

Air Quality in México: Toward Clean Air—in a Decade

Report from México Air Pollution Workshop

México City, 13 April 2004

Mario Molina, Chair

**National Institute of Ecology of México
The William and Flora Hewlett Foundation**

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List of Co-Authors

Diane BAILEY (Retrofit and Costs), Natural Resources Defense Council Inc., Public Health Program

Katherine BLUMBERG (Health Benefits), University of California, Berkeley, Energy and Resources Group & Dept. of Civil and Environmental Engineering

Verónica GARIBAY (Health Benefits), National Institute of Ecology of México, Emissions Inventories and Modeling, Under-Director

Daniel GREENBAUM (Health Benefits), Health Effects Institute, President

Adrián FERNÁNDEZ-BREMAUNTZ (Action Plan, Editor), National Institute of Ecology of México, Research on Global, Regional and Local Air Pollution, General Director

Hal HARVEY (Executive Summary, Introduction, Editor), The William and Flora Hewlett Foundation, Environment Program, Director

Richard KASSEL (Retrofit and Costs), Natural Resources Defense Council Inc., Senior Attorney

David PARK (Costs), Northeast Clean Air Foundation, Environmental Engineer

Leonora ROJAS BRACHO (Health Benefits, Editor), National Institute of Ecology of México, Air Quality Research, Director

Joseph RYAN (Editor), The William and Flora Hewlett Foundation, Latin American Relations Program, Co-Director

Sergio SANCHEZ MARTINEZ (Editor), Natural Resources and Environmental Secretariat, General Director for Air Quality Management, Emissions Registry, and Pollution Dispersion

Alejandro VILLEGAS-LÓPEZ (Editor, Appendix A), Consultant on Sustainable Transportation and Environment for The William and Flora Hewlett Foundation

Michael WALSH (Pollution Sources, Modern Standards), International Fuel & Vehicle Technology Consultant

Miriam ZUK (Health Benefits), National Institute of Ecology of México, Air Quality Strategic Studies, Under-Director

National Institute of Ecology of México

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Executive Summary

In spite of the progress made during the last decade, many Mexican cities still have unhealthy air, laden with pollutants from cars and diesel trucks and buses. Fortunately, new technologies and clean fuels can reduce the pollution from new vehicles by more than 95 percent. These technologies, including advanced catalytic converters and, for heavy-duty vehicles, diesel particulate filters, are becoming standard equipment in much of the world. México already produces such cars (that meet the very stringent TIER 2 standards), but these models are aimed primarily at the U.S. market with little commercialization in México. The extra cost of an ultra-clean car compared to today's models is about \$250 USD per vehicle.

The clean exhaust technologies for vehicles, however, also require very clean fuels, especially ultra-low-sulfur-content gasoline and diesel, and that will mean a significant investment in upgrading PEMEX refineries. The cost of upgrading the refineries will be \$2 billion to \$4 billion USD, or two to six cents per gallon of fuel. This study concludes, however, that the positive results of that cleanup—in reduced sickness and premature death—will be many times the cost, and the economy as a whole will benefit.

As new cars and trucks get equipped with clean technologies, it will also be necessary to turn attention to retrofitting, retiring, or replacing the oldest, dirtiest trucks and buses. Good programs to clean up engines, or to retire the dirtiest engines, will save billions of dollars in health care costs and make México's cities much more livable.



Clean air in México does not have to be a dream. The costs of new cleanup technologies are affordable; they have been proven in other countries; and are already manufactured in México. The benefits of clean air would be enormous—in thousands of lives saved per year, and millions fewer cases of asthma and other medical conditions. This paper, written by scientists, but based on discussions of México's leading policymakers, scientists, and experts around the world, shows the way.



Introduction: Clean Air for México—in a Decade

México City, the second-largest city in the world, sits on a spectacular site, 8,000 feet above sea level, surrounded by volcanoes. But the mountains surrounding the city are often totally obscured by air pollution, and México's 18 million inhabitants, on a typical day, have to breathe air that is dangerous to their health. Many other Mexican cities also suffer from unhealthy air. Ciudad Juárez, Guadalajara, Mexicali, Monterrey, Tijuana-Rosarito, and Toluca all have air quality below both Mexican and international air quality standards.

Dr. Mario Molina and a team of scientists have been working for years to understand in detail the sources of air pollution in México, and to develop a strategy to clean the air. Their work has been complemented by that of scientists from El Instituto Nacional de Ecología (INE), La Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), and the Ministry of Energy, as well as local authorities from the Distrito Federal and the State of México. A recent conference of Mexican and international air pollution and energy experts, chaired by Dr. Molina and sponsored by INE and the Hewlett Foundation, put forth a strategy that, if followed in full, will make enormous progress toward clean air—and in only ten years. This report describes how to do this.

The air pollution in Mexican cities comes predominantly from the cars, trucks, and buses that ply the road. Most vehicles do not have adequate pollution controls, nor are they fueled with especially clean fuel. In contrast, advanced technology vehicles with ultra-low-sulfur fuel can have emissions that are as much as 99 percent lower than the average car, and 97 percent lower than the average truck.

This report therefore proposes a three-part plan to clean the air:

1. Introduce ultra-low-sulfur fuels, both gasoline and diesel, which are required for the newest and cleanest car and truck technologies.
2. Tighten the “tailpipe standards” on all new cars, trucks, and buses sold in México, so they conform to world-class standards.
3. Launch a program to retrofit or retire the dirtiest fleets of truck, buses, and cars.

The report that follows describes the air pollution problem, considers the health consequences of the pollution, discusses each element of the solution, weighs the costs and benefits of the strategy, and then makes recommendations for next steps.

The Health Benefits of Reducing Motor Vehicle Emissions

Before discussing each element of the three-part plan, it is important to understand the impact that air pollution and, in particular, vehicle emissions have on the health of México’s population. Air pollution has been linked to a number of health effects on the heart and lungs. The World Health Organization, in its recent “World Health Report” estimated that—at current ambient levels—air pollution causes 35,000 premature deaths each year in Latin America. Research over the past several decades has found a variety of effects from the different pollutants, including effects on the respiratory, neurological, and cardiac systems and the promotion of several different types of cancer. Some subgroups (e.g., the elderly, asthmatics, children, people with heart disease) appear to be at much greater risk from exposure to air pollution.

Most estimates of the benefits of reducing air pollution are based on the effects of particulate matter air pollution (PM), which is emitted from vehicles and other combustion sources. For decades now scientists have known that PM at high

levels causes illness and death. Short- and long-term epidemiologic studies published in the U.S. and Europe in the 1990s found associations of PM with increased mortality and morbidity at much lower levels. The most recent epidemiologic studies (in particular time series analyses)—conducted in México City and elsewhere in Latin America—have strengthened even more the link between exposure to PM and mortality and morbidity.¹

The benefits of reducing pollution discussed in this analysis are based primarily on the substantial body of science linking PM exposure and health. PM is not, however, the only motor vehicle emission that adversely affects human health. Four other key pollutants have also been extensively studied and, although they are not included in this analysis, an overall reduction of motor vehicle emissions would also serve to reduce the amount of these pollutants in the air—thereby creating substantial additional benefits beyond those estimated below. The four pollutants are:

1. *Carbon Monoxide*. High levels of exposure are known to be lethal; low levels found in ambient settings can advance the time of angina (chest pain) in people with heart disease. Some recent epidemiologic studies have linked increased CO levels to increases in illness and death.²
2. *Ozone*. Formed from nitrogen oxide and volatile organic compound emissions, ozone is known to reduce the ability of sensitive individuals to breathe. Epidemiologic studies have linked increased asthma attacks and related hospitalization to increased ambient levels of this pollutant. Ozone may also increase the lung's reaction to allergens and other pollutants. Recent multi-city studies in Europe and the U.S. have also linked short-term exposures to ozone with premature mortality.³
3. *Diesel exhaust particulate matter*. In addition to the health dangers caused by PM described above, diesel exhaust has been cited as a probable human carcinogen by several national and international agencies (including the International Agency for Research on Cancer and the U.S. Environmental Protection Agency) because of findings of lung cancer in exposed workers. Recently it has also been found in some studies to exacerbate asthma and allergic responses.
4. *Air Toxics*. Most air toxics emitted from motor vehicles are animal carcinogens. Benzene is a known human carcinogen. 1,3-Butadiene was recently designated as a probable human carcinogen by the

¹ Evans, J., J. Levy, J. Hammitt, C.S. Burgoa, and M. Castillejos. "Health Benefits of Air Pollution Control." In *Air Quality in the Mexico Mega City: An Integrated Assessment*, edited by L.T. Molina and M.J. Molina. Dordrecht: Kulwer Academic Publishers, 2002.

² Environmental Protection Agency, *Air Quality Criteria for Carbon Monoxide*, Office of Research and Development, Washington, D.C., June 2000b

³ Expert Panel on Air Quality Standards *Ozone* HMSO Publications Centre, London, 1997 and Health Effects Institute, *Research Report 65, Part XI: Consequences of Prolonged Inhalation of Ozone on F344/N Rats; Integrative Summary*, Cambridge, Massachusetts, April 1995

International Agency for Research on Cancer, and as a known human carcinogen by the U.S. National Institutes of Health. Several aldehydes (including formaldehyde and acetaldehyde) have also been designated as probable human carcinogens and have been linked with acute respiratory effects. In 2000, the U.S. Environmental Protection Agency identified a total of twenty-one air toxics emitted from motor vehicle exhaust.⁴

A good pollution control strategy targeting mobile sources will dramatically reduce all these emissions—and do so with benefits far exceeding costs. The next section describes the current situation in México.

Pollution Sources in México

There are seven metropolitan areas in México that already have air quality plans based on emissions inventories: Ciudad Juárez, Guadalajara, Mexicali, México City, Monterrey, Tijuana-Rosarito, and Toluca. These cities together are home to more than a quarter of México's population.

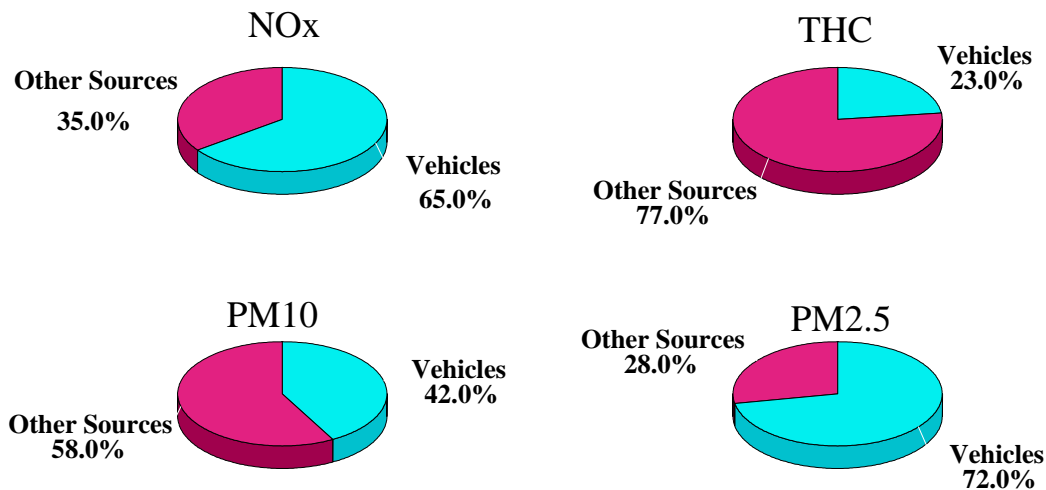


Figure 1: Sources of Pollution in Mexico City

Source: Victor Hugo Paramo Figueroa
Frankfurt, September 9th 2003

Ambient pollutants concentrations measured in six Mexican metropolitan areas show that ozone and particulate matter (both PM10 and PM2.5) are the main pollutants of concern—affecting some 25 million residents.⁵

Summary results on air quality in those cities show that ozone is the main pollutant in Guadalajara, México City, and Puebla, whereas PM concentrations are higher in Toluca, Monterrey, and Ciudad Juárez.

⁴ Environmental Protection Agency, *Draft Mobile Source Air Toxics Study*, Office of Transportation and Air Quality, Washington, D.C July 2000c

⁵ INE, "Segundo Almanaque de la Calidad del Aire en Seis Ciudades Mexicanas," Instituto Nacional de Ecología, México, D.F.

Clean Air Requires Clean Fuels

The first component in the effort to clean up México's air in a decade involves cleaning up fuels, both gasoline and diesel. Stringent vehicle standards (discussed below as part two of this clean air approach) are predicated on clean fuels. México currently has some of the highest quality transportation fuels in Latin America. In fact, this month Pemex announced the reduction of the average sulfur levels in Premium gasoline from 500 ppm to 250 ppm. This is a significant step. However, it still leaves the sulfur content at ten times necessary levels. The next step toward controlling emissions and cleaning up the air requires even cleaner fuels, specifically ultra-low-sulfur (15 ppm) gasoline and diesel.

High sulfur in fuel makes it virtually impossible to use the advanced technologies (filters and traps) to control particulate matter (PM) and smog precursors—the pollutants that most threaten the health of Mexicans. However, when ultra-low-sulfur fuels are used in combination with advanced control technologies, the emissions reductions from diesel and gasoline vehicles are dramatic. For example, catalyzed filters can reduce particle emissions from diesel vehicles by up to 95 percent. This technology could reduce levels of these life-threatening pollutants in México City by 30 percent and save thousands of lives throughout the country each year. With low-sulfur fuel, filters can also be placed on many *existing* vehicles and can reduce emissions by 80-95 percent, making this one of the most cost effective ways to clean up the air in the near term.

Levels of sulfur in gasoline currently preclude the introduction of more effective catalytic converters, which could greatly reduce emissions of nitrogen oxides (NO_x) and hydrocarbons (HC), both of which are the precursors of ozone and smog. Lowering sulfur levels in fuels will also increase the effectiveness of in-use catalytic converters, which have come standard on all new passenger cars in México since 1993.

But getting sulfur out of fuels is not easy. The upgrades needed for refineries to remove sulfur are expensive.⁶ Pemex estimates it will cost \$3 billion USD to upgrade México's nine refineries for production of ultra-low-sulfur gasoline—this includes installing the pollution control equipment required by recent emissions standards for industrial sources (NOM 085). In its most recent analysis, Pemex suggests that ultra-low-sulfur gasoline and diesel would carry an added incremental cost of roughly six cents per gallon.

Without question, a major capital investment will be required to upgrade Mexican refineries, both to reduce refinery emissions and to produce cleaner,

⁶ However, costs continue to decrease with the development of new catalysts and novel processes that reduce energy requirements. Weighed against the emissions reduction potential of low-sulfur fuels, studies show the benefits to be far greater than the costs. The Appendix has more detail on costs.

ultra-low-sulfur fuels. Annualized costs, assuming a fifteen-year lifetime, range from \$50 million to \$350 million USD. Pemex was able to take advantage of foreign investment and generous loan terms in upgrading refineries for the transition to lead-free gasoline in México. Similar financing arrangements are necessary for this next step, in order for México to make the transition to world-class fuel and vehicle standards.

Modern-day refineries tend to have very slim profit margins, making it difficult to raise investment capital. This is further complicated by the many restrictions against private and foreign investment in Pemex. This is not an uncommon problem. An Asian Development Bank study identifies access to the necessary capital funds as the greatest obstacle to achieving ultra-low-sulfur fuels.⁷ Innovative financing arrangements can overcome this obstacle and also add value and profitability to the industry. Currently, representatives from INE, SEMARNAT, and Pemex are working together to develop a financing package that they will present to Hacienda to address the needed capital for refinery upgrades.

Pemex, for its part, has proposed to lower sulfur in premium gasoline to an average of 30 ppm in 2006.⁸ This would accelerate the early introduction of passenger cars that meet U.S. Tier 2 standards. In September 2008, Pemex would reduce sulfur in diesel fuel to meet a 15 ppm cap and introduce low sulfur levels in all gasoline grades. This would allow the introduction of heavy-duty vehicles meeting U.S. standards in that same time frame.

In the end, ultra-low-sulfur fuels will allow México to once again keep pace with U.S. vehicle standards and will ease the barriers to trade in the automobile manufacturing, trucking, and fuel refining industries. Timing is critical: Once ultra-low-sulfur fuels are available we can move quickly to the second component of the clean-air-in-a-decade campaign: stricter vehicle emissions standards.

Modern Standards for Vehicles

Stricter vehicle standards are critical to the air cleanup effort because they ensure that—technologically speaking—all new cars, trucks, and buses are cleaner, more efficient, and pollute far less than previous models. México's standards for new cars were tightened in 1999 to conform to U.S. Tier 1 standards.⁹ However, much more stringent standards are now possible and are already being introduced in the U.S. As shown in Figure 2, the Tier 2 standards in the U.S. will reduce NOx emissions by approximately *80 percent below the*

⁷ Asian Development Bank, Policy Guidelines for Reducing Vehicle Emissions in Asia: Clean Fuels, http://www.adb.org/Documents/Guidelines/Vehicle_Emissions/cf_exec_summary.pdf

⁸ The sulfur content would have a cap of 80 ppm.

⁹ These standards, adopted in the U.S. in 1994, are set at 0.156 grams per kilometer (g/km) for non-methane hydrocarbons, 2.11 g/km for carbon monoxide, 0.25 g/km for NOx, and 2.0 g/km for evaporative hydrocarbons. These standards will apply to vehicles made from 2004 onward that run on gasoline, natural gas, or liquefied petroleum gas (propane and butane).

Tier 1 standards. In addition, the Tier 2 standards will also require light trucks and sport utility vehicles to achieve the same emissions levels as cars. Further, these new standards require diesel vehicles to meet the same emissions levels as gasoline-fueled vehicles. Moving quickly to Tier 2 will ensure that new vehicles put on Mexican streets will be extremely clean.

The majority of vehicular PM and ozone precursors come from trucks and buses. Therefore, adopting stricter standards for these vehicles will also go a long way in making sure that no more highly polluting heavy-duty vehicles are put into circulation in México. The current standards for heavy trucks and buses in México remain at levels that applied during the 1990s in the U.S. As illustrated below, standards for NOx and PM from new heavy-duty engines will be dramatically reduced in the next several years in the U.S. PM emissions, in particular, will be reduced by over 90 percent. The 2007-10 U.S. standards require extended durability and will rely on the use of particulate traps or filters, among other items.¹⁰ Right now, México has no plans to move quickly to adopting these stricter heavy-duty standards; but it should. Such standards are essential for making sure that the thousands of trucks and buses sold every year in this country do not worsen the already dirty air people breathe.

The U.S. Office of Management and Budget recently carried out an assessment of all major regulations adopted by the U.S. government

Figure 3: U.S. Heavy Duty Emissions Limits

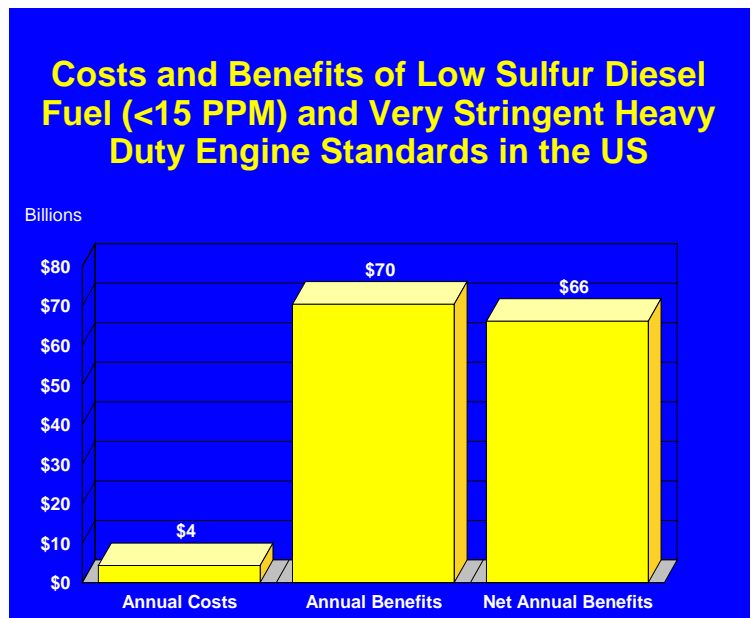
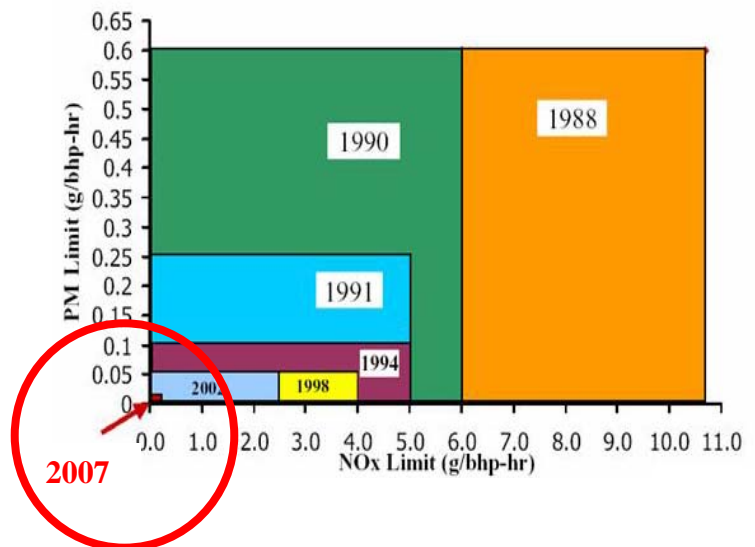


Figure 4: Costs and Benefits of U.S. Heavy Duty Standards

¹⁰ In conjunction with the tighter standards EPA will also be introducing a new enforcement concept, called "not to exceed" standards (NTE). The NTE requirements mean that in-use testing of heavy-duty engines can take place anywhere on the engine map and that the vehicle must meet standards or it will be found to be out of compliance.

over the past decade. The report concluded that the two programs highlighted above, Tier 2 light-duty standards and the 2007 heavy-duty program for diesel vehicles, were among the most beneficial. Just focusing on the heavy-duty standards along with the parallel introduction of low-sulfur fuel, the OMB found that the annual benefits, approximately \$70 billion per year, were seventeen times higher than the annual costs, approximately \$4 billion per year. Among other items, they estimated that over 8,000 lives would be saved each year.

Ironically, Mexican auto companies are already producing some cars that meet the Tier 2 standards, but most of them are exported for sale in the United States. Why? Because the advanced filters and traps used to meet these tough standards would be destroyed by the amount of sulfur in current Mexican fuels. In order for México to benefit from these advanced technologies, and to accelerate the wide introduction of ultra-clean vehicles, it needs to have cleaner fuels, especially fuel with lower sulfur content. Once the sulfur in fuel is drastically reduced and all new vehicles are meeting world-class emissions standards, we can turn to part three of this clean air campaign: the current fleet.

Retiring, Replacing, and Retrofitting Heavy-Duty Vehicles

The third component to cleaning up México's air in a decade deals with the millions of old cars, trucks, and buses currently on the road. Emissions of particulate matter from diesel vehicles in México City are high due to the age of the fleet (fifteen years average), the lack of emissions controls in over half of the vehicles, poor maintenance, high sulfur content in fuel, and incomplete combustion at high altitudes. Diesel vehicles last an incredibly long time, sometimes running for a million miles or more. So waiting for the current fleet of old diesel vehicles to die of natural causes and be replaced with newer, cleaner vehicles would delay clean air in México literally by decades. Therefore, just as stricter standards ensure that new vehicles pollute less and less, a program of retrofitting old vehicles will ensure that the worst polluting heavy trucks and buses are either cleaned up or are taken out of operation. An effective emissions reduction program must address both new and current vehicles.

A recent study (Stevens et al., 2004) analyzed the costs and benefits of implementing a retrofit program in México City using four different retrofit technologies: a catalyzed diesel particulate filter (DPF), a self-regenerating DPF, a removable DPF, and a diesel oxidation catalyst (DOC). Only model years post-1994 were considered for the catalyzed DPF, and the authors assumed that tractors would not be compatible with the removable DPF. The following costs were included in the calculation: the capital cost of the emissions control device and the operation and maintenance costs, including the cost of any fuel penalty, incremental cost for lower-sulfur fuel, and cost of cleaning the filter.

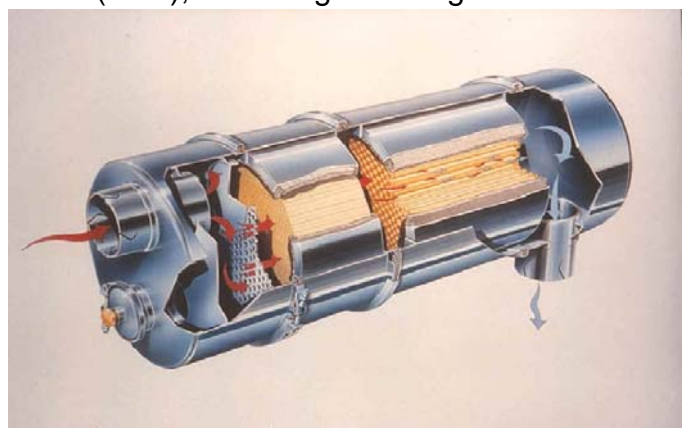


Figure 5: Diesel Particulate Filter

To quantify the benefits of the retrofit programs, the Stevens study analyzed the reductions in mortality associated with PM_{2.5}-related emissions from diesel vehicles of primary particulate matter, SO₂ and HC. Health benefits were estimated as (1) the product of the emissions reduction, (2) the proportion of these emissions that would have been inhaled as PM_{2.5}, (3) the concentration-response slope, and (4) the monetary value of a unit health effect. Table 1 summarizes the findings of this analysis.

Table 1: Net benefits per year per 1000 vehicles retrofit, in million USD.

	Buses & Trucks		Tractor Trailers	
	<i>Model Year '94 and Newer</i>	<i>Model Year '93 and Older</i>	<i>Model Year '94 and Newer</i>	<i>Model Year '93 and Older</i>
Retrofit in 2008				
Oxidation Catalyst (DOC)	1.9	3.9	0.3	1.2
Removable DPF	3.4	14		
Self-Regenerating DPF	3.8	14	0.6	3.8
Catalyzed DPF	4.0		1.1	

Note: Gray areas indicate retrofits that are not possible because of the vehicle's technology or usage characteristics.

The retrofit of diesel vehicles in México City could provide significant net benefits to society. Retrofit of older, higher-polluting vehicles provides greater net benefits than retrofitting newer vehicles (assuming that the emissions control device has a ten-year lifespan on either type of vehicle). Finally, retrofit of buses and trucks that circulate within the city provides greater benefits than retrofit of vehicles, such as long-haul trucks, that circulate outside of the city.¹¹

Adopting policies and programs that reduce real-world, so-called “in-use” emissions from México’s existing fleets of buses and trucks should be a critical component of any plan to achieve clean air in México in the next decade. Indeed, taking steps to retire the oldest, dirtiest buses and trucks and to retrofit the remaining vehicles can be a cost-effective way to reduce emissions from México’s vehicles. Moreover, such a “Retire, Replace and Retrofit” strategy would complement a longer-term emissions reduction strategy that includes ultra-low-sulfur fuels and stringent, technology-based emissions standards for new engines and vehicles (as well as operational strategies to reduce engine idling and improve engine maintenance).

When adopting a “Retire, Replace and Retrofit” Program, Mexican officials should consider various mechanisms to fund the program. In the U.S., state and federal agencies have funded replacement and retrofit programs—typically, these include cost-sharing provisions that require fleet operators to provide

¹¹ Stevens, G, A. Wilson, and J. Hammitt “Benefit-Cost Analysis of a Diesel Particulate Filter Retrofit program in the Mexico City Metropolitan Area” (Draft). Harvard Center for Risk Análisis, 2004.

some level of matching funds to the government's contribution, which helps ensure that the fleet operators are fully committed to the program's success. These programs include California's Carl Moyer Program, the Texas Emission Reduction Plan (TERP), and the Sacramento Emergency Clean Air Transportation (SECAT) Program¹², as well as many metropolitan area programs administered through the U.S. Department of Energy's Clean Cities Program, local air quality management districts, or regional government authorities.

In addition to a diesel retrofit program, another measure that would greatly contribute to clean air is the replacement of high-use, high-polluting vehicles such as taxis and minibuses. For example, by substituting the 70,000 old VW beetle taxis circulating in México City with new vehicles that meet Tier 2 standards, emissions of nitrogen oxides and hydrocarbon (the main ingredients of ozone) would drop by more than 15 percent. Given that some four-door 1000 cc subcompacts now available in México offer double the fuel efficiency as the old beetle, taxi owners could actually make back the cost of their new vehicle in as little as two years through fuel savings alone.¹³ Substitution of old taxis can prove to be a very cost efficient measure for reducing air pollution in most large urban areas throughout México.

In the End, it is about Our Health

The health benefits of introducing a system of clean fuels and stringent vehicle standards would be tremendous for both México City and the entire nation. Even with the most conservative estimate of costs, México can expect to reap at least \$8 billion in annual net benefits when clean vehicles and fuels are in place.¹⁴ Lower costs are more likely (given the real-world experiences in other parts of the world), pushing the net benefits up to \$11 billion USD, or even higher, annually. The benefits are largest for México City, where high levels of particulate matter are closely linked to premature mortality, along with other chronic and debilitating health impacts.

In México City, advanced diesel vehicles will result in a reduction of fine particle concentrations by 10 $\mu\text{g}/\text{m}^3$ from current average concentrations of 35 $\mu\text{g}/\text{m}^3$, almost a 30 percent reduction. **This level of improvement in air quality is expected to result in roughly 4,000 fewer premature deaths each year in México City. Monetizing these and other health benefits using values developed specifically for México, this translates into \$3 billion to \$5 billion USD in annual health benefits for México City alone.**

¹² US EPA, Voluntary Diesel Retrofit Program, Funding Sources, <http://www.epa.gov/otaq/retrofit/retrofitfunding.htm>.

¹³ In recent years, a limited number of credits have been made available to taxi owners, but these have only accounted for less than 20 percent of the total number of units that should be replaced.

¹⁴ Full benefits of advanced vehicle standards should be achieved by the year 2030. Up until that point, the health and other benefits of the program will increase over time.

Nationally, clean fuels and vehicles will offer even more significant emissions reductions. Advanced diesel vehicles will reduce direct particulate matter emissions by 150 tons **each day** nationwide, only seventeen tons of which are emitted in México City. Nitrogen oxides and sulfur oxides, both precursors for particulate matter, will be reduced by sixty and seventy tons per day throughout the country. Using benefit values developed by the U.S. EPA, national emissions reductions represent an annual benefit of \$10 billion USD.

Advanced vehicles and clean fuels will greatly reduce emissions of diesel particulate matter throughout México, resulting in a huge benefit for human health at a reasonable cost. In fact, the annual health benefits are roughly ten to

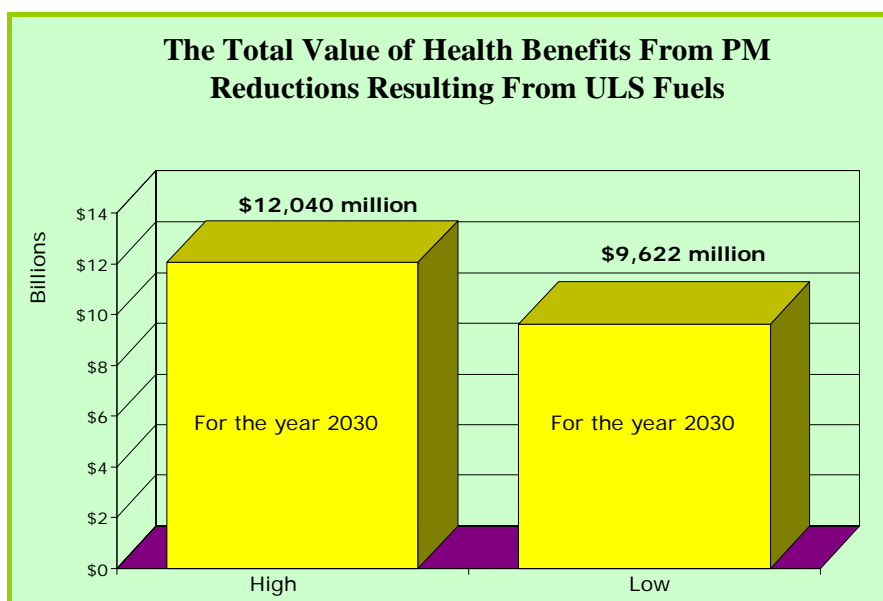


Figure 6: Net Benefits from Ultra-Low-Sulfur Fuels

twenty times higher than the expected costs, and up to forty times higher for highly polluted México City.

Action Plan

The agenda described in this report is ambitious, but affordable and achievable. All the programs described in this report have been tested in other countries. All have shown benefits that are many times higher than the costs.

In order to achieve clean air in México in the next decade, the following actions are required.

1. Low-sulfur fuels will be required in order to adopt the Tier 2 standards. This in turn will require significant investment in upgrading Pemex refineries. The authors of this report recommend an “ecotax” of approximately four cents USD per gallon to be added to gasoline. The proceeds from the ecotax would be used to modernize Pemex refineries and to help support the diesel engine Retire, Replace, and Retrofit program (below).

2. SEMARNAT, Pemex, and the Ministries of Energy and Environment have agreed on a strong, focused proposal to bring automobiles up to U.S. Tier 2 standards by 2008. This plan needs formal approval.
3. A similar set of standards for heavy-duty vehicles, probably modeled on the U.S. heavy-duty regulations, should be adopted.
4. A diesel engine cleanup program should be established to retire the dirtiest engines and replace or retrofit newer models. This program should be designed to get the maximum cost-effective reductions, and be developed and funded jointly with the private sector. This program should be designed within a year and implemented immediately thereafter.
5. Substitution of old taxis should be mandatory in large cities. Low-interest loans should be available for taxi owners from environmental trusts. Loans could be repaid in no more than two to three years in the savings from gasoline costs alone.

Conclusion

Science, economics, technology, and human health experts from México's government, industry, and academic sectors agree that air pollution is dangerous to human health; they have reached consensus on what is required to clean up the air; and they have confirmed that the benefits are many times greater than the costs.

This conclusion, matched by political will, can be used to clean up México's air—quickly and cost effectively. It is time to begin.