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Climate Change and Transportation

Summary of Key Information

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Preface

This summary of key findings covers a variety of studies on climate change and its ramifications for the transportation sector conducted by the National Research Council (NRC), the principal operating agency of the National Academy of Sciences, and the National Academy of Engineering; NRC's Transportation Research Board (TRB); and other organizations. The summary was prepared by Cynthia J. Burbank, Joyce A. Wenger, and Daniel Sperling, members of the TRB Special Task Force on Climate Change and Energy. The document includes references that identify the sources of findings from the studies cited in this summary. Any conclusions drawn from the studies are those of the authors and do not necessarily represent the views of the Special Task Force, TRB, or NRC.

Summary of Key Information

Emissions and levels of carbon dioxide and other greenhouse gases have been rising.

A 2010 report from the U.S. Environmental Protection Agency (EPA) spells out trends in greenhouse gas (GHG) emissions from human activity (*1*):

- United States: 14% increase in GHG from human sources since 1990;
- World: 26% increase in GHG from human sources since 1990; and
- GHG level in the atmosphere is at its highest in thousands of years.

GHG emissions linger in the atmosphere for many years, with the predominant GHG—carbon dioxide (CO_2)—ranging from 100 to 500 years (*2*). The greenhouse effect derives its name from the heat-trapping effects of greenhouses. On a global scale, infrared radiation is trapped in the atmosphere by the increase in CO_2 and other gases, leading to warming of the atmosphere. This is a natural process that is augmented by human activity, especially through the burning of fossil fuels.

"A strong, credible body of scientific evidence shows that climate change is occurring, is caused largely by human activities, and poses significant risks for a broad range of human and natural systems."

—National Research Council of the National Academies, Advancing the Science of Climate Change, America's Climate Choices, 2010

Global climate systems are already changing, largely as a consequence of human (anthropogenic) activity.

Reviews by the National Academy of Sciences and the scientific academies of more than 30 countries have concluded that anthropogenic global warming is occurring (*3*).

The growing evidence of climate change and its risks are summarized in the following statements (*1, 4-5*):

- The warmest decade on record worldwide was 2000 to 2009.
- Heat stored in oceans has increased substantially.
- Sea surface temperatures have been higher during the past three decades than at any other time since large-scale measurement began in the late 1800s.
- In recent years, a higher percentage of precipitation in the United States has come in the form of intense, single-day events.
- Eight of the top 10 years for extreme 1-day precipitation events in the United States have occurred since 1990.
- Six of the 10 most active hurricane seasons have occurred since the mid-1990s.
- Sea-level rise has accelerated to more than 1 inch per decade.

- Oceans have become more acidic over the past 20 years; rising acidity is associated with increased levels of CO_2 in the water and affects sensitive organisms such as corals.
- In 2009, arctic sea ice was 24% below its historical average from 1979 to 2000.
- Glaciers worldwide have lost more than 2,000 cubic miles of water since 1960.

Climate change presents many risks to humans, causing many scientific organizations to recommend significant reductions in GHG emissions by 2050.

Scientists are concerned that we are already "locked in" to a temperature increase of at least 2°C, and that beyond 2°C loom the most severe ecological and economic risks (*6*). Figure 1 (below) shows risks associated with increases in global temperature.

To hold temperatures below 2°C, climate scientists have identified the need for a reduction of 50% to 80% in GHG emissions below 1990 levels by 2050 (*8*). Because most GHG emissions accumulate in the atmosphere with a long life (100 to 500 years for CO_2), scientists also have emphasized the need for near-term actions to reduce the rate of GHG growth much sooner than 2050. Based on the scientific evidence, many developed countries and states in the United States have adopted targets of 50% to 80% reductions by 2050, along with nearer-term targets for 20% to 50% reductions (*9, 10*). These targets are, however, a rather broad band; accordingly, the National Academy of Sciences report *America's Climate Choices* recommends that climate goals and strategies be periodically updated in light of new information and understanding, emphasizing the importance of an "iterative risk management" framework for climate change (*11*).

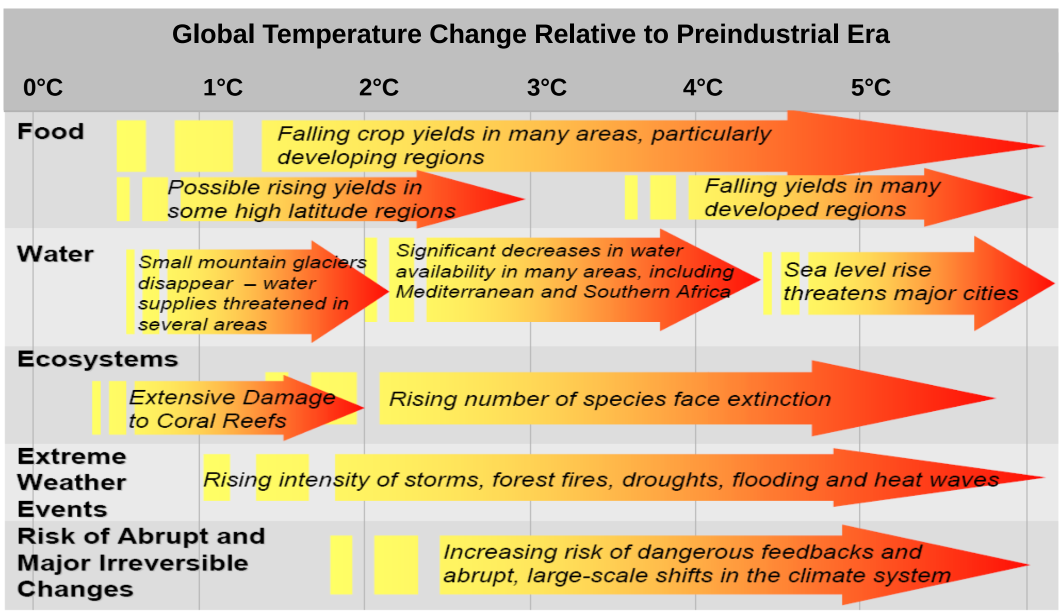

FIGURE 1 Risks associated with increases in global temperature (*7*).

Many private-sector companies; federal, state, and local governments; and the U.S. military are moving forward with plans to reduce GHG emissions and to adapt to a changing climate.

Concern over climate change risks has propelled a wide range of organizations to take steps to reduce GHG emissions and adapt to the effects of climate change.

Corporations

The U.S. Climate Action Partnership (CAP) includes 20 major corporations that have called on the federal government to "quickly enact strong national legislation to require significant reductions of greenhouse gas emissions" (*12*). These companies also have committed to steps to reduce carbon and energy consumption associated with their own operations. CAP includes mainstream businesses such as Alcoa, Chrysler, Dow Chemical, Duke Energy, DuPont, General Electric, Honeywell, Johnson & Johnson, PepsiCo, Shell, Siemens, and Weyerhauser. Other companies, such as Wal-Mart, are leveraging their suppliers and adopting other innovative approaches to reduce energy consumption and costs, which reduces GHG emissions.

U.S. Military

All branches of the military increasingly are concerned about the security threat from global, destabilizing climate change, as well as the vulnerability of their bases to climate change. They are developing strategies to reduce GHG and adapt to climate change, based on the awareness that "the Cold War was a specter, but climate change is inevitable … . The challenge is to stabilize things—to stabilize carbon in the atmosphere … . We have to act if we're going to avoid the worst effects" (*13*).

State and Local Governments

Twenty-three states have adopted GHG reduction targets (*14*); 35 states have developed climate action plans (*15*); 10 northeastern states are implementing a cap and trade program for electric utilities; and California is implementing an economywide cap and trade program that other states and Canadian provinces are expected to join. More than 500 mayors have signed the U.S. Conference of Mayors' Climate Protection Agreement. Many state and local governments are implementing transportation strategies to reduce GHG, such as S.B. 375, California's legislation on land use and transportation planning, and programs that provide electric vehicle infrastructure in Washington, Oregon, California, Tennessee, and mid-Atlantic states.

Federal Government

In 2010, with the support of the auto industry, EPA and the National Highway Traffic Safety Administration (NHTSA) finalized regulations to establish a 35.5-mpg standard for new light-duty vehicles by 2016. The following year, EPA and NHTSA proposed additional rules for a 54.5-mpg standard by 2025, and adopted additional GHG and fuel economy standards for medium and heavy-duty trucks. Federal agencies also are pursuing a wide range of climate

"Either you are at the table or you are on the menu. If transportation is absent from the climate change table, others will take the lead. They will not necessarily provide the balance between the transportation system's economic and environmental interests. Transportation solutions are not simply about engineering, but are about engaging to provide a reliable, responsible, and sustainable transportation system for the long term."

—Paula Hammond
Secretary, Washington State DOT, and Chair, American Association of State Highway and Transportation Officials

adaptation research and support, including FHWA's funding of five pilots for state departments of transportation (DOTs) and metropolitan planning organizations (MPOs) to apply a climate adaptation risk assessment model (16).

Nearly 30% of U.S. GHG emissions are from the transportation sector.

In the United States, transportation is the second largest source of GHG emissions, as shown in Figure 2 (page 5). Within transportation, light-duty vehicles represent almost 60% of GHG. Transportation emissions have been increasing, with freight transportation GHG expected to grow three times as fast as GHG from passenger vehicles from 2009 to 2035 (17).

GHG reductions may be achieved through various means from transportation.

According to a National Cooperative Highway Research Program report (*18*), strategies for transportation GHG reduction can be grouped into five areas.

Vehicles

Examples of vehicles and vehicle-related efforts include: more fuel-efficient conventional vehicles; electric vehicles drawing on low-carbon energy sources; hydrogen fuel cell vehicles; medium- and heavy-duty vehicle efficiency; more efficient truck and off-road diesel engines (including retrofits); light-duty vehicle feebate programs; energy-efficient and low-carbon transit buses; and more efficient aircraft, trains, and maritime vessels.

Fuels

The list of fuels and fuel standards is extensive and includes the following: biodiesel, sugarcane, and corn-based ethanol; low-carbon fuel standards; algae-based fuels; cellulosic fuels, including fuels from municipal waste; and electric power from low-carbon utility sources. Debate continues about the GHG content of different

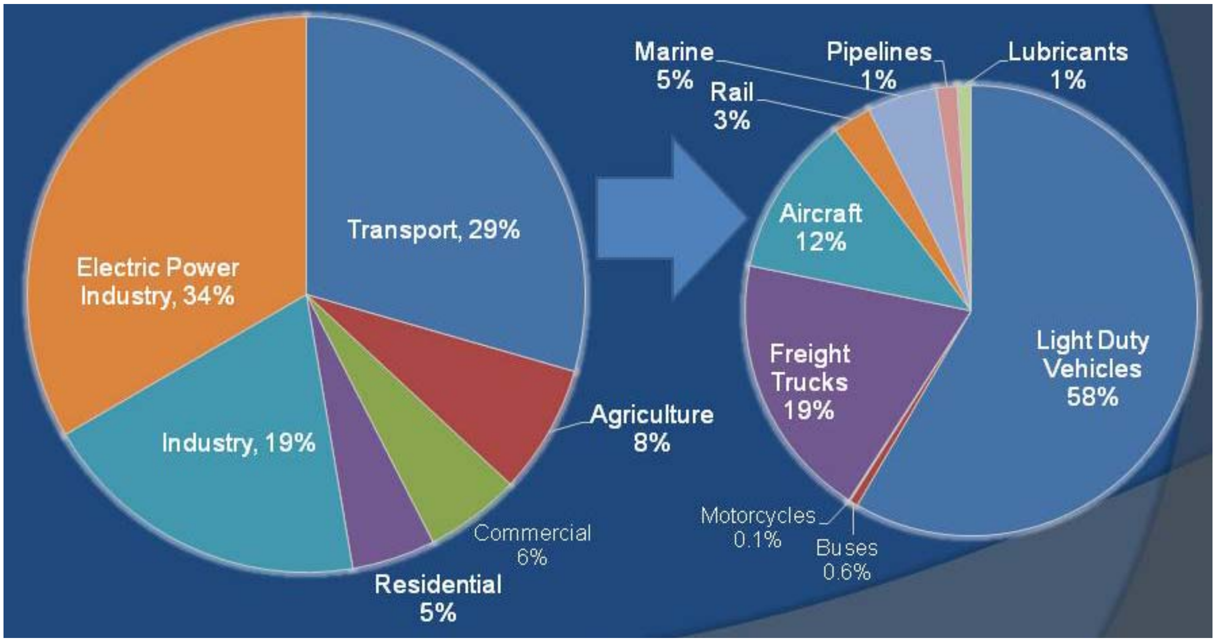

FIGURE 2 Transportation shares of GHG emissions in the United States. [Source: U.S. Department of Transportation, *Report to Congress*, 2010 (*17*).]

fuels, and variability occurs within different fuel types depending on specific production attributes. It is particularly important to consider life-cycle GHG for different fuels.

Vehicle Miles Traveled

The growth in vehicle miles traveled (VMT) can be reduced through a variety of measures, including: carbon fees; VMT-based user fees; congestion pricing; pay-as-you-drive auto insurance; parking pricing and parking supply management; compact land use policies and mixing of land uses; carpooling and vanpooling; telework programs; improvements and incentives for transit use, such as biking, walking, and trip-chaining; and optimizing freight use of rail and marine transportation.

Operational Efficiency

Operational efficiency encompasses speed enforcement and speed management; promoting energy-efficient driving practices, or ecodriving; synchronized traffic signalization; traveler information systems; better management of traffic work zones; anti-idling programs for trucks and light-duty vehicles; traffic roundabouts; and improved freight logistics, including urban freight consolidation centers.

Construction, Maintenance, and Agency Operations

Another strategy for transportation GHG reduction includes low-carbon pavements and paving practices; longer-life pavements; other low-carbon materials, including recycled materials; LED traffic lights and roadside lighting; retrofitting construction engines to minimize black carbon; energy-efficient construction practices; energy-efficient vehicle fleets; energy-efficient transportation facilities and administrative buildings; and solar- and wind-powered installations in highway rights-of-way.

Price signals and transportation pricing are powerful in reducing GHG.

Strong price signals can be powerful in reducing GHG, and transportation pricing can have a multipronged effect in achieving GHG reduction goals. Climate change studies have identified higher carbon or energy pricing as the most essential and most powerful strategy for reducing GHG emissions across all sectors (*7–8*).

Higher prices would internalize the costs associated with GHG emissions and would motivate households and businesses to effect both technological and behavioral change. However, studies suggest that, within the transportation sector, carbon pricing is not as powerful in reducing GHG as it is in other sectors. Nonetheless, the power of pricing was demonstrated in 2008 when gasoline prices spiked, leading to reduced driving and an increase in the purchases of fuel-efficient vehicles. A wide variety of transportation pricing options have the potential for reducing GHG and energy consumption: congestion pricing, cordon pricing, vehicle feebates, parking pricing, and pay-as-you-drive insurance, several of which are analyzed in TRB Special Report 307 (*19*). Moreover, these pricing strategies may amplify other GHG-reducing policies and could help mitigate congestion, reduce environmental impacts, and create revenue that is needed for maintaining transportation and developing low-carbon alternatives.

"A carbon pricing system is widely viewed as having the potential to affect emissions in the broadest and most economically efficient manner."

***—TRB Special Report 307: Policy Options for Reducing Energy Use and GHG Emissions from U.S. Transportation* (2011)**

Growth in travel could present a challenge to achieving GHG reduction targets.

If people travel more, higher VMT and higher GHG emissions are generated. VMT per capita are higher in the United States than in Europe and Canada, contributing to higher GHG emissions. However, VMT growth rates in the United States have been dropping steadily for several decades, with absolute declines in VMT since the economic downturn in 2007. VMT in the United States were lower in 2011 than in 2005 (*20*). Although economic conditions undoubtedly were a major factor, VMT analysts point to evidence that other factors have contributed to slower VMT growth, especially demographic shifts (*21*). If future per-capita VMT stays flat, total VMT in the United States still would grow at about 1% per year because of population growth, offsetting some of the technological improvements in vehicles and fuels. Recognizing the effect of VMT on GHG, the states of California and Washington both have established goals of reducing VMT per capita.

Alignment of transportation and land use planning may support the achievement of emissions reduction goals over the longer term.

Many studies have concluded that more compact land use can help reduce transportation GHG. A 2009 TRB study (*22*) provided an estimate for the middle scenario of land use change. This moderate scenario achieves 1% household transportation GHG reduction in 2030 and up to 2% reduction in 2050, based on assumptions that 25% of new and replacement housing units will be built in more compact developments and that residents of those developments will drive 12% less.

While the TRB study found the GHG reductions associated with land use policies were modest and faced many obstacles, the TRB panel concluded that there were other benefits and encouraged policies to support more compact, mixed-use development. In that vein, California is implementing a groundbreaking law, S.B. 375, to achieve GHG reductions through better land use and other strategies, using the MPO planning process. The state of California enacted a law that requires GHG reductions for passenger travel through improvements in land use, pricing, and transit. Metropolitan areas are required to reduce GHG emissions—mostly via VMT reductions—by 6% to 8% per capita by 2020 and 13% to 16% per capita by 2035. The TRB study also concluded that "combining density increases with transit investment, mixed uses, higher parking fees, and other measures … could provide the synergies necessary to yield significant reductions in VMT" (*22*).

Freight GHG is growing three times as fast as passenger GHG and may require special efforts.

Freight represents 25% of transportation GHG, and this share will grow substantially in the future (*17*). The U. S. Department of Energy projects that freight energy use (equivalent to GHG) will grow three times as fast as light-duty vehicle energy use from 2009 to 2035, with 47% growth for freight versus 15% for light-duty vehicles (*23*). Significant reductions in freight GHG are likely through new heavy-duty vehicle standards and technological and fuel improvements as well as retrofitting of heavy-duty truck engines to reduce black carbon and CO_2 emissions (*17*). But with expected growth in truck VMT, other strategies will be needed, requiring care to avoid adverse effects on the economy and U.S. competitiveness.

Climate adaptation will require significant changes for transportation.

As climate change intensifies, the risks and impacts will increase for transportation systems, facilities, and operations (*24*). Concerns in coastal states include rising sea levels, storm surges, and more intense tropical storms, but adaptation needs are not limited to coastal

FIGURE 3 SR-7 in Maury County, Tennessee, after intense rainfall and record-level flooding in May 2010.

areas. Already, many states are experiencing more intense precipitation with record-level flooding—as occurred in Tennessee (Figure 3, above), Rhode Island, Iowa, and Wisconsin in 2010, and during Tropical Storm Irene in 2011 in Vermont. Alaska is responding to the thawing permafrost that affects transportation structures and roadways. State DOTs, MPOs, and local transportation agencies are working with climate scientists to better understand the risk and to incorporate climate change into transportation asset management planning. Climate change adaption confronts all transportation modes and all functions: planning, environmental review, design, construction, operations, and maintenance (*24*).

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