Air Quality Management

Successes and Emerging Challenges

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Solving the air pollution problems caused by transportation, particularly from highways, has been a focus of U.S. policy makers for decades. California introduced the first pollution control requirements on new motor vehicles 40 years ago. The federal government took legislative action via the Clean Air Act (CAA) and the National Environmental Policy Act, both introduced in 1970. Today, the Environmental Protection Agency (EPA) has the responsibility to set, review, and revise the National Ambient Air Quality Standards (NAAQS).

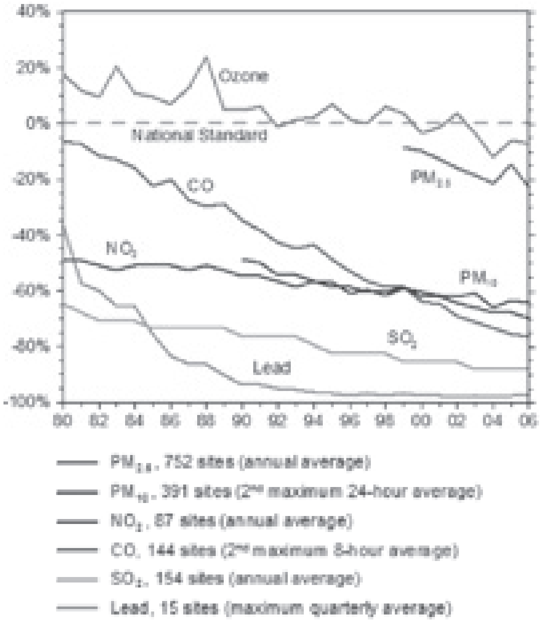
Smog in Atlanta, Georgia.

Targeting Pollutants

The NAAQS focuses on six criteria pollutants: carbon monoxide (CO), ozone, particulate matter (PM), nitrogen dioxide, sulfur dioxide, and lead. Highway sources contribute significantly to emissions of CO, the precursors of ozone, and PM; the other pollutants derive primarily from industrial sources.

Since the introduction of air quality standards, the United States has reduced the levels of criteria pollutants (Figure 1). Between 1980 and 2006, aggregate emissions of the criteria pollutants have decreased by 49 percent, despite an increase of 121 percent in the gross domestic product; of 101 percent in vehicle miles of travel (VMT); of 32 percent in population; and of 29 percent in energy consumption (*1*). Nevertheless, ground-level concentrations of ozone and fine PM continue to provide challenges in many areas of the country—in 2000, more than 100 million people were living in counties that exceeded the NAAQS limits for these pollutants (*1*).

FIGURE 1 Comparison of criteria pollutant levels to the National Ambient Air Quality Standards (*1*). National levels are shown, which are averaged across all sites with complete data for the time period.



Concerns about climate change have increased attention on the greenhouse gas (GHG) emissions from the transportation sector. Transportation is the largest source of carbon dioxide (CO_2) emissions in the United States and is the second-largest source of all GHG emissions combined (2). The U.S. highway system is the world's fourth largest emitter of CO_2, after China, Russia, and the rest of the United States (*3*).

In the past decade, transportation air quality activities have focused on mobile source air toxics (MSATs), which have adverse health effects but are not subject to ambient air quality standards. MSATs of particular concern are benzene, a carcinogen; 1,3-butadiene; and diesel PM. In addition, EPA has identified dozens of other chemicals that are emitted by motor vehicles and that can lead to adverse health impacts.

Air Quality Successes

CO Attainment

In 1990, EPA designated nearly 90 communities in nonattainment of the ambient air quality standard for CO; today only 3 remain in nonattainment. Since 1990, EPA has observed a decreasing trend in CO emissions nationwide (*1*); from 1990 to 2006, the second maximum 8-hour average concentrations of CO decreased by 62 percent. Transportation remains by far the largest source of CO emissions, but the decrease was attributable in part to technological advances, namely the catalytic converter and oxygenated fuels.

Emissions Reduction Technology

In the past 30 years, drastic changes have occurred in emissions reduction technology. Computer-controlled fuel injection systems have replaced the carburetor; catalytic converters and evaporative emissions control systems are commonplace; and on-board diagnostic computers monitor the fuel and emissions control systems and notify the driver of any problems.

In addition, new materials—including high-strength steels, ceramics, and carbon fiber—have reduced vehicle weight and fuel consumption. Hybrid-electric drivetrains are available on several vehicle models, and advanced electric drive technologies, including fuel cells, plug-in hybrid vehicles, and all-electric vehicles powered by lithium batteries, are being tested on the road. New fuels, such as biodiesel and cellulosic ethanol, are starting to reduce the carbon footprint of the fuel supply, improving U.S. energy security at the same time by reducing dependence on imported oil.

Transportation Conformity

The CAA requires that transportation planning conform to the goals set in air quality planning. Long-range transportation plans therefore cannot generate emissions that exceed the targets set in air quality improvement plans. This conformity requirement has led to better coordination between air quality and transportation planners, improvements in travel and air quality modeling, and better-informed decision making.

Congestion Mitigation and Air Quality

The Congestion Mitigation and Air Quality (CMAQ) Improvement Program provides funds to transportation agencies for projects that reduce criteria air pollutants from transportation-related sources. The legislation requires agencies distributing CMAQ funds to give priority to diesel engine retrofits and to other cost-effective emissions reduction and congestion mitigation activities that provide air quality benefits. A 2002 review of CMAQ by a National Research Council–appointed committee found that the program had been successful in achieving its intended objectives, but that improvements could be made in quantifying the benefits from projects (*4*).

PHOTO COURTESY OF PORTLAND GENERAL ELECTRIC

Portland General Electric's charging stations support both plug-in electric and plug-in hybrid vehicles, a step in reducing vehicle emissions.

Emissions Modeling

Models have been developed to quantify the differences in air quality emissions from changes in travel activity. Advances in urban travel demand modeling have helped planners simulate real-world travel activity. For instance, EPA's MOBILE6.2 emissions model has improved the characterization of vehicle emissions under different conditions, and EPA's MOVES model promises additional improvements.

New measurement technologies have improved the scientific understanding of emissions under various conditions and have improved emissions estimates. For example, portable emissions monitoring systems can measure tailpipe emissions as a vehicle drives down the road. Other research includes advanced traffic counts, speed studies, and instrumented vehicle studies to characterize vehicle activity.

Future Challenges

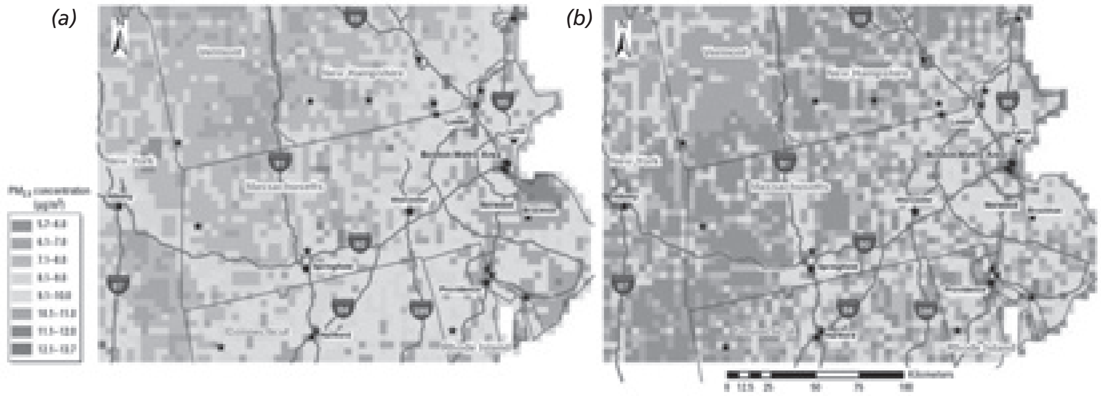
Thirty years of research and experience have improved understanding of transportation-related air pollution, but new issues require attention. Following are some of the key air quality challenges facing the transportation community in the next decade and beyond.

Tighter Air Quality Standards

EPA periodically revisits each of the criteria pollutant air quality standards and makes adjustments as necessary. In the past 3 years, EPA has tightened the standards for ozone and PM. As a result, more areas are or will be in nonattainment.

These nonattainment areas will need to identify new control strategies to reduce emissions and comply with the standards. Some of these areas are having to comply with the CAA transportation conformity requirements for the first time, and local officials will need to understand the regulatory

Mean concentrations of particulate matter (PM) with diameters ≤ 2.5 μm during an entire modeling period (*a*) predicted by the aerosol optical depth (AOD) model and (*b*) by the non-AOD model. Stars represent the U.S. EPA monitoring sites.



requirements and the necessary modeling tools. Another problem is reconciling the trade-offs when mitigation strategies reduce the emissions of one pollutant but increase the emissions of another.

PM Hotspot Analysis

For a long time, EPA has been concerned that PM hotspots—that is, areas of elevated PM concentrations—may develop in the vicinity of highway and transit projects. A lack of adequate modeling tools, however, has delayed the quantitative analysis of potential PM hotspots; improved models are expected to be available soon, and agencies will be required to calculate the PM concentrations near proposed projects. Departments of transportation nationwide will need to develop expertise in the tools for performing this analysis.

MSATs and Roadside Health Issues

Epidemiological studies of occupational exposure to high concentrations of some MSAT compounds have documented adverse human health effects, including cancer and irritation of the respiratory tract. Recent roadside epidemiological studies also have raised health issues; some report that proximity to roadways is related to adverse health outcomes, particularly respiratory problems. As a result, government agencies are concerned about public exposure to MSATs.

The policies applied to MSATs and to other roadside health issues—as well as those crafted to deal with criteria air pollutants—have significant gaps, however. In 2001 and 2007, EPA issued rules to control MSATs through motor vehicle emission and fuel standards, and FHWA released guidance for gauging the potential impacts of proposed highway projects. But other strategies adopted for criteria pollutants do not apply to MSATs, including the clean air goals or criteria set by the NAAQS, the transportation conformity process, and the CMAQ program.

The Health Effects Institute (HEI) has completed objective reviews of the health issues that result from exposure to MSATs (*6, 7*). The findings show that exposure to many MSATs comes from sources other than vehicles. HEI concluded that the data in most cases are insufficient for assessing the effects of ambient concentrations on human health; for example, considerable uncertainty remains about the lowest concentration associated with adverse health effects from benzene exposures. No national consensus has been reached on acceptable levels of MSAT exposure.

Congestion Implications

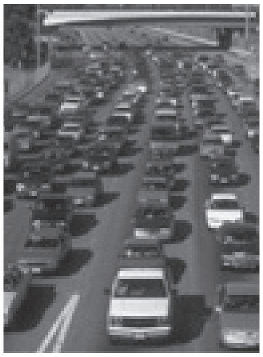
As travel activity grows and new infrastructure does not keep pace, congestion has increased on urban and rural roadways. Congestion has implications not only for air quality, because vehicle emission rates are generally higher under congested conditions, but also for energy consumption and GHGs, because vehicles are less efficient under congested conditions. If congestion is not addressed and the trends continue, fulfilling air quality goals and climate change goals will be more difficult.

Improving Emissions Models

New air quality challenges have led to the need for better models. The transportation community needs better tools to assess the finer-scale impacts of projects on PM and MSATs. Better local-scale tools would improve understanding of the energy consumption and GHG impacts of projects, as well as of the travel activity impacts of smart growth projects.

In 2009 and 2010, transportation agencies will need to develop expertise in EPA's MOVES model, which will replace the MOBILE model used since the 1970s. The differences in emissions estimates between MOVES and California's Emfac model also will need to be reconciled.

Better integration of transportation models and air quality models will help planning agencies meet the growing demands of transportation and air quality analyses. Also needed are better projections of future VMT growth, including a better understanding of the effects on VMT from increased fuel prices and from changes in demographic trends.



Addressing Climate Change

Significant steps have been taken to reduce GHG emissions from the transportation sector and to prepare areas for the possible future impacts of climate change. Examples include the aggressive fuel economy standards and renewable fuels program of the 2007 Energy Independence and Security Act (*5*), and voluntary programs to reduce transportation GHG emissions, such as the SmartWay Transport program to reduce emissions from hauling freight.

The United States is also a hub of climate research. In March 2008, the Transportation Research Board, working with the National Research Council's Board on Earth and Life Studies, published a special report on the potential impacts of climate change on transportation (*8*); and FHWA issued a study on the effects of potential climate changes on the highway infrastructure of the Gulf Coast—the first-ever attempt to quantify mode-specific climate impacts in a specific region of the United States (*9*).

More than 30 states have adopted climate action plans. Most of these include actions to reduce transportation GHG emissions through cleaner vehicles and renewable fuels, through increased public transit, and through the implementation of smart growth strategies to reduce growth in VMT. About half of the plans include requirements to analyze the potential GHG emission impacts of transportation plans or individual projects.

Climate change raises two challenges for transportation:

- Mitigation, reducing GHG emissions; and
- Adaptation, preparing for the impacts of climate change on transportation infrastructure.

On the mitigation side, major reductions are needed in transportation GHG emissions to achieve the levels that scientists have determined are necessary to avoid the worst impacts of climate change. The new programs in the 2007 energy bill will halt the increase of transportation-related GHG emissions but do not provide substantial reductions.

Addressing transportation GHG emissions requires a comprehensive suite of measures, including more fuel-efficient vehicles, cleaner fuels, smarter development to reduce per capita VMT, increased public transit, and carbon sequestration. Many of these activities will yield additional benefits, such as reduced urban air pollution and greater energy security.

Adaptation poses a significant challenge because of the uncertainty about the timing and magnitude of climate impacts. Transportation agencies routinely make investment decisions for infrastructure that will last many decades, and decisions made today can

Vehicle in the SmartWay Transport Partnership, an innovative collaboration between the U.S. Environmental Protection Agency and the freight industry to increase energy efficiency while reducing greenhouse gases and air pollution.

help prevent costly impacts in the future. Tools are needed to help planning agencies factor climate vulnerability and risk into the decision-making process. Although much work is under way, the 2008 TRB and FHWA reports offer valuable advice to help agencies get started.

Applying the Framework

The study of transportation's impacts on air quality has increased in complexity in the past three decades. Despite many successes, new challenges have arisen.

A comprehensive policy framework, established to control the criteria air pollutants, was a major contributor to many of the successes. Can this same framework be applied or adapted to meet the new challenges? Dedicated professionals in the field, with broad expertise and experience, will continue to work to improve air quality through research, innovation, and implementation of strategies to reduce emissions.

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