Air Quality and the Transportation Community

Executive Committee of the Transportation Research Board Addresses this Issue in a Special Session

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- Babies in Mexico City, breathing air heavily polluted with lead from gasoline, will probably grow up mentally retarded.
- On a very hot, still day in Chicago, elderly residents are warned that the ozone concentration in the air outside is so high that it could be fatal if they exert themselves.
- According to many researchers, if the upper level of the ozone layer is totally depleted, everyone on earth risks skin cancer.

These are all rather dramatic statements, but the debate in the United States over the causes and cures of air quality problems has become intensified because of such comments. An additional source of controversy is the potentially immense cost of dealing with the heterogeneous set of problems that affect air quality.

If a new generation of strict air quality programs is implemented, the costs will be borne not only now but far into the future. President Bush, in calling for a greatly strengthened Clean Air Act, estimated that eliminating excessive ozone at the surface, emissions that cause acid rain, and other pollutants would cost the United States as much as $19 billion per year.

The National Academy of Sciences *(1)*, in a series of papers dealing with major science and technology issues today, noted that elevated concentrations of greenhouse gases and chlorofluorocarbons that erode the ozone shield are causing substantial global changes. The NAS urges researchers to "explore means of reducing energy demand without impeding economic growth" and to try to develop new energy sources that do not produce carbon dioxide (CO_2). The air quality problem at large has obviously gained a high level of political attention, a degree of concern that has been reinforced with research and analysis by the U.S. scientific community.

At a special session held at the 1989 summer meeting of the TRB Executive Committee, a panel of national experts made presentations describing aspects of the air quality problem. The following issues were addressed:

- Nature of air quality and air pollution,
- Transportation component of the air quality problem,
- Nature of transportation solutions to the air quality problem, and
- The professional response and TRB's role.

The Air Quality Problem

According to Alan Robock of the University of Maryland, one of the panel members at the TRB Executive Committee session on Air Quality, the atmosphere, an extremely complex envelope of gases that surrounds the earth, is highly sensitive to the products of the human environment. Very slight changes in the balance of gases within the atmosphere can cause significant changes in climate, producing a dramatic effect on the environment and the way that people live. The NAS report mentioned previously notes both the severity and the perma-

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nence of the air quality problem. Many atmospheric scientists believe that the best approach to the air quality problem is to slow down the rate of evolution of ongoing changes. In this way, the chances of causing dramatic changes in the climate will be minimized.

The conditions that Robock identified as affecting the air include

- Greenhouse effect,
- Depletion of the ozone layer, and
- General air pollution.

Greenhouse Gases

The depletion of the ozone layer appears to be a long-term change in the atmosphere. Solutions to this problem have been examined not only by the international science community, but also by the international political community. In 1987, international concerns resulted in the establishment of "The Montreal Protocol." This document calls for a 50 percent reduction in the use of chlorofluorocarbons, which are considered a major cause of ozone depletion. Among the many sources of chlorofluorocarbons are air conditioning refrigerants, including those from car and truck air conditioners.

The greenhouse effect is the accumulation in the atmosphere of certain transparent gases, including CO_2, that prevents or retards the escape of the solar heat that radiates back from the earth's surface. The accumulation of gases causes a buildup of heat in the atmospheric layer called the troposphere, a phenomenon that can lead to gradual but steady atmospheric warming. Some of the heat buildup is normal and desirable, but the possible intensification of the effect by the rapidly increasing production of "greenhouse gases" has become a concern.

Carbon Dioxide Greenhouse

The global population has increased at a rapid rate since 1850. A study of the data that indicate increases in CO_2 caused by fossil fuel use in that same period would show a strikingly similar pattern of growth, which appears to demonstrate the contribution of fossil fuel to the greenhouse effect.

"Can [the ozone problem], growing in intensity and extent, be controlled in a nation so wedded to the automobile?"

At least half of the current greenhouse effect is caused by the continued pumping of CO_2 into the atmosphere. The net result of the greenhouse effect, and the source of most of the current concern, is an increase in global warming. Many models now predict an average temperature increase of 2° to 6°C by 2060. Models have been used to demonstrate that the effects caused by this warming might range from melting of the polar ice caps, with a resulting increase in sea level that could submerge coastal cities, to the creation of dust bowls in fertile plains.

Any changes of climate, however, might produce geographical areas that could be considered "winners," as well as the "losers" already mentioned. The uncertainty of the model results makes it clear that human activities may be creating problems the dimensions of which are not understood and may not be controllable by human means. Many researchers believe that the greenhouse effect must somehow be restrained at or near current levels.

Robock noted a lag between the burning of fuel, with the attendant release of CO_2 into the atmosphere, and subsequent atmospheric warming. To keep atmospheric CO_2 near its current level, future production of this gas must be cut significantly. The production of CO_2 is closely tied to population. World population continues to grow rapidly, and so does the production and use of motor vehicles. A total of 60 percent of transportation-produced CO_2 comes from motor vehicles. The linkage between transportation—particularly motor vehicles—and the global warming problem is plain.

Other Air Pollution

The final component of the air quality issue, according to Robock, is general air pollution. The burning of fossil fuels produces lead, carbon monoxide, carbon dioxide, nitrogen oxides, sulfuric acid, volatile organic compounds, ozone, and other by-products. Many of these substances are the by-products of burning gasoline and diesel fuel. To a certain extent, they can be controlled at the source of combustion.

As noted previously, transportation is one of the primary sources of greenhouse warming. Other major sources include the electric utility industry [33 percent of U.S. CO_2 emissions (2)] and deforestation [10 to 20 percent of greenhouse gases (2)]. Controlling vehicle emissions is only one of many significant steps that must be taken if progress is to be made in reducing the greenhouse effect and improving overall air quality.

Transportation and Air Quality

The burning of fuels in motor vehicles is identified in air quality programs as the greatest source of undesirable transportation-related emissions. The Environmental Protection Agency has been the leader in the battle to ensure the quality of our atmosphere.

According to John Calcagni of EPA in his presentation to the TRB Executive Committee on "The Fight for Clean Air," the landmark Clean Air Act is the "teeth" of the agency's regulatory program. The Clean Air Act rapidly led to the redesign of engines and exhaust systems, as well as the installation of emission controls by U.S. motor vehicle manufacturers. Leaded fuel has all but disappeared. The legislation

- Established automobile tail pipe emission standards,
- Established national ambient air quality standards for various pollutants,
- Required states to develop and

adopt air quality attainment plans,

- Established dates for the attainment of air quality standards, and
- Established requirements for states that wished to have time extensions to attain air quality standards through transportation control measures and inspection maintenance programs.

EPA's Campaign

EPA has had mixed success in its push for cleaner air. The removal of lead from gasoline, of course, was a major EPA victory. In cities in many other parts of the world where controls are less stringent, the use of leaded gas has led to devastating health problems. Two major vehicle emissions problems remain: low-level ozone creation and carbon monoxide.

More than 100 million people live in "ozone nonattainment areas" in regions in the United States that violate the National Ambient Air Quality Standards (NAAQS) for these gases. There is little hope that any relief from the problems will occur unless changes are made to existing transportation systems and technology.

An Increasing Problem

The number of motor vehicles and, accordingly, the number of vehicle miles traveled, have increased steadily for the last 50 years. How severe are the resultant problems? Currently, the principal uncontrolled air quality concern is low-lying ozone. This widespread problem occurs when chemical reactions take place in a hot, dusty atmosphere that is charged with car exhaust. The ozone becomes increasingly severe as temperatures get warmer.

The picture so often seen of the hazy, murky Los Angeles Basin, blanketed in ozone produced primarily by automobile exhaust, also occurs in cities as different as Portland (both Oregon and Maine), Salt Lake City, and Charlotte. This poisonous ozone haze exists not just above crowded highways but over entire regions.

Can this problem, growing in intensity and extent, be controlled in a nation so wedded to the automobile? The results of extensive traffic measures taken during the 1984 Los Angeles Olympic Games, described by Calcagni, appear to indicate a qualified "yes."

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Ways and Means

The control measures taken during the Olympics included roadway improvements, traffic management techniques, alternative work schedules, and ordinances to regulate construction schedules and permits. A 14 percent decline in ozone concentrations was attributed primarily to the mitigation of traffic congestion. A concurrent benefit was the reduction in traffic accidents.

The strong set of actions taken in Los Angeles in 1984, however, might not be sustainable for periods longer than a special event such as the Olympics. Additionally, this particular combination of actions might not be suitable for every nonattainment area. It is clear, nevertheless, that strong actions can indeed reduce the severity of the ozone problem. With motor vehicle use increasing in all U.S. cities, some action, at some cost to the public, must be taken.

Daniel Sperling, of the University of California-Davis, another panelist at the Executive Committee session on Air Quality, noted that TRB can, as it has for many other transportation issues, serve as a forum for the review and evaluation of the many air quality programs that will emerge as federal policy becomes more demanding in the push for local compliance with national air quality standards.

Today's Solutions

Because most people in the United States are not willing to reduce driving or the delivery of goods by truck, current approaches to solving air quality problems usually involve modifying some aspect of the motor vehicle environment. These approaches can be grouped as follows:

- Technical solutions involving the hardware or power plant,
- Technical solutions involving vehicle fuels, and
- Behavioral solutions involving changes in the way people use their motor vehicles.

Hardware Solutions

A number of approaches seek to control emissions through the technology of the vehicle itself. In general, these approaches involve either stricter controls on what now exists or redesign of the vehicle and power plant. EPA, although concerned with both strategies, obviously must deal with the entire mix of motor vehicles now operating, whereas industry must be responsive to current and anticipated guidelines.

Roberta Nichols, of the Ford Motor Company, gave the Executive Committee an overview of the hardware and the alternative fuel options being examined by the automotive industry. She noted that EPA is encouraging states to improve the quality of emissions "inventories" collected by regulatory researchers. Assessments of vehicle miles traveled projections, the lifetime and average operating conditions of motor vehicles, and the conditions under which emissions are sampled must all be made. Because these inventories are crucial in providing data for the models used to project air quality, the quality of the procedures used to collect the data must be improved.

Hardware changes that can reduce emissions include

- Stricter controls on new vehicles;
- Improved maintenance to keep engines working to specifications;
- Development and installation of antitampering devices to avoid bypass of pollution controls;
- Development of heavy-duty engines and engines that can use alternative fuels; and
- Integration of variable transmissions, multivalve engines, and more lightweight materials for continued improvement in fuel economy.

Each of these changes may have only a small effect, but collectively they can be significant. Inspection and maintenance programs are critical, for example, because the existing vehicle fleet is an incredibly heterogeneous mix of old and new vehicles. Some still use leaded gasoline. Some get 8 mpg, and some can achieve 40 mpg. The city of Phoenix, Arizona, anticipates a 6.1 percent reduction in emissions from its inspection and maintenance program. Chicago, which has had an inspection program since 1984, has reduced many chemical emissions levels (although the city is still not in compliance with ozone standards); other ambient chemicals also have been reduced. California, in recognition of the increased sophistication of automotive emissions control hardware, has mandated that by 1994, new automobiles must have better on-board computers to monitor the pollution control systems and diagnose system malfunctions.

Presentations on Air Quality and Transportation at TRB Executive Committee Policy Session

Topic	Discussant
The Greenhouse Effect	Alan D. Robock Associate Professor Department of Meteorology University of Maryland
EPA and the Cities: The Fight for Clean Air	John Calcagni Director Air Quality Management Division Office of Air Quality Planning and Standards Environmental Protection Agency
TRB Activities	Daniel Sperling Associate Professor Civil Engineering Department University of California-Davis
South Coast Air Quality Program	John D. Dunlap III Public Advisor and Acting Director of Transportation Programs South Coast Air Quality Management District California
Alternative Fuels	Roberta Nichols Principal Research Engineer Scientific Research Laboratory Ford Motor Company

Alternative Fuels

Because hardware controls will not be sufficient to significantly reduce harmful emissions, the automotive industry is evaluating alternative fuels. These new fuels provide different burning characteristics, but all (with the exception of batteries and hydrogen) generate some CO_2. The amount produced by burning alternative fuels will be only 5 to 15 percent less than that produced by burning current gasoline blends.

Alternative fuels that have been considered are either gaseous, such as hydrogen, methane, and propane, or liquid, such as alcohol (methanol, ethanol, or blends), gasoline derived from methanol, direct fuel extenders, oil-stable hydrocarbons, and coal-derived hydrocarbons, according to Nichols. Four of these fuels are currently being tested: liquefied petroleum gas, compressed natural gas, ethanol, and methanol. Each of these alternatives can cause problems if used as a direct substitute for gasoline. The primary difficulties include fuel storage at the source and in the vehicle, fuel transfer and pumping into the vehicle, performance over the range of vehicle operations, and the equivalent Btu/gallon of the alternative.

Using Alternative Fuels

Nichols noted that research conducted by the Ford Motor Company indicates that of these four fuels, methanol might be most suitable for long-term replacement of current fuels. Methanol can be produced from coal or from other organic materials. Ford has been testing the existing methanol technology in a "flexible fuel vehicle" of its own design. This automobile, intended as a transition vehicle, can use any blend of methanol, ethanol, and gasoline.

Although methanol is a cleaner-burning fuel, some problems remain to be overcome before its use can be accepted. Because methanol provides less Btu output per gallon, more fuel must be stored in the vehicle to allow the same cruising range. The issues of cold start capability, formaldehyde emissions, and

long-term engine durability are still being investigated.

Electrical Power

Another alternative approach is a hybrid engine fueled by a fuel cell. In research sponsored by the U.S. Department of Energy, buses with methanol-powered fuel cells will be tested to examine the viability of this approach. Electricity is often suggested as a prime source of vehicle power, perhaps in the form of batteries that could be recharged at fuel stations. Unfortunately, at this time, the likeliest source for the energy provided at these "charging stations" is the burning of fossil fuels. As noted previously, the combustion of fossil fuels adds to the CO_2 level of the atmosphere, as well as producing undesirable particulate matter.

Behavioral Changes

Changes in hardware and fuel will not be enough to reduce CO_2 and other emissions to acceptable levels. Owners and operators must think about the ways in which they use their motor vehicles. Reductions in harmful emissions may well be possible by achieving significant changes in vehicle use patterns.

The most familiar strategies for changing behavior primarily address single-occupant vehicles. Examples include congestion relief through added highway capacity, intersection improvements, or relocation of activity centers. However, the rapid growth of suburban areas such as Orange County, California, and Du Page County near Chicago, Illinois, shows that yesterday's solutions are today's problems.

Increasing Vehicle Occupancy

John D. Dunlap III, of the South Coast Air Quality Management District in California, in a discussion of the measures being taken to improve air quality in the Los Angeles region, stated that suburbanization has intensified congestion by making high-occupancy vehicle modes, including transit, difficult to use. Strategies to help urban-suburban congestion include HOV lanes on highways, transit improvements, freeway flow improvement techniques (especially those involving "smart cars" or "smart highways"), increased bicycle and pedestrian incentives, and alternative work schedules. If vehicle emissions are to drop, the overall vehicle miles of travel must somehow be reduced. When traffic flow is congested, vehicle engines operate below peak efficiency, generating more pollutants. Fewer vehicles, each carrying more passengers, will mean smaller quantities of emissions.

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California's Commuter Program

Traffic control measures have come together in one program that may well serve as an example for similar projects across the country. Regulation XV, known as the Commuter Program, was developed by the South Coast Air Quality Management District. The district covers four California counties that have experienced severe air quality problems: Los Angeles, Orange, Riverside, and San Bernardino. It exists to ensure that federal and state air quality standards are met.

The program has one simple goal: to reduce the number of vehicle trips being taken in the district. The Commuter Program requires employers of more than 100 people at a single site to increase the current average vehicle ridership (AVR) on the trip to and from work. During rush hour, the average car in the district now carries 1.13 persons. The program objective is to increase that number to 1.5. If this goal is accomplished, it is estimated that daily benefits will include (3)

- 25 percent reduction in commuter drivers;
- 750,000 fewer commuter vehicle trips;
- Carbon monoxide reduction ranging from 100 to 216 tons; and
- Nitrogen oxide reduction ranging from 16 to 34 tons.

Dunlap added that to increase the AVR, employers must develop and implement a plan encouraging employees to reduce their driving. Possible methods include carpools, vanpools, additional transit, flexible work schedules, and even telecommuting and work-at-home options. Each employer's plans must be approved by the district on an annual basis.

The district is also examining other programs to further the quest for clean air. A truck management program regulates truck delivery times. A mandated clean fuels program will require 40 percent of passenger vehicles and 70 percent of freight vehicles to use clean fuel by the year 2000. Eventually, smaller companies (with 25 or fewer employees) will be included in the Regulation XV program.

Changes like these will not be stopping at the California border. New York, New Jersey, and the New England states also intend to adopt stringent air quality standards.

Solutions for the Future

In the Los Angeles area, 80 percent of the carbon monoxide emitted comes from automobiles, buses, and trucks. Of the emissions that act as sources for the creation of ozone, 50 percent comes from motor vehicles. The region's population of 12 million is expected to grow by another 50 percent (to 18 million) by the year 2000. Most of these people will want to travel by automobile. This is a recipe for a devastating increase in air pollution.

Transportation is inarguably a significant contributor to the air pollution prob-

lem. The search for solutions is on. Southern California has responded by stating that changes in travel behavior must accompany the typical technical fixes. Critics of the California plans, however, state that this kind of solution might not be worth the expected benefits.

Tough Questions

Daniel Sperling raised the following issues in his discussion at the TRB Executive Committee meeting:

- Should government standards be lowered?
- What are the relative strengths of technological and behavioral changes to accomplish the objective of improved air quality?
- What is the true cost-effectiveness of the approaches being suggested?
- Is there a national commitment to a clean environment?

Sperling recommended that TRB take a much more active role in encouraging the cooperation of the transportation community with state and local governments and with the international community. He urged transportation professionals to address issues broader than simple technological fixes, stating that emphasis must be placed on lifestyle changes.

Mission for TRB

The Executive Committee recommends that the Transportation Research Board stimulate discussion in all aspects of transportation, with the aim of uncovering the best of the complex policy alternatives currently being considered. The transportation community needs to consider the wider issues in its analysis of technical or behavioral solutions to transportation's contribution to the air quality problem:

- Is travel demand in the United States growing even faster than current control measures can be put in place?
- Is travel demand stimulated by increasing affluence, poor land use, and an insatiable demand for more cars?
- If Americans change the ways in which they use the motor vehicle, will any of the impetus for the changes come from the automobile industry?
- Can the U.S. automobile industry assume a leadership role in the use of new air quality control technology as it is developed?
- How will the mandated changes be paid for?
- Do the citizens and residents of the United States believe that the costs of control are worth the benefits of improved air quality?
- Should other communities (such as developers) bear a significant portion of the responsibility for solving the air quality problem and implementing the necessary changes?

It is likely that TRB committees will become more active in these areas and will apply their own unique approaches toward dealing with the transportation components of the nation's air quality problems. By integrating the work of these committees and by organizing special studies, the Transportation Research Board will be able to provide a well-thought-out critical overview of the solutions that will be needed during the next decade.

References

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3. *A Guide for Chief Executives.* South Coast Air Quality Management District, 1988.