NATIONAL GOVERNORS' ASSOCIATION

NGA Center for
Best Practices

Natural Resources
Policy Studies Division

State Innovations To Reduce Vehicle Emissions

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ISBN 1-55877-341-X

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Printed in the United States of America.

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Acknowledgements

The National Governors' Association (NGA) Center for Best Practices acknowledges the generous financial support in the preparation and publication of this report made possible through a cooperative agreement with the Office of Natural Environment of the Federal Highway Administration, U.S. Department of Transportation. Specifically, NGA would like to thank Cecilia Ho for her leadership and guidance of this project.

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This publication reflects the efforts of many people. Sincere appreciation is extended to the Governors' representatives and state agency officials who spent considerable time and effort reviewing the data and text of the report. The author is indebted to Barbara Wells for her exceptional skills at organizing such sundry information, for her savvy editing abilities, and for her endless good humor. The author gratefully acknowledges the assistance of Cecilia Ho, Mike Savonis, and Daniel Wheeler in the U.S. Department of Transportation who provided insightful advice on the data and the report's preparation. Kathy Skidmore-Williams and Susan D. West patiently provided expert editorial and production assistance.

Executive Summary

Vehicles and fuels have become much cleaner since the 1970 passage of the Clean Air Act, but the trends of increased driving and ever-worsening congestion could threaten continued air quality improvements. States are responsible for designing strategies that achieve and maintain national air quality standards, as established by the U.S. Environmental Protection Agency (EPA) for the mobile-source pollutants: carbon monoxide, nitrogen oxides, volatile organic carbons, and particulate matter.

Federal regulations largely control fuel formulas and vehicle emissions standards, but states have a wide range of other options for controlling mobile source pollution. State programs to curb pollution from motor vehicles can be grouped into the following four general categories:

- ensuring tailpipe emissions standards are met through inspection and maintenance;
- slowing the increase in vehicle miles traveled;
- mitigating congestion; and
- encouraging the purchase of alternative fuel vehicles.

This report examines a selection of innovative strategies in each of these four categories and discusses how these strategies might be applied to maximize the potential for emissions reduction.

Inspection and Maintenance

The most cost-effective approach to lowering motor vehicle emissions in some metropolitan areas is to ensure that the national tailpipe emissions standard for each vehicle is met over the life of the vehicle. One effective way to achieve this is through inspection and maintenance (I&M) programs, which ensure that vehicles continue to operate efficiently and emit air pollutants only at their certified level. These programs involve periodic testing or remote sensing of vehicles for malfunctioning emissions equipment and require repairs of vehicles not making the grade.

To be most effective, I&M programs should be implemented in ways that minimize expense and inconvenience to motorists. Because the majority of pollution comes from older vehicles, the most effective programs target these vehicles for inspection and repair. Vehicles with newer technology gradually penetrate the market, resulting in the turnover of the total fleet, but vehicles with less-advanced technology or malfunctioning systems are a significant pollution source.

One example of an innovative I&M program is Missouri's clean-screening program, which uses remote sensing technology to detect vehicle emissions on the road. The technology enables the state to exempt the cleanest vehicles from the inconvenience of station testing, while still requiring inspection and repair of dirtier cars. The state decreases the burden on the public while maintaining the air quality benefit of the program.

Slowing the Growth of Vehicle Miles Traveled

States also help reduce air pollution by slowing the growth in the number of miles driven. Many states encourage less driving on days or in seasons of high pollution rather than seeking reductions in driving every day. States actively emphasize the use of alternative travel modes on these days and may provide financial incentives to people who use them. States publicize vehicle miles traveled (VMT) reduction strategies either through mass advertising or by engaging business and governmental entities in a VMT reduction program. Some conduct outreach efforts only on specifically selected "ozone action days," and some attempt to lower VMT and ozone production during the entire summer. Methods to reduce vehicle miles traveled are often similar to the methods to reduce congestion.

An example of a state VMT reduction strategy is the Partnership for a Smog-free Georgia, a program that enlists public agencies and private-sector companies to encourage driving reductions. The goal of the program is to decrease single-occupant vehicles during the ozone season, and a noticeable decrease in peak traffic volume has been observed since the start of the program.

Mitigating Congestion

States attempt to minimize congestion because stop-and-go traffic contributes more of some pollutants than does free-flowing traffic. Common techniques include carpooling and vanpooling, transit use, bike and pedestrian programs, high-occupancy vehicle (HOV) lanes, land-use planning, and signal timing. Congestion mitigation tends to focus on high travel times of the day, whereas VMT reduction strategies are geared toward changing overall driving habits on certain days or during certain seasons. Though the tools are the same, the way they are implemented determines whether they have the desired effect.

An innovative congestion mitigation strategy is employed in California, where a congestion-sensitive toll pricing system has been put in place on a heavily traveled highway in Los Angeles. This system charges commuters more during peak commute hours, and therefore encourages ridesharing and non-peak hour travel. The length of rush hour has decreased on this highway since the dynamic pricing system was instituted.

Encouraging Alternative Fuel Vehicles

The use of alternative fuels, such as compressed natural gas, liquefied petroleum gas, electricity, methanol, or ethanol may reduce emissions of air pollutants. Reductions vary in degree and type depending on the kind of alternative fuel used. Alternative fuel vehicles (AFVs) help to reduce emissions even in the absence of VMT or congestion reduction from the fleet. Drawbacks to using AFVs include their generally higher costs and the inconvenience and expense of maintenance and fueling. New conventional-fuel vehicles are generally achieving lower emissions criteria, and national strategies are expected to continue this trend. Therefore the use of AFVs tends to be confined to operators of fleets of vehicles. Many states have begun to offer financial incentives for the purchase of vehicles or building of the necessary infrastructure to support AFVs.

An example of an AFV incentive program is the Oklahoma Alternative Fuel Program, which provides a revolving fund for no-interest loans to governmental entities for vehicle conversion or the installation of refueling infrastructure. The program has funded the purchase of 370 vehicles and the building of 9 fueling stations since its inception.

Introduction

Background

Progress has been made to reduce tailpipe emissions even as the rate of vehicle miles traveled (VMT) has increased. However, there are limits to future technological progress. Moreover, two trends are working to negate progress: increasing VMT and congestion. Innovative strategies may be needed to reduce the air pollution contributions from rising VMT and worsening congestion and to ensure that vehicle emissions systems function on the road according to their design standards.

Air quality over the past 30 years has improved significantly in terms of decreases in carbon monoxide (CO), nitrogen oxides (NO_x), volatile organic compounds (VOC), lead (Pb), and sulfur dioxide (SO_2). Mobile source emission reductions have contributed most to these improvements, particularly reductions from technological controls. According to the U.S. Environmental Protection Agency (EPA), today's new cars are up to 90 percent cleaner than their 1970 counterparts. Many provisions in the Clean Air Act (CAA) will further reduce harmful emissions from all sources. However, continued increases in automobile travel could, in 20 years to 30 years, begin to erode the progress made in lowering vehicle emissions if technology does not keep pace. States can help address this problem through a number of innovative programs to reduce total emissions from mobile sources.

Progress Made in Reducing Mobile-source Air Pollution

Significant reductions in air pollutants from automobiles have been made since the CAA's passage in 1970. Specifically, cleaner fuel formulations; use of new engine designs and tailpipe treatments, on-board diagnostics, and vehicle tailpipe emissions standards; and the associated inspection and maintenance programs to ensure the achievement of these standards have brought substantial air quality gains over the last three decades. These approaches have been largely federal in scope; under the CAA, states are generally prevented from individually establishing tailpipe emissions or fuel standards. (Two important exceptions to this prohibition are the opt-in to the federal reformulated gasoline program and state adoption of a Reid vapor pressure (RVP) requirement that is more stringent than the federal requirement.) Since the implementation of these programs, on-road vehicle emissions of NO_x are down 60 percent, CO by 40 percent, and coarse particulate matter (PM_{10}) by 25 percent. These substantial reductions reflect the success of the federal vehicle and fuel regulations.

Future Challenges to Continued Air Quality Improvements

Despite the progress made in reducing tailpipe emissions from cars, two trends present challenges to future reductions: VMT has grown rapidly and continues to increase, and congestion levels are continually increasing in metropolitan areas across the country. In the last 30 years, the total VMT in the country grew by 125 percent, roughly 4 times the rate of population growth. VMT growth also outpaced inflation-adjusted gross domestic product and the number of vehicles on the road by 25 percent each. Americans simply continue to drive more miles per person and have more cars per household. This trend is projected to

The Dirty Half-dozen: Criteria Pollutants Regulated by the U.S. Environmental Protection Agency

Ozone: Also known as "smog," ozone is a powerful lung irritant and inhibitor of plant growth. Because its formation is sunlight dependent, it is a greater problem on summer days. It is formed from a reaction between nitrogen oxides and organic gases.

CO: Carbon monoxide is a poisonous gas formed from incomplete fuel combustion. Mobile sources account for about three-quarters of CO emissions.

NO_2: Nitrogen dioxide and nitrogen oxide are collectively referred to as "NO_x," a class of pollutants from fuel combustion that contributes to acid rain and to ozone formation. Mobile sources account for one-third of NO_x emissions.

PM_{10}: Particulate matter includes tiny particles of soot, smoke, and dust, and small droplets of other pollutants. Mobile and industrial sources combined make up 10 percent of particulate matter emissions.

Pb: Lead has been removed from gasoline so mobile sources are no longer a major contributor.

SO_2: Mobile sources are not a major contributor of sulfur dioxide.

continue, with VMT growth possibly outpacing emissions reductions in 2020. This projected date is area-specific, with faster-growing metropolitan areas facing the problem sooner than slower-growing metropolitan areas.

In recent years, the number of light-duty trucks sold has grown; they now represent half of new vehicle sales. Because light-duty trucks, including pick-up trucks, minivans, and sport utility vehicles, currently have less-stringent tailpipe emissions standards than passenger cars, the growth of this vehicle market has increasingly contributed to mobile-source air pollution. Under EPA's Tier 2 standards, this contribution should begin to decline after model year 2004, when light-duty trucks will be required to meet the same standards as passenger cars.

In the time that VMT more than doubled, the number of new route miles added to the highway system grew by only 5 percent. The explosion in VMT, coupled with only a modest growth in road miles, has resulted in increased traffic congestion. This increase has been a larger problem in urban areas with more concentrated driver populations. At least 20 of the nation's large cities have seen increases of 30 percent or more in congestion over the last 25 years. Increased congestion brings increased emissions, as cars release more of certain pollutants under stop-and-go or slow conditions.

Traffic congestion is the top quality-of-life concern in numerous public surveys. Several governors have taken action to influence growth and land-use planning to alleviate what is seen as a threat to citizens' desired quality of place. Governors cite the undesirable outcomes of higher governmental costs and threatened economic growth from this decreasing quality of life as reasons for implementing smart growth strategies. These strategies were explored in the recent NGA report, *Growing Pains: Quality of Life in the New Economy.*

The emissions from continued growth in VMT and congestion offset some of the gains from the original federal regulations for tailpipe standards and fuels, despite the enormous air quality benefits of the federal strategies. Many areas have been unable to comply with the national air standards in the time prescribed under the CAA.[1]

Road Building May Not Be the Only Solution to Congestion

In some areas, the solution to the growing congestion problem may be simply to build more roads. This can be a challenge for some states that may not have the space to build these roads or the funds for construction. In addition to building new roads, states should maximize the usefulness of existing roads through construction improvements and through technologies to facilitate smoother flow of traffic.

Though there are many issues surrounding road building beyond just air quality concerns, this report does not address programs and policies concerning road construction.

Technology Will Not Provide Immediate Answers to the Air Quality Threat

Further technological advances in emissions control will not solve this problem right away. The National Low-Emission Vehicles Program (NLEV) first makes lower-emission vehicles available in nine northeastern states, and later (in model year 2001) in the rest of the country. Completely new technology, such as fuel-cell-powered vehicles or hybrid electric-gasoline vehicles, will eventually provide air quality benefits with greenhouse gas reductions, but significant nationwide use of these technologies cannot be expected in the near future. The first privately developed vehicles with extraordinarily high fuel efficiency will be coming on the market in some areas in the next few years, and these will provide greenhouse gas emissions reductions. However, it is unknown whether these vehicles will be cost-effective enough for large-scale industry production, and whether they will be priced competitively enough for a large enough market to produce large air quality gains. A federal research and development program called the Partnership for a New Generation of Vehicles exists to create a new class of vehicles with gas mileage of at least 80 miles per gallon. However, these cars are not expected to be sold until at least 2004. Affordability remains a major challenge.

States may have to consider programs to supplement federally enacted control strategies because of the timing of the newest standards. The most advanced vehicle emissions technology improvements will not have a pronounced impact upon regional air quality until placed into production and made available for purchase. The full impact will not be realized until the existing regional fleet of vehicles is retired and replaced.

Changes in fuel formulation are also unlikely to yield large emissions reductions. Like the removal of lead additives from gasoline, which in the mid 1970s virtually eliminated lead emissions, dramatically reduced gasoline sulfur levels under new fuels standards (Tier 2) will achieve significant reductions in hydrocarbons (HC), CO, and NO_x emission components. The reduction of sulfur in fuels is likely to increase the effectiveness of tailpipe controls remarkably. In addition, Phase II of the reformulated gasoline program recently went into effect in the nation's smoggiest cities to help reduce ozone precursor emissions. However, after these two new clean fuels strategies, improvements in gasoline formulation may be politically more difficult.

Cleaner Diesel Vehicles Will Provide Future Emission Reductions

EPA is currently gathering information on the best strategy for requiring cleaner diesel fuel. Although new car emission rates have decreased 85 percent to 99 percent with Tier 2, depending on the pollutant, diesel truck emission rates have only declined by 10 percent to 60 percent. Diesel vehicles contribute about one-third of on-road NO_x emissions and about three-quarters of on-road particulate emissions, so these future federal regulations, EPA's Heavy-duty Engine Rulemaking, will provide another piece of the solution to the mobile source air pollution problem. A Notice of Proposed Rulemaking (NPRM) was published October 6, 1999, for the first phase of the standards that take effect in the 2004 model year. The second phase—more stringent standards along with sulfur controls that will result in a reduction of more than 90 percent in NO_x and PM—could take effect as early as 2007 under a separate NPRM published May 17, 2000.

Innovative Strategies Will Reduce Mobile Source Emissions

The CAA brought a number of additional strategies that states can use to reach required air quality goals. The provisions include planning strategies, VMT reduction and traffic congestion mitigation (programs collectively called transportation control measures or TCMs), regional fuel reformulations, alternative fuel programs, and new inspection and

National Fuel and Tailpipe Regulations to Achieve and Maintain Air Quality

Federal requirements for gasoline and automobile tailpipe emissions have had significant impacts on air quality since they were first implemented. EPA has the authority to regulate fuel composition, vehicle fleets, and emissions from on- and off-road vehicles.

Federal standards currently regulate standard or "baseline" gasoline to meet certain limits on sulfur, vapor pressure, and toxics, and require a minimum octane concentration. EPA is tightening these requirements under new regulations that will substantially limit the amount of sulfur in everyday gasoline.

Federal law also limits emissions from new-vehicle tailpipes. These standards have reduced tailpipe emissions from new cars by 95 percent. Emission standards are required over the entire useful life of the vehicle. Under the Tier 2 regulations, "useful life" is defined as 120,000 miles. Changes to federal regulations will further reduce NO_x levels by 70 percent to 90 percent and bring cars and light-duty trucks (i.e., pickups, sport utility vehicles, and minivans) under the same emission control requirements.

California is the only state allowed under the CAA to pass its own regulations on fuels or vehicle emissions. Under these provisions California adopted the Low Emission Vehicle/ Clean Fleet program, which requires lowered tailpipe emissions, use of clean fuels, and the sale of Zero Emission Vehicles (ZEV). Other states can adopt some of California's stricter legal requirements if they choose. In particular, several East Coast members of the Ozone Transport Commission petitioned EPA to require the LEV/ZEV portion of California's program in the northeast ozone transport region. This program, known as the National Low Emission Vehicle (NLEV) program, represents a voluntary agreement among the northeast states and automobile companies to put cleaner vehicles on the road in the northeast states several years before they will be available to consumers in the rest of the country.

maintenance (I&M) procedures. State program efforts are critical to reducing pollution to meet the national ambient air quality standards (NAAQS). States have some flexibility in the implementation of required programs, and they have the freedom to select additional programs that suit their needs.

These CAA provisions do not, however, reduce emissions by a large amount relative to ongoing reductions from cleaner fuels and new, more strict vehicle emissions standards. Most emission reductions in the past have come from cleaner cars and cleaner fuel. Although on-road mobile source emissions are declining as a percentage of total emissions and total emissions are declining for most pollutants, mobile sources still account for about 30 percent of volatile organic compounds and NO_x pollution and about 60 percent of CO emissions. There is clearly room for additional reductions.

However, the states, not the federal government, have the responsibility for air quality control, and the CAA gives them specific requirements and defines the flexibility they have to create plans to meet air quality goals. The variety of options available also presents states with the challenge of building the most effective strategy from the many available tactics.

Implementation Options for Air Quality Control Programs

Through a combination of national standards and state-implemented programs, the nation's air has become significantly cleaner. However, the air pollution problem cannot be declared "solved," as VMT and congestion may continue to be issues. States need flexibility to implement innovative or pilot programs to determine which are the most successful at alleviating their pollution problems.

This report presents a selection of state programs for ensuring national tailpipe standards, slowing the growth in VMT, reducing congestion, and encouraging the purchase of alternative fuel vehicles. It highlights strategies that push the boundaries of integrated transportation and clean air planning and explains how and why such measures work.

Ensuring National Emissions Standards Through Inspection and Maintenance

EPA points out that today's cars are up to 90 percent cleaner than their 1970 counterparts. However, older, poorly kept vehicles emit far more air pollution than do newer and properly maintained vehicles. Malfunctioning and poorly maintained vehicles produce excess emissions, sometimes as high as 17 times the pollution they were designed and certified to emit. To help control emissions from mobile sources in areas of high ozone pollution, the Clean Air Act Amendments of 1990 (CAAA) require inspection and maintenance (I&M) programs that involve periodic checks of a vehicle's emission control system and mandatory repairs of any malfunctioning system. EPA has established a model program rule to enable states to meet the minimum emission reduction requirements and performance standards required of I&M programs.

Of all the programs presented in this report, I&M has produced the greatest emissions reductions. I&M can reduce vehicle-related hydrocarbon and carbon monoxide emissions by up to 30 percent and nitrous oxide emissions by up to 10 percent. The total cost of this pollution reduction has been estimated at $500 to $1,000 per ton, making it also one of the most cost-effective pollution reduction methods presented here. Other approaches can cost 10 times as much.

On-board diagnostic (OBD) systems in newer cars help supplement the states' I&M programs. The OBD system assures proper emission control system operation for the vehicle's lifetime by monitoring emission-related components and systems for deterioration and malfunction. OBD can detect a system problem before the driver notices a driveability problem. Furthermore, OBD can detect problems that may not be noticeable upon visual inspection because many component failures that impact emissions can be electrical or even chemical in nature. By detecting these emission-related failures and alerting drivers to the potential need for repair, OBD systems make it possible for vehicles to be repaired before emissions become a problem. EPA requires OBD systems on light-duty vehicles and light-duty trucks beginning with the 1994 model year.

EPA allows a state to vary the design elements of a given model I&M program, as long as the program meets the minimum performance standard for CO, HC, and NO_x. States have the flexibility to vary the testing network (test-only or test-and-repair), the frequency of inspections, the types of vehicles tested, the type of testing equipment, the stringency of the test, and the use of repair waivers.[2]

Despite its cost effectiveness, I&M is not necessarily the first choice for air pollution control in all regions. Several areas, including the Detroit metropolitan area and Minnesota, used I&M for several years to attain air compliance and then discontinued the program without detriment to their air quality. Though I&M has advantages, it is not a panacea for a region's air quality concerns.

Table 1: I&M in the States

Types of I&M Programs Used by States		
Network Type	**Number of States/Areas**	**States**
Test-and-Repair Network	19	Alaska, California (basic I/M), Colorado, Idaho, Louisiana, Maine, Massachusetts, Nevada, New Hampshire, New Mexico, New York, North Carolina, Oklahoma, Pennsylvania, Rhode Island, Texas, Utah, Vermont, Virginia
Test-Only Network	17	Arizona, Colorado, Connecticut, Delaware, District of Columbia, Florida, Illinois, Indiana, Kentucky, Maryland, Missouri, Ohio, Oregon, Tennessee, Utah, Washington, Wisconsin
Hybrid Network	3	California (enhanced I/M), Georgia, New Jersey
Test Type		
IM240 Test	10	Arizona, Colorado, District of Columbia, Illinois, Indiana, Maryland, Missouri, Ohio, Utah, Wisconsin
Idle Test	15	Arizona, Colorado, Delaware, District of Columbia, Florida, Idaho, Indiana, Kentucky, Maryland, Missouri, New Jersey, New York, Ohio, Tennessee, Washington
2-Speed Idle Test	12	Alaska, California (basic I/M), Colorado, Georgia, Nevada, New Mexico, North Carolina, Oregon, Pennsylvania, Texas, Utah, Virginia
Accelerated Simulation Mode Test	9	California (enhanced I/M), Connecticut, Georgia, New Jersey, Ohio, Pennsylvania, Utah, Virginia, Washington
On-board Diagnostic Test	4	Colorado, Utah, Vermont, Wisconsin
Other Testing Procedures	8	Louisiana, Maine, Massachusetts, New Hampshire, New York, Oklahoma, Oregon, Rhode Island

**Data from EPA's Office of Transportation Air Quality, as of December 1999.*

I&M Implementation Problems

Two challenges are inherent in maintaining successful I&M testing programs. First, some vehicle owners fail to achieve the expected emissions reductions because they do not submit to testing or neglect to perform the required repairs. Tests cost between $10 and $50, and repairs average between $90 and $210. Second, some vehicle owners may tamper with emissions control systems after testing, therefore emitting at higher levels than they would from normal wear and tear.

States have responded to these difficulties with some innovative modifications to the federally mandated I&M program. Two states conduct on-road remote sensing to complement and verify the accuracy of station testing and to improve the convenience of I&M. Remote sensing can either detect high-emitting vehicles and single them out for repair or it can "clean screen" vehicles to exempt the cleanest cars from the inconvenience of station testing. Two states supplement their I&M programs by providing additional assistance to vehicle owners to obtain repairs for vehicles with excessive emissions.

Table 1 lists the various I&M programs in use in the states. Many states make use of this cost-effective pollution reduction tool but use a variety of implementation strategies. The flexibility of this program provides states with a wide range of options in the comprehensiveness of testing procedures, the organization of testing and repair facilities, and the use of new technologies such as remote sensing.

Improving Detection of High-emitting Vehicles

The Arizona Department of Environmental Quality (ADEQ) started an I&M program in 1976, and switched to an enhanced test in 1995. In recent years, focus has increased on catching high-emitting vehicles, with the chief concern being vehicles developing emissions problems between their required periodic inspections. Because of the continued high growth rate and consequent elevated VMT growth rate in Arizona's urban areas, ADEQ needed additional measures to keep emissions in check. In 1995 ADEQ began supplementing the station-testing program by conducting random remote sensing to identify potentially high-emitting vehicles. ADEQ assumed this new approach would capture about 60 percent of the total vehicle population for only a small percent of the cost of the station-testing program. Remote sensing is predicted to reduce carbon monoxide by 6.1 tons per day and VOC by 0.22 tons per day in metropolitan Phoenix alone.

Arizona's vehicle emissions testing program requires a biennial, high-technology test for the newest cars (model years 1981 and newer), and a simpler test annually for older vehicles (model years 1967–1980). Cars from the newest five model years are exempt because these vehicles were manufactured at a standard that usually gives them a very low failure rate. Arizona uses mobile units to conduct random on-road remote sensing. Vehicles identified as high emitters are required to undergo a station test and, if found to be malfunctioning, must be repaired. Thus, the remote testing serves as a check of the traditional inspection program. In addition to catching vehicles that become high emitters between their required station inspections, remote sensing eliminates some of the concern about the reproducibility of results from even the most modern station tests.

One shortcoming of remote screening is that it cannot test for evaporative hydrocarbon (HC) emissions, the unburned gasoline vapors that vent into the air along with combustion products. (Enhanced station I&M does test for these using a pressure test of a vehicle's gas cap.) Evaporative HC emissions can contribute as much as tailpipe HC emissions from some vehicles. Weather conditions, such as wind speed and precipitation, also greatly affect the accuracy of test results. Therefore, it is unlikely that remote sensing will ever completely replace station testing. However, it will continue to serve as a method to identify vehicles that have fallen into disrepair between required station tests. This includes vehicles with malfunctioning or tampered-with emissions controls systems and vehicles registered outside the areas where they do most driving.

Increasing the Convenience of I&M Programs in Missouri and Colorado

Regular inspection of vehicles can be a burden to motorists. Bringing a vehicle to a designated testing station is often inconvenient and time consuming, and more so when testing is centralized in a small number of facilities. Testing can also be frustratingly inconsistent; a vehicle may fail, submit to retesting, and pass the second time, despite the fact that no repairs were performed. Finding a suitable mechanic to perform necessary repairs is also an inconvenience, exacerbated in states with separate inspection and repair facilities.

The inconveniences make states reluctant to expand I&M programs. Some states have discontinued I&M upon achievement of their air quality goals. The Minnesota legislature voted in April 1999 to discontinue the state's I&M program after achieving compliance with national CO standards, citing the cost and inconvenience to motorists. According to the Minnesota Pollution Control Agency, public perception was that I&M was ineffective because 80 percent to 90 percent of the cars tested passed without needing repair. (However, the bulk of the emissions reduction comes from the other 10 percent to 20 percent of vehicles.) This decision is noteworthy since

I&M is one of the most cost-effective and significant methods for reducing mobile source pollution in a state. Negative public perception of I&M is a significant detriment to its effectiveness.

Missouri Screens to Exempt the Cleanest Cars From Station Tests

Missouri began a new I&M program in April 2000 in the St. Louis nonattainment area that will avoid some of the inconveniences by exempting motorists from station tests. Missouri will exempt about 20 percent of its fleet, using remote sensing clean screening. Another 20 percent of the fleet will be excused from testing due to exemptions for the two most recent model years and exemptions based on low-emitter profiling. Mandatory testing did not start until May 2000, so the results from this state's experiences are inconclusive.

The mobile sensor measures emissions and records the vehicle's license plate number as it drives by the sensor's location. Car owners receive a postcard in the mail once they pass two clean screens in a row. Motorists still have to pay the $24 inspection fee, but they can do so by mail and their car is exempted from that biennium's cycle of station testing.

Missouri will be the first state to combine a remote sensing-based clean-screening program with an enhanced vehicle emissions inspection program. Unlike Arizona's high-emitter remote sensing program, Missouri's program will exempt the cleanest cars from periodic station tests. Using a roadside detector to measure HC, CO, and NO_x, the state will excuse cars from the next scheduled station test if the car's emissions are below certain cutpoints. This clean-screening program eliminates the inconvenience of station tests. It will result in more cost-effective air quality improvements by testing only the vehicles that are not identified as clean by either remote sensing or low-emitter profiling.

Despite the improvements in motorist convenience, the use of remote sensing programs typically reduces the credit assigned to the program in the state's air quality plan, as some higher-emitting cars may be mistakenly identified as clean and exempted from a station test. In part, this is because of the inability to screen for evaporative HC emissions. It is difficult to estimate the amount of state implementation plan (SIP) credit reductions lost through clean screening because the loss of credits depends upon the age mix of vehicles on the road. EPA estimates that up to one-third of cars can be excused from emissions testing with remote sensing, with only a 5-percent to 10-percent loss in HC emission reduction credits. Therefore, clean screening is best used as a complement to a station-testing program, not as a testing program in itself.

Colorado Aims to Raise Customer Satisfaction Through an Emissions Repair Guide

Like Missouri, Colorado soon will be running a remote clean screening in an effort to make the Air Care Colorado program as customer friendly as possible. It is estimated that this program will exempt 35 percent of the cleanest cars from the next inspection cycle. The cost for the individual car owner is the same as the station test, but the clean screen is quicker and easier.

Clean screening is just one of several techniques used to make the I&M process more efficient. Another approach is to make the repair part of the process easier, and hence, more readily acceptable to car owners. Colorado hopes to achieve a more customer-friendly repair program to attain the most cost-effective repair standards. The state's Customer Assistance for Repair and Services program features the *Emissions Repair Guide*, a handbook listing repair technicians and repair effectiveness grades for each facility. This idea was initially received with some skepticism by the auto repair industry but has come to be seen as an important resource for consumers.

Colorado's customer service facilities also provide free evaluations and repair guidance to owners of 1982 and newer vehicles that have failed the test and been repaired more than once. The state estimates that in 1997, vehicles that failed an I&M test and were repaired averaged a 62-percent reduction in carbon monoxide emissions.

To complement the improved customer service aspects of Colorado's I&M program, the department of public health and environment reaches out to car repair technicians to achieve the best repair standards. For example, the department runs a "Dirty Dozen" program, wherein 12 particularly dirty vehicles are taken out of service and used to train mechanics in emissions systems. Diagnostics and repair procedures are then formulated using these vehicles.

Financial Guarantees for On-time Service in Colorado and Missouri

To improve customer convenience even further, both Colorado and Missouri use financial incentives to motivate their contractors to perform vehicle inspections efficiently. Colorado has implemented a policy of fining the I&M contractor for excessive customer wait time at the inspection facilities. In the first year of this rule, the contractor was fined $1.5 million, which was then used for the

Retrofit Success In Massachusetts

In the densely populated and frequently reconstructed Northeast, emissions of the approximately 200,000 construction vehicles account for 25 percent of mobile source PM and 8 percent of all NO_x pollution. Although heavy-duty diesel vehicles, such as buses and trucks, have been retrofitted with modern pollution control technology for years and with much success, this is only starting to be applied to the non-road construction sector. The Northeast States for Coordinated Air Use Management (NESCAUM) initiated a diesel vehicle retrofit program on 25 percent of off-road equipment used in the long-term, large-scale Central Artery/Tunnel (CA/T) project in Boston. This program will reduce CO emissions by 25 tons per year, HC emissions by 5 tons per year, and PM emissions by 3 tons per year. This is the equivalent of taking 1,300 diesel buses off the streets of Boston each year.

The considerable number of non-road construction vehicles represents an opportunity to achieve significant emissions reductions quickly and cost effectively. Because regulations for this emissions sector passed only in 1996, the vast majority of non-road construction equipment is not currently federally regulated or limited. A NESCAUM study found that non-road diesel vehicles emit as much air pollution in the Northeast as the entire fleet of on-road trucks and buses. Heavy-duty diesel construction equipment contributes about a quarter of mobile source particulate matter (PM) emissions and, absent new federal standards, would emit about 35 percent of all diesel PM by 2010.

To demonstrate the pollution control effectiveness of diesel engine retrofit technology, NESCAUM formed a partnership with the Massachusetts Turnpike Authority (which oversees the CA/T project), the Massachusetts Department of Environmental Protection, the Massachusetts Executive Office of Environmental Affairs, EPA Region 1, and the Manufacturers of Emissions Control Association. This partnership implemented the Clean Air Construction Initiative, which began in 1998 to retrofit 25 percent of the permanent heavy-duty construction equipment of the CA/T project with advanced pollution control devices. These are roughly the same technologies used to retrofit over 10,000 buses under the mandatory federal Urban Bus Retrofit/ Rebuild Program and used by engine manufacturers in over 1 million trucks to comply with emissions standards. This program represents the first time these control technologies have been used on a major construction project. The retrofitting involved purchasing and installing:

- oxidation catalysts, which cost about $2,000 apiece and reduce PM by 25 percent and CO and HC by up to 90 percent; and
- particulate filters, which cost about $9,000 apiece and reduce PM by up to 90 percent and, if combined with an oxidative coating, can further reduce HC and CO up to 90 percent.

An additional benefit is that these devices can reduce diesel air toxics emissions up to 70 percent.

This project will reduce total emissions by 198 tons over the six remaining years of the CA/T project. Although this public works project is of a larger scale than typical road construction projects (it has been likened to putting the Panama Canal underneath an urban area), the emissions benefits of this innovation are easily transferable to other locations. Although equipment may not be used in one specific location for as long as the CA/T project, retrofitting provides an air quality benefit that lasts for the lifetime of the vehicle, no matter where it is used. The participating agencies are continuing to work to expand this program, on a voluntary basis, to other large construction projects within Massachusetts.

Clean Fuel Fleets program. In the second year, efficiency at the inspection stations was improved to the extent that no fines were assessed.

Missouri is taking a slightly different approach. If motorists wait more than 30 minutes before their emissions test begins, the cost of the inspection is discounted by $10, so motorists are immediately compensated if there are long wait times. The fee reduction applies only to the contractor's portion of the $24 inspection fee, and does not reduce the state's share.

Slowing the Increase in Vehicle Miles Traveled

Reducing the number of miles driven will reduce mobile source pollution contributions. However, in this highly mobile and largely vehicle-dependent era, mandatory driving restrictions are not feasible. To slow VMT growth, citizens must be presented with alternatives to driving and an incentive to exercise these alternatives.

One approach many states take is to encourage less driving on days or times of high pollution, rather than seeking reductions in driving every day. States actively emphasize use of alternative travel modes on these days and may provide financial incentives to those who exercise them. States promote vehicle miles traveled (VMT) reduction either through mass advertising or to specific entities participating in a VMT reduction program. Some conduct outreach efforts on specifically selected "ozone action days," others attempt to lower VMT and ozone production during the entire summer. Methods to reduce vehicle miles traveled are often similar to the methods to reduce congestion, which are discussed in the next chapter.

This chapter looks at the various ways states control VMT through episodic emissions reduction programs, land-use and transportation planning strategies, and mass transit.

- In Georgia, public and private-sector organizations voluntarily participate in a program to reduce vehicle trips throughout the ozone season.
- In the Baltimore-Washington, D.C., area, a group called ENDZONE Partners encourages the general public to change pollution-causing behaviors on ozone risk days.
- In Maine, a passenger transportation plan provides integration of transportation modes to allow for car-free vacations.
- In Oregon, transportation and land-use planning are integrated, and transit is expanded to account for rising demand because of denser development.

Enlisting Public Agencies and the Private Sector to Reduce Seasonal Pollution in Georgia

In 1997, after failing for nearly two decades to meet ozone limits in the Atlanta metropolitan area, Governor Zell Miller started the Partnership for a Smog-Free Georgia (PSG)[3] by executive order. In an effort to reduce ozone levels and decrease the number of annual "smog alert days," the order requires state agencies to reduce the number of single-occupant vehicle commute trips by 20 percent. Private-sector employers also committed to making similar reductions. In the first year of the program, the Georgia Department of Transportation reported a 1.67-percent reduction in peak regional traffic volume on smog alert days. In the summer ozone season of 1999, the department found a 2-percent to 3-percent reduction in metropolitan area traffic volume, compared with the non-ozone season—a reduction of almost 500,000 highway miles per day.

A significant opportunity for voluntary emissions reductions exists in Atlanta because three-quarters of area air emissions are not covered by federal regulations. A large portion of these air emissions come from weekday peak-hour traffic; Atlanta motorists drive on average 35 miles each per day, more than the residents of any other metropolitan area in the

Episodic Programs and the Eight-hour Standard

In 1999 the Partnership for a Smog-free Georgia (PSG) began forecasting its smog alert days using EPA's new eight-hour ozone standard. The stringency of the new standard will bring more exceedances, and hence a need for more smog alert days. In 1999 PSG called 68 smog alert days and exceeded the eight-hour standard on 68 occasions (though not the same 68 days as forecasted).

It is unclear if and when this new proposed standard will be adopted nationally (see box *U.S. Court Rejects Ozone and PM Standards* in Appendix B), but it is evident from PSG's experience that a new strategy for episodic programs will be needed under the new standard. Many episodic programs rely on public reaction on a few ozone high-risk days of the year. Dramatically increasing high-risk days would probably decrease the amount of public response to any one of them. Although citizens may be willing to carpool for 5 days or 10 days of the summer, it is doubtful they would be as responsive to 50 or 60 such requests. For this reason, many states may see the benefit in choosing seasonal ozone response programs under an eight-hour ozone standard.

country. This significant mobile source pollution contribution, combined with the fact that approximately 400,000 Atlanta area residents fall into high-risk categories for respiratory problems on high-ozone days, makes clear the need for a program to reduce pollution on high-ozone days.

All state agencies, departments, and universities, whose combined employees account for a third of downtown Atlanta's workforce, have been members of PSG since 1998. They were required to develop and implement plans to reduce their single-occupancy vehicle (SOV) trips by 20 percent on smog alert days in 1998 and for the entire ozone season beginning in 1999. In addition, Governor Miller wrote to the top 100 businesses in the Atlanta area to specifically request their participation in the program. His letter stressed the restrictions and regulations that would be placed on highway construction and industry in Atlanta if pollution levels were not reduced. He emphasized the negative impact on the quality of life in the region because of these penalties.

The Georgia Environmental Protection Division (EPD) has found that employers prefer a seasonal approach. It is more fruitful to encourage behavior-changing activities (such as teleworking, carpooling, or riding transit) over a period of several months than on only a few specific days. Attempting to change behavior for a certain day and on very short notice was often difficult, as employees are not always able to respond quickly enough to make the necessary arrangements. The seasonal approach to VMT reduction has resulted in a 2-percent to 3-percent reduction in metropolitan area traffic volume and a 33-percent reduction in single-occupancy vehicles over the entire ozone season. An unexpected benefit of the seasonal approach is that employers found several of the ride-reducing practices were so popular with employees that these were continued even into the non-ozone season.

The Georgia EPD suggests activities and provides information for the formation of the emission reduction plans for all program participants. VMT reduction techniques include transit incentives, vanpool subsidies, ridematching, telecommuting, alternative or flexible work schedules, and bicycling. Other suggested personal activities are refueling vehicles after sundown and decreasing use of non-road vehicles, such as small-engine or heavy-duty equipment. Georgia's program is funded through the Congestion Mitigation and Air Quality Improvement Program (CMAQ), state general funds, and in-kind contributions from EPD and participating agencies in the PSG program.

The Georgia EPD considers the first complete season of the program a success. Employers are asked to monitor the success of their plans and report results to PSG. After the first year of public education, awareness of air quality as a priority environmental problem increased 18 percent. The most positive result of the program was that drivers changed their behavior during the 1998 ozone season, as corroborated by Georgia DOT traffic counts. Moreover, although 35 smog alert days were forecast, the one-hour ozone standard was exceeded only 22 times. This implies that, at best, PSG helped avert 13 ozone standard exceedances. The decrease in peak-hour and total summer traffic levels contributed to the reduction in ozone formation. Appeals to the public for general air quality improvements, as well as specific smog alert day action, were received and acted upon.

Predicting and Publicizing High Ozone Days: Baltimore-Washington's ENDZONE

ENDZONE Partners began in 1994 as a volunteer, nonprofit, public-private organization in response to respiratory health concerns related to ground-level ozone pollution. In 1997 the Metropolitan Washington Council of Governments and the Baltimore Metropolitan Council chartered ENDZONE as a formal organization. ENDZONE Partners is a group of 51 government agencies, businesses, and health and environmental interest groups from across the Baltimore-Washington, D.C., region. ENDZONE forecasts high ozone days, encourages its 260 ozone action day (OAD) participating organizations to take voluntary action to reduce ozone levels, and coordinates media coverage and outreach to the public. Through this combined forecasting and public education campaign, ENDZONE can reduce as much as 20 tons of ozone precursor emissions per action day, according to projections in an EPA-sponsored study. There are usually between 8 and 12 action days per summer.

Forecasting Ozone Alert Days

Days of high ozone risk must be forecast in advance and communicated to the public for them to change their driving behavior. Virginia and Maryland meteorologists forecast the next day's ozone levels during the ozone season (May through September). Based on these predictions, the Maryland Department of the Environment (MDE) and the Metropolitan Washington Council of Governments assign an ozone alert level.[4] If ozone levels are high enough, they designate an OAD.[5] ENDZONE Partners' spending on forecasting OADs is about $480,000, or more than 45 percent of the total budget.

Communicating the Alert

ENDZONE communicates an OAD through evening newscasts, weather reports, and television advertisements. In the summer of 1998, a local weather forecaster was featured in a series of television spots urging viewers to take voluntary actions to reduce pollution. Weather and news commentators announced code-red alerts and made suggestions for voluntary behavior changes, based on information from ENDZONE Partners. In 1999 ENDZONE tapped into the radio market to announce OADs. A weekly radio program during the ozone season provided a forum for discussion of ozone health effects and ozone prevention.

The 260 participants of ENDZONE Partners' OAD program agreed to inform their employees of OADs and to suggest appropriate measures, such as ridesharing, transit use, and refueling after dark. Some members provide unique services to reduce emissions on OADs, such as free bus rides on code-red days. Four counties in Maryland and Northern Virginia report ridership increases of 1 percent to 3 percent on these days.

According to ENDZONE surveys, about 90 percent of the public sees air quality as a top environmental problem. In a 1998 survey on OADs, 70 percent of the population had heard about the ozone alert from television, and 20 percent from the radio. This combination of media was the most cost-effective way to raise public awareness about OADs in the region.

To educate the public about ozone, ENDZONE Partners produced and aired a number of television and radio public service announcements during the peak weeks of the ozone season. Total spending on public education accounted for about 20 percent of ENDZONE's 1998 budget, or about $200,000.

Taking Action

Once the public is informed about high ozone days, they need information about what they can do to help solve the problem. The potential for behavior changes to reduce ozone formation is significant, if the information about preventative actions is communicated effectively. Surveys indicate that 90 percent of individuals would be willing to take action, and about 70 percent of people named driving as a source of air pollution. However, at least 15 percent of individuals thought that they did nothing to contribute to air pollution, indicating a large audience for public education. A survey conducted immediately following an OAD found that a large number of people heard about the alert, about half of whom heard of what actions they could take, and about 20 percent voluntarily took some action.

The largest reductions from voluntary actions are expected in vehicle driving and refueling, since these are the source of 60 percent of the total NO_x and VOC in the area.[6] ENDZONE suggests modifying behavior by carpooling, taking transit, refueling after dark, combining errands into one trip, and cutting down on excess idling. These choices reflect areas where the potential to modify behavior and reduce emissions is largest and the desired behavior change is clear.

Portland Integrates Transportation and Land-Use Planning

Portland has adopted a smart growth plan to slow uncontrolled urban growth and reduce congestion and the resultant emissions from vehicles. The Metro 2040 Growth Concept was adopted in 1994, and it clearly establishes the long-term planning goals for the region. Its philosophy is to preserve access to nature while building better communities. A multimodal transportation system that assures the mobility of people and goods throughout the region is an important part of the idea. The concept's realization in policy, the Urban Growth Management Functional Plan, seeks to coordinate this transportation system with local land use to create a compact urban design and reduce sprawl.

As cities grow outward, new suburban communities quickly build new roads to meet the area's transportation needs, but transit systems are often slow to follow. Thus, the movement of people within and among the outlying areas is primarily via single- or low-occupancy vehicles. Encouraging development in preexisting urban areas helps reduce roadway congestion as transit becomes an increasingly viable means of transportation. A general rule of thumb is that per capita vehicle miles traveled are reduced by 25 percent to 30 percent when density is doubled. This is due to increased alternative transportation means and decreased automobile use. Additionally, concentrated, mixed-use development makes longer car trips less necessary.

Portland's metropolitan planning organization (MPO), the Portland Metro Council, has the authority to shape development in this way because, unlike other MPOs, it has legal authority over local government land-use planning. Several concept mechanisms guide development within the region. The first of these is the urban growth boundary (UGB), which is a limit on development that forces creation of higher density areas. Within the UGB, three mechanisms steer development in the urban area.

- There are required densities for each of several land-use categories. For example, the station community is a node of dense development focused near a significant transit hub.
- Regional parking policy restricts the construction of new parking spaces. This encourages more efficient use of land, promotes non-auto trips, and protects air quality.
- Development of retail areas in industrial and high-employment areas. Again, this type of mixed-use development diminishes the need for automobile travel.

Oregon has included these strategic measures in the ozone maintenance plan, but has not yet quantified emissions reductions from them. Portland is in the maintenance level of attainment, and no further reductions are necessary at this time.

EPA has issued draft guidance that identifies the specific ways land-use policies and projects could be accounted for in the air quality and transportation planning processes. The guidance, when finalized, will give states and communities methods to quantify air quality benefits and account for these benefits in the state implementation plan (SIP) or in the conformity process.

Portland Expands Transit Service to Meet Demand

Improvement of the transit system helps reduce congestion by providing alternatives to automobiles. This can involve the expansion and improvement of the underlying transit system infrastructure as well as upgrading the range of services. Transit agencies have responded to increased demand using higher technology and other creative, but low-technology approaches. Transit planners seeking to increase ridership must overcome two hurdles: the slower speed of mass transit relative to personal automobiles and the impaired flexibility in fixed-route transit. Transit authorities have responded to this with restructured service and advanced technology.

Portland's Growth Concept directs the area's regional transportation plan to expand transit service to meet the anticipated non-automobile transportation needs of the growing population. Oregon's population is expected to grow 30 percent by 2020; VMT is expected to increase by 38 percent in the same time period. The regional transportation plan calls for additional infrastructure, increased service, and an increasingly multimodal transportation system. The plan will accommodate 500,000 riders every weekday by 2020, as compared to 186,000 riders served at present.

Transit service will be expanded in a number of ways.

- Transit service hours will increase by an average of 1.5 percent annually.
- Light rail will be expanded to provide high-speed, high-capacity transit between the central city and the regional centers.
- Bus service will be designed so heavily traveled routes are served by frequent buses with minimum stops. Passenger amenities will be improved to add to passenger comfort.
- All newly constructed or redeveloped corridors will provide a broader range of travel options, such as bicycle and pedestrian networks.

These transit improvements will help encourage ridership and provide viable alternative modes of travel as the roads grow more congested in coming years. Making the improvements now helps provide a solution to a situation before it becomes a major problem.

Maine's Strategic Passenger Transportation Plan Links Urban Areas to Rural Tourist Destinations

In a slightly different approach to transportation planning, Maine developed a transportation plan that, among other goals, aims to improve air quality by expanding transit systems and facilitating interconnectedness among various transit modes. These steps are taken to enable car-free vacations in Maine—a state where tourism is a cornerstone of the economy. The Maine DOT is using CMAQ funds to accomplish these goals, and it must furnish emission reduction estimates at the end of each fiscal year. In fiscal 1997 (the most recent for which data are available) the plan reduced VOC emissions by 198 tpy and NO_x by 170 tpy.

Facilitating use of transit and encouraging more efficient transportation are not unique to urban centers. Rural states face their own challenges to moving people and goods in a way that will reduce auto emissions. Maine's plan is to create an integrated, multimodal passenger transportation capacity that supports tourism. Through this plan, Maine hopes to strengthen its already well-developed alternative transportation system. The plan will:

- develop hubs in urban areas supporting air, rail, marine, and highway interconnections;
- extend AMTRAK and private rail service throughout the state;
- expand existing high-speed ferry service and develop a water taxi service; and
- expand the network of bike/pedestrian trails spanning all areas of the state.

Funding for this plan has come from private and public sources. Annual CMAQ funds of $4.5 million and transportation enhancement funds of $2.9 million have stimulated capital investment in various projects.

Mitigating Congestion

State transportation officials and metropolitan planning organizations can prevent some mobile source pollution by reducing congestion-related emissions. Large-scale planning decisions improve traffic flow and hence reduce the amount of time motorists idle in traffic. This will alleviate some emissions, as it will cut down on total releases, especially VOC. Vehicle emissions of VOC and CO are as much as 250 percent higher under congested conditions than in free-flowing traffic. However, as vehicle speeds exceed about 50 mph, CO levels and NO_x emissions begin to increase. Thus, there is an upper limit to traffic flow improving air quality. Still, congestion mitigation is an important component of the emissions reduction toolbox.

As mentioned earlier, congestion mitigation and VMT reduction strategies often employ the same tools to achieve different goals. Common techniques include carpooling and vanpooling, transit use, bike/pedestrian programs, and land-use planning. Congestion mitigation tends to focus on high travel times of the day, whereas VMT reduction strategies aim to change overall driving habits on certain days or during certain seasons. Though the tools are the same, the way they are implemented determines whether they have the desired effect.

States have employed a variety of approaches to reduce chronic regional congestion.

- In California, a congestion-sensitive toll pricing system that charges commuters more during peak commuting hours was established on a heavily traveled highway in Los Angeles.
- In Arizona, an integrated intelligent transportation system was built to alleviate congestion in the Phoenix area using mainly existing transportation technology infrastructure.
- In Illinois, transit-oriented intelligent transportation technologies were employed to move people more efficiently on existing transit systems.
- In Utah, citizens are encouraged to decrease driving to prevent congestion during a four-year construction project.
- In Baltimore, new homebuyers are offered incentives to live near their work, and transit hubs are refurbished to reduce the need to commute.
- In Chicago, a vanpool program meets the needs of the underserved suburban commuter market and reduces use of single-occupancy vehicles.

In California, Time is Money: Using the Market To Alleviate Highway Traffic Congestion

The Los Angeles metropolitan area has a serious traffic congestion problem. L.A. commuters experience 2.4 million hours of delay every business day (about 65 hours per driver annually) and waste almost 660 million gallons of fuel stuck in traffic each year. In 1995 two-thirds of L.A.'s rush hour traffic was congested. The Los Angeles area has very high levels of ozone pollution. Although this air pollution problem is partly due to other factors (such as topography, climate, and stationary sources), mobile sources contribute significantly to the inferior air quality in this car-dependent, congested, and rapidly growing urban area.

As a partial solution to this problem, four new lanes were added to California State Route 91 (SR-91), a major commuter route within one of the most heavily congested corridors in California. The new lanes use a dynamic pricing mechanism that charges commuters more during peak hours of congestion and offers incentives to drivers of high-occupancy vehicles. A year after the express lanes opened, the afternoon rush hour delay had decreased from 30-40 minutes to about 13 minutes. This could bring at most a 2-percent decrease in NO_x, a 7-percent decrease in VOC, and a 3-percent decrease in PM_{10}, for a total emissions reduction of at most 12 percent. However, this project is too new to conclusively demonstrate positive results. It should be noted that this type of project could add capacity and demand, therefore increasing pollution.

The California Department of Transportation (Caltrans) worked in partnership with the California Private Transportation Company (CPTC) to add the capacity to SR-91. CPTC designed, constructed and operates the facility. Caltrans helped fund a monitoring and evaluation study of the project to determine its applicability to other roadways in the state and throughout the U.S.

Construction of the highway was funded by CPTC. Costs are being recouped with the tolls, which range from 60 cents to $3.75, depending on the traffic level. High-occupancy vehicles pay a reduced fee. By the third month of operation, the company could completely cover its operating costs using the toll income, and it expects to cover operating costs and debt service by the end of the third year of operation. The lanes generated $12.7 million in revenue in 1997, offsetting that year's $9.1 million operating costs and chipping away at the $133 million in capital costs.

An obvious benefit of the added capacity is reduced commuting time. The average commute delay has decreased by more than half. Moreover, the number of people in vehicles has increased: Caltrans reports a 40-percent increase in rush hour HOV use since the toll lanes opened. The reduction in congestion and decrease in single-occupancy vehicles will produce benefits for air quality—as long as the reduction in congestion does not draw

What does the public think?

Los Angeles commuters have gradually warmed to the concept of for-profit congestion-based pricing. The High Occupancy Toll (HOT) lane project is seen positively by:

- 65 percent of express lane customers,
- 62 percent of HOV users who do not pay tolls, and
- 53 percent of drivers in the adjacent, non-tolled lanes.

Initial controversy . . . .

Although 80 percent of commuters favored toll-financed lane capacity additions, the idea of varying tolls based on congestion severity took longer to catch on. Another somewhat contentious issue is the for-profit nature of the road. There remain two strong schools of thought on the issue: those in favor cite the private sector's efficiency at providing services; those opposed believe the government should provide for infrastructure and that for-profit highways are unfair to lower income travelers.

Response . . . .

In response to initial negative reactions, CPTC undertook a public education and marketing strategy. Part of the strategy offered a discounted toll rate to frequent users. Surveys found that commuters in higher income groups were twice as likely to be regular toll lane users as lower income groups, reflecting the general demographics of the highway users. Commuters in lower income groups were no more likely to switch to higher occupancy vehicles to cut their toll costs. This implied that the toll did not present a significant economic barrier to HOT lane use.

more drivers to the now more efficient highway. This behavior is known as "induced VMT." This oft-debated effect of added capacity on driver behavior may offset gains from adding lane miles.

Since the HOT lane opened, total miles driven on the highway has increased, due in part to the increase in lane capacity. Not enough data exist on the long-term VMT increase on the highway to determine how much of this growth is from population growth and how much is from induced demand. The faster road has not induced significant demand because bus/rail ridership on routes competitive with the highway were unaffected and the vehicle traffic on alternative street routes did not increase.

Arizona's Road-based Intelligent Transportation Systems Smooth Traffic Flow

Intelligent transportation systems (ITS) alleviate congestion by using technology to move the maximum number of travelers in the shortest time possible. Road-based ITS use various technologies to minimize unnecessary slowing or stopping of vehicles. It decreases roadway congestion and eliminates unnecessary vehicle stops. This reduces some emissions, as engines run more efficiently at steady, moderately high speeds than at variable or low speeds. Transit-based ITS make the transit system more user-friendly and efficient. Increasing mass transit convenience and efficiency will encourage more travelers to use non-automobile travel, which will reduce emissions.

However, ITS technologies have mixed effects on air quality, depending on the technology employed. The additional roadway carrying capacity from VMT reduction, congestion mitigation and higher roadway speeds would induce an amount of highway traffic to the less crowded roadways, which may again offset air quality gains. Traffic moves more smoothly because of ITS, but because cars emit more pollution at their highest speeds (above 55 mph), gains from congestion reduction may be offset. ITS is not a technological cure for mobile source pollution. The emissions benefits of ITS programs can vary considerably depending on the system's components.

Individual components of ITS can have either positive or negative emissions impacts. Technological components must be combined to create the best system for a region's specific air quality and transportation needs. The key to the development of successful ITS is the linking of existing and new technological infrastructure into a coherent transportation support system. Studies of integrated ITS program areas find that a comprehensive program involving transit- and road-based components will not only reduce emissions, but also save money by reducing traffic delay and increase highway safety.

Arizona currently has 10 nonattainment areas, and the state will have to deal with future air quality impacts from continued growth. From 1995–2025, Arizona's total population is expected to increase by 2.2 million people, a 50-percent increase in total population. Mobile sources already account for 60 percent of ozone precursor pollutants, so this population increase will doubtless bring a significant number of new vehicles and the consequent air pollution.

To relieve current congestion levels and to plan for further VMT growth, the Arizona Department of Transportation (ADOT) developed an integrated ITS called AZTech for the Phoenix metropolitan area, the nation's fastest growing city of its size. The emissions benefits of this initiative are difficult to quantify, especially as regional VMT is constantly increasing because of the area's rapid population growth.

AZTech's objective is to integrate existing ITS infrastructure into a regional transportation management system. When completed, AZTech will serve a little over half the state's total population. The cost of this system was rather small. About $250 million in infrastructure was already in place, so an additional $7.5 million in federal funds, $3.5 million in private funds, and $4.6 million in state funds were all that was needed. The project will take seven years (two years of implementation and five years of operation). It will include:

- traveler information services through roadway message signs and kiosks;

- coordinated traffic signals across traditional jurisdictional boundaries to facilitate traffic flow along the length of an arterial;
- quick response to freeway accidents through detection of incidents, information dissemination to motorists, and routing of emergency vehicles to the scene;
- transit information systems; and
- commercial vehicle operations.

AZTech was created under a federal program to encourage state-of-the-art transportation systems across the nation. A significant portion of the freeway management system infrastructure (such as message signs, in-road sensors, and closed-circuit cameras) was already in place, so ADOT constructed an integrated ITS with relatively little capital investment. The program was developed and implemented by a wide-reaching public-private partnership among ADOT, city government, and the private sector. Private industries operate under contract with ADOT for the duration of the project.

The major tasks of the initiative were to link existing infrastructure to a cohesive network and then expand the network. The main benefit of ITS comes from information exchange. In this instance the traffic data gathering equipment was largely in place so it took only modest investment to integrate this equipment and data into a cohesive system. Costs stemmed largely from the planning and coordination involved with linking the infrastructure, not from the infrastructure itself. When completed, the system will serve more than half of the state's population. This widespread benefit will come with relatively little draw on state funds. However, the specific air quality gains of this system are difficult to discern.

Costs of ITS versus Costs of Building Roads

- To keep pace with VMT growth over the next 10 years, the U.S. Department of Transportation estimates that 34 percent more highway capacity is needed, at a cost of about $150 billion. Building an ITS infrastructure from scratch would cost $10 billion and provide 67 percent of this required new capacity.
- For the same cost as about eight miles of urban freeway construction, a metropolitan area the size of Washington, D.C., could design and completely build an ITS infrastructure.

Chicago's Transit-based ITS Increases Efficiency and Passenger Satisfaction

Traffic congestion in the Chicago region is the third worst in the nation. If it could build itself out of this congestion, the Chicago area would have to add 271 lane miles to the roadway system each year. Congestion is particularly problematic in the suburbs, where transit coverage is not as extensive as in denser urban centers. In some parts of the northwest suburban region, roadway capacity is exceeded by demand partially because transit accounts for less than 10 percent of commuter trips. Rush hour congestion is so severe that bus service is slowed significantly. Subsequently, few commuters have been willing to make the switch from automobiles and transit ridership has stayed low. In response to this, suburban Chicago's Pace has implemented several features of transit-based ITS to its bus fleet.

In developing ITS for its bus fleet, Pace wanted to increase bus ridership by decreasing passenger travel time and improving passenger convenience. It determined that reduced travel time was more important to customers than extending the range of transit service. As a result of ITS strategies, Pace increased its passengers for the third straight year in 1998. There are three main components to Pace's transit-based ITS strategy.

- Transit vehicle signal priority. Some Pace buses are equipped with devices to alert traffic signals to turn green as they approach. Preliminary studies show a 33-percent decrease in travel times without congesting cross streets. Other transit systems have found this technology reduces bus travel times by 5 percent to 10 percent, depending on the number intersections and the amount of traffic load. This public-private venture is being closely watched by local officials to determine its applicability to dense urban areas.

- Advanced bus communications and automatic vehicle locators (AVLs). A number of Pace buses allow drivers to communicate with the garage and with other drivers on the road using both data and voice transmissions. The AVL allows a driver to look at an on-board screen and see if his or her vehicle is on time and following the right route. This helps drivers adhere to schedules and routes, greatly improving dependability and system interconnectedness. Subsequently, increased customer satisfaction results in increased ridership.
- Advanced traveler information. These systems communicate information about schedules using overhead signs and interactive kiosks at transit centers. This information improves customer satisfaction because it allows riders to plan their travel with greater precision. Data are not available yet for Pace's system, but similar services in Baltimore and Milwaukee report 25-percent improvements in on-time service.

Utah Encourages Citizens to "Skip a Trip" and Prevent Congestion During Construction

Voluntary driving reductions represent a proactive approach to reducing congestion. Similar strategies to those discussed in the previous chapter can be used to alleviate congestion. The programs are often targeted for a specific time period, such as during a significant highway construction project. This approach has high public acceptance because actions are voluntary. However, emissions benefits of voluntary programs are very difficult to quantify as there is often no way to accurately count participants.

The 4-year reconstruction of 17 miles of Interstate 15, a main highway through the Salt Lake City urban area, presented increased congestion and emissions. In response to this temporary elevated congestion level, Governor Michael O. Leavitt initiated a voluntary VMT reduction program called Skip a Trip. This program encourages citizens and businesses to reduce trips in any of a number of suggested ways. It was kicked off by a month of encouraging focused trip reduction. The month-long intensive program will be repeated yearly during the construction project to remind citizens to reduce congestion and the related emissions. In October 1998, commuters made approximately 10,000 fewer round trips than during a normal commuting month.

The Skip a Trip campaign advocates a variety of trip reduction strategies. Through the Utah Transit Authority (UTA), a variety of incentives and means of technical assistance is provided for the campaign.

- The Skip a Trip campaign places much emphasis on pooled commuting.
  - UTA offers no-interest loans for van purchases—a savings of $3,500 to $5,000 in interest—plus yearly savings on gas, insurance, maintenance, and parking costs. This program increased the number of van loans by 80 percent in its first year.
  - UTA leases vans for those not interested in purchase. UTA provides the insurance, back-up vehicles in the event of breakdown, and it allows for personal use of the vehicle. In 1998 this program increased the number of leased vans by 100 percent.
  - UTA offers an online match list service for vanpools. Interested commuters submit an online form and UTA provides a list of commuters with similar travel requirements.
- UTA offers technical assistance to employers to set up programs for compressed work weeks, flexible work hours, and telecommuting.
- UTA helps facilitate biking/walking to work by providing bike racks on buses.
- Employers can sponsor the purchase of Eco-Passes for their employees, which provide unlimited public transportation. This program comes with a guaranteed ride-home program so commuters can get home in emergency or unexpected situations.

The Skip a Trip campaign is part of Utah's broader trip reduction program. Utah also has a mandatory statewide VMT reduction program for some employers. Unlike trip reduction regulations in other states that are based on company size, Utah's regulation applies to companies only in counties with elevated congestion levels. This program works with the voluntary VMT reduction program to maximize public involvement.

Maryland Refurbishes Transit Stations to Encourage Ridership

Encouraging a dense, mixed-use development means more destinations can be reached by traveling shorter distances. Trip chaining, the combination of several trips into one, is much easier when the destinations are close together. When mixed-use development is located near a transit center, the need for automobile travel is reduced. Thus it follows that encouraging transit-oriented development decreases vehicles on the road.

Maryland's Transit Station Smart Growth program—part of the state's overarching Smart Growth plan, encourages economic development near transit hubs and increases ridership by providing safer, more attractive stations. The current program provides grants to cities or municipalities for redevelopment in areas near transit stations. Typical grants range from $50,000 to $300,000, and they are used for improvements such as better sidewalks, lighting, signage, parking and furniture. The program has been well received and oversubscribed—with $16 million in requests for about $5 million in state funding. The Maryland Department of Transportation offers some technical assistance to those areas denied funding. Governor Parris N. Glendening hopes to double daily transit trips by 2020, and Maryland DOT already reports some modest ridership gains due to this program.

Chicago's Vanpools Bring Transit to the Suburbs

As discussed above, Chicago's suburban area lacks a transit system sufficient for its needs. The Pace vanpool program was started in order to meet the needs of the underserved suburban commuter market in a way that decreased air emissions. It also helps stave off further transit ridership losses and the resultant detrimental effect on air quality. Creating a flexible transit option helped fit the unique transportation needs of the suburban rider and prevented further VMT growth.

Pace's Vanpool Incentive Program's (VIP) primary niche is longer duration (over 30 minutes) inter-suburb travel in the low-density area surrounding Chicago. This does not compete with other transit providers in the region that offer service from the suburbs to the city or shorter distances within the suburban area. The program's flexibility allows it to continue to meet the needs of the suburban area as it grows. When it started in 1991, the program had only two vans; it now has over 300. There is little fiscal constraint on the continued growth of the program because Pace recovers nearly all of the costs of the program from fares.

The promising growth of the VIP has encouraged officials to expand the program in hopes of achieving further air quality improvements. Though transit only accounts for a small percentage of total daily trips, if there was no transit system VMT would be 12.7 million miles per day higher and daily NO_x emissions would be 40 tons greater. Preventing VMT growth is a primary objective of regional air quality plans, so the VIP program has been included as a transportation control measure (TCM) in the SIP. Vanpools take riders through many congested corridors not served by other transit. They do not compete with other transit, but open a new market of passengers—82 percent of whom report they would otherwise drive single-occupancy vehicles.

VIP is a public transit program with several unique features.

- Routes are designed using geographic information systems, and any changes must be officially approved by Pace. This ensures optimal routing of vehicles, which helps control costs and keeps fares low.
- The driver does not collect fares from passengers. Individuals are billed monthly.

This reinforces that VIP is a transit program and not a private arrangement or employee benefit.

- Drivers use fleet gas cards to eliminate out-of-pocket expenses. This makes it easier to monitor expenses and eliminates some responsibilities and inconveniences facing drivers in conventional vanpools.
- Vanpool fares are zonal, calculated based on the total distance traveled for each individual passenger compared to the flat fee in conventional vanpools.
- The VIP program makes travel easier on other modes of transit in the region. Riders can obtain a card allowing them to use all suburban buses at no extra charge. For an additional charge, commuters can purchase a pass for all suburban and city routes.

Pace has found the most successful vanpools are those in which vanpool planning agencies take an active interest in forming pools and integrating them into existing transit routes and fare systems.

Emissions reductions from the program constituted 26 tpy in 1996, according to an analysis by Michael Baker Jr., Inc., a transportation and engineering consulting firm. Since then, vanpools have increased by about 50 per year. The approximate cost-effectiveness of this reduction is $7,000 per ton and is dependent only on the cost of the vehicles, since operating costs are covered by fares.

Encouraging Purchase of Alternative Fuel Vehicles

Alternative fuel vehicles (AFVs) may emit fewer of the six federally regulated criteria pollutants and may cost less to operate per mile than do conventional fuel vehicles. Incorporating AFVs into a state's vehicle population will immediately lower emissions upon purchase.[7] Alternative fuels include compressed natural gas, liquified petroleum gas (propane), electricity, methanol, and ethanol. AFVs are a natural choice for public and private fleet owners who are required to reduce emissions but constrained by an inability to significantly reduce vehicle miles traveled (VMT) or change travel times to avoid congestion.

However, one problem for AFV fleet owners is that the vehicle purchase cost tends to be higher. The refueling infrastructure also is often inadequate. As a General Accounting Office report states, "The economic disadvantages of alterative fuel vehicles relative to conventional fuel are substantial." Thus many states have begun to offer grants, buydowns (incentives offered to vehicle distributors instead of consumers), tax incentives, and low-interest loans to fleet owners and individuals for the purchase of vehicles or the necessary infrastructure.

States offer several types of incentives for the purchase of original equipment manufacturer (OEM) AFVs or for the after-market conversion of vehicles to run on alternative fuels. These incentive strategies include:

- grants and rebates—the state offers a cash incentive directly to the vehicle purchaser and offers grants to municipalities for regionwide programs to promote alternative fuel use;
- loans—the state offers low- or no-interest loans to the vehicle purchaser; and
- buydowns—the state offers cash incentives to the vehicle seller.

Each of these incentives helps offset the higher sticker price of AFVs, and they are targeted mainly toward fleet owners, including municipalities, state agencies, and private businesses.

States can combine these three strategies to create a program suited to an area's needs and opportunities.

- Oklahoma offers low- or no-interest loans to fund vehicle purchase/conversion and infrastructure development.
- New York City offers incentives to taxi drivers to buy alternative fuel vehicles.
- Arizona offers grants and tax credits to build refueling stations.

Oklahoma Finances Autos and Infrastructure with Low- or No- Interest Loans

It is likely that Tulsa and Oklahoma City will go out of ozone attainment by 2000; both areas exceeded the NAAQS four times in 1998. If these urban areas move into serious ozone nonattainment and are required by the CAA to institute the Clean Fueled Fleet Program (CFFP), the state anticipates a significant economic burden. (See Appendix B for details on the Clean Air Act.) This would

Grants and Rebates for Fleet AFV Purchase

AFVs can cost several thousand dollars more than conventional vehicles, so states offer incentives for vehicle purchase and alternative fuel use. Vehicle grants are often geared towards fleet owners who purchase many vehicles and thus have a greater cumulative emissions impact. AFVs make good fleet vehicles because the vehicles can refuel at one central fleet-owned station—an important consideration given the scarcity of alternative refueling sites. Grants can often be used for either new AFV purchase or for gasoline vehicle conversion. The grants range from $400 to $1,000, and may include matching funds by various public-private partnerships.

Table 2 compares the cost, fuel economy and emissions class for variously fueled light-duty pickup trucks, which represent about a quarter of total AFV sales. This comparison shows that LPG, ethanol, and compressed natural gas (CNG) pickups cost approximately $8,000 more than a conventionally fueled truck, and electric vehicles cost almost $16,000 more. These figures demonstrate why comprehensive state AFV incentive programs can be helpful to initiate widespread AFV use.

Table 2: Comparison of Available AFV Types

Fuel Type	Model	Sticker Price	City/Highway Fuel Economy	Emissions Class
Gasoline	Ford Ranger FFV '99	$12,500	17/22 mpg	
Electric	Ford Ranger EV '98 (Lead acid battery)	$27,995	.38/.44 kilowatt-hr/mile	ZEV
LPG (bifuel)	Ford F-150 '99	$20,130	14/18 mpgge*	LEV
Ethanol (flexible fuel)	Ford Ranger FFV '99	$20,490	12/16 mpgge	TBD
CNG	Ford F-250 '99	$20,230	11/15 mpgge	ULEV and ILEV (CA-SULEV)
CNG (bifuel)	Ford F-150 '98	$20,490	11/15 mpgge	TBD

** mpgge = miles per gasoline gallon equivalent*

require fleets to purchase additional AFVs, and the need to develop infrastructure to support these fleets would cause a financial burden the state hopes to spread over more years than the CFFP schedule allows. Oklahoma's legislature hopes early introduction of fleets and supporting infrastructure will ease the transition to the requirements of the CFFP. This program helps support the state's alternative fuel production industry; Oklahoma is the second largest producer of compressed natural gas and propane in the nation.

The Oklahoma Alternative Fuel Program, offered through the state department of central services, provides a revolving fund for no-interest loans to governmental entities for vehicle conversion or infrastructure installation. From its inception in 1993 until 1999, the program loaned $1.6 million to 12 entities, facilitating the purchase/conversion of 370 vehicles and the construction of 9 fueling stations. Assuming these are light-duty vehicles consuming the national average of 500 gge of liquefied petroleum gas (LPG) per year, this would save 185,000 gallons of gasoline per year, or roughly 0.6 tons/year in NMOC emissions, 5.61 tons/year in CO emissions, and 1.1 tons/year in NO_x emissions.[8] In addition, natural gas vehicles have almost no evaporative emissions, which make up half of a conventional vehicle's HC emissions. This means 370 LPG vehicles would save an additional 1,100 kg of HC emissions per year from evaporative emissions.[9]

Loans can be up to $5,000 for vehicle purchase/conversion and up to $100,000 for fueling station construction. Loan payments are made from the price difference between gasoline and the alternative fuel, which may cost up to 70 percent less than gasoline. So far the program has received over $1.1 million in payments back to the fund. In addition to the no-interest loans to governmental agencies, Oklahoma's Department of Commerce offers

Emissions from AFVs

Total emissions from alternative fuel vehicles are lower than those from gasoline or diesel fuel vehicles. Their emissions are dependent on the type of fuel selected and the make and emissions class of the vehicle. Emissions from various alternative fuels as compared to gasoline are depicted in Table 3 below. In nearly every category these are lower than gasoline. Notable exceptions are volatile organic carbons from LPG and CNG vehicles due to fuel evaporation and SO_x and PM from emissions of electric power plants that supply the vehicles.

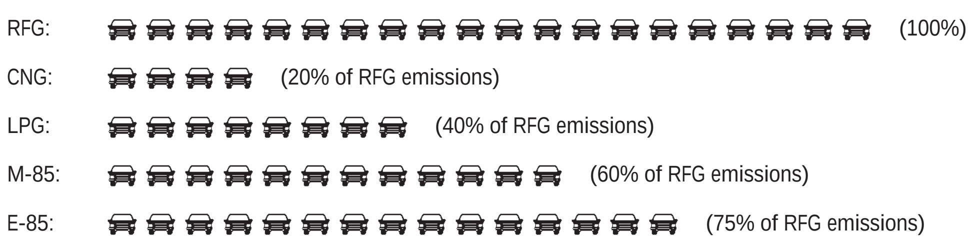
Table 3: Total Emissions from Alternative Fuels, Relative to Gasoline

Pollutant	E-85 (85% Ethanol in Gasoline)	Liquefied Petroleum Gas (Propane)	Compressed Natural Gas	M-85 (85% Methanol in Gasoline)	Electricity
Oxides of Nitrogen (NO_x)	Varies*	Equal	Equal	Equal	Less
Volatile Organic Compounds (VOC)	Equal	More	More	Equal	Less
Total O_3 precursors (NO_x and VOC)	Varies**	Less	Less	Less	Less
Carbon Monoxide (CO)	Equal or less	Less	Less	Equal	Less
Oxides of Sulfur (SO_x)	Less	None	None	Less	More***
Particulate Matter (PM)	Less	Less	None	None	More***

** More for splash-blended gasohol with higher Reid vapor pressure, equal for gasohol with controlled Reid vapor pressure and for ethanol fuels.*
*** More for splash-blended gasohol, less for specially reformulated gasoline and for ethanol fuels.*
**** Assumes roughly half of the power plant feedstock is coal.*

Total ozone precursor emissions (HC and NO_x) from various alternative fuels are compared to reformulated gasoline (RFG) emissions in Figure 1. RFG is gasoline specially blended to reduce VOC and air toxics such as benzene. Compressed natural gas offers the greatest ozone precursor reduction per gasoline gallon equivalent. The emissions of ozone precursors from electric vehicles vary greatly based on the feedstock of the supplying power plant. (About half of the electricity in the country is produced by coal-fired plants that emit NO_x, HC, SO_x and PM. Natural gas-fired power plants will contribute significant HC emissions.) Despite the variation, electric vehicles in general emit less HC and NO_x than other alternative fuel vehicles.

Figure 1: Total Ozone Precursor Emissions From Fuels, Relative to RFG



similar revolving low-interest loans to private organizations as well.

New York Offers Incentives to AFV Dealers

New York City has some of the poorest air quality in the country and is currently in severe ozone nonattainment. According to a study by the Texas Transportation Institute, more fuel is wasted in traffic in New York City than in any other city in the nation except Los Angeles. The majority of air emissions in the city come from mobile sources, including a fleet of 12,000 taxis, many of which travel 100,000 miles or more per year within the city. In 1996, the New York State Energy Research and Development Authority (NYSERDA) and the City of New York developed an incentive program to encourage the purchase of alternative fuel taxis. The program has resulted in the purchase/conversion of about 300 CNG vehicles. This reduces roughly 85 tons/year of CO, roughly 8 tons/year of NO_x, and roughly 17 tons/year of evaporative HC.[10] CNG vehicles emit virtually no PM, so this would reduce PM by 6 tons/year over the baseline from gasoline vehicles. This case study represents a small percentage of New York's taxis, but demonstrates that significant reductions can come from a technology that is feasible and practical.

This program reimburses vendors of OEM AFV for the "incremental cost" of the vehicles—the difference in sticker price between alternative and conventional fuel vehicles. Thus the cost to the purchaser is almost the same as for a conventional fuel vehicle, and the purchaser does not need to apply for a loan, grant, or tax credit. Through the New York City Clean-Fuel Taxi Program, NYSERDA pays 80 percent of the incremental cost of voluntarily purchasing a CNG taxi or 80 percent of the conversion cost, with a maximum payment of $6,000. For a 1998 Ford Crown Victoria, a common taxi model, the incremental cost of a CNG model is about $8,000. Incentive payments are made directly to the dealerships or conversion shops.

Because this is a voluntary program, NYSERDA works in partnership with the New York Taxi and Limousine Commission, the New York Department of Transportation and the Brooklyn Union Gas Company to stir up interest and disseminate information. The commission instituted several policy incentives to encourage individual drivers and fleets to participate. NYSERDA also provides marketing materials to vehicle dealers to encourage sales.

The program is funded using federal CMAQ money, so the air quality benefits come at very little cost to the state. In 1997 this program was funded by a federal grant of about $2 million.

Arizona Gives Grants and Tax Credits for Building AFV Refueling Stations

Although AFVs are readily available for purchase and are a straightforward way to achieve immediate emissions reductions, the refueling infrastructure is not yet in place to support widespread alternative fuel use. Officials from federal agencies and state governments who administer vehicle fleets cited the lack of refueling infrastructure as the main impediment to using alternative fuels. Table 4 describes the various factors that encourage or inhibit the development of infrastructure for the different types of alternative fuel.

Arizona's AFV incentive program is one of the most comprehensive in the country. Like the incentives for vehicle purchase or conversion discussed above, Arizona offers grants to individuals, small businesses, and public agencies for infrastructure installation to overcome another barrier to AFV use. In 1994 the state legislature created the Clean Air Fund from state general funds, fees collected from car

> As this report was going to print, a special session of the Arizona legislature passed a one-year moratorium on this tax incentive program. In the five months since it was created, the wildly popular program had received applications for $400 million in tax credits for AFV purchases, or roughly 7 percent of the state's budget. In order for the legislature to reach consensus on the program, a requirement to run bifuel vehicles full time on an alternative fuel was struck out, and bifuel vehicles could use gasoline the majority of the time. Bifuel vehicles made up 88 percent of the participating vehicles. Because the program represented such a large financial investment for the state without guarantee that the vehicles would run on alternative fuels and provide emissions reductions, the legislature passed the moratorium to provide time to reevaluate the program. The legislature appears to be in consensus that an alternative fuel vehicle incentive program is an important mechanism to improve air quality, but should be redesigned in order to provide maximum air quality benefits for the money invested.

Table 4: Factors in Alternative Fuel Infrastructure Development

Fuel Type	Number of Fuel Stations	Factors Inhibiting Infrastructure Development	Factors Facilitating Infrastructure Development	Price of Gasoline Gallon Equivalent (gge)
Compressed Natural Gas (CNG)	1,267[11]	Piped CNG is at a lower pressure than that needed for vehicles. Special CNG is needed to meet standards for powering vehicles.	Development of a CNG refueling network will require the least investment, as an extensive pipeline from wellhead to consumer already exists in every state.	$0.70- $1.00
Liquified Petroleum Gas (LPG or Propane)	4,181	Pipeline does not adequately serve western and southwestern states. Special shipping and refueling equipment needed.	A limited LPG pipeline system exists, serving areas near major refineries in the Midwest, Northeast, Southeast, and Texas.	About $1.00
Ethanol	45	Ethanol cannot be piped, must be distributed by barge or truck, and cannot be stored in existing gasoline facilities. Use is largely confined to the Midwest.	Ethanol use is already near areas of production, which is the cornbelt of the Midwest.	$1.03-1.30[12] for GGE pure or "neat" alcohol (E-100)
Electricity	489	Overnight recharging is usually required at residential sites.	Infrastructure complete; the only requirement is purchase of recharging units.	$0.2613

owners exempt from I&M testing, and the state lottery. The Clean Air Fund provides various air quality grants, including monies for the installation of AFV refueling stations.

The energy office in the Arizona Department of Commerce implements a program that offers grants for up to $100,000 to entities that build alternative fuel stations accessible to the general public. Since the program's inception in 1994, grants ranging from $4,200 to $100,000 have established 39 refueling stations. Spending between 1994 and 1999 totaled $1.6 million. Tax credits are also available for construction costs not covered by grants. For public access stations, this can be taken for 100 percent of non-grant costs, up to $400,000; for restricted access stations, this can be taken for 50 percent of non-grant costs, up to $200,000. Commercial alternative fuel station tax credits may be carried forward for 15 years against taxes owed.

The same office offers a grant of up to $2,000 for each AFV that will use home or small business refueling equipment. This grant is to be applied to the purchase and installation of alternative fuel refueling systems on the individual's property. Arizona also offers tax credits for the purchase or lease of new and used AFVs, as well as for AFV conversions. The highest credits (50 percent of cost, or $10,000) are for zero-emission vehicles (ZEVs). The lowest credits (15 percent of cost, or $2,500) are for purchase of LEVs or of used, converted AFVs.

State Tax Incentives to Offset Alternative Fuel Vehicle Operating Costs and Inconvenience

Alternative fuels vary in price regionally and, except for ethanol, tend to be cheaper than conventional fuels. At least one preliminary study has found that operating, refueling and repairing CNG vehicles, a popular type of AFV, may be cheaper than for gasoline vehicles. However, savings at the pump may not be a sufficient incentive for a fleet operator or an individual to purchase an AFV, especially when considering the relative inconvenience of refueling. In fact, some AFVs, known as dual-fuel or flexible-fuel vehicles, can also be run on traditional fuels. Thus a fleet may continue to use gasoline or diesel, even though it has met requirements for AFV purchases, simply because it is easier. There are currently about 7,500 refueling stations for all types of alternative fuels combined, compared to roughly 200,000 gasoline stations. As a means to offset the inconvenience of a sparse refueling infrastructure, many states encourage alternative fuel use through tax incentives. This brings the price per gallon well below that of even the lowest grade of conventional gasoline.

A common method among states is a slight exemption in the excise tax on alternative fuels. For example, Massachusetts provides an 11-cent per gallon gasoline-equivalent tax reduction on CNG and LPG. Another approach is to provide a direct incentive for fuel production. In Kansas, producers receive 20 cents per gallon for ethanol fuel produced in the state. California offers a unique incentive. Its Sacramento Air Quality Management District offers $500 worth of free M-85 fuel for both public and private owners of flexible-fuel vehicles that operate 75 percent of the time in the air district.

In addition to reductions in fuel costs, states offer other tax incentives to facilitate the use of alternative fuels. One such tax incentive is the reduction in AFV license taxes. Arizona reduces the annual license tax on the vehicle by $4 for every $1,000 of vehicle value for AFV. Washington exempts CNG and LPG-powered vehicles from motor fuel excise taxes and instead requires an $85 annual fee. In Arizona, AFV owners receive special license plates allowing them to travel at all times in HOV lanes, regardless of the number of passengers in the vehicle. The increased convenience of reduced travel time may encourage prospective vehicle owners to consider AFVs they otherwise may not have.

Appendix A: Challenges to Quantifying Mobile Source Emission Reduction Strategies

This report highlights a selection of innovative and emerging ideas for reducing mobile source emissions. Because these programs are on the cutting edge of air quality control, they often do not have the years of data and quantifiable results of more tried-and-true methods. A number of challenges exist to not only the quantification of individual programs, but also to the side-by-side comparisons of different strategies. This appendix highlights some of these challenges to the analysis of results of these newer strategies. Several problems underlie the ability to quantify and compare certain mobile source air quality control strategies. These can be broken down into two shortcomings. First of all, there is a lack of measured emissions data. Second, the computer modeling used to extrapolate emissions reductions from these air quality measurements has its limitations, posing problems for accurate results and comparability of results among strategies.

Lack of Consistently Measurable Outcomes Prevents Quantification

A fundamental stumbling block to the quantification of mobile source air programs is a lack of numerical data. Some air quality strategies just do not lend themselves to rigorous analysis producing hard numbers for pollution reduction. In these cases, a qualitative assessment based on a logical examination of how the project or program will decrease emissions is the most appropriate option for discussion of results. For example, an educational program that informs citizens about behavioral changes to decrease air pollution has results that may be hard to quantify. In this example, an interview or survey is the best method for determining what effect the program had. These types of data, however, have an inherently large margin of error because they are self-reported.

These difficult-to-measure programs can be referred to as "directionally sound." That is, they contribute to the reduction of air pollution, but the programs have yet to be measured and their impact has yet to be determined. Some states may undertake programs of this nature because they can be very visible and popular with the general public. States either do not expect quantifiable results rigorous enough to be used for federal reporting purposes, or they may be waiting for standardized federal guidance and submission requirements before attempting to produce numerical results. EPA has tried to assist states and localities in quantifying emission reductions from voluntary programs through their Voluntary Measures Policy.

It is difficult to quantify programs because of the challenge in separating the effects of various air quality programs. Programs adopted as part of a comprehensive air quality plan may be hard to evaluate individually. This becomes more difficult when programs work synergistically—when the whole sometimes *is* greater than the sum of its parts. For example, transportation control measures are often mutually reinforcing. Charging higher tolls during peak travel hours and simultaneously making transit service more efficient and extensive will decrease driving miles more than the sum of the effects of each strategy operating individually.

There are only a few measurements air quality officials can make: the numbers of cars on a stretch of road, the emissions from individual vehicles, and the amount of pollutants in the air at certain monitored locations. All other numbers are projections based on these measurements. Therefore, it becomes necessary to use elaborate computer models to paint the most accurate picture of the pollution situation on a statewide or regionwide scale and to predict the emissions reductions from a particular strategy.

Inherent Shortcomings in Computer Modeling Can Hinder the Calculation of Air Benefits

The available models for calculating the effectiveness of air quality programs are not always well suited to measuring results from the newer strategies outlined in this report. The newest models for air agencies to calculate emissions estimates for federally required state air quality plans are quite complex and take into account several factors, including varied roadway speeds and conditions, differences in gasoline compositions, use of prescribed alternative fuels, variations in vehicle emissions standards, and different types of I&M programs (excluding remote sensing).[14] Though this model is much improved, it is still not accurate in determining emissions in localized areas, and it does not help metropolitan areas determine whether new transportation projects will achieve air quality attainment goals. Newer models are being developed to more accurately portray transportation emissions in smaller areas and over much larger regions, but they are unlikely to completely replace EPA-approved versions. This competition among the various computer models will likely necessitate future guidance from EPA as to which model's projections are acceptable for federally required calculations.

Data Input Categories

These models cannot consistently input the variables involved in more innovative programs. Groundbreaking programs may use different fuels or new I&M technology, for example. There is no consistent method to perform calculations for these programs. States would be required to provide extensive justification and demonstration of emissions reductions if using alternative modeling programs. This would require significant time and resource investment with no guarantee of EPA approval. For this reason, most innovative mobile source emission reduction programs are not yet included or credited in state air quality plans.

If programs use CMAQ monies, states must perform some demonstration of emissions reductions, but there is no single reporting standard required of the programs receiving this funding. FHWA guidance on the matter reads,

> "Across the country, state and local transportation/air quality agencies have different approaches, analytical capabilities and technical expertise with respect to such analysis. At the national level, it is not feasible to specify a single method of analysis applicable in all cases. While no single method is specified, every effort must be taken to ensure that determinations of air quality benefits are credible and based on a reproducible and logical analytical procedure that will yield quantitative results of emission reductions. Of course, if an air quality analysis has been done for other reasons, it may also be used for this purpose."

A growing problem with using modeling to estimate emissions reductions is that periodic modeling software updates will produce an apparent change in air quality benefits, though no actual emissions change took place. The different variables of air quality programs are weighed differently over time under the constantly evolving modeling software. As the models become more complex, new project features are added to the calculations. Therefore modeling cannot provide an accurate picture of an air quality program's emissions reductions over a long span of time.

Inconsistency in Data Evaluation and Among Air Quality Program Targets

Because there does not exist any one standard for calculating the emissions reductions of more innovative programs, states are often left to devise their own logic for estimating emissions reductions. This helps to demonstrate that a program may be more effective than the baseline scenario (i.e., it's directionally sound and better than doing nothing), but it becomes more challenging to say *how* effective the program may be, and nearly impossible to compare it to a program using a different strategy. It should be noted that state's improvised methods for determining emissions reductions may be useful for drawing comparisons among similar programs, but because there is no standardization of the measurements and calculations, it is not certain that numbers from different air agencies will be suitable for such evaluation.

Often, the programs present the proverbial "apples and oranges" problem: the programs are too dissimilar for side-by-side comparison. Several variables may prevent the comparability of programs, including the timetable of programs, the pollutant(s) targeted, the geographic scope, and the synergistic effect of several programs working together toward one air quality goal.

Differing Control Periods

Different control periods are associated with various air regulatory programs. Some may be in effect only certain days of the year (episodic), some for one season of the year (seasonal), some year-round (annual), and some may demonstrate results gradually over a number of years. While it is common to report emissions reductions in tons per year, this may overlook the important benefit of targeted emissions reductions on specific days or seasons. This reduction may appear slight in the context of the entire year's emissions but may be crucial to averting NAAQS exceedances on high-pollution days.

Duration of Programs

Time spans of different programs also may be vastly different. A program may contribute air quality benefits continuously over decades, whereas another may provide reductions for only a few months. The total number of tons reduced may be similar, but the impact of the reductions accomplishes different goals. The former provides for long-term air quality improvement or maintenance of current air quality, and the latter provides immediate short-term air benefits. Calculation of the per-ton cost-effectiveness of a strategy is difficult to calculate because a program may have an indefinite end point and will continue to provide emissions benefits for many years to come for a one-time capital investment.

Change in Effectiveness Over Time

A program's effectiveness may change through its duration. This "growth curve" must be evaluated before attempting to draw conclusions about a program's success. One long-term program could offer the same benefits every year. Another could offer decreasing benefits, as when equipment ages and deteriorates. Still another could show consistently increasing benefits, as with growing public participation in a program.

Different Target Pollutants

The total tonnage of pollution reduced includes many different pollutants. However, an area may be concerned with only one pollutant. An area solely in ozone nonattainment probably will not be concerned with particulate matter reduction. In this case, particulate matter reduction would be a waste of resources and a smaller-scale ozone reduction strategy would be a "better" idea. The total reduction must be viewed in the framework of the pollution problem of the area.

Geographic Scope

The geographic scope of programs can differ widely. Strategies may bring about small air quality improvements over an entire region or may provide reductions in a small, targeted area. As with temporal differences in scope, the relative importance of these emissions reduction strategies cannot be determined outside the context of the situation. These also must be weighed against the extent of the pollution problem as well, since a program that provides ozone reduction to an attainment area would be less desirable than one that concentrates results on the area with the pollution problem.

Inability to Compare Proxy Measurements

Proxy measurements that states use to demonstrate air quality improvement present a fundamental stumbling block to comparison among different innovative air pollution control strategies. The success of a given program may be expressed by a decrease in traffic volume, an increase in roadway speeds or in transit ridership, a survey of individuals showing percentages of participation in voluntary actions, or an amount of money given away through a grant program. By their nature, these results do not facilitate side-by-side comparisons, although they qualitatively demonstrate the success of a given approach.

No Single Number Can Easily Compare Innovative Emissions Reductions Strategies

Trying to compare a series of innovative air quality programs using one number, or trying to rank a list of programs from best to worst based on one characteristic, is difficult at best. The newness of approaches, complexity of programs, and number of contributing variables in each strategy make it challenging to come up with a single number for comparison. In established programs, it is common to use dollars/ton to compare pollution reduction efficiency, but in groundbreaking programs these figures are harder to come by.

There is merit to evaluating the pros and cons of various strategies and attempting to see how they fit into the overall picture of mobile source emissions reductions. One must be aware of the limitations of quantifying emissions reductions and the problems in comparing various strategies but still see the qualities that contribute to more successful programs in a specific area. There are many useful lessons and ideas to be gleaned from successful air quality programs.

Appendix B:
Primer on the Provisions in the 1990 Clean Air Act Amendments Affecting Mobile Source Air Emissions

The Clean Air Act (CAA) seeks to protect people and the environment from dangerous air pollution. It delegates to EPA the authority to set appropriate pollution standards and to develop programs to achieve these standards. States have the responsibility to carry out these programs. The CAA deals with air quality standards, mobile source air pollution, toxic pollutants, acid rain-forming pollutants, stationary sources permitting, stratospheric ozone protection, and enforcement of the various CAA programs. This appendix discusses the first two sections of the act.

National Ambient Air Quality Standards (NAAQS)

The CAA requires EPA to set standards for common air pollutants. EPA has promulgated air quality standards for six criteria pollutants: ozone, nitrogen dioxide (NO_2), carbon monoxide (CO), particulate matter ($PM_{2.5}$ and PM_{10}), sulfur dioxide (SO_2), and lead. EPA has established for each a maximum concentration above which public health and welfare is threatened. EPA is required to review the scientific data on which the standards are based every five years and revise the standards if necessary. (See box "U.S. Court Remands Ozone and PM Standards.")

Ozone

Naturally formed ozone is beneficial when found in the upper atmosphere because it shields the earth's surface from ultraviolet radiation. On the other hand, surface ozone (commonly called smog) causes respiratory health problems. Ozone damages lung tissue in at-risk populations, and sustained exposure to low levels can harm healthy individuals.

Ozone is not emitted directly; it is formed from nitrogen oxides (NO_x), volatile organic compounds (VOC), and sunlight. Ozone levels are higher in summer, and an area may have an "ozone season" (typically May through October) during which control efforts are intensified.

The current ozone standard value is 0.12 parts per million (ppm) measured over a one-hour period. An area meets the ozone NAAQS if no more than one day per year is above this value. For attainment, an area must meet the ozone NAAQS for three consecutive years. An area is allowed one NAAQS exceedance per year, and the next highest value (the design value) is used to characterize an area's nonattainment status.

Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a highly reactive air pollutant formed from fuel combustion in vehicles and other high temperature processes occurring in the presence of air. The two pollutants NO and NO_2, known as NO_x, play a significant pollution role as ozone precursors.

U.S. Court Remands Ozone and PM Standards

On May 14, 1999, a three-judge panel of the U.S. Circuit Court of Appeals in Washington, D.C., remanded EPA's most recent revisions to national ambient air quality standards for ozone and fine particulate matter and sent them back to EPA for reassessment. The court found that EPA lacked any determinate criterion for setting the specific standards and contended that EPA had thus unconstitutionally usurped Congressional authority (the "nondelegation doctrine" that prevents Congress from giving its legislative power to agencies). As a result, EPA must give further consideration to the standards for ozone and particulates.

The U.S. Department of Justice sought a rehearing before the full U.S. Circuit Court of Appeals, but it was denied. EPA has appealed to the Supreme Court, which is expected to hear arguments in the fall of 2001; a decision is likely in 2001.

EPA believes this rule will have no effect on its ability to proceed with Tier II regulations on gasoline formation and automobile emissions. EPA will proceed with the development of the small particulate matter monitoring system. EPA will continue to designate attainment status based on the new eight-hour standard, but these designations cannot be enforced. EPA proposes to reinstate the one-hour standard in areas where it had been revoked.

Table 5: Ozone Nonattainment Area Facts, As of August, 1999

Ozone Nonattainment Classifications				
Classification	**Deadline for Attainment**	**Number of Areas**	**Population of Areas**	**Design Value (ppm)**
Marginal	1993	5	1,260,000	0.121-0.138
Moderate	1996	8	8,438,000	0.138-0.160
Serious	1999	14	28,962,000	0.160-0.180
Severe-15	2005	4	10,666,000	0.180-0.190
Severe-17	2007	5	31,387,000	0.190-0.280
Extreme	2010	1	13,000,000	0.280 and above

Source: EPA's Greenbook: Nonattainment Areas for Criteria Pollutants

They pose a health risk due to the respiratory effects they cause, and they are a major contributor to acid rain formation.

The NAAQS for NO_2 is 0.053 ppm average concentration over the entire year. Unlike the ozone nonattainment classifications, there is no tiered ranking for NO_2 nonattainment. There are currently no nonattainment areas for NO_2. Mobile source NO_x emissions, which account for about a third of total NO_x emissions, are reduced in part by catalytic converter technology that converts NO_x into harmless nitrogen gas (N_2).

Carbon Monoxide

Carbon monoxide (CO) is a colorless and poisonous air pollutant formed from the incomplete burning of carbon. CO is harmful because it impairs the body's ability to supply oxygen to organs and tissues. This can impair visual perception, manual dexterity, thought and reflexes, and may threaten cardiovascular function in those with cardiovascular disease and angina.

The nonattainment classifications for CO are based on CO concentrations measured over eight hours. An area is in attainment for CO if it does not exceed 9 ppm CO more than once per year for two consecutive years. Mobile

Table 6: CO Nonattainment Area Facts, as of August, 1999

Carbon Monoxide Nonattainment Designations			
Classification	**Number of Areas**	**Population of Areas**	**Design Value (ppm)**
Moderate	13	16,521,000	9.1-16.4
Serious	7	17,595,000	16.5 and above

Source: EPA's Greenbook: Nonattainment Areas for Criteria Pollutants

Table 7: PM Nonattainment Area Facts, as of August, 1999

Particulate Matter Nonattainment Designations			
Classification	**Number of Areas**	**Population of Areas**	**Design Value ($\mu g/m^3$)**
Moderate	72	11,005,000	Over 150 microgram/m^3 24-hour average, or over 50 microgram/m^3 annual average
Serious	6	18,744,000	N/A

Source: EPA's Greenbook: Nonattainment Areas for Criteria Pollutants

sources account for 77 percent of CO emissions nationwide, so the focus of CO reduction strategies is on this contribution.

Particulate Matter

Particulate matter (PM) includes soot, smoke, dust, and dirt emitted directly or produced by windblown and reintrained dust. PM can be formed by condensation in the atmosphere of gases, such as SO_2 and VOC, into larger droplets called aerosols. PM irritates lung tissue, can aggravate respiratory and cardiovascular disease, and has been found to cause cancer, premature death, and increased infant mortality. PM is a major contributor to impaired visibility, or haze.

EPA currently regulates PM with a diameter of 10 microns or smaller (PM_{10}). A region must have a PM_{10} concentration below 150 microgram/m^3 averaged over a 24-hour period and must have PM_{10} concentrations below 50 microgramg/m^3 averaged over the entire year. As of August 1999, there are 6 areas in serious nonattainment and 72 areas in moderate nonattainment.

Sulfur Dioxide

Sulfur dioxide (SO_2) is a noxious gas largely produced by stationary sources. It affects breathing and aggravates respiratory conditions, and it is the most significant precursor to acid rain. For attainment of SO_2 NAAQS, an area must have a maximum annual mean concentration of 0.03 ppm, and not exceed the 24-hour level of 0.14 ppm and the 3-hour level of 0.50 ppm more than once per year. As of August 1999, there are 33 areas in nonattainment for SO_2.

Lead

The mobile source contribution to atmospheric lead pollution has decreased by 99 percent since lead was removed from gasoline in 1986; most lead emissions today come from stationary sources involving metals processing. The health effects of lead exposure can be quite severe, including central nervous system damage, such as seizures, mental retardation, and behavioral disorders. Young children and infants are particularly susceptible to the effects of lead exposure. The NAAQS for lead is 1.5 micrograms per cubic meter averaged over three months. There are currently 10 areas in nonattainment for lead.

State Implementation Plans

States are required under Section 110 of the CAA to develop plans to come into compliance with the NAAQS described above. These plans, known as state implementation plans (SIPs) are submitted to EPA to ensure they adequately meet statutory requirements. A SIP first defines the extent of the pollution problem using computer model predictions of future NAAQS exceedances based on actual emission inventories from mobile, stationary, and area sources. If the model predicts that exceedances will occur, states must impose additional controls on transportation, industry, and individuals to reduce current sources of pollutants.

Sanctions

If a state neglects to submit a SIP, fails to submit an adequate SIP, or fails to implement a SIP, EPA must impose sanctions unless the state corrects the error within 18 months. The first of these is a "2-to-1 emissions offset" on new or modified pollution sources. This means any newly permitted source of pollution must be offset by a double reduction of the new pollutant amount elsewhere in the sanctioned region. This type of sanction has been imposed 14 times since passage of the CAAA in 1990. The second type of sanction EPA can impose is the withholding of certain federal highway funds in the event the deficiency is not corrected within another six months. This sanction has been enforced twice since the 1990 amendments. Despite the imposition of sanctions, projects improving air quality or safety are allowed to proceed.

Transportation Conformity

Transportation conformity ensures transportation investments match a state's plan for meeting the NAAQS. It ensures that transportation activities do not worsen air quality by creating new NAAQS violations, increase the frequency or severity of existing NAAQS violations, or delay attainment of the NAAQS.

Transportation plans, programs, and projects in nonattainment or maintenance areas funded or approved by FHWA or FTA must conform with the SIP. Conformity determinations for transportation plans and programs are made by the metropolitan planning organization (MPO) before they are submitted to U.S. DOT for review and approval. Conformity determinations for individual projects are the responsibility of U.S. DOT and the project sponsor, which is usually the state DOT.

Conformity determinations must be made at least every three years, or as changes are made to plans, programs, or projects. Certain events, such as SIP revisions that establish or revise a transportation-related emissions budget or add or delete transportation control measures (TCM), may also trigger new conformity determinations.

The key components of the conformity determinations include regional emissions analyses, project-level analysis, and, if TCMs are part of the attainment demonstration, evidence of timely TCM implementation.

During a conformity lapse, only limited types of projects can proceed. If an area is in a lapse, FHWA and FTA can only make approvals or grants for projects that are exempt from the conformity process, TCMs that are included in approved SIPs, and projects that have received funding commitments for construction before the lapse. In addition, federal aid cannot continue to fund active design projects or right-of-way acquisition projects (with minor exceptions) during a lapse. Detailed discussion of what projects can advance during a lapse can be found in EPA guidance (May 14, 1999) and FHWA/FTA guidance (June 18, 1999).

Specific CAA Strategies to Reduce Mobile Source Emissions Contributions

The CAA delegates to states the responsibility of achieving NAAQS. In areas that exceed the standards, EPA requires states to adopt air quality control programs. The programs that apply to mobile sources fall into three general categories: cleaner vehicles, cleaner fuels, and lower VMT through transportation control measures. The most stringent requirements are placed on areas with the worst air quality.

Cleaner Vehicles

Cars and Light-duty Trucks

Title II of the CAA has prescribed automobile tailpipe emissions standards since 1968. In 1990 these standards were tightened considerably; Tier 1 standards reduced allowable tailpipe HC levels by 40 percent and tailpipe NO_x levels by 50 percent. In 1999 EPA finalized more stringent Tier 2 tailpipe emissions standards, affecting model year 2004. Tier 2 requires the same tailpipe emissions from cars and light-duty trucks—the first time these vehicles types are subject to the same national pollution control requirements. Tier 2 will mean a 77-percent NO_x emissions reduction for cars, and 65 percent to 95 percent NO_x reduction for light-duty trucks. Tier 2 also requires gasoline sulfur reductions.

Heavy-Duty Vehicles

In 1997 EPA adopted emissions standards for heavy-duty diesel engines in trucks and buses. The new standards regulate both HC and NO_x emissions, and bring a 50-percent reduction in NO_x from older standards. The new standard affects engines manufactured starting in 2004. Buses in cities of at least 750,000 people had to meet 60-percent stricter PM emission standards starting in 1993. EPA can determine that buses are not meeting the standards and require use of low-polluting fuels, such as ethanol, propane, or CNG. Buses built before 1993 are also required to meet PM emissions standards or be retrofitted with emissions-reducing technologies. A proposed second phase to this strategy includes more stringent emission standards and fuel sulfur reduction by 2007.

California Standards

California is given the authority under Section 209 (b) to develop its own stringent vehicle emissions standards. The state has created a program requiring the availability of low-emission vehicles (LEVs), ultra-low-emission vehicles (ULEVs), and zero-emission vehicles (ZEVs). Other states can choose to adopt these standards, as several states in the Northeast have done.

Inspection and Maintenance (I&M)

I&M is used to ensure vehicle emissions control systems are functioning correctly. Periodic inspections and required repairs ensure that vehicles continue to operate at the same emissions standards as when they were originally manufactured. I&M targets vehicles that have fallen into disrepair and emit more pollution than their design standard allows.

Basic I&M is required in areas with moderate or above ozone nonattainment status and in some marginal areas. It requires an idle test of tailpipe emissions and a visual inspection of critical control components. Enhanced I&M is required in areas with serious or worse ozone status. This is a more comprehensive and sophisticated test addressing evaporative emissions, a significant portion of hydrocarbon emissions. Enhanced I&M prohibits stations that conduct I&M tests from performing the vehicle repairs, but gives states other programmatic flexibility.

Fuels

Reformulated and Oxygenated Gasoline

Reformulated gasoline (RFG) burns cleaner than regular gas, and it must be sold in the worst ozone nonattainment areas to prevent smog formation. RFG is blended to reduce exhaust and evaporative emissions and toxic compounds such as benzene. As of 1999, 10 areas were required to sell RFG; 19 additional nonattainment areas have voluntarily opted to sell RFG. The CAA amendments also require that oxygenated gasoline, which has a higher oxygenate concentration, be sold in the worst CO nonattainment areas. The oxygenates methyl tertiary butyl ether (MTBE) and ethanol are most commonly used to meet the required oxygen content of oxygenated and reformulated gasoline.

Alternative Fuels

The CAA amendments encourage use of alternative fuels through the Clean Fuel Fleet Program (CFFP) in the worst ozone and CO nonattainment areas. (Alternative fuels here include methanol, ethanol, RFG, reformulated diesel, natural gas, liquefied petroleum

The MTBE Controversy

The gasoline additive methyl tertiary butyl ether (MTBE) used to reduce motor vehicle tailpipe emissions is contaminating drinking water supplies across the country. Much uncertainty and controversy about the health and environmental risks of this contamination exists, but consumers reject—and are increasingly alarmed about—the foul taste and smell of even slightly contaminated water.

To address public concerns about drinking water and curb expensive cleanup costs, some states have banned or restricted MTBE use. More such actions are likely. However, stopping MTBE use is not simple. It is one of very few chemicals that can satisfy the oxygen requirement for reformulated gasoline under the federal Clean Air Act (CAA), and it is widely used to increase octane in standard gasoline.

The federal government and the private sector do not favor a patchwork of MTBE regulations and fuel formulation requirements in different states. The threat of gasoline supply problems and higher prices encourage national resolution of the issue.

Repealing the oxygenate mandate requires congressional action, but EPA can regulate MTBE use under the Toxic Substances Control Act. EPA has given advance notice that it will propose elimination of MTBE as a fuel additive, but is also encouraging a legislative solution.

gas, hydrogen and electricity.) This program affects public and private fleet owners with 10 or more centrally fueled vehicles. The CFFP requires that an increasing proportion (30 percent at first and 70 percent after three years) of vehicle purchases to fleets be clean-fueled vehicles. As of 1999, this affected 22 metropolitan areas.

California is required to sell certain numbers of clean fuel vehicles; by 1999, it was required to sell 300,000 clean fuel vehicles per year.

Fuel Vapor Recovery

Areas with moderate or worse ozone nonattainment status must require gasoline dispensing systems above a certain size to install and operate gasoline vapor recovery systems to capture emissions from the refueling of vehicles. This might be waived once "on-board" vapor recovery systems are in widespread use throughout the motor vehicle fleet.

Requirements for Ozone, Carbon Monoxide, And Particulate Matter Nonattainment Areas

The CAA requires pollution control strategies in nonattainment areas. The requirements vary based on the type and severity of the pollution problem. These mobile source requirements, which are included in the SIP, become stricter with increasing nonattainment severity.

Reducing Ozone

Marginal (0.121-0.138 ppm): Submit an emissions inventory of all hydrocarbon sources and revise every three years thereafter until attainment. Implement current SIP and correct any SIP deficiencies. If a basic inspection and maintenance (I&M) was in place before designation, it must now meet EPA standards or the requirements of the SIP, whichever is more stringent.

Moderate (0.138-0.160 ppm): SIP must reduce baseline HC emissions by 15 percent over the first 6 years of enactment. Utilize basic I&M program and Stage II vapor recovery program. Contingency transportation control measures (TCMs) must be developed so they may be implemented if the state fails to achieve its required emissions reductions on time.

Serious (0.160-0.180 ppm): Demonstrate a 3-percent reduction on average for years 7 to 9 after the 15-percent reduction already required by year 6. Adopt contingency TCMs if VMT or vehicle HC emissions are higher than expected. Improve monitoring. Utilize enhanced I&M programs and clean fuel fleet programs.

Severe (0.180-0.280 ppm): Requires VMT limitation strategies and use of reformulated gasoline.

Extreme (0.280 ppm and above): Requires heavy-duty emissions control programs.

Reducing Carbon Monoxide

Moderate (9.1-16.4 ppm): Submit an emissions inventory and control plan and revise every three years until attainment. Forecast total VMT for the area. Demonstrate annual improvements sufficient to attain the standard. Plan contingency TCMs in the event VMT exceeds predicted levels or the area fails to attain the NAAQS. Adopt enhanced I&M program.

Serious (16.5 ppm and above): Adopt specified transportation control measures. Implement oxygenated fuels program.

Reducing Particulate Matter

Moderate: Submit a SIP and meet quantitative milestones every three years.

Serious: Submit a SIP and demonstrate attainment within 10 years of submission.

Appendix C: Primer on the Provisions in the Transportation Equity Act for the 21st Century Affecting Mobile Sources

Funding for most projects under the Transportation Equity Act for the 21st Century (TEA-21) comes from federal taxes on fuels paid into the Federal Highway Trust Fund. Each state receives an annual apportionment of these funds according to TEA-21 formulas, and U.S. DOT obligates funds, limited by TEA-21 authorizations. Unobligated funds may be available for future projects.

Out of a total of $218 billion authorized, TEA-21 sets aside roughly $12.4 billion from fiscal 1998–2003 for programs to reduce environmental impacts of transportation. Each of these programs is discussed in this primer in more detail.

- The Congestion Mitigation and Air Quality Improvement program ($8.1 billion: fiscal 1998–2003) helps states achieve the NAAQS by reducing traffic and pollution.
- The Transportation Enhancements program ($3.3 billion: fiscal 1998–2003) strengthens cultural, aesthetic, and environmental aspects of the transportation system.
- The Intelligent Transportation System program ($1.28 billion: fiscal 1998–2003) funds technology to reduce congestion and pollution and to improve highway and transit efficiency.
- The Clean Fuels Formula Grant program ($750 million: fiscal 1999–2003) helps transit systems acquire cleaner buses.
- The Advanced Vehicle Technologies program ($250 million: fiscal 1999–2003) funds research to improve the efficiency, safety and cost effectiveness of the transportation system.

Congestion Mitigation and Air Quality Improvement Program (CMAQ)

TEA-21 provides a six-year, $8.1-billion flexible funding source to state and local governments for transportation programs and projects that reduce transportation-related emissions. Generally, only programs in nonattainment or maintenance areas for O_3, CO, and PM_{10} are funded. Eligible activities include transit improvements, demand management, traffic-flow improvements, and cleaner fueled fleets.

Funding Priority and Apportionment

The highest priority for CMAQ funding is the implementation of transportation control measures (TCMs) in a state's improvement plan. Each state is apportioned at least 0.5 percent of each year's total CMAQ funding for this purpose. Beyond this minimum level, funds are apportioned according to weighted factors based on pollution severity. States with nonattainment areas are required to spend their CMAQ dollars largely in those areas.

Project Eligibility Requirements

CMAQ funds have a 20-percent state match requirement and must follow four general guidelines.

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Table 8: Programs and Projects Eligible for CMAQ Funds

Type of Program	Eligibility Criteria and Examples of Programs	Restrictions and Ineligible Activities	Notes
Transportation Control Measures (TCM)	• Improved public transit • HOV lane construction, provision of pooled ride services • Employer-based transportation incentives and flextime • Trip reduction ordinances, programs to reduce SOV travel • Emissions-reducing traffic flow improvements • Fringe and corridor parking lots for HOV and transit • Bike lanes and storage facilities; bike/ped path construction • Limiting vehicle idling • Extreme low-temperature cold start programs	• Scrappage programs for pre-1980 vehicles	SIP programs have highest priority for CMAQ funding. Air quality benefits will have already been documented. Scrappage of pre-1980 vehicles is included as a TCM in the CAA. Low-temperature cold start programs previously ineligible.
Public-Private Partnerships	• Before project starts, partnerships must specify use of funds, roles of the participants, and cost-sharing arrangements. • Programs must demonstrate strong emission reductions	Not for required private-sector obligations unless they exceed obligations.	The public agency must apply through the metropolitan planning process and oversee the funds.
Alternative Fuels	• Purchase of publicly-owned AFVs. • Establishment of publicly-owned refueling facilities in the absence of adequate privately owned facilities.	AFV must address the pollutant of the NAAQS exceedance.	Fleet conversions no longer are specifically identified in the SIP.
Traffic Flow Improvements	• Traffic signal control • Freeway, incident, and transit management • Electronic fare payment, electronic toll collection • Regional multimodal traveler information	Operating funds available only for three years unless a project is needed for NAAQS achievement.	Large urban areas must have a congestion management system. State ITS must be consistent with national ITS architecture.

Table 8: Programs and Projects Eligible for CMAQ Funds (CONTINUED)

Type of Program	Eligibility Criteria and Examples of Programs	Restrictions and Ineligible Activities	Notes
Transit Projects	• Purchase of new facilities and replacement vehicles • Three years of operating costs of a new facility • Fare subsidies in a program to avoid NAAQS exceedances	Rebuilding or maintaining existing transit. Operating costs after three years.	Included as a TCM in the CAA. These are CMAQ-eligible only if increase in ridership is expected.
Travel Demand Management (TDM)	• Market research and capital costs for TDM implementation • Emissions-reducing traffic calming measures • Up to three years of TDM operating costs • Public education/marketing of TDMs		TDMs are most successful with complementary measures to discourage SOV use, such as parking restrictions.
Outreach and Rideshare Activities	• Public education on transportation and air quality • Marketing of alternatives to SOV travel • Technical assistance to employers promoting HOV travel • Vanpool operating expenses for up to three years • Up to three years of start-up costs for Transportation Management Associations (TMA)	Purchase of publicly owned vehicle for a vanpool in competition with private-sector initiatives	
Telecommuting	• Planning and training • Technical and feasibility studies • Coordination, marketing and promotion	Construction of telecommuting centers; equipment purchases.	
Fare/Fee Subsidy Programs	• Transit subsidies, as part of a program to reduce SOV use • Subsidies for other demand-management strategies • Incentives for carpooling, bicycling and walking	Three-year limit on fare/fee subsidies.	

Table 8: Programs and Projects Eligible for CMAQ Funds (CONTINUED)

Type of Program	Eligibility Criteria and Examples of Programs	Restrictions and Ineligible Activities	Notes
Planning and Project Development	• Preliminary engineering or project planning studies • National Environmental Policy Act (NEPA) documentation and other transportation/air quality project planning • TCM project development • Monitoring to determine air quality impacts of projects	General planning or monitoring; NEPA or other environmental documentation unrelated to an air quality project.	
I&M	• Construction of I&M facilities • Purchase of I&M equipment • One-time start-up activities such as software development • Up to three years of operating expenses	Any expenses for privately owned facilities, except as part of a public-private partnership	
MagLev Technology	Planning, engineering and construction project costs of the Magnetic Levitation Transportation Technology Program		
Experimental Pilot Projects	Transportation projects that can reasonably be expected to reduce emissions by reducing VMT or fuel use. VMT, trip, or emissions reductions will need to be documented using before-and-after studies.		MPO, state DOT, FHWA/FTA, EPA and state/local air agencies must approve. Projects may not exceed 25 percent of a state's yearly CMAQ apportionment.

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1. Capital Investment—Funds should be used for new or expanded transportation projects and programs to reduce emissions, often in the form of capital investment in infrastructure or program establishment.
2. Operating Assistance—Funds *may* be used for three years of new transportation services, but other funding should eventually supplant the CMAQ portion of operating costs.
3. Emissions reductions—Projects must show reductions in CO, O_3 precursors, or PM_{10}.
4. Public Good—Funds must be used for emissions reductions. Public-private partnerships *may* be eligible if they demonstrate an emissions reduction that would benefit the community (see Table 8).

Eligible Programs and Projects

For a project to be considered for CMAQ funding it must be a transportation project, be in a nonattainment or maintenance area, and reduce emissions.

Project Selection Process

Estimates of emission reductions in CMAQ project proposals provide an objective cost-benefit comparison of funding requests. The type of analysis required is at the discretion of the Federal Highways Administration (FHWA), the Federal Transit Administration (FTA) and EPA. In the absence of a quantifiable emissions projection, a qualitative assessment based on reasoned and logical examination of how the project will decrease emissions and contribute to attainment of a NAAQS is acceptable.

State Program Oversight Responsibilities

Decisions on CMAQ program funding must be made through the appropriate metropolitan or statewide planning process. States, metropolitan planning organizations (MPOs), and transit agencies are encouraged to consult with air quality agencies to develop criteria to select CMAQ projects.

All projects funded under Title 23 of the United States Code, including CMAQ, must be included in plans and transportation improvement programs (TIPs). The TIP must contain a list of priority projects to be funded over a three-year period. Close coordination is required between states (that oversee the statewide program) and MPOs (that approve projects sponsored by local entities) to ensure funds are used appropriately and effectively. States must submit annual reports to FHWA listing the amounts of CMAQ funds that have been obligated and what emissions reductions have been achieved.

Transportation Enhancements

Transportation enhancements (TE) are transportation-related activities that strengthen the environmental, cultural or aesthetic aspects of the national transportation system.

To be eligible for TE funds, a project must fall under one or more of twelve activities specified in TEA-21. Traffic control measures included on this list are:

- provision of facilities for pedestrians and bicycles; and
- preservation of abandoned railway corridors, including the conversion and use thereof for pedestrian or bicycle trails.

Vehicle Technology

Intelligent Transportation Systems

The Intelligent Transportation Systems (ITS) program provides $1.28 billion over six years for research, development, and operational testing of ITS strategies that solve congestion and safety problems, improve efficiency of transit and commercial vehicles, and reduce the environmental impact of growing VMT. The most technically feasible and cost-effective technologies will be deployed in an integrated nationwide system. The U.S. Department of Transportation is responsible for developing and maintaining the national ITS architecture, supporting standards to promote consistent widespread use of ITS technology, and ensuring interoperability and efficiency of the integrated system to the maximum extent possible.

ITS research and development is funded at $603.2 million from fiscal 1998 to fiscal 2003. Research and development must follow priorities outlined in TEA-21. ITS deployment is funded at $679 million from fiscal 1998 to fiscal 2003. Small grants are available to state and local governments to integrate ITS infrastructure and to fund commercial vehicle ITS infrastructure deployment.

Advanced Vehicle Technology Program

Projects in this program must seek to alleviate transportation-related problems and must be undertaken by a statewide or multistate organization that is more than three years old. The organization must solicit participation from the private sector and projects must be at least 50-percent non-federally funded.

Alternative Fuels

Clean Fuels Formula Grant Program

This program accelerates the deployment of cleaner bus technologies. It provides grants to transit systems to purchase or lease clean fuel buses, construct alternative fuel facilities, rebuild older engines with clean fuel technology, and utilize alternative fuels. The funds are for vehicles fueled by compressed natural gas, liquefied natural gas, biodiesel, batteries, alcohol fuels, hybrid electric power, fuel cells, clean diesel, or other low- or zero-emissions technologies.

Grants are awarded based on the size of the vehicle fleet, the number of passenger miles traveled, and the severity of the area's air quality violation. No more than $15 million can be used in areas with a population under 1 million, and no more than $25 million can be used in areas with populations of 1 million or more. The federal match is 80 percent of the project cost.

Bicycle and Pedestrian (Bike/Ped) Projects

TEA-21 seeks to integrate bicycling and walking into the transportation mainstream. A number of funding sources are available for bike/ped projects, including funds from CMAQ, TE, the National Highway System, Surface Transportation Program, Recreational Trails, Federal Lands Highway Program, National Scenic Byways Program, and Transit Enhancement Activity Program. The federal share of a bike/ped project is usually 80 percent; state and local match funds for federal-aid projects may include in-kind contributions.

Transportation and Community and System Preservation Pilot Program

TEA-21 provides planning and implementation grants ($120 million from fiscal 1999–2003) to improve transportation system efficiency; reduce environmental impacts of transportation and the need for costly future public infrastructure investments; ensure efficient access to jobs, services, and centers of trade; and encourage private-sector development patterns that serve these purposes. This can be accomplished by concentrating spending in high-growth areas, establishing growth boundaries to guide urban expansion, creating green corridors that provide access to major highway corridors for efficient and compact development, and similar programs.

Unfunded Environmental Provisions in TEA-21

- States can permit single-occupancy, low-emission vehicles to use HOV lanes.
- DOT is required to develop and implement a coordinated concurrent environmental review process for federal agencies, ensuring that transportation projects move through the process in a timely manner.
- EPA must designate nonattainment areas for the new air quality standards issued in 1997. EPA must provide funding to states to establish a $PM_{2.5}$ monitoring system and designate $PM_{2.5}$ areas before implementing new controls on regional haze.
- TEA-21 changes the tax code to help bring employer benefits for parking and commuting into approximately the same range. These changes make it easier for an employer to offer transit and vanpool benefits or cash to an employee in lieu of parking. Under the Taxpayer Relief Act of 1997, transit and vanpool benefits are given the same tax treatment.

Appendix D:
Acronyms Used In This Report

Acronym	Definition
ADEQ	Arizona Department of Environmental Quality
ADOT	Arizona Department of Transportation
AFV	Alternative fuel vehicle
ASM	Acceleration simulation mode test
AVL	Automatic vehicle locator
BMC	Baltimore Metropolitan Council
CA/T	Central Artery/Tunnel Project (Boston, Massachusetts)
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
Caltrans	California Department of Transportation
CARS	Customer Assistance for Repair and Services (Colorado)
CFFP	Clean Fuel Fleet Program
CMAQ	Congestion Mitigation and Air Quality Improvement Program
CNG	Compressed natural gas
CO	Carbon monoxide
CPTC	California Private Transportation Company
CTA	Chicago Transit Authority
DOT	U.S. Department of Transportation
E-100	Pure or “neat” ethanol
E-85	85 percent ethanol, 15 percent gasoline
EPA	U.S. Environmental Protection Agency
EPACT	Energy Policy Act
EV	Electric vehicle
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GA EPD	Georgia Environmental Protection Department
GADOT	Georgia Department of Transportation
GGE	Gasoline gallon equivalent
GIS	Geographic information systems
HOT	High-occupancy toll
HOV	High-occupancy vehicle
I&M	Inspection and maintenance
IDOT	Illinois Department of Transportation
ILEV	Inherently low-emission vehicle
ITS	Intelligent transportation system
LNG	Liquified natural gas
LPG	Liquified petroleum gas (propane)
M-85	85 percent methanol, 15 percent gasoline
MDE	Maryland Department of the Environment
MPGGE	Miles per gasoline gallon equivalent
MPO	Metropolitan planning organization
MTBE	Methyl tertiary butyl ether
NAAQS	National ambient air quality standards
NESCAUM	Northeast States for Coordinated Air Use Management
NLEV	National low-emission vehicle program
NMHC	Non-methane hydrocarbon

Acronym	Definition
NMOC	Non-methane organic compounds
NO_x	Oxides of nitrogen
NYSERDA	New York State Energy Research and Development Authority
O_3	Ozone
OAD	Ozone Action Day
OEM	Original equipment manufacturer
OMS	EPA's Office of Mobile Sources
PM	Particulate matter
PM_{10}	Particulate matter 10 microns or smaller in diameter
$PM_{2.5}$	"Small" particulate matter, 2.5 microns or smaller in diameter
PPM	Parts per million
PSG	Partnership for a Smog-Free Georgia
RFG	Reformulated gasoline
RSD	Remote sensing device
RTA	Regional Transportation Authority (Chicago area)
RVP	Reid vapor pressure
SIP	State implementation plan
SOV	Single-occupancy vehicle
SO_x	Oxides of sulfur
SR-91	California State Route 91
STP	Surface Transportation Program
SULEV	Super ultra low-emission vehicle
TCM	Transportation control measure
TEA-21	Transportation Equity Act for the 21st Century
THC	Total hydrocarbon
TIP	Transportation improvement program
TLEV	Transitional low-emission vehicle
UGB	Urban Growth Boundary (Portland, Oregon)
ULEV	Ultra low-emission vehicle
UTA	Utah Transit Authority
VIP	Vanpool incentive program
VMT	Vehicle miles traveled
VOC	Volatile organic compound
WashCOG	Metropolitan Washington D.C. Council of Governments
ZEV	Zero-emission vehicle

Appendix E: Glossary

Alternative Fuels: Non-gasoline fuels used to operate motor vehicles. Includes methanol, ethanol, or other alcohols and blends; natural gas; liquefied petroleum gas; hydrogen; and electricity.

Area Source: Small stationary and non-transportation pollution sources that are too small and/or numerous to be included as point sources, but may collectively contribute significantly to air pollution.

Attainment area: An area with air quality that meets or exceeds EPA health standards. An area may be an attainment area for one pollutant and a nonattainment area for others.

California Low-Emission Vehicles: California will require four new, tailpipe standards for cars sold in the state beginning in 1994. The standards are more stringent than federal standards. California will introduce four additional vehicle categories having even more stringent emission standards: TLEVs, LEVs, ULEVs and ZEVs. This program allows manufacturers to use any combination of control technology, conventional and clean-fueled cars, and alternative fuels to meet the standards. This approach treats vehicles and fuels as a system, providing flexibility and encouraging cooperation among fuel and automobile industries.

CAAA: Clean Air Act Amendments of 1990.

Carbon Monoxide (CO): A colorless, odorless gas produced through incomplete combustion of organic fuels. Automobiles are primary sources of CO.

Clean-Fueled Vehicles: Vehicles that must meet or exceed strict emission standards. They could include those powered by natural gas, alcohol fuels, or electricity.

Cold-Start Emissions: Emissions resulting during the first few minutes of vehicle operation before the catalyst heats up and becomes effective.

Catalytic Converter: A device containing a catalyst for converting automobile exhaust into modestly harmless products.

Conformity: The Clean Air Act Amendments of 1990 (CAAA) require that the transportation plans, programs, and projects conform to the purpose of the state implementation plan (SIP) and forbid federal approval or funding of any project that would cause or contribute to a violation of a national ambient air quality standard (NAAQS). Under the amendments, a conforming transportation plan, program, or project is one that "does not result in or contribute to a new violation in the NAAQS in any area; does not increase the severity or frequency of a NAAQS violation; and does not cause the delay in attainment of the NAAQS or other interim emissions reduction goals or other milestones in any area."

Congestion Pricing: A road fee levied based on the peak periods of travel.

Congestion Mitigation and Air Quality Improvement Program (CMAQ): A funding program created with the Intermodal Surface Transportation Equity Act of 1991 (ISTEA) that directs funding to projects that help meet national air quality standards. CMAQ funds generally may not be used for projects that result in the construction of new capacity available to single-occupancy vehicles.

Emission Budgets: The part of the state implementation plan (SIP) that identifies the allowable emissions levels, mandated by the NAAQS, for certain pollutants emitted from mobile, stationary, and area sources. The emissions levels are used to meet emission reduction milestones, attainment, or maintenance demonstrations.

Emissions Inventory: A complete list of sources and amounts of pollutant emissions within a specific area and time interval.

Emission Fees: Charges based on an estimate of a vehicle's emissions. Fees may be levied at the time of registration based on a reading of the vehicle odometer and a measurement of the tailpipe emissions.

Employer Commute Options (ECO): Employer-based transportation management plans. Employers with more than 100 employees in some nonattainment areas were originally required to adopt plans under the CAAA to increase occupancy-for-work commutes by 25 percent. Such programs are now optional and used only in a few states.

Employee Paid Parking: Charging employees for previously free parking. Revenues may be used to subsidize transit and ridesharing incentives.

Episodic Measures: Activity-based mobile source programs that are implemented during identified periods of high pollutant concentrations, varying by meteorological conditions. These measures may or may not be continuous in nature, depending on program design.

Gasoline Taxes: Highway user fees mandated by Congress to fund transportation improvements.

High-Occupancy Toll Lanes (HOT lanes): Special highway lanes that charge a higher fee to single- or low-occupancy vehicles, usually during peak travel periods.

High-Occupancy Vehicle (HOV) Lanes: Special highway lanes that prohibit single-occupancy vehicles, usually during peak travel periods.

Hot-Soak Emissions: Emissions that primarily come from the engine area where fuel is vaporized for combustion and from overload of the carbon canisters that are designed to control evaporation from the tank and engine. A good pressure cap will prevent most vapors from leaving the tank.

Hot Spot: An area where high concentrations of carbon monoxide and particulate matter occur. One criterion for conformity that individual projects must meet is to demonstrate that the project will not cause a hot spot.

Hydrocarbon (HC): HCs are compounds of carbon and hydrogen and include volatile organic compounds such as aldehydes and alcohols. Transportation-related HCs are produced primarily through unburned fuel that enters the atmosphere in vehicle exhaust.

Inspection and Maintenance (I&M): An emissions testing and inspection program to ensure that the catalytic converter or other emissions control devices on in-use vehicles are properly maintained.

Intermodal: The ability to connect modes of transportation.

ISTEA: Intermodal Surface Transportation Efficiency Act of 1991. This was a legislative initiative that restructured funding for transportation programs. ISTEA authorized increased levels of highway and transportation funding and an increased role for regional planning commissions/MPOs in funding decisions. ISTEA required comprehensive regional and statewide long-term transportation plans and increased emphasis on public participation and transportation alternatives.

Land-Use Planning: Community-based planning for future development. Fostering land-use patterns that minimize vehicle travel may achieve more efficient use of the transportation infrastructure.

Lead: A poisonous heavy metal that damages the nervous system and kidneys and impairs mental function. It entered the atmosphere as a result of the combustion of gasoline that contained lead antiknock compounds. Phase-out of leaded gasoline was mandated under the CAAA.

Low-Emission Vehicle (LEV): A vehicle meeting emission standards stricter than Tier 1 and less strict than TLEV, ULEV, and ZEV.

Metropolitan Planning Organization (MPO): The organizational entity designated by law with lead responsibility for developing transportation plans and programs for urbanized areas of 50,000 or more. MPOs are established by agreement of the governor.

Mobile Source: These include motor vehicles, aircraft, seagoing vessels, and other transportation modes. The mobile source-related pollutants are CO, VOCs, NO_x, and PM_{10}.

Mode Shifting: Incentives or mandates to alter travel behavior, such as telecommuting, compressed work weeks and flexible work schedules.

National Ambient Air Quality Standards (NAAQS): Health-based standards for airborne particulates, lead, nitrogen dioxide, ozone, carbon monoxide, and sulfur dioxide.

Nitrogen Oxide (NO_x): Oxides of nitrogen. This includes a number of compounds resulting from the burning of fossil fuels.

Nonattainment area: An area that exceeds NAAQS and has been formally designated as nonattainment by EPA. The CAAA divides CO and ozone nonattainment areas into categories based on severity of pollution. It requires certain programs in all areas and additional control measures in areas that have more severe pollution. An area remains in nonattainment until EPA redesignates it to attainment.

Non-Road Vehicle and Engine Controls: Emission controls for construction equipment, lawn and garden equipment, and recreational marine engines. Program can be developed to encourage turnover of older, uncontrolled equipment.

Onboard Diagnostics: Computerized systems that detect emission control failures and notify the driver of malfunctions so the vehicle can be repaired.

Onboard Vapor Recovery: Canisters on vehicles that capture gasoline fumes released during refueling.

Oxygenated gasoline: Gasoline enriched with oxygen-bearing liquids to reduce CO production by permitting more complete combustion.

Ozone: Also known as smog, ozone is produced through a reaction of NO_x and VOC emissions in sunlight.

Particulates/Particulate matter: A category of air pollutant that includes all solid particles and liquid droplets in the air, except water. Particulate matter may be in the form of fly ash, soot, dust, fog, fumes, etc.

Pricing Strategies: Market-based policies or economic incentives to change travel behavior.

Reformulated Gasoline (RFG): Gasoline reformulated to meet federal requirements to reduce VOCs, NO_x, and toxics. RFG is required in many ozone nonattainment areas.

Road fees: Similar to tolls and other charges for road use; may employ automatic vehicle identification (AVI) technology.

Scrappage: Program to accelerate retirement of older, more polluting vehicles, often through buy-back programs.

Seasonal Measures: Emissions reduction programs that are in effect only during the season when the area experiences high pollutant concentrations.

Single-Occupancy Vehicle (SOV): Vehicles driven by one person with no passengers.

State Implementation Plan (SIP): These are detailed plans states must develop and implement under federal clean air laws to bring areas that exceed the NAAQS into compliance. State and local air quality agencies have the primary responsibility for preparing the SIP. The SIP development process must allow for public review of plans and public hearings, and it must be supported by adequate legislation before the governor submits it to EPA for approval.

Stage II Vapor Recovery: A system to capture and recover evaporative emissions from refueling vehicles.

Stationary Source: Relatively large, fixed sources of emissions (e.g., chemical process industries, petroleum refineries, etc.).

Tailpipe Standards: Federally mandated standards established for CO, hydrocarbons (or VOCs), and NO_x. The CAAA of 1990 strengthened existing standards. In 1994, Tier 1 Tailpipe Standards were phased in for vehicles sold nationwide. Tier 2 Tailpipe Standards are twice as stringent as Tier 1 and will be required beginning in 2004.

Tier 1: New tailpipe standards for VOCs (from 0.41 grams per mile (gpm) to 0.25 gpm) and NO_x (from 1 gpm to 0.4 gpm) established under the CAAA; CO remains at 3.4 gpm. Phased in beginning in 1994 for vehicles sold nationwide.

Tier 2: Tailpipe standards twice as stringent as Tier 1; required beginning in 2004.

Traffic Flow Improvement Programs: Signalization or other strategies to reduce congestion.

Transit: Passenger service provided to the general public along established routes with fixed or variable schedules at published fares.

Transportation Control Measure (TCM): Any action intended to adjust traffic patterns or decrease vehicle use to reduce air pollutant emissions. Examples include transit, HOV and HOT lanes, traffic-flow improvements, car- and vanpooling, flextime, telecommuting, and bike/pedestrian programs.

Transportation Plan and Transportation Improvement Program (TIP): The metropolitan transportation planning process requires each urbanized area to develop a transportation plan and a TIP. The MPO must approve the transportation plan, and the MPO and the state's governor must approve the TIP to receive federal funds for the transportation projects. The transportation plan is a 20-year plan describing policies, strategies, and facilities to accommodate current and future travel demands and to make more efficient use of the existing transportation system. The TIP is a three-year program of transportation projects consistent with the transportation plan. The TIP includes a priority list of projects and project segments to be carried out within each three-year period after the adoption of the TIP. The TIP is developed by the MPO, in cooperation with the state and affected transit operators, and it must be updated at least once every two years. These are then submitted to FHWA for approval.

Trip-Reduction Ordinances: Prohibitions against driving during certain periods or on certain days.

Transitional Low-Emission Vehicle (TLEV): A vehicle in the emissions class more stringent than Tier 1, and less stringent than LEV, ULEV, and ZEV.

Ultra-Low-Emission Vehicles (ULEV): A vehicle in the emissions class more stringent than Tier 1, TLEV, and LEV, and less stringent than ZEV.

Vehicle Miles Traveled (VMT): This refers to the total number of miles traveled by vehicles in a given area.

Volatile Organic Compounds (VOCs): Also referred to as non-methane hydrocarbons (NMHCs) or reactive organic gases (ROGs). VOCs are compounds containing carbon and hydrogen (in combination with any other element) that have a high volatility. They are reactive in sunlight, forming ozone or smog when mixed with nitrogen oxides in the atmosphere.

Voluntary Measures: Emission reduction programs that rely on voluntary actions of individuals or other parties for achieving emission reductions.

Zero-Emission Vehicle (ZEV): A vehicle that does not contribute directly to air pollution. The only current technology that fulfills this definition is an electrically powered vehicle.

References

California Department of Transportation. "Emission Reduction Calculation Methodologies: General Instructions." Sacramento, Calif.: California Department of Transportation, 1996.

ENDZONE, Maryland Department of the Environment, Metropolitan Washington Council of Governments, and Baltimore Metropolitan Council of Governments. *Model Pilot Program: SIP Credit for Voluntary Air Quality Measures.* Baltimore, Md.: ENDZONE Partners, 1998.

Energy Information Administration. *Alternatives to Traditional Transportation Fuels: An Overview.* Washington, D.C.: U.S. Department of Energy, 1994.

Glover, Ed. *Analysis of the Arizona IM240 Test Program and Comparison with the TECH5 Model.* (EPA 420-R-97-001.) Washington, D.C.: U.S. Environmental Protection Agency, 1997.

"Guidance on Incorporating Voluntary Mobile Source Emission Reduction Programs in State Implementation plans (SIPs)." Memorandum to regional administrators from Richard D. Wilson, Acting Assistant Administrator for Air and Radiation, U.S. Environmental Protection Agency, Washington, D.C., October 24, 1997.

Hirschhorn, Joel. *Growing Pains: Quality of Life in the New Economy*. Washington, D.C.: National Governors' Association, 2000.

Ozone Transport Assessment Group. "Mobile Sources Assessment: NO_x and VOC Reduction Technologies for Consideration by the Ozone Transport Assessment Group—April 11, 1996." Washington, D.C.: Ozone Transport Assessment Group, 1996.

Snow, Heidi. *Cleaner Fuels, Cleaner Vehicles and Altered Driving Habits: New Measures Under the Clean Air Act to Control Pollution from Highway Vehicles.* Washington, D.C.: National Governors' Association, 1992.

Transportation Research Board. *The Emissions Reduction Potential of the Congestion Mitigation and Air Quality Improvement (CMAQ) Program: A Preliminary Assessment.* TRB Paper Number 981579.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. "Alternative Fuel Case Study: Barwood Cab Fleet Study Summary." Report Number NREL/FS-540-26334. (May, 1999).

U.S. Department of Energy. *Comparative Alternative/Clean Duel Provisions of the Clean Air Act and the Energy Policy Act.* Washington, D.C.

U.S. Department of Transportation. *The Congestion Mitigation and Air Quality Improvement (CMAQ) Program Under the Transportation Equity Act for the 21st Century (TEA-21): Program Guidance.* Washington, D.C., 1999.

U.S. Department of Transportation, Federal Highway Administration. *Transportation Air Quality: Selected Facts and Figures.* Washington, D.C., 1998.

U.S. Department of Transportation. *Transportation Conformity: A Basic Guide for State and Local Officials.* Washington, D.C., 1997.

U.S. Department of Transportation, Federal Highway Administration. *Congestion Mitigation and Air Quality Improvement Program: A Summary of Sixth-Year Activities (FY 1997) October 1996-1997.* Washington, D.C., 1999.

U.S. Environmental Protection Agency. *Granting Air Quality Credit for Land-Use Measures: Policy Option.* Report No. SR99-09-01.

U.S. Environmental Protection Agency. *Recognizing the Air Quality Benefits of Local and State Land-Use Policies and Projects in the Air Quality Planning Process: Public Comment Draft*. Report No. EPA420-P-00-002. (June 2000.)

U.S. Environmental Protection Agency. *MOBILE6: A Revised Model for Estimation of Highway Vehicle Emissions.* Report No. EPA420-S-99-001.

U.S. Environmental Protection Agency. "Description of the MOBILE Highway Vehicle Emission Factor Model." Washington, D.C., 1999.

U.S. Environmental Protection Agency. "Clean Cars for Clean Air: Inspection and Maintenance Programs." EPA 400-F-92-016, (January 1993).

U.S. Environmental Protection Agency. "High-Tech Inspection and Maintenance Tests (Procedures and Equipment)." EPA 400-F-92-001. (January 1993.)

U.S. Environmental Protection Agency. "Remote Sensing: A Supplemental Tool for Vehicle Emission Control." EPA 400-F-92-017. (August 1993.)

U.S. Environmental Protection Agency. *Program User Guide for Interim Vehicle Clean Screening Credit Utility: Draft Report*. EPA 420-P-98-007. (May 1998.)

U.S. Environmental Protection Agency. *Background Information for Land-Use SIP Policy.* Washington, D.C., 1998.

U.S. Environmental Protection Agency. *Indicators of the Environmental Impacts of Transportation.* Second edition. Washington, D.C., 1999.

U.S. Environmental Protection Agency. *Major Elements of Operating I&M Programs.* EPA 420-B-9-008. (December 1999.)

U.S. Environmental Protection Agency. "Technical Highlights: Clean Screening in Inspection and Maintenance Programs." EPA 420-F-98-023. (May 1998.)

U.S. Environmental Protection Agency. *Creating Transportation Choices: Congestion Mitigation and Air Quality Improvement Program Success Stories.* Washington, D.C.: Environmental Protection Agency, 1999.

U.S. General Accounting Office. "EPA's Inspection and Maintenance Program." GAO/RCED-96-63. (March 1996.)

U.S. General Accounting Office. *Energy Policy Act of 1992: Limited Progress in Acquiring Alternative Fuel Vehicles and Reaching Fuel Goals*. Washington, D.C., 2000.

Wenzel, Tom and Sawyer, Robert. *Analysis of a Remote Sensing Clean Screen Program in Arizona.* Berkeley, Calif.: Lawrence Berkeley National Laboratory, 1998.

Endnotes

1. Although mobile sources are a significant piece of the puzzle, stationary, natural, and area sources also contribute to the air quality problem. However, non-mobile sources are beyond the scope of this document.

2. The Clean Air Act requires that vehicle owners spend at least $450 towards emissions-related repairs before a waiver is granted, but states may increase this amount to obtain extra credits or use vehicle scrappage programs, where old, dirty vehicles are destroyed to lower the minimum required expenditures.

3. The program was known as The Voluntary Ozone Action Program at the time.

4. This alert level is based on EPA's air quality index: 125 ppb and above is a red alert, 105ppb-125 ppb is an orange alert, and 61ppb-105 ppb is a yellow alert. An OAD designation is usually reserved for the red alert days but may also be used for consecutive days at orange alert.

5. An ozone action day (OAD) in the ENDZONE program is comparable to a Smog Alert Day in the Partnership for a Smog-Free Georgia program.

6. Non-transportation categories of voluntary reductions come from non-commercial painting, lawn and garden equipment, and consumer aerosol use.

7. This assumes the vehicles are dedicated AFVs, running solely on the alternative fuel. Some AFVs can run on conventional fuel as well, but these do not provide emissions benefits.

8. Vehicles are assumed to burn 500 gasoline gallon equivalent (gge) of LPG per year, with a fuel efficiency of 11 mpgge, based on data from DOE's Alternative Fuels Data Center. These vehicles are categorized as CNG Light-Duty Truck 4. The Ford F-250 pickup truck is an example and it meets federal ULEV standards.

9. Calculations use estimates of evaporative emissions based on Mobile 5a modeling. This calculation assumes summer temperatures of 65 degrees-72 degrees, 32 miles per hour average speed. This results in about 0.56 g evaporative HC per mile. The vehicles are assumed to burn 500 gge of LPG per year and achieve a fuel efficiency of 11 mpgge.

10. Calculations assume vehicles drive 100,000 miles per year, and emit the Federal Tier I emissions of 3.4g/mi for CO, and 0.4g/mi for NO_x for the a baseline emissions profile for 270 gasoline taxis. Emissions for the CNG taxis were assumed to be 0.476g/mi for CO, and 0.132g/mi for NO_x, based on data from the Natural Gas Vehicle Coalition. These emissions reductions assume the same parameters as above for evaporative emissions.

11. As of July 1999.

12. This is the at-pump price, which includes a $0.54/gal. federal tax credit. Without the credit, GGE prices would be $1.57-1.84/gal. It may be possible to produce biomass ethanol for $1.22/gal.

13. This is for a vehicle with a 17 mpg - 25 mpg rating, and an EV efficiency of 4.0 mi/kW-hr with a $.05/ kW-hr. electricity price.

14. This refers to the MOBILE6 model. Although this is not currently in use in the states, the shortcomings of this most sophisticated model further highlight the inability of older models to account for results of innovative programs.