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DRAFT FOR REVIEW

Compendium of Greenhouse Gas Control Strategies

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Executive Summary

There is scientific evidence that greenhouse gas (GHG) emissions deteriorate air quality, contribute to human health problems, and cause adverse changes to the earth's climate. The transportation sector is the second largest contributor to global GHG emissions. However, proactive approaches to addressing this complex issue will be a formidable task for entities across the U.S. and the world. Suitable, cost-effective climate mitigation solutions will likely need to come from a wide variety of places—from industry, other state and local agencies, and private citizens.

Changes in climate have significant implications for present lives, for future generations, and for ecosystems on which humanity depends. Consequently, climate change—and appropriate strategies to mitigate its effects—has been the subject of intensive scientific research and public debate. There is a strong need for providing policymakers with "best practice" strategies undertaken by federal, state, and local governments.

This paper has four primary objectives:

- **Explore credible current knowledge** regarding climate change, GHG emissions, and transportation's role in each;
- **Review policies and initiatives** based on five major approaches that federal, state, and local governments have taken to address GHG emissions;
- **Present effective GHG mitigation strategies and methodologies** learned from other states and localities, with a focus on current Texas Department of Transportation (TxDOT) programs and policies that could be enhanced or encouraged; and
- **Discuss potential directions in GHG mitigation** and how federal changes might affect Texas in the future.

This report accomplishes these objectives by first presenting an overview of the current state of knowledge concerning GHG emissions and transportations' role in contributing to GHG emissions. This report then discusses current policy and legislative developments in the area of GHG emissions. Texas Transportation Institute (TTI) researchers categorized GHG mitigation strategies into four major approaches: (1) fuel/technology standard and technology development, (2) transportation control measures, (3) fleet strategies, and (4) incentive/voluntary programs. This report provides additional examples of policy examples in appendices.

This report also provides an overview of political considerations that may challenge adoption of mitigation policies and offers an example of a methodology developed by TTI for the Houston-Galveston Area Council to quantify GHG relevant mitigation techniques. Finally, this paper presents common selection criteria used to select GHG mitigation strategies and offers future policy changes to consider in the months and years to come. Ultimately, this report can be a valuable resource for Texas agencies considering strategies they wish to consider as they evaluate how to do their share to help reduce the severity of climate change by reducing GHG emissions.

1. Climate Change: Current State of Knowledge

Since the days of the Industrial Revolution, human activities have substantially added to the amount of heat-trapping GHGs in the atmosphere. There is strong evidence that human activity contributed to the warming of the Earth over the last half-century. The size of future temperature increases and other aspects of climate change, especially at the regional scale, are still subject to uncertainty. Energy burned to run cars and trucks, heat homes and businesses, and power factories is responsible for about 80 percent of the carbon dioxide emissions in the U.S., about 25 percent of U.S. methane emissions, and about 20 percent of global nitrous oxide emissions. Increased agriculture, deforestation, landfills, industrial production, and mining also contribute a significant share of emissions. The U.S. emits about 25 percent of the total global GHGs.[1] This chapter provides a brief review on the current state of knowledge on the science behind climate change.

What is Climate Change?

Climate change refers to major changes in temperature, rainfall, snow, or wind patterns lasting for decades or longer. Climate change may result from:

- **Natural factors**, such as changes in the sun's energy or slow changes in the earth's orbit around the sun;
- **Natural processes** within the climate system (e.g., changes in ocean circulation); and
- **Human activities** that change the atmosphere's makeup (e.g., burning fossil fuels) and the land surface (e.g., cutting down forests, planting trees, building developments in cities and suburbs, etc.).

There is strong evidence to indicate that climate change has occurred on a wide range of different timescales from decades to many millions of years. Once a climate forcing mechanism has initiated a climate response, this climate change can lead to further changes. One example is in response to a warming, the amount of water vapor will usually increase, the extent of snow and ice will typically decrease, and properties of clouds change. Such changes can further modify the amount of energy absorbed from the sun, or the amount of energy emitted by the earth and its atmosphere, and lead to either a reduction or amplification of climate change.

Current understanding of the physics (and increasingly the chemistry and biology) of the climate system is represented in a mathematical form in climate models, which are used to simulate past climate and provide projections of possible future climate change. By applying established laws of fluid dynamics and thermodynamics, the more complex climate models simulate many important weather phenomena that determine the climate.[2]

What is the "Greenhouse" Effect?

The "greenhouse effect" is the heating of the earth due to the presence of GHGs. This effect is analogous to glass panes in a greenhouse, whereby heat enters but is trapped and limited in its ability to escape. GHGs cause a similar effect in earth's lower atmosphere. Shorter wavelength solar radiation passes through the "blanket" created by GHGs, causing the earth to warm. Energy that reaches the earth's surface from the sun reradiates back into space as longer wave infrared radiation. However, because some of the GHGs selectively transmit some of the infrared waves back into space while blocking others, earth's lower atmosphere traps the heat. As a result, GHG's absorb some infrared waves and reemit them back to the earth's surface, causing the lower atmosphere to heat up. Deforestation and the burning of fossil fuels such as coal and oil have caused the concentration of "greenhouse gases" to increase significantly in the atmosphere.[3]

Measurements from the surface, research aircraft and satellites, together with laboratory observations and calculations, show that, in addition to clouds, the two gases making the largest contribution to the greenhouse effect are water vapor and carbon dioxide (CO_2). In its annual GHG Emissions Inventory Report, the U.S. Environmental Protection Agency (EPA) identified six principal GHGs that trap heat in the atmosphere.[4]

- **Carbon Dioxide (CO_2)** is a colorless, odorless non-flammable gas and is one of the most important GHGs found in the earth's atmosphere. CO_2 enters the air through the burning of fossil fuels (such as oil, natural gas, and coal), solid waste, trees and wood products, along with other factors. CO_2 is also one of the leading GHGs that result from transportation-related activities.[5] According to the National Atmospheric and Oceanic Administration (NOAA), the U.S. produces about 25 percent of global CO_2 emissions from burning fossil fuels and without significant changes in current trends, CO_2 emissions could increase by nearly 50 percent by 2030 and 80 percent by 2050.[6]

- **Methane (CH_4)** is a colorless, odorless, flammable gas that remains in the atmosphere for 9-15 years and represents about 9 percent of total GHG emissions. CH_4 is over 20 times more effective in trapping heat in the atmosphere than CO_2.[7] Sources of CH_4 include landfills, natural gas and petroleum systems, agricultural activities, coal mining, wastewater treatment facilities, stationary and mobile combustion, and certain industrial processes. Over the past 250 years, the concentration of CH_4 in the atmosphere has increased by 148 percent.

- **Nitrous Oxide (N_2O)** is a colorless GHG that comprises about 5 percent of total GHG emissions. Burning fossil fuels and using certain fertilizers can contribute to GHG emissions. N_2O emissions have risen by more than 15 percent since 1750.

- **Fluorinated Gases,** such as Hydrofluorocarbons (HFCs), are synthetic, powerful GHGs emitted from a variety of industrial processes. Studies have shown that some HFCs trap heat in the atmosphere, thereby contributing to global warming.

- **Black Carbon:** While the EPA does not formally recognize "black carbon" as a GHG of interest, recent scientific studies have indicated that "soot" is the second leading global warming contributor to human-induced global warming. Black carbon is formed through the incomplete combustion of fossil fuels, biofuel, and biomass, and is emitted in both anthropogenic and naturally occurring soot. It consists of pure carbon in several linked forms. Black carbon warms the planet by absorbing heat in the atmosphere and by reducing albedo, the ability to reflect sunlight, when deposited on snow and ice. According to some estimates, black carbon may be responsible for as much as 18 percent of the planet's warming, making it the number two contributor to climate change after CO_2. [8] Globally, transportation accounts for 25 percent of all black carbon emissions, of which diesel engines account for approximately 70 percent.

What's Known

As with any field of scientific study, there are uncertainties associated with the science of climate change. Well-known physical laws and documented historical trends allow scientists to predict with virtual certainty some aspects of climate change. According to the EPA, scientists know with virtual certainty that:[9, 10]

- Human activities are changing the composition of Earth's atmosphere. Increasing levels of greenhouse gases such as CO_2 in the atmosphere since the 1700s are well documented and understood;
- The atmospheric buildup of CO_2 and other GHGs is largely the result of human activities such as the burning of fossil fuels;
- An "unequivocal" warming trend of about 1.0 to 1.7° Fahrenheit (F) occurred from 1906-2005. Warming occurred in both the Northern and Southern Hemispheres, and over the oceans;
- The major GHGs emitted by human activities remain in the atmosphere for periods ranging from decades to centuries. It is therefore virtually certain that atmospheric concentrations of GHGs will continue to rise over the next few decades; and
- Increasing GHG concentrations tend to warm the earth.

Generally, it is known that human activities—primarily the burning of fossil fuels—have increased the GHG content of the earth's atmosphere significantly over the past few centuries.[11]

What's Very Likely

The Intergovernmental Panel on Climate Change (IPCC) has stated that most of the observed increase in global average temperatures since the mid-20th century is likely due to the observed increase in human-caused GHG concentrations. In short, a growing number of scientific analyses indicate, but cannot prove, that rising levels of GHGs in the atmosphere are contributing to climate change. In the coming decades, scientists anticipate that as atmospheric concentrations of GHGs continue to rise, average global temperatures and sea levels will continue to rise as a result and precipitation patterns will change. Human activities have enhanced the natural greenhouse effect by adding GHGs to the atmosphere, and there is a greater than 90 percent chance that this is causing the earth's average temperature to increase. These additional GHGs are produced by burning fossil fuels such as coal, natural gas, and oil to power our cars, factories, power plants, homes, offices, and schools. Cutting down trees, generating waste, and farming also produce GHGs.[12]

What's Not Certain

Important scientific questions remain about how much warming will occur, how fast it will occur, and how it will affect the global climate system. Answering these questions will require advances in scientific knowledge in a number of areas:

- Improvements in understanding natural climatic variations, changes in the sun's energy, land-use changes, the warming or cooling effects of pollutant aerosols, and the impacts of changing humidity and cloud cover;
- Better determination of the role human activities play in contributing to climate change; and
- More precise projections of future greenhouse emissions and how the climate system will respond in the future.

2. Problem: Transportation and Climate Change

Transportation contributes over one-quarter of all GHG emissions in the U.S. GHG emissions have grown steadily over the past half-century and will likely continue to grow in the future. Growth in vehicle miles traveled (VMT) (particularly in urban areas) due in part to population growth has far outpaced improvements in vehicle fuel economy. Texas is certainly no exception—the state's population will likely double by 2050. This is problematic because climatologists predict that human health, agriculture, coastal property, and wildlife are all at risk from changes in climate. This chapter provides an overview of trends in transportation-related GHG emissions and likely long-term consequences if emissions reductions recommendations set forth by the IPCC are not met.

Transportation and Climate Change: Trends and Forecasts

Transportation activities accounted for 30 percent of all U.S. GHG emissions in 2008, second only to electricity generation. [13] Passenger cars contributed 35 percent of transportation GHGs, with light duty-trucks (which include sport utility vehicles, pick-up trucks, and minivans) contributing 29 percent. Freight trucks contributed 19 percent of total transportation GHGs. Transportation emissions have increased by 22 percent over the past 20 years because of increased travel demand and relative stagnation in fuel efficiency improvements for on-road mobile sources.

Overall, for 2007, transportation accounts for 30 percent of total CO_2 emissions in Texas. CO_2 emissions from the transportation-related activities sector increased from 152 million metric tons (MMT) of CO_2 in 1990 to 203 $MMTCO_2$ in 2007, a 33 percent increase. This is in contrast to a 27 percent increase in overall U.S. CO_2 emissions from transportation. As with the U.S., VMT in Texas has increased by as much as 8 percent each year since 1990, with double-digit increases seen in some urban areas. Texas is also experiencing above-average population growth with millions more people only adding to the increasing amounts of GHG emissions on Texas roadways in the future.

Vehicle Miles Traveled

Over the past 20 years, total VMT has also increased substantially. According to the Federal Highway Administration (FHWA), total annual VMT increased from 2.1 trillion in 1990 to nearly 3 trillion in 2005. The average annual increase in VMT was approximately 2.2 percent per year, outpacing population growth by 1.4 percent.[14] The U.S. Department of Energy (DOE) estimated that VMT would grow by 1.6 percent from 2008-2030.[15] At this rate, VMT would rise from 3 trillion in 2006 to approximately 4.5 trillion in 2030. VMT for light-duty vehicles is projected to rise from 2.7 trillion in 2006 to approximately 4 trillion by 2030. The DOE also predicts that while fuel efficiency will improve, growth in VMT will continue to grow and outpace these gains in efficiency. This implies that transportation-related GHG emissions will increase significantly between now and 2030.[16]

In major urban areas in Texas, VMT increased throughout the 1990s, particularly in the San Antonio, Austin, and Dallas regions.[17] Between 1992 and 2005, per capita VMT increased 19 percent in San Antonio, 16 percent in Austin, 14 percent in the Dallas/Ft. Worth area, and 6 percent in Houston. In recent years, both Houston and Dallas have developed light rail systems and have encouraged higher density development in the city. This, along with the employment of high-occupancy vehicle (HOV) lanes and higher gasoline prices, may have slowed the rate of growth of VMT.[18]

Vehicle Fuel Economy

Fuel economy among new vehicles sold in the U.S. declined from 1990-2004 due to the increasing market share of light-duty trucks (such as SUVs), which grew from about one-fifth of vehicle sales to little over one-half. Since 2004, however, increasing fuel prices have caused consumers to move increasingly toward more fuel-efficient vehicles. Over the next 20 years, the DOE predicts a gradual improvement in vehicle fuel economy. After accounting for new federal requirements imposed on corporate automotive manufacturers, the DOE predicts that incremental fuel improvement can be expected between now and 2030.[19] Ultimately, DOE projects that average fuel economy for all light-duty vehicles (including light-duty trucks) will increase from 19.9 miles per gallon (mpg) in 2005 to 27.9 mpg in 2030, a 30 percent increase. Average fuel efficiency for new light-duty vehicles will increase by 1.3 percent per year, rising from 25.9 mpg in 2005 to 36.6 mpg in 2030. Future policy changes in Corporate Average Fuel Efficiency (CAFE) standards could result in even greater improvements in fuel economy.

Population

Over the next 20 years, the state's population will likely increase significantly. According to the Texas State Demographer, Texas' population is projected to grow to close twice the U.S. rate, adding anywhere between 7 million and 17 million people by 2030.[20] The Texas State Demographer's Office predicts that the state will most likely grow by 11.2 million residents by 2030.[21] This growth in population will possibly contribute to more drivers, further driving up transportation-related GHG emissions in Texas.

Climate Change: Potential Consequences

Failing to curb GHG emissions growth could result in long-term economic and social consequences for Texas in the future. The IPCC recommends that the U.S. cut its transportation-related CO_2 emissions by at least 50 percent by 2050 from current emissions levels to avoid some of most severe consequences of climate change. Senior Energy Analyst Lew Fulton argues that transportation must play a significant role in achieving these deep cuts. "Even with deep cuts in emissions from all other energy-using sectors," Fulton argues, "transportation will need to reduce emissions significantly to stabilize atmospheric conditions of GHGs in the range of 450-550 parts per million of CO_2 equivalent by 2050."6 The EPA predicts several risks likely to health, agriculture, and coastal areas because of climate change: [22]

- **Health:** Longer, more intense and frequent heat waves may cause more heat-related death and illness. There is virtual certainty of declining air quality in cities since greater heat can also worsen air pollution such as ozone, or smog. Insect-borne illnesses are also likely to increase as many insect ranges expand. Health effects are especially serious for the very young, very old, or for those with heart and respiratory problems. Conversely, warmer winter temperatures may reduce the negative health impacts from cold weather.

- **Agriculture and Forestry:** The supply and cost of food may change as farmers and the food industry adapt to new climate patterns. A small amount of warming coupled with increasing CO_2 may benefit certain crops, plants and forests, although the impacts of vegetation also depend on the availability of water and nutrients. For warming of more than a few degrees, the effects can become increasingly negative, especially for vegetation near the warm end of its suitable range.

- **Water Resources:** In a warming climate, extreme events like floods and droughts are likely to become more frequent. More frequent floods and droughts will affect water quality and availability. For example, increases in drought in some areas may increase the frequency of water shortages and lead to more restrictions on water usage. An overall increase in precipitation may increase water availability in some regions, but also create greater flood potential.

- **Coasts:** Texas coastal residences may be impacted by sea level rise and an increase in storm intensity. Rising seas may contribute to enhanced coastal erosion, coastal flooding, loss of coastal wetlands, and increased risk of property loss from storm surges.

- **Energy:** Warmer temperatures may result in higher energy bills for air conditioning in the summer, and lower bills for heating in the winter. Energy is needed for irrigation, which will most likely increase due to climate change. Changing participation patterns will also impact hydropower (and the energy it produces).

- **Wildlife:** Warmer temperatures and precipitation changes will likely affect the habitats and migratory patterns of many types of wildlife. The range and distribution of many species will change, and some species that cannot move or adapt may face extinction.

- **Recreational opportunities:** Some outdoor activities may benefit from longer periods of warm weather. However, increased beach erosion, increased heat waves, decreased snowfall, retreating glaciers, reduced biodiversity, and changing wildlife habitats can compromise many other outdoor activities.

3. Approach 1: Vehicle and Fuel Standards and Technologies

Since vehicle emissions are such a large part of total GHG emissions, federal, state, and local government officials can design policies based on the belief that vehicle and fuel standards are an effective method toward reducing GHG emissions. Strategies consistent with this approach involve policies that mandate or incentivize vehicle or fuel improvements that lead to GHG emissions reductions. Technological vehicle improvements include low-rolling resistance tires, streamlining, tailpipe retrofits, and low-friction engine oil. Fuel technology improvements include bio-fuel development and the creation of an alternative fuel infrastructure. Low emissions vehicle standards pioneered in California restrict the sale of vehicles that do not meet minimum GHG emissions thresholds. Policies that prohibit the sale of high carbon fuels can be other such techniques for policymakers to reduce transportation-related GHG emissions. The following sections review vehicle and fuel standards and technology initiatives that reduce GHG emissions. Appendix A provides a list of potential GHG mitigation strategies that could be pursued at the state and local levels.

Vehicle Standards and Technologies

Vehicle climate change standards refer to public initiatives that address greenhouse gas emissions from transportation vehicles. Fuel economy standards currently pursued at the federal level serve as a way to curb GHG emissions. The Energy Independence and Security Act of 2007 act increased CAFE standards by boosting fleet-wide gas mileage requirements to 35 mpg by 2020.[23] In March 2009, the EPA established preliminary GHG emissions standards for light-duty vehicles. In 2010, EPA issued a rule requiring passenger cars and medium-duty passenger vehicles manufactured from 2012-2016 to meet an estimated combined average emissions level of 250 grams of CO_2 per mile, equivalent to 35.5 mpg. This requirement will cut GHG emissions by an estimated 960 MMT and 1.8 billion barrels of oil over the lifetime of the vehicles sold.[24] These broad-based federal level initiatives are likely to reduce transportation-related GHG emissions in the years to come.

During the past several years, California lawmakers have pursued several important climate policy actions. These initiatives not only reduced the state's GHG emissions but also spurred national and international efforts to counter global climate change.[25] In 2002, the California Legislature passed a law that requires reductions in GHG emissions from light-duty vehicles. The standard requires that new vehicles, on average, achieve an emissions reduction of 30 percent by 2016. California officials have also pursued Clean Cars/Vehicle Climate Change Standards for Light-Duty Vehicles. This program seeks to achieve the maximum feasible and cost-effective GHG emissions reductions by passenger vehicles and light-duty trucks. By 2020, this program will reduce GHG emissions by 30 MMT of CO_2 equivalent ($MMTCO_2E$). The California low emissions vehicle (LEV) II regulations of 2004 were adopted by 13 other states and were the basis for the national standard adopted in April 2010. California's new LEV III program includes regulations pertaining to criteria pollutants (applicable as of 2014) and the "Pavley" regulations for reduction of GHGs (applicable as of 2017).[26] The new vehicle technology standards will reduce GHG emissions from California passenger vehicles approximately 22 percent by 2012 and approximately 30 percent by 2016. The California Air Resources Board (CARB) is working in partnership with the EPA to ensure that California's post-2017 vehicle standards will be consistent with the coming federal standards.

Other states and cities have also proposed fuel and vehicle standard and technology initiatives to mitigate GHG emissions. Arizona is currently pursuing a State Clean Car Program. This program would reduce the net emissions of GHGs from passenger vehicle operations by opting into California vehicle standards. This program could remove more than 5 MMT of CO_2 by 2020. In Massachusetts, strict federal CAFE standards mean greater savings for travelers. As much as 3.0 $MMTCO_2E$ will be saved. Minnesota predicts that it could reduce GHG emissions by 1.16 $MMTCO_2E$ by adopting the California Clean Car Standards. This would cost approximately $39 for every ton of CO_2 removed. If adopted, North Carolina's State Clean Car Program plan calls for more stringent tailpipe GHG standards—at a cost of $38 per ton of CO_2.

Florida is proposing a strategy to improve the fuel economy of the light-duty vehicle fleet by reducing the rolling resistance of replacement tires without reducing tire lifetime. This initiative will likely reduce GHG emissions by 1.84 $MMTCO_2E$ by 2025 at a cost of $90 per ton of CO_2E removed. Arizona is considering low-rolling resistance tires to improve the fuel economy of the light-duty vehicle by setting minimum energy efficiency standards for low-rolling resistance replacement tires. This strategy will reduce GHG emissions by 0.8 $MMTCO_2E$ by 2020. Finally, Maryland is pursuing technologies reduce GHG emissions from both on-road vehicles and off-road engine vehicles through deploying technology designed to cut GHG emissions rates per unit of travel activity. This strategy will reduce GHG emissions by 0.8 $MMTCO_2E$ by 2020.

Miami-Dade County, FL is seeking to increase its fuel efficiency standard by adopting an increase in national gas mileage standards to 45 miles per gallon. The City of Hamden, CT is considering increasing the CAFE standards for cars to 40 mpg and SUVs to 27.5 mpg. This action will likely reduce GHG emissions by 76,401 tons of CO_2 E by 2015.

Fuel Standards and Technologies

Fuel standards and technologies refer to public strategies to mandate the use of low-carbon fuels or to develop alternative fuel technologies. The Renewable Fuel Standard (RFS) program, as required by the Energy Independence and Security Act of 2007, currently ensures that transportation fuel sold in the U.S. contains a minimum volume of renewable fuel. The new renewable fuel standards increase the volume of renewable fuel blended into transportation fuel to 36 billion gallons by 2022. In June 2011, the EPA released a proposed rule that might increase the total amount of renewable fuel required in the nation's motor fuel supply in 2012. For 2012, the agency is proposing 15.2 billion gallons of renewable fuel, about 9.2 percent of all fuel used in the U.S., and up from 13.95 billion gallons in 2011.[27]

Several states are also pursuing low carbon fuel standards. Iowa is seeking to reduce GHG emissions by decreasing the carbon intensity of vehicles fuels sold in Iowa. This strategy will reduce GHG emissions by 5.1 $MMTCO_2E$ by 2020 at a cost of $62 per ton of CO_2E removed. South Carolina is also seeking to reduce GHG emissions by decreasing the carbon intensity of all passenger vehicle fuels sold in the state. This strategy will reduce GHG emissions by 3.7 $MMTCO_2E$ by 2020 at a cost of $183 per ton of CO_2E removed. Montana is seeking to increase the use and market penetration of low-carbon fuels to offset traditional fossil fuels. This strategy will reduce GHG emissions by 0.04 $MMTCO_2E$ by 2020. North Carolina is seeking to offset fossil fuel use (gasoline) with production and use of starch-based and cellulosic ethanol. This strategy will reduce 0.04 $MMTCO_2E$ by 2020. The City of Austin, TX is developing infrastructure for fueling stations and electric plugs. The City of Seattle, WA is examining the use of smaller, more fuel-efficient vehicles as taxicabs and offering incentives to taxicab owners to use gas-electric hybrid vehicles.

4. Approach 2: Transportation Control Strategies

Federal, state, and local officials can create policies based on the premise that reducing VMT and reducing fuel use leads to GHG emissions reductions. Strategies and policies consistent with this belief seek as their primary goal to reduce GHG emissions by limiting the use of fuel or modes through price or other mechanisms. Examples of strategies consistent with this approach include the promotion of transit and commuter choice programs, idling reduction, and transportation management systems. This section reviews federal, state, and locally enacted or proposed strategies for GHG mitigation through reducing VMT or maximizing transportation system efficiency.

Smart Growth/Efficient Land Use Patterns

In an effort to reduce public over-reliance on personal motor vehicles, the U.S. Department of Transportation (USDOT) is currently in the process seeking to reduce GHG emissions by incorporating "livability" concepts into its multi-year transportation planning agenda. By incorporating livability concepts into transportation planning, USDOT predicts that non-motorized improvements, including construction of highly-connected pedestrian and bicycle transportation networks through dedicated rights-of-way, have potential for reducing GHG emissions. These measures would reduce GHGs by 0.2-to-0.6 percent by 2030, at moderate investment costs (less than $200 per ton of CO_2E emissions reduced), or a net savings when reduced vehicle operating costs are considered. President Obama has also sought to push "livability" concepts into metropolitan planning processes by initiating a collaborative effort between the Department of Housing and Urban Development (HUD), USDOT, and the EPA to help foster planning for more "livability." One of the main goals for this interagency agreement includes promoting "a wide variety of transportation options… in order to reduce GHG emissions." [28]

Arizona is seeking GHG reductions by facilitating fewer vehicle trips and total VMT. This strategy will reduce GHG emissions by 4 $MMTCO_2E$ by 2020. The City of Camden, CT is examining the possibility of promotion urban infill and denser, mixed-use development built to a human scale, with an emphasis on walkability and a more humane architecture.

Transit, Rail, and Park-and-Ride Development

Arkansas is proposing a new program that will improve existing transit service and expansion of transit routes that can shift passenger transportation from single-occupant vehicles to public transit. This strategy will reduce GHG emissions by 7,000 tons of CO_2E by 2025. Maryland is pursuing enhanced connectivity of non-automobile transportation modes between cities through infrastructure and technology investments. This strategy will reduce GHG emissions by 300,000 tons of CO_2E by 2025. Minnesota is seeking to expand infrastructure and programs to increase transit ridership, carpooling, bicycling, and walking. This strategy will reduce GHG emissions by 300,000 tons of CO_2E by 2025. Iowa is seeking to achieve an annual ridership increase of 100% by the year 2020. This strategy will reduce GHG emissions by 206,000 tons of CO_2E by 2020. Arkansas is encouraging the reduction of transportation sector GHG emissions when transporting students to schools, colleges, and universities. This strategy will reduce GHG emissions by 13,000 tons of CO_2E by 2020. Iowa is reducing VMT associated with commuters traveling to and from work. This strategy will reduce GHG emissions by 13,000 tons of CO_2E by 2020.

The City of Pittsburgh, PA is introducing new transit management programs, such as encouraging rideshare programs and telecommuting. The City of Alameda, CA is seeking to develop transit-oriented streets. These streets will provide transit and shuttles with signal priority lanes and queue jumpers to make transit a more attractive alternative to the automobile. The City of San Rafael, CA is considering providing transit and car pool incentives to city employees, including alternate work schedules and telecommuting opportunities to all its employees. This strategy will reduce GHG emissions by 155 tons of CO_2E by 2013. Evanston, IL is seeking to encourage businesses to adopt strong employee commuting and telecommuting programs, providing resources and incentives to reduce the number of single-occupancy vehicle (SOV) commuters. The city is also seeking to support car-share programs by expanding designated parking for car-share vehicles, high-density neighborhoods, at new developments, and along transit lines. This strategy will reduce GHG emissions by 6,684 tons of CO_2E by 2020.

Transportation System Improvement and Other Strategies

Minnesota lawmakers are seeking to create a seamless multimodal system to serve all modes, improve traffic flow, and decrease vehicle idling and congestion. This strategy will reduce GHG emissions by 100,000 metric tons of CO_2E by 2020. New Jersey is seeking to manage and operate the transportation system to help transportation networks meet demand in an effective and efficient manner. South Carolina is seeking to improve vehicle flow on the roadway system to reduce fuel use and GHG emissions. This strategy will reduce GHG emissions by 100,000 metric tons of CO_2E by 2020.

States are also pursuing other GHG mitigation strategies. Virginia is seeking to make new or upgraded roads more pedestrian and bike friendly. Wisconsin is considering a strict enforcement policy of the existing 65 mph speed limit, support for a study of potential future speed limit reductions, and support and recognition for voluntary measures. Virginia is considering a program to evaluate the costs/benefits of a commuter tax credit, offering businesses tax savings for providing their employees with transportation benefits that provide an alternative to SOV commuting. North Carolina is considering an initiative to vary motor vehicle registration fees by vehicle emissions to provide a surcharge on higher emitting vehicles. The City of Worcester, MA is seeking ways to increase employee carpooling and offer employee telecommuting. This strategy will reduce GHG emissions by 2.2 $MMTCO_2E$ at a cost of $117 per ton of CO_2E removed. The City of Evanston, IL is implementing traffic calming and speed reduction strategies reducing unnecessary stops and starts. Finally, the City of Seattle, WA is looking to implement a 10 percent commercial parking tax to be phased in over three years.

Finally, Texas could enhance existing programs to reduce GHG emissions through controlling VMT. For example, TxDOT is currently pursuing a shuttle van program that provides trips between office buildings at their Austin office location. The service might operate on a schedule for people who want to go to other office buildings for meetings or they may set up the system on a reservation basis. Expanding this program could help mitigate GHG emissions by reducing total drivers on the roadway.

5. Approach 3: Fleet Emission Reduction Strategies

Federal, state, and local officials can create policies based on the belief that reducing off-road and fleet vehicles leads to reductions in GHG emissions. Business or government agencies, rather than families or individuals, tend to own these vehicles. Policies designed to reduce fleet emissions typically target trucking companies, distributors, and governments. However, they can be beneficial on a smaller scale when applied to other transportation actions in large organizations. While these strategies are less prevalent, they can often serve as an incentive for government to "set an example" for the public.

Fleet Vehicle Incentives

Several federal policy initiatives will impose stricter measures on large and heavy-duty trucks. In 2011, the Obama administration issued a final rule that sets the first GHG emissions and fuel economy standards for medium and heavy-duty trucks. The rule, which is applicable to vehicles in model years 2014 through 2018, sets separate standards for large highway combination tractors that typically pull trailers; heavy-duty pick-up trucks and vans; "vocational" trucks, such as garbage, cement, and utility vehicles; and buses. These standards will reduce CO_2 emissions by about 270 MMT and save 530 million barrels of oil over the lives of the vehicles produced within the program's first five years.[29]

States have also pursued strategies through fleet vehicle incentives. Alaska is encouraging public and private on-road diesel fleets to participate in the EPA SmartWay Transport Partnership. This program is an innovative collaboration between EPA and the freight sector designed to improve transport energy efficiency, reduce GHG and air pollutant emissions, and improve energy security. This strategy will reduce GHG emissions by 50,000 tons of CO_2E at a cost of $56 per ton of CO_2E removed. Arkansas is seeking to enact state and local agencies' procurement policies joining the EPA's Smart Way Program resulting in lower-emitting vehicle fleets. Arizona is pursuing a program to reduce GHG black carbon emissions from heavy-duty diesel vehicles by replacement and retirement of the highest-emitting diesel vehicles. This strategy will reduce GHG emissions by 300,000 tons of CO_2E by 2020. Iowa policymakers are considering a plan to reduce GHG emissions by improving incentives to trucking companies that improve the fuel economy of their fleet. New Mexico and Georgia are pursuing a strategy to reduce their fleet emissions by offering support for truck rest stops and bus terminals to install auxiliary power units. This ensures that the truck or bus does not run at night.[30]

Cities are also seeking initiatives to reduce their GHG emissions. Durham, NC is encouraging the use of higher fuel efficiency vehicles, especially hybrids, or use of alternative fuel such as biodiesel and ethanol. San Francisco, CA is seeking to purchase alternative fueled vehicles in municipal operations and downsizing the city fleet. Aspen, CO is attempting to create a city policy that sets a minimum fuel-efficiency for each class/type of vehicle purchased, requiring the use of low or no CO_2E technologies in all city vehicles, and maintain vehicles according to EPA's "Best Environmental Practices for Fleet Maintenance."[31] Hamden, CT is seeking to replace diesel buses with hybrid buses, an option that could reduce GHG emissions by 420 tons of CO_2E. Evanston, IL is considering several GHG mitigation alternatives for its fleet: (1) consider stricter vehicle maintenance standards; (2) ensure that the vehicle purchased "fits" the size of the job that is intended; (3) pool city vehicles as opposed to assigning vehicles to various departments and divisions to improve efficiency and reduce the size of the fleet; and (4) investigate the feasibility of using car-share vehicles to reduce the size of the city's fleet.

Private companies are also pursuing several initiatives to reduce fleet wide GHG emissions. In 2011, Wal-Mart announced plans to perform tests on two different types of hybrid options to improve vehicle efficiency and remove GHG emissions. The first option is an innovative hybrid model that provides electrical and mechanical propulsion. At low speeds, the electric motor kicks in. After the truck is moving, the electric motor and the mechanical side both work together until they reach optimum speed. The energy from braking is also used within this hybrid system. The second system has an idle reduction function and a special hybrid transmission. The company plans on testing this option in the Washington D.C. area, Houston, southern California, and in Atlanta.[32]

Other Programs

North Carolina is seeking to reduce diesel emissions from older diesel engines and emissions systems through its “Retrofit and/or Retirement Program.” This program will result in a 2.2 million reduction of $MMTCO_2E$ by 2020. Nevada is incorporating incremental fleet conversion requirement—25% of public transit fleets must include clean-fueled buses by year 2015, 50% by year 2020, and 90% by 2025). The City of Los Angeles, CA is planning to fuel 85% of its city fleet through alternative fuels. This strategy will reduce 10,700 metric tons of CO_2E by 2020.

Policymakers could enhance several successful fleet wide programs already pursued in Texas for greater reductions in GHG emissions. The Texas Emissions Reduction Program (TERP) provides financial incentives to eligible individuals, businesses, or local governments to reduce emissions from polluting vehicles and equipment but only in counties generally in Texas’ largest urban areas. The Texas Clean Fleet Program (TCFP) offers grants to replace heavy-duty and light-duty on-road diesel vehicles with alternative and hybrid vehicles. In fiscal year 2010, TxDOT’s fleet of approximately 2,321 alternative fuel vehicles helped reduce gasoline consumption by 302,000 gallons. Of those 2,321 vehicles, 918 run on propane and 130 are hybrid. TxDOT also has almost 1,229 flex fuel vehicles, which run on either gasoline or ethanol. Some of the department's diesel-powered vehicles can utilize biodiesel. Continuing this program could lead to even greater GHG emissions reductions.[33]

6. Approach 4: Incentive and Voluntary Programs

Federal, state, and local officials can create policies based on the belief that incentives and voluntary strategies are viable solutions to reduce GHG emissions. Many who believe that most GHG standards and requirements are unlikely to achieve emissions reduction goals see merit in this approach. Incentive programs include passenger vehicle incentives and outreach programs directed at educating the public about effective GHG mitigation techniques. Federal, state, and local programs can encourage the purchase of more fuel-efficient vehicles or discourage the purchase of inefficient ones.

Passenger Vehicle Purchase Incentives

There are several strategies pursued by some states to encourage less driving. Arizona is pursuing a combination of public education and information and financial incentives to promote the sales of light-duty vehicles with a hybrid gasoline engine. Maine is imposing a fee on purchases of relatively high-emitting (more CO_2 per mile) vehicles and purchasers of low emitters would receive a rebate. This strategy will reduce 20,000 metric tons of CO_2E by 2020. New York is pursuing a vehicle sales tax incentive credit. This strategy will reduce 5,000 metric tons of CO_2E by 2020. Virginia is pursuing enacting state incentives for the purchase of fuel-efficient vehicles, regardless of energy source. This strategy will reduce 4 $MMTCO_2E$ by 2020.

Education and Outreach Programs

Several states and municipalities have also pursued GHG education and outreach programs aimed at educating and convincing travelers to make efforts to reduce emissions associated with their travel. Texas has the longest running statewide program, "Drive Clean Across Texas." This program encourages Texans to reduce emissions by maintaining vehicles according to manufacturer recommendations, driving less and combining trips, buying "cleaner" vehicles, driving within the speed limit, and not idling. Fort Worth also has an active outreach and education program that explains steps people can take to perform proper maintenance, conserve energy, and reduce emissions.[34] Houston's "commute solutions" educational program encourages carpooling, vanpooling, and other ridesharing options.[35] In 2011, the Massachusetts DOT launched a new campaign with tips and advice to help drivers save money on fuel, improve fuel economy by up to 33 percent, and help reduce CO_2 and other GHG emissions. The state's website includes tips on driving less, driving slower, avoiding fast stops and starts, avoiding idling, and maintaining appropriate tire pressure.[36] The North Carolina DOT is currently pursuing a "Drive Green, Save Green" campaign. This campaign serves as a way to inform drivers how to reduce CO_2 emissions and save money.[37] The City of Denver, CO is pursuing the first internet-based vehicular GHG management system. This program will empower organizations to reduce CO_2 emissions, increase vehicle mpg, and lower fuel costs.[38]

All of these outreach and education programs encourage drivers to take actions that will reduce emissions associated with their travel. Since the results and benefits of these programs derive from implementation through other programs or types of actions (e.g., purchasing low-emitting vehicles), it is difficult to estimate the effect of outreach and education programs.

7. Policy Implementation: Methodologies and Best Practices

Implementing public GHG mitigation policies can sometimes be costly and face significant political challenges. However, some state and local agencies have succeeded in evaluating and adopting GHG mitigation initiatives. This section presents criteria used most often by state advisory committees and explores elements of successful GHG mitigation strategies. Promising mitigation techniques and a quantification methodology developed by TTI for the Houston-Galveston Area Council (HGAC) could serve as a valuable resource for future GHG policy implementation.

Selection Criteria

Selection criterion most frequently employed by agencies and planning committees for mitigating GHG emissions include:

- **GHG Mitigation:** The primary selection criterion for most agencies and stakeholders is the amount of GHG that a given strategy will potentially remove, usually expressed in units of $MMTCO_2E$.

- **Cost-Effectiveness.** Cost-effectiveness of proposed strategies is usually expressed as the net cost (or cost savings) per metric ton of GHG reduced (dollars/$MTCO_2E$). Some of the plans simply list strategies as being cost-effective or not (without specifying the cost per ton), and/or have not calculated the cost-effectiveness for every proposed strategy.

- **Feasibility Issues.** These generally include technical, economic, political, and/or institutional issues that may either enable or impede the implementation of a strategy.

- **Potential Co-Benefits.** The most common co-benefits include a strategy's potential contribution to cost savings, energy savings, reduction of criteria pollutant emissions, improved mobility, and economic development opportunities.

- **Timelines of Costs and Benefits.** Besides considering whether a given strategy will help to reach emissions reductions goals over a specified time, some planning agencies require that the costs and benefits of the strategy are incurred within a specified time period, such as for the duration of confirmed funding.

See Appendix B for more information on selection criteria used for state GHG mitigation strategies.

Elements of Successful GHG Strategies

Not all GHG mitigation strategies are created equal. Some GHG mitigation strategies have proven more successful at both reducing GHG emissions in concert with other goals. Successful GHG emissions initiatives worthy of consideration include:

- **Strategies with broadest reach.** Strategies such as fuel economy improvement mandates yield the greatest reductions in GHG emissions by reaching the most travelers, VMT, or high emissions rate activity. Conversely, because they affect the largest number of people, such strategies can take time to fully implement and sometimes be costly.

- **Strategies with Vehicle and Technology Standards.** National strategies, such as federal CAFE and emissions standards affect the largest number of vehicles and are not dependent on individual travel behavior. Since they do not depend on traveler behavior, they are almost certain to be implemented over time. Future state-level actions pertaining to vehicle technology may lie primarily in fuel infrastructure development.

- **Strategies Implemented over Broad Geographic Area.** Truck idling policies, 60 mph speed limits, transportation pricing, and other fuel conservation programs are more effective when implemented over a multi-state region. Approaches that involve partnerships with other states have also proven effective at reducing GHG emissions.

Lessons Learned and Promising Mitigation Techniques

These are some general "lessons learned" regarding the selection and implementation of GHG mitigation strategies in the transportation and land use areas. The following outlines these lessons:

- **Focus on GHG Mitigation Strategies with Popular Co-Benefits.** A heavy focus on climate change and GHG-specific goals can be a hard sell politically in Texas; it can be more productive to focus on the co-benefits of GHG mitigation strategies. Reducing GHG emissions also reduces other criteria pollutants (and vice versa); states and local areas that need to find strategies for further reducing ozone under the new EPA standards will also realize GHG benefits, since many of the strategies work for both objectives. Improving energy efficiency, whether for buildings or vehicles, often saves money in the long run in addition to reducing emissions. Of course, demonstrating costs savings and convenience benefits are often well received.

- **Develop GHG Strategies that Complement Other State and Local Goals.** Working in the context of other state and local goals can help identify "no regrets" strategies that will bring benefits beyond emissions reduction. Long-standing support for sustainable communities in Florida is expected to ease the way for GHG-reducing land use strategies in Florida's Climate Change plan. Incentive programs in the Phoenix area such as HOV access for certain types of hybrid vehicles and a Nissan-sponsored promotion of the Nissan Leaf plug-in electric vehicle (including establishment of residential and commercial re-charging stations) are a good fit with a growing statewide interest in alternate fuels. Denver, CO is one of several rapidly-growing cities in which transit (including a planned light and commuter rail expansion) will play a significant role in maintaining mobility for its residents—the city's bus and rail accounted for 99 million trips in 2009.

- **Support Multi-State Policy Collaboration.** Collaborating with other states/areas on strategies could be more effective and potentially more cost-effective on a larger scale, such as truck idling policies and speed limits. For example, Arizona is a state that, as with Texas, does not at this time plan to participate in the cap-and-trade strategy that is the cornerstone of the Western Climate Initiative (WCI). Arizona policymakers recognize that complementary policies to guidelines established by the WCI will result in greater total GHG reductions.

- **Encourage Vehicle and Fuel Technology Research and Development.** While vehicle and fuel technologies will possibly have the largest long-range effect on GHG emission levels, the development of cleaner technologies and energy sources is still in its early stages and is evolving rapidly; several of today's fuel and vehicle technologies will possibly become obsolete in a few years. Rather than investing large amounts of funding in a particular fuel or vehicle technology now, it may be better to focus on policies that facilitate continued research and development of technologies, promote efficient use and conservation of existing resources, and lay the groundwork for long-term sustainability in land use, transportation, and energy production.

- **Provide Education and Incentives.** Targeted groups for implementation need to understand and be encouraged to embrace and implement the selected strategies. This is especially true of voluntary programs. Education helps potential participants learn about and understand the reasons and benefits associated with a program and outreach encourages participation. Incentives can convince potential participants that the total benefits warrant whatever cost or efforts are required.

Quantifying GHG Mitigation Strategies: A Texas Case Study

In 2011, researchers at TTI provided the HGAC with an approach and methodology to address the issue of GHG emissions and mitigation for on-road mobile sources. The research team made a final set of recommendations of GHG mitigation strategies for analysis based on considerations of:

1) HGAC's interest in the strategy;
2) whether the GHG impacts of the strategies were scientifically quantifiable; and
3) whether the strategies could potentially achieve a reasonable magnitude of GHG reductions.

After consultation with HGAC staff, nine strategies were selected for final inclusion in the analysis tool. (See Appendix C for more information on GHG Quantification methodology) These strategies include:

- Implementation of anti-idling policy;
- Idle reduction for long-haul trucks;
- Vehicle fleet electrification;
- Transit facilities;
- HOV facilities;
- Mixed-use developments;
- Highway capacity addition;
- Retiming of traffic signals; and
- Bicycle facilities.

TTI researchers developed a generic analysis tool to analyze the GHG reductions due to various strategies. This tool can be further refined and customized to fit specific projects, regions, or corridors. Some of the assumptions made in quantifying the GHG reductions may also be refined using local data or improved estimation methods. For example, the estimation for the HOV strategy currently does not incorporate the issue of re-distribution of vehicles (i.e., existing HOVs that may use HOV lanes), which could potentially result in over-estimation of emissions reductions. Further local information, even at the project level, regarding average trip lengths, existing truck idling durations, truck stop utilization rates, etc., would greatly enhance this analysis.

As the issue of GHG emissions and climate change are emerging as being of great importance to the transportation sector, the findings from this project will help agencies such as HGAC take a scientific approach to the evaluation and implementation of GHG control strategies. The analysis tool developed can set the stage for more sophisticated methodologies and tools to benefit other agencies in Texas who are exploring the area of control strategies for mobile-source GHG emissions.

8. Future Directions in Climate Change Policy

Federal and state transportation-related GHG emissions are increasing rapidly and climatologists around the world are warning government leaders to act quickly. Furthermore, VMT and population in Texas will outpace national levels by as much as 5 percent annually. This could mean that Texas could be a prime target for new federally mandated GHG regulations. In addition, recent moves by federal officials could change how state transportation agencies will be required to address climate change in the future. Federal "livability" strategic initiatives could result in new planning requirements that state and local transportation officials will need to consider. The following provides significant legislative acts and initiatives that could influence Texas transportation in the future.

EPA/CAFE Standards and Regulations

Regardless of what happens on the legislative front, the Supreme Court has ruled that the Clean Air Act requires the EPA to regulate GHG emissions. Sensing potential economic consequences that might result from future vehicle emissions regulation, Texas officials have challenged EPA's endangerment finding. However, many legal experts predict that Texas will be unsuccessful in its effort. Therefore, Texas transportation officials should be aware of the potential results this ruling may have on transportation planning and funding. This finding will require EPA to: 1) take action to prevent harm before it occurs; and 2) consider the limitations and difficulties inherent in information on public health and welfare.

In terms of transportation, this means that EPA will have the authority to regulate GHG emissions from new motor vehicles. However, the endangerment finding does not cover other transportation-related sources of GHG emissions, such as emissions from aircraft and other non-road mobile sources. EPA will have limited discretion over the development of these standards for new vehicles in these sectors. This finding also could trigger compliance requirements for vehicle manufacturers and import restrictions as well. This could mean a reduction in overall transportation-related GHG emissions for Texas and could accelerate declining motor fuels tax revenues due to increasing fuel efficiency standards.[39] Furthermore, EPA and USDOT are beginning to tighten fuel efficiency standards for passenger vehicles and have released stringent new fuel efficiency requirements for model year 2012 through 2016 vehicles. President Obama has recently directed the EPA and USDOT to work together to develop even more stringent regulations for model years 2017 and beyond. That could further affect state fuel tax revenues.

Livability Initiative

President Obama has pushed for federal policies that encourage states and local communities to embrace "smart growth" land use strategies aimed at encouraging compact development and reducing automobile trave. In June 2009, HUD, USDOT, and EPA joined to form the Partnership for Sustainable Communities. This partnership will be in charge of coordinating federal housing, transportation and environmental investments, protecting public health and the environment, promoting equitable development, and helping to address the challenges of climate change. With an increasing share of transportation funding being aimed toward "livability" initiatives, Texas transportation officials would benefit from examining ways to reduce GHG emissions through promotion of "livability" initiatives. Coordination and adaptation will be important toward addressing these initiatives for the future. Recently, *New York Transportation Journal* author Paul Larroussee argued that while federal officials "should promote and allow flexibility with state and local officials in the use of its funds," local governments will "better position themselves" if they show more willingness to adopt and incorporate livability initiates in their planning process. Larrousse further argued that once USDOT puts a comprehensive approach toward transportation and land use in place, states that quickly adapt to and incorporate these "livability" initiatives will benefit most.[40]

9. Conclusion and Looking Forward

Climate change will affect different regions, ecosystems, and sectors of the economy in many ways, depending not only on the sensitivity of those systems to climate change, but also on their institutional willingness and ability to adapt to risks and changing conditions. While questions on the exact causes of climate change remain, the rate of warming observed in recent decades leaves little doubt that human activities are changing the composition of earth's atmosphere. For this reason, human-caused climate change represents a serious challenge—one that could require new approaches and ways of thinking to ensure the continued health, welfare, and productivity of society and the natural environment in the future.[41] Texas faces serious economic, social, and health consequences in the years ahead from changes in climate patterns. According to the Texas Climate Initiative:[42]

- temperatures *will rise;*
- heat waves will occur *more frequently*;
- there will be *less rain* west of the Interstate 35 corridor;
- severe weather will *become more frequent,* in-stream flows *will fall*;
- biodiversity *will declin*e, and
- the sea level *will rise*, affecting coastal areas with inundation or occasional flooding as much as 10 miles inland.

This report provides an extensive reference for GHG emissions reduction strategies that are being considered or pursued by state and local governments around the country. Appendix A explores mobile source strategies considered at the state and local levels. This appendix lists strategy descriptions, expected GHG reduction benefits, and where available, total cost savings pursued by other states. Appendix B provides selection criteria used by select states to prioritize GHG mitigation strategies. Cost effectiveness, feasibility, potential co-benefits, and timeliness of costs and benefits are all important realities that Texas policymakers face every day—how other states approach strategy selection could prove to be a key component for successful implementation. Finally, Appendix C explores nine strategies determined by HGAC to be most effective for quantifying emissions impacts of GHG reduction strategies.

The objective of this report is to concisely explore current knowledge on GHG emissions, review policies and initiatives for mitigation strategies, and discuss potential new directions in GHG mitigation. The goal of this report is to equip Texas policymakers with relevant, useful knowledge when deciding which GHG mitigation technique to pursue in the future. The value of the report is to inform TxDOT and other Texas agencies what other agencies are considering or already pursuing to help address the impacts of GHG and the resulting climate change. These attributes may help Texas agencies consider strategies they may wish to consider as they evaluate how to do their share to help reduce the severity of climate change by reducing GHG emissions.

Appendix A. Mobile Source Strategies for GHG Mitigation

The strategies listed on the following pages are organized in tables by category (list below shows titles and page numbers). Information about each strategy is taken from a state or local plan and includes (as available) a brief description of the strategy, expected GHG reduction benefits (listed in tons for local areas and in millions of tons for states), cost or savings per ton of GHGs removed, and the name of the state or local area in which the strategy has been proposed or adopted. In most cases, the wording of the strategy name and description are shown as they appeared in the state or local plan; in some cases, wording has been altered for clarity. Strategies from city and county GHG plans are shown in the tables in italics to distinguish them from state-level strategies.

Vehicle Standards and Technologies

Table 1. Vehicle Climate Change Standards.

Program	Description	GHG Reduction (Ton CO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
State Clean Car Program	Reduce the net emissions of GHGs from passenger vehicle operation by opting into California vehicle standards.	0.3M (2010)	5.6M (2020)	-$90	Arizona
Clean Cars/ Vehicle Climate Change Standards (Light-Duty Vehicles)	Develop and adopt regulations that achieve the maximum feasible and cost-effective reduction of climate change emissions emitted by passenger vehicles and light duty trucks	1M (2010)	30M (2020)		California
Clean Cars	Ensure that automakers reduce GHG emissions from new automobiles.				Colorado
Adopt California Low Emission Vehicle	Low emission vehicle (LEV) requirement and the advanced technology vehicle program	0.04M (2010)	0.47M (2020)		Connecticut
Tailpipe GHG Standards	The state's LEV II regulation will need to be amended to include the new motor vehicle GHG standards.	0.05M (2010)	2.63M (2020)	-$136 (2010)	Connecticut
Federal Fuel Economy Standard	*Support the increase of the Corporate Average Fuel Economy (CAFÉ) standards for cars to 40 mpg and SUVs to 27.5 mpg*	*76,401 (2015)*			*(City of Hamden, CT)*
New Vehicle Standards for Increased Fuel Economy and Reduced Greenhouse Gas Emissions	Promotes the development of a state clean car program		0.8M	-$60	Iowa
Implement Tailpipe GHG Emissions Standards	Adopt California GHG tailpipe standards for passenger vehicles	0.14M (2010)	0.93M (2020)	-$48	Maine
Adopt Advanced Technology Component (Formerly ZEV) of LEV II Standards	Adopt Advanced Technology component of California LEV II Standards	0 (2010)	0.05 (2020)	$0	Maine

Vehicle Efficiency	Large savings anticipated through the effects of stricter federal Corporate Average Fuel Economy (CAFE) standards	3.0M[a] (2020)			Massachusetts
Adopt California Clean Car Standards	Reduces GHG emissions from new motor vehicles	0.74M (2015)	1.16M (2025)	–$39	Minnesota
Light-Duty Vehicle Clean Car Standards	Reduce GHG emissions from new light-duty vehicles	0.00M (2010)	0.95M (2020)	–$100	Montana
Heavy-Duty Vehicle Emissions Standards and Retrofit Incentives	Approach to diesel engine emission reductions include vehicle scrappage and replacement, repowering (engine replacement), and retrofit with exhaust after-treatment devices	0.00M (2010)	0.02M (2020)	$79	Montana
Tailpipe GHG Standards	Adopt the State Clean Car Program to reduce emissions of GHGs from vehicle operation.	0M (2010)	8.1M (2020)	–38	North Carolina
Adopt California Low Emission Vehicle (CALEV) Standards	Adopt California Low-Emission Vehicle (CALEV) standards, including the tailpipe GHG emissions standards	0.00M (2012)	0.89M (2025)		New Hampshire
Support Stricter Corporate Average Fuel Economy Standards	Support more stringent, near-term Corporate Average Fuel Economy (CAFE) standards for all passenger vehicles and light trucks up to 10,000 lbs. gross vehicle weight rating	0.09M – 0.27M (2012)	1.13M – 2.37M (2025)		New Hampshire
Support Fuel Economy Standards for Heavy-Duty Vehicles	Support fuel economy standards for all new vehicles greater than 8,500 lbs. gross vehicle weight rating (GVWR) to achieve greater CO2 reductions from future vehicles	0.22M (2012)	0.94M (2020)		New Hampshire
Support Strong Climate Action at the Federal Level	Include increased vehicle fuel economy standards, appliance energy efficiency standards, investment in regional transportation networks and a national cap and trade mechanism for GHG				New Hampshire
State Clean Car Program	Adopt the State Clean Car Program in order to reduce GHG emissions from new light-duty vehicles	0.4M (2012)	1.9M (2020)	-$117	New Mexico
Monitor the Status of California Motor Vehicle Emissions Standards for Greenhouse Gases	The proposed California GHG emissions standards are nearly twice as effective in reduce GHG emissions as the new federal energy bill Corporate Average Fuel Economy (CAFE) standards alone.				Nevada
GHG Tailpipe Standards (or GHG-based Feebates)	In both the short and long terms, vehicle GHG emissions rate improvements are a crucial complement to VMT reduction measures. New York will need to look to short-term solutions such as vehicle maintenance, medium-term solutions such as GHG tailpipe standards or GHG-based feebates, and long-term solutions, such as R&D on fuel-cell vehicles.	0.200M (2010)	2.59M (2020)	-$77 - $143	New York

Adopt Low Emission Vehicle (LEV II) Standards	The LEV II program establishes emission standards for all new cars sold in California or any state that adopts the program.		0.24M (2025)	Cost-effective	Oregon
Adopt Greenhouse Gas Tailpipe Emission Standards	Achieve the maximum feasible and cost effective reduction of GHG from motor vehicles by adopting California Pavley standards.		> 6.0M	Cost-effective	Oregon
Pennsylvania Clean Vehicles (PCV) Program, and Federal Vehicle GHG Emissions and CAFE Standards	Realize the emission reductions associated with California's GHG-certified vehicles through the existing requirement that new vehicles have CARB certification		12.3M (2020)		Pennsylvania
Adopt South Carolina Clean Car Standards	Reduce GHG emissions from new light-duty vehicles sold by adopting legislation to require a reduction in GHG emissions from new cars and light trucks sold in the state.	0.21M (2012)	1.14M (2020)	–$46 - $227	South Carolina
Clean Car Program	New vehicles sold in Utah by each manufacturer would need to, on average, be 30 percent more efficient by 2016.				Utah
Evaluate and Implement a Low Carbon Fuel Standard	Evaluate and implement a low carbon fuel standard (LCFS) that would yield 10 percent less carbon intensive motor fuel by 2020.				Washington
Zero Emission Vehicle (ZEV) Standard	ZEV requirements mandate that a particular number of vehicles that produce no air emissions are delivered and sold in a state.				Washington
Adopt California Vehicle Emission Standards	The California emissions standard would require greater GHG emission reductions for on-road passenger vehicles and light trucks sold in Wisconsin.		2.6M (2020)		Wisconsin
Increase Fuel Efficiency Standard	*Promote an increase in national gas mileage standards to 45 mpg*				*(Miami-Dade County, FL)*

[a]*benefit combined with promotion of fuel-efficient driving practices (listed in Incentive/Voluntary programs).*

Table 2. Low-Rolling Resistance Tires.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Low Rolling Resistance Tires	Improve the fuel economy of the light-duty vehicle by setting minimum energy efficiency standards for replacement tires of low rolling resistance	0M (2010)	0.8M (2020)		Arizona
Low Rolling Resistance Tires and Tire Pressure Program	Includes minimum fuel efficiency standards for replacement tires and a consumer information/education program.	Part of "Other New Light Duty Vehicle Technology" in Table 3.			California
Low Rolling Resistance Tires and Other Add-On Technologies	Improve the fuel economy of the light duty vehicle (LDV) fleet by reducing the rolling resistance of replacement tires without reducing tire lifetime	0.8M (2017)	1.84M (2025)	-$90	Florida
Fuel Efficient Replacement Tires Program	Improve the fuel economy of the LDV fleet by setting minimum energy efficiency standards for replacement tires and requiring that greater information be provided about low-rolling resistance replacement tires	0.0M (2010)	0.03M (2020)	–$90	Montana
Low-Rolling Resistance Tires	Improve the fuel economy of the light duty vehicle (LDV) fleet by setting minimum energy efficiency standards for replacement tires and requiring that greater information be provided about Low-Rolling Resistance replacement tires	0.5M (2012)	0.6M (2020)	-$92	New Mexico
Low Rolling Resistance Tires		0.003M (2010)	0.017M (2020)	-$338 – -$260	New York
Adopt state standards for high efficiency tires	Fuel efficiency is directly related to rolling resistance (RR). The greater the RR, the more fuel is burned.		0.12M (2025)	Cost-effective	Oregon
Low-Rolling-Resistance Tires	Improve fuel efficiency in all vehicles, typically at relatively low cost		0.68M (2020)	-$310	Pennsylvania

Table 3. Other Emission-Reducing Vehicle Technologies.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Study the Feasibility of Plug-In Vehicles	Study a set of actions regarding evaluating the benefits and feasibility of plug-in hybrid electric vehicles and accelerating the deployment of a commercially viable technology	(2015)	(2025)		Arkansas
Heavy-Duty Vehicle Emission Reduction Measures	Reduce emissions with improved aerodynamics, engine-based improved efficiency, vehicle weight reduction, and rolling/inertia resistance improvements	0M (2010)	3M (2020)		California
Other New Light Duty Vehicle Technology	Reduce climate change emissions from new motor vehicles; includes low rolling resistance tires, low-friction engine oil, and window glazing.	0M (2010)	4M (2020)		California
Transportation Technologies	Reduce GHG emissions from both on-road vehicles and off-road engine vehicles through deploying technology designed to cut GHG emission rates per unit of travel activity	0.40M (2012)	0.44M (2020)	-$200 - $1,500	Maryland
Advanced Vehicle Technology	Expand the development and use of more efficient vehicle design and/or hybrid propulsion systems	0.01M (2015)	0.03M (2025)	$1,458	Michigan
Install Retrofits to Address Black Carbon Emissions	Install retrofit technologies on diesel trucks with a model year of 2006 and older, or retire diesel trucks and replace them with new technology and cleaner operating engines for the purpose of reducing black carbon particulate matter	0.07M – 0.23M (2012)	0.4M – 1.30M (2020)		New Hampshire
Low Friction Engine Oil		0.003M (2010)	0.005M (2020)	$19	New York
Advanced Technology Vehicle RD&D	Research and development on fuel-cell vehicles	0.274M (2010)	0.314M (2020)	$76	New York
Advanced Technology Incentives	Fuel cells, plug-in hybrid, low-weight carbon-fiber bodies, and other technologies will require research, development, and commercialization				North Carolina
Diesel Engine Emission Reductions and Fuel Efficiency Improvements	Promote a variety of technology practices that provide greater efficiency in diesel fuel use	0.03M (2012)	0.19M (2020)	–$114	South Carolina
Clean Diesel and Black Carbon	Accelerate use of ultra-low sulfur diesel engine improvements, tailpipe control technology	0.8M (2010)	2.4M (2020)	$6 - 13	Connecticut

Clean Diesel Technologies to Reduce Black Carbon	Accelerate the use of lower sulfur diesel and provide incentives to accelerate adoption of engine improvements and tailpipe control technology to reduce emissions of black carbon	0.38M (2010)	0.74M (2020)	$14	Maine
Promote Low-Carbon Fuels and Vehicle Technologies	Reduce GHG emissions through improved fuel efficiency through variable valve timing, cylinder deactivation, efficient transmissions, as well as hybrid drives and natural gas and cleaner diesel fuels				Utah
Plug-in Hybrids	Research into plug-in hybrid vehicles; included in the policy "Alternative Fuels and Infrastructure"				Vermont
Vehicle Electrification	Plug-In Hybrid Electric Vehicles (PHEVs) and Electric Vehicles (EVs) could displace petroleum with electricity, with significant potential to reduce GHG emissions and expenditures on oil imports				Washington
Facilitate Use of Electric Cars	*City of Philadelphia will seek state legislation making the use of electric cars legal on Pennsylvania state highways (which includes many streets within the city).*				*(City of Philadelphia, PA)*

Table 4. Off-Road Engines and Vehicles GHG Emissions Reductions.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Off-Road Engines and Vehicles GHG Emissions Reductions	Emissions from off-road engines can be reduced by adoption of GHG emissions standards and through retrofit technologies.				Montana
Off-road Equipment GHG Reductions	Voluntary and mandatory emission reduction measures to reduce GHG emissions from off-road sources		1.6M (2020)		Wisconsin

Fuel Standards and Technologies.

Table 5. Low Carbon Fuels Standards and Requirements.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Standards for Alternative Fuels	Develop and enforce standards for ethanol, biodiesel, and other alternative fuels				Arizona
Alternative Fuels: Biodiesel Blends	Develop regulations to require the use of 1 to 4 percent biodiesel displacement of California diesel fuel	<1M (2010)	<1M (2020)		California
Alternative Fuels: Ethanol	Use E-85 without any equipment modifications	<1M (2010)	3.2M (2020)		California
Fuel Strategies: Low-Carbon Fuel Standard	Reduce GHG emissions by decreasing the carbon intensity of vehicles fuels sold in Iowa	0.60M (2012)	5.11M (2020)	-$62	Iowa
Low Carbon Fuels Standard	Create a low carbon fuel standard based on California's proposal, requiring a 10 percent reduction in the carbon content of all passenger vehicle fuels sold in Illinois.		5.2M – 5.7M (2020)		Illinois
Set a Low-GHG Fuel Standard	Require minimum low-GHG fuel content in all fuel sold in the state	0.064M (2010)	0.64M (2020)	$34	Maine
Low-GHG Fuel Standard	Adopt a low-GHG fuel standard (LGFS), create a market-based program to reduce the GHG emissions from transportation fuels, and diversify transport fuel options for consumers	1.7M (2015)	3.6M (2025)		Minnesota
Adopt a Low-Carbon Fuel Standard	establish an emission standard measured in CO2-equivalent mass per unit of fuel energy sold	0.16M (2012)	1.78M (2020)		New Hampshire
Requiring Low-Carbon Fuels in the Transportation Sector	Reduce GHG emissions and increase cost-effectiveness of a low-carbon fuel standard (LCFS) that would reduce carbon intensity by 10% by 2020		4.53M (2020)	$171	New Jersey
Low-GHG Fuel Standard	Reduce GHG emissions by decreasing the carbon intensity of all passenger vehicle fuels sold in the state	0.38M (2012)	3.67M (2020)	$1 – $183	South Carolina
Low Carbon Fuel Standard	The LCFS seeks to reduce life-cycle carbon emissions from transportation fuels.		4.0 M – 4.3M (2020)		Wisconsin

Alternative and Clean Fuels Strategy	• *Evaluate impact of biodiesel on County fleet/customer fleets, and make decision on feasibility of biodiesel use* • *Work with stakeholders to expand existing clean fuel requirements and supply, and to develop a City and community strategy to respond to "peak oil" concerns about reduced oil production worldwide, projected rising energy costs and national energy security issues*				*(City of Albuquerque, NM)*
Emission Standards	*Implement tougher emission standards on all vehicles*				*(City of Durham, NC)*
Increase Fuel Efficiency and Use of Biofuels	• *Increase fuel efficiency and the use of biofuels by commercial fleets through a "Smart Fleets" educational outreach program* • *Increase the use of biodiesel blend from 20 percent biodiesel (B20) to as much as 40 percent (B40)* • *Transit all of non-pursuit vehicles to efficient gas-electric hybrids* • *Examine the use of smaller, more fuel efficient vehicles as taxicabs and offering incentives to taxicab owners to use gas-electric hybrid vehicles*				*(City of Seattle, WA)*

Table 6. Alternative Fuels Infrastructure, Incentives, and Promotion.

Program	Description	GHG Reduction ($MMtCO_2e$)		Cost Savings per Ton GHG Removed ($\$/tCO_2e$)	State (*Local*)
		(Year1)	(Year2)		
Biodiesel Implementation	Increase market penetration of biodiesel fuel	0.1M (2010)	1.1M (2020)	$0	Arizona
Advanced Biofuels Development and Expansion	Encourage state and national fuel industries for advanced biofuel producing fewer GHG emissions	0.88M (2015)	2.54M (2025)	-$108	Arkansas
Hydrogen Highway	Statewide effort to diversify the sources of transportation energy through the development of hydrogen fuel stations along major highways				California
Green Fleet Policy	*Electric & Plug-In Hybrid Vehicle Recharging Stations*	*7,000 (2012-2015)*			*(City of Menlo Park, CA)*
Develop and Expand Low-GHG Fuels	Reduce GHG emissions by decreasing the carbon intensity of vehicle fuels sold in Florida	6.20M (2017)	12.62M (2025)	–$142	Florida
Low-GHG Fuel Infrastructure	Expand infrastructure for compressed natural gas, propane, and other low GHG fuels	0.0004M (2010)	0.002M (2020)	$1,482	Maine
Promote Low-Carbon Fuel Use in Transportation	Promote low-carbon transportation fuels through a package of incentives, education, and standards, including recommendations by the Michigan Renewable Fuels Commission (RFC)	2.6M (2015)	5.9M (2025)	$16	Michigan
Low Carbon Fuels	Increase the use and market penetration of low carbon fuels to offset traditional fossil fuels	0.00M (2010)	0.04M (2020)		Montana
Biofuels Bundle	Offset fossil fuel use (gasoline) with production and use of starch-based and cellulosic ethanol	1.9M (2010)	4.5M (2020)		North Carolina
Promote Alternative Fuel and Advanced Technology Vehicles and Supporting Infrastructure	Promote development and deployment of alternative fuel vehicles, advanced technology vehicles, and associated fueling and powering infrastructure in order to speed market penetration of such vehicles and reduce transportation related greenhouse gas emissions				New Hampshire
Alternative Fuels Use	Expand the availability and use of alternative fuels and expand the use of hybrid vehicles, low speed vehicles, and zero emission vehicles for transportation in New Mexico	0.4M (2012)	1.7M (2020)	-$13	New Mexico
Incentives for Ethanol Fuels	Ethanol contains oxygen and helps regular gasoline burn cleaner, more efficiently, and helps to reduce tailpipe carbon monoxide emissions by as much as 39% - 46%				Nevada

Incentives for Biodiesel Fuels	Biodiesel is a cleaner burning diesel replacement fuel made from natural, renewable sources such as new and used vegetable oils, animal fats, and algae. Biodiesel reduces almost all of the major exhaust pollutants.				Nevada
Biodiesel in State Fleets	New York creates a State biofuels program for the production and use of renewable, low-GHG biofuels.	0.007M (2010)	0.010M (2020)	$200	New York
B-2 by 2010 B-20 by 2020	New York creates a State biofuels program for the production and use of renewable, low-GHG biofuels.	0.065M (2010)	0.355M (2020)	$200	New York
Ethanol	New York creates a State biofuels program for the production and use of renewable, low-GHG biofuels.	0.046M (2010)	0.185M (2020)	$34 - $68	New York
Promote biofuel use and production	Recommended biofuels include biodiesel and ethanol that reduce GHG emissions		1.0M (2025)	Cost-effective	Oregon
Alternative Fuel	*Increase the use of biodiesel as alternative fuel for a diesel*				*(City of Portland, OR)*
Diesel Engine Emission Reductions and Fuel Efficiency Improvements	Promote practices that provide alternatives to diesel fuel use, e.g. biodiesel.	0.05M (2012)	0.38M (2020)	-$15 --$164	South Carolina
Alternative-Fuel Infrastructure	Increase market penetration of alternative fuels in South Carolina through accelerated development of an alternative-fuel infrastructure	0.02M (2012)	0.24M (2020)	$70	South Carolina
Promote Low-Carbon Fuels and Vehicle Technologies	Reduce GHG emissions through improved fuel efficiency through variable valve timing, cylinder deactivation, efficient transmissions, as well as hybrid drives and natural gas and cleaner diesel fuels				Utah
Increase use of Alternative Fuels	Promote and support siting of refueling and recharging stations for low-carbon fueling stations				Virginia
Alternative Fuels and Infrastructure	Seeks to increase market penetration of low-carbon fuels in Vermont via a low-carbon fuel standard	0.12M (2012)	0.42M (2020)		Vermont
E85 Infrastructure Development & Pricing Incentives	Legislation (1) supporting the further development of Wisconsin's E85 infrastructure to provide satisfactory availability; and (2) creating retail E85 pricing incentives to make E85 competitive with regular gasoline on a MPG-adjusted basis.				Wisconsin
Alternative Fuels	*Increase the use of alternative fuels*	*0.68M*			*(City of Chicago, IL)*
Fuel Infrastructure	*Develop infrastructure for fueling stations and electric plugs*				*(City of Austin, TX)*
Alternative Fuel Program	• *Maximize the use of clean transportation fuels* • *Seek local and federal support to expand the use of alternative fuels and clean energy technologies*				*(King County, WA)*

Table 7. Alternative Fuels Research and Development.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Alternative Fuels Research and Development	Support research and development of alternative transportation fuels that are feasible in the Alaska climate				Alaska
Research and Development of Renewable Transportation Fuels	Support R&D of renewable transportation fuels in order to increase the capacity of the state university system to develop and produce such fuels cost-effectively				Arkansas
Hydrogen Infrastructure Research and Development Program	Assess potential barriers to development of a hydrogen infrastructure and identify the implications for Connecticut transportation infrastructure and businesses				Connecticut
Biofuel development and In-State Production Incentive Act	Analyze the costs and GHG emission reductions associated with expanded use of biofuel in the transportation sector		3.47M (2020)	-$26	Pennsylvania
Prepare for Peak Oil	*Conduct a study of the potential effects of peak oil on the community and develop a peak oil adaptation plan.*				*(City of Albany, CA)*
Transportation Fuels and Technologies	*Research, evaluate and report to the Executive and Council on best practices, innovations, trends and developments in transportation fuels and technologies*				*(King County, WA)*

Transportation Control Measures: Reducing Vehicle Miles Traveled and Increasing Efficiency

Table 8. Transit, Rail, and Park-and-Ride Infrastructure, Facilities, and Technologies.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Improve and Expand Transit Service and Infrastructure	Improve existing transit service and expansion of transit routes that can shift passenger transportation from single-occupant vehicles to public transit	0.001M (2015)	0.007M (2025)	$1,479	Arkansas
Expand & Improve Transit Infrastructure	Achieve an annual ridership increase of 100% by the year 2020, to be measured on a per capita basis	0.004M (2012)	0.026M (2020)	+$57	Iowa
Support Passenger Rail Service In Iowa	Reduce single occupant vehicle travel by establishing and promoting a statewide passenger rail system in Iowa to supplement existing long-distance service		0.008M (2020)	+$597	Iowa
Passenger and freight rail upgrades	1) Fully fund and implement passenger rail upgrades and service restoration throughout the state 2) fully fund and implement the CREATE freight rail improvement program		0.13M (2020)		Illinois
High Speed Rail	*Intercity high-speed passenger rail plan*				*(City of Chicago, IL)*
Intercity Travel: Aviation, Rail, Bus and Freight	Enhance connectivity of non-automobile transportation modes between cities through infrastructure and technology investments	0.2M (2012)	0.3M (2020)		Maryland
Expand Transit, Bicycle, and Pedestrian Infrastructure	Expand infrastructure and programs to increase transit ridership, carpooling, bicycling, and walking	0.1M (2015)	0.3M (2025)	$0	Minnesota
Maintain and Expand Passenger Rail Service	Maintain and expand passenger rail service within New Hampshire as part of a balanced, state-wide, multi-modal transportation system that keeps the state competitive with and accessible to the region	0.00M (2012)	0.05M (2025)		New Hampshire
Expand Park-and-Ride Infrastructure	Expand and improve park-and-ride infrastructure to support public bus transit and carpooling	0.03M (2012)	0.04M (2025)		New Hampshire
Sustainable Transportation Mode Choices	• *Increase multi-modal trail infrastructure throughout the City to connect people from where they live to services and work through walking, bicycling, etc* • *Lobby policy makers to make changes in transportation policy to support the development of state-wide multi-modal transportation infrastructure in areas less susceptible to significant climate impacts*				*(City of Keene, NH)*

Improvements to Freight Railroads and Intercity Passenger Railroads	Rail emissions are 2 to 4 times less than for the same trip or service by car or truck				Washington
Transit Improvement	*Improve transit corridor and reliability*				*(City of Seattle, WA)*
Park-and-ride lots	*Develop park-and-ride lots and expand ridesharing opportunities in large-scale developments at major transportation access nodes*				*(City of Alameda, CA)*
Improve Mass Transit Infrastructure.	*Bus stops and bus lanes should be convenient and efficient. Bus stops should be clearly marked. Consider possibilities for increasing service, more effective hours, and serving currently unserved arterials*				*(City of Arcata, CA)*
New Fare Card Technologies	*Smart-card technology for SEPTA transit system to improve ease and convenience of use.*				*(City of Philadelphia, PA)*
Service Improvements	*Real-time transit information available via Google Transit and on SEPTA website, subway stop identification system, cleaner transit stops.*				*(City of Philadelphia, PA)*
Invest in Current Transit Infrastructure	*Repair and renovate existing SEPTA stations and depots; re-open an abandoned subway stop to restore service. Plans for expanded service are also recommended.*				*(City of Philadelphia, PA)*
Park and Ride Stations	*Create park and ride stations at critical locations throughout the City*				*(City of Charleston, SC)*

Table 9. Expanding Transit Service.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Transit, Ridesharing, and Commuter Choice Programs	Provide the leadership and resources necessary to help expand Alaska's public transit and ridesharing system	0.002M (2015)	0.005M (2025)	$651	Alaska
Transit, Smart Growth, and VMT Reduction Package	Increasing accessibility and low GHG travel choices in Connecticut, such as transit (rail and bus), vanpools, walking, and biking	0.22M (2010)	0.49M (2020)	$280	Connecticut
Shuttle Buses for "Magic Mile"	*A shuttle bus service to make it possible for shoppers to go easily from store to store without getting in their cars*				*(City of Hamden, CT)*
Implement smart growth initiatives and expansion of mass transit	Expansion of mass transit in Northeastern Illinois and in urban centers across the state, 2) Implementation of planning policies to facilitate smart growth and restrain urban sprawl		0.26M – 0.39M (2020)		Illinois
Transit	*Increase Public transit*	*0.83M (2020)*			*(City of Chicago, IL)*
Environmental Study for High Speed Train between Las Vegas and Anaheim	Encourage and support the continued development and ultimate completion and operation of a high speed train between Southern California and Las Vegas				Nevada
Improve Existing Local/Intra-Regional Transit (Bus) Service	Improve local bus service within New Hampshire on existing routes by providing more frequent service, better passenger amenities and facilities, and increased marketing to expand ridership	0.01M (2012)	0.11M (2020)		New Hampshire
Expand Local/Intra-Regional Transit (Bus) Service	Expand the service areas of existing local and intra-regional transit (bus) systems and create new systems				New Hampshire
Improve Existing Inter-City Bus Service	Improve the quality of facilities and increase the frequency of service on current inter-city bus routes in New Hampshire to increase ridership levels and reduce vehicle-related carbon emissions	0.01M (2012)	0.02M (2020)		New Hampshire
Implement a Stable Funding Stream to Support Public Transportation	Identify and implement a stable funding stream to support significant expansion of public transportation				New Hampshire

Doubling transit ridership and enhancing greenhouse commuting programs	Improvement and expansion of existing transit service and implementation of new, innovative transit services		0.65M (2020)		New Jersey
Improve mass transit and inter-city transit links.	Greater commitment at the state level to funding urban transit system expansion and operation as well as inter-city transit passenger rail and bus				Oregon
Rail System	*Expand regional light-rail system*				*(City of Portland, OR)*
Increasing Federal Support for Efficient Transit and Freight Transport in PA	Examine the effects of a larger influx of federal support for public transit and freight transport operations in PA[c]		1.17M (2020)	$78	Pennsylvania
Public Transit	• *Expand fuel perks programs to Include public transit* • *Reestablish trolley service*				*(City of Pittsburgh, PA)*
Public Transportation	• *Transit Passes* • *Encourage BUSD to reinstate school buses*				*(City of Benicia, CA)*
Public Transportation	• *Research methods to expand and enhance shuttles and public transportation services to increase shuttle ridership and public transportation alternatives*	*96 (2020)*			*(City of Burlingame, CA)*
Green Fleet Policy	*Expand Community Shuttle Service*	*0.5 (2009-2012)*			*(City of Menlo Park, CA)*
Increase the Use of Public Transit as an Alternative to Driving	• *Expand local transit service* • *Increase funding for major local service improvements* • *Expand and improve regional service and connections* • *Develop regional pass system* • *Improve safety, customer service and user-friendliness of Muni* • *Implement "Smart Bus" technology* • *Increase marketing and promotion of public transit* • *Expand transportation impact fee assessment* • *Create a free tourist shuttle system*	*87,000 (2012)*			*(City of San Francisco, CA)*
Expanding Transit Service	*Coordinate with Marin Transit and the Transportation Authority of Marin to pursue funding opportunities to increase transit service and improve convenience to encourage greater ridership*	*870 (2014-2020)*			*(City of San Rafael, CA)*
Alternative Transit	*Expand City policies to further encourage alternative transit*				*(City of Aspen, CO)*

Mass Transit & Road Improvements	• *Expansion of Metromover (i.e., an electrically powered, fully automated light-rail people mover system) to Brickell and Omni* • *Extend Transit South Miami-Dade Corridor/South Dade Busway Extension* • *Extend Transit Extend Metrorail to Palmetto Expressway* • *Implement ElectroWave (i.e., electric shuttle bus system) Shuttle on Miami Beach*	*10,181 (2012)*			*(Miami-Dade County, FL)*
Shuttle Buses	*Provide shuttles to common destinations at popular times*				*(City of Chevy Chase, MD)*
Commuter Rail Feasibility Study	• *Provide and explore additional transit bus service* • *Continue to explore the creation of the Dan Patch metropolitan commuter rail line*				*(City of Northfield, MN)*
Transit Program	• *Promote transit pass programs*				*(City of Albuquerque, NM)*
Transit Program	• *Provide new commuter rail access to Manhattan* • *Improve local commuter rail service* • *Expand transit access to undeserved areas* • *Improve access to existing transit Expand ferry service* • *Initiate and expand Bus Rapid Transit*				*(City of New York, NY)*
Transit Program	*Operate a comprehensive network of busses throughout the City, supplemented by the Frontrunner train and two light-rail TRAX lines*				*(Salt Lake City, UT)*

Table 10. Promoting Transit, Ridesharing, and Commuter Choice Programs.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Promoting Multi-modal Transit	Promote multi-modal transit options				Arizona
School and University Transportation Bundle	Encourage the reduction of transportation sector GHG emissions when transporting students to schools, colleges, and universities	0.006M (2015)	0.013M (2025)		Arkansas
Transit Management	*Establish a public transportation system that includes park-and-ride lots, beginning with downtown-to-Spit shuttle service during high traffic*				*(City of Homer, AK)*
Adopt Best Workplaces for Commuters in Iowa	Reducing the VMT associated with commuters traveling to and from work	0.02M (2012)	0.02M (2020)	$84	Iowa
Distributed Workplace Model	Community work model that moves beyond the "work from home" methodology of telecommuting and remotely supporting employees, and instead provides community-based multi-location work centers				Iowa
Transit promotion	Seek to shift passenger mode choice to transit and carpooling	1.1M (2012)	2.8M (2020)	Net Savings	Maryland
Transit and Travel Options	Reduce the number of single-occupant vehicle trips and improve the efficiency of daily travel	0.13M (2015)	0.54M (2025)	$185	Michigan
Multi-Modal Transportation and Promotion	Shift passenger transportation mode choice to lower emitting choices	3.7M (2010)	5.8M (2020)	–25	North Carolina
Smart Growth/Transit	Improve, expand, and encourage use of more GHG-efficient modes (transit, bicycling, walking); and discourage use of less efficient modes (single-occupancy vehicles)	0.658M (2010)	1.087M (2020)	$0 - $275 (Incremental Cost per MtCE ($2000))	New York
Commuter Choice/ Transit Benefits	Improve, expand, and encourage use of more GHG-efficient modes (transit, bicycling, walking); and discourage use of less efficient modes (single-occupancy vehicles)	0.128M (2010)	0.256M (2020)	-$2,244 - $0	New York

Utilizing Existing Public Transportation Systems	Advocate taking steps to make the infrastructure investments needed to improve the Commonwealth's public transportation systems without implementing any new policies or regulations. This strategic approach is expected to shift passenger mode choice towards increased transit ridership.		0.05M (2020)	$6,000	Pennsylvania
Increasing Participation in Efficient Passenger Transit	Illustrate the importance of marketing and incentivizing the use of the transit options available to Pennsylvania citizens as another key component of increasing ridership		0.12M (2020)	<$0	Pennsylvania
Transit Management	• *Encourage ridesharing and telecommuting* • *Encourage employee transit use* • *Compile port authority transit Information*				*(City of Pittsburgh, PA)*
Commuting Efficiency Program	Considers a number of incentives to improve the efficiency of commuting trips, through special High Occupant Vehicle (HOV) facilities, transit subsidies/vouchers, Park-and-Ride lots, and Guaranteed Ride Home programs to provide an occasional subsidized ride home to commuters		0.019M (2020)	-$22 - -$32	Rhode Island
Commuting Trip Reduction Initiative	Provide incentives to reduce vehicular trips through telecommunications, telecommuting and internet commerce, all of which can substitute for physical travel		0.018M (2020)	-$22 - -$32	Rhode Island
Transit & Bike-Pedestrian	Enable personal trip making to move from SOVs to lower-GHG-emitting transportation options, such as walking, bicycling, ridesharing, and mass transit	0.02M (2012)	0.02M (2020)	–$1	South Carolina
Plan for Enhanced Rail	Improved freight rail service and new passenger rail services have the potential to reduce overall GHG emissions, compared to movement by highway.				South Carolina
Develop and Implement Aggressive Mass Transit Strategy	A long term mass transit strategy needs to be developed in conjunction with quality growth land use planning principles.				Utah
Alternative Transportation	*Incentives for the use of alternative transportation and car pools*				*(Salt Lake City, UT)*
Alternatives to Single-Occupancy Vehicles	Shift passenger transportation mode choice to lower emitting and clean alternatives including transit, ridesharing, bicycling, and walking	0.28M (2012)	0.32M (2020)	Net savings	Vermont
Regional Intermodal Transportation System – Freight and Passenger	Decrease GHG emissions and the state's VMT by increasing the access, frequency, travel time, and quality of service for passenger rail and intercity bus service	0.05M (2012)	0.20M (2020)		Vermont

Washington State Transportation Access Network	Assure that public transportation provides vital transportation connections to enable travel throughout Washington and provide affordable alternatives to a car dependent lifestyle				
Enhancements to Urban Commute Trip Reduction and Rideshare Programs	Focus primarily on urban commute trips and emphasize expanding the number of commute trips by vanpool, carpool, and telework, and implementation of compressed work week (CWW) schedules statewide		2.58M (2020)		Washington
Statewide Residential Trip Reduction Program	Encourage all travelers, not just commuters, to try ways other than driving alone for their trips				
Transit Program	• *Offer residents access to the use of a shared vehicle* • *Achieve comprehensive plan on alternative transportation mode shift goal (Transit, Bicycle, and pedestrian)*	*20,655 (2020)*			*(City of Bellingham, WA)*
Climate-Friendly Modes of Transportation	• *Expand and encourage use of alternative modes of transportation such as public transit, carpooling, car-sharing, bicycle and pedestrian trails, sidewalks and non-motorized travel* • *Work with government partners to include smart transit investments*				*(King County, WA)*
Transit Enhancement and Travel Demand Management	Integrate three transit alternatives to create and fund broader regional transit options and promote Commute Trip Reduction programs for employees to reduce single-occupant vehicle use for workplace travel		1.4M (2020)		Wisconsin
Develop Transit-oriented Streets	*Provide transit and shuttles with signal priority lanes and queue jumpers to make transit a more attractive alternative to the automobile*				*(City of Alameda, CA)*
Make Public Transit More User-Friendly	• *Conduct a public transit gap study that analyzes strategies for increasing transit use within the City and identifies funding sources for transit improvements* • *Work with AC transit to provide bus stops with safe and convenient bicycle and pedestrian access and essential improvements such as shelters, route information, benches, and lighting* • *Provide passes and shuttles to transit to encourage use of alternative transportation by City employees*	*126 (2020)*			*(City of Albany, CA)*
Travel Demand Management	*Increase Carpooling to 15% of Mode Share by 2020* • *Carpool program* • *Carpool incentives for city employees*				*(City of Benicia, CA)*
Transit Management	*Make transit information easily available, understandable, and translated into multiple languages*				*(City of Los Angeles, CA)*
Increase the Use of Ridesharing as an Alternative to Single-Occupancy Driving	• *Increase the number of miles of HOV lanes* • *Expand carpool and vanpool designated parking* • *HOV requirements in new large developments* • *Implement school ridesharing program* • *Increase Marketing and Promotion of Ridesharing*	*42,000 (2012)*			*(City of San Francisco, CA)*

Promoting Transit and Carpool Program	*Provide transit and carpool incentives to City employees, including alternate work schedules and telecommuting opportunities*	*155 (2012-2013)*			*(City of San Rafael, CA)*
Mass Transit-Oriented Transportation Alternative	*Create a mass transit-oriented transportation alternative that is more convenient and affordable and has lower GHG emissions per passenger mile than the average private vehicle*				*(City of Aspen, CO)*
Alternative Transportation	*2% CO2e Reduction by 2012* • *Promote the transition over time to the use of alternative transportation mode (such as bicycles, telecommuting, walking, van/car pools, and mass transit)* • *Promote alternatively fueled and high-fuel economy vehicles car-share programs*				*(City of Denver, CO)*
Commuter Program	• *South Florida Commuter Services Program promoting alternatives to the Single Occupancy Vehicle (SOV), e.g., carpooling, vanpooling, and use of mass transit* • *South Florida Vanpool Program encouraging commuters to rideshare to work utilizing a passenger van that can seat 7 – 15 individuals, depending on the size of the ridesharing group*	*30,042 (2002-2005)*			*(Miami-Dade County, FL)*
Employee Commuting and Telecommuting Programs	• *Encourage businesses to adopt strong employee commuting and telecommuting programs, providing resources and incentives to reduce the number of SOV commuters* • *Support car-share programs by expanding designated parking for car-share vehicles, high density neighborhoods, at new developments and along transit lines* • *Increase awareness of car-share program benefits*	*6,684-8,136*			*(City of Evanston, IL)*
Public Transit	• *Work with other agencies to improve bus stops, concrete pads, benches, shelters and route and schedule information* • *Continue to support the development of an Evanston stop on the CTA Yellow Line*	*1,972*			*(City of Evanston, IL)*
Mass Transit with Transit-oriented Development	*Invest in a premium transit system including major improvements to existing rail and bus infrastructure, and additional routes to better connect higher density, transit-oriented neighborhood centers and corridors*				*(City of New Orleans, LA)*
Transit Improvement	*Promote the use of non-motorized transportation, carpooling and transit to citizens and employees*				*(City of Durham, NC)*
Alternative transportation	*Promote carpools, vanpools, bicycling, or walking*				*(City of Winston-Salem, NC)*

Use Van Pools and Car Pools	*Promote the use of van pools and car pools*				*(City of Northfield, MN)*
Transit Service	• *Update the existing transit strategy so it includes sustainability goals and GHG emissions reduction targets* • *Coordinate the transit and land use strategies for the City to ensure land use over time supports the desired transit supply network*				*(City of Albuquerque, NM)*
Transit Strategy	*Evaluate and implement parking areas specifically for transit hubs*				*(City of Albuquerque, NM)*
Public Transportation	*Explore other improvements to bus service*				*(City of New York, NY)*
Public Transportation Improvement	*Increase bus ridership*				*(City of Chattanooga, TN)*
Transportation Management	*Promote and develop alternative transportation (e.g., Telecommuting, vanpools, bicycling) and the related infrastructure*				*(City of Chattanooga, TN)*
Alternative Transportation	*Implement school and campus transportation management programs to use alternative transportation when traveling to school*				*(City of Durham, NC)*

Table 11. Smart Growth/Efficient Land Use Patterns.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Promote Efficient Development Patterns (Smart Growth)	GHG emission reduction through efficient, sustainable (i.e., smart growth) land development patterns	0.019M (2015)	0.066M (2025)		Alaska
Smart Growth Bundle	Reduce GHG emissions by facilitating fewer vehicle trips and total vehicle miles traveled	1.47M (2010)	4.0M (2020)	0	Arizona
Smart Growth, Pedestrian and Bicycle Infrastructure	Practice a land-use development reducing vehicle travel and sprawl, and maximizing environmental, fiscal, and economic resources	0.06M (2015)	0.17M (2025)	≤ 0 (Net Savings)	Arkansas
Compact Development	• *Support denser, more compact development and increased emphasis on developing infrastructure for nonmotorized transportation* • *Update City planning and zoning regulations to promote land use strategies* • *Institute traffic calming measures and "complete street" designs to make bicycling and walking safer and more pleasant*				*(City of Homer, AK)*
Smart Land Use and Intelligent Transportation	Encourage jobs/housing proximity, promote transit-oriented development, and encourage high-density residential/commercial development along transit corridors	5.5M (2010)	18M (2020)		California
Promote Pedestrian- and Transit-Oriented Development	• *Provide public education about benefits of well-designed, higherdensity housing and relationships between land use and transportation* • *Update planning documents to promote high-quality, mixed-use, pedestrian- and transit-oriented development in the San Pablo/Solano Commercial district* • *Evaluate GHG emissions associated with development proposals and work with applicants to reduce emissions during project review and incentivize projects that generate low levels of GHG emissions*	*860 (2020)*			*(City of Albany, CA)*
Smart Growth.	*Compact, mixed-use development, higher density development, and infill*				*(City of Arcata, CA)*

Land Use	*Reduce VMT 1% by Increasing Compact Mixed-Use Development* • *Form-based codes intentionally emphasize building form rather than use* • *Live/work and work/live developments allow residents to live at their place of work* • *Amend development regulations to accommodate small neighborhood shopping centers and individual retail establishments in residential neighborhoods* • *Promote infill development including mixed-use, commercial services, parks, community gardens*				*(City of Benicia, CA)*
Smart Growth	*Encourage development that is mixed use, infill and higher density*				*(City of Burlingame, CA)*
Land Use Development for VMT Reductions	• *Encourage greater residential and commercial densities within walking distance of high frequency transit centers (at least every 15 min.)* • *Consider land use and transportation alternatives (better bicycle and pedestrian access and increased transit feeder service) to best use the future Civic Center SMART station*	*6,775 (2009 – 2011)*			*(City of San Rafael, CA)*
Transit, Smart Growth, and VMT Reduction Package	Increase accessibility and low GHG travel choices in Connecticut, such as transit (rail and bus), vanpools, walking, and biking	0.22M (2010)	0.49M (2020)	$280	Connecticut
Encourage Pedestrian-Friendly Zones	*Promote urban infill, and denser, mixed-use development built to a human scale, with an emphasis on walkability and a more humane architecture*	*0.006M*			*(City of Hamden, CT)*
Smart-Growth Planning	Land use planning, site planning, and urban design at the Community level can help achieve carbon and GHG emission reduction goals				Florida
Land Use Planning Processes and Increasing Choices in Modes of Transportation	Ensure that local and state land use and transportation planning consider the impact of land use and transportation decisions on the reduction of GHG emissions	1.77M (2017)	3.54M (2025)		Florida
Long Range Transportation Plan	• *Construct all road improvements listed in the long range transportation plan consistent with the other transportation and land use measures in this plan* • *Review and amend regulations to encourage implementation of transit and pedestrian-oriented development (TOD) principles in new development* • *Encourage infill development by requiring utilization of TOD development principles within activity centers and along major transit corridors*				*(Miami-Dade County, FL)*

Smart Growth Bundle with Transit	Encourage smart growth, including downtown revitalization, transit-oriented development, and enhancing the pedestrian and bicycle infrastructure, thereby reducing VMT	0.076M (2012)	0.242M (2020)	-$245	Iowa
Implement smart growth initiatives and expansion of mass transit	1) Expansion of mass transit in Northeastern Illinois and in urban centers across the state, 2) Implementation of planning policies to facilitate smart growth and restrain urban sprawl		0.26M – 0.39M (2020)		Illinois
Transit-Oriented Development	*Transit-oriented development*	*0.63M (2020)*			*(City of Chicago, IL)*
Transit Improvement Plan	• *Provide spaces for bikes and car-share in new developments as well as sidewalks* • *Encourage developers to unbundle living units and parking spaces and eliminate the assignment of specific stalls to specific occupants, thus pooling the available spaces and reducing the total requirement* • *Consider adopting a housing policy goal for Evanston's housing stock to mirror the incomes paid by Evanston based employers to their workforces* • *Consider adopting a housing policy goal for Evanston's housing stock to mirror the incomes paid by Evanston based employers to their workforces*	*0.015M*			*(City of Evanston, IL)*
Integrated Planning for Land Use and Location Efficiency	Implementation of integrated land use planning, transportation and development strategies that encourage people to drive fewer miles while ensuring a competitive economy	1.1M (2012)	4.6M (2020)	Large Net Savings	Maryland
Reduce VMT through Clustered Development	Reduce the length of automobile trips and the number of trips with clustered development, which also facilitates walking, bicycling, and public transit	1.6M (2020)			Massachusetts
Land Use Planning and Incentives	Encourage local and regional planning and development strategies in order to reduce the projected growth of VMT and corresponding GHG emissions	0.14M (2015)	0.43M (2025)	–$189	Michigan
Improved Land-Use Planning and Development Strategies	Improve land-use planning and development practices to target growth in ways that reduce the number and length of vehicle trips, thus reducing GHG emissions	0.7M (2015)	1.9M (2025)	*Net savings*	Minnesota
Growth and Development Bundle	Reduce GHG emissions through promotion of multimodal transit options and land use practices	0.00M (2010)	0.14M (2020)	<$0	Montana
Land Development Planning	Promote land planning and development that supports more compact development and reduces growth in driving and emissions	2.6M (2010)	8.0M (2020)		North Carolina

Transit-oriented Development	• *Integrate non-motorized transportation into all transportation and land-use planning activities* • *Use planning practices and design standards that accommodate the widest range of potential users* • *Strengthen and uphold policies that control urban sprawl for not only reducing the number and distance of motorized vehicle trips, but also helps to conserve forests*				*(City of Durham, NC)*
Public Improvement Plan	*Encourage the use of public transportation and new development that does not increase urban sprawl*				*(City of Winston-Salem, NC)*
Infill, Brownfield Redevelopment	Increase its efforts to reuse land that is already developed but is now vacant, underused, or even mildly polluted, and meet the growing demand by a larger number of households comprised of singles, working parents and single parents for housing located close to services, jobs and transit	1.2M (2012)	1.3M (2020)	$0>	New Mexico
Transit-Oriented Development	Expand efforts to supportive of building of compact development around transit stops and clustering employment centers around transit in ways that allow meet transportation needs to be met by foot, bicycle, or transit				
Smart Growth Planning, Modeling, Tools	Expand its efforts in the areas of Smart Growth planning, modeling, and tools, and thus allow, support, and encourage location-efficient growth in communities that are proximate to household needs and amenities as opposed to growth in areas that are not proximate and require greater travel distance and have less mode choice				
Multi-Modal Transportation Bundle	Establish objectives and implementation strategies that aim to shift the State's focus from roads to an integrated, multimodal system				
Promote LEED for Neighborhood Development	Lower emissions and reductions in other public costs of development meeting "Leadership in Energy and Environmental Design Neighborhood Development (LEED-ND)" standards integrating the principles of smart growth, urbanism, and green building into the first national standard for neighborhood design				
Smart Growth/Transit	Improve, expand, and encourage use of more GHG-efficient modes (transit, bicycling, walking); and discourage use of less efficient modes (single-occupancy vehicles)	0.658M (2010)	1.087M (2020)	$0 - $275 (Incremental Cost per MtCE ($2000))	New York
Integrate land use and transportation decisions with GHG consequences	Reduce the need to travel (or reduce trip length) by providing nearby access to goods and services		0.40M (2025)	Cost-effective	Oregon

Enhanced Support for Existing Smart Growth/Transportation and Land-Use Policies	Use existing policies and regulations to further promote smart growth and efficient transportation and land use		0.76M – 1.84M (2020)	<$0	Pennsylvania
Transit-Oriented Design (TOD), Smart Growth Communities, & Land-Use Solutions	Promote smart growth communities and sustainable land use practices			Included in "Enhanced Support for existing smart growth ~"	Pennsylvania
Transit Oriented Development	*$60M set aside by Pennsylvania Community Transportation Initiative for TOD projects, including improved lighting, sidewalks, car-sharing parking spots, rezoning to accommodate mixed use development.*				*(City of Philadelphia, PA)*
Smart Growth	*Encourage smart growth*				*(City of Pittsburgh, PA)*
Transit Oriented Development And Enhancing Transit Options And Operations Initiative	Reduce automobile use and associated pollution, increase access, create socially and physically more attractive neighborhoods, and increase productivity		0.019M (2020)	-$22 - -$32	Rhode Island
Urban/Suburban Forestry Program	Urban and community trees can remove both conventional pollutants and carbon dioxide from the air.		<0.12M (2020)		Rhode Island
Open Space Protection Program	The loss of open space in Rhode Island, through conversion to residential as well as commercial development, has been a cause for public concern in terms of reduced recreation, buffer zone, and visual amenity.		0.06M (2020)		Rhode Island
Improve Development Patterns	Help South Carolina grow in a way that protects the state's environment, climate, economy, and quality of life	0.41M (2012)	2.31M (2020)	< $0	South Carolina
Quality Growth Program	80% of the population lives along the rapidly growing Wasatch Front region. Smart growth is a vital component to any strategy that seeks to reduce CO2 emissions from transportation.				Utah
Land Use Planning	Encourage local and regional land use patterns which minimize GHG emissions; require that land use planning include coordination of transportation and land use as a key policy goal and to require the plan to include quantifiable measures.				Virginia
Transit Oriented Development	Promote compact, walkable, transit oriented development areas				Virginia
Compact and Transit-Oriented Development Bundle	Implement land use planning and development that supports protection of natural and cultural resources, strengthens communities, creates more compact development, and reduces growth in driving and emissions	0.26M (2012)	0.99M (2020)	Net savings	Vermont

GHG-Related Transportation Funding Mechanisms	Find an alternative to a gas tax–based transportation funding system				Vermont
Promote and Support Housing and Employment Density	Attract multi-family development and innovative housing strategies such as accessory dwelling units, lot size averaging, cottage and other types of infill developments to existing, emerging or planned CTOD areas		1.7M[c] (2020)		Washington
Encourage Urban Brownfield Redevelopment	Result in opportunities for land aggregation, promoting town centers, and promoting compact development		1.7M[c] (2020)		Washington
Transit-oriented Development	*Continue to work with local governments and the Puget Sound Regional Council to promote growth in designated, transit-oriented urban areas of the county*				*(King County, WA)*
Energy Efficient Communities	Encourage development patterns that reduce dependency on automobiles by providing viable alternatives for mobility, such as walking and transit options		6.2M (2020)		Wisconsin
New Development Pattern	• *Transit-oriented development* • *Support a transportation demand management* • *Revise street design standards and reengineering existing streets to promote pedestrian and bicycle use and encourage the use of alternative modes of transportation*				*(City of Alameda, CA)*
Sustainable Modes of Transportation	• *Smart Growth* • *Increase density along transit corridors*				*(City of Berkeley, CA)*
Land Use	• *Promote high-density housing close to major transportation stops* • *Promote and implement transit-oriented development*				*(City of Los Angeles, CA)*
New Development Projects	• *Establish City policy that requires a net decrease in transportation related emissions compared to existing developments* • *Continue to support the connection between land use and transportation impacts* • *Expand the City's TOPs Program, which includes policies to reduce VMT and increase non-motorized vehicle trips* • *Implement new parking ratios in the Land Use Code and support programs that allow for innovative new development to occur with alternative transportation in design*				*(City of Aspen, CO)*

Compact Growth	*2 % CO2e Emission Reduction by 2012; greater than 10 % Reduction by 2020* • *Support additional population growth around transit in the metro area to promote denser, more pedestrian-, bicycle-, and transit-friendly neighborhoods reducing the demand for motorized personal transport*				*(City of Denver, CO)*
Land-use and Transit-oriented Development	• *Provide land use regulations, guidance and incentives to encourage walkable, transit-oriented or accessible neighborhood centers along existing and potential future transit routes* • *Establish a "complete streets" policy to provide for pedestrians and bicycles, as well as vehicles, in repairs of major streets with design guidelines* • *Provide a wide range of transportation choices* • *Promote compact infill development in existing neighborhoods* • *Preserve natural and open spaces and enhance the environmental value of urban green spaces* • *Promote walkable and "bike-able" development patterns and a safe and pleasant pedestrian environment*				*(City of New Orleans, LA)*
New Development Plan	• *Incorporate requirements into site plan, subdivision, or zoning regulations that require a grid system for future street layout patterns* • *Change design requirements for new or refurbished roadways to include different pitches combined with stormwater design and/or use of more permeable surfaces to effectively remove water from the roadway*				*(City of Keene, NH)*
"Complete Street" Standards	• *Develop a comprehensive plan for the pedestrian and bicyclist network and construct portions of the pedestrian and cyclists network every year until it is complete* • *Meet and exceed standards set forth by the American Association of State Highway and Transportation Officials (AASHTO)* • *Research leading examples of innovative street designs such as Home Zones, radical streets and Seattle's C-streets* • *Develop a pilot project set of standards and develop some examples of innovative streets in new developments and in upgrading older neighborhood areas* • *Implement innovative design standards across the city. Some examples include the use of recycled materials for street construction and design*				*(City of Albuquerque, NM)*

New Development Plan	• *Continue to develop pedestrian and bicycle facilities as a viable means of transportation* • *Transit oriented developments*				*(City of Chattanooga, TN)*

Table 12. Incorporating Vehicle Miles Traveled (VMT) and GHG Reduction Goals into Transportation Planning.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
VMT and GHG Reduction Goals in Planning	Empowering transportation planners to evaluate alternative proposals on the basis of VMT/GHG generation	0.019M (2015)	0.066M (2025)		Alaska
Measures to Improve Transportation Energy Efficiency	Provide a framework for expanded and new initiatives including incentives, tools and information that advance cleaner transportation and reduce climate change emissions	1.8M (2010)	9M (2020)		California
Telecommuting	• *Encourage the City employers to provide opportunities for telecommuting schedules to reduce VMT* • *Expand the geographic area of the work/live ordinance to provide greater opportunities for reduced work-related commutes*				*(City of Alameda, CA)*
Dependence on Driving	• *Improve vehicle fuel efficiency* • *Reduce the fuel's carbon content* • *Reduce vehicle miles traveled (VMT)* • *Promote walk or bicycle to a school* • *Increase the use of BART station*				*(City of Alameda, CA)*
Reduce Vehicle Emission and Trips	• *Work with ABAG and neighboring cities to improve the jobs-housing balance within the City and regional transit corridors* • *Improve fuel efficiency of the City vehicle fleet by purchasing lower zero-emission vehicles when vehicles are retired from service* • *Incentivize electric and plug-in hybrid vehicles through development of automobile charging infrastructure and preferential street parking spaces* • *Create and implement a voluntary transportation demand management (TDM) program to reduce weekday peak period single occupancy commute and school trips* • *Evaluate and consider implementation of community parking management strategies*	*1,384 (2020)*			*(City of Albany, CA)*
Transportation Plan	*Incorporate energy and climate policy into the City's transportation plan and encourage policies at all levels for efficient and non-polluting transportation*				*(City of Arcata, CA)*

Municipal Transportation	*Reduce municipal fleet related emissions 20% by 2020* • *Establish mandatory criteria for new fleet vehicles* • *Municipal bicycle program* *Reduce municipal transportation infrastructure related emissions 50% by 2020* • *Increase the efficiency of streetlights* • *LED lighting for intersection walk signals* • *Recycled content in street surfaces* • *Traffic signal and stop sign optimization*				*(City of Benicia, CA)*
VMT Reduction	• *Reduce vehicle miles traveled (VMT) by encouraging residents and employees to use alternative modes of transit, by improving the effectiveness of the transportation circulation system, and through land-use and zoning mechanisms* • *Reduce VMT of passenger vehicles to 30 percent below business-as-usual projections by 2050* • *Reduce VMT of heavy trucks to 10 percent below business-as-usual projections by 2050*	*9,626 (2020)*	*99,174 (2050)*		*(City of Hayward, CA)*
VMT Reduction Policy	*Enhanced Transit Pass/Carpooling Programs*	*22*			*(City of Menlo Park, CA)*
Slowing VMT Growth	Slow vehicle miles traveled (VMT) growth and increase the availability of low-GHG travel choices, such as transit (rail and bus), vanpools, walking, and biking	0.09M (2010)	0.29M (2020)		Maine
"Fix-it-First" Transportation Investment Policy and Practice	Maintain existing roads, and design new and expanded roads to serve higher-density, more compact, pedestrian-friendly development in priority growth areas				Minnesota
Continue/Expand Funding, Education, and Technical Assistance to Municipalities	Support/expand technical assistance and funding made available through existing programs to promote coordinated local planning for land use, transportation, and the environment				New Hampshire
Incorporate GHG emission impacts into transportation planning decisions	Provide an opportunity to give priority to those service improvements and expansions that offer the greatest GHG reductions			Cost-effective	Oregon
VMT Reduction	*30 % VMT Reduction from 2008 levels* • *Reduce vehicle miles traveled (VMT) by increasing walking, bicycling, and taking transit and carpool*				*(City of Portland, OR)*

Make Full Use of CMAQ Funds	Allocate all Congestion Mitigation and Air Quality (CMAQ) funding to reduce transportation-related emissions and fund various emission reduction strategies with emphasis on projects that reduce GHGs				Rhode Island
Transportation Planning	Adopt a "complete streets" policy to design and operate roadways to allow safe, attractive, and comfortable travel for all users				Virginia
Transportation Planning	Work with regional and local governments to harmonize the state transportation plans and local land use plans				Virginia
HOT Lane Evaluation	Evaluate the impact of High Occupancy Toll (HOT) lane networks on GHG emissions				Virginia
Washington State Transportation Access Network	Assure that public transportation provides vital transportation connections to enable travel throughout Washington and provide affordable alternatives to a car dependent lifestyle				Washington
Transportation Concurrency	Enable state's transportation concurrency policy (sets level of service standards for transportation facilities and services) to address all modes of transportation. Proposed developments may be denied by local ordinance if they would cause the level of service of a local transportation facility to decline below the adopted standard.		1.7M[c] (2020)		Washington
Align Investments and Operations with the Achievement of the VMT and GHG reductions	State, regional, and local transportation investments and operations should be aligned with the achievement of the VMT and GHG reductions of ESSHB 2815				Washington
Pursue New Revenue Sources	Continue to pursue new revenue sources to support transportation choices, particularly transit operations				Washington
Commute Trip Reduction Program	*Conduct the City employee commuter survey, and reduce in vehicle miles traveled (VMT) per employee*	*43 (2020)*			*(City of Bellingham, WA)*
Carbon-Audited Transportation Investment	Carbon audits that reveal high levels of induced VMT would favor dismissal of the proposed project, compared to the status quo.		1.7M (2020)		Wisconsin
Assess Greenhouse Gas Emission Impact Fees	Assess a state impact fee based on the estimated GHG impact of the project, and/or enable municipalities to adopt similar programs				New Hampshire
Streamline Approvals for Low-Greenhouse-Gas Development Projects	Adopt new policies to streamline permit review processes, apply alternative requirements, or otherwise reduce barriers for development projects in existing community centers with low-GHG footprints				New Hampshire
Develop Model Zoning to Support Bus/Rail Transit	Develop a model zoning ordinance governing land use around bus/rail service access points to promote ridership and reduce GHG emissions				New Hampshire

Develop Model Zoning for Higher-Density, Mixed-Use Development	Develop a model zoning ordinance to promote and facilitate higher-density, mixed-use, walkable development in designated areas of a community				New Hampshire
Explore Funding Options for the Suite of Transportation and Land Use Options	Adequate funding is a critical enabler to several of the transportation/land use policy options.				Utah
Environmental reviews	Require environmental analysis and review of major transportation projects/networks				Virginia
Trip Reduction Program	• *Continue to track County fleet VMTs for developing a success indicator to measure progress* • *Provide web conferencing opportunities to reduce employee VMT*				*(Pima County, AZ)*
VMT Reduction	*Reduce per employee VMT in City vehicles by promoting teleconferencing and the availability of pedestrian and bicycle transit and carpool options for business commutes and trips*				*(City of Aspen, CO)*
Reduce Vehicle Miles Traveled (VMTs) Thru Technology Improvements	*Clerk of Courts Voice Response System providing information to the County citizens in regards to the court system, without having to leave their homes*	*751 (1999-2005)*			*(Miami-Dade County, FL)*

Table 13. Transportation Systems Management/Improving Roadway Efficiency.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Transportation System Management	Reduce GHG emissions through improvements to transportation system management.	0.006M (2015)	0.006M (2025)	–$105	Alaska
Improving Transportation System Management	Utilize a variety of strategies based on advanced technologies, market based incentives, regulations, and design standards	3.94M (2017)	6.98M (2025)	-$80	Florida
Congestion Mitigation	Improve traffic flow and travel time through expanding the use of intelligent transportation systems	0.08M (2015)	0.18M (2025)	–$81	Michigan
Infrastructure Management	Create a seamless multimodal system to serve all modes, improve traffic flow, and decrease vehicle idling and congestion	0.04M (2015)	0.1M (2025)		Minnesota
Develop Local Transportation Infrastructure	• *Facilitate efficient motor vehicle use and non-motorized transportation* • *Use roundabouts rather than stop signs or traffic lights* • *Implement the recommendations of the Non-motorized Transportation Task Force and the Northfield Parks, Open Space and Trails Master Plan*				*(City of Northfield, MN)*
Transportation System Management	Reduce GHG emissions from the transportation sector through improvements to transportation system management				Montana
Maintaining a Good State of Repair in Roads Infrastructure and Operation while Mitigating GHG Impacts	Manage and operate the transportation system to help transportation networks meet demand in an effective and efficient manner		0.006M (2020)	-$831	New Jersey
Set up traffic flow engineering "Best Practices."	Traffic flow can be optimized through targeted infrastructure investments, traffic signal re-timing, value pricing, and investments in alternatives to the automobile.				Oregon
Transportation Systems Management	Broad array of strategies including: driver communication, incident response systems, and other approaches designed to reduce congestion on our existing network				Washington
Traffic Signal	*Replace traffic signals with much more efficient LED bulbs*				*(City of Bellingham, WA)*

Increase Highway Automobile Efficiency	Explore ways to maximize efficiency in highway vehicle travel, including reduction of average travel speeds on state and interstate highways and improvement on driving habits to improve overall vehicle fuel efficiency				New Hampshire
Improve Traffic Flow	Revise state guidance and policies to promote the use of appropriate measures to reduce congestion, improve traffic flow, and reduce GHG emissions associated with motor vehicle travel	0.01M (2012)	0.04M (2020)		New Hampshire
Transportation Demand Management	• *Explore roadway materials that may be utilized in road construction that are more tolerant to quick changes in hot or cold weather in order to decrease repair costs, enhance safety, and increase longevity of road surfaces* • *Identify and implement Transportation Demand Management (TDM) techniques* • *Identify and obtain funds for the development of a local public transportation system that connects with the regional transportation system*				*(City of Keene, NH)*
Transportation System Management	Improve vehicle flow on the roadway system, which can reduce fuel use and GHG emissions	0.01M (2012)	0.04M (2020)	< $0	South Carolina
Signalization standards	Create signalization standards to improve the timing and the intelligence of traffic signalization				Virginia
Focus on Mobility for People, Not Cars	*Complete the Automated Traffic Surveillance and Control System (ATSAC)*	*269,075*			*(City of Los Angeles, CA)*
Further Improve Traffic Flow	*Reduce the amount of time drivers spend waiting at stoplights*	*1,822*			*(City of Hamden, CT)*
Reduce Traffic Congestion	*Eliminate single occupancy vehicle (SOV) trips and/or decrease the length of those SOV trips*				*(City of Atlanta, GA)*
CREATE Program	*Chicago Region Environmental and Transportation Efficiency (CREATE) program*	*1.61M (2020)*			*(City of Chicago, IL)*
Coordination Improvement	*Improve coordination between city, regional and state agencies relating to transportation policies and projects*				*(City of New Orleans, LA)*
Traffic Flow Management	*Synchronize traffic signals to maximize traffic flow and reduce vehicle idling times*				*(City of Durham, NC)*
Traffic Flow Improvement	• *Plan and build greenways, bike lanes, and pedestrian facilities* • *Implement safety improvement program for reducing accident and congestion*				*(City of Winston-Salem, NC)*
Transportation Management Plan	*Inventory the current bicycle and greenway network, identify key linkages to the regional and county network and establish key goals for the network*				*(City of Albuquerque, NM)*

Capacity Management Plan	• *Address congested areas around the City* • *Seek to fund five projects that eliminate capacity constraints* • *Dedicate Bus/High Occupancy Vehicle (HOV) lanes on the East River Bridges* • *Improve access to John F. Kennedy International Airport*				*(City of New York , NY)*
Transportation Management	• *Install bus priority traffic signals, alternatives for school bus parking in downtown, and sidewalk and loading zone evaluation* • *Cooperate with the Oakland Transportation Management Association*				*(City of Pittsburgh, PA)*
Traffic Signals and Exit Signs	*Switch to Energy Efficient LED Traffic Signals and Exit Signs*				*(City of Charleston, SC)*

Table 14. Increasing Freight Movement Efficiencies.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Promote and Facilitate Efficiency	Promote and facilitate freight efficiency by improving railroad infrastructure and rail yards, increasing rail and river shipping capacity, and providing electrification at truck stops to reduce idling	0.33M (2015)	0.47M (2025)	$104	Arkansas
Multistate Intermodal Freight Initiative	Divert a portion of the projected 70 percent growth in regional truck traffic to rail and barge modes in order to reduce significantly the GHG impact of freight transportation	0.0M (2010)	0.14M (2020)		Connecticut
Incentive Programs for Increased Vehicle Fleet Efficiency	Encourage the purchase of low GHG emission vehicles through monetary and convenience rewards and incentives	0.84M (2017)	1.56M (2025)		Florida
Increasing Freight Movement Efficiencies	Reduce the trucking industry's carbon footprint and GHG emissions, while maintaining the current level of service to the state and nation	0.59M (2017)	1.10M (2025)		Florida
Freight Strategies	Reduce Iowa's overall GHG emissions generated by freight movement through a combination of identifying actions to support efficient freight movement, remove both physical and operational bottlenecks, encourage railroad capital investment, and provide incentives for trucking companies to invest in hybrid technology	0.39M (2012)	0.63M (2020)	+$5	Iowa
Increase Rail Capacity and Address Rail Freight System Bottlenecks	Encourage more energy efficient freight movement via railroads, where it is practical to do so	0.10M (2015)	0.19M (2025)	$35	Michigan
Great Lakes Shipping	Promote the use of marine transportation as the most energy efficient form of surface transportation to move cargo over long distances	0.24M (2015)	0.27M (2025)	NQ	Michigan
Freight Mode Shifts: Intermodal and Rail	Expand intermodal rail service and the competitiveness of rail rates for decreasing truck VMT				Minnesota
Intermodal Freight Transportation	Encourage the expansion of intermodal rail service for Montana shippers	0.02M (2010)	0.09M (2020)		Montana
Maintain and Expand Freight Rail Service	Maintain and expand freight rail service within New Hampshire as part of a balanced, state-wide, multi-modal transportation system				New Hampshire
Freight Management Plan	*Identify alternate routes and modes for goods transport and evacuation efforts during emergency situations*				*(City of Keene, NH)*
Transition to Low-Carbon Methods of Goods Movement	Encourage truck stop electrification, promote the use of plug-in trailer refrigeration units, and encourage increased use of shuttle rail to move goods		1.40M (2020)	-$51	New Jersey

Intermodal Freight Initiatives	Implement policies and programs that result in the shifting of the transport of freight goods from the roadway system to rail	0.1M (2012)	0.5M (2020)		New Mexico
Cutting Emissions from Freight Transportation	Potential GHG emissions savings from using the most energy efficient mode of freight transport to move goods		0.99M (2020)	-$295	Pennsylvania
Increasing Federal Support for Efficient Transit and Freight Transport in PA	Examine the effects of a larger influx of federal support for public transit and freight transport operations in PA		1.17M (2020)	$78	Pennsylvania
Hudson Rail Crossing & Brooklyn Port	Construct tunnel for freight rail and expand Brooklyn port.	0.036M (2010)	0.055M (2020)	$2,745	New York
Multimodal Rail Investment, Truck Tolls					New York
Freight (truck/rail) Transportation Efficiency	Site industrial land/facilities along key freight corridors and encourage warehouse and distribution center development in existing urban areas. Also, work with ports statewide to adopt “green port” goals and promote state and federal investment in rail/truck/barge mode split.				Oregon
Freight Improvement	*Improve the efficiency of freight movement within and through the Portland metropolitan area*				*(City of Portland, OR)*

Table 15. Bicycle/Pedestrian Projects.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Bike and Pedestrian Infrastructure	Improve, add, and promote sidewalks and bikeways to increase pedestrian and bicycle travel, thus reducing automobile use			Included in transit costs	Maryland
Encouraging Walking	• *Encourage residents to walk to Bethesda for their errands, entertainment, and to access public transportation* • *Sponsor contests and recognize residents who substitute bikes for cars, install bike racks, give away bike odometers and set up a monthly mileage registry*				*(City of Chevy Chase, MD)*
Expand and Improve Bicycle and Pedestrian Infrastructure	Improve and expand bicycle and pedestrian infrastructure to increase the viability of these travel modes as options for shorter-distance local trips, particularly within existing community centers, around transit-access points, and in other areas of higher-density, compact, mixed-use development	0.02M (2012)	0.08M (2020)		New Hampshire
Bike and Ped Infrastructure	Improve, expand, and encourage use of more GHG-efficient modes (transit, bicycling, walking); and discourage use of less efficient modes (single-occupancy vehicles)	0.030M (2010)	0.045M (2020)	$0 - $352	New York
Bike Master Plan	*Complete the City's 1,800-mile bike master plan*				*(City of New York, NY)*
Bicycle and Pedestrian Infrastructures Initiative	Expand bicycle and pedestrian infrastructures through improved paths and bike lanes; take measures to address specific roadway hazards and improve security for cyclists and pedestrians; provide a better connected street network and clustered development; and impose speed and vehicle restrictions		0.019M (2020)	-$22 to -$32	Rhode Island
Transit & Bike-Pedestrian	Enable personal trip making to move from SOVs to lower-GHG-emitting transportation options, such as walking, bicycling, ridesharing, and mass transit	0.02M (2012)	0.02M (2020)	–$1	South Carolina
Bike/Pedestrian Infrastructure	Make new or upgraded roads more pedestrian- and bike-friendly				Virginia
Encourage Bicycle and Pedestrian Accessibility	Affirm that walking and bicycling for transportation purposes offer many benefits to individuals, their communities, and the state, including improved health for individuals and no harmful pollution		1.7M[c] (2020)		Washington
Bike and Pedestrian Program	• *Double the existing 25 miles of marked and striped bicycle lanes* • *Make walking more attractive by installing 200 new pedestrian curb ramps and upgrading 50 marked crosswalks*				*(City of Seattle, WA)*

Green Bike Program	*Create a Green Bike Program*				*(Pima County, AZ)*
Alternative Transportation	• *Promote development of a "free bike" program* • *Establish a "bike library" program that allows local residents and visitors to pay a refundable fee to "check out" a bicycle at different locations in town.* • *Provide bike racks at all City buildings and parks*				*(City of Homer, AK)*
Facilitate Walking and Biking	• *Expand and enhance bicycle infrastructure throughout the City* • *Install bike racks in commercial and civic areas of the City where racks do not currently exist* • *Evaluate the community's walking infrastructure, identify potential barriers, and implement improvements* • *Strictly enforce pedestrian rights laws on City streets* • *Encourage additional neighborhood-serving commercial uses and mixed-use development within the City's existing commercial districts. Strive to provide access to daily goods and services within ¼-mile of residences*	*2,295 (2020)*			*(City of Albany, CA)*
Improve Bicycle Infrastructure.	• *Create more bike lanes on existing roads and make bridges and intersections more bicycle-friendly* • *Improve Pedestrian Infrastructure (sidewalks, paths, and walkways)*				*(City of Arcata, CA)*
Alternative Transportation	• *Increase bicycle infrastructure at city facilities and for new development* • *Implement bicycle and pedestrian safety measures* • *Bicycle and pedestrian master plan* • *Revise streetscape design standards*				*(City of Benicia, CA)*
Bike & Pedestrian Plan	*Accelerate Implementation of the City's Bicycle & Pedestrian Plans*				*(City of Berkeley, CA)*
Non-motorized Improvement	*Promote walking and biking to work, within neighborhoods, and to large events and venues*				*(City of Los Angeles, CA)*
Green Fleet Policy	*Implement Bike Improvements*	*9,000 (2015-2020)*			*(City of Menlo Park, CA)*

Increase Bicycling and Walking as an Alternative to Driving	• *Continue to increase the number of bicycle lanes, routes, and paths* • *Continue to improve safe access and passage on pedestrian walkways* • *Improve bicycle access to transit* • *Continue to improve and expand bicycle parking facilities* • *Increase workplace shower facilities for bicyclists* • *Increase marketing and promotion of bicycling*	*10,000 (2012)*			*(City of San Francisco, CA)*
Bike Share Program	*Facilitate creation of a bike share program, particularly in the downtown area.*	*525 (2012-2013)*			*City of San Rafael, CA)*
Install Bike Racks and Stripe	*Increase the use of bicycle transportation*	*238*			*(City of Hamden, CT)*
Bikes on Trains Implementation	• *Implement Bikes on TriRail* • *Expand Bikes-on-Trains Program to include counter-flow and first hour service*	*585 (2002-2005)*			*(Miami-Dade County, FL)*
Walking and Biking Plan	• *Encourage walking and biking to school by designating routes* • *Facilitate sidewalk enhancements and maintenance* • *Facilitate the installation of sheltered, secure bike racks downtown and at transit stations* • *Facilitate the full implementation of the City bicycle plan*				*(City of Evanston, IL)*
Bike Master Plan	*Increase biking and walking as a means of transport*				*(City of Worcester, MA)*
Walkable Community	*Plan for a more walkable community*				*(City of Durham, NC)*
Pedestrian & Bicycle Plan	• *Develop design guidelines for the pedestrian and bicyclist network to maximize value and minimize cost* • *Inventory the radius of children walking to school (footprint)*				*(City of Albuquerque, NM)*
Bicycle/Motor Scooter Parking	• *200 linear feet of bicycle parking and 430 linear feet of motor scooter parking set aside in 2009; 1400 new bike racks on sidewalks*				*(City of Philadelphia, PA)*
Pedestrian/Bicycle Master Plan	• *Plan, developed by Philadelphia City Planning Commission, includes continuous bicycle network, sidewalk design policies.*				*(City of Philadelphia, PA)*
Bicycle Commuter	*Promote a bicycle commute program*				*(City of Portland, OR)*
Bike Program	*Install bike racks at city buildings and create a bike program*				*(City of Pittsburgh, PA)*
Pedestrian Program	*Plan for pedestrian-friendly neighborhoods*				*(City of Chattanooga, TN)*

Bicycle and Pedestrian Master Plan	• *Incorporate bicycle and pedestrian mobility and facility needs into community planning, land use planning, and the development process* • *Expand the existing pedestrian and bicycle system, and improve on-street bicycle travel between neighborhoods, within the City, and to connecting intra-city locations* • *Improve the quality of the existing system* • *Promote safe bicycling and enhance pedestrian safety* • *Maximize the use of available federal and state funding opportunities to support pedestrian and bicycle mobility*				*(Salt Lake City, UT)*

Table 16. Idling Reduction.

Program	Description	GHG Reduction (MMtCO2e) (Year1)	(Year2)	Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
Heavy-Duty Vehicle Idling Regulations and/or Alternatives	Reduce idling times for diesel and gasoline heavy-duty vehicles, buses, and other vehicles through a combination of statewide anti-idling regulations and by promoting the use of idling reduction technologies	0.004M (2015)	0.009M (2025)	$255	Alaska
Reduction of Vehicle Idling	Reduce idling from diesel and gasoline heavy-duty vehicles, buses, and others	0.7M (2010)	1.3M (2020)	-$22	Arizona
Idle Reduction	*Develop anti-idling policy*				*(Pima County, AZ)*
Idle Reduction	*Establish anti-idling policies for City vehicles/drivers*				*(City of Homer, AK)*
Diesel Anti-Idling	Reduce idling time of heavy-duty diesel trucks	1M (2010)	1.4M (2020)		California
Idling Policy	*Limit Commercial Vehicle Idling*				*(City of Menlo Park, CA)*
Idling Reduction	*Adopt a policy to limit City vehicle idling where practical. Evaluate equipping trucks with an auxiliary electrical system for illumination and warning signs*	*190 (2009-2011)*			*(City of San Rafael, CA)*
Encourage Anti-Idling Measures: Freight	Support programs to fund infrastructure or develop incentives to reduce truck, locomotive, and marine engine idling through electrification and other technologies, enforcement, and congestion management	0.012M (2010)	0.03M (2020)		Maine
Truck Idling Policies	Aim to reduce GHG and other emissions from unnecessary idling of heavy duty vehicles, including trucks and buses	0.36M (2015)	0.76M (2025)	–$85	Michigan
Heavy-Duty Vehicle and Locomotive Idle Reduction	Promote and expand the use of technologies that reduce long-term idling, including the use of truck stop electrification	0.01M (2010)	0.02M (2020)	–$44	Montana
Advance Travel Center Electrification	Allow truckers to shut down their truck's engine, and still obtain electrical power and comfort needs without idling				Nevada
Address Vehicle Idling	Implement a robust idling reduction program for all motor vehicles	0.01M (2012)	0.02M (2020)		New Hampshire
Truck Stop Electrification/ Anti-Idling	Develop and implement a statewide ordinance banning idling by heavy-duty vehicles in most situations	0.4M (2012)	0.7M (2020)	$4	New Mexico

Truck Stop Electrification		0.018M (2010)	0.054M (2020)	$37	New York
Idle Reduction/ Elimination Policies	Implement state and local policies to reduce hours of operation and thus emissions from idling trucks and buses (principally), perhaps off-road engines as well	0.1M (2010)	0.2M (2020)	–$4	North Carolina
Idle Reduction Procedure	*Start with an enforceable anti-idling by-law within the community, and a strict emissions testing procedure*				*(City of Durham, NC)*
Idle Restriction	• *Limit idling time* • *Maintain and repair all major off-road equipment for optimum performance*				*(City of Winston-Salem, NC)*
Set and meet goals for reduced truck idling at truck and safety stops	Establish a core network of facilities along the West Coast I-5 corridor that use techniques to enable truck drivers to rest or “overnight” in their sleeper cabs for reducing idling		0.08M (2025)		Oregon
Diesel Anti-Idling Program	Evaluate the costs and GHG emission reductions of reduced heavy-duty truck and school bus idling in Pennsylvania		0.07M (2020)	-$273	Pennsylvania
Anti-idling	*Enforce anti-idling laws*				*(City of Pittsburgh, PA)*
Idle-Reduction Program	School buses, developing no-idle programs for public-sector buildings, and strategies for heavy-duty trucks should be the target for idle reduction programs.				Utah
Anti-idling and truck stop electrification	Increase enforcement of the anti-idling statute and evaluate the cost effectiveness of state funding to accelerate the electrification of truck stops and the adoption of idling avoidance technology				Virginia
Idle Reduction	Limit truck idling at depots, over night rest areas and other long-term parking circumstances. The rule would limit idling to a maximum 5 minutes except under the following circumstances.		0.2M (2020)		Wisconsin
Idling Restriction	*Develop a public education and awareness campaign to limit idling of automobiles/trucks*				*(Miami-Dade County, FL)*
Anti-idling Policies	• *Enforce the citywide Anti-idling and consider expanding it to apply to all vehicles* • *Connect residents and businesses to resources and information for awareness around the environmental effects and costs of idling* • *Consider revising the citywide Anti-Idling Ordinance* • *Continue to provide staff with resources and information to increase awareness around the environmental effects and costs of idling* • *Investigate the feasibility of implementing planned routes that minimize the number of left hand turns as a method to reduce idling for City service vehicles*				*(City of Evanston, IL)*

Anti-idling Policy	• *5-Minute shut-off in municipal trucks* • *Municipal anti-idling policy (more than 5 min.)*	*671*			*(City of Worcester, MA)*
Idling Policy	*Establish a policy that buses staging for more than two minutes should not be idled except in extremely cold weather*	*5,295 (2020)*			*(City of Bellingham , WA)*

Table 17. Speed Limit Reduction and Enforcement.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Speed Reduction	Strict enforcement of existing 65 mph speed limit, support for a study of potential future speed limit reductions, and support and recognition for voluntary measures		0.25M – 0.68M (2020)		Wisconsin
60mph Speed Limit for Commercial Trucks	Reduce speed limit for commercial trucks to 60 mph	0.3M (2010)	0.5M (2020)	$35	Arizona
Reduce Maximum Speed Limits	Reduce maximum speed limits on highways in Minnesota to improve fuel economy and reduce GHG emissions per mile traveled	0.4M (2015)	0.4M (2025)	$50 ($2.40/gal) –$19 ($3.40/gal)	Minnesota
Reduced Speed Limit for Commercial Trucks	Reduced vehicle speeds increase fuel economy, reduce CO2 emissions, and improve safety	0.2M (2012)	0.3M (2020)		New Mexico
Enforce Current Speed Limits for Trucks		0.010M (2010)	0.013M (2020)	$211	New York
Enforce Current Speed Limits-Cars		0.047M (2010)	0.070M (2020)	$26	New York
Enforcement of Traffic Violations	• *Expand the force of Traffic Enforcement Agents* • *Enable all TEAs to issue blocking-the-box tickets* • *Expand the use of traffic enforcement cameras*				*(City of New York, NY)*
Speed Reduction	Part of state's Eco-Driving strategy		1.96M (2020)	$94	Pennsylvania
Stricter Enforcement of Speed Limits	Improve fuel economy, reduce CO2 emissions, and improve safety	0.10M (2012)	0.12M (2020)		South Carolina
Vehicle Speed Reduction	Federal Highway Administration tests of nine vehicles in 1997 found that fuel economy declined on average by 3.1 percent when speed increased from 55 mph to 60 mph and by 8.2 percent increasing from 65 to 70mph.	0.198M (2015)	0.218M (2020)		Utah
Speed Reduction Plan	*Implement traffic-calming and speed reduction strategies reducing unnecessary stops and starts*				*(City of Evanston, IL)*

Table 18. Pay-As-You-Drive Insurance.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Pay-As-You-Drive Insurance	Charge part of vehicle insurance payments from fixed charges to per-mile charges	0M (2010)	2.8M (2020)	$0	Arizona
Pay As You Drive Insurance	A vehicle's insurance premiums are based directly on how much it is driven.	0.007M (2010)	0.38M (2020)		Maine
Pay-as-You-Drive Insurance	Tie consumer insurance costs to actual motor vehicle travel use, so premiums would be directly related to hours or miles driven	1M (2012)	4.3M (2020)	Net Savings	Maryland
Climate-Friendly Transportation Pricing/Pay-as-You-Drive	Encourage drivers to choose transportation alternatives, purchase more efficient vehicles, drive less, and/or drive more efficiently	1.1M (2015)	2.1M (2025)	–$1	Minnesota
Pay-As-You Drive Insurance	Pricing converts a portion of insurance to a variable cost with respect to vehicle travel	2.3M (2010)	5.3M (2020)		North Carolina
Pay-As-You-Drive Insurance	Change the state insurance regulations to allow Pay-As-You-Drive (PAYD) insurance, and initiate and promote an aggressive pilot of PAYD in 2008	0.2M (2012)	1.0M (2020)	$0	New Mexico
Pay-As-You-Drive Insurance	Part of state's Eco-Driving strategy		0.43M (2020)	-$651	Pennsylvania
Pay-As-You-Drive Insurance	Convert a portion of insurance to a variable cost with respect to vehicle travel, so premiums are directly related to mileage	0.20M (2012)	0.32M (2020)	Net savings	Vermont
Pay-As-You-Drive Insurance	Encourage insurance companies to offer pay-as-you-drive insurance as an option to motorists				Virginia
Pay-As-You-Drive Insurance	*Implement a "Pay-As-You-Drive" vehicle insurance demonstration project*				*(King County, WA)*

Table 19. Employer-based Trip Reduction Programs.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed (\$/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Workplace Tools to Encourage Carpooling, Bicycling, and Transit Ridership	Encourage employers to offer a Commuter Benefits program at the workplace to increase the use of transit, ridesharing, and non-motorized transportation	0.3M (2015)	0.4M (2025)	*Large net savings*	Minnesota
Implement Commuter Trip Reduction Initiative	Establish a state-supported initiative to increase the number of employers implementing commuter trip reduction programs				New Hampshire
Expand "Transportation Choices Programs" and "Travel Smart Pilots."	Provide tax credits and technical assistance to businesses that encourage alternatives to driving alone, such as telecommuting (teleworking)			Cost-effective	Oregon
Commuter Choice and Commuter Benefits Programs	Provide options for employees to reduce SOV commutes and GHG emissions	0.12M (2012)	0.43M (2020)	–\$240	South Carolina
Trip Reduction, Rideshare, Vanpool, Telecommuting	Reduce commuter vehicle miles traveled during the peak travel periods, thereby reducing fuel consumption and GHG emissions				Utah
Commuter Choice/ Commuter Benefits	Reduce emissions by focusing on the workplace and reducing SOV commutes	0.06M (2012)	0.19M (2020)	–\$1	Vermont
State Employee VMT reduction	Promote telework and flextime standards for eligible state employees				Virginia
Commuter Tax Credit	Evaluate the costs/benefits of a commuter tax credit, offering businesses tax savings for providing their employees with transportation benefits that provide an alternative to single occupancy vehicle commuting				Virginia
Alternative Transportation	• *Establish creative programs for the City to reduce their travel-related carbon footprint* • *Establish creative programs to encourage carpooling and nonmotorized transportation*				*(City of Homer, AK)*
Flex Working Hours	*Encourage the City employers to provide opportunities for "flex hours," compressed workweek*				*(City of Alameda, CA)*

Support Trip Reduction through Employer-Based Programs	• *Expand employer commute assistance and outreach* • *Implement countywide guaranteed ride home program* • *Conduct general marketing and promotion of commuter services* • *Expand employer transportation management requirements*	*28,000 (2012)*			*(City of San Francisco, CA)*
City Employee VMT Reduction Plans	• *Increase employee carpooling* • *Offer employee telecommuting* • *Increase employee commuters traveling by public transportation/biking/walking*	*7,567*			*(City of Worcester, MA)*
Employee Commuter Program	*Create city employee commuter incentive program*				*(City of Pittsburgh, PA)*

Table 20. Transportation Pricing and Parking Management.

Program	Description	GHG Reduction (MMtCO2e) (Year1)	GHG Reduction (MMtCO2e) (Year2)	Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
Surcharges to Raise Revenue	Vary motor vehicle registration fees by vehicle emissions to provide a surcharge on higher emitting vehicles	1.2M (2010)	2.2M (2020)	–117	North Carolina
Parking Management	*Parking can be discouraged directly, through higher parking fees.*				*(City of Durham, NC)*
Transportation Pricing Recommendations	Increase the effect of pricing to achieve the per capita VMT and GHG emission reductions		1.0M (2020)		Washington
Endorse Congestion Pricing	Slow the growth rate of vehicle miles traveled (VMT); discourage use of less efficient modes (single-occupancy vehicles)	0.005M (2010)	0.023M (2020)	$286	New York
Develop Congestion Pricing Programs	Involve establishing congestion pricing to discourage vehicle use during peak times or along constrained transportation routes.				Utah
Parking Incentives	*Free metered parking for Green Vehicles, 41+ miles to the gallon or an alternative fuel such as propane, compressed natural gas, or electricity*				*(Salt Lake City, UT)*
Develop and Provide Parking Incentives and Management	Provide direction and education at the state level that recognizes the importance of parking management		1.7M[c] (2020)		Washington
Parking Policies	*Increased on-street parking meter prices to $2 per hour in 2008 to encourage drivers to use parking garages or take public transit into downtown. "Smart" meters that charge according to time of day are now being considered.*				*(City of Philadelphia, PA)*
Pay for Parking	*Expand pay-for-parking areas on the Homer Spit, to encourage use of public transportation and help cover the costs*				*(City of Homer, AK)*
Parking Standards	*Revise parking standards that if parking area are appropriately sized and fully utilized, then other alternatives may be more attractive*				*(City of Alameda, CA)*
Alternative Transportation Strategies	*Implement a new transportation mitigation fee to fund alternative transportation priorities*				*(City of Alameda, CA)*
Parking Management	*Manage parking more effectively to minimize driving demand and to encourage and support alternatives*				*(City of Berkeley, CA)*
Discourage Driving	• *Increase the gas tax* • *Implement congestion pricing and cordon tolls* • *Cap or reduce the number of parking spaces* • *Collect parking lot taxes from hotels*	*155,000 (2012)*			*(City of San Francisco, CA)*

Parking Management Plan	*Investigate a City–wide residential parking permit and state-wide registration fee based on a vehicle's GHG emissions*				*(City of Aspen, CO)*
Parking Fee Management	*2 % CO_2e Emission Reduction by 2012* • *Access fee discounts for hybrid taxis*				*(City of Denver, CO)*
Parking Management	*Investigate a payment option for developers in lieu of parking spaces*				*(City of Evanston, IL)*
Efficient Modes of Travel and Transportation	• *Develop design guidelines to reduce the number of parking spaces based on the type of developments* • *Designate free parking areas for hybrid vehicles* • *Develop design guidelines for environmentally friendly parking area designs that manage runoff in an ecologically sensitive manner and that mitigate heat island impacts* • *Construct bicycle stations and facilities to complement parking requirements*				*(City of Albuquerque, NM)*
Congesting Management	*Establish congestion fees*				*(City of Pittsburgh, PA)*
Transit-oriented Development	*Investigate reducing the number of parking spaces provided in developments near transit*				*(City of Evanston, IL)*
Pricing Policy in Transportation	• *Implement a 10 percent commercial parking tax to be phased in over three years* • *Analyze and develop road pricing scenarios and address any legal and implementation issue*				*(City of Seattle, WA)*

Reducing Emissions from Vehicle Fleets

Table 21. Fleet Vehicle/Off-Road Equipment Policies or Incentives.

Program	**Description**	**GHG Reduction (MMtCO_2e)**		**Cost Savings per Ton GHG Removed ($/t$CO_2$e)**	**State (*Local*)**
		(Year1)	**(Year2)**		
SmartWay	Encourage public and private on-road diesel fleets to participate in the EPA SmartWay® Transport Partnership Program.	0.050M (2015)	0.084M (2025)	–$56	Alaska
Heavy-Duty Vehicle Phase Out	Provide incentives to phase out “old” (1988 and older) high-GHG-emitting on-road heavy duty diesel engines	0.025M (2015)	0.0M (2025)	$106	Alaska
Public Fleets	Develop incentives for agencies-managed vehicle fleets to develop and implement plans to reduce GHG emissions	0.016M (2015)	0.037M (2025)		Alaska
Accelerated Replacement/Retirement of High-Emitting Diesel Fleet	Reduce GHG black carbon emissions from heavy-duty diesel vehicles by replacement and retirement of the highest-emitting diesel vehicles	0.2M (2010)	0.03M (2020)		Arizona
Alternative Fuel Vehicles	*Use alternative fuels in 25% of fleet vehicles by 2008; 30% by 2009; 50% by 2010* • *Purchase hybrid replacement vehicles*				*(Pima County, AZ)*
Procurement of Efficient Fleet Vehicles (Passenger and Freight)	Enact state and local agencies’ procurement policies joining the EPA’s Smart Way Program resulting in lower-emitted vehicle fleets				Arkansas
Fuel Efficient Vehicles	• *Develop program to retire older less efficient vehicles* • *Institute policies to match vehicles to ensure that City employees drive only when necessary and use the most fuel-efficient vehicle*				*(City of Homer, AK)*
Vehicle Fleet Incentives and Initiatives	A variety of incentives and initiatives can encourage public and private owners of vehicle fleets to purchase low GHG vehicles.				Connecticut
Light-Duty Vehicle Fuel Efficiency Incentives	Reduce GHG emissions within Iowa by improving the fuel economy of the light duty vehicle fleet by providing incentives	0.44M (2012)	3.65M (2020)		Iowa

Fuel Efficient Operations for Light-Duty Vehicles	Improve the efficiency of light-duty vehicles by increasing the utilization of simple add on devices	0.11M (2012)	0.65M (2020)	-$90	Iowa
Voluntary Fleet Emission Reductions	Measure GHG impact of fleet, review current vehicle mix and vehicle operation parameters, and then analyze options to see where efficiencies can be gained	0.4M (2015)	0.4M (2025)		Minnesota
Procurement of Efficient Fleet Vehicles	Enact procurement policies and/or joining the EPA SmartWay program and utilizing the SmartWay Upgrade Kits that result in adoption of lower emitting vehicle fleets				Montana
Facilitating Widespread Use of Low and Zero Emissions Vehicles	Support state goal of reducing carbon intensity by 10% by 2020.		4.52M (2020)	$138	New Jersey
Clean Fueled Bus Program	Incorporate incremental fleet conversion requirements (i.e. 25% of public transit fleets must include clean-fueled buses by year 2015, 50% by year 2020, and 90% by 2025)				Nevada
Clean Fleets: Emphasize GHGs		0.005M (2010)		$141	New York
Diesel Retrofits	Reduce diesel emissions from older diesel engines and emission systems through retrofit and/or retirement	0.3M (2010)	2.2M (2020)		North Carolina
Encourage Fuel Efficient Vehicles	• *Encourage use of higher fuel efficiency vehicles, especially hybrids, or use alternative fuel such as biodiesel and ethanol* • *Stabilize emissions from off-road engines through programs such as encouraging community members to use rakes and shovels, rather than leaf and snow blowers*				*(City of Durham, NC)*
Alternative Fuel Vehicles	• *Encourage the use of alternative fueled vehicles, hybrid, E85, CNG, and electric vehicles* • *Reduce and conserve fuel from fuel management and vehicle acquisition policy* • *Reduce the size of fleet thru utilization policy*				*(City of Winston-Salem, NC)*
Diesel vehicle retrofit/retirement	Reduce emissions from older diesel engines (e.g., trucks, school buses) through the establishment of a retrofit or retirement program				Virginia
Alternative Fuel Vehicles	*Convert the City's fleet to alternative fuel vehicles, such as biodiesel, electric, and other alternative fuels*				*(City of Alameda, CA)*

Green Fleet	*Green the vehicle fleet used by the City government and increase alternative transportation options for employees of public institutions*				*(City of Berkeley, CA)*
Green the City Fleet.	• *Use fuels or energy sources which emit fewer greenhouse gases, such as electricity/natural gas* • *Create a purchasing policy for acquiring new City vehicles that are more fuel efficient such as hybrids*				*(City of Arcata, CA)*
Decrease Carbon-Intensity of Vehicles	*Encourage people to switch to vehicles with higher fuel economy or cleaner-fueled vehicles and by advocating for state and federal programs and policies that would reduce the carbon-intensity of vehicles*	*129,060 (2020)*	*532,735 (2050)*		*(City of Hayward, CA)*
Alternative Fuels	• *Require 85% of City fleet to be powered by alternative fuels* • *Convert 100% of City refuse collection trucks and street sweepers to alternative fuels* • *Convert 100% of Metropolitan Transportation Authority (Metro) buses to alternative fuel* • *Convert 100% City Department of Transportation (DOT) Commuter Express diesel buses to alternative fuel*	*10,700 (2014)*			*(City of Los Angeles, CA)*
Alternative Fuel Vehicles in Municipal Operations	• *Purchase alternative fueled vehicles in Municipal operations* • *Right sizing and down sizing of the City fleet.*				*(City of San Francisco, CA)*
Increase the Use of Clean Air Vehicles and Improve Fleet Efficiency	• *Lobby for Increased CAFE Standards* • *Support LEV/ZEV Sales Mandates in California* • *Support state-level development of GHG standards* • *Implement tiered vehicle registration fees based on vehicle size or emissions* • *Introduce tiered parking rates based on vehicle size* • *Promote bridge toll and HOV lane waivers for AFV's* • *Lobby regional agencies to open grants for private sector uses* • *Support efforts to expand city carshare* • *Promote and enforce bus idling traffic code*	*641,000 (2012)*			*(City of San Francisco, CA)*

Use of highly Fuel-efficient and Low Emissions Fuel Engines	• *Create City policy that sets a minimum fuel-efficiency for each class/type of vehicle purchased.* • *Require the use of low or no-CO2-e technologies in all City vehicles* • *Maintain EPA's "Best Environmental Practices for Fleet Maintenance."*				*(City of Aspen, CO)*
CTTransit Hybrid Buses	*Replace diesel buses with hybrid buses having even better fuel economy*	*420 (2015)*			*(City of Hamden, CT)*
Fleet Management	*Fuel efficient vehicles*				*(City of Chicago, IL)*
Fleet Management	• *Encourage taxi companies, local shuttle services and school buses to convert to hybrids or other fuel efficient vehicles* • *Consider stricter vehicle maintenance standards* • *Consider collecting odometer readings on vehicle registration applications* • *Continue to replace higher emitting vehicles* • *Ensure that the vehicle purchased "fits" the size of the job that is intended* • *Pool City vehicles as opposed to assigning vehicles to various Departments and Divisions to improve efficiency and reduce the size of the fleet* • *Investigate the feasibility of using car-share vehicles to reduce the size of the City's fleet* • *Continue to retrofit all viable City vehicles with emission reduction technology*				*(City of Evanston, IL)*
Green Fleet Initiative	• *Increase fuel efficiency of vehicle fleet by purchasing vehicles with a higher MPG rating* • *Downsize vehicles* • *Optimize vehicle use* • *Incorporate efficiency into bid specifications* • *Maximize efficiency* • *Eliminate fleet vehicles* • *Buy vehicles that run on alternative fuels* • *Use transit, bike, walk, or telecommute* • *Go with electric drive*				*(City of Worcester, MA)*

Fleet Management	• *Use biodiesel for public transportation and encourage retail stations to supply a biodiesel blend (B5)* • *Undertake an analysis of vehicle usage, and a reduction in fleet size by analyzing existing City of Pittsburgh fleet* • *Incorporate alternative vehicles and/or zipcars into City Vehicle Fleet*				*(City of Pittsburgh, PA)*
Car sharing	• *Philadelphia began using private car-sharing service to reduce number of city-owned cars while serving employee travel needs. Reduced fleet cars by 300 in 2003; 500 additional cars to be eliminated by 2009. City also minimized "take-home" privileges for managers using city-owned cars.*				*(City of Philadelphia, PA)*
Cleaner City Fleets	• *Philadelphia has replaced many city-owned SUVs with sedans and hybrid cars, uses biodiesel fuel in sanitation trucks, and installed filters and diesel oxidation catalysts on other city vehicles to reduce emissions.*			*total savings of $292K in fuel costs*	*(City of Philadelphia, PA)*
Hybrid Diesel Buses	• *SEPTA public transit system will buy 440 hybrid diesel buses over next three years (2009-2012), replacing 60 percent of fleet. Buses that are not replaced will be retrofitted with emission-reducing filters.*				*(City of Philadelphia, PA)*
Alternative Fuel Vehicle	• *Implement biodiesel for fleet vehicles* • *Purchase the most cost-effective and lowest emission vehicle possible*	*981-986*			*(City of Charleston, SC)*
Fuel Efficient Fleet	*Promote the use of alternative vehicles, electric, hybrid, CNG, ethanol, and biodiesel vehicles*				*(City of Chattanooga, TN)*
Alternative Fueled Fleet	• *Converse/purchase for existing fleet, including heavy duty to alternative fuels and technologies* • *Use of 4 bicycles at Regional parks for staff to use instead of trucks*				*(City of Austin, TX)*
Fleet Use and Replacement	• *Replace older, high mileage equipment in order to reduce current and future maintenance costs, increase vehicle reliability, and decrease emissions* • *Expand the use of hybrid vehicles with compact and mid-size sedans* • *Reduce emissions from the city's fleet of nearly 2,800 diesel-powered units by utilizing emerging clean emissions technology*				*(City of Houston, TX)*

Fuel Efficient Fleet	• *Increase the use of various hybrid gas-electric vehicles* • *Increase Utilization of Biodiesel in Municipal Fleet* • *Require the vehicle fuel at least 10% ethanol in gasoline and 5% biodiesel in diesel*				*(City of Bellingham, WA)*
Fleet Management	• *Maximize the use of hybrid-electric, electric and other clean transportation technologies* • *Implement demonstration projects that use electric and hybrid-electric transportation technologies and biofuels, hydrogen, and other clean transportation fuels, to showcase new applications for both public and private sector*				*(King County, WA)*

Table 22. State or Local Agency Lead-by-Example.

Program	Description	GHG Reduction (MMtCO2e) (Year1)	GHG Reduction (MMtCO2e) (Year2)	Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
State Lead-by-Example	Enact procurement policies/join the EPA SmartWay program	0.03M (2010)	0.04M (2020)	$0	Arizona
Alternative Fuel Vehicles for County Fleet	*Use alternative fuels in 25% of fleet vehicles by 2008, 30% by 2009, 50% by 2010* • *Purchase hybrid replacement vehicles* • *Evaluate impact of biodiesel on County fleet/customer fleets, and make decision on feasibility of biodiesel use* • *Create a Green Bike Program*				*(Pima County, AZ)*
Trip Reduction Program	*Achieve a minimum 30% participation rate by FY 2010 in Trip Reduction Program* • *Continue to track County fleet VMTs for developing a success indicator to measure progress* • *Provide web conferencing opportunities to reduce employee VMT*				*(Pima County, AZ)*
Other Measures	• *Develop anti-idling policy* • *Expand marking of County vehicles* • *Right-size fleet (number and size of vehicles; purchase vehicles no larger than necessary to optimize gas mileage)* • *Purchase and install nitrogen tire inflation systems*				*(Pima County, AZ)*
Procurement of Efficient Fleet Vehicles (Passenger and Freight)	Enact state and local agencies' procurement policies joining the EPA's Smart Way Program resulting in lower-emitted vehicle fleets				Arkansas
Fuel Efficient Vehicles	*Develop program to retire older less efficient vehicles*				*(City of Homer, AK)*
Trip Reduction Program	*Institute policies to match vehicles to ensure that City employees drive only when necessary and use the most fuel-efficient vehicle*				*(City of Homer, AK)*
Alternative Transportation	• *Establish creative programs to encourage carpooling and nonmotorized transportation* • *Promote development of a "free bike" and "bike library."*				*(City of Homer, AK)*

Transportation Management Plan	• *Establish anti-idling policies for City vehicles/drivers* • *Establish a car plug-in program to reduce cold engine starts*				*(City of Homer, AK)*
Reduction the Volume of Single Occupancy Traffic	• *Reduce per employee VMT in City vehicles by promoting teleconferencing and the availability of pedestrian and bicycle transit and carpool options for business commutes and trips* • *Continue to encourage City telecommuting and flexible hours policies*	*420 (2007-2009)*			*(City of Aspen, CO)*
CTTransit Hybrid Buses	*Replace diesel buses with hybrid buses having even better fuel economy*				*(City of Hamden, CT)*
Fuel Efficiency	• *Develop a public education and awareness campaign to limit idling of automobiles/trucks* • *Develop a team of local public/private representatives to identify and promote the most practical and cost effective alternative fueled vehicles*				*(Miami-Dade County, FL)*
Fuel efficiency and/or low carbon fuel requirements for government vehicles.	Illinois law requires the state to purchase flex-fuel vehicles and hybrids unless it is not feasible.		0.006M (2015)		Illinois

Reduce City Fleet Vehicle Emissions	• *Continue to replace higher emitting vehicles* • *Ensure that the vehicle purchased "fits" the size of the job that is intended* • *Pool City vehicles as opposed to assigning vehicles to various Departments and Divisions to improve efficiency and reduce the size of the fleet* • *Investigate the feasibility of using car-share vehicles to reduce the size of the City's fleet* • *Offer bicycling and walking within Police and Parking Enforcement* • *Consider revising the citywide Anti-Idling Ordinance* • *Continue to retrofit all viable City vehicles with emission reduction technology* • *Continue to provide staff with resources and information to increase awareness around the environmental effects and costs of idling* • *Achieve Platinum level membership in Clean Air Counts* • *Investigate the feasibility of implementing planned routes that minimize the number of left hand turns as a method to reduce idling for City service vehicles*				*(City of Evanston, IL)*
Low GHG Fuel for State Fleets	Maximize use of non-petroleum, renewable fuel or other low GHG-fuels for State Fleets where feasible	0.02M (2010)	0.16M (2020)	$10	Maine
Anti-Idling	*5-Minute shut-off in municipal trucks*	*671*			*(City of Worcester, MA)*
Increase Fuel Efficiency of a Vehicle Fleet	*Increase fuel efficiency of vehicle fleet by purchasing vehicles with a higher MPG rating*	*224*			*(City of Worcester, MA)*
Alternative Transportation	• *Increase employee carpooling* • *Offer employee telecommuting* • *Increase employee commuters traveling by public transportation/biking/walking*	*7,667*			*(City of Worcester, MA)*
Evaluate the GHG Emissions from Major Projects	Require State agencies to conduct an evaluation of the resulting transportation and land use GHG emissions related to State and local major capital projects such as major road construction or modifications, and State capital investments in new buildings	NA	NA		Maryland
Transportation Planning	• *Educate city planners in non-motorized transportation planning principles* • *Promote the use of non-motorized transportation, carpooling and transit to citizens and employees*				*(City of Durham, NC)*

Low-GHG Operation of State Fleet Vehicles	Reduce GHG emissions due to operation of state-owned vehicles by enacting legislation, and require that the State increase its use biofuels in the fleet of State vehicles				New Mexico
Clean Fueled Bus Program	Incorporate incremental fleet conversion requirements (i.e. 25% of public transit fleets must include clean-fueled buses by year 2015, 50% by year 2020, and 90% by 2025)				Nevada
State Fleets Alternative Fuel Cars	Many alternative fuels, such as biodiesel, E-85 ethanol, and hybrids have the potential to significantly reduce greenhouse gas emissions				Nevada
Reduce GHG emissions through changes in government fleet purchase and vehicle use	Public fleets can lead by example in implementing effective purchasing policies and best maintenance practices				Oregon
State and local governments should switch to “clean diesel” fuel, vehicle purchases and retrofits	Promote voluntary retrofit of diesel engines in both on- and off-highway situations		0.10M (2025)	Cost-effective	Oregon
Government Owned And Private Fleet-Vehicle Efficiency Initiative	Adopt “green fleet” policies, including optimizing efficiency of use, purchasing cleaner vehicles		<0.025M (2020)	-$22 - -$32	Rhode Island
Short Term Strategies	• *Install bike racks at city buildings and create a bike program* • *Use biodiesel for public transportation and encourage retail stations to supply a biodiesel blend (B5)* • *Encourage employee transit use*				*(City of Pittsburgh, PA)*
Medium-Term Strategies	• *Undertake an analysis of vehicle usage, and a reduction in fleet size by analyzing existing City of Pittsburgh fleet* • *Incorporate alternative vehicles and/or zipcar into City Vehicle Fleet*				*(City of Pittsburgh, PA)*
Long-Term Strategies	*Create city employee commuter incentive program*				*(City of Pittsburgh, PA)*

Alternative Fuel Vehicle	*Implement biodiesel for fleet vehicles*	*971*			*(City of Charleston, SC)*
Green Fleets	*Purchase the most cost-effective and lowest emission vehicle possible*	*10-15*			*(City of Charleston, SC)*
Vehicle Conversion and non-motorized Transportation	*Converse/purchase for existing fleet, including heavy duty to alternative fuels and technologies*				*(City of Austin, TX)*
Fleet Use and Replacement	*Replace older, high mileage equipment in order to reduce current and future maintenance costs, increase vehicle reliability, and decrease emissions*				*(City of Houston, TX)*
The Mayor's Hybrid Initiative	*Expand the use of hybrid vehicles with compact and mid-size sedans*				*(City of Houston, TX)*
Emerging Technology	*Reduce emissions from the city's fleet of nearly 2,800 diesel-powered units by utilizing emerging clean emissions technology*				*(City of Houston, TX)*
State Fleet Lead by Example	The State should lead by example in the purchase of low-carbon fuels and vehicle technologies.				Utah
VMT Reduction	Promote its telework and flextime standards for eligible state employees				Virginia
Hybrid Vehicles	*Increase the use of various hybrid gas-electric vehicles*	*665 (2020)*			*(City of Bellingham, WA)*
Commute Trip Reduction Program	*Conduct the City employee commuter survey, and reduce in vehicle miles traveled (VMT) per employee*	*43 (2020)*			*(City of Bellingham, WA)*
Biodiesel	• *Switch from fossil fuels to agriculturally based fuels* • *Increase Utilization of Biodiesel in Municipal Fleet* • *Require the vehicle fuel at least 10% ethanol in gasoline and 5% biodiesel in diesel*	*618 (2020)*			*(City of Bellingham, WA)*
Climate-Friendly Modes of Transportation	• *Provide multiple incentives (Free rides on Metro Transit buses, a vanpool fare subsidy, etc.) for employees to use alternative transportation* • *Expand and encourage use of alternative modes of transportation such as public transit, carpooling, car-sharing, bicycle and pedestrian trails, sidewalks and non-motorized travel*				*(City of Bellingham, WA)*
Transportation Fuels and Technologies	• *Maximize the use of hybrid-electric, electric and other clean transportation technologies* • *Maximize the use of clean transportation fuels*				*(King County, WA)*

Government Fleet Adoption of Plug-in Hybrid Electric Vehicles	Legislation for achieving: (1) reduction in consumption of non-renewable motor fuels; and (2) reduction in the emission of green house gases (GHG), particularly CO2.		0.001M (2020)		Wisconsin
Alternative Transportation Strategies	*Charge staff to engage actively with federal, state and regional organizations to secure capital and operating funding for sustainable transportation*				*(City of Alameda, CA)*
Alternative Fuel Vehicles	*Convert the City's fleet to alternative fuel vehicles, such as biodiesel, electric, and other alternative fuels*				*(City of Alameda, CA)*
Flex Working Hours	*Encourage the City employers to provide opportunities for "flex hours," compressed workweek and telecommuting schedules to reduce VMT*				*(City of Alameda, CA)*
Make Public Transit	*Provide passes and shuttles to transit to encourage use of alternative transportation by City employees*	*11 (2020)*			*(City of Albany, CA)*
Municipal Transportation	*Reduce municipal fleet related emissions 20% by 2020* • *Establish mandatory criteria for new fleet vehicles* • *Municipal bicycle program*				*(City of Benicia, CA)*
Green Vehicles	*Green the vehicle fleet used by the City government and increase alternative transportation options for employees of public institutions*				*(City of Berkeley, CA)*
Alternative Fuels	• *Require 85% of City fleet to be powered by alternative fuels* • *Convert 100% of City refuse collection trucks and street sweepers to alternative fuels* • *Convert 100% of Metropolitan Transportation Authority (Metro) buses to alternative fuel* *Convert 100% City Department of Transportation (DOT) commuter express diesel buses to alternative fuel*	*10,700 (2014)*			*(City of Los Angeles, CA)*
Alternative Fuel Vehicles in Municipal Operations	• *Purchase alternative fueled vehicles in municipal operations* • *Right sizing and down sizing of the City fleet*				*(City of San Francisco, CA)*
Promoting Transit and Carpool Program	*Provide transit and carpool incentives to City employees, including alternate work schedules and telecommuting opportunities*	*155 (2012-2013)*			*(City of San Rafael, CA)*
Idling Reduction	*Adopt a policy to limit City vehicle idling where practical. Evaluate equipping trucks with an auxiliary electrical system for illumination and warning signs*	*190 (2009-2011)*			*(City of San Rafael, CA)*

Table 23. Marine and Aviation-based Strategies.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Marine Vessel Efficiency Improvements	Promote efficiencies and conservation options for commercial and recreational fishing, marine tourism, and other forms of marine transportation.	0.012M (2015)	0.032M (2025)	$76	Alaska
Aviation Emission Reductions	Support modernization of the air traffic management system, identify existing/new operational best practices, and promote alternative fuels for aviation				Alaska
Reduced GHG Emissions from Aviation	Encourage the federal government to take actions to reduce GHG emissions from the aviation portion of the transportation sector				Montana
Airport Ground Equipment	Total emissions attributed to ground support equipment (GSE), ground-access vehicles, and aircraft comprise about two to three percent of total emissions for a typical metropolitan area.	0.050M (2010)		$120	New York
Fleet Management	• *Right-size fleet (number and size of vehicles; purchase vehicles no larger than necessary to optimize gas mileage)* • *Purchase and install nitrogen tire inflation systems*				*(Pima County, AZ)*
Airport shuttle Improvement	*Expand FlyAway shuttles serving Los Angeles International Airport and other regional airports, and convert existing FlyAway buses to alternative fuels*	*215*			*(City of Los Angeles, CA)*
Airport Bus Service	*Investigate the feasibility of establishing a regular bus service to O'Hare Airport*				*(City of Evanston, IL)*
Enhanced Intercity Transportation	• *Support improvements at Louis Armstrong New Orleans International Airport and to interregional passenger rail infrastructure* • *Invest in port and freight transportation infrastructure and operations*				*(City of New Orleans, LA)*
Increase Number of Hybrid or CNG Taxis at Airport	• *Philadelphia International Airport and city's Air Management Services researching a preferred queuing option for hybrid or alternative fuel taxis at the airport; would benefit these taxis by reducing wait time and enabling them to carry more passengers per day.*				*(City of Philadelphia, PA)*

Incentive and Voluntary Programs

Table 24. Passenger Vehicle Incentives.

Program	Description	GHG Reduction (MMtCO2e) (Year1)	GHG Reduction (MMtCO2e) (Year2)	Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
Hybrid Promotion and Incentives	A combination of public education and information and financial incentives to promote the sales of light-duty vehicles with hybrid gasoline engine				Arizona
Feebates	A fee on relatively high emissions/lower fuel economy and a rebate on low emissions/higher fuel economy vehicles				Arizona
Fuel Efficiency: Clean Car Incentive	Paying disincentives to those who purchase new vehicle of less fuel-efficient				Arkansas
GHG Feebate Program	Incentives and disincentives to induce consumer buying practices that reflect the negative externalities associated with the purchase of a motor vehicle.	0.036M (2010)	0.109M (2020)	-$166.70 (2010)	Connecticut
Incentives for Fuel Efficient Vehicles	Encourage the purchase of more fuel efficient vehicles.		1.5M - 4.5M (2020)		Illinois
GHG Feebates	A fee on purchases of relatively high-emitting (more CO2 per mile) vehicles and would receive a rebate on the purchase of relatively low-emitting, higher efficiency vehicles	0.004M (2010)	0.02M (2020)	$0	Maine
Incentives, Pricing and Resource Measures	Encourage wise stewardship when consumers make transportation choices	2.7M (2012)	4.7M (2020)	Net Savings	Maryland
Financial and Market Incentives for Low GHG Vehicle Ownership and Use	Create incentives and disincentives for the purchase and operation of vehicles with varying fuel economy				Montana
Clean Fuels and Clean Vehicle Incentive Program	Purchase or lease new technologies/low emission vehicles such as electric hybrid and advanced fuel cell (hydrogen powered) vehicles reduce greenhouse gas emissions generated by light-duty automobiles and trucks in Nevada				Nevada

Create a Point-of-Sale Financial Incentive for High-Efficiency Vehicles	Create a new vehicle point-of-sale “feebate,” that provide financial incentives to purchase vehicles for high in fuel-efficiency and low in GHG emissions, accompanied by financial disincentives to purchase low-efficiency, high-CO2-emitting vehicles	0.23M - 0.34M (2012)	0.73M - 1.07M (2020)		New Hampshire
Incentive/ Disincentive Options Bundle	Study and develop policy options that create incentives for the purchase and operation of vehicles that emit low levels of GHGs				New Mexico
Vehicle Sales Tax Credit		0.005M (2010)	0.007M (2020)	$633	New York
Rebates/Feebates to Change Fleet Mix	Charge or rebate a sliding scale of fees and rebates for new light-duty vehicles based on their environmental impacts	0M (2010)	< 0.5M (2020)	–$40 to +$10	North Carolina
Review and enhance state tax credits and local incentives for citizens purchasing high efficiency vehicles	Review and consider modifying the Business Energy Tax Credit and the Residential Energy Tax Credit programs to ensure that they are effectively promoting the purchase of more fuel-efficient vehicles				Oregon
Adopt state and local incentives for high efficiency vehicles	Shift the amount drivers pay to title and register their cars in a revenue neutral manner, raising the $55 title transfer fee and $27 per year registration fee for cars with below average MPG and lowering the fees for more efficient vehicles			Cost-effective	Oregon
Feebates	Part of Eco-Driving Program		0.41M (2020)	-$320	Pennsylvania
Local Fuel Economy Improvements (Feebate) Initiative	Take the form of tax incentives to vehicle owners to purchase vehicles with higher than average fuel economy		0.125M (2020)	-$22 - -$32	Rhode Island
Tax Credits for Efficient Vehicles	Improve tax incentives in place for alternative-fuel and energy efficient vehicles	0.02M (2012)	0.12M (2020)	$359	South Carolina
Fuel efficient vehicle incentives	Enact state incentives for the purchase of fuel efficient vehicles, regardless of energy source		4M		Virginia
Incentives for Electric, Hybrid and Plug-In Hybrid Electric Vehicles	Provide education and incentives for purchasing Hybrid Electric Vehicles (HEV), Plug-in Hybrid Electric Vehicles (PHEV) and Electric Vehicles (EV)		0.3M (2020)		Wisconsin
Climate-Friendly Modes of Transportation	*Provide multiple incentives (Free rides on Metro Transit buses, a vanpool fare subsidy, etc.) for employees to use alternative modes of transportation*				*(King County, WA)*

Promote Energy Savings	*Encourage ownership of plug-in electric vehicles, as they become available and in use, by providing charging stations in City garages and parking lots, consider requirements for charging stations in newly constructed private parking facilities, and participate in regional efforts to encourage widespread availability of charging stations*	*130 (2012-2013)*			(City of *San Rafael, CA)*

Table 25. Education and Outreach Programs.

Program	Description	GHG Reduction (MMtCO2e)		Cost Savings per Ton GHG Removed ($/tCO2e)	State (*Local*)
		(Year1)	(Year2)		
Promotion of Alternative-Fuel Vehicles	Replacement of existing light-duty vehicle fleets with Alternative-Fuel Vehicles (AFVs), and informing the public of the benefits of purchasing AFVs and providing incentives	0.026M–0.084M (2015)	0.054M–0.173M (2025)	$135 – $740	Alaska
Public Education	Informing the public of the measures individuals can take to reduce the transportation-related GHG emissions				Arkansas
Public Education Initiative on Transportation	Raise public awareness about the benefits of low GHG vehicles				Connecticut
Fuel-Efficient Driving Practices	"Smart driving"—changing driving behavior and vehicle maintenance practices to improve mpg	3.0M[a] (2020)			Massachusetts
Eco-Driver Program	Help drivers maximize the fuel efficiency from their existing vehicles by better understanding the direct impact that driving style, driving patterns, vehicle technologies, and vehicle maintenance have on a vehicle's fuel economy	1.1M (2015)	2.2M (2025)	–$176	Michigan
Consumer Information on Vehicle Miles Per Gallon (MPG)	Provide consumers with information about the fuel efficiency and cost in relation to the purchase, maintenance, and operation of their vehicles				Montana
Reduce GHG Emissions from Motor Vehicles	The Center for Climate Strategies has estimated that Nevada's gasoline and diesel derived transportation GHG emissions in 2005 was 11.5 million metric tons of CO2e. Reductions in these emissions can be realized through consumer and driver education and smart vehicle purchases.				Nevada
Driver Training	Driver outreach and training regarding driving habits that reduce emissions.	0.023M (2010)		$62	New York
Vehicle Maintenance	Public education program.	0.028M (2010)		-$143 - $186	New York
Establish a consumer awareness education link to transportation choices					Oregon

Eco-Driver training	Part of Eco-Driver outreach program		0.62M (2020)	-$206	Pennsylvania
Tire Inflation	Part of Eco-Driver outreach program		0.09M (2020)	-$282	Pennsylvania
"Buy Local" Program	Reduce vehicle miles traveled and associated GHG emissions through the encouragement of consumers to buy locally-produced goods				Utah
Education Program	Focus on transportation, including, but not limited to vehicle choice, transit options, vehicle maintenance, driving habits/speeding/idling, and proper tire inflation				Utah
Vehicle Emissions Reductions Incentives	Purchasers of the most efficient vehicles, such as hybrids, would receive the largest incentives; those purchasing the least efficient vehicles, such as large SUVs, would pay the highest fees	0.11M (2012)	0.63M (2020)	–$10	Vermont
Public Outreach	Explore ways to send consumers better, more accurate signals of the costs of transportation				Virginia
Public Outreach	Promote efforts to educate all drivers, including those taking driver education, about behavioral changes that can significantly boost energy efficiency				Virginia
Education for County Employees on VMT Reduction	• *Expand Driver Energy Conservation Awareness Training* • *Educate County employees about green fleets and the impact of vehicles on the environment and the community*				*(Pima County, AZ)*
Education	• *Expand Driver Energy Conservation Awareness Training* • *Educate County employees about green fleets and the impact of vehicles on the environment and the community*				*(Pima County, AZ)*
Eco-Driving	*Educate to Discourage Driving and Create Incentives to Lessen Driving*				*(City of Arcata, CA)*
Education	*Educate and encourage businesses and residents to limit vehicle idling*				*(City of San Rafael, CA)*
Eco-driving Education	*Educate all employees on fuel-efficient driving practices*				*(City of Aspen, CO)*
Public Education	*Educate on energy-saving measures and emission reduction opportunities*				*(City of Winston-Salem, NC)*

Public Education	• *Provide education and easy-to-use tools that support transit ridership, such as an Internet-based trip planning service* • *Implement a public education effort regarding the pedestrian and bicyclist network* • *Public education and outreach regarding mass transportation use and options* • *Provide information about alternative fuels and their benefits* • *Educate and reassure parents on the benefits of children walking to school* • *Promote bicycle education in the schools* • *Educate the public about trails and bicycle routes* • *Provide public information about driver and bicyclist etiquette* • *Educate the public about the benefits of alternative vehicle use* • *Provide vehicle maintenance training for the public*				*(City of Albuquerque, NM)*
Travelwise School Curriculum Project	*Educate on an elementary school curriculum about how to analyze the consequences and sustainability of travel choices*				*(Salt Lake City, UT)*

[a]Combined benefit with Vehicle Efficiency strategy, listed in Table 1.

Appendix B – Selection Criteria for State GHG Mitigation Strategies

State	Selection Criteria
Alaska	• GHG reduction potential • Cost effectiveness • Potential co-benefits • Potential feasibility issues
Arizona	• Net GHG reduction potential • Net cost per metric ton reduced • Geographic inclusion • Direct vs. Indirect Effects • Non-GHG impacts and costs • Discounted and "Levelized" Costs • Time period of analysis • Aggregation of impacts • Policy design specifications • Transparency
Arkansas	• GHG reduction potential • Cost effectiveness • Potential co-benefits • Potential feasibility issues • Projected costs of delayed actions
California	• Implementation steps, • Timeline, • Estimated potential emission • reductions and costs • Broad coverage • Flexibility • Economic assesment • Impact on low-income and minority community
Colorado	• GHG reduction potential • Cost effectiveness • Co-benefits • Feasibility issues
Connecticut	• Expected GHG Reductions • Expected Cost per Ton GHG • Estimated CoBenefits
Florida	• GHG reduction potential • Cost effectiveness • Externalities (Co-Benefits or co-costs) • Feasibility issues
Illinois	• Emissions Impacts • Economic Impacts

State	Selection Criteria
Iowa	• Estimates of GHG Reductions • Estimates of Costs/Cost Savings • Additional Costs and Benefits
Maine	• Carbon Savings Potential • Costs / savings: • Potential for reducing GHG emissions
Maryland	• Cost-effectiveness • Co-benefits • Feasibility
Massachusetts	• Cost-effective GHG reductions; • Lowering costs for • consumers • Increasing energy independence • Promoting a clean energy • economy • Providing equity in costs and benefits • Seizing opportunities for • economic development • Capitalizing on • the Commonwealth's strategic advantages • Creating complementary policies
Michigan	• GHG reduction potential • Cost-effectiveness • Co-benefits • Feasibility issues.
Minnesota	• GHG reduction potential • Cost-effectiveness • Co-benefits • Feasibility issues
Montana	• GHG reduction potential • Cost effectiveness
North Carolina	• GHG reduction potential • Cost effectiveness
New Hampshire	• CO2 Emissions Reduction • Economic Impact • Timing of Economic Impact • Parties Economically Impacted
New Jersey	• Net reduction in GHG emissions • Significant reductions in GHGs relative to the cost • Reduce energy use; • Co-benefits to the State, • GHG reduction potential • Cost effectiveness

State	Selection Criteria
New Mexico	• GHG reductions • Cost effectiveness • Contributing issues • Cost • Benefits • Ancillary impacts • Feasibility issues
New York	• Cost effectiveness • GHG impact • Ancillary impacts • Economic development effects • Compatibility with other programs • Feasibility • Equity effects
Oregon	• Greenhouse gas savings • Feasibility • Cost effectiveness
Pennsylvania	• Potential GHG Reductions • Economic Costs:
Rhode Island	• Carbon reductions • Cost effectiveness • Co-benefits
South Carolina	• GHG reduction potential; • Cost effectiveness • Co-benefits • Feasibility
Utah	• CO2 reduction potential • Cost savings • Associated energy security and air quality benefits
Virginia	• GHG Reductions • Cost Effectiveness
Washington	• Actual net reduction in GHG emissions. • Reductions that would occur regardless of an offset market • Verifiable • Permanent • Enforceable
Wisconsin	• Estimated Greenhouse Gas Emissions Reduction • Estimated Costs

Appendix C—Quantification Methods of Interest

TTI research scientists, in consultation with HGAC staff, selected nine GHG control strategies for further analysis in a project to develop a methodology for determining GHG mitigation strategies. Generic estimation methodologies have been developed for the strategies that would allow for GHG reductions to be calculated based on user inputs. Depending on the type of strategy, the inputs may be for a region (such as a county) or for a specific transportation facility. The estimation of some of the control strategies, such as HOV projects, transit projects, highway capacity addition projects, and mixed-use developments ("livable centers") enable specific projects listed in HGAC's RTP to be evaluated where sufficient project-level data is available. Default inputs, which include the MOVES model emissions rates for the HBG region and other assumptions, are included, and may be changed by the user if desired.

This appendix describes each of the strategies analyzed, provides information about the quantification of GHG emissions reduction attributable to the strategy, the scope of implementation, assumptions made, and default data used as part of the analysis tool. Note that while the analysis tool and methods focus on GHG control strategies, in the case of certain strategies (such as highway capacity addition or signal retiming), there is a possibility of a strategy resulting in increased CO_2 emissions in the case of a particular combination of input conditions. In such cases, the methodologies described will result in a "negative" CO_2 emissions reduction as the output of the quantification process, which denotes an increase in emissions.

Strategy 1: Implementation of Anti-Idling Policy

This strategy considers the implementation of an anti-idling policy targeting local heavy-duty fleets (i.e., short-haul truck fleets). The reduction of emissions is evaluated by considering the effect of placing restrictions on idling time, for example, the implementation of a "five minute" idle restriction, which would reduce the overall time these vehicles idle, and consequently, the associated emissions.

This strategy can be applied at a regional level (e.g., a county) and requires identifying a target fleet (e.g., short-haul diesel trucks) and knowledge of compliance and existing idling levels. The levels of compliance, number of target vehicles, and average idling time per vehicle prior to implementation of an idling restriction vary significantly from one county to another; however, many counties in Texas such as Bastrop, Caldwell, Hays, Travis, and Williamson allow a maximum idling time of 5 minutes from April to October.[43]

General Quantification Approach

Equations 1 through 3 show the general quantification of the impact of this strategy.

Daily Emission Reduction (gram/day) = $A \times B$ *(1)*

$$A = N_V \times F_C \quad (2)$$

$$B = EF_I \times (t_B - t_A) \quad (3)$$

Where,

EF_I = Idling emissions factor, i.e., CO_2 emissions rate for the target fleet (gram/hour);

N_V = Number of vehicles in the target fleet found to idle per day (vehicles per day);

F_C = Compliance factor, i.e. percentage of vehicles in compliance with the strategy (percentage);

t_A = Time vehicles are allowed to idle under new restriction (hours per vehicle); and

t_B = Average idling time per vehicle prior to implementation of restriction (hours per vehicle).

Implementation in Analysis Tool

Required inputs for this strategy include:

- Number of target vehicles (vehicles per day);
- Average idling time per vehicle prior to implementation of restriction (hours per vehicle);
- Time vehicles are allowed to idle under new restriction (hours per vehicle); and
- Compliance factor (percentage)

Optional inputs are the idling emissions factor (grams/hour), which may be input by the user if desired. Currently, default values from the MOVES model for single-unit short-haul trucks are provided for two evaluation years 2011 and 2040. These defaults may be changed to target different vehicle types or different analysis years.

The output of this strategy is expressed in the CO_2 emissions reductions in gram per day (or ton per day).

Strategy 2: Idle Reduction for Long-Haul Trucks

This strategy can reduce emissions by reducing the extended idling of long-haul trucks during mandatory rest periods. The estimation of this is based on usage of electrified parking spaces (i.e., truck stop electrification, TSE) or auxiliary power units (APUs) as an alternative to idling the truck engine. This strategy can be applied to all truck stops at a regional or county level. The target fleet is heavy-duty diesel long-haul trucks. TTI has performed previous research on utilization of truck spot parking spaces, including those with and without TSE. Average occupancy rates of parking spaces with and without TSE are 0.27 and 0.50 according to a TTI study[44], and these values are used as suggested defaults in the analysis tool.

General Quantification Approach

Equations 4 through 6 shows the general quantification of the impact of this strategy.

$$\text{Daily Emission Reduction} = A + B \qquad (4)$$

$$A = 24 \times N_1 \times AVR_1 \times P_{APU} \times (EF_I - EF_{APU}) \qquad (5)$$

$$B = 24 \times N_2 \times EF_I \qquad (6)$$

Where,

AVR_1 = Average daily utilization of parking spaces without TSE (percentage);

AVR_2 = Average daily utilization of parking spaces with TSE (percentage);

EF_I = Idling emissions factor for trucks (gram/min);

EF_{AUP} = Emissions factor of using APU (gram/min);

N_1 = Number of parking spaces without TSE;

N_2 = Number of parking spaces with TSE; and

P_{AUP} = Percentage of vehicles in non-TSE spaces using APU (percentage).

Implementation in Analysis Tool

Required inputs for this strategy include:

- Number of available parking spaces with and without TSE;
- Average daily utilization of parking spaces with and without TSE; and
- Percentage of vehicles in non-TSE spaces using APU.

Optional inputs are emission factors for truck idling and for APU (gram/min), which may be input by the user if desired. Note that no emissions are associated with the use of TSE. Currently, default values of emissions factors for idling from the MOVES model for combination long-haul trucks are provided for two evaluation years – 2011 and 2040. Default values of emissions factors for APU are based on a TTI study for the HARC.[45] These defaults may be changed to target different analysis years.

The output of this strategy is expressed in the CO_2 emissions reductions in gram per day (or ton/day).

Strategy 3: Vehicle Fleet Electrification

This strategy considers the potential impact of increasing the market share of electrified vehicles (hybrids, plug-in hybrids or fully-electric vehicles) over and above the projected fleet penetration levels through implementation of a marketing/incentive program. This strategy can be applied at a regional level. The quantification of emissions reductions is attributed to reduced emissions rates of these vehicles in comparison with the fleet averages. Emission factors of electrified vehicles vary significantly depending on the vehicle make and the electrification type. For example, as a typical hybrid vehicle, the fuel efficiency of 2011 Toyota Prius is 50 miles per gallon (mpg)[46], and the corresponding emission rate is 176 grams/mile; as a typical plug-in hybrid vehicle, the fuel efficiency of 2011 Chevrolet volt can reach 93 mpg, and the corresponding emissions rate is 94 grams/mile. These recommended values may be used in the calculations in the absence of specific emissions data.

General Quantification Approach

Equations 7 through 9 show the general quantification of the impact of this strategy.

Daily Emission Reduction = $A \times B$ *(7)*

$$A = N_E \times VMT_{AVE} \quad (8)$$

$$B = EF_B - EF_A \quad (9)$$

Where,

EF_A = Emissions factor after replacement (i.e., for a representative "electrified" vehicle – this value would be zero for purely electric vehicles, but will have a value for hybrids or PHEVs; gram/mile);

EF_B = Emissions factor before replacement – i.e., average emissions factor for a Light-duty vehicle in the fleet (gram/mile);

N_E = Number of electrified vehicles considered to replace existing passenger cars due to incentives/programs put in place (i.e., over and above levels that are ordinarily projected and included in the MOVES model or other emissions rates); and

VMT_{AVE} = Average daily VMT per vehicle (mile).

Implementation in Analysis Too

Required inputs for this strategy include:

- Number of electrified vehicles considered to replace existing passenger cars due to implementation of specific incentives/programs;
- Average daily VMT per vehicle (mile); and
- Emissions factor after replacement (gram/mile) – in the case of a mix of vehicles being considered (for example, hybrids and electric vehicles), a weighted average value may be used.

Optional inputs are emissions factors before the replacement (gram/mile), which can be input by the user, or can be calculated from look-up tables by selecting the roadway type (1 represents arterial; 2 represents freeway), and speed (from 5 to 75 mph) most representative of the vehicles' operation. The emissions look-up table is developed using the MOVES model for passenger cars in the evaluation year of 2011 and 2040. Currently, the road type is assumed to be arterial, and the speed 60 mph. These defaults may be changed to target different vehicle types or different analysis years.

The output of this strategy is expressed in the CO_2 emissions reductions in gram per day (or ton/day).

Strategy 4: Transit Facilities

This strategy considers the expansion of existing transit facilities or service, or introduction of new service, including bus, rail, or paratransit. The emissions reductions are attributed to the VMT reduced by transit users who were originally automobile users. This strategy can be applied to selected projects listed in the RTP, or quantified at a regional level. This strategy will require knowledge of the new transit ridership and the percentage of those new users that previously were automobile drivers. This percentage varies significantly from city to city; for example, it is as low as 60 percent in Washington D.C., but it can reach 100 percent in Denver.[47]

General Quantification Approach

Equations 10 through 12 show the general quantification of the impact of this strategy.

Daily Emission Reduction = $VMT_R \times EF_B$ *(10)*

$$VT_R = N_{TR} \times F_{T,SOV} \quad (11)$$

$$VMT_R = VT_R \times T \quad (12)$$

Where,

EF_B = Emissions factor for passenger cars on affected roadway or region before implementation of transit service (gram/mile);

$F_{T,SOV}$ = Percentage of users of new/expanded transit services that previously were automobile drivers (percentage);

N_{TR} = New transit ridership (person/day);

L = Average auto trip length (mile)'

VMT_R = Reduction in daily automobile VMT (VMT/day); and

VT_R = Reduction in number of daily automobile vehicle trips (trip/day).

Implementation in Analysis Tool

Required inputs for this strategy include:

- New transit ridership (person/day); and
- Percentage of users of new/expanded transit services that previously were automobile drivers (percentage).

Optional inputs are emissions factors for passenger cars (gram/mile) and the average trip length (mile) for passenger cars, which can be input by the user, or can be calculated from look-up tables by selecting the roadway type (1 represents arterial; 2 represents freeway), and speed (from 5 to 75 mph) most representative of the vehicles' operation. The emissions look-up table is developed using the MOVES model for passenger cars in the evaluation years of 2011 and 2040. Currently, the road type is assumed to be arterial, and the speed 60 mph. These defaults may be changed to target different analysis years. The 8.6 mile average trip length is provided by a previous HGAC livable center project.[48]

The output of this strategy is the emissions reduction in gram/day (or ton/day).

Strategy 5: High Occupancy Vehicle (HOV) Facilities

This strategy considers HOV facilities – separate lanes on controlled access highways are created for vehicles containing a specified minimum number of passengers. In this case, emissions reductions computed are based on reduced VMT due to increased occupancy. This strategy can be applied to existing HOV facilities or planned facilities as contained in RTP.

General Quantification Approach

Equation 13 shows the general quantification of the impact of this strategy.

Daily Emission Reduction = $EF \times L \times N_p \times (AVO_A - AVO_B)/AVO_A$ *(13)*

Where,

AVO_A = HOV occupancy requirement (person/vehicle);

AVO_B = Existing average passenger car occupancy (person/vehicle);

EF = Emissions factor for passenger cars (gram/mile);

N_P = Total number of vehicles using/expected to use HOV lanes (vehicle per day); and

L = Length of HOV facility (mile).

Implementation in Analysis Tool

Required inputs for this strategy include:

- Total number of vehicles using/expected to use HOV lanes (vehicle per day);
- Length of HOV facility (mile);
- Existing average passenger car occupancy (person/vehicle); and
- HOV occupancy requirement (person/vehicle).

Optional inputs are emissions factors for passenger cars (gram/mile) and the average trip length (mile) for passenger cars, which can be input by the user, or can be calculated from look-up tables by selecting the roadway type (1 represents arterial; 2 represents freeway), and speed (from 5 to 75 mph) most representative of the vehicles' operation. The emissions look-up table is developed using the MOVES model for passenger cars in the evaluation years of 2011 and 2040. Currently, the road type is assumed to be freeway, and the speed 70 mph. These defaults may be changed to target different vehicle types or different analysis years.

The output of this strategy is the emissions reduction in gram/day (or ton/day).

Strategy 6: Mixed-Use Developments

Mixed land uses can reduce vehicle trips through "internal trip capture" by locating various land uses adjacent to each other. This measure can be applied to "livable centers" being planned in the Houston-Galveston area, or to other planned or existing mixed-use developments. The estimation method for internal trips comes from Institute of Transportation Engineers (ITE) recommendations.[49] In addition, the calculation process adopts trip generation rates in a recently (*48*) and internal capture rates in (*49*). Advanced users can also modify these rates in the calculation sheet.

General Quantification Approach

- Step 1- Document Characteristics of Multi-Use Development (three use types).
- Step 2 - Compute Baseline Trip Generation for Individual Land Uses (based on size/number of units and standard trip generation rates).
- Step 3- Estimate Anticipated Internal Capture Rate between Each Pair of Land Use.

- Step 4 -Estimate “Unconstrained Demand” Volume by Direction.
- Step 5 -Estimate “Balanced Demand” Volume by Direction.
- Step 6 - Estimate the Internal and External Trips for Each Land Use.
- Step 7 -Estimate the reduction of VMT and translate to emissions (i.e., emissions reduced = daily trips reduced x average trip length x emissions factor).

Implementation in Analysis Tool

Required inputs for this strategy include:

- Area of office land use (square foot);
- Area of retail land use (square foot); and
- Units of residential land use.

Optional inputs are emissions factors for passenger cars (gram/mile) and the average trip length (mile) for passenger cars which can be input by the user, or can be calculated from look-up tables by selecting the roadway type (1 represents arterial; 2 represents freeway), and speed (from 5 to 75 mph) most representative of the vehicles’ operation. The emissions look-up table is developed using the MOVES model for passenger cars in the evaluation years of 2011 and 2040. Currently, the road type is assumed to be arterial, and the speed 60 mph. These defaults may be changed to target different vehicle types and different analysis years. The 8.6 mile average trip length is provided by a previous HGAC livable center project (*48*).

The output of this strategy is the emissions reduction in gram/day (or ton/day).

Strategy 7: Highway Capacity Addition

Adding highway capacity provides higher road capacities and mitigates traffic congestion. However, it must be noted that it is not a viable long-term emissions control strategy on account of induced demand, and will remain an emissions benefit only if traffic volumes do not increase in future years. However, its estimation has been included to allow for the evaluation of capacity addition projects from the RTP. Since the emissions benefit is calculated based on improved travel speed and reduced fuel consumption, the benefits are only applicable during the peak hours when traffic is congested. This strategy can be applied on a project basis. Travel speeds before and after the capacity additions are critical to calculate emissions. Users can input those speeds directly or estimate them from the traffic volume and number of lanes using the Bureau of Public Roads (BPR) function.

General Quantification Approach

Equation 14 shows the general quantification of the impact of this strategy.

Daily Emission Reduction = $D_p \times (EF_B - EF_A) \times L \times Q$ *(14)*

Where,

D_P = Duration of peak hours (hours);

EF_A = Emissions factor after adding lanes (gram/mile), determined by V_A;

EF_B = Emissions factor before adding lanes (gram/mile), determined by V_B;

L = Length of facility (mile);
Q = Traffic volume (vehicle/hour);
V_A = Speed along the corridor after adding lanes (mph), estimated with the BPR function; and
V_B = Speed along the corridor before adding lanes (mph), estimated with the BPR Function.

Implementation in Analysis Tool
Required inputs for this strategy include:

- Duration of peak hours (hours);
- Traffic volume (vehicle/hour);
- Length of facility (mile); and
- Numbers of lanes before and after adding lanes (if using the BPR function).

Given the importance of considering induced demand in future scenarios for this strategy, the inputs of this strategy include separate volume entries for the base and future years, to allow for this to be appropriately included in the estimation.

Optional inputs are travel speeds before and after the capacity addition, which are similarly required for both the base and future years. Without this input, the calculator estimates them from the traffic volume and number of lanes using the BPR function. In the BPR function, $T = T_0 \times \left[1 + a \times \left(\frac{V}{C}\right)^b\right]$

Where,

- a and b are constants;
- C is the capacity, which is estimated by multiplying the number of lanes by 2000 vehicles per hour per lane (vphpl);
- T_0 is the travel time at the free flow condition, which is estimated by dividing the facility length by the free flow speed (The free flow speed on the facility is assumed to be 70 mph.); and
- T is the actual travel time, which is equal to the facility length divided by the actual travel speed.

a and b are set to 1.0 and 5.4 for a typical mutilane freeway with the speed limit of 70 mph. [50] The capacity is assumed to 2000 vehicles per hour per lane (vphpl).

The output of this strategy is the emissions reduction in gram/day (or ton/day).

Strategy 8: Retiming of Traffic Signals
This measure considers the potential improvement of signal timing at intersections that can reduce emissions by reducing vehicle delay and stops. This strategy can be applied on a project basis, for example for an arterial or corridor, or for a region. The quantification methodologies are based on a National Cooperative Highway Research Program Report, NCHRP 409. [51] This strategy requires

knowledge of traffic conditions before and after signal retiming, such as VMT, total delay and stops, and cruise speed along the corridor.

General Quantification Approach

Equations 15 through 17 shows the general quantification of the impact of this strategy.

Daily Emission Reduction = $EF \times (FC_B - FC_A)$ *(15)*

$$FC_A = k_{1A} \times VMT_A + k_{2A} \times D_A + k_{3A} \times S_A \quad (16)$$

$$FC_B = k_{1B} \times VMT_B + k_{2B} \times D_B + k_{3B} \times S_B \quad (17)$$

Where,

- D_A = Total delay after retiming (hour);
- D_B = Total delay before retiming (hour);
- EF = Emissions factor per gallon of fuel consumption (gram/gallon);
- FC_A = Fuel consumption after retiming (gal);
- FC_B = Fuel consumption before retiming (gal);
- k_{1A} = Constant – $0.075283 - 0.0015892 \times V_A + 0.000015066 \times V_A^2$;
- k_{1B} = Constant – $0.075283 - 0.0015892 \times V_B + 0.000015066 \times V_B^2$;
- k_{2A} = Constant – 0.7329;
- k_{2B} = Constant – 0.7329;
- k_{3A} = Constant – $0.0000061411 \times V_A^2$;
- k_{3B} = Constant – $0.0000061411 \times V_B^2$;
- S_A = Number of stops after retiming (vehicle/hour);
- S_B = Number of stops before retiming (vehicle/hour);
- VMT_A = Vehicle mile traveled after retiming (mile);
- VMT_B = Vehicle mile traveled before retiming (mile);
- V_A = Cruise speed along the corridor after retiming (mph); and
- V_B = Cruise speed along the corridor before retiming (mph).

Implementation in Analysis Tool

Required inputs for this strategy include:

- Total VMT before and after retiming (mile);
- Total delay before and after retiming (hour);
- Numbers of stops before and after retiming (vehicle/hour); and
- Cruise speeds before and after retiming (mph).

One optional input is the emissions factor (gram/gallon), which is used to convert fuel consumption to CO_2 emissions. Currently, this input is set to 9117.3 based on the 2010 Texas data (23.3 percent diesel + 76.7 percent gasoline.[52] In this case, base and future year calculations are not differentiated since the estimation methodology is not based on rates from the MOVES model or other emissions models.

The output of this strategy is the emissions reduction in gram/day (or ton/day).

Strategy 9: Bicycle Facilities

This measure considers the potential impact of a new bicycle facility that can attract more cyclists. Based on this increasing number of cyclists, the reduction of VMT and emissions are estimated. This strategy can be applied on a project level or for a region, and the estimation methodology for increased bicycle trips is from a National Cooperative Highway Research Program Report NCHRP 552. [53]

General Quantification Approach

Equations 18 through 21 shows the general quantification of the impact of this strategy.

Daily Emission Reduction = $EF \times (BT_1 + BT_2 + BT_3) \times L$ *(18)*

$$BT_1 = BR \times (D_1 \times L_F \times 0.25 \times 2) \times IR_1 \quad (19)$$

$$BT_2 = BR \times (D_2 \times L_F \times 0.25 \times 2) \times IR_2$$

(20)

$$BT_3 = BR \times (D_3 \times L_F \times 0.50 \times 2) \times IR_3 \quad (21)$$

Where,

BR = bicycling rates (0.02 for low estimation, 0.028 for moderate estimation, and 0.066 for high estimation);

BT_1 = Increased bicycle trips within 0.25 mile from the bicycle facility;

BT_2 = Increased bicycle trips within 0.25 to 0.50 mile from the bicycle facility;

BT_3 = Increased bicycle trips within 0.50 to 1.00 mile from the bicycle facility;

D_1 = Population density for area within 0.25 mile from the bicycle facility;

D_2 = Population density for area within 0.25 to 0.50 mile from the bicycle facility;

D_3 = Population density for area within 0.50 to 1.00 mile from the bicycle facility;

EF = Emissions factor (gram/mile);

IR_1 = Trip increase rate within 0.25 mile from the bicycle facility (1.93);

IR_2 = Trip increase rate within 0.25 to 0.50 mile from the bicycle facility (1.11);

IR_3 = Trip increase rate within 0.50 to 1.00 mile from the bicycle facility (0.39);

L = Average trip length; and

L_F = Facility length.

Implementation in Analysis Tool

Required inputs for this strategy include:

- Bicycle facility length; and
- Population densities for area within 0.25, 0.25 to 0.50, and 0.50 to 1.00 mile from the bicycle facility.

Optional inputs are emissions factors (gram/mile) and the average trip length (mile). By selecting the road type (1 represents arterial; 2 represents freeway), and speed (from 5 to 75 mph), emissions factors can be estimated from look-up tables with respect to speed. The emissions look-up tables contain rates from the MOVES model for passenger cars in the evaluation years of 2011 and 2040. Currently, the road type is assumed to be arterial, and the speed 60 mph. These defaults may be changed to target different vehicle types and different analysis years. The 8.6 mile average trip length is provided by a previous HGAC livable center project (*48*).

In addition to the emissions factor and the average trip length, other optional inputs include bicycling rates and trip increase rate within 0.25, 0.25 to 0.50, and 0.50 to 1.00 mile from the bicycle facility, which currently adopt the values suggested in the NCHRP report (*53*).

The output of this strategy is the emissions reduction in gram/day (or ton/day).

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