

Chapter 1. Policies that Improve the Environment and Environmental Public Health



1 Introduction: Policies that Improve the Environment and Environmental Public Health

Chapter 1 presents policies that would reduce the transportation system’s impacts on the environment and environmental public health, chiefly through reducing the negative effects of transportation-related emissions. This can be accomplished through two approaches: reducing the amount of emissions that are generated and reducing exposure to these emissions when they do occur.

Tailpipe emissions, which are the by-products of fuel combustion, and emissions from electricity-generating sources (in the case of electric-powered vehicles) have the most direct impact on the environment and human health. Their health effects are well-documented—higher incidence of:

respiratory disease (such as asthma and chronic obstructive pulmonary disease), cardiovascular disease, and adverse pregnancy outcomes. Pregnant women, children, and the elderly are the most vulnerable.^{1,2}

Yearly costs incurred to treat related diseases and the costs incurred by the premature deaths associated with exposure to these emissions range from \$50 to \$80 billion adjusted to 2008 dollars.³ In addition to financial costs, there are losses in productivity; one impact indicator is missed days at school or at work. In 2008, 58.7 percent⁴ of all child asthma sufferers and 33.2 percent⁵ of adult asthma sufferers missed some school or work that year as a result of an attack.

On the larger-scale level of environmental health, one of the largest impacts from transportation-related emissions is the generation of greenhouse gases—carbon dioxide, primarily—which are associated with climate change.

Opportunities for Improving the Environment and Environmental Public Health

Very substantial progress can be achieved by reducing emissions and reducing exposure to emissions when they occur. We have identified nine policies within three areas where substantial improvements in environmental health can be made. The three areas are:

- Reduce human exposure to transportation-related emissions
- Reduce transportation's contribution to climate change
- Promote a reduction in vehicle-miles travelled through pricing mechanisms

Reduce Human Exposure to Transportation-Related Emissions

Transportation-related emissions with the most direct effect on human health include carbon monoxide, nitrogen dioxide, ozone (the primary ingredient in smog), particulate matter, sulfur dioxide, and toxins such as lead.⁶

¹ Boothe, V. and D.G. Schendell. 2008. Potential Health Effects Associated with Residential Proximity to Freeways and Primary Roads; Review of the Literature 1999-2006. *Journal of Environmental Health*, 70 (8): 33-41, 55-56.

² Friedman, M.S., K.E. Powell, et al. 2001. Impact of Changes in Transportation and Commuting Behaviors During the 1996 Summer Olympic Games in Atlanta on Air Quality and Childhood Asthma. *The Journal of the American Medical Association*, 285 (7): 897-905.

³ American Public Health Association. 2010. *The Hidden Health Costs of Transportation*. Available at: <http://www.apha.org/NR/rdonlyres/F84640FD-13CF-47EA-8267E767A1099239/0/HiddenHealthCostsofTransportationShortFinal.pdf> [accessed April 21, 2011].

⁴ Centers for Disease Control and Prevention, National Center for Health Statistics. 2008. National Health Interview Survey. *Proportion of Children Aged 5 to 17 Years with Asthma Who Miss School Days, Percent*. Available at: http://www.healthindicators.gov/Indicators/Missedschooldays_1410/Profile/Data [accessed April 25, 2010].

⁵ Centers for Disease Control and Prevention, National Center for Health Statistics. 2008. National Health Interview Survey. *Proportion of Adults Aged 18 to 64 Years with Asthma Who Miss Work Days, Percent*. Available at: http://www.healthindicators.gov/Indicators/Missed-work-days_1411/National_0/Profile/Data [accessed June 13, 2011].

⁶ U.S. Environmental Protection Agency. 2011. *National Ambient Air Quality Standards*. Available at: <http://www.epa.gov/air/criteria.html> [accessed May 22, 2011].

Short-term exposure to these pollutants can exacerbate existing symptoms for those with asthma and chronic obstructive pulmonary disease, along with other respiratory diseases.⁷ Populations that are exposed over longer terms—people living near high-traffic roadways, for example—experience excess rates of cardiopulmonary mortality,^{8,9} as well as adverse pregnancy outcomes such as pre-term birth and low birth weight.^{10,11}

The adoption of advanced emission control devices and clean-engine technologies, in addition to tighter fuel efficiency standards, have resulted in reduced vehicle emissions, but until the economic downturn, the total number of vehicle-miles traveled was steadily increasing, counteracting some of these technological and regulatory gains.¹²

Steps to reduce exposure to transportation-related emissions include: improving air quality monitoring systems to give individuals and communities the information they need to make healthier choices; separating high-polluting facilities—especially those that have high rates of “fine” particulates, those that measure 2.5 micrometers across or less (PM_{2.5})—from vulnerable populations; and further reductions in tailpipe emissions and improvements in fuel efficiency.

Reduce the Transportation System’s Contribution to Climate Change

Greenhouse gases in the atmosphere trap heat and contribute to rising surface temperatures. This can trigger a multitude of mechanisms—including weather patterns and sea level rise—that can have adverse environmental health effects.¹³ From 1990 to 2009, transportation’s total greenhouse gas emissions (nearly all of which were carbon dioxide) rose 17 percent.¹⁴ Put another way, in 2009, transportation was responsible for 33 percent of total carbon dioxide emissions, nearly 64 percent of which were from gasoline consumption for personal use.¹⁵

Converting transportation to low-carbon power, such as natural gas, hydrogen, and wind-, solar-, or natural gas-generated electricity will decrease transportation’s contribution to climate change.

⁷ Brunekreef, B. and S.T. Holgate. 2002. Air Pollution and Health. *The Lancet*, 360 (9341): 1233-1242.

⁸ Gan, W.Q., L. Tamburic, et al. 2010. Changes in Residential Proximity to Road Traffic and the Risk of Death from Coronary Heart Disease. *Epidemiology*, 21 (5): 642-649.

⁹ Ostro, B., M. Lipsett, et al. 2010. Long-Term Exposure to Constituents of Fine Particulate Air Pollution and Mortality: Results from the California Teachers Study. *Environmental Health Perspectives*, 118: 363-369.

¹⁰ Wu, J., M. Wilhelm, J. Chung and B. Ritz. 2011. Comparing Exposure Assessment Methods for Traffic-Related Air Pollution in an Adverse Pregnancy Outcome Study. *Environmental Research*, 111 (5): 685-92.

¹¹ Brauer, M., C. Lencar, et al. 2008. A Cohort Study of Traffic-Related Air Pollution Impacts on Birth Outcomes. *Environmental Health Perspectives*, 116 (5).

¹² U.S. Environmental Protection Agency. 2011. *2011 U.S. Greenhouse Gas Inventory Report*. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009. Chapter 3. Available at: <http://www.epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Chapter-3-Energy.pdf> [accessed May 17, 2011].

¹³ Centers for Disease Control and Prevention. 2009. *Policy on Climate Change*. Available at: http://www.cdc.gov/climatechange/pubs/Climate_Change_Policy.pdf [accessed 21 April 2011].

¹⁴ U.S. Environmental Protection Agency. 2011. *2011 U.S. Greenhouse Gas Inventory Report*. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009. Chapter 3. Available at: <http://www.epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Chapter-3-Energy.pdf> [accessed May 17, 2011].

¹⁵ Ibid.

Additionally, decreasing the size disparity in the motor vehicle fleet will bring down the overall consumption of fuel and reduce greenhouse gas emissions. Finally, shifting travelers' behavior from driving alone to carpooling, vanpooling, and using active transportation and public transportation is an important way to reduce carbon emissions.

Promote a Reduction in Vehicle-Miles Traveled Through Pricing Measures

The overwhelming number of vehicle-miles traveled (VMT) in the U.S. are made in motor vehicles—some 3 trillion miles in 2007.¹⁶ In 2009, 83 percent of all trips made by the American public were in private vehicles.¹⁷ The other three modes—railroads, transit, and domestic air carrier—account for 11.5 billion VMT combined; by contrast, motor vehicle VMT was more than 3 trillion.¹⁸

Between 1990 and 2009, the total VMT for passenger cars and light-duty trucks in the U.S. increased by 39 percent, as a result of population growth, economic growth, increasingly dispersed land use practices, and relatively low fuel prices.¹⁹

To reduce VMT and its impacts, some motor vehicle trips can be replaced by alternatives, such as transit, carpooling, walking, or bicycling; or they can be made when there is less congestion; or trips can be combined. Changing the price of operating a motor vehicle through user fees or other charges; changing the price of access to road facilities depending on time of day and other factors (while providing adequate support for alternatives); and changing the price of access to parking depending on time of day and demand, can all promote changes in behavior that result in fewer VMT.

Chapter 1 at a Glance

In this chapter, we examine three policies that improve the environment and environmental public health:

1.1 Reduce Human Exposure to Transportation-Related Emissions

1.2 Reduce Transportation's Contribution to Climate Change

1.3 Promote a Reduction in Vehicle-Miles Traveled Through Pricing Measures

¹⁶ Research and Innovative Technology Administration Bureau of Transportation Statistics. 2009. *Transportation Statistics Annual Report. U.S. Vehicle-Miles: 1998-2007*. Available at: http://www.bts.gov/publications/transportation_statistics_annual_report/2009/html/chapter_01/table_01_02_10.html [accessed April 21, 2011].

¹⁷ Federal Highway Administration. Summary of Travel Trends: 2009 National Household Travel Survey. Available at: <http://nhts.ornl.gov/2009/pub/stt.pdf> [accessed July 8, 2011]

¹⁸ Research and Innovative Technology Administration Bureau of Transportation Statistics. 2009. *Transportation Statistics Annual Report. U.S. Vehicle-Miles: 1998-2007*. Available at: http://www.bts.gov/publications/transportation_statistics_annual_report/2009/html/chapter_01/table_01_02_10.html [accessed April 21, 2011].

¹⁹ Ibid.

1.1 Reduce Human Exposure to Transportation-Related Emissions

1.1.1 Background: Reduce Human Exposure to Transportation-Related Emissions

Prevalence of and Human Exposure to Transportation-Related Emissions

Transportation-related emissions with the most direct effect on human health include carbon monoxide, nitrogen dioxide, ozone, (the primary ingredient in smog), particulate matter (especially the “fine” particulates, known as PM_{2.5}), sulfur dioxide, and toxics such as lead.²⁰

Fifty-eight percent of people in the U.S. live in areas with unhealthful levels of ozone. Looking at the two most vulnerable age groups, more than 20.4 million adults over age 65 and almost 44 million children under age 18 live in counties with unhealthy ozone levels. Approximately one in three Americans is at elevated risk for PM_{2.5}-related health impacts.²¹

Impact of Transportation-Related Emissions on Disease

Exposure to traffic-related pollutants is associated with asthma, non-asthma respiratory symptoms, impaired lung function, and cardiovascular mortality and morbidity.^{22,23} Populations that are exposed over longer terms—people living near high-traffic roadways, for example—experience increased levels of cardiopulmonary mortality,^{24,25} as well as adverse pregnancy outcomes such as pre-term birth and low birth weight.^{26,27} Particulate exposure has been directly associated with decreases in lung function in older adults already suffering from chronic

²⁰ U.S. Environmental Protection Agency. 2011. *National Ambient Air Quality Standards*. Available at: <http://www.epa.gov/air/criteria.html> [accessed May 22, 2011].

²¹ U.S. Environmental Protection Agency. 2010. *Fine Particle Designations. Particulate Matter FAQs*. Available at: <http://www.epa.gov/pmdesignations/faq.htm#0> [accessed November 18, 2010].

²² Health Effects Institute. 2010. *Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects*. HEI Panel on the Health Effects of Traffic-Related Air Pollution. Available at: <http://pubs.healtheffects.org/view.php?id=334> [accessed on June 21, 2011].

²³ Brunekreef, B. and S.T. Holgate. 2002. Air pollution and Health. *The Lancet*, 360 (9341): 1233-1242.

²⁴ Gan, W., Q.L. Tamburic, et al. 2010. Changes in Residential Proximity to Road Traffic and the Risk of Death from Coronary Heart Disease. *Epidemiology*, 21 (5): 642-649.

²⁵ Ostro, B., M. Lipsett, et al. 2010. Long-Term Exposure to Constituents of Fine Particulate Air Pollution and Mortality: Results from the California Teachers Study. *Environmental Health Perspectives*, 118: 363-369.

²⁶ Wu, J., M. Wilhelm, J. Chung and B. Ritz. 2011. Comparing Exposure Assessment Methods for Traffic-Related Air Pollution in an Adverse Pregnancy Outcome Study. *Environmental Research*, 111 (5): 685-92.

²⁷ Brauer, M., C. Lencar, et al. 2008. A Cohort Study of Traffic-Related Air Pollution Impacts on Birth Outcomes. *Environmental Health Perspectives*, 116 (5).

obstructive pulmonary disease and in children with asthma.²⁸ Long-term exposure to PM_{2.5} is associated with increased risk of cardiopulmonary mortality.²⁹

Generally, children and infants are the most susceptible to air pollutants because of their increased levels of physical activity and the fact that their lungs are still developing.³⁰ Financially disadvantaged populations and minorities are disproportionately impacted by air pollution because they are more likely to live in areas with worse air quality.³¹

Potential for Reducing Exposure to Transportation-Related Emissions

Evidence of the negative health impacts of traffic-related air pollutants has led to increasingly strict controls, resulting in reductions in motor vehicle emissions and subsequent improvements in air quality. However, many of these gains have been offset by an increase in vehicle-miles traveled (rising rapidly until the economic downturn) and the increasing urbanization of the population, which puts homes, workplaces, and schools near highways.³²⁻³³⁻³⁴

National strategies for reducing exposure to transportation-related emissions have included an extensive system for monitoring pollution, policies to separate high-pollution sources from vulnerable populations, and encouraging adoption of technologies to reduce emissions.

We examine four policies that have contributed or could contribute further to these strategies.

Policy 1: Improve monitoring of locations where pollution sources are concentrated

Policy 2: Locate residential and community facilities away from transportation-related emissions

Policy 3: Minimize exposure to PM_{2.5}

Policy 4: Encourage adoption of technologies to reduce vehicle emissions

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- ²⁸ Tranga, C. et al. 2006. Effect of Particulate Air Pollution on Lung Function in Adult and Pediatric Subjects in a Seattle Panel Study. *Chest*, 129 (6): 1614-1622.
- ²⁹ Ostro B., M. Lipsett, P. Reynolds, D. Goldberg, A. Hertz, C. Garcia, et al. 2010. Long-Term Exposure to Constituents of Fine Particulate Air Pollution and Mortality: Results from the California Teachers Study. *Environmental Health Perspectives* 118: 363-369.
- ³⁰ Schwartz, J. 2004. Air Pollution and Children's Health. *Pediatrics*. American Academy of Pediatrics. 113 (S3): 1037-1043.
- ³¹ Houston, D., J. Wu, P. Ong, A. Winer. 2004. Structural Disparities of Urban Traffic in Southern California: Implications for Vehicle-Related Air Pollution Exposure in Minority and High-Poverty Neighborhoods. University of California, Los Angeles. *Journal of Urban Affairs* 26 (5): 565-592.
- ³² U.S. Environmental Protection Agency. 2011. 2011 *U.S. Greenhouse Gas Inventory Report. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009*. Chapter 3. Available at: <http://www.epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Chapter-3-Energy.pdf> [accessed May 17, 2011].
- ³³ Balbus, J.M. and D.Y. Triola. 2005. Transportation and Health. In H. Frumkin ed. *Environment Health: from global to local*. San Francisco, Jossey-Bass: 414-453.
- ³⁴ Health Effects Institute. 2010. Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects. HEI Panel on the Health Effects of Traffic-Related Air Pollution. Available at: <http://pubs.healtheffects.org/view.php?id=334> [accessed on June 21, 2011].

1.1.2 Impact of Policies: Reduce Human Exposure to Transportation-Related Emissions

Policy 1—Improve monitoring of locations where pollution sources are concentrated

Definition

The U.S. Environmental Protection Agency (EPA) maintains the nation’s chief repository of ambient air quality data, which is obtained from more than 10,000 monitors operated by state, tribal, and local agencies.³⁵⁻³⁶

History of Deployment

The 1970 Clean Air Act provides the legislative basis for the EPA’s program of air pollution monitoring and regulation by establishing the EPA’s enforcement authority, setting national standards and state performance standards for ambient air quality, and establishing regulations for stationary sources (e.g., factories, power plants, and the like) and motor vehicle emissions. Major amendments were made in 1977 and 1990, expanding the Clean Air Act’s scope.³⁷

Effectiveness and Impact

The EPA’s network of monitors tracks ambient air quality in most parts of the country where there are significant transportation-related emissions. Without this system, the implementation of current regulation and documentation of exposure and subsequent disease would not be possible. A geographically more comprehensive monitoring network and further development of statistical models would enhance the system’s effectiveness.

Economic Factors

According to the EPA, the benefits of Clean Air Act programs in 2010 totaled about \$110 billion in prevented illnesses and premature deaths versus a cost of \$27 billion.³⁸ While economic factors associated with monitoring air quality are not broken out separately, Clean Air Act programs would not be possible without an extensive system for monitoring exposure and related disease outcomes.

³⁵ U.S. Environmental Protection Agency. *Technology Transfer Network (TTN) Air Quality System (AQS)* Available at: <http://www.epa.gov/ttn/airs/airsaqs/index.htm> [accessed May 16, 2011].

³⁶ U.S. Environmental Protection Agency. *Monitoring Pollutant Concentration in the Ambient Air*. Available at: <http://www.epa.gov/apti/course422/ce3.html> [accessed November 17, 2010].

³⁷ U.S. Environmental Protection Agency. *History of the Clean Air Act*. Available at: http://epa.gov/oar/caa/caa_history.html [accessed May 22, 2011].

³⁸ U.S. Environmental Protection Agency. *Benefits and Costs of the Clean Air Act*. Available at: <http://yosemite.epa.gov/EE/epa/erm.nsf/vwRepNumLookup/EE-0295A?OpenDocument> [accessed June 15, 2011].

Conclusion

The current monitoring system should be continued and enhanced. For example, areas with persistently high ozone levels, mostly large cities, warrant more extensive monitoring of ozone and its precursors.³⁹ Also, vulnerable populations—people with heart and lung diseases, older adults, children, and people with diabetes—should be protected from excessive pollution exposure. Simultaneously, additional information about the effectiveness and costs associated with air quality monitoring is needed.

Policy 2—Locate residential and community facilities away from transportation-related emissions

Definition

Proximity to sources of transportation-related emissions increases the probability of adverse health effects.⁴⁰

History of Deployment

This is a developing area of research and regulatory policy. Policies are being developed for some facilities. For example, in November 2010, the Environmental Protection Agency (EPA) issued draft voluntary guidelines for selecting locations for schools, because they serve children, who are especially vulnerable to air pollution. Proximity to air pollution sources—including traffic—is one of the considerations.⁴¹

Effectiveness and Impact

The distance at which adverse health effects decline significantly varies by pollutant and is not well-documented for all of the major transportation-related emissions. However, living near high-traffic roadways is associated with adverse health effects.⁴² The effects of transportation-related emissions on asthma are strongest among those who live within 150 meters (0.09 miles) of a main road.⁴³⁻⁴⁴ One class of pollutant that has been extensively studied is fine particulates—those that

³⁹ U.S. Environmental Protection Agency. *Air Pollution Monitoring*. Available at: <http://epa.gov/airquality/montring.html> [accessed November 17, 2010].

⁴⁰ Health Effects Institute. 2010. *Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects*. HEI Panel on the Health Effects of Traffic-Related Air Pollution. Available at: <http://pubs.healtheffects.org/view.php?id=334> [accessed on June 21, 2011].

⁴¹ U.S. Environmental Protection Agency. 2010. *School Siting Guidelines*. Available at: <http://www.epa.gov/schools/siting/criteria.html#> [accessed March 28, 2011].

⁴² Boothe, V.L. and D.G. Shendell. 2008. Potential Health Effects Associated with Residential Proximity to Freeways and Primary Roads: Review of Scientific Literature, 1999-2006. *Journal of Environmental Health*, 70 (8): 33-41, 55-56.

⁴³ Venn, A.J., S.A. Lewis, M. Cooper, R. Hubbard, J. Britton. 2001. Living Near A Main Road and the Risk of Wheezing Illness in Children. *American Journal of Respiratory and Critical Care Medicine*, 164: 2177-2180.

⁴⁴ Environmental Defense Fund. 2006. *Motor Vehicle Air Pollution and Public Health: Asthma and Other Respiratory Effects*.

are 2.5 micrometers or less in diameter (PM_{2.5}). Exposure is greatest within the first 300 meters (0.18 miles) of a major source, with levels decreasing to ambient upwind concentrations at distances greater than that.⁴⁵

Economic Factors

There is insufficient data to determine economic factors involved in locating key facilities away from major roadways.

Conclusion

Proximity to roadways with heavy traffic is associated with disease outcomes. Land use planning requirements for new facilities serving vulnerable populations and for road projects anticipated to carry high levels of traffic should take into consideration proximity of vulnerable populations to transportation-related emissions.

Policy 3—Minimize exposure to PM_{2.5}

Definition

“Fine” particulate matter is defined as PM_{2.5}, 2.5 micrometers or less in diameter. It poses a health threat because its small size means it can become deeply lodged in the lungs.⁴⁶ Sources of PM_{2.5} include motor vehicle engines—especially older diesel engines—power plants, wood burning, and some industrial processes.^{47,48}

History of Deployment

U.S. regulations setting limits for particulate emissions date back to 1971. In 1987, they were updated to include a standard for PM₁₀, targeting particles with a diameter of 10 micrometers or less.⁴⁹ In 1997, the EPA revised the PM standard to include PM_{2.5}. In September 2006, the agency lowered the acceptable levels of PM_{2.5} emissions.⁵⁰

⁴⁵ California Air Resources Board. 2003. *Health Impacts of Research on Fine and Ultrafine PM Exposure*. Available at: <http://www.arb.ca.gov/research/pmr/pmr-sum1.htm> [accessed November 18, 2010].

⁴⁶ U.S. Environmental Protection Agency. 2010. *Fine Particle Designations. Particulate Matter FAQs*. Available at: <http://www.epa.gov/pmdesignations/faq.htm#0> [accessed November 18, 2010].

⁴⁷ Ibid.

⁴⁸ U.S. Environmental Protection Agency. *Particulate Matter (PM-10)*. Available at: <http://www.epa.gov/airtrends/aqtrnd95/pm10.html> [accessed June 16, 2011].

⁴⁹ Ibid.

⁵⁰ U.S. Environmental Protection Agency. 2006. *PM Standards Revision*. Available at: <http://www.epa.gov/PM/naaqsrev2006.html> [accessed November 17, 2010].

Effectiveness and Impact

PM_{2.5} exposure is greatest within the first 300 meters (0.18 miles) of a major source, with levels decreasing to ambient upwind concentrations at distances greater than 300 meters.⁵¹ Long-term exposure to PM_{2.5} is associated with increased risk of cardiopulmonary mortality.⁵² Limiting PM_{2.5} emissions within 300 meters of residential areas would greatly reduce exposure.

Economic Factors

The monetized value of the public health impacts of PM_{2.5} exposure is estimated to be in the tens of billions of dollars annually, which is significant enough to make its reduction a consideration in setting transportation policy.⁵³

Conclusion

To reduce the negative impacts of PM_{2.5} exposure on vulnerable populations, the distance from high-traffic locations should be used as a consideration in development of facilities used by vulnerable populations or facilities where long-term exposure will result.

Policy 4—Encourage adoption of technologies to reduce vehicle emissions

Definition

Advanced motor vehicle emission control technologies for gasoline engines include catalytic converters, advanced ignition and fuel injection systems, on-board computers, and electronic controls, which are all standard components of today's new cars.⁵⁴ For diesel engines, there are numerous retrofit technologies for existing engines. They include: catalyst mufflers, diesel particulate filters, crankcase filtration systems, diesel oxidant catalyst conversions, and cetane enhancers.⁵⁵

⁵¹ California Air Resources Board. 2003. Health Impacts of Research on Fine and Ultrafine PM Exposure. Available at: <http://www.arb.ca.gov/research/pmr/pmr-sum1.htm> [accessed November 18, 2010].

⁵² Ostro B., M. Lipsett, P. Reynolds, D. Goldberg, A. Hertz, C. Garcia, et al. 2010. Long-Term Exposure to Constituents of Fine Particulate Air Pollution and Mortality: Results from the California Teachers Study. *Environmental Health Perspectives*, 118: 363-369.

⁵³ Levy J.I., J.J. Buonocore and K. von Stackelberg. 2010. Evaluation of the Public Health Impacts of Traffic Congestion: A Health Risk Assessment. *Environmental Health*, 9: 65.

⁵⁴ Manufacturers of Emission Controls Association News. 2000. *Advanced Motor Vehicle Emission Control Technology Celebrates 25th Anniversary*. Available at: <http://www.meca.org/galleries/default-file/25thannivpr.pdf> [accessed May 22, 2011].

⁵⁵ U.S. Environmental Protection Agency. *Verified Technologies*. Available at: <http://epa.gov/cleandiesel/verification/verif-list.htm> [accessed May 22, 2011].

History of Deployment

Starting in 1970, automobiles sold in the United States were required to meet emissions standards for six criteria pollutants.⁵⁶ In the 1975 model year, the first automobiles with catalytic converters were sold on the U.S. market,⁵⁷ simultaneously with the broader rollout of unleaded gasoline that the converters required. The following decades saw changes in fuel formulas, combined with engine technologies.⁵⁸

As of 2008, overall national air quality has improved significantly compared with 1990: ozone is down 14 percent, lead is down 78 percent, nitrogen dioxide has fallen 35 percent, carbon monoxide has been cut 68 percent, and sulfur dioxide has been reduced by 59 percent. Annual PM_{2.5} concentrations dropped by 17 percent between 2001 and 2008.⁵⁹

In October 2010, the EPA and the National Highway Traffic Safety Administration announced a joint fuel standards program to regulate greenhouse gas emissions and fuel economy as part of a package that included the first-ever greenhouse gas emissions standards for heavy-duty vehicles.⁶⁰

Effectiveness and Impact

The development and enforcement of greenhouse gas emission standards will create significant reductions in fuel consumption and emissions for gasoline- and diesel-powered heavy trucks and commercial vehicles.⁶¹

Economic Factors

The EPA estimates that the joint fuel standards program will provide \$41 billion in net benefits over the lifetime of model year 2014 to 2018 vehicles.^{62,63}

⁵⁶ U.S. Environmental Protection Agency. *National Ambient Air Quality Standards*. Available at: <http://www.epa.gov/air/criteria.html> [accessed May 22, 2011].

⁵⁷ Manufacturers of Emission Controls Association News. 2000. *Advanced Motor Vehicle Emission Control Technology Celebrates 25th Anniversary*. Available at: <http://www.meca.org/galleries/default-file/25thannivpr.pdf> [accessed May 22, 2011].

⁵⁸ U.S. Environmental Protection Agency. 1999. *Air Trends*. Available at: <http://www.epa.gov/airtrends/aqtm99/pdfs/table2-2.pdf> [accessed May 18, 2011].

⁵⁹ U.S. Environmental Protection Agency. 2010. *Our Nation's Air*. Available at: <http://www.epa.gov/airtrends/2010/report/highlights.pdf> [accessed May 18, 2011].

⁶⁰ U.S. Environmental Protection Agency. 2010. EPA and NHTSA Announce a First Step in the Process for Setting Future Greenhouse Gas and Fuel Economy Standards for Passenger Cars and Light Trucks. EPA-420-F-10-051. Available at: <http://yosemite.epa.gov/opa/opei/rulegate.nsf/byRIN/2060-AP61> [accessed June 15, 2011].

⁶¹ U.S. Environmental Protection Agency. *Regulatory Initiatives*. Available at: <http://www.epa.gov/climatechange/initiatives/index.html> [accessed November 22, 2010].

⁶² Ibid.

⁶³ U.S. Department of Transportation. 2010. *DOT, EPA Propose the Nation's First Greenhouse Gas and Fuel Efficiency Standards for Trucks and Buses*. EPA News Release. Available at: <http://yosemite.epa.gov/opa/admpress.nsf/e77fdd4f5afd88a3852576b3005a604f9b3706622f4ac560852577c7005ea140!OpenDocument> [accessed June 15, 2011].

Conclusion

There are a variety of advanced motor vehicle emission control technologies that have already had enormous impacts in reducing emissions and associated disease. The joint fuel standards proposal will provide impetus for another significant gain in reducing emissions.

1.1.3 Conclusions: Reduce Human Exposure to Transportation-Related Emissions

Reducing human exposure to transportation-related emissions that most directly affect human health—carbon monoxide, nitrogen dioxide, ozone, (the primary ingredient in smog), particulate matter, sulfur dioxide, and toxins such as lead—can be accomplished through reducing emissions and reducing exposure.

A number of policies can achieve these goals: expanding current monitoring systems by focusing on, for example, urban areas with persistently high ozone levels; planning long-term facilities and those that serve vulnerable populations in a way that provides an adequate buffer, with special attention paid to PM_{2.5} exposure; continue to build on the success of advanced motor vehicle emission control technologies and fuel efficiency efforts that have already had enormous impacts in reducing emissions and associated disease.

1.2 Reduce Transportation's Contribution to Climate Change

1.2.1 Background: Reduce Transportation's Contribution to Climate Change

Prevalence of and Threat from Greenhouse Gas Emissions

Greenhouse gases—primarily carbon dioxide or CO₂—trap heat and contribute to rising surface temperatures, which can trigger a multitude of mechanisms—including changing weather patterns and sea level rise—that can have adverse environmental health effects.⁶⁴ Some greenhouse gases occur and are emitted through natural processes. Others are created and emitted solely as a result of human activities.⁶⁵

From 1990 to 2009, transportation's total greenhouse gas emissions (nearly all of which were CO₂) rose 17 percent. Put another way, in 2009, transportation was responsible for 33 percent of

⁶⁴ Centers for Disease Control and Prevention. 2009. *Policy on Climate Change*. Available at: http://www.cdc.gov/climatechange/pubs/Climate_Change_Policy.pdf [accessed April 21, 2011].

⁶⁵ U.S. Environmental Protection Agency. *Greenhouse Gas Emissions*. Available at: <http://epa.gov/climatechange/emissions/index.html> [accessed March 25, 2011].

total CO₂ emissions, and 64 percent of those were from passenger cars and light-duty trucks.⁶⁶ Additional transportation-related sources of greenhouse gas emissions are the result of the manufacturing of vehicles, as well as the construction of roadways and other infrastructure.⁶⁷

Without a change in current policies, transportation's greenhouse gas emissions are expected to grow by about 10 percent by 2035, and will account for one-quarter of all global transportation emissions.⁶⁸

Impact on Climate Change and Subsequent Health Outcomes

The effects of climate change on human health are diverse.⁶⁹ For example, large fluctuations in temperature and rainfall can cause vector-borne and water-borne disease epidemics, heat exhaustion, hypothermia, and related respiratory and cardiovascular disease. Sea-level rise can cause flooding and economic dislocation, including the destruction of food crops.⁷⁰⁻⁷¹

Potential for Reducing Transportation's Impact on Climate Change

There has been little progress in reducing transportation's greenhouse gas emissions, which are closely tied to overall fuel consumption, which has been rising steadily. There is potential to reduce transportation sector emissions by up to 65 percent from current levels by 2050 through improvements in vehicle efficiency, use of less carbon-intensive fuels, and alterations in travel behavior.⁷² Plug-in electric vehicles (PEVs) are gaining attention as a way to replace petroleum with electricity generated from cleaner, lower-carbon sources.⁷³ For the gasoline-powered vehicle fleet, reducing the overall size of vehicles through regulations and incentives such as the

⁶⁶ U.S. Environmental Protection Agency. 2011. *2011 U.S. Greenhouse Gas Inventory Report*. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009. Chapter 3. Available at: <http://www.epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Chapter-3-Energy.pdf> [accessed May 17, 2011].

⁶⁷ Greene, D.L. and S.E. Plotkin. 2011. *Reducing Greenhouse Gas Emissions from U.S. Transportation*. Pew Center on Global Climate Change. Available at: http://www.environmentportal.in/files/Reducing_GHG_from_transportation.pdf [accessed June 18, 2011].

⁶⁸ U.S. Environmental Protection Agency. *Greenhouse Gas Emissions*. Available at: <http://epa.gov/climatechange/emissions/index.html> [accessed March 25, 2011].

⁶⁹ The Interagency Working Group on Climate Change and Health. 2010. *A Human Health Perspective on Climate Change*. Environmental Health Perspectives and the National Institute of Environmental Health Sciences. Available at: <http://www.niehs.nih.gov/about/od/programs/climatechange/index.cfm> [accessed June 18, 2011].

⁷⁰ Centers for Disease Control and Prevention. Climate Change and Public Health. Cardiovascular Disease and Stroke. Available at: <http://www.cdc.gov/climatechange/effects/stroke.htm> [accessed April 20, 2011].

⁷¹ McMichael, A.J. et al. Eds. 2003. *Climate Change and Human Health—Risks and Responses*. World Health Organization.

⁷² Greene, D.L. and S.E. Plotkin. 2011. *Reducing Greenhouse Gas Emissions from U.S. Transportation*. Pew Center on Global Climate Change. Available at: http://www.environmentportal.in/files/Reducing_GHG_from_transportation.pdf [accessed June 18, 2011].

⁷³ *Plug-in Electric Vehicles: A Practical Plan for Progress*. 2011. The Report of an Expert Panel. School of Public and Environmental Affairs. Indiana University. Available at: http://www.indiana.edu/~spea/pubs/TEP_combined.pdf [accessed June 16, 2011].

Corporate Average Fuel Economy (CAFE) program could reduce fuel consumption and thereby reduce greenhouse gas emissions.⁷⁴

Policies to Reduce Transportation’s Contribution to Climate Change

The policy suggestions discussed here are ways to decrease carbon emissions without changing overall travel behavior. In addition to technological solutions such as electric vehicles or reduction in vehicle weights, travelers who choose to drive fewer miles in single occupancy vehicles also reduce carbon emissions. This can be achieved by shifting to a different mode of transportation. Reduction in vehicle-miles traveled (VMT) through mode shift away from single-occupancy vehicles is an overarching strategy to reduce vehicle carbon emissions. Reducing VMT through mode shift offers multiple co-benefits. Shifting to carpooling or vanpooling takes cars off the road, contributing to a reduction in traffic congestion and traffic emissions, reduces wear and tear on roads and subsequent maintenance, and increases social interaction. Shifting from single-occupancy vehicles to public transit, bicycling or walking has all the benefits of carpooling, and it also contributes to the traveler getting the recommended amount of physical activity.

We discuss two policies to reduce transportation’s contribution to climate change by reducing carbon outputs of motor vehicles.

Policy 1: Encourage electric vehicle propulsion from clean sources

Policy 2: Give incentives to carmakers to reduce weight disparities within their fleets

These policies emphasize technological solutions to carbon emissions, however, another solution not analyzed in this report is encouraging travelers to shift from driving alone to carpooling, vanpooling, and using active transportation and public transportation.

1.2.2 Impact of Policies: Reduce Transportation’s Contribution to Climate Change

Policy 1—Encourage electric vehicle propulsion from clean sources

Definition

The electric vehicle technology being developed for broad market introduction with the greatest potential for greenhouse gas reduction is the “plug-in” electric vehicle (PEV), which can recharge by connecting to the power grid. Many vehicles currently in development are hybrids—plug-in hybrid electric vehicles, or PHEVs—which can switch to gasoline as a way of extending their

⁷⁴ U.S. Department of Transportation National Highway Traffic Safety Administration. *CAFE Overview - Frequently Asked Questions*. Available at: <http://www.nhtsa.gov/cars/rules/cafe/overview.htm> [accessed April 5, 2010].

range.⁷⁵ Within the bounds of current, market-ready technology, electric vehicles are classed as 10-mile vehicles, which can drive that distance on all-electric power, and 40-mile vehicles.⁷⁶

History of Deployment

Interest in PEVs and PHEVs has grown with improvements in battery technology⁷⁷ and with the 2009 U.S. government announcement committing federal research dollars to invest in technology with the goal of having half a million PEVs on the road by 2015.⁷⁸ Hybrid and all-electric vehicles are currently available from some of the largest domestic and foreign auto manufacturers; more than 20 additional PEV models are expected by the end of 2012.⁷⁹

Effectiveness and Impact

Powering vehicles with electricity can significantly reduce transportation's greenhouse gas emissions as long as the electricity is generated from low-carbon sources (natural gas, wind, water, and solar). For a significant reduction in greenhouse gas emissions, tens of millions of PEVs will have to be in use. For purposes of comparison, by 2010—13 years after Toyota Motor Corporation's Prius was introduced—1,888,971 hybrid vehicles had been sold in the United States.⁸⁰

The impact on greenhouse gas emissions is difficult to predict. Among the unknowns: level of market penetration by PEVs and PHEVs; development of battery technology to increase the distance that can be driven on battery power; and level of emissions associated with the electricity used for powering vehicles.⁸¹

⁷⁵ *Plug-in Electric Vehicles: A Practical Plan for Progress*. The Report of an Expert Panel. 2011. School of Public and Environmental Affairs. Indiana University. Available at: http://www.indiana.edu/~spea/pubs/TEP_combined.pdf [accessed May 18, 2011].

⁷⁶ *Transitions to Alternative Transportation Technologies—Plug-In Hybrid Electric Vehicles*. 2010. Board on Energy and Environmental Systems. The National Academies Press. Available at: http://www.nap.edu/catalog.php?record_id=12826 [accessed May 19, 2011].

⁷⁷ *Ibid.*

⁷⁸ Markel, T. 2010. *Plug-in Electric Vehicle Infrastructure: A Foundation for Electrified Transportation*. National Renewable Energy Laboratory. Golden, CO. Presented at MIT Energy Initiative Transportation Electrification Symposium. April 8, 2010. Available at: <http://web.mit.edu/mitei/docs/reports/trans-infrastructure-markel.pdf> [accessed May 19, 2011].

⁷⁹ Cullen, G. 2011. *Impact of Grid Integration and Diffusion: Reliability and Other Impacts of EVs and Alternative fuel vehicles*. Electric Drive Transportation Association. Available at: http://docs.google.com/viewer?a=v&q=cache:UUIp5M9F1KQJ:www.eei.org/meetings/Meeting%2520Documents/2011May17EPARegulationCullenPres.pdf+%22Impact+of+Grid+Integration+and+Diffusion%22&hl=en&gl=us&pid=bl&srcid=ADGEEShgsVTijC_6NbCHwqvQ0WFGN8YAbYAPLDC9EhtzmMpQNUW6SFXueNPqQS94GXS9VVpLT0ZGmSNQoptoRUHcl2INj8Dsec4PRbHicMkDFPQVv3gygXiLp8tmQ612JvYQKGSggCa9&sig=AHIEtbQz32Sfm8_ej7tCF2LF_x_Z3-v1AQ [accessed June 16, 2011].

⁸⁰ Alternative Fuel Vehicles (AFVs) and Hybrid Electric Vehicles (HEVs): *HEV Sales by Model*. Alternative Fuels and Advanced Vehicle Data Center (U.S. DoE). Available at: <http://www.afdc.energy.gov/afdc/data/vehicles.html> [accessed February 26, 2011].

⁸¹ *Transitions to Alternative Transportation Technologies—Plug-In Hybrid Electric Vehicles*. 2010. Board on Energy and Environmental Systems. The National Academies Press. Available at: http://www.nap.edu/catalog.php?record_id=12826 [accessed May 19, 2011].

Economic Factors

PEVs, even with the lowest cost projections using current information, will be considerably more expensive than internal combustion engine vehicles for the near-term. This will slow market penetration, as new-car buyers are conservative in their willingness to invest in untested technologies of uncertain resale value and reliability. Most analyses assume that government subsidies will be required.⁸²

For PEVs to achieve the required reliability, significant investments in charging infrastructure and adjustments to the electrical grid to absorb the added demand as well as to accept “reverse” charging will have to be made.⁸³

Conclusion

The use of electricity to power motor vehicles has the potential to reduce transportation’s greenhouse gas emissions, depending on the source of electricity. However, there are numerous uncertainties, such as barriers to market acceptance, driver willingness to make full use of all-electric modes, and the degree of investments in infrastructure required.

Policy 2—Give incentives to carmakers to reduce weight disparities within their fleets

Definition

The current incentive system is the Corporate Average Fuel Economy (CAFE) standard.⁸⁴

History of Deployment

CAFE standards were enacted in 1975 in response to the 1973-74 Arab oil embargo. The original goal was to double new car fuel economy by model year 1985.⁸⁵ The original focus was on passenger vehicles, with more lenient requirements for light trucks. Because they were weighted for each automaker based on the fuel economy of its fleet, and weighted by sales for each year, carmakers sought to offset less fuel-efficient models with larger numbers of smaller, more efficient models, which created size disparities in fleets.⁸⁶ The standards remained relatively

⁸² Ibid.

⁸³ Markel, T. 2010. *Plug-in Electric Vehicle Infrastructure: A Foundation for Electrified Transportation*. National Renewable Energy Laboratory. Golden, CO. Presented at MIT Energy Initiative Transportation Electrification Symposium. April 8, 2010. Available at: <http://web.mit.edu/mitei/docs/reports/trans-infrastructure-markel.pdf> [accessed May 19, 2011].

⁸⁴ U.S. Department of Transportation National Highway Traffic Safety Administration. *CAFE Overview - Frequently Asked Questions*. Available at: <http://www.nhtsa.dot.gov/cars/rules/cape/overview.htm> [accessed April 5, 2010].

⁸⁵ Ibid.

⁸⁶ McCarthy, T. 2007. *Auto Mania: Cars, Consumers, and the Environment*. Yale University Press. New Haven, CT.

unchanged for 20 years, resulting in a decrease in fuel economy as a whole, as more exempt light trucks and light truck-type vehicles were purchased.⁸⁷

Starting in 2007, with CAFE II, the standards were tightened and the timeline for complying with them accelerated. Additionally, the method for determining a company's compliance has changed: instead of being able to average its fuel economy rates across all the vehicles in its light truck or passenger vehicle categories, the company has to use each vehicle's actual size (the "footprint" or rectangle formed) as part of its formula for compliance, so that a smaller footprint vehicle has a higher standard to meet, giving incentive to reduce the size disparity of vehicle fleets.⁸⁸

Effectiveness and Impact

By encouraging automakers to reduce the size disparities in their fleets, CAFE II is expected to reduce consumer demand for larger, less fuel-efficient vehicles purchased out of safety concerns.⁸⁹

Economic Factors

Carmakers can comply with CAFE II with existing technology.⁹⁰ Insufficient data is available to determine the effect on the cost of new vehicles produced under these rules.

Conclusion

The CAFE II standards create carmaker incentives that could reduce consumer demand for oversized vehicles and thereby reduce fuel consumption and greenhouse gas emissions associated with climate change.

1.2.3 Conclusions: Reduce Transportation's Contribution to Climate Change

Electric vehicles have the potential to reduce transportation's greenhouse gas emissions, though there are unknowns about driver acceptance and other factors such as infrastructure investments and vehicle costs.

The new CAFE standards that use a size-based indexing system create incentives for carmakers to reduce size disparities in the motor vehicle fleet, which can reduce consumer demand for large vehicles and thereby improve fuel economy and decrease greenhouse gas emissions.

⁸⁷ Klier, T. and J. Linn. 2010. Corporate Average Fuel Economy Standards and the Market for New Vehicles. Resources for the Future. Washington, D.C. Available at: <http://www.rff.org/RFF/Documents/RFF-DP-10-68.pdf> [accessed May 19, 2011].

⁸⁸ Ibid.

⁸⁹ Ibid.

⁹⁰ U.S. Department of Transportation, Environmental Protection Agency and National Highway Traffic Safety Administration. 2010. Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule. *Federal Register*, 75: 25324-25728 Available at: <http://federalregister.gov/a/2010-8159> [accessed May 19, 2011].

1.3 Promote a Reduction in Vehicle-Miles Traveled Through Pricing Measures

1.3.1 Background: Promote a Reduction in Vehicle-Miles Traveled Through Pricing Measures

Vehicle-Miles Traveled

Motor vehicles account for nearly all vehicle-miles traveled (VMT) in the U.S.—some 99 percent in 2007. The other three modes—railroads, transit, and domestic air carrier—accounted for 11.5 billion VMT combined; by contrast, motor vehicle VMT was more than 3 trillion. Between 1990 and 2009, the total VMT for passenger cars and light-duty trucks in the U.S. increased by 39 percent, as a result of population growth, economic growth, increasingly dispersed land use practices, and relatively low fuel prices.⁹¹

Potential Impact of Pricing Measures to Reduce Vehicle-Miles Traveled

VMT is responsive to various pricing measures, including mileage or other user fees (including fuel taxes), pay-as-you-go insurance, fees for access to road facilities through cordon pricing (tolls paid by motorists to drive in a particular area, such as a city center), and other congestion charges.⁹² A third approach involves charging for access to street parking, depending on the time of day and demand, and pricing street spaces to create turnover. This approach reduces VMT two ways: by discouraging unnecessary vehicle trips and by eliminating the need or incentive to circle for an open space.⁹³

Policies to Promote a Reduction in Vehicle-Miles Traveled Through Pricing Measures

We discuss three policies to promote a reduction in VMT through pricing measures.

Policy 1: Spur adjustments in the costs of operating a motor vehicle

Policy 2: Encourage variable tolls and congestion pricing

Policy 3: Spur adjustments in the prices for street parking

⁹¹ Research and Innovative Technology Administration Bureau of Transportation Statistics. 2009. *Transportation Statistics Annual Report. U.S. Vehicle-Miles: 1998-2007*. Available at: http://www.bts.gov/publications/transportation_statistics_annual_report/2009/html/chapter_01/table_01_02_10.html [accessed April 21, 2011].

⁹² Deakin, E., G. Harvey, R. Pozdena, G. Yarema. 1996. *Transportation Pricing Strategies for California: as assessment of congestion, emissions, energy, and equity impacts. Final Report*. California Air Resources Board. University of California Transportation Center. Available at: <http://www.uctc.net/papers/434.pdf> [accessed May 19, 2011].

⁹³ Shoup, D. 2005. *The High Cost of Free Parking*. Chicago: American Planning Association Planners Press. Available at: <http://www.uctc.net/papers/351.pdf> [accessed June 19, 2011]

1.3.2 Impact of Policies: Promote a Reduction in Vehicle-Miles Traveled Through Pricing Measures

Policy 1—Spur adjustments in the costs of operating a motor vehicle

Definition

Measures aimed at increasing the costs of operating a motor vehicle include fuel taxes, pay-as-you-drive insurance, and mileage charges.⁹⁴ We discuss congestion pricing and tolls in Policy 2: Encourage variable tolls and congestion pricing.

History of Deployment

Fuel taxes: In 1956 the Highway Revenue Act and the Federal-Aid Highway Act established the Federal Highway Trust Fund, using dedicated revenues from a motor fuel tax, which was set at a fixed amount per gallon. It was last increased in 1993 to 18.4 cents per gallon.⁹⁵⁻⁹⁶

Pay-as-you-drive insurance: Starting in late 2010, a number of automobile insurance companies began to offer some version of pay-as-you-drive insurance. Most plans involve using odometer readings to give discounts on future premiums via yearly adjustments. A few use telemetric information to offer discounts more precisely correlated to distance driven.⁹⁷

Mileage pricing: This method has been tested in a small pilot study, but the focus was on the feasibility of the technology and its potential for capturing revenue, more than its effect on VMT.⁹⁸

Effectiveness and Impact on Reducing VMT

Fuel taxes: Gas price increases, which can be a proxy for higher fuel taxes, can reduce VMT by spurring work or residential relocations to shorten or eliminate trips, reducing car ownership, and increasing the use of transit, active transportation, and car-sharing.⁹⁹ However, gas price

⁹⁴ Atkinson, R.D. 2009. *Paying Our Way: A New Framework for Transportation Finance*. Final Report of the National Surface Transportation Infrastructure Financing Commission. Available at: <http://www.itif.org/publications/paying-our-way-new-framework-transportation-finance> [accessed June 18, 2011].

⁹⁵ Ibid.

⁹⁶ Wachs, M. 2009. After the Motor Fuel Tax: Reshaping Transportation Financing. *Issues in Science and Technology Online*. Available at: <http://www.issues.org/25.4/wachs.html> [accessed May 19, 2011].

⁹⁷ The Associated Press. 2011. *Low-Mileage Drivers Benefit from Insurers' Pay-as-You-Drive Plans*. April 11, 2011. Available at: <http://wvgazette.com/ap/ApBusiness/201104110175> [accessed May 22, 2011].

⁹⁸ Hanley, P.S. and J.G. Kuhl. 2011. *National Evaluation of a Mileage-Based Road User Charge: Initial Results*. Presentation at TRB 2011 Annual Meeting, National Academies of Science.

⁹⁹ Lane, C. 2006. *Effect of Gas Prices on Mode Choice*. Parsons Brinckerhoff Quade & Douglas, Inc. Presentation to the Transportation Research Board Energy Committee. Available at: http://cta.ornl.gov/TRBenergy/trb_documents/LANE-Gas%20Price%20Effect%20on%20Mode%20Choice-1-25-06.pdf [accessed on June 18, 2011]

increases also spur drivers to purchase more fuel-efficient cars, with the result that nearly 60 percent of the reduction in gasoline use comes from more efficient engines, not fewer VMT.¹⁰⁰

Pay-as-you-drive insurance: It could reduce VMT by a meaningful amount, though there are numerous uncertainties, given the size and heterogeneity of the driving population and driving conditions.¹⁰¹

Mileage pricing: More consideration has been given to its effectiveness in generating revenues, with other goals, such as reducing emissions and congestion given secondary consideration.¹⁰² What data there is on VMT reduction is insufficient to conclude its impact, though preliminary study suggests it could encourage switching to alternative modes.¹⁰³

Economic Factors

Fuel taxes: Given the complexity of transportation economics, it is difficult to predict the economic effects of raising fuel taxes. Any increase would have to be substantial to produce a significant reduction in VMT.¹⁰⁴

Pay-as-you-drive insurance: Pay-as-you-drive insurance is expected to reduce the cost of driving for most drivers. Insurance companies could incur start-up costs outweighing any resulting revenue gains, if they were to install complex, real-time monitoring.¹⁰⁵

Mileage pricing: Due to the lack of data, there has been no rigorous analysis of the economic effects.¹⁰⁶

Conclusion

Increasing the cost of operating motor vehicles is likely to reduce VMT, although, given the complexities of economic behavior and tradeoffs involving personal transportation decisions, the scope of the reduction is not fully understood.

¹⁰⁰ Parry, I.W.H. and K.A. Small. 2005. Does Britain or the United States Have the Right Gasoline Tax? *American Economic Review*, 95 (4): 1276–1289.

¹⁰¹ Bordoff, J.E. and J.N. Pascal. 2008. *Pay-As-You-Drive Auto Insurance: A Simple Way to Reduce Driving-Related Harms and Increase Equity*. Hamilton Project Discussion Paper. Washington, DC: Brookings Institution. Available at: http://www.brookings.edu/~media/Files/rc/papers/2008/07_payd_bordoffnoel/07_payd_bordoffnoel.pdf [accessed May 19, 2011].

¹⁰² Sorensen, P., L. Ecola, M. Wachs, M. Donath, L. Munnich, B. Serian. 2011. *Implementable Strategies for Shifting to Direct Usage-Based Charges for Transportation Funding*. NCHRP Web-Only Document 143. National Cooperative Highway Research Program. Transportation Research Board. Washington, D.C. Available at: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w143.pdf [accessed May 22, 2011].

¹⁰³ Whitty, J.M. 2007. *Oregon's Mileage Fee Concept and road User Fee Pilot Program: Final Report*. November 2007. Oregon Department of Transportation. Available at: http://www.oregon.gov/ODOT/HWY/RUFPP/docs/RUFPP_finalreport.pdf?ga=1 [accessed May 19, 2011].

¹⁰⁴ Bordoff, J.E. and J.N. Pascal. 2008. *Pay-As-You-Drive Auto Insurance: A Simple Way to Reduce Driving-Related Harms and Increase Equity*. Hamilton Project Discussion Paper. Washington, DC: Brookings Institution. Available at: http://www.brookings.edu/~media/Files/rc/papers/2008/07_payd_bordoffnoel/07_payd_bordoffnoel.pdf [accessed May 19, 2011].

¹⁰⁵ Ibid.

¹⁰⁶ Ibid.

Policy 2—Encourage variable tolls and congestion pricing

Definition

Variable tolls: Variable tolls can change either in response to actual demand, known as dynamic pricing, or at pre-determined times.¹⁰⁷

Cordon/congestion pricing: Prices are set at entries, usually based on time of day and level of congestion.¹⁰⁸

History of Deployment

Variable Tolls: With the advent of automated toll collection, states began converting their free carpool lanes to toll lanes.¹⁰⁹ As of October 2010, there were high occupancy toll lanes (HOT lanes) in the metropolitan areas of San Francisco, Seattle, Miami, Los Angeles, San Diego, Houston, Salt Lake City, Denver, and Minneapolis-St. Paul.

Cordon/congestion pricing: No cordon pricing has been implemented in the U.S. In 2007, New York City proposed the first cordon for a major city, but it was blocked by the state legislature.¹¹⁰ In San Francisco, a cordon proposal was shelved after negative public reaction, with a final decision not likely until 2013 or 2014.¹¹¹ Singapore, London, and Stockholm are the only large cities with cordon pricing schemes.¹¹²

Effectiveness and Impact

Toll lanes have been found to improve roadway vehicle throughput, increasing the number of vehicles using the system by smoothing out peak demand; it remains unclear whether they can be used to reduce VMT rather than simply shift VMT to less expensive times of day.¹¹³ Cordon

¹⁰⁷ U.S. Department of Transportation Federal Highway Administration. *Congestion Pricing: A Primer*. Available at: <http://ops.fhwa.dot.gov/publications/congestionpricing/sec2.htm> [accessed April 14, 2011].

¹⁰⁸ Ibid.

¹⁰⁹ U.S. Department of Transportation Federal Highway Administration. 2010. *Value pricing pilot program*. Available at: http://ops.fhwa.dot.gov/tolling_pricing/value_pricing [accessed November 5, 2010].

¹¹⁰ Schaller, B. 2010. New York City's Congestion Pricing Experience and Implications for Road Pricing Acceptance in the United States. *Transport Policy*, 17 (2010) 266-273. Available at: http://www.nyc.gov/html/dot/downloads/pdf/schaller_paper_2010trb.pdf [accessed May 19, 2011].

¹¹¹ San Francisco County Transportation Authority. 2010. Mobility, Access, and Pricing Study. Available at: <http://www.sfcta.org/content/view/302/148> [accessed May 19, 2011].

¹¹² Schaller, B. 2010. New York City's Congestion Pricing Experience and Implications for Road Pricing Acceptance in the United States. *Transport Policy*, 17 (2010) 266-273. Available at: http://www.nyc.gov/html/dot/downloads/pdf/schaller_paper_2010trb.pdf [accessed May 19, 2011].

¹¹³ Lee, K., A.G. Hobeika, H.B. Zhang and H. Jung. 2010. Travelers' Response to Value Pricing: Application of Departure Time Choices to TRANSIMS. *Journal of Transportation Engineering*. 136, 811 (2010); doi:10.1061/(ASCE)TE.1943-5436.0000139 Available at: http://ascelibrary.org/teo/resource/1/jtpedi/v136/i9/p811_s1?isAuthorized=no [accessed May 22, 2011].

pricing in London reduced private automobile, van, and truck traffic by shifting trips to public transit, bicycles and taxis.¹¹⁴

Economic Factors

The economic effects of pricing measures that limit access to transportation facilities through tolls or cordons are not fully understood, given the complexities of transportation economics and the need to factor in social welfare gains and losses.¹¹⁵

Conclusion

Cordon pricing has been demonstrated to reduce VMT. Further study is needed to determine whether tolling merely shifts trips to other times of day. The economic effects of either approach are not fully understood.

Policy 3—Spur adjustments in the prices for street parking

Definition

Using programmable meters, and inputs from pavement sensors or other data sources, parking meter rates can be changed dynamically.¹¹⁶

History of Deployment

Only a few cities have implemented dynamic parking pricing, and most projects are in their early stages.¹¹⁷⁻¹¹⁸⁻¹¹⁹⁻¹²⁰⁻¹²¹

¹¹⁴ Leape, J. 2006. The London Congestion Charge. *Journal of Economic Perspectives*, 20 (4): 157-176. Available at: <http://www.jstor.org/stable/30033688?seq=9>, p.165 [accessed May 19, 2011].

¹¹⁵ Viegas, J.M. 2001. Making Urban Road Pricing Acceptable and Effective: Searching for Quality and Equity in Urban Mobility. *Transport Policy*, 8 (4) 289-294.

¹¹⁶ San Francisco County Transportation Authority. *Value Pricing in San Francisco*. Project Report for the U.S. Department of Transportation. Federal Highway Administration Tolling and Pricing Program. Available at: http://ops.fhwa.dot.gov/tolling_pricing/value_pricing/pubs_reports/projectreports/sfcta_arearoad.htm [accessed May 22, 2011].

¹¹⁷ Kittelson & Associates. 2008. *Parking Management with Variable Pricing*. December 2008. Available at: <http://www.mwcog.org/transportation/activities/tlc/pdf/DDOT-report.pdf> [accessed November 15, 2010].

¹¹⁸ Zack, D. 2005. *The Downtown Redwood City Parking Management Plan*. Available at: <http://www.redwoodcity.org/bit/transportation/parking/pdf/DowntownRedwoodCityParkingPlan.pdf> [accessed November 15, 2010].

¹¹⁹ City of Seattle. 2008. *Seattle Urban Mobility Plan: Chapter 7*. January 2008. Available at: <http://www.seattle.gov/transportation/docs/ump/07%20SEATTLE%20Best%20Practices%20in%20Transportation%20Demand%20Management.pdf> [accessed November 15, 2010].

¹²⁰ FHWA. 2009. *Projects Not Involving Tolls: Parking Pricing*. Available at: http://ops.fhwa.dot.gov/tolling_pricing/value_pricing/projects/not_involving_tolls/parking_pricing/index.htm [accessed November 15, 2010].

¹²¹ Performance-Based Parking Pilot Program. District Department of Transportation. Available at: <http://ddot.dc.gov/DC/DDOT/On+Your+Street/Traffic+Management/Parking/Performance+Based+Parking+Pilots>. [accessed November 15, 2010].

Effectiveness and Impact

Most metered or street parking is not efficiently priced. Availability-based pricing can set prices that insure that sufficient parking spaces are free at any time to eliminate prolonged searches for free spaces, reducing VMT.^{122,123} Pricing on-street parking based on availability also reduces VMT by increasing the use of alternative transport modes, and discouraging low-priority vehicle trips.¹²⁴

Economic Factors

The initial cost of installation of parking pricing systems varies depending on the scope of the program, though the operation is revenue-neutral. By reducing demand for new parking spaces, such systems can save money on construction, maintenance, and the like, as well as the opportunity costs associated with foregone land value. Those savings can support reductions in rents or sales prices of properties.¹²⁵

Conclusion

Setting parking prices based on demand and availability, and changing them to maintain an optimum “vacancy rate” is a low-cost or revenue-neutral way to reduce VMT.

1.3.3 Conclusions: Promote a Reduction in Vehicle-Miles Traveled Through Pricing Measures

Pricing measures are a relatively low-cost mechanism for reducing VMT. They target three aspects of motor vehicle transportation: the cost of operating a motor vehicle (fuel prices, insurance prices, and mileage costs); the cost of access to transportation facilities (tolls and cordon charges); and the cost of housing the vehicle at the destination (parking costs).

While increasing the cost of operating motor vehicles is likely to reduce VMT, results are mixed for the individual measures. Fuel taxes would have to increase substantially for any significant reduction. Pay-as-you-drive-insurance and mileage charging schemes would provide incentives to drive fewer miles, but there has been no widespread deployment to test the hypothesis.

Cordon pricing has been demonstrated to reduce VMT, but more study is needed to determine whether tolling merely shifts trips to other times of day or results in absolute reductions. Finally,

¹²² Shoup, D. 2005. *The High Cost of Free Parking*. Chicago: American Planning Association Planners Press. Available at: <http://www.uctc.net/papers/351.pdf> [accessed June 19, 2011].

¹²³ Litman, T. 2011. *Parking Management Strategies, Evaluation and Planning*. Victoria Transport Policy Institute. Available at: http://www.vtpi.org/park_man.pdf [accessed on June 11, 2011].

¹²⁴ Shoup, D. 2006. Cruising for Parking. *Transport Policy*, 13 (2006) 479-486.

¹²⁵ Shoup, D. 2005. *The High Cost of Free Parking*. Chicago: American Planning Association Planners Press. Available at: <http://www.uctc.net/papers/351.pdf> [accessed June 19, 2011].

parking pricing based on availability has resulted in VMT reductions, both in terms of fewer miles driven “cruising” for spaces and fewer discretionary trips.

1.4 Conclusions for Chapter 1

Reducing human exposure to transportation-related emissions that most directly affect human health—carbon monoxide, nitrogen oxide, ozone, (the primary ingredient in smog), particulate matter, sulfur dioxide, and toxics such as lead—can be accomplished through reducing emissions or reducing exposure or both.

Reductions in human exposure can be accomplished by expanding current monitoring systems by focusing on, for example, urban areas with persistently high ozone levels; siting long-term facilities and those that serve vulnerable populations in a way that provides an adequate buffer away from high-pollution sources, with special attention paid to PM_{2.5} exposure; and continuing to build on the success of advanced motor vehicle emission control technologies and fuel efficiency efforts.

The transportation sector’s level of greenhouse gas emissions and its contribution to climate change can be reduced by increasing the share of electric vehicles, though there are unknowns about driver behavior, infrastructure investments, and vehicle costs. Another approach is to reduce size disparities among vehicles by reducing their size overall, which can reduce consumer demand for large vehicles and thereby improve fuel economy and decrease transportation-related greenhouse gas emissions. The new CAFE standards that use a size-based indexing system create incentives for carmakers to reduce size disparities in their fleets.

Another method to reduce overall transportation-related emissions is to use pricing measures to reduce vehicle-miles traveled (VMT). These measures address three elements of transportation: the cost of operating a motor vehicle (fuel prices, insurance prices, and mileage costs); the cost of access to transportation facilities (tolls and cordon charges); and the cost of housing the vehicle at the destination (parking costs). Results are mixed for achieving VMT reductions through changing the price of operating costs. Fuel taxes would have to increase substantially for any significant reduction in VMT. Pay-as-you-drive-insurance and mileage charging schemes would provide incentives to drive fewer miles, but there has been no widespread deployment to test the hypothesis. Changing the way access to facilities is priced also shows varying results. Cordon pricing has reduced VMT in some settings. In the case of tolling, more study is needed to determine whether it causes absolute reductions or merely shifts trips to other times of day. Parking pricing has resulted in VMT reductions, both in terms of fewer miles driven “cruising” for spaces and fewer discretionary trips.