

TRAFFIC EMISSIONS REDUCTION

GOAL

Reduce operational mobile-source emissions to improve air quality and human health.

CREDIT REQUIREMENTS

Show that **congestion pricing** was used on this project. This usually is part of a larger congestion pricing program. Use the EPA MOVES2010 software to compute the total greenhouse gas emissions and criteria pollutant emissions reduced by the tolling or pricing program compared to the non-priced alternative for the length of the project.

Details

Emissions modeling will require establishing a **baseline case**. This should consist of the length of the project without congestion pricing and should use the same assumptions that are made in the **congestion pricing** case. **Congestion pricing** schemes reduce the number of vehicles on a roadway by charging money for use during peak periods, therefore reducing fuel use and total emissions. **Congestion pricing** need not apply to all lanes of a roadway.

DOCUMENTATION

Copy of the project design report showing the project's planned congestion pricing and a copy of the executive summary for the MOVES2010 traffic model study completed for the project for both the **baseline case** and **congestion pricing** case. The summary should include the same details of the model as noted above.



AE-4

5 POINTS

RELATED CREDITS

- ✓ PR-1 Environmental Review Process
- ✓ AE-2 Intelligent Transportation Systems
- ✓ AE-3 Context Sensitive Solutions
- ✓ AE-5 Pedestrian Access
- ✓ AE-6 Bicycle Access
- ✓ AE-7 Transit & HOV Access

SUSTAINABILITY COMPONENTS

- ✓ Ecology
- ✓ Equity
- ✓ Economy
- ✓ Extent
- ✓ Expectations

BENEFITS

- ✓ Reduces Fossil Fuel Use
- ✓ Reduces Air Emissions
- ✓ Reduces Greenhouse Gases
- ✓ Improves Mobility
- ✓ Increases Service Life
- ✓ Improves Human Health & Safety
- ✓ Reduces Lifecycle Cost

APPROACHES & STRATEGIES

- Become an early adopter agency of the MOVES2010 software.
- Consider implementing intelligent transportation systems (ITS) for dynamic pricing and conversion of existing high occupancy vehicle (HOV) lanes to high-occupancy toll (HOT) lanes.
- Note that some tolled facilities were not installed to manage congestion. In order for toll facilities to meet the intent of this credit, roadway projects within a tolled system, especially if the user cost is static, reduces congestion using the MOVES2010 software and providing supporting information as noted.

Example: Congestion Pricing in Puget Sound - Traffic Choices Study

In 2002, the Puget Sound Regional Council (PSRC) received a grant to become a pilot project with the Value Pricing Pilot (VPP) program with the Federal Highway Administration. The object of the study was to monitor behavioral changes (number of trips, mode, route, and time of vehicle trips) to variable or congestion-based tolling. The Traffic Choices Study (PSRC, 2008) used global positioning system (GPS) tolling meters to track driving patterns for 275 volunteer households, before and after experimental tolls were charged for use of major freeways and arterials in Seattle. While no cost was incurred by the volunteers, several important changes in travel demand were observed that have significant implications on reducing emissions. These results included:

- All trips (tours per week) decreased 7%
- Vehicle miles traveled (miles per week) decreased 12%
- Drive time (minutes of driving per week) decreased 8%
- Tour segments (segments of tours per week) decreased 6%
- Miles driven on tolled roads (tolled miles per week) decreased 13%.

More information about the Traffic Choices Study is available at: <http://www.psrc.org/transportation/traffic>.

POTENTIAL ISSUES

1. Note that the transportation sector designation of many energy use or GHG emissions statistics do not include processes for design or construction of roadways. This is likely due to the small time scale of construction activities when compared to the much longer service life of the road itself. Depending on the lifecycle model used and what the system boundaries of that model are, either the use phase (i.e. vehicular emissions) or the production of materials (i.e. the manufacturing or construction process) have been shown to have the highest overall impact on GHG and energy use. These values are highly variable dependent on location, capacity, type of roadway, multi-modal access, maintenance, and amount of congestion, to name just a few.
2. The EPA MOVES2010 model is currently the best available quantitative approach to modeling use-phase vehicle emissions. (EPA, 2009f) As with any software program, this model has built-in assumptions that may be counter-indicative of appropriateness for a particular roadway project. The limitations of EPA MOVES2010 should be understood prior to pursuing this credit.

RESEARCH

Though Greenroads is intended to be most easily implemented during the design and construction phases of the roadway lifecycle, the impact of the use and operations phase and the planning implications of the roadway in this phase are unavoidable. Ignoring these implications would be remiss, since clearly implementing such emissions reduction programs results in a roadway that is more sustainable overall. This credit rewards planning steps that have been implemented in order to reduce the overall lifecycle emissions impact due to vehicular traffic from roads in order to promote human and environmental health. Additionally, research in these areas also shows that there are external benefits, such as increased service life (and therefore, reduced long term maintenance costs) and human health improvements, that are associated with systematic tolling programs.

Air Emissions Impacts of the Transportation Sector

The most recent statistical data available from the EPA (2009a) and the Department of Energy (DOE: Davis, Diegel & Boundy, 2009) show that the transportation sector is one of the biggest contributors for many of the air emissions considered greenhouse gases and criteria pollutants. This is primarily due to the combustion of fossil fuels, most commonly gasoline and diesel. The amounts of these gases that are released during combustion depend primarily on the carbon content of the fuel. (Davis, Diegel & Boundy, 2009)

What are Greenhouse Gases?

Greenhouse gases (GHGs) are a group of 22 long-lived chemical compounds (Solomon et al., 2007) that are found in air emissions from human activities and natural processes. Increasing concentrations of these gases in the Earth's atmosphere have been identified to be major factors in global warming and climate change (sometimes these are combined to one term "global change"). High levels of these gases in the atmosphere disturb the energy balance of Earth's climate systems and act like a blanket around the Earth, trapping heat from solar radiation within the Earth's atmosphere which might otherwise escape via normal climate processes. The potency or concentration of these gases is measured in units of change in radiative forcing, which is a reflection of their overall warming (or cooling) influence. Currently, most GHG emissions are not as strictly regulated or otherwise monitored by the EPA.

The four GHGs that have been identified are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and halocarbons (a group of gases with fluorine, chlorine or bromine). Each gas has a different influence on global warming due to their properties and lifetimes. Typically, the gases are compared to a baseline unit of CO₂ using an index (multiplier) called Global Warming Potential (GWP) that reflects that compounds relative radiative forcing compared to CO₂. GWP is usually expressed in units of carbon dioxide equivalent (CO₂e, sometimes CO₂-eq) emissions, but does not necessarily reflect the same climate responses. (Bernstein et al., 2007) For example, 1 unit emission of methane has a GWP in 100 years equivalent to 25 units of carbon dioxide according to the Intergovernmental Panel on Climate Change Fourth Assessment Report, so it is expressed as 25 CO₂e. (Solomon et al., 2007; Bernstein et al., 2007)

The 2009 U.S. Greenhouse Gas Inventory Report (EPA, 2009a) states:

From 1990 to 2007, transportation emissions rose by 29 percent due, in large part, to increased demand for travel and the stagnation of fuel efficiency across the U.S. vehicle fleet. The number of vehicle miles traveled by light-duty motor vehicles (passenger cars and light-duty trucks) increased 40 percent from 1990 to 2007, as a result of a confluence of factors including population growth, economic growth, urban sprawl, and low fuel prices over much of this period. A similar set of social and economic trends has led to a significant increase in air travel and freight transportation by both air and road modes during the time series.

According to this report, the transportation sector was responsible for 33% of CO₂ emissions, 26% methane (CH₄) emissions, and 67% of nitrous oxide (N₂O) emissions from fossil fuel combustion. These statistics have been adjusted for end-use sector (so contributions due to electricity generation have been included) and do not include air and freight modes. Generally, the end-use adjustment increases overall percentage contributions and direct emissions are less. The transportation sector is also accountable for 0.9% of the halocarbon emissions, mostly in the form of the refrigerant HFC-134a. (EPA, 2009a). End-use adjusted statistics were not specified for halocarbons in the transportation sector.

What are Criteria Pollutants?

The criteria pollutants are six common pollutants in air that are known have detrimental human health impacts as well as potential to damage property. The pollutants are particulate matter (PM₁₀ and PM_{2.5}), ground-level ozone (O₃), nitrogen oxides (NO_x), carbon monoxide (CO), sulfur dioxide (SO₂), and lead (Pb). Of these pollutants, particle pollution and ground-level ozone are the greatest threats to human health and environmental damage. (EPA, 2009d) The six pollutants are called "criteria" pollutants because concentrations

in the air are regulated by the EPA, who compares tested levels to allowable levels set in the 1990 Clean Air Act (CAA) amendments (40 CFR § 50) National Ambient Air Quality Standard (NAAQS). (EPA, 2009b; EPA, 2009c)

It is important to note fuel combustion also accounts for most of the indirect greenhouse gases (EPA, 2009a) which include CO, NO_x, non-methane volatile organic compounds (NMVOCs), and SO₂. Indirect greenhouse gases “do not have a direct global warming effect, but indirectly affect terrestrial radiation absorption by influencing the formation and destruction of tropospheric and stratospheric ozone, or, in the case of SO₂, by affecting the absorptive characteristics of the atmosphere. Additionally, some of these gases may react with other chemical compounds in the atmosphere to form compounds that are greenhouse gases.” (EPA, 2009a)

Table AE-4.1 summarizes the percentage contributions of selected pollutants from the transportation sector. Most of the emissions come from use of highway vehicles and heavy trucks. Also, notably, transportation accounts for the majority of carbon monoxide and nitrogen oxide emissions in the United States (Davis, Diegel & Boundy, 2009).

Table AE-4.1: Transportation’s Share of U.S. Emissions of Various Pollutants, 2007
(Adapted from Table 12.1 in Davis, Diegel & Boundy, 2009)

Pollutants	Chemical Symbol	Percentage of Total U.S. Emissions (%) in 2007
Carbon monoxide	CO	68.4
Nitrogen oxides	NO _x	57.1
Volatile organic compounds (VOC)	Various	33.9
Sulfur dioxide	SO ₂	8.9
Ammonia	NH ₃	5.7
Particulate matter	PM ₁₀	2.7
	PM _{2.5}	7.2
Lead	Pb	Not included
Ozone	O ₃	Not Included

Note that the term transportation sector means human use of vehicles on roadways, and commonly the air pollutant contributions due to construction are omitted from statistical reports. The DOE data in Table AE-4.1 were also not specifically adjusted for end-use electricity or energy for the transportation sector and includes contributions from air and freight modes. Due to the increased availability of unleaded gasoline and related regulations since the mid-1980s, the prevalence of the criteria pollutant lead has decreased significantly (EPA, 2009d) and it is not included in the statistics shown. Similarly, ground-level ozone is not included because it is not emitted directly; instead, it is formed due to a chemical reaction of nitrogen oxides and VOCs in sunlight (2009d).

How are Air Emissions from Transportation Modeled?

The EPA is required by the CAA to continually track and update air quality data from mobile source emissions, as well as its software models used to measure vehicle emissions. Prior to the December 2009 release of MOVES2010 software from the Office of Transportation and Air Quality (OTAQ), either MOBILE6.2 or previous versions of the MOVES program were required to be used to develop emissions models during creation of state implementation plans for air quality performance. Now, the EPA states that MOVES2010 is the best available tool for emissions modeling for transport. (EPA, 2009f) Recent data (collected within the last 10 years using the best available technologies and improved monitoring and controls) was used to develop the emissions algorithms in MOVES2010. Currently, there is a two year grace period before the EPA will require adoption of the MOVES2010 software in all regulated agencies. (EPA, 2009f) The added features of MOVES2010, when compared to MOBILE6.2, allow improved calculation of greenhouse gas emissions (as well as criteria pollutants) because it is based upon user inputs for transportation planning, vehicle-miles traveled (VMT) and speeds and not solely upon fuel consumption. (ICF Consulting, 2006)

Human Health, Air Quality & Public Policy

Human health impacts due to poor air quality, especially due to criteria pollutants from mobile sources like traffic, are well-documented. A systematic review by Woodcock et al. (2007) found that the health impacts of transport pollution are evidenced by increased total deaths, increased respiratory and cardiovascular death and diseases, increased allergies and also potentially link to cases of lung cancer. Additional deaths result from health dangers such as traffic accidents, and are commonly argued to be due to behavioral choices and lifestyles. An excerpt from the foreword of the 2005 World Health Organization (WHO) report, *Health Effects of Transport-Related Air Pollution*, frames the situation well:

Transport plays a fundamental role in the lives of societies and individuals: how people interact, work, play, organize production, develop cities, and get access to services, amenities and goods is inextricably linked with the development of mobility and the choices people make about it. In societies that rely heavily and increasingly on private motorized transport, vehicles are expected to become safer, more luxurious and powerful, and to be driven more frequently. These expectations, however, often do not take account of the ensuing consequences: increased fuel consumption, greater emissions of air pollutants and greater exposure of people to hazardous pollution that causes serious health problems. The increased intensity of and reliance on transport also increase the risk of road-traffic injuries, exposure to noise and sedentary lifestyles. These risks are a disproportional threat to the most vulnerable groups in the population, such as children and the elderly, and they raise important questions about social inequalities. (Krzyżanowski, Kuna-Dibbert, & Schneider, 2005)

While the health effects of criteria pollutants are both well-documented and regulated, the health effects of greenhouse gas emissions are less well-understood. In 2009, Haines et al. published a summary for policy makers at the end of a comprehensive series of studies on the public health impact of greenhouse gases. All scenarios modeled by that group (see Woodcock et al. 2009) demonstrated significant increases in total human health based on three indicators (physical activity, outdoor air pollution and road traffic injury) when sustainable transport policies were implemented, as well as active transport and multi-modal solutions. Also, all scenarios demonstrated decreases in overall CO₂e emissions. (Woodcock et al. 2009) However, Chan (2009) notes that many policy makers have not made the connection between climate change and public health. She also notes that the carbon-reduction policy can provide benefits to public health which could be substantial, and includes reductions in chronic health problems such as heart disease, cancer, obesity, diabetes and respiratory ailments. Some regions have recently begun to change course and carbon-reduction policy is becoming more prevalent (Chan, 2009).

Haines et al. (2009) provide some key messages to policy makers, some of which are highlighted below:

- Substantial health benefits can be recognized by policies and measures made toward reducing greenhouse gas emissions at both regional and global levels.
- Specific transportation policies that can reduce GHG emissions and improve public health are increased walking and cycling modal access and reduced private vehicle use in urban areas.
- Some measures may have negative health effects too, but these tradeoffs must be weighed accordingly during decision-making (for example, reducing the danger of car accidents by encouraging cycling may increase danger of bicycle accidents).
- Costs of these measures vary but may be offset by the savings in healthcare costs, and in some cases the savings may outweigh costs in the long-term.
- Woodcock et al. (2009) also state that the avoided costs of healthcare are potentially enormous, though difficult to model.

The Role of Congestion Pricing

The concept of congestion pricing is not new (Congressional Budget Office: CBO, 2009). Pollution due to congestion is higher because stop-and-go traffic tends to increase fuel demand and therefore can produce more emissions. Increasing roadway physical capacity to meet traffic demand has been found to encourage additional demand and therefore increase vehicle trips, fossil fuel use, and air pollutant emissions. While

substantial improvements in vehicle fuel efficiency have been achieved in the past decades, there are simply more drivers on the road at peak hours in many locations than can fit comfortably. Congestion pricing offers a means of approaching these challenges through more effective use of roadway capacity and influencing traveler behaviors through economic tools.

Congestion pricing works by applying a variable cost to the users of the roadway facility during peak travel times, thereby lowering travel demand, reducing the number of vehicles on a roadway, and reducing emissions due to fewer idling vehicles (CBO, 2009; Daniel & Bekka, 2000). Daniel & Bekka (2000) note that “Travelers do not consider costs of delay or pollution they impose on others, but only their own travel costs. Assessing congestion fees equal to the additional travel costs that travelers impose on others internalizes these costs and promotes efficient use of limited roadway capacity.” Because congestion pricing improves efficiency (by not overloading the structural capacity of the pavement), the lifetime of the roadway is increased, which corresponds to less lifetime maintenance need and therefore reduced lifecycle costs. Also, congestion pricing has also been found to produce enormous net social benefits valued between \$19-45 billion (2005 dollars) (CBO, 2009), and once implemented, has a surprisingly low public disapproval rating in most cases (Verbruggen, 2008).

A Brief Note on Equity

The role of equity in the debate over air quality in transportation policy is complex, as with any ethical debate regarding politics, economics and communities of people. Woodcock et al. (2007) notes that current levels of automobile use in high-income communities are not sustainable because they do not provide equal access or mobility. A recent study by Dietz & Atkinson (2005) highlights several of the core equity issues, including disparity between pollution distribution because of physical processes (i.e. some areas have lower air quality than others), economic policy (where the economic or tax burden of transport policies is often unevenly distributed, and sometimes hardest hit are low-income groups), and accountability for the generation of transportation emissions. However, the CBO (2009) reports that studies of the equity challenges due to congestion pricing have found support among all income groups where it has been implemented. Notably, Dietz & Atkinson (2005) point out “the fact that some enjoy cleaner air than others is significant.” From this it follows that because cleaner air benefits everyone and the environment, the human equity discussion (while both important and inevitable) is secondary to the overall environmental quality goal. Also, other important equity issues can arise between communities and roadways due to certain placement or location near high density traffic areas (Appatova, Ryan, LeMasters & Grinshpun, 2008), or proximity and density of certain communities to low-rise structures which can trap pollutants in a “street canyon” effect (Salizzoni, Soulhac & Mejean, 2009). Equity issues regarding access and mobility needs are further addressed in subsequent Greenroads credits for multi-modal transport alternatives and solutions. However, Greenroads does not address land use, planning and zoning or other community location issues; it is not known if this is either possible or appropriate for such a metric, and in general these issues fall outside the scope of Greenroads.

Project Level Implications

The Clean Air Act (CAA) and well as former federal mandates, such as the Intermodal Surface Transportation Efficiency Act (ISTEA), the Transportation Equity Act for the 21st Century (TEA-21), and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) give state agencies the authority to regulate and control air pollution through a variety of means (Daniel & Bekka, 2000) [*Note that as of this writing, the SAFETEA-LU regulation has expired and no replacement has been passed by Congress. It is assumed the state authority will be preserved.*] In general, implementing broad agency policies that provide mitigation strategies for curbing air emissions are likely to be very challenging (Fisher & Costanza, 2005) and also unfamiliar. Congestion pricing schemes may also be unfamiliar (or worse, unwanted) by public stakeholders (Verbruggen, 2008, CBO, 2009). But, D’Avignon et al. (2009) show that while global air emissions impacts do not translate well enough to be measured easily or meaningfully at local and regional scales, the impacts of local emissions policies can still be effective at reducing local sector contributions. Similarly, congestion pricing has been well-established as an effective measure for reducing vehicle emissions and increasing efficiency of roadway capacity. (FHWA, 2009; Hecker, 2003; CBO, 2009; Verbruggen, 2008)

D'Avignon et al. (2009) state that this is true especially when emissions inventories are used to establish initial policy benchmarks, reduction targets, and local action plans for mitigation. (For more information on emissions inventories, see Project Requirement PR-3 Life Cycle Inventory). While an emissions action plan or policy does not guarantee success or effectiveness, especially if targets are continually unmet or pushed further into the future, it does allow for increased local adaptability for long range climate change planning and project-specificity for emissions, as well as uniformity of local and regional policy and practice (Fisher & Costanza, 2005). The introduction of pricing schemes in the short-term might assist in future acceptance of such policies.

Pricing schemes differ in utility at a project level compared to regional policies because they can be applied on a project-by-project basis. Basically, this allows a corridor to be built and pricing to be implemented in a piecewise manner, which is more manageable and realistic on a project scale. However, piecewise management also comes with tradeoffs because it still requires adequate and thoughtful planning as well as public involvement prior to being implemented successfully and effectively.

Additional Resources

The American Association of State Highway and Transportation Officials (AASHTO) as part of National Cooperative Highway Research Program (NCHRP) of the Transportation Research Board (TRB) Task 25-25 completed a comprehensive study in 2006 of available assessment techniques for modeling greenhouse gas emissions in transportation projects (ICF Consulting, 2006). This report reviews the best available techniques and policy recommendations for transportation planners, and also highlights various tools for calculation, strategic planning, and energy/economic forecasting. The document discusses the advantages and limitations of the EPA MOVES software for emissions modeling. More information is available in *NCHRP 25-25(17), Assessment of Greenhouse Gas Analysis Techniques for Transportation Projects*.

The EPA provides up-to-date and detailed statistical information about GHG, indirect GHG, and criteria pollutant emissions due to fossil fuel combustion and the transportation sector. Additionally, the EPA provides and manages distribution of the free MOVES2010 software and provides policy guidance for implementing in SIPs. More information on these topics is available here:

- 2010 U.S. Greenhouse Gas Inventory Report: <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>
- Green Book: Non-Attainment Areas on Criteria Pollutants (includes NAAQS and data links): <http://www.epa.gov/oar/oaqps/greenbk/index.html>
- The Motor Vehicle Emissions Simulator (MOVES2010) and all relevant guidance and technical documentation: <http://www.epa.gov/otaq/models/moves/index.htm>

While the United States did not ratify the Kyoto Protocol, many individual states have become involved at a policy level in climate change and emissions targeting (Fisher & Costanza, 2005; Mayors' Climate Protection Center, 2009). The Mayors Climate Protection Center lists 1,016 individual cities whose mayors have agreed to reduce local emissions from 1990 values by 7% in 2012. There are also many regional initiatives, such as the Regional Greenhouse Gas Initiative (RGGI) and the Western Climate Initiative which have started CO₂ budget trading programs. More information about local and regional GHG initiatives can be found here:

- Mayors Climate Protection Center: <http://usmayors.org/climateprotection/list.asp>
- Western Climate Initiative: <http://www.westernclimateinitiative.org/>
- Regional Greenhouse Gas Initiative: <http://www.rggi.org/home>

The Congressional Budget Office (CBO) recently (2009) published a comprehensive review of congestion pricing in the United States, *Using Congestion Pricing to Reduce Traffic Congestion*. This document is available for free at <http://www.cbo.gov/ftpdocs/97xx/doc9750/03-11-CongestionPricing.pdf>

GLOSSARY

AASHTO	American Association of State Highway and Transportation Officials
Baseline case	The benchmark used to compare alternative emissions scenarios
CAA	Clean Air Act
CBO	Congressional Budget Office
Congestion pricing	An economic transportation planning tool increases the efficiency of the roadway by charging for use during peak periods
Criteria pollutant	One of six common pollutants in air that are known have detrimental human health impacts as well as potential to damage property
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
GHG	Greenhouse gas
Greenhouse gas	A long-lived chemical compound found in the atmosphere as a result of human and natural activities
ISTEA	Intermodal Surface Transportation Efficiency Act
NAAQS	National Ambient Air Quality Standard
NCHRP	National Cooperative Highway Research Program
Non-attainment area	Areas of the U.S. where air pollution levels persistently exceed the national ambient air quality standards
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SIP	State implementation plan
State implementation plan	A plan for a state that shows how it is to comply with the Clean Air Act
TEA-21	Transportation Equity Act for the 21 st Century
TRB	Transportation Research Board
WHO	World Health Organization

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