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MITIGATING THE IMPACT OF THE ROAD SYSTEM ON CLIMATE CHANGE

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ABSTRACT

OVERVIEW OF US APPROACH TO REDUCE GREENHOUSE GASES

While climate change policy within the United States continues to evolve, the US and State Departments of Transportation, among others, are already findings ways to reduce greenhouse gases (GHGs). Multiple initiatives are being undertaken in transportation, energy, and other sectors of the economy.

In July 2009, at the G8 Summit in Aquila, Italy, President Obama and the leaders of Canada, France, Germany, Italy, Japan, Russia and the United Kingdom signaled their agreement to reduce emissions by 80% by 2050. Under the Copenhagen Accord, the United States submitted to the United Nations Framework Convention on Climate Change its intention to reduce greenhouse gas (GHG) emissions 17% by the year 2020[i]. According to the US submission on 28 January 2010, this goal is subject to ratification by the US Congress, the body responsible for making US law.

While greenhouse gas reduction is still pending in the US Congress, the President issued Executive Order 13514[ii] which directs agencies of the Executive Branch of the US government, including the Department of Transportation, to reduce its own greenhouse emissions. The overall target for the US government is a 28% reduction by 2020.

Individual US States have the legislative ability to set their own approaches on greenhouse gas mitigation and adaptation. By November 2009, 30 States had developed climate action plans and 24 of these had set greenhouse gas reduction targets. Another three had plans under development. State plans included analysis years in the 2020 – 2030 time frame and targeted reductions between 10 and 88 percent of their GHG emissions by the target year. One of the more significant of these is the California, "Global Warming Solutions Act" of 2006[iii]. This law covers virtually every aspect of the Californian economy and requires that greenhouse gas levels return to what they were in 1990 by 2020, an estimated reduction of 29%.

In the 30 State plans, more than 300 transportation strategies were proposed to reduce GHGs. The five most popular of these are: low carbon fuel measures, improved public transport and alternatives to driving, new vehicle fuel efficiency standards (based on the California model), and incentives to purchase lower emitting vehicles. Some states have engaged in regional cooperative approaches. The Regional Greenhouse Gas Initiative, instituted by States in the Northeastern portion of the US, and the Western Climate Initiative among the western States are two examples. Both these groups have established programs to implement cap-and-trade efforts to reduce emissions.

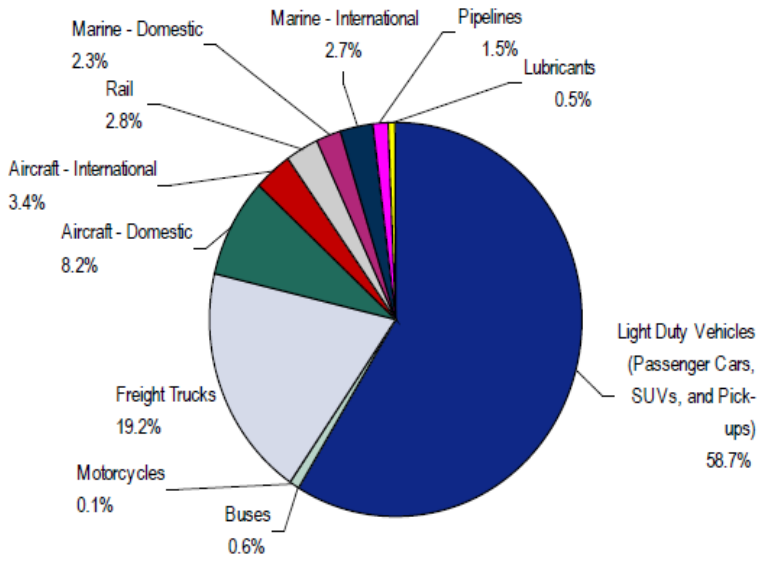
Legislation has been introduced in the Congress to create a comprehensive US approach to greenhouse gas mitigation. The American Power Act was proposed by Senators Kerry and Lieberman on May 12, 2010, and action on the bill is pending in the US Senate as of this report's writing. The American Clean Energy and Security Act of 2009, has already been passed by the House of Representatives on June 26, 2009, which would establish a cap-and-trade program nationally. Providing that the Senate passes the American Power Act, the two bills will be combined and their differences reconciled. Senate action is expected later in 2010.

TRANSPORTATION SECTOR APPROACHES TO REDUCE GREENHOUSE GASES

1. Introduction

US transportation alone constitutes about five percent of global emissions and account for 29 percent of all US GHG emissions. Road transport represents the majority of those emissions. Light duty vehicles, buses, motorcycles and freight trucks represent almost 79 percent of all transportation emissions. Since the transportation sector emits about 1,856 million metric tons (mmt) of carbon dioxide equivalent (CO2e), road transport emissions are about 1,466 mmt CO2e annually. These statistics do not include other transportation lifecycle emissions stemming from the manufacture of vehicles, extraction and mining, or construction of infrastructure and maintenance.

Figure ___: **U.S. Greenhouse Gas Emissions by Transportation Mode,** *2006*



Source: U.S. EPA (2008). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 to 2006.*

In the US, several strategies are being pursued to reduce GHGs from road transport: improving the efficiency of passenger vehicles and freight trucks to reduce energy used per mile of travel, introducing alternative and renewable fuels to lower the carbon content, better planning to reduce the need for carbon intensive travel, improving system efficiency to reduce the amount of fuel wasted on congestion roadways, implementing demand management strategies to lower carbon intensity per passenger-mile, reducing emissions from construction and maintenance, and research and development into new fuels and propulsion systems, in particular.

2. Fuel Efficiency of Vehicles

A major strategy for the United States to reduce its greenhouse gases is to improve the fuel efficiency of the vehicles on the road. As fuel efficiency increases, GHG is reduced because the amount of fuel burned per mile, and thus the main product of combustion,

carbon dioxide, is reduced. Building on the extensive experience garnered since the oil crisis of the 1970's, President Obama announced on May 19, 2009, a National Fuel Efficient Policy and asked the Department of Transportation (DOT) and the Environmental Protection Agency (EPA) to establish a coordinated federal fuel economy and GHG program for passenger vehicles and light trucks.[iv] The DOT's and EPA's successful collaboration resulted in new fuel economy standards for passenger cars and light trucks, released on April 1, 2010.

The Energy Policy and Conservation Act was passed in 1975 to reduce fuel consumption. It required that Corporate Average Fuel Economy (CAFE) standards be set to govern the allowable fuel economy of new passenger vehicles sold in the United States. The law has been amended several times, most recently by the Energy Independence and Security Act (EISA), which required that the CAFE standards reach 35.5 miles per gallon (mpg) by the year 2020.

Under the 2010 standards, the goal under EISA was accelerated. The CAFE regulation covers passenger cars and light trucks that will be sold in the US starting in 2012 through 2016. Under the regulation, fuel economy must reach 34.1 mpg by 2016. Since the fuel economy of these vehicles is already required to reach 27.6 mpg by 2011 under previous regulations, the new CAFE standard represents an average improvement of 4.3 percent per year for 2012-2016. In addition, the GHG standards for new cars promulgated by the EPA require manufacturers to take additional steps to further reduce GHGs and fuel consumption, such as making improvements to vehicle air conditioning systems, that will reach a combined fuel economy rating equivalent to 35.5 mpg by 2016. Thus the EISA goal will be reached 4 years sooner than required by law.

Table ____: Average Required Fuel Economy (mpg)

	2012	**2013**	**2014**	**2015**	**2016**
Passenger Cars	33.3	34.2	34.9	36.2	37.8
Light Trucks	25.4	26.0	26.6	27.5	28.8
Combined	29.7	30.5	31.3	32.6	34.1

Source: Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule. May 7, 2010[v]

Since the CAFE/GHG regulation apply to new vehicle purchases, it will take about 25 years for the fleet of vehicles in the US as a whole to turnover and the full energy, GHG, and climate benefits to be realized. However, the fuel and GHG benefits are substantial when viewed in the aggregate. Over the lifetimes of the vehicles covered by the regulation, an estimated 61 billion gallons of fuel will be saved over business-as-usual. In addition, the reduction of carbon dioxide emissions is expected to be 960 million metric tons.

Not only will these vehicles be more environmentally friendly, costs to individual owners are expected to decrease, as well. The purchase price of a new vehicle is anticipated to increase from $434 to $926, but the costs to re-fuel it will decline. A net savings of about $3000 on average is expected over the life of a new vehicle.

While the fuel and GHG savings are relatively large under the CAFE regulation, the ultimate climate effects are not surprisingly small. Under the business-as-usual case, CO2 concentrations are expected to reach about 783 ppm if significant action to reduce GHGs

is not undertaken. Under the CAFE regulation, this will be decreased to about 778 ppm. According to the analysis done by DOT and EPA, this will result in slightly lower global temperatures, which will serve to reduce future climate effects, such as sea level rise and storm intensity. This is unsurprising given the global and multi-generational scale of climate change. Although passenger vehicles are a significant source of emissions (17 percent in the US), they are not the only one. Further the regulation only covers new purchases in the US for a five-year time frame. Finally, current and expected CO2 concentration levels depend not only on emissions in one year, but the cumulative emission of these gases over a century.

In addition to specifying future fuel economy targets for passenger vehicles, the EISA also required that DOT examine the need for fuel economy regulations covering heavy duty truck. On May 21, 2010, the President directed DOT and EPA to begin development on a new regulation to establish fuel efficiency and greenhouse gas emissions standards for commercial medium and heavy duty trucks beginning with model year 2014. The goal is to issue a final regulation by July 30, 2011. Heavy duty trucks represent about half of the emissions from this sector. Preliminary estimates indicate that GHG emissions can be reduced by as much as 20 percent using existing technologies[vi].

3. Alternative and Renewable Fuels

Road transportation depends very heavily on petroleum products (gasoline and diesel) for fuel. About 97 percent of the fuel used on the roads is from petroleum sources. Since gasoline and diesel are combusted to carbon dioxide, reducing the carbon content of fuels is a key strategy for reducing greenhouse gas emissions. Some alternative fuels generate less CO2 per unit of energy produced. Renewable fuels are made from plants and take in CO2 as they grow. While their combustion produces CO2, these effects balance out. Alternative fuels strategies to reduce GHGs have primarily been examined in the light duty vehicle sector, although other applications are being explored as well. To compete successfully with the relatively cheap and energy-intensive petroleum fuels, production costs of alternative and renewable fuels must be reduced. Further alternative and renewable fuels may require changes in refueling infrastructure if their use is to become widespread.

Several policy options are under consideration, though the majority would require enabling legislation in order to be realized and effective. Fuel standards such as the recent Renewable Fuel Standard (explained below) could be more widely employed. Market incentives could be used to speed the adoption of less carbon intensive fuels. Pricing and tax changes could be considered to make alternative and renewable fuels more competitive with petroleum based fuels. Finally additional funding for research and development could be dedicated toward the creation of low carbon fuels.

3.1 Renewable Fuels Program

In 2005, the US Congress mandated that a Renewable Fuels Standards (RFS) Program be created and that 7.5 billion gallons of renewable fuel be blended into gasoline by 2012 under the Energy Policy Act. The EISA increased this amount to be 36 billion gallons by 2022. It also addressed diesel fuel and required life cycle analysis of GHG emissions to ensure that these standards would represent an overall reduction commensurate with the levels specified in the law for each type of renewable fuel. The EPA published its implementing regulation on March 26, 2010, effective July 1, 2010.

In the regulation, EPA has set standards for quantities of different types of renewable fuels, including cellulosic, biomass-based diesel, and total advanced renewable fuels. For 2010, these amounts are as follows: cellulosic (6.5 million gallons); biomass-based diesel (1.15 billion gallons); and the standard for the total amount of renewable fuels is set at 12.95 billion gallons. By 2022, the cellulosic standard will increase to 16 billion gallons; an advanced biofuel standard will be set at 21 billion gallons to meet the total standard under EISA of 36 billion gallons.

The benefits of this regulation are expected to be relatively large. The EPA's Regulatory Impact Assessment estimates that GHG reductions will be 138 mmt CO2e in the 2010 to 2022 period. It will also reduce gasoline and diesel use by 13.6 billion gallons. The rule is expected to increase some air pollutant emissions while decreasing others, and add to food costs by about $10 per person in 2022.

3.2 Other Alternative Fuels

Some alternative fuels compete reasonably well in terms of performance and cost, and federal policy has been to allow or encourage funding for these technologies. Funding for clean fuel buses and public fleets exist under the transit programs as well as the Congestion Mitigation and Air Quality Improvement Program. Natural gas, for example, has been estimated to reduce GHGs by about 15 percent for gasoline vehicles, but is comparable to diesel, and it produces fewer emissions of other air pollution. Widespread implementation of natural gas vehicles would require major changes to the vehicles and to refueling infrastructure nationwide. As such, its use appears to be better suited to fleets using centralized refueling and maintenance facilities. Natural gas buses are commonplace in many metropolitan areas.

Electric hybrid vehicles have grown popular in the US, and plug-in hybrids are soon to be introduced. Vehicles that depend on electricity for all or part of their power can reduce GHGs by about 33 percent on a per vehicle basis, although this will depend on the type of vehicle, the technology employed, and the source of the electricity. In the US, power generation uses a variety of fuels including coal, hydro, nuclear, petroleum and natural gas. Other fuels, like hydrogen, will likely require additional research and development.

4. Transportation Planning and Funding

Surface transportation infrastructure is funded from multiple sources within the US[vii]. The federal government provides funding to States under specific programs that serve to meet the mobility, economic and environmental needs that are of national interest as specified under law. States and some metropolitan areas have their own dedicated funding for road transportation. And in some cases, funding from private firms is employed for specific projects. Federal funding constitutes about half of all surface transportation investments on average, although it is much more significant for some States and much less for others. Different federal funding programs are used to invest in a variety of transportation projects, including road, transit, bicycle, pedestrian, and some freight activities.

Federal transportation funding programs have different overarching purposes. These include new road capacity, operational improvements, environmental mitigation, and air quality improvement, among other things. Greenhouse gas mitigation is not currently listed as an activity eligible for federal government funding under current surface transportation law, but many activities funded under existing programs can have GHG

benefits, including measures to improve system efficiency and demand management strategies. The determination of which potential projects to fund is made by the States and metropolitan areas, even when federal funds are to be used. The federal role is to determine whether proposed projects satisfy program criteria and safety, environmental and other requirements, to ensure that national program goals are advanced.

The planning process for federally funded or approved surface transportation projects is detailed in the law and subordinate regulations. It requires that a plan be developed that considers future needs over a 20-year time horizon and a transportation improvement program (TIP). It specifies that certain factors be considered in the development of the plan and TIP, including the environment.

Several new pieces of legislation have been proposed over the past two years that would specify that GHG reduction is an explicit goal of the federal transportation program. These proposed laws are similar in that they would require that the States and metropolitan areas develop an inventory of GHGs from surface transportation and emission reduction targets. Most significantly, plans and TIPs would have to be analyzed and the expected GHG impacts would have to be consistent with the emissions targets before federal funding could be approved. The proposed legislation where these provisions have been identified include the American Power Act, proposed by Senators Kerry and Lieberman on May 12, 2010; the Surface Transportation Authorization Act of 2009, proposed by Representative Oberstar, Chairman of the House Transportation and Infrastructure Committee, on June 19, 2009; and the American Clean Energy and Security Act of 2009, passed by the House of Representatives on June 26, 2009.

Several States, including Oregon and California, have passed laws to reduce GHGs through transportation planning**.** In March 2010, the State of Oregon enacted Senate Bill 1059, which calls for a statewide transportation strategy to achieve greenhouse gas emission reduction goals and requires metropolitan areas within the State to consider how regional transportation plans could be changed to reduce GHGs. California enacted a similar law that will attempt to reduce GHGs through better transportation and land use planning. It requires that the 27 metropolitan areas in the state develop "sustainable communities strategies (SCS)" and includes new requirements to align housing needs assessments and the regional transportation plans to meet the GHG targets as part of their regional transportation plans.

5. System Efficiency Measures

Road congestion is a major problem in the US, as it is in many places. Congestion has been estimated to cost $87.2 billion, and waste 2.8 billion gallons of fuel annually[viii] which, in the unlikely case it were eliminated entirely, would translate to 25 million metric tons of GHG emissions. There are a variety of strategies that States and metropolitan areas employ to stem the tide of rising congestion in major and small metropolitan areas and communities. These include strategies to improve highway operations and management as a whole and truck operations and management as a particular area of focus. While neither of these is normally accomplished specifically for GHG mitigation purposes at this point in time, system efficiency measures can reduce stop-and-go traffic patterns, raising speeds and fuel efficiency, which will have a positive impact on emissions. Other measures addressed in this section, such as eco-driving or speed reductions, can reduce GHGs by improving the rate at which emissions are generated.

Greater system efficiency can be achieved through a variety of mechanisms, using Intelligent Transportation systems approaches, regulatory measures, targeted capacity expansions, education and new technologies.

- Improved traffic management projects include signal coordination, faster clearance of incidents, and freeway ramp metering.
- Real-time traveler information projects provide up-to-date information to travelers and truckers to avoid delays.
- Bottleneck relief increases capacity at specific points on the transportation network where demand exceeds capacity ("bottlenecks"), such as interchanges, intersections, and lane drops.
- Reduced speed limits maintain engines at speeds closer to their optimal efficiency.
- Eco-driving, i.e. piloting a vehicle to maximize fuel efficiency and minimize GHG emission, can employ both technological and educational means to reduce fuel use.
- Truck idle reduction (such as electrical hook-ups at truck stops or on-board auxiliary power supplies) reduce long-duration idling of heavy vehicles.
- Truck size and weight limits include changes to Federal law to allow vehicles exceeding 80,000 pounds to operate on Interstate highways; and/or to allow longer (53') trailers or double or triple trailers in all States.
- Urban Consolidation Centers where deliveries (retail, office, or residential) can be consolidated for subsequent delivery into the urban area in an appropriate vehicle with a high level of load utilization.

The effectiveness of highway operational improvements may be limited to a greater or lesser extent by the "induced demand" phenomenon. Induced demand occurs when demand for passenger travel increases because the real cost of driving along a roadway has been reduced typically through capacity expansions. Since operational improvements improve the efficiency of transportation corridors, travel demand may be induced as routes become more attractive to potential travelers. Induced demand represents completely new or longer trips that are not diverted from other roads and exceed demand increases due to population growth.

There are many methodological challenges in estimating the effectiveness of system efficiency measures to reduce GHGs. Variations in traffic patterns and weaknesses in emissions models are two of them, in addition to the difficulty in estimating induced demand. But due to the very large size of the transportation network in the US, and the relatively small size of individual roadway improvements, as well as the likelihood of induced demand, the effectiveness of system efficiency improvements is likely to be small compared to total US road transport emissions.

The effectiveness of system efficiency improvements may be significantly enhanced through new concepts of active traffic management (ATM) and integrated corridor management (ICM). Interest in ICM and active traffic management is growing within the US. Integrated corridor management requires institutional and operational coordination across transportation managers, including freeway management and transit organizations, for example, and the technical capability using ITS and other means to manage multiple transportation services as a single system. ICM's potential is to maximize existing capacity across modes. ATM entails the use of comprehensive traffic management strategies and real time information to manage the road network based on current conditions, adjusting access to the network through ramp metering, speeds, use of shoulders, signal timing, and other means. ATM elevates the management of the network to new levels of sophistication and beyond project-level considerations. As flow is

improved network-wide from these innovations, GHG emissions may be reduced more substantially.

6. Demand Management Strategies

Under the transportation planning described above, virtually all States and major metropolitan areas use federal government funding to manage the demand for surface transportation by creating alternatives to driving alone or by making them more attractive. Some also employ market pricing measures to reduce demand for road transportation or redirect it away from the most congested areas, among other purposes.

6.1. Alternatives to Driving Alone

Since passenger vehicles generate a substantial amount of GHG largely generated by the burning of petroleum products, meeting the demand for passenger travel by means other than the automobile can reduce GHGs. Making public transport more available, attractive and convenient is one way to accomplish this. Improving non-motorized travel modes (bicycle and pedestrian infrastructure and services) can also meet travel demand in less fuel intensive ways. Sharing rides through carpooling can reduce the number of vehicles on the road.

In addition to making alternatives to driving alone more attractive, some cities and States are attempting to reorient their land use patterns to be more transit- and pedestrian-friendly. Improved urban design can increase the number of transit, biking and walking trips. Related to this is improving the connections between modes of transportation so that travel is more seamless and more of it can be met through environmentally-friendly means.

In March 2009, DOT Secretary LaHood testified before Congress on the President's plan to make communities in the US more livable by providing enhanced funding and cooperation across key federal agencies, including transportation, housing and environment. "We have a window of opportunity to think differently about transportation and propose bold, new approaches to improve the livability of our nation's communities," he told the Congress earlier this year. While GHG reduction is not an explicit goal of the Livability Initiative, it could be an important by product as transportation choices are expanded.

Some cities are employing demand management strategies specifically for GHG reduction. Others use them for their other benefits, like enhanced mobility and economic vitality in densely populated areas and improved livability. Nonetheless, these projects will also have the added benefit of GHG reductions.

The US invests more than $47 billion annually in public transport from all levels of government, and Americans take nearly 10 billion trips annually. Transit has been the fastest growing mode of surface transportation since 1998. While increased ridership is possible, significant additional investment levels would be necessary to achieve this.

A 2010 US DOT Report to Congress estimated the effectiveness of a concerted effort to reduce GHGs by improving alternatives to driving alone and is shown in the table. It shows that in general GHG reduction by this means alone are likely to be small, individually on the order of just 1 – 4 percent. Synergistic impacts, particularly when transit is combined with pricing mechanisms or large fuel price increases, can be greater[ix].

Table _____: Effectiveness of Select Measures to Reduce Greenhouse Gas Emissions by Improving Alternatives to Driving Alone on a National Basis

Measure	**Percent Reduction in 2030**	**Key Assumptions**
Public Transport	0.4 – 1.6	2.4 - 4.6% annual increase in service
Non-motorized Travel	0.2 – 0.6	Comprehensive urban bike/ped improvements 2010-2025
Land Use	1.2 – 3.9	60 - 90% of new urban growth in approx. >5 units/acre
Commuter Trip Reduction	0.1 – 0.6	Widespread employer outreach and alternative mode support
Telework/Compressed Work Week	0.5 – 0.7	Doubling of current levels
Individualized Marketing	0.3 – 0.4	Reaches 10% of population

Source: Transportation's Role in Reducing Greenhouse Gas Emissions, US DOT Report to Congress, Vol. 1, Synthesis Report (April 2010).

6.2. Pricing/Market Measures

Raising the costs of driving, parking, and vehicle or driver registration can reduce the demand for road transportation and thus reduce GHG emissions. Usually such measures have been employed by States and metropolitan areas to raise revenue for construction or operation of the roadways, but the need to address climate change has policy experts considering the impacts of such measures on GHG emissions.

Raising the cost of driving can be accomplished by increasing fuel taxes or adding an additional tax on the vehicle miles traveled (VMT) of a car. US gas taxes are low by comparison to other developed nations, at slightly more than 18 cents per gallon of gasoline. States, however, also impose additional fuel taxes. Still the total cost of a gallon of gasoline, including all State and local taxes is comparatively small. Additional fuel taxes have been unpopular in the US predominantly because of the impact on economic growth. Other pricing measures have been more generally employed. Parking costs in major cities can be quite high. Major roads are frequently tolled. And places like New York City already charge for entry through the bridges and tunnels into Manhattan.

There is a great deal of interest in developing an alternative insurance system, "Pay-as-you-drive". The idea behind this is to couple insurance costs with the amount of driving a person does. There is also a great deal of interest and several metropolitan areas have begun to implement congestion pricing measures where tolls are increased on certain roads as the level of congestion increases at peak times. A more comprehensive system

of congestion pricing could serve to limit the amount of driving and thus reduce GHGs from a business-as-usual perspective.

The effectiveness of all pricing measures depends on how much travel (VMT) will be reduced per increase in the cost of driving, i.e. the elasticity of travel with cost. Current estimates of the price elasticity of demand with fuel cost is rather low -- at about 11 percent in the short term and perhaps 25 percent in the long term for a doubling in the real price of fuel. As a result, effectiveness depends on the increase in costs. But as costs increase, the attractiveness of the strategy diminishes.

Based on recent estimates of certain measures to introduce or expand pricing measures, the effectiveness ranges from less than one percent to as much as five percent for individual measures at levels of cost increase that are being discussed in academic literature and some policy circles.

Table ___: Effectiveness of Pricing Measures on a National Basis

Measure	**Key Deployment Assumptions**	**Percent Reduction**	**GHG Reduction 2030 (mmt CO2e/yr)**
VMT Tolls	VMT fee of 2 to 5 cents per mile	1.1-3.1%	17-50
Intercity Tolls	Toll of 2 to 5 cents per mile on rural Interstate highways	0.1-0.2%	1-3
Pay-as-You-Drive Insurance	Require states to permit PAYD insurance (low)/Require companies to offer (high)	1.4-4.7%	23-75
Congestion Pricing	Price to maintain minimum levels of service (D) on all roads	0.6-2.2%	19-43
Cordon Pricing	Cordon charge on all U.S. metro area central business districts	0.1-0.2%	2-3

A cap-and-trade program, such as that proposed under the American Clean Energy and Security Act passed by the House of Representatives, will act as a pricing measure similar to those discussed above. Its effectiveness will likely be modest, adding an estimated $0.20 to the price of a gallon of gasoline.

7. Construction

In the US, most roads are constructed from either concrete (made from Portland cement) or asphalt. Greenhouse gas emissions are generated from the production of Portland cement, which requires a large amount of heat in its production process. Emissions can be reduced through the use of less energy-intensive construction materials by State and local highway departments and other transportation agencies.

Recycled fly ash can be used in the cement production process to form concrete, which the California Department of Transportation has done. California currently uses a 25 percent fly ash mixture, which has reduced GHG emissions from cement production by 25 percent, and it has a future goal of using a 50 percent fly ash mixture. Crushed rock or gravel, known as "aggregate", is another ingredient in concrete, and also contributes to GHG emissions through the mining and transportation of these materials. Recycling the aggregate from existing roadways and reusing it can reduce GHGs.

Asphalt is produced by combining an asphalt binder with an aggregate. The traditional "hot-mix" asphalt heats the asphalt binder to high temperatures for proper mixing and paving. A new material, warm-mix asphalt, uses chemical additives to lower the temperature needed to achieve the proper viscosity which in turn reduces the amount of fuel used and therefore GHG emissions. Lowering
the temperature of the asphalt itself also lowers direct GHG emissions from the oxidation of the asphalt material. While a number of demonstration projects using warm mix asphalt have occurred, the use of this technology is not yet widespread.

Transportation infrastructure construction and maintenance practices show modest potential for reductions in GHG emissions. Perhaps the most significant strategy currently available is the use of fly ash or other recycled materials in cement, a proven technology that has the potential to reduce GHG by an additional 15 mmt CO2e annually. Use of warm- and cold-mix asphalt has the potential to reduce GHG by about 3 mmt CO2e annually, but research on the application of these technologies in the U.S. is still in progress. Other actions by transportation agencies also have the potential to contribute modestly to GHG reductions. These include the use of alternative fuels in transportation agency vehicles and equipment, reduced idling of construction equipment, and increased energy efficiency in transportation agency buildings. These actions are estimated to provide benefits of about 2-3 mmt CO2e per year

Other transportation agency operating practices to reduce GHG emissions could include using increased vehicle fuel efficiency, alternative fuel construction vehicles and fleets, reduced idling, better equipment maintenance, driver training, properly sized equipment, replaced or repowered equipment, bio-fuels for trucks and construction equipment, and alternatives to diesel generators, energy efficient buildings, and work zone management to reduce traffic congestion.

Data are lacking on the effectiveness of such measures to reduce GHGs. One study indicated that a combination of reduced idling of vehicles used in construction, use of a 20 percent blend of biodiesel, better vehicle maintenance and driver training could decrease GHG emissions by 0.37 mmt CO2e.

8. Research and Development

The use of existing and new technologies will be necessary to meet the requirements of the National Fuel Efficiency Program and Renewable Fuels Standard, and in the longer term, even greater advances are possible through enhanced research and development

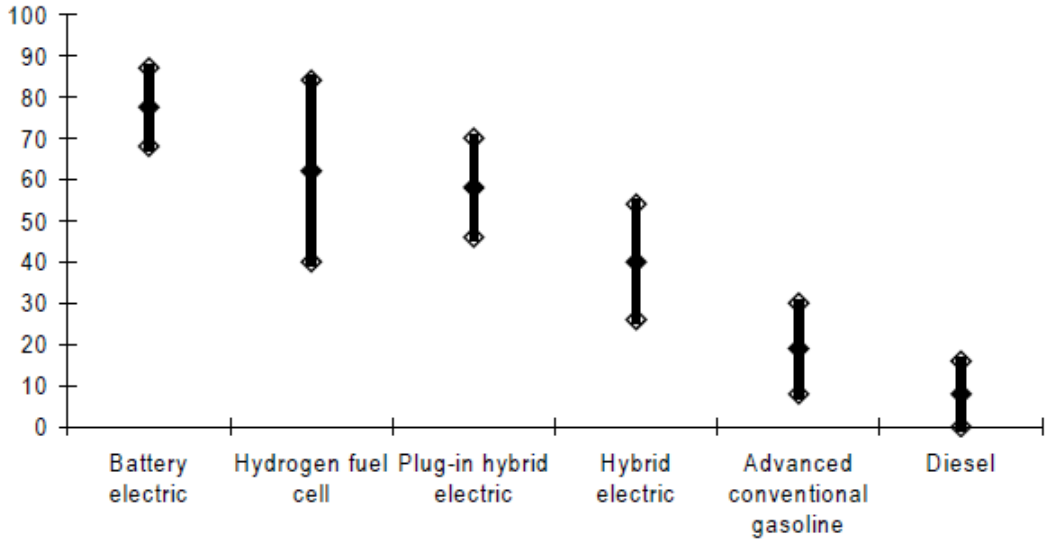
programs. New propulsion systems that convert power more efficiently and lower carbon fuels like cellulosic ethanol and hydrogen are being developed. Further exploration of these potential systems is necessary to overcome known technological hurdles, lower costs and produce vehicle/fuel combinations that can successfully compete in the marketplace. The Annual Energy Outlook from the Department of Energy anticipates that vehicles can become more energy efficient by 40 percent, or more, by 2030 as existing regulations are implemented and fuel prices rise.

The future potential of improved vehicle/fuel combinations is large if technological and cost hurdles can be overcome. While estimates are highly uncertain because energy sources and actual production methods are not fully known, they provide a benchmark for future development. Figure ____ provides an indication of the longer term GHG reduction benefits of some alternative fuel/vehicle technology combinations. As shown, future reductions can approach 90 percent by 2050 as compared to standard gasoline using battery electric technology. Even advanced gasoline engines are may demonstrate lower GHG emissions by as much as 30 percent. The ranges show estimated reductions by 2030 and beyond. The upper values for battery electric and hydrogen are for 2050. Introduction of the technology and fleet turnover are modeled to develop these estimates.

These and other technologies are being explored by the federal government, auto manufacturers, fuel companies, research institutions and others. The US Department of Energy (DOE) conducts and sponsors critical research under the Climate Change Technology Program. Over 2007 – 2010, DOE has invested about $2 billion per year in research on renewable fuels and energy efficiency, a portion of which is dedicated to transportation improvements. In 2009, the US government significantly increased funding for research and development under the American Recovery and Reinvestment Act, providing a one-time increase of $16 billion for these purposes.

In addition to increased funding for research and development, other policy drivers can be employed to quicken the pace of research, development and deployment of new technologies. Technology-forcing mechanisms, like the CAFE/GHG standards and Renewable Fuels Standard, can be effective to stimulate research. Tax breaks or other incentives can be provided to make new technologies more cost competitive to existing ones, or existing technologies can be taxed for the same purpose. And public-private partnerships can be forged to demonstrate new lower carbon ways of reducing emissions.

Figure ____: Percent Reduction in Life Cycle GHG Emissions versus Conventional Gasoline



Source: Transportation's Role in Reducing Greenhouse Gas Emissions, US DOT Report to Congress, Vol. 1, Synthesis Report (April 2010)

CONCLUSION

The U.S. Department of Transportation is committed to reducing the impact of the road transportation system on climate change. While the overarching policies and approaches to reduce greenhouse gases continue to evolve in the United States, significant actions are already being taken. New fuel efficiency standards have been set for vehicles purchased between 2012 and 2016. A Renewable Fuels Standard has been implemented that requires inclusion of 36 billion gallons of renewable fuels to be blended into existing stocks by 2020. The Department's livability initiative supports low carbon transportation options, such as public transportation, walking and biking, and virtually every State has implemented demand management and system efficiency strategies.

As shown by this study, all of these actions can reduce greenhouse gas emissions. The effectiveness varies with fuel efficiency and renewable appearing to be of higher effectiveness. Other measures such as system efficiencies and demand management may be more effective as new more comprehensive measures are tried and used in combination with one another. Research and development into new technologies and fuels are likely to play critical roles if transportation is to reduce its emissions commensurately with the challenge that climate change poses to the world.

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