the vehicle itself. (Energy is required to produce the hydrogen fuel supply for the vehicles; if fossil fuels are used to produce the hydrogen, then there will be some GHG emissions associated with the use of hydrogen-powered vehicles.) Hydrogen-powered vehicles are unlikely to become widespread by 2030, but they could become more widely used between 2030 and 2050.

**Strategies to Reduce Growth in VMT.** There is great interest in policies to reduce the growth of highway demand by shifting trips to other modes of travel. AASHTO, for example, supports a policy to double transit ridership by 2030. There is hope that making more trips by biking, walking, and telecommuting could help reduce GHG emissions as well.

**Potential of Transit and Land Use.** Many hope that increased transit usage can result in a net reduction in GHG emissions. What is not clear is to what extent. Research done for the Pew Center for Global Climate Change found that, "reducing emissions via increased use of transit would require momentous efforts as transit accounts for only one percent of passenger-miles traveled in the United States today." A recent report, published by several smart growth advocacy groups concluded that the combination of aggressive land-use strategies and

increased transit ridership could bring about transportation-related CO<sub>2</sub> emission reductions in the range of 7 to 10 percent.

**Reducing Congestion to Reduce GHG Emissions.** Many transportation agencies believe that reducing traffic congestion can make a significant contribution to reducing GHG emissions. They point to the billions of gallons of fuel burned by vehicles stuck in traffic that would no longer take place if congestion could be reduced. Smoothing out traffic so vehicles can travel at speeds that burn fuel at more optimal rates has been documented as reducing emissions. Some researchers support congestion relief as a strategy that would result in net reductions in emissions. Others do not recommend congestion reduction as a desired strategy, because of the fear it could encourage more driving and thus increase VMT.

**Department of Energy Projections Show Reduction of Road-Related GHG Emissions Will Be Difficult.** With regard to increasing fuel economy, DOE projects that the average fuel economy for all light-duty vehicles, new and existing, will rise from 19.9 mpg in 2006 to 27.9 in 2030. DOE shows most of this increase occurring by 2021, with little additional improvement between 2021 and 2030. DOE makes similarly conservative assessments of the change expected to occur from alternative fuels. Finally, DOE forecasts that VMT will increase by 1.6 percent annually through 2030. (Figure 1)

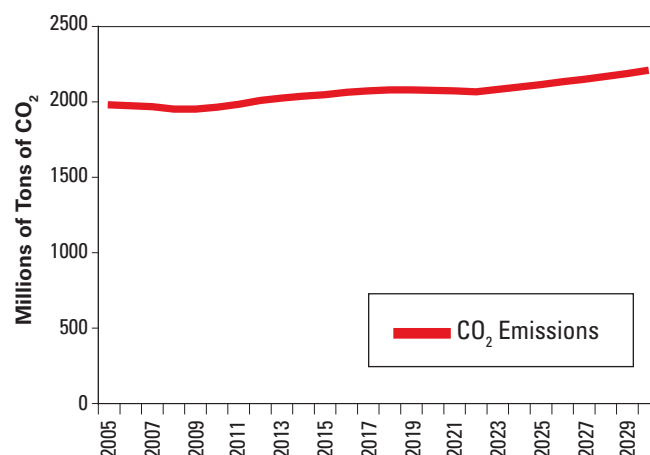
**More Potential for Transportation Sector GHG Emission Reductions May Exist Because High Petroleum Prices Are Expected to Stimulate Technological Innovation and Market Changes.** While official forecasts are important to consider, they do not reflect the potential impact of major technological breakthroughs or policy changes.

### Scenarios Illustrate GHG Emission Reductions Possible Through Changes in Technology and Policy

AASHTO-sponsored research tested four scenarios to see the GHG emission reductions that could be achieved through significant increases in fuel efficiency and reductions in VMT growth. The most

aggressive scenario was for average fuel economy increasing to 100 mpg-ge\*, and VMT increasing one percent annually through 2050. *This scenario achieved a decrease in CO<sub>2</sub> emissions from light-duty vehicles of 68 percent from 2005 levels by 2050.*

**Figure 1a. DOE 2030 Forecast for CO<sub>2</sub> Emissions from All Transportation Sources**

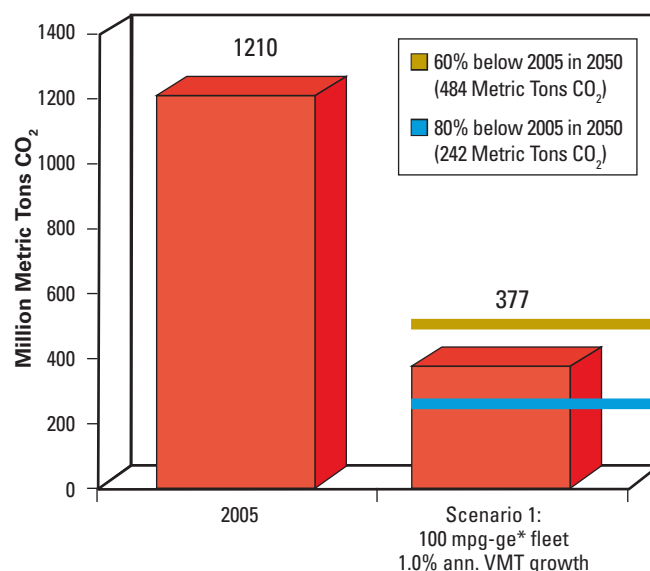


Source: U.S. DOE, Annual Energy Outlook 2008, Revised Early Release (March 2008).

Based on 35 mpg CAFE standard.

**Figure 1b. AASHTO Emissions Showing Major Reductions in CO<sub>2</sub> Emissions from Light-Duty Vehicles**

CO<sub>2</sub> Reduction Scenario for 2050 100 mpg, 1% VMT Growth



\* Miles per gallon-gasoline equivalent.

With average fuel economy equaling 100 mpg-ge and vehicle miles traveled increasing 1 percent annually CO<sub>2</sub> emissions from light-duty vehicles would be reduced to 377 million metric tons, a decrease of approximately 68 percent, by 2050.



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# Part I: The Causes and Impacts of Climate Change



**T**he science of climate change is evolving and complex, but there is widespread agreement among leading scientists and governments around the world on three key points:

- ***The global climate is becoming warmer.*** Global average temperatures have increased measurably in the past century. The temperature increase is widespread across the globe.
- ***Global warming, if allowed to continue unchecked, will cause severe and lasting impacts.*** The impacts of global warming are now evident in rising sea levels, shrinking polar ice, warmer winters, and retreating glaciers. As global warming continues, these impacts will become more severe. While impacts will vary by region, all parts of the world will be affected by climate change.
- ***Global warming is caused in large part by human activities.*** Human activities contribute to climate change by releasing greenhouse gases, which accumulate in the atmosphere and trap the earth's heat. Human activities also contribute to climate change by reducing the earth's ability to

*absorb* greenhouse gas emissions by converting forested lands to other uses.

There are many excellent sources of information on the causes and potential impacts of climate change. For a general introduction, refer to the *Climate Change 101* series published by the Pew Center for Global Climate Change, including "Climate Change 101: The Science and Impacts." See Reference Materials section.

## The Evidence of Climate Change

There have been hundreds of scientific studies in recent years that have attempted to measure the pace of global climate change and determine the role of human activities in causing that change. To synthesize this vast body of research, the Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the U.N. Environment Programme and the World Meteorological Organization. The IPCC includes leading scientists from around the world. Its role is to synthesize the latest scientific research on climate change.<sup>1</sup>

The IPCC's *Fourth Assessment Report*, issued in November 2007, concludes that the evidence of global

<sup>1</sup>For more information, refer to the IPCC web site: <http://www.ipcc.ch/index.htm>.

warming is now “unequivocal.” Some of the IPCC’s most important findings include:

- **Rising Temperatures.** Eleven of the twelve years from 1995 to 2006 rank among the 12 warmest years for global surface temperature since 1850, when recordkeeping began. This temperature increase is widespread over the globe, and is greater at higher northern latitudes.<sup>2</sup>
- **Rising Sea Levels.** Since 1961, global average sea level has risen at an average rate of 1.8 millimeters (mm) per year. Since 1993, the average rate has increased to 3.1 mm/yr.<sup>3</sup>
- **Retreating Arctic Ice.** Since 1978, the annual average extent of Arctic Sea ice has shrunk by 2.7 percent per decade. The summer average extent of Arctic Sea ice—that is, the average during the warmest part of the year—has shrunk by 7.4 percent per decade. Similarly, glaciers and snow cover have been shrinking.<sup>4</sup>

The IPCC’s conclusions have been widely accepted as representing the consensus of opinion in the scientific community. For example, while the United States government has been reluctant to adopt specific goals for reducing greenhouse gas emissions, the Environmental Protection Agency (EPA) accepted the main conclusions stated in the IPCC’s Fourth Assessment Report.<sup>5</sup> Recent publications from the Transportation Research Board (TRB) and the Federal Highway Administration (FHWA) also accept the IPCC’s conclusions as authoritative.<sup>6</sup>

Businesses—including many of the largest corporations in the United States—have also accepted the IPCC’s conclusions and are acting to minimize risks and take advantage of opportunities presented by climate change. A recent report from McKinsey &

Company, a consulting firm, noted that many U.S. businesses are establishing aggressive greenhouse gas abatement plans and are investing heavily to capture the business opportunities presented by climate change.<sup>7</sup> Lloyds of London, one of the world’s largest and oldest insurers, issued a report in June 2006 concluding that the climate change presents substantial, immediate risks for insurers.<sup>8</sup>

### The Impacts of Climate Change on the Transportation System

The Transportation Research Board (TRB) recently issued a comprehensive national report on the potential impacts of climate change on the U.S. transportation system.<sup>9</sup> Based on the IPCC’s Fourth Assessment Report and numerous other sources, the TRB report identified five climate changes of particular importance for the transportation system in the United States:

- **Increases in very hot days and heat waves.** “It is highly likely (greater than 90 percent probability of occurrence) that heat extremes and heat waves will continue to become more intense, longer lasting, and more frequent in most regions during the 21st century. In 2007, for example, the probability of having five summer days at or above [110°F] in Dallas is about 2 percent. In 25 years, this probability increases to 5 percent; in 50 years, to 25 percent; and by 2099, to 90 percent.” (p. 2)
- **Increases in Arctic temperatures.** “Arctic warming is virtually certain (greater than 99 percent probability of occurrence), as temperature increases are expected to be greatest over land and at most high northern latitudes. As much as 90 percent of the upper layer of permafrost could thaw under more pessimistic emission scenari-

<sup>2</sup> IPCC, *Fourth Assessment Report*, “Summary for Policymakers,” p. 1.

<sup>3</sup> IPCC, *Fourth Assessment Report*, “Summary for Policymakers,” p. 1.

<sup>4</sup> IPCC, *Fourth Assessment Report*, “Summary for Policymakers,” p. 1.

<sup>5</sup> U.S. EPA, Notice of Decision Denying a Waiver of Clean Air Act Preemption for California’s 2009 and Subsequent Model Year Greenhouse Gas Emissions Standards for New Motor Vehicles, 73 Fed. Reg. 156 (Feb. 29, 2008).

<sup>6</sup> TRB, *Special Report 290: Potential Impacts of Climate Change on U.S. Transportation* (2008); Federal Highway Administration, *Information on Climate Change and Transportation* (March 2008).

<sup>7</sup> McKinsey & Co., *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost* (Dec. 2007).

<sup>8</sup> T. McAlister, “Lloyd’s Tells Members Climate Change Could Destroy Insurers,” *The Guardian* (June 6, 2006); see also Lloyds of London, “Climate Change Adapt or Bust” (June 2006), available at: [http://www.lloyds.com/News\\_Center/360\\_risk\\_project/the\\_debate\\_on\\_climate\\_change/adapt\\_or\\_bust/](http://www.lloyds.com/News_Center/360_risk_project/the_debate_on_climate_change/adapt_or_bust/).

<sup>9</sup> TRB, *Special Report 290: Potential Impacts of Climate Change on U.S. Transportation* (2008).

os. The greatest temperature increases in North America are projected to occur in the winter in northern parts of Alaska and Canada as a result of feedback effects of shortened periods of snow cover....” (p. 2)

- ***Rising sea levels.*** “It is virtually certain (greater than 99 percent probability of occurrence) that sea levels will continue to rise in the 21st century as a result of thermal expansion and loss of mass from ice sheets. The projected global range in sea level rise is from [7.1 inches] to [23.2 inches] by 2099, but the rise will not be geographically uniform....These estimates do not include subsidence in the Gulf and uplift along the New England Coast. Nor do the global projections include the full effects of increased melting of the Greenland and Antarctic ice masses because current understanding of these effects is too limited to permit projection of an upper bound on sea level rise.” (p. 2)

- ***Increases in intense precipitation events.*** “It is highly likely (greater than 90 percent probability of occurrence) that intense precipitation events will continue to become more frequent in widespread areas of the United States.” (p. 2)

- ***Increases in hurricane intensity.*** “Increased tropical storm intensities, with larger peak wind speeds and more intense precipitation, are projected as likely (greater than 66 percent probability of occurrence).” (pp. 2–3)

These changes in climate will affect the transportation system in many ways. The TRB report noted several specific examples, including:

- ***Operational and maintenance impacts of excessive heat.*** “Periods of excessive summer heat are likely to increase wildfires, threatening communities and infrastructure directly and bringing about road and rail closures in affected areas. Longer periods of extreme heat may compromise pavement integrity (e.g., softening asphalt and increasing rutting from

traffic); cause deformation of rail lines and derailments or, at a minimum, speed restrictions; and cause thermal expansion of bridge joints, adversely affecting bridge operation and increasing maintenance costs.” (p. 66)

- ***Increased flooding of coastal roads and rail lines.*** “The most immediate impact of more intense precipitation will be increased flooding of coastal roads and rail lines. Expected sea level rise will aggravate the flooding because storm surges will build on a higher base, reaching farther inland....[The IPCC] identifies coastal flooding from expected sea level rise and storm surge, especially along the Gulf and Atlantic coasts, as one of the most serious effects of climate change. Indeed, several studies of sea level rise project that transportation infrastructure in some coastal areas along the Gulf of Mexico and the Atlantic will be permanently inundated sometime in the next century.” (p. 68)

- ***Disruption of coastal waterway systems.*** “[A] combination of sea level rise and storm surge could eliminate waterway systems entirely. For example, the Gulf Coast portion of the intercoastal waterway will likely disappear with continued land subsidence and disappearance of barrier islands. This will bring an end to coastal barge traffic, which helps offset rail and highway congestion; all ships will have to navigate the open seas.” (p. 69)

- ***Impacts on Alaskan infrastructure.*** “The effects of temperature warming are already being experienced in Alaska in the form of continued retreat of permafrost regions (see the discussion of Alaska below), creating land subsidence issues for some sections of the road and rail systems and for some of the elevated supports for above-ground sections of the Trans-Alaska pipeline. Warming winter temperatures have also shortened the season for ice roads that provide vital access to communities and industrial activities in remote areas.” (p. 68)

Several other studies have also concluded that climate change is likely to have widespread and severe impacts on transportation infrastructure. These studies include:

- **U.S. DOT Gulf Coast Study.** This study examined the potential impacts of climate change on transportation infrastructure in the Gulf Coast region. The study recognized “four key climate drivers” in the Gulf Coast region: rising temperatures, changing precipitation patterns, rising sea levels, and increasing storm intensity. It suggested a range of possible responses, including raising transportation facilities in low-lying areas; hardening them to withstand storm events; relocating them to areas that are less vulnerable; and expanding redundant systems where needed.<sup>10</sup>
- **ICF Studies of Sea-Level Rise.** This two-part study focused specifically on the potential impacts of sea-level rise (not climate change in general) on transportation infrastructure. Phase 1 included maps showing impacts of sea-level rise under a range of scenarios on the District of Columbia, Maryland, Virginia, and North Carolina. Phase 2, which is still under way, will evaluate impacts of sea-level rise on seven additional states on the East Coast: New York, New Jersey, Pennsylvania, Delaware, South Carolina, Georgia, and the Atlantic Coast of Florida.<sup>11</sup>

As these studies reflect, there is a growing consensus that climate change has already begun to have impacts on the transportation system and that those impacts will become more severe over time as the global climate continues to warm.

## The Causes of Climate Change

Greenhouse gases (GHGs) exist naturally in the earth’s atmosphere. Indeed, their presence allows the earth to remain warm enough to support life. The problem

of global warming is that GHG concentrations in the atmosphere are increasing above their natural levels, which in turn results in warming temperatures. According to the IPCC, global atmospheric concentrations of CO<sub>2</sub> and other GHGs “have increased markedly” since 1750 and now “far exceed pre-industrial values.”<sup>12</sup> For example, the concentration of CO<sub>2</sub> rose from **280** parts per million (ppm) in 1750 to **380 ppm** in 2005.<sup>13</sup> The IPCC found that the current global atmospheric concentration of CO<sub>2</sub> far exceeds the natural range over the past 650,000 years.<sup>14</sup>

The IPCC has concluded, and the majority of scientists agree, that the increasing GHG concentrations in the atmosphere can only be explained by taking into account human activities. Specifically, scientists have identified two primary drivers of climate change: (1) the **increase in GHG emissions** that result from the combustion of fossil fuels and other human activities; and (2) the **decrease in carbon absorption** that results from deforestation and other land-clearing.

## Increasing GHG Emissions

In recent years, GHG emissions have grown substantially, despite increases in energy efficiency. These increases are evident both in the United States and around the world. The rising trends in GHG emissions result from demographic, economic, and social changes that are, in many respects, accelerating. In particular, booming economic growth in developing countries such as China and India has greatly increased GHG emissions in those countries.

**GHG Emissions Trends in the United States.** In its most recent inventory of GHG emissions in the United States, the EPA found that:

- **Total GHG emissions in the United States have been increasing.** From 1990 to 2006, total GHG emissions in the United States rose **14.1 percent**.

<sup>10</sup> U.S. DOT, *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase 1—Final Report* (March 2008).

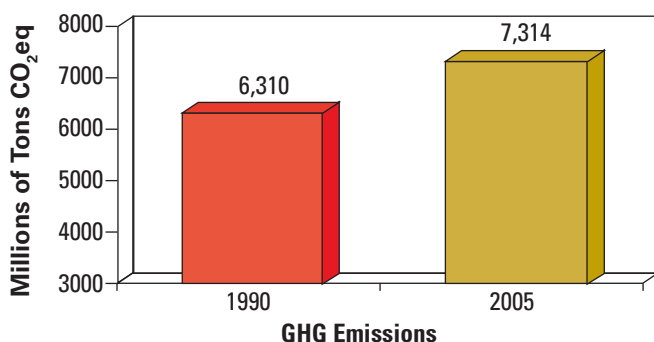
<sup>11</sup> See ICF International Inc., *The Potential Impacts of Global Sea Level Rise on Transportation Infrastructure, Phase I Final Report* (Nov. 2007).

<sup>12</sup> IPCC, *Fourth Assessment Report*, Topic 2, p. 37.

<sup>13</sup> *Ibid.*

<sup>14</sup> IPCC, *Fourth Assessment Report*, Topic 2, p. 3.

**Figure 2. Total U.S. GHG Emissions—1990 and 2005**

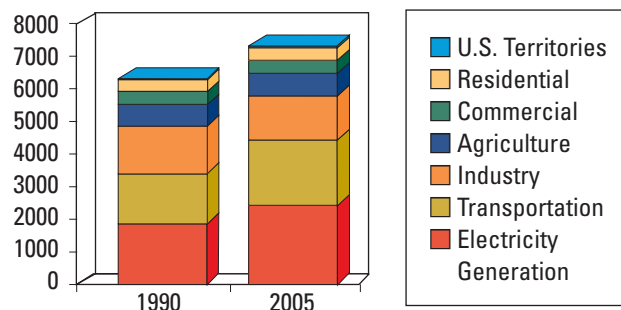


Source: EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks (Feb. 2008).

Total GHG emissions in the United States in 2006 were approximately 7.2 billion metric tons. Emissions in 2006 actually decreased slightly from 2005, when the total was approximately 7.3 billion metric tons.<sup>15</sup> (Figure 2)

- ***CO<sub>2</sub> emissions make up the majority of GHG emissions in the United States.*** In 2006, CO<sub>2</sub> emissions represented approximately **83 percent** of GHG emissions in the United States. Total CO<sub>2</sub> emissions in the United States in 2006 were approximately 6 billion metric tons.<sup>16</sup> The vast majority (94 percent) of CO<sub>2</sub> emissions result from the combustion of fossil fuels.<sup>17</sup> (Figure 3)
- ***CO<sub>2</sub> emissions have been increasing at a faster rate than other GHGs.*** From 1990 to 2006, emissions of CO<sub>2</sub> increased **19.4 percent**, which is faster than the overall rate of increase for GHG emissions (14.1 percent).<sup>18</sup>
- ***The transportation sector contributes a large—and increasing—share of GHG emissions.*** Transportation sources—including roads, rail, air, and marine travel—accounted for approximately **27 percent** of all GHG emissions in the United States in 2005; the electricity sector was the only larger contributor, with 33 percent of all GHG emissions.<sup>19</sup> (Table 1)

**Figure 3. GHG Emissions 1990 and 2005 by Economic Sector**



Source: EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks (Feb. 2008).

**Table 1. Percentage of Greenhouse Gas Emissions by Economic Sector**

| Sector                 | Percent of U.S. Greenhouse Gas Emissions in 2006 |
|------------------------|--------------------------------------------------|
| Electricity Generation | 33%                                              |
| Transportation         | 27%                                              |
| Industry               | 19%                                              |
| Agriculture            | 10%                                              |
| Commercial             | 6%                                               |
| Residential            | 5%                                               |
| U.S. Territories       | 1%                                               |

Source: U.S. EPA Inventory of Greenhouse Gas Emissions and Sinks (Feb. 2008).

Emissions from both the electricity generation and transportation sectors have been trending upward. By contrast, GHG emissions in other sectors—such as agriculture and industry—have been declining due to structural changes in the U.S. economy.

The following charts, which are based on data from the EPA emissions inventory, show these trends in GHG emissions. The first (Figure 2) shows the increase in GHG emissions from 1990 to the present; the second (Figure 3) shows the contribution from the energy, transportation, and other sectors of the economy; the third (Table 1) shows the percentage of GHG emissions by economic sector in 2006.<sup>20</sup>

<sup>15</sup> EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990–2006—Public Review Draft* (Feb. 2008), p. ES-16.

<sup>16</sup> EPA, *GHG Inventory 1990–2006*, p. ES-7.

<sup>17</sup> *ibid.*

<sup>18</sup> EPA, *GHG Inventory 1990–2006*, p. ES-16.

<sup>19</sup> *ibid.*

<sup>20</sup> EPA, *GHG Inventory 1990–2006*, pp. ES-4 and ES-14.

Based on official United States government forecasts, McKinsey & Company projects that GHG emissions will continue to increase, in the absence of major policy changes, at approximately 1.2 percent annually through 2030. McKinsey notes that, while this annual rate may appear small, it would result in a **35 percent increase in total GHG emissions in the United States by 2030**. Under this baseline scenario, GHG emissions would rise from 7.2 billion metric tons of CO<sub>2eq</sub> in 2005 to 9.7 billion metric tons in 2030.<sup>21</sup>

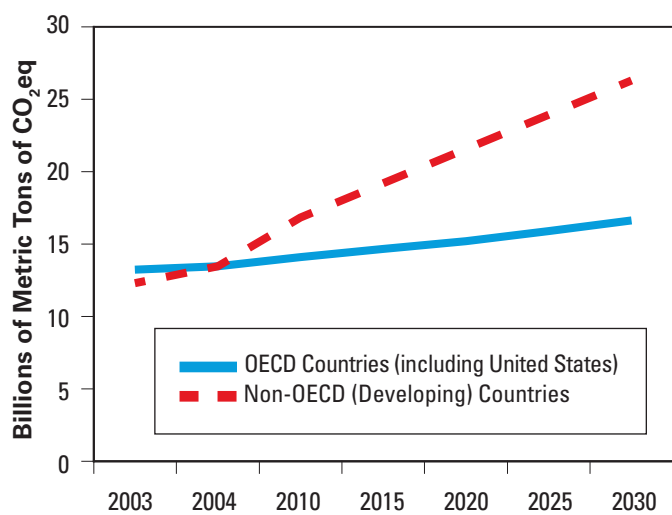
**Global Trends in GHG Emissions.** GHG emissions are increasing faster in developing countries than in the United States. China is rapidly approaching—and may have even surpassed—the United States as the world’s largest emitter of GHGs. Despite their rapid growth, per capita emissions in China and India are expected to remain a small fraction of the

United States’ level for the coming future: by 2025, China is expected to have a per capita rate that is only one-fourth, and India one-fourteenth, the level of America’s per capita emissions.<sup>22</sup> But even with these lower per-capita levels, total GHG emissions from developing (non-OECD) countries are projected to exceed those of developed (OECD) countries by a substantial margin by 2030.<sup>23</sup> (Figure 4)

### Reducing Carbon Absorption

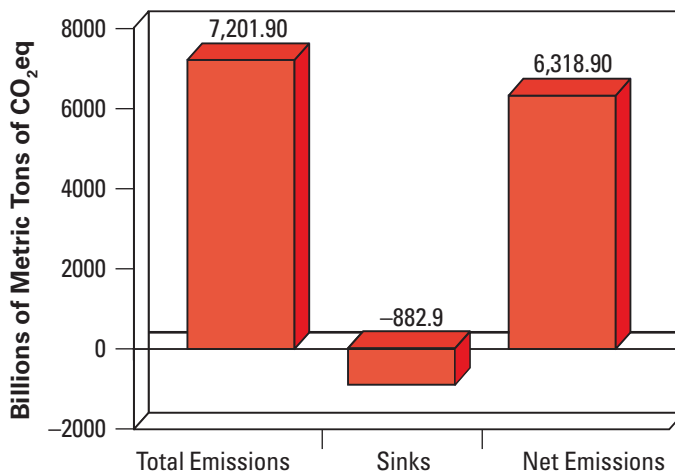
Human activities also affect the earth’s ability to absorb CO<sub>2</sub> from the atmosphere. Forests and grasslands are considered “carbon sinks” because they naturally absorb large quantities of CO<sub>2</sub> through the process of photosynthesis. Clearing these lands, which occurs when they are converted to agricultural use or development, reduces the absorption

**Figure 4. Total GHG Emissions Worldwide—2005 to 2030**



Source: USDOE, International Energy Outlook 2007.

**Figure 5. Net GHG Emissions in United States in 2006—Sources and Sinks**



Source: EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks (Feb. 2008).

<sup>21</sup> McKinsey Report, p. 6.

<sup>22</sup> Pew Center on Global Climate Change, “Climate Change 101: International Actions.”

<sup>23</sup> U.S. DOE, *International Energy Outlook 2008*, Fig. 77. The OECD is the Organization for Economic Cooperation and Development. Its members include the United States and other developed (higher-income) nations.