Appendices

Appendix I: Methodology

Policy recommendations detailed in the chapter or listed in Appendix VI were identified through a literature review, found in Appendix III, in addition to personal interviews with advisors from the transportation and land use sectors. The policy recommendations were then prioritized based on the criteria set forth in Appendix V: Method for Identifying and Prioritizing Mitigation Policies and Strategies.

Potential advisors were identified by the Center for Neighborhood Technology with the intention of forming a group with the following competencies, which address the supply and demand sides of transportation carbon emissions: new vehicle technologies, alternative fuels, urban design and transit-oriented development, mass transit, behavioral change incentives and other VMT reduction strategies.

Potential advisors were invited to participate in the development of the Transportation and Land Use Chapter of the Presidential Climate Action Plan via a letter—faxed and/or emailed—from Scott Bernstein, President of the Center for Neighborhood Technology (CNT). The letter of invitation, which outlined CNT's request for input on literature to review, experts to contact, and mitigation strategies to explore, was sent to thirty-five potential advisors. Letters of invitation were followed by phone calls (often resulting in voice messages) to confirm receipt of letter and to inquire about interest in and capacity for serving as an advisor.

Twenty people responded affirmatively to the request to advise CNT. Phone interviews were scheduled and held with fifteen of these people. The phone interview, conducted by Nicole Friedman of CNT, started with an overview of what the PCAP is, CNT's role in drafting the Transportation and Land Use chapter, the objectives of the chapter, and the timeline for the process. After providing the overview, the following general questions were posed:

- What are promising short-term strategies to mitigate climate change in the areas of travel demand reduction, alternative fuels, and advanced vehicle technologies?

- What are promising long-term strategies to mitigate climate change in the areas of travel demand reduction, alternative fuels, and advanced vehicle technologies?
- What barriers exist for implementing these strategies?
- How might the proposed strategies be funded?
- In the areas of transportation and land use, what should the next administration focus on?

Advisors, those interviewed and those unavailable for one-on-one interviews at this time, received a list of possible strategies with accompanying GHG savings range potential, identified in large part by the Center for Clean Air Policy, for review and comment. Next advisors were sent an outline of policy recommendations with related costs—direct and indirect, benefits, policy implementation considerations, and authority to implement strategy. Advisor comments were incorporated into the draft chapter.

A draft chapter will be sent to advisors who will have 10-14 days to peer review the chapter. Advisors have been asked to respond via email or phone or during a scheduled conference call on Wednesday, April 25, 2007. CNT incorporate comments and revisions as it deems appropriate to the draft chapter for submittal on May 4, 2007.

A list of advisors can be found in Appendix II.

Appendix II: Chapter Advisors

<u>PLEASE NOTE</u>: While the following people provided guidance and insight, the opinions expressed in this report are those of the authors and do not necessarily reflect the views of the advisors' or their organizations. Any factual errors are strictly the responsibility of the authors.

Name	Affiliation	Focus Area(s)
Mark Delucchi	UC Davis, Institute of Transportation Studies	Fuel economy, vehicle technologies
John Holtzclaw	Sierra Club	Smart growth, location efficiency
David Goldstein	Natural Resource Defense Council	Transit, smart growth
Tom Radulovich	Livable Cities & BART	Transit, rail, smart growth (zoning & legislation)
DeWitt John	Bowdoin College	Environmental studies
Bill Anker	Missouri Transportation Institute	Supply & demand
David Burwell	Project for Public Spaces	Land use planning
Tom Downs	Eno Foundation	Rail, transit, land use, transportation planning at large
Gerrit Knaap	National Center for Smart Growth	Smart growth
John Wells	BP UK	Fuels, vehicle technologies
Don Shoup	UCLA	Parking
Sue Anderson	City of Portland	Sustainable development
Bill Millar	American Public Transportation Association	Public transportation
Lavinia Gordon	Transportation Options	Travel demand reduction
George Schoener	Former DOT	DOT

Note: Only people who were interviewed are listed above. Comments were sought from other interested parties who were not interviewed.

Appendix III: Literature Review

Drafted March 20, 2007
REVISED: March 31, 2007

Prepared for: Presidential Climate Action Plan (PCAP), Transportation & Land Use

Prepared by: Nicole Friedman, Center for Neighborhood Technology

There is a body of literature that illuminates how the transportation sector contributes to climate change through greenhouse gas emissions. A quantity of this literature also addresses the reduction of carbon emissions, directly or indirectly, with possible and promising mitigation strategies. The scope of this literature review, which will be ongoing as the chapter develops, is recent—within the last ten years or less—with a focus on:

- The extent of the problem and the current state of things;
- What the goals are for addressing the problem; and
- Mitigation (Supply and Demand) Strategies
    - Alternative fuels
    - Vehicle Technologies
    - Travel demand reduction

Researchers will draw on the below, in addition to advisory committee interviews and recommendations, when reviewing and developing policy proposals for reducing CO2 in the transportation sector by 80 percent by 2050 (using 1990 emissions as a baseline). The literature review was undertaken to determine what data exists, what policy structures are in place, what strategies result in CO2 emission reductions, and policy shifts that could support reduction strategies.

I. Problem: Quantity of CO2 from Transportation

Data reported by the Environmental Protection Agency, the Department of Energy (Energy Information Administration), and the Department of Transportation (Federal Highway Administration, Federal Transit Administration, Federal Aviation Administration, Maritime Administration) clearly show that a significant quantity of greenhouse gas emissions are produced by the transportation sector. The Intergovernmental Panel on Climate Change's work also recognizes that fossil fuel use, which is dominant in the transportation sector, is a leading contributor to carbon dioxide concentrations, which are increasing each year. The data available from the EPA's 2007 Draft US Greenhouse Gas Inventory Report (http://epa.gov/climatechange/emissions/usinventoryreport07.html), the Energy Information Administration's Emissions of Greenhouse Gases in the U.S. in 2005 (http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html) and Annual Energy Outlook 2007 (http://www.eia.doe.gov/oiaf/aeo/index.html), and the Bureau of Transportation Statistics are detailed in the accompanying spreadsheet—Transportation and CO2 Emissions Overview.

The transportation sector is responsible for 28 percent of greenhouse gas emissions and 26 percent of carbon emissions in the United States (EPA). The Energy Information Administration, in the *Emissions of Greenhouse Gases in the U.S. in 2005*, notes "transportation is the largest contributing end-use sector to total emissions." The Intergovernmental Panel on Climate Change's most recent report—Climate Change 2007: The Physical Science Basis—focuses on the significant responsibility of human action, namely "fossil fuel use and land-use change," for the global increase in carbon dioxide concentration (2). The transportation sector "accounted for 33 percent of CO2 emissions from fossil fuel combustion in 2005" (EPA, 2-10).

Emissions are growing as the demand for travel increases (EPA). The percent of emissions has increased each year by 1.5 percent on average (EIA). "From 1990 to 2004, transportation emissions rose by 29 percent due, in part, to increased demand for travel and the stagnation of fuel efficiency across the U.S. vehicle fleet" (EPA, 2-26). By 2030, under business as usual, vehicle miles traveled are expected to increase 2% annually (EIA, Energy Outlook 2007).

There is widespread agreement that transportation, and its greenhouse gas emissions, contribute to climate change and that there must be solutions adopted in the transportation sector to curb and reduce the growth of emissions (CNT, CCAP, STPP: Climate Matters 2003).

II. Goals

CO2 Emission Reductions

A widely touted goal, and that being used to shape the policy recommendations in the Presidential Climate Action Plan and the Transportation and Land Use chapter for the plan, is an 80 percent reduction of CO2, using 1990 data for baseline emissions, by 2050. Assuming that reduction should happen equally across all sectors, the goal then, using EPA's most recent draft—Greenhouse Gases Inventory (2007), is to have CO2 emissions at a level no higher than 292.8 teragrams from the transportation sector. A level similar to the 2001 transportation emissions of just California and New York combined (214.9 and 68.7 Tg respectively, WRI CAIT-US).

This great reduction cannot come from one transportation source, mode, sector or strategy (Rosenfeld 2007). The "long-term growth of driving is expected to outpace the CO2 emissions benefits of vehicle technology improvements" so technological advancements do not take away the need for travel demand reduction (6, CCAP Guidebook). Use of alternative fuels, advanced vehicle technologies and travel demand reduction in combination can help to reach short-term and long-term goals.

Sample Climate Change Action Plans

There are developing strategies on local and state levels, as well as growing debate on a federal level, on how to mitigate GHG emissions in the transportation sector.

The State of Oregon released a Strategy for Greenhouse Gas Reductions in December of 2004 that outlines fifteen transportation-related initiatives for reducing GHG emissions. The plan includes the integration of land use considerations into transportation planning and the promotion of the production and use of biofuels that have lower GHG emissions than gasoline and diesel (Oregon Governor's Advisory Group on Global Warming). Other strategies: developing an incentive program for the purchase of high efficiency vehicles, adopting state standards for high efficiency/low rolling resistance tires, changing government fleet purchase and vehicle use to include more fuel efficient vehicles (Oregon Governor's Advisory Group on Global Warming).

The City of Seattle has developed a Climate Action Plan, on a city-level. The plan focuses on high-priority, near-term investment and actions that can be taken (Seattle Climate Action Plan 2006). In the area of transportation, the plan calls for increasing investment in public transit, expanding biking and walking infrastructure, developing a road pricing system with tollways being more expensive at times when congestion is higher, increasing parking tax (while ensuring that transit options can replace former driving options), improving average fuel efficiency of city's car fleet, and planning for denser development that supports a strong public transit system (Seattle Climate Action Plan).

In 2004, Princeton researchers Pacala and Socolow outlined a model for addressing global climate change over 50 years using existing technology. Their "wedge analysis" —which divides the gap between business as usual over time and an emissions reduction path into equal reduction wedges—has been widely cited. The transportation solutions they discuss are a doubling of fuel economy from 30 to 60 mpg, a 50 percent reduction in miles traveled per vehicle, production of hydrogen with 4 million 1 megawatt wind turbines, and an expansion of ethanol production by 5,000 percent. Any one of these solutions is estimated to avoid 1 Gt CO2 emissions globally in 2054, assuming 2 billion autos on the road. The solutions are not additive, however, as a 60 mpg automobile uses less fuel than a 30 mpg automobile, so the emissions reduction achieved by clean fuels will be less in the higher efficiency auto. (Pacala and Socolow 2004)

Climate Change Legislation

Many Climate Change Action Plans that have been or are being developed have some grounding in California's AB 32 and/or California's AB 1493, commonly known as the "Pavley Law" (Carbon Control News). "[Pavely] requires the California Air Resources Board (ARB) to develop and adopt regulations that reduce greenhouse gases emitted by passenger vehicles and light duty trucks" (CARB, fact sheet). Regulations, as developed through public meetings, were adopted by the California Air Resources Board in 2004 and mandated a 30 percent reduction by 2016 of CO2 emissions from passenger vehicles and light-duty trucks starting with 2009 and later model years (Union of Concerned Scientists). Therefore, California is set to exceed United States' fuel economy standards by increasing efficiency to 40mpg. The Alliance of Automobile Manufacturers and the Association of International Automobile Manufacturers are suing the people of California to stop the Pavley Law regulations from going into effect citing such claims as violation of commerce clause (Sierra Club). At the time of this writing, the judge hearing the lawsuit has put the case on hold pending judgment in a related case before the Supreme Court—Massachusetts vs. EPA.

California's 2006 AB32 Global Warming Solutions Act places a cap on GHG emissions that requires 2020 emissions to equal 1990 levels—a likely 25 percent reduction by 2020 statewide. The regulations to implement this law are being developed, and its full economic impact is yet to be seen, but a study by David Roland-Holst of UC Berkeley estimates that working towards the reduction will add 83,000 jobs and $4 billion in income to California (Roland-Holst 2006). Arthur Rosenfield, in his presentation to a March 2007 California Air Resources Board Symposium, proposed transportation mitigation strategies in the following areas:15% smart growth, 2% renewable fuels, 28% clean cars—among other reductions related to buildings, energy, etc.—in the short-term to reach 30% of 2020 Business as Usual (BAU) CO2 emissions.

One of the provisions of AB32 is the development of a CO2 emissions registry. California passed legislation to create a voluntary registry in 2001. Known as the California Climate Action Registry, it has over 250 members and is evolving into the registry mandated by AB32. In a parallel process, California along with 30 other states, is currently participating in the development of a Multi-State Climate Registry (MSCR Briefing Materials) that has made a case for the "quantification standards" and consistent accounting of CO2 emissions from high-level and individual sources that can be used to support mitigation policies. While the Multi-State Climate Registry is not transportation-specific, it demonstrates the growing interest in collecting standard baseline data on emissions from which CO2 savings can be measured and strategies for these savings evaluated.

Federal Transportation Legislation

Three main pieces of Federal legislation have shaped of Federal efforts to improve the environmental impact of transportation to date—the Clean Air Act, the transportation omnibus bills, and the Corporate Average Fuel Economy Standards, which were created as part of the Energy Policy Conservation Act of 1975 (NHTSA).

States have been very active in developing climate change action plans. Some of the strategies put forward are fundable through the most recent transportation omnibus bill, the Safe, Accountable, Flexible, Transportation Equity Act: A Legacy for Users (SAFETEA-LU), which was passed into law on August 10, 2005 and will be in effect for a five-year period (FHWA). Environmental Defense, as well as other advocacy and policy groups, have given SAFETEA-LU mixed reviews citing more funding for bicycling and pedestrian projects including a $612 million provision over five years for Safe Routes to School, which could lead to reduced vehicle miles traveled and related emissions, with a negative component being the emphasis on highway projects (Environmental Defense). The Center for Clean Air Policy, in Green-TEA...a legacy for the planet? (draft February 2007), points out that the funding formulae in SAFETEA-LU awards dollars for vehicle miles traveled, fuel use, and quantity of lane miles—in essence, more driving, and GHG emissions.

Federal transportation policy impacts climate change and what mitigation solutions can and will be adopted (Ed. Riggs 2003). Papers produced from discussion at an Aspen Institute Climate Change three-day policy dialogue, discuss the range of options from working with vehicle manufacturers to creating more efficient vehicles to providing incentives to fuel producers for making more low GHG fuels available. The papers, reaching no definitive conclusions, explore the merit and complexities of cap-and-trade programs, emission taxes, technology and emissions standards.

III. Mitigation Strategies/Policy Recommendations

The following touches on the three focus areas—alternative fuels, vehicle technologies, and travel demand reduction with an emphasis on land use policies.

A. Alternative Fuels & Advanced Vehicle Technologies

From the Energy Information Administration:

> *"Almost all (98 percent) of transportation sector emissions result from the consumption of petroleum products: motor gasoline, at 60 percent of total transportation sector emissions; middle distillates (diesel fuel) at 22 percent; jet fuel at 12 percent of the total; and residual oil (i.e., heavy fuel oil, largely for maritime use) at 3.3 percent of the sector's total emissions. Motor gasoline is used primarily in automobiles and light trucks, and middle distillates are used in heavy trucks, locomotives, and ships."*

Alternative Fuels

Alternative fuels that could reduce and/or replace the use of fossil fuels include ethanol (derived from corn, sugarcane or cellulose), hydrogen (from "steam reformation of natural gas, gasification of natural gas, gasification of petroleum coke or biomass, and electrolysis of water"), natural gas, biodiesel (from yellow grease or restaurant waste, rapeseed, mustard seed or soybeans), electricity, and propane (Tiax, LLC 2007).

The greenhouse gas emissions, costs, and other environmental impacts of alternative fuels have been a source of much research and controversy. This controversy has many sources. First, some fuels that may have zero net greenhouse gas impacts at the tailpipe may generate higher levels of smog forming pollutants. Other fuels may be extremely environmentally friendly but extremely costly. Finally, many fuels, including traditional transportation fuels, have much greater environmental impact when looked at on a lifecycle, or "wells-to-wheels", basis than their impacts from vehicle combustion.

Source	Fuel	Potential Savings	Notes
Pickrell (2003)	Ethanol from corn	2-3%	Alternative fuel mixed with gasoline
	Petroleum, diesel, biodiesel, electricity	8-11%	Alternative fuel mixed with gasoline
	Compressed natural gas (CNG), Liquefied petroleum gas (LPG), and hydrogen	5-6%	
Published in Stoddard and Murrow (2006)	Cellulosic Ethanol	52-88%	Low range takes land use impact into account.
	Corn Ethanol	-6 to 13%	Low range takes land use impact into account.

The above table (results also referenced in text below) is a small sample of the research that has been conducted on the potential savings of different alternative fuels.

Alternative fuels are the focus of federal policy first with the Energy Policy Conservation Act (which the CAFE standard was developed from) and then with the Alternative Fuels Act of 1988 and the Energy Policy Act of 1992 with the federal government's growing concern with energy security and reducing reliance on foreign sources of oil. The Energy Policy Act of 1992 generally outlines the requirements that apply to government fleets, mandating a reduction of petroleum consumption and an increase of non-petroleum fuels (DOE). Transit agencies have also been introducing alternative fuels and alternative fuel vehicles to their fleets. CNT et al, in a Transit Cooperative Research Program Report, look at the emissions from alternative fuels when used for buses, finding that the lowest quantity of life cycle CO2 per mile was generated by hydrogen from electrolysis with the greatest emissions coming from gasoline (Table 4-1 using Argonne National Laboratory's GREET model), but the costs of hydrogen from electrolysis remain quite high and the potential for large-scale production has been questioned (Romm 2004).

Wang notes that “in general, fuel switching by itself has limited GHG emission reduction potential. Combinations of fuel switching and use of advanced technologies...achieve larger GHG emission reductions” (p. 75). As of 2005, there were 890,281 alternative fuel vehicle and hybrids introduced on the road—1,753 of which are buses (EIA 2005). New York City Transit tested compressed natural gas (CNG) buses and hybrid buses using diesel buses as a baseline case. The results showed hybrid buses having the highest fuel economy (Chandler et al 2006). Evaluation is ongoing to determine the best fuel base for additions to the NYCT bus fleet.

There is much ongoing research and development to determine the most appropriate fuels and technologies to invest in given life-cycle costs and emissions, including production, distribution, and use. Pickrell in a study of GHG emissions for alternative fuels reported the following results: using ethanol from corn could result in 2-3% GHG emission reduction; petroleum diesel, biodiesel, or electricity could lead to 8-11% GHG emission reduction; reduction of GHG by 5-6% when replacing a portion of gasoline with CNG, LPG, or hydrogen. The largest displacement of GHG emissions when replacing 25 percent of gasoline with alternative fuels is with E90, which means a fuel blend with 90 percent ethanol to 10 percent gasoline (Pickrell 2003). The costs per ton of GHG emissions avoided ranges from $100 for biodiesel to over $600 for corn-based ethanol (Pickrell 2003). Besides being a more expensive source of reductions, Stoddard and Murrow found that there are no real reductions, when including land use impact, of replacing gasoline with ethanol from corn.

Tiax, LLC's research and reports for the California Energy Commission, a study undertaken to determine how to increase the use of alternative transportation fuels under the direction of the California's AB 1007—State Plan to Increase the Use of Alternative Transportation Fuels, evaluates energy consumption and emissions from the Well-to-Wheel. This recent life cycle study (report is still in draft form) found that ethanol produced from sugarcane and cellulose have greater GHG emission reductions than ethanol produced from corn.

Stoddard and Murrow, comparing three life-cycle fuel analyses, finds a range of 52-88 percent (52 percent when considering land use impacts) emission reduction potential when replacing gasoline or diesel (as baseline) with ethanol. Hydrogen is another fuel with great reductive potential, although there are still issues, such as handling distribution, that need to be reviewed.

Welch cautions at the beginning of his study that there is a trend in the United States in focusing on one alternative fuel, like hydrogen, as a “silver bullet” when in fact, there have been similar efforts, like the Zero Emission Vehicle program which have stalled after a lot of hype. Welch reviews three models for introducing and supporting a hydrogen based transportation system, noting in his findings that there must be attention paid to the types and length of incentives to ensure that a new technology takes hold in the market.

Freight

Freight transportation modes, particularly freight trucks, are a growing contributor to emissions with a 69 percent increase in CO2 from trucks from 1990 to 2005 (EPA). The Annual Energy Outlook cites heavy trucks used for freight as growing at the “fastest annual rate among the major forms of transport” (p. 88).

In the area of freight, Frey and Kuo identify thirty-three best practices that, if implemented in the truck mode—which makes up 60% of freight's transport—could result in a 60 percent reduction of CO2 emissions in 2025. Best practices that support this level of reduction include use of B20 biodiesel, weight reduction, and introduction of hybrid trucks (Frey 2007). Frey and Kuo also detail strategies for potential CO2 savings in the areas of freight transport by rail and water. Rail and water mode improvements that can reduce CO2 include anti-idling measures.

Walsh, in a presentation at a meeting of the International Council on Clean Transportation, shows that North America is responsible for the largest share of energy use for heavy duty trucks. Japan is taking a leadership role in improving fuel efficiency—a 12% improvement from 2002 levels by 2015—through thermal efficiency, anti-idling, and other strategies (Walsh).

Another proposal for reducing CO2 emissions in the area of freight is shifting freight currently transported by truck to rail. There is a potential 8 percent GHG savings potential by switching a segment of freight on trucks to rail (Dierkers and Winkelman). Greene and Schafer emphasize that the reduction of emissions will be realized by ensuring that "allow freight to be transferred quickly and efficiently among modes" (p. 37). Expensive and time consuming transfer of goods between and among modes can offset anticipated emission savings.

Fuel Economy

According to An and Sauer, "automobile fuel economy standards have proven to be one of the most effective tools in controlling oil demand and greenhouse gas emissions from the transportation sector" (2). In the United States, automobile fuel economy is set with the Corporate Average Fuel Economy (CAFE), which originated in 1975 with the Energy and Policy Conservation Act. Yet, despite our long history of regulating automobile fuel efficiency, the United States, when considered in the company of Japan, China, and the European Union, has the lowest fuel economy standards (An and Sauer 2006). The United States' CAFÉ standard for passenger vehicles is 27.5 miles per gallon (mpg), a level that was set in 1990 and remains the same today (FHWA). While increases are periodically discussed, the Annual Energy Outlook assumes just an average of 29.2 mpg for new cars and light trucks, and 22.2 mpg for the national light vehicle fleet in 2030 in its base case model.

Hybrids

Hybrid vehicles are those that two or more sources of power (HybridCars). Most hybrid vehicles run off of rechargeable batteries, which can use the braking power for recharge, and gasoline. The costs of hybrid vehicles are coming down, market share is increasing, and even with incentives phased out, there is a big interest in hybrid technology and purchasing hybrid cars even if they are more expensive than non-hybrid vehicles (Greene et al. 2004). Hybrid cars have the potential to increase vehicle fuel economy by 30 percent (Ibid). With a variety of hybrid cars on the road, there is growing interest in the potential of plug-in hybrid vehicles that get most of its propulsion energy from electricity (Sanna 2005). The plug-in hybrid is being used and tested across the country. As quoted in Sanna, in urban driving idling accounts for 10-15 percent of total vehicle emissions, with hybrids eliminating the idling.

There are currently a range of incentives available to people who drive hybrid vehicles and alternative fuel vehicles. The incentives include tax credits and tax deductions for different manufacturers and models (see fueleconomy.gov). Although credits and tax deductions play a role in bringing newer technologies to scale, there is some speculation that they will be phased out in 2008 (Greene et al 2004).

General

The range of policy initiatives that can impact lower CO2 emissions from transportation are found in CCAP's Guidebook and include, in part: regulating replacement tires with low rolling resistance tires, supporting a fuel tax, increasing use of biodiesel fuels and hybrid vehicles. The Guidebook also provides a good format for ordering the complex issues and opportunities within the transportation sector.

It is worth noting that many studies do not take into account the full cost of driving, which includes the manufacturing of vehicles, the building of roads, and the processing and transporting of fuels (RMI). If emissions from all of these were taken into account, increasing fuel economy and improving vehicle technologies do little to reduce overall emissions. There has been a debate waging online regarding the report published by CNW Research Inc. claiming that when taking the life of a vehicle into account—inception to scrappage—the Hummer 3, for example, produces less emissions than smaller, more fuel efficient cars like the Prius, which is the number-one selling hybrid (CNW Marketing Research Inc., Hybrid Car).

B. Travel Demand Reduction

One of the critical ways to reduce the amount of CO2 is to reduce the amount of driving since the largest proportion of CO2 in the transportation sector comes from passenger vehicles and there are significant increases in VMT for light-duty vehicles and freight trucks (EPA 2007). Travel demand reduction acknowledges that transportation is not an end in itself and that transportation choices are shaped by the cost of housing, the location and reputation of schools, job locations, and the availability of services and amenities (Lipman 2006). The percentage of income spent on transportation correlates with distance from work with the cost of transportation increasing as the distance increases (ibid). The physical form of a place results in travel patterns and options and associated costs for households and the environment (TCRP 93).

Transportation is the number two household expense, second only to housing, with lower income households paying a higher percentage of their budget for transportation (Bernstein et al 2005). Climate Matters clearly outlines the connection between vehicle miles traveled and land use. The greater density in an area, the less VMT per household; the less density, the greater the VMT. Sprawl causes “induced [auto] demand.” Sprawling areas where there is a mismatch between where people live and where they work results in a higher rate of vehicle miles traveled. In addition to household expense, a reliance on car travel has other negative implications including higher rates of physical inactivity (i.e., with less opportunities to walk to services or to transportation), greater instances of obesity and other chronic health conditions that have been linked to inactivity and mapped to sprawling areas in contrast with more compact areas (McCann et al 2003).

In dense urban areas where public transportation and services are readily accessible, emissions per household are lower (TCRP 93). Strategies that promote a reduction in travel demand include: transit-oriented development, infill/brownfield development, pedestrian-oriented design, smart school siting, improved transit service, light rail transit networks, bus rapid transit corridor, bicycle initiatives, road pricing, commuter incentives, pay-as-you drive insurance, green mortgages, smart growth, municipal parking programs, and safe routes to school plans (Dierkers et al). Each of these strategies is possible when land use planning is paired with transportation planning.

Transit-oriented development (TOD), as one in a potential suite of options, refers to the placement of retail or commercial space located near transit that people can access from transit. Dierker et al estimates that regional TOD makes walking and transit more attractive, and can result in a 5 percent decrease in vehicle miles traveled in that given area. This modest reduction can be linked with other strategies for greater impact. Dierker et al quantifies potential reduction of vehicle miles traveled from each of the aforementioned strategies, each accompanied with case studies and links to resources.

Many of the travel demand reduction strategies imply that there is a functioning public transportation system in place. Public transportation ridership went up 24 percent between 1995 and 2002, largely due to transit investments made through TEA-21 (Hemily 2004). Because public transit miles and corresponding emissions are averaged over the number of passengers and public transit boasts more passengers, emissions from public transit are much less per person than those produced from travel in a car. Hemily notes that despite the uptake of transit, there are still growing trends of sprawling development and increased vehicle ownership that threatens the or growth of public transportation. In 2004, 67,362,000 vehicle miles were traveled on light rail primarily relying on electricity for power (APTA). Complete data on the cost, quantity and use of public transit is available on APTA's website.

Another possible strategy for reducing the demand for travel and related GHG emissions is car sharing. There are car sharing programs—short-term, pay-as-you go access to a car—throughout the United States which have been developed to address the economic and environmental costs involved with owning a vehicle. Cevero et al, in reviewing the impact of San Francisco City CarShare, found that car sharing members' “mean VMT and fuel consumption went down faster than nonmembers” and that vehicle ownership declined among members (39).

Air travel is also a big source of CO_2 emissions that be reduced through the introduction of high speed rail and, overall a more integrated transportation system that reduces the frequency of flights that are 100-400 miles (Dittmar et al). Developing high speed rail in the12 corridors that are currently proposed, would deter some air, train, bus, and car travel, which could total savings of 2.7 teragrams of CO_2 per year (CCAP, CNT 2006).

In summary, proposals to reduce VMT and related emissions should include: a shift in funding towards more efficient alternatives, location efficient development, environmentally friendly travel choices, diverse freight networks, and choices for intercity travel (CNT, CCAP 2003).

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Appendix IV: Data Analysis

CO_2 Savings: Passenger Vehicles (1-3)

1) Travel Demand Reduction (2 scenarios)

Formula:

Savings Potential	=	Base Case – Policy Case
Base Case	=	VMT / mpg adjusted * lbs of CO2 per gallon
Policy Case	=	VMT * compounded annual reduction % from 2005 / mpg adjusted * lbs of CO_2 per gallon

Sources:

- VMT for 1990 and 2005 from Environmental Protection Agency (using passenger vehicles and light duty vehicles); VMT projections to 2030 (Annual Energy Outlook 2007 growth rate: 1.9% annual); VMT projections from 2030 to 2050 (slightly slower growth rate: 1.7% annual based on US Census Bureau population projections and GDP projections—both projected to grow at a slower rate between 2030 and 2050)
- Rate of VMT reduction: 0.25-1% annually (Center for Clean Air Policy); used 1% for aggressive case and 0.5% for less aggressive case
- MPG projections (Environmental Protection Agency rated); MPG adjusted for actual on-road performance (78% -- based on Energy Information Administration) and penetration of vehicle rate
- lbs of CO_2 per gallon = 19.6 (Environmental Protection Agency)
- lbs CO_2 converted to MMT CO_2 by dividing pounds by 2205 million

Vehicle Miles Traveled or VMT (in billions):

	2005	**2010**	**2020**	**2030**	**2050**
Projected Business as Usual	2655	2799	3474	3474	5937
1% annual reduction	2655	2771	3109	3290	3017
0.5% annual reduction	2655	2785	3296	3782	4623

2) Increased fuel efficiency

Formula:

Savings Potential	=	Base Case – Policy Case
Base Case	=	VMT / mpg adjusted * lbs of CO_2 per gallon
Policy Case	=	VMT / (mpg adjusted * compounded annual increase % in efficiency from 2005) * lbs of CO_2 per gallon

Sources:

- Please see #1.

- 4% annual increase in fuel efficiency has been proposed by President Bush and by Congressional legislation.
- Penetration rate of fuel efficiency into the car fleet was also considered using research by David Greene (analysis provided by Center for Clean Air Policy)

Fuel Economy (adjusted):

	2005	2010	2020	2030	2050
Projected Business as Usual	19.6	19.8	21.2	22.2	33.0
4% annual increase		19.9	24.4	34.0	77.7
3% annual increase		19.8	23.0	25.7	29.3

* Both projected BAU and the annual increase numbers have been adjusted for on-road performance and weighted by the penetration of the new standard in the fleet.

3) Increased use of low GHG fuels

Formula:

Savings Potential	=	Base Case – Policy Case
Base Case	=	VMT/mpg adjusted * lbs of CO2 per gallon
Policy Case	=	VMT/mpg adjusted * (1 – GHG Reduction %) * lbs of CO_2 per gallon in 2005
More Aggressive GHG Reduction %	=	3%, 10%, 20%, 40% in 2010, 2020, 2030, 2050 respectively
Less Aggressive GHG Reduction %	=	2%, 6.5%, 13%, 25% in 2010, 2020, 2030, 2050 respectively

Sources:

- Please see #1
- 3%-40% reduction of lbs CO_2 per gallon of fuel is based on the increased introduction of biofuels (to supplement and replace use of gasoline); reduction potential based on studies summarized in Stoddard, Michael and Derek Murrow. Climate Change Roadmap for New England and Eastern Canada. Environment Northeast. 2006 (Table 2-1, p. 124) and review of the Center for Clean Air Policy (see CCAP Guidebook at http://www.ccapguidebook.org) and California's Low Carbon Fuel Standard (LCFS) (see http://gov.ca.gov/index.php?/press-release/5074/)

Low GHG Fuels (lbs CO_2 per gallon):

	2005	2010	2020	2030	2050
Projected Business as Usual (using gasoline)	19.6	19.6	19.6	19.6	19.6
With 3%, 10%, 20%, 40% CO_2 Savings per gallon	19.6	19.1	17.7	15.7	11.8
With 2%, 6.5%, 13%, 25% CO_2 Savings per gallon		19.2	18.4	17.1	14.7

CO_2 Savings: Freight (5-7)

5) Truck: Increased Efficiencies and other measures

Formula:

Savings Potential	=	Base Case – Policy Case
Base Case	=	projected business-as-usual CO_2 emissions
Policy Case	=	Base Case * projected % savings from increasing efficiency and taking other measures

Sources:

- Base Case established using EPA Inventory of US GHG Emissions and Sinks, Feb 2007 Draft and Energy and Information Administration's Annual Energy Outlook
- Policy Case assumes that the following measures from the Center for Clean Air Policy are taken. Potential savings listed next to each measure are based on availability of technology multiplied by assumed rate of penetration introduced incrementally from 2010-2050:
  - Improve tractor aeroprofile (1.7%)
  - Improve tractor aerofeatures (1.8%)
  - Improve trailer aerodynamics (1.9%)
  - Use of wide-based tires (1.3%)
  - Auto tire inflation (0.3%)
  - Weight reduction (0.9%)
  - Low friction lubricant (0.8%)
  - Speed reduction (3.4%)
  - Hybrid Technology (9.0%)
  - Idle Reduction (4.5%)
  - Driver training (1.9%)
  - Shift some truck to rail (8.0%)
  - Increased use of Biodiesel (6.9%)

6) Rail: Increased Efficiencies and other measures

Formula:

Savings Potential	=	Base Case – Policy Case
Base Case	=	projected business-as-usual CO_2 emissions
Policy Case	=	Base Case * projected % savings from increasing efficiency and taking other measures including diverting truck freight to rail

Sources:

- Base Case established using EPA Inventory of US GHG Emissions and Sinks, Feb 2007 Draft and Energy and Information Administration's Annual Energy Outlook

- Policy Case assumes that the following measures from the Christopher Frey and Po-Yao Kuo's *Best Practices for Greenhouse Gas Emission Reductions in Freight Transportation*, prepared for: Talking Freight Seminar Series, FHWA, on January 17, 2007, are taken (with potential savings—based on availability of technology * assumed rate of penetration—introduced incrementally from 2010-2050):
    - Reducing idling
    - Reducing weight
    - Improving rolling resistance
    - Increasing the use of biodiesel (B20)

7) Water: Increased Efficiencies and other measures

Formula:

Savings Potential	=	Base Case – Policy Case
Base Case	=	projected business-as-usual CO_2 emissions
Policy Case	=	Base Case * projected % savings from increasing efficiency and taking other measures

Sources:

- Base Case established using EPA Inventory of US GHG Emissions and Sinks, Feb 2007 Draft and Energy and Information Administration's Annual Energy Outlook
- Policy Case assumes that the following measures from the Christopher Frey and Po-Yao Kuo's *Best Practices for Greenhouse Gas Emission Reductions in Freight Transportation*, prepared for: Talking Freight Seminar Series, FHWA, on January 17, 2007, are taken (with potential savings—based on availability of technology * assumed rate of penetration—introduced incrementally from 2010-2050):
    - Improving the propeller system
    - Reducing idling
    - Increasing the use of biodiesel (B20)

CO_2 Savings: Intercity Passengers (8-9)

8) Air: Increased Efficiencies and Other Measures

Formula:

Savings Potential	=	Base Case – Policy Case
Base Case	=	projected business-as-usual CO_2 emissions
Policy Case	=	Base Case * projected % savings from increasing efficiency and taking other measures

Sources:

- Base Case established using EPA Inventory of US GHG Emissions and Sinks, Feb 2007 Draft and Energy and Information Administration's Annual Energy Outlook
- Policy Case assumes that the following measures from the International Air Transportation Association (http://www.iata.org/whatwedo/environment/fuel_efficiency.htm) (with potential savings—based on availability of technology * assumed rate of penetration—introduced incrementally from 2010-2050):
    - Improved air traffic management (12%)
    - Operational improvements (6%)

9) High Speed Rail (HSR)

Formula:

Savings Potential	=	Saved Emissions – HSR Emissions
Saved Emissions	=	CO_2 from trips diverted from passengers vehicles, short airplane routes, and conventional train trips
HSR Emissions	=	Emissions from HSR operating in 12 corridors using IC-3 rail technology

Sources:

- Numbers taken from the high speed rail study conducted by the Center for Neighborhood Technology and the Center for Clean Air Policy—High Speed Rail and Greenhouse Gas Emissions in the US. January 2006. Available online at http://www.cnt.org.
- Policy Case numbers adjusted from CNT and CCAP study to use Business as Usual fuel efficiency used in Passenger Vehicle portion of this analysis (fuel economy projected numbers are from the Environmental Protection Agency and adjusted for on-road performance and fleet penetration)

CO_2 Savings: Overall (10)

10) Overall

Formula:

Savings Potential	=	Passenger Vehicle Savings + Freight Savings + Air Savings + HSR Savings
Passenger Vehicle Savings	=	Passenger Vehicle Base – Passenger Vehicle Combined Policy
Passenger Vehicle Base	=	VMT / mpg adjusted * lbs of CO_2 per gallon

Passenger Vehicle Combined Policy	=	VMT * compounded annual reduction % from 2005 / (mpg adjusted * compounded annual increase % in efficiency from 2005) * (1 – GHG Reduction %) * lbs of CO_2 per gallon in 2005
Freight Savings	=	Sum of savings from 5) through 7)
Air Savings	=	See 8)
HSR Savings	=	See 9)

The combined savings was computed by combining the effects of VMT reduction, increase in fuel economy, and decrease in GHG/gallon of fuel for passenger vehicles summed with the savings calculated independently for freight and intercity travel by air and rail. Two scenarios were computed using different estimates for the VMT, mpg, GHG/gallon used for the passenger vehicle calculations.

Savings Scenarios

	Annual VMT % Reduction	**Annual mpg % increase**	**GHG Reduction in 2010, 2020, 2030, 2050**
More Aggressive	1%	4%	3%, 10%, 20%, 40%
Less Aggressive	.5%	3%	2%, 6.5%, 13%, 25%

Appendix V: Method for Identifying and Prioritization Mitigation Policies and Strategies

MITIGATION POLICIES and STRATEGIES IN THE FOLLOWING AREAS:

TRAVEL DEMAND[1]
Journey to work
Goods movement
Tourism
Economic Generators
Community Travel

VEHICLE TECHNOLOGIES[2]
Passenger Vehicles
Light Duty Trucks
Heavy Duty Trucks
Buses
Aircraft
Boats and Ships
Locomotives

ALTERNATIVE FUELS[3]
Ethanol
Natural Gas
Hydrogen
Biodiesel
Electricity
Propane

GOAL: Reduce CO_2 in transportation sector by 80% by 2050 (from 1990 levels).

METHODS

1) Share of total projected baseline emissions effected with Reduction Potential

2) Cost Effectiveness/ Return on Investment

Upfront costs; implementation costs; annual overall costs; who bears the cost? And when? Social costs/benefits, health costs/benefits? Environmental cost/benefits?

3) Builds on current initiatives

Review case studies; are there success stories that can be replicated or scaled?

4) Potential for Partnerships and Funding

Private/Public; Local/State/Federal

5) Barriers to Overcome

Technical
Legal
Cultural
Political

6) Meets Multiple Goals/Other Benefits/Optimizes Adaptation

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1) Anker, William. Revisiting Transportation Planning. Public Works Management & Policy, Vol. 9 No. 4, April 2005: 270-277.
2) Vehicle technologies will be reviewed in each of the applicable categories used by the Environmental Protection Agency and Energy Information Administration for reporting and predicting emissions.
3) US Department of Energy. Alternative Fuels Data Center (http://www.eere.energy.gov/afdc/altfuel/altfuels.html)

Appendix VI: Complete Set of Policy Recommendations

Please see Excel Spreadsheet entitled "Complete Reco Set 5-3-07"

Appendix VII: Top Policy Recommendations by Presidential Power

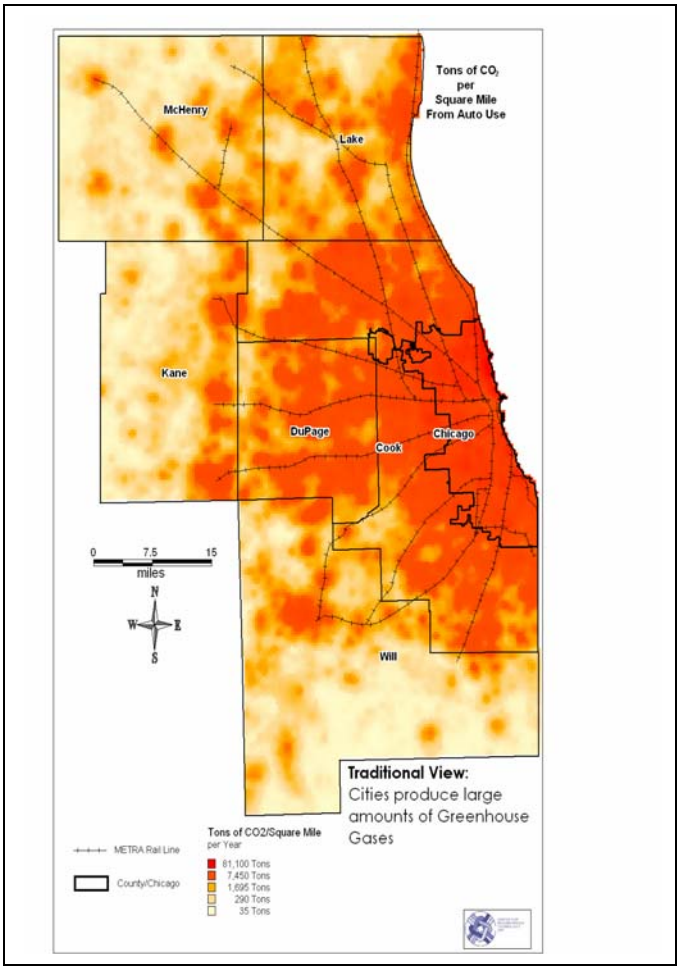
Action Type	Category	Sub-category	Policy Recommendation	Policy Strategy
Executive Order				
	PASSENGER VEHICLES			
		Travel alternatives		
			Increase Usage of Existing Technology	
				Use the Internet to reduce number of trips for work and administrative type activities
			Encourage greater use of current public transportation systems	
				Invest more in transit operations and expansion
				Equalize transit and parking benefits & Offer parking cash-out benefits
			Increase access to and support travel alternatives	
				Expand car sharing
		Land use		
			Plan for more efficient communities through increasing density and mixed usages	
				Support transit-oriented development
	LOW GHG FUELS			
		Electricity		
			Support ongoing development of innovative technologies	
				Continue to investigate the feasibility of plug-in hybrids

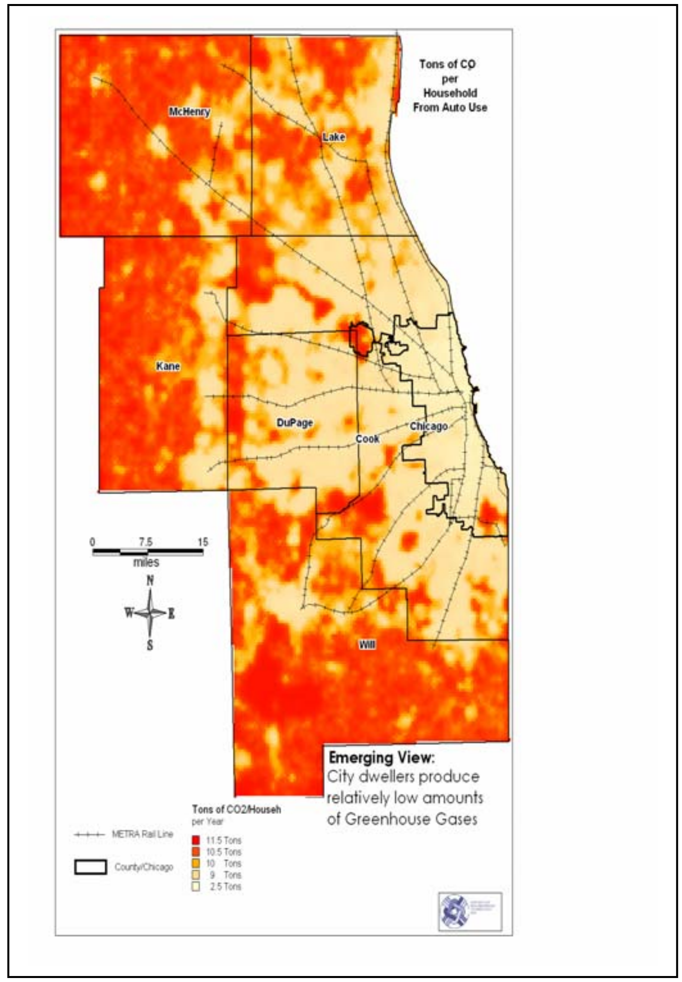
Budgetary				
	PASSENGER VEHICLES			
		Travel alternatives		
			Increase Usage of Existing Technology	
				Use the Internet to reduce number of trips for work and administrative type activities
			Encourage greater use of current public transportation systems	
				Invest more in transit operations and expansion
				Equalize transit and parking benefits & Offer parking cash-out benefits
				Award bonus points to transit in a cap-and-trade system
		Land use		
			Plan for more efficient communities through increasing density and mixed usages	
				Support transit-oriented development
		Incentives		
			Create market demand for travel alternatives	
				Implement congestion pricing for roads
	LOW GHG FUELS			
		Biofuels		
			Increase use of low GHG emitting alternative fuels	
				Support the use and distribution of alternative fuels
		Electricity		
			Support ongoing development of innovative technologies	
				Continue to investigate the feasibility of plug-in hybrids
	FREIGHT			
		Truck		
			Increase freight truck efficiencies	
				Adopt freight truck efficiency measures
	INTERCITY PASSENGER			
		High Speed Rail		
			Create lower emission, innercity travel options	
				Support private investment and innovative funding for the development of high speed rail

Directive				
	PASSENGER VEHICLES			
		Travel alternatives		
			Increase Usage of Existing Technology	
				Use the Internet to reduce number of trips for work and administrative type activities
			Encourage greater use of current public transportation systems	
				Invest more in transit operations and expansion
				Equalize transit and parking benefits & Offer parking cash-out benefits
		Land use		
			Plan for more efficient communities through increasing density and mixed usages	
				Support transit-oriented development
		Incentives		
			Create market demand for travel alternatives	
				Implement congestion pricing for roads
	FUEL ECONOMY			
		Regulation		
			Increase fuel economy	
				Increase CAFE standards
	LOW GHG FUELS			
		Biofuels		
			Increase use of low GHG emitting alternative fuels	
				Support the use and distribution of alternative fuels
	FREIGHT			
		Truck		
			Increase freight truck efficiencies	
				Adopt freight truck efficiency measures
	INTERCITY PASSENGER			
		High Speed Rail		
			Create lower emission, innercity travel options	
				Support private investment and innovative funding for the development of high speed rail

Legislative				
	PASSENGER VEHICLES			
		Travel alternatives		
			Increase Usage of Existing Technology	
				Use the Internet to reduce number of trips for work and administrative type activities
			Encourage greater use of current public transportation systems	
				Invest more in transit operations and expansion
				Equalize transit and parking benefits & Offer parking cash-out benefits
				Award bonus points to transit in a cap-and-trade system
		Incentives		
			Create market demand for travel alternatives	
				Implement congestion pricing for roads
Leadership				
	PASSENGER VEHICLES			
		Travel alternatives		
			Encourage greater use of current public transportation systems	
				Equalize transit and parking benefits & Offer parking cash-out benefits
			Increase access to and support travel alternatives	
				Expand car sharing
		Land use		
			Plan for more efficient communities through increasing density and mixed usages	
				Support transit-oriented development
	LOW GHG FUELS			
		Biofuels		
			Increase use of low GHG emitting alternative fuels	
				Support the use and distribution of alternative fuels
	FREIGHT			
		Truck		
			Increase freight truck efficiencies	
				Adopt freight truck efficiency measures

Appendix VIII: Density Maps (2) Chicago CO_2 per Household





Tradition View **Emerging View**

Appendix IX: Glossary

PASSENGER VEHICLE REDUCTIONS

Transit-oriented development (TOD)- refers to residential and commercial centers designed to maximize access by transit transportation

Smart growth- is a general term for policies that integrate transportation and land use decisions

Pedestrian-oriented design- refers to residential and commercial centers designed to maximize access by non-motorized transportation

Congestion Pricing- refers to variable road pricing (higher prices under congested conditions and lower prices at less congested times and locations) intended to reduce peak-period vehicle trips.

Parking Cash Out- means that commuters who are offered a free or subsidized parking space have the option of choosing the cash equivalent**,** resulting in a reduction of employees driving to work.

Carsharing- automobile rental services intended to substitute for private vehicle ownership. It makes occasional use of a vehicle affordable, while providing an incentive to minimize driving.

*Definitions taken from Travel Demand Management Encyclopedia: http://www.vtpi.org/tdm/tdm61.htm

FUEL ECONOMY

Fuel Economy- is defined as the average mileage traveled by an automobile per gallon of gasoline (or equivalent amount of other fuel) consumed as measured in accordance with the testing and evaluation protocol set forth by the Environmental Protection Agency.

Corporate Average Fuel Economy (CAFÉ)- is the sales weighted average fuel economy, expressed in miles per gallon (mpg), of a manufacturer's fleet of passenger cars or light trucks with a gross vehicle weight rating (GVWR) of 8,500 lbs. or less, manufactured for sale in the United States, for any given model year

Feebate- either a fee is charged or a rebate is given relative to specific regulation. Feebates are intended to be revenue neutral meaning that the fees directly subsidize the rebates.

* Definitions taken from the National Highway Traffic & Safety Administration

FREIGHT

Anti-idling or Idle reduction- is used to describe technologies and practices that reduce the amount of time engines idle. Reducing idle time saves fuel, engine wear, and money. In addition, it reduces emissions and noise.

Rolling resistance - is the parasitic energy a tire consumes while rolling under load

* Definitions taken from Alternative Fuels Data Center : http://www.eere.energy.gov/

ALTERNATIVE FUELS

Ethanol- can be produced chemically from ethylene or biologically from the fermentation of various sugars from carbohydrates found in agricultural crops and cellulosic residues from crops or wood. Used in the United States as a gasoline octane enhancer and oxygenate.

Natural Gas- a mixture of gaseous hydrocarbons, primarily methane, occurring naturally in the Earth and used principally as a fuel.

Propane- a gas whose molecules are composed of three carbon and eight hydrogen atoms. Propane is present in most natural gas in the United States, and is refined from crude petroleum.

Hydrogen- a colorless, highly flammable gaseous fuel

Biodiesel- a biodegradable transportation fuel for use in diesel engines that is produced through transesterification of organically derived oils or fats.

Electricity- electric current used as a power source. Electricity can be generated from a variety of feedstocks, including oil, coal, nuclear, hydro, natural gas, wind, and solar.

Methanol- a liquid fuel formed by catalytically combining CO with hydrogen in a 1 to 2 ratio under high temperature and pressure. Commercially, it is typically manufactured by steam reforming natural gas

P-series fuels- fuels designed by the Pure Fuel Corporation to run in E85/gasoline flexible fuel vehicles

*Definitions taken from the Alternative Fuels Data Center : http://www.eere.energy.gov/afdc/resources/glossary.html

INTERCITY TRAVEL

Travelports: link air, rail, and intercity bus into one convenient facility

High Speed Rail: intercity passenger ground transportation] that is time-competitive with air and/or auto for travel markets in the approximate range of 100 to 500 miles.

*Definitions taken from Reconnecting America and US DOT