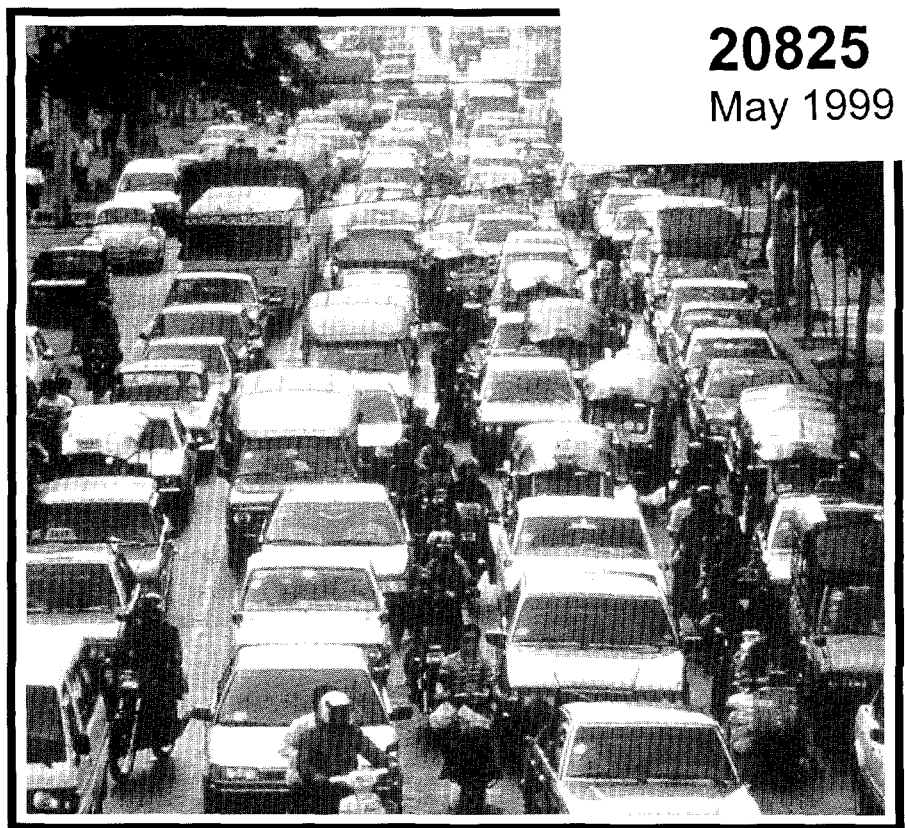


Eliminating a Silent Threat

World Bank Support for the Global Phaseout of Lead from Gasoline

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20825
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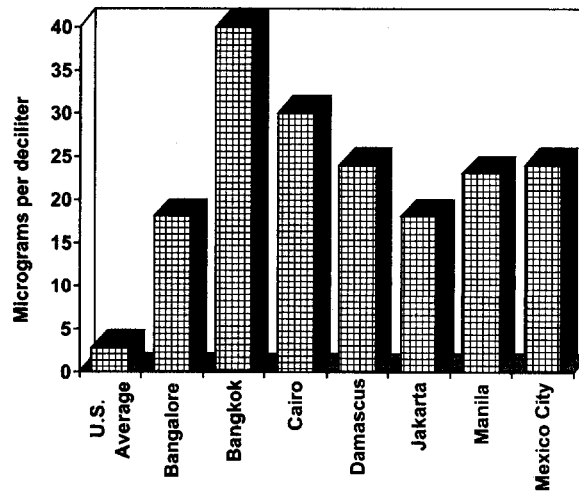
Why care about lead?

Lead ranks as one of the most serious environmental threats to human health, especially in urban areas. Perhaps its most alarming effect is on the mental development of children. Young children are especially susceptible: their digestive systems absorb heavy metals rapidly, and they ingest lead-contaminated dust and soil simply by putting their fingers in their mouths or by chewing on contaminated toys. Poor children are most at risk because malnourishment intensifies lead absorption. For adults, lead absorption can cause hypertension, high blood pressure, and cardiovascular problems.

The health effects can be detected even at low levels of exposure; medical evidence shows no identifiable threshold below which the adverse impacts are not found. And current exposures—as measured by sample blood lead levels—are alarmingly

high in many developing countries, often 10 to 20 times the blood lead levels currently prevailing in industrial countries such as the United States (Figure 1).

Figure 1. Average blood lead levels of sampled populations in selected cities, 1980s to 1990s



Note: The figure is only an indication of the blood lead levels occurring at various locations. The sample size, age group, sampling method, year of sampling, and representativeness of samples varied across countries. The results therefore cannot be interpreted as a cross-country comparison of lead exposure.

Source: Lovei 1998.

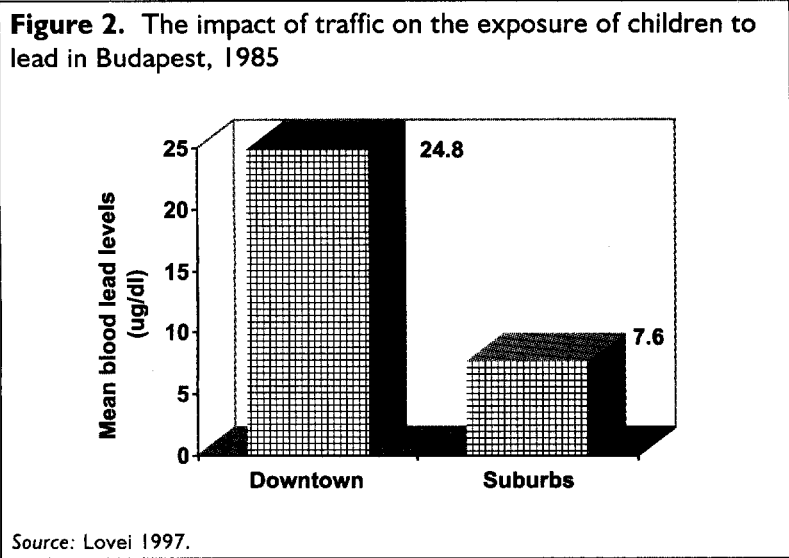
Phasing out lead in gasoline is highly effective

The sources of exposure to lead include gasoline, lead pipes or lead-based solder in water supply systems, cottage industries, and lead-based paint. The importance of particular sources varies across countries and locations, meaning that targeted programs and interventions are required. In India, for example, the use of cosmetics containing lead is a major source of exposure; in Mexico it is the widespread use

of lead for glazing pottery used to hold food and water. In Egypt lead solder used in the grinding stone of flour mills was recently found to cause alarming levels of lead poisoning. Many of these problems can be reduced by public education and awareness raising.

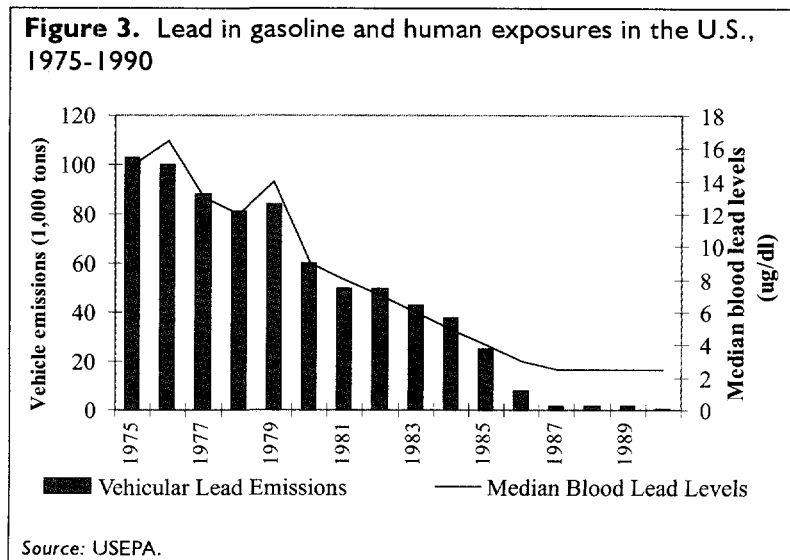
Unlike these locally important sources, leaded gasoline is a problem worldwide; in large cities where it is still used, it accounts for 80 to 90 percent of airborne lead pollution. Lead contamination and exposure in cities are typically 3 to 4 times higher than in the suburbs and 10 times higher than in rural areas (see Figure 2 for an example). As a result of this exposure, children living in the inner cities may suffer as much as a 4-point IQ loss compared with those in the suburbs.

The problems will worsen if use of leaded gasoline continues. Vehicle use is soaring in developing cities. In 1990, there were some 518 million cars and trucks



worldwide; by 2010, that number will grow to 816 million, with most of the growth occurring in developing countries. Furthermore, the growth of cities means that more and more people are being exposed to lead pollution. Today, 1.7 billion people live in cities, by 2025 the global urban population will have doubled, to 4 billion.

The obvious solution is to phase out lead in gasoline. Eliminating leaded gasoline has a swift and marked effect on exposure. As Figure 3 shows, the average blood lead levels of the U.S. population declined as lead was phased out. In 1976, when leaded gasoline was still used extensively, the average blood lead level of Americans was 16 micrograms per deciliter ($\mu\text{g}/\text{dl}$), in 1980 it dropped to around 10 $\mu\text{g}/\text{dl}$, and today it is less than 3 $\mu\text{g}/\text{dl}$. Similar improvements in environmental quality and health conditions have been observed in all countries that have phased out leaded gasoline.



Technical solutions are widely available

Alternatives to lead as an octane enhancer in gasoline are commercially available and technically well understood. The environmental effects of the various lead phaseout alternatives differ, and some solutions may create environmental concerns of their own. (For example, greater reformer severity increases the volatile aromatics in gasoline.) Although such health concerns are far less serious than those associated with lead additives, they should be considered in making decisions about refining alternatives. Isomerization and alkylation processes, as well as the use of oxygenates that help fuels burn cleaner and more completely, could be part of environmentally responsible lead phaseout strategies.

All cars can use unleaded gasoline

There is a common misconception that only vehicles with catalytic converters can use unleaded gasoline. This is wrong. Vehicles equipped with catalytic converters *must* use unleaded gasoline, but any vehicle *can* use it. In several countries that have phased out leaded gasoline completely, the market share of vehicles with catalytic converters has remained relatively low.

Technological advances have rendered invalid the reasons for adding lead to gasoline. Octane rating can be enhanced in other ways, as noted above. Another reason for adding lead was that it lubricated the exhaust valves, allowing vehicle manufacturers to use low-grade soft metals for engine valve seats. During the 1970s and 1980s, however, most manufacturers switched to using hardened valve seat technology. Vehicles with hardened valve seats no longer need lead for lubrication.

A few older vehicles produced with soft valve seats may experience valve seat recession if they are run on unleaded gasoline. However, the recession mainly occurs under severe driving conditions (e.g., high speed), and it can be prevented by adding lubricants to unleaded gasoline. The availability of such additives has enabled several countries (for example, Slovakia) to phase out lead even though a relatively large share of vehicles in their fleets have soft valve seats.

Switching from leaded to unleaded gasoline actually reduces vehicle maintenance costs. “Lead scavengers” (chlorinated hydrocarbons) have to be added to leaded gasoline to prevent excessive deposition of lead in the engine. These substances react with lead and form volatile compounds, which, in addition to their adverse health effects, contribute to the formation of halogen acids. The acids in leaded gasoline cause increased corrosion, requiring more frequent muffler, spark plug, and oil changes.

The costs of lead removal are modest compared with the benefits

Shifting from the production of leaded to unleaded gasoline is technically simple. Modern refineries do not need to make extensive investments; old refineries, however, often use obsolete technology that cannot produce unleaded gasoline. Many such refineries operate at a loss and should be either modernized—if the investment can be shown to be economically viable in the long run—or closed down. The success of a lead phaseout program depends on whether these difficult measures are taken.

The costs of removing lead from gasoline depend on many factors, including the price of alternative octane enhancers, the technical complexity of refineries, the price of imported gasoline, and the cost of capital. Generally, they are in the range of US\$0.01–\$0.02 per liter of gasoline. In many cases, the objective of lead removal can be incorporated into ongoing refinery restructuring programs, thus optimizing long-term investments and reducing the cost of lead phaseout.

Lead phaseout costs are especially modest when compared with the significant social benefits. These benefits include the avoided costs of:

- Lives lost because of increased infant mortality and premature deaths of adults as a result of strokes and heart attacks
- Reduced productivity and lower lifetime earnings of people with disturbed intellectual development
- Medical care
- Extra educational costs for children who have behavioral and learning problems as a result of exposure to lead.

The monetary value of these benefits varies from country to country and depends on several factors, including the cost of providing health care, the costs of labor and capital, labor productivity, life expectancy, and the value people place on their health and lives. In the United States, the estimated benefits of phasing out lead are more than ten times the costs. The size of the expected health benefits in developing countries suggests that phasing out lead from gasoline is highly cost-effective there as well.

Key conditions for success

The main constraints on lead phaseout are thus not technical; they are policy related. Four key conditions have to be in place for successful phaseout of lead:

- **Government commitment** to regulating the use of lead and the content of other harmful substances in gasoline. Limiting the amount of lead additives in gasoline brings about a dramatic decline in the amount of lead emitted into the atmosphere. Total phaseout of lead can be accomplished very quickly, given political commitment, appropriate regulations, and a clear schedule to facilitate proper timing of any investments.
- **Incentive policies** designed to influence gasoline demand and supply and promote a smooth transition from leaded to unleaded gasoline. On the demand side, *higher taxes* on leaded than on unleaded gasoline can influence consumer habits. A 5 to 10 percent retail price difference in favor of unleaded gasoline is usually recommended to effectively influence the structure of gasoline demand. On the supply side, *macroeconomic policies that permit market signals to work*—for example, liberalization of prices and foreign trade—ease the adjustment of gasoline supply. These policies allow operators in the downstream petroleum sector to import the necessary gasoline additives or blendstocks without restriction, and they encourage optimal investment schemes.
- A broad **consensus among the key stakeholders**, which include various government agencies and ministries (health, finance, transport, industry or energy, trade, and so on), the refining sector, car manufacturers, gasoline distributors and retailers, vehicle owners, auto clubs, and nongovernmental organizations (NGOs). For example, in European countries vehicle manufacturers' cooperation in lowering the octane requirement of cars has played a significant role in the adjustment of refineries to production of unleaded gasoline.

- Finally, **public understanding, acceptance, and support**. Public support can be mobilized by information and education programs that address such issues as the health effects of lead; proper fueling practices; and the feasibility of using unleaded gasoline in old cars.

Progress worldwide

Box 1. Lead-free countries and jurisdictions, 1999

Antigua and Barbuda
Argentina
Austria
Bahamas
Bermuda
Bolivia
Brazil
Canada
Columbia
Costa Rica
Denmark
Dominican Republic
El Salvador
Finland
Germany
Guatemala
Haiti
Honduras
Hungary
Japan
Mexico
Nicaragua
Norway
Saba
Slovak Republic
St. Eustasius
Sweden
Thailand
United States

Since the 1970s there has been a steady decline in the use of lead additives in gasoline worldwide. This happened partly because of the introduction of catalytic converters that required unleaded gasoline and partly because of an increasing awareness of the health damage caused by lead.

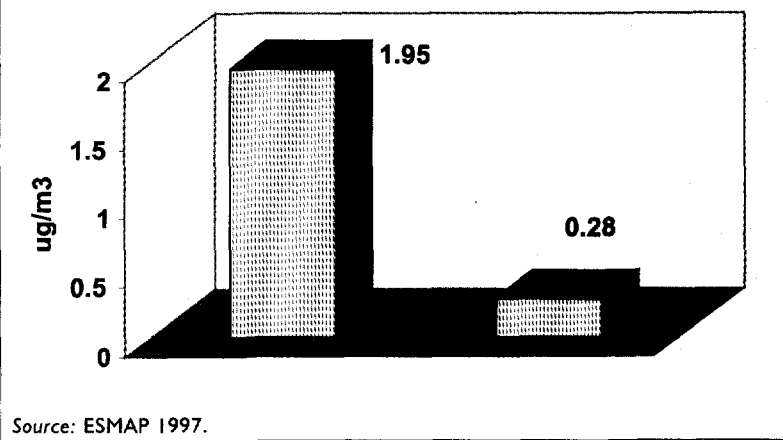
By early 1999, 29 countries had completely phased out leaded gasoline (Box 1). The list includes both high-income and lower-income economies, indicating that economic development is only one factor affecting the process. The number of lead-free countries is constantly growing (Box 2).

In **Thailand**, a health assessment study gave impetus to a clean fuels and lead phaseout program, supported by political commitment (Box 3). Key elements in the success of the program were environmental and fuel regulations, measures for price and market liberalization, fiscal measures such as differentiated taxation between leaded and unleaded gasoline, a community awareness program, and refinery adjustment.

El Salvador was able to phase out lead in only one year. This may be a good example of what can be done in a small country with a small refinery and a significant volume of imported gasoline. Several factors contributed to the rapid phaseout. The petroleum sector was privately owned, and there was thus no pressure on the government to provide subsidies; product prices had been liberalized (in 1994); high-octane gasoline components could be imported; and the phaseout did not involve significant investment.

Lead phaseout is often a first step toward solving broader air quality issues by addressing fuel specifications, air quality monitoring, environmental regulations, and inspection and maintenance (I&M) programs. In **Peru**, for example, a steering committee and a multisectoral commission were set up to develop pilot programs for improving air quality in selected cities and to identify specific actions to support

Figure 4. Ambient atmospheric concentrations and lead phaseout in Mexico City



Box 2. Recent developments in lead phaseout

Bangladesh has been steadily reducing lead in gasoline by importing only unleaded gasoline and blending it with domestic leaded gasoline.

In **China**, the National Petroleum Corporation is planning to phase out lead by 2000. As of July 1997, 56 percent of all gasoline produced in China was unleaded.

Egypt, which introduced unleaded gasoline in 1996, plans to phase lead out by 1999, with assistance from the U.S. Agency for International Development (USAID).

Haiti, which meets all of its gasoline demand with imports, phased out lead at the end of 1998. After observing that unleaded gasoline has often been cheaper than leaded gasoline in recent years in the Caribbean market, Haiti took and rapidly implemented a decision to eliminate leaded gasoline.

Hungary banned the distribution of leaded gasoline starting April 1, 1999. To protect the estimated 400,000 vehicles with soft valve seats, a new brand of research octane number (RON) 98 gasoline containing a lubricating additive was introduced.

In **India**, four metropolitan cities became lead free in 1999. Unleaded gasoline is now available in all large cities and along highways, and Indian refineries have committed themselves to phasing out lead by April 1, 2000.

Kuwait, which introduced unleaded gasoline in October 1998, plans to convert almost completely to unleaded by October 1999, making it the first country in the Middle East to do so. The government will double the price of leaded gasoline to encourage consumers to switch.

In **Malaysia**, as of July 1997 only 30 percent of gasoline was unleaded, but phaseout by 2000 is planned.

lead phaseout. Separate committees were established to work on fuel specifications, air quality and environmental monitoring, development of norms and standards, and public awareness and education.

When lead has been phased down, the effects on ambient air quality and health have been immediate. In *Mexico City*, for example, ambient lead concentrations dropped to a mere 14 percent of their original level following a similar reduction in the amount of lead added to gasoline (Figure 4). The expected positive effects on blood lead levels of exposed populations have been noted.

How the World Bank is helping?

There are three key areas in which the World Bank can help promote the phaseout of lead from gasoline:

- Raising awareness and building political commitment
- Supporting governments in adopting appropriate policies and developing strategies
- Facilitating the implementation of policies and lead phaseout strategies.

Experience shows that political commitment and supportive policies can result in a rapid phaseout of leaded gasoline. The World Bank has accordingly focused on the policy area.

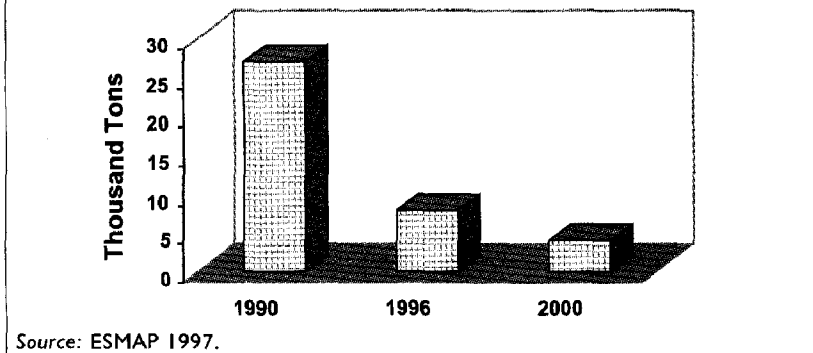
Under the right policy framework, financing for refinery investments is typically available from commercial sources, and the private sector is able to carry out refinery adjustments. Investors, however, may be deterred by the perceived risks from changing government policies and political uncertainties. Guarantees through

the International Bank for Reconstruction and Development (IBRD) or the Multilateral Investment Guarantee Agency (MIGA), both part of the World Bank Group, can mitigate private sector risk in these cases. Because of the World Bank's credibility, its involvement attracts investors and builds private sector confidence. Another source of assistance is the International Finance Corporation (IFC), a member of the World Bank Group, which makes direct loans or equity investments for private sector ventures. In all these cases, the World Bank Group acts as a catalyst rather than a major financier.

Regional programs

Latin America and the Caribbean. Under the Bank's leadership, a regional program has been undertaken to support the preparation of national plans for the phaseout of leaded gasoline in Latin America and the Caribbean. The Bank has been working on this project with several other agencies and organizations, including Reciprocal Assistance for Latin American Oil Companies (ARPEL), the Latin American Energy Organization (OLADE), the Pan-American Health Organization (PAHO), the U.S.

Figure 5. Lead added to gasoline in Latin America and the Caribbean, 1990, 1996, and 2000



Environmental Protection Agency (USEPA), the U.S. Department of Energy (US DOE), the Canadian International Development Agency (CIDA), and the Organization of American States (OAS).

The project has included health and technical studies, regional and country-based technical assistance, and dissemination of information and experience. As a result of the program, several countries have made commitments to phase out leaded gasoline by 2000, and several have accelerated their phaseout plans. The use of lead in gasoline is declining, from 27,000 tons in 1990 to an estimated 6,000 by the end of the century (Figure 5). The number of lead-free countries in the region is expected to rise to 14.

Central and Eastern Europe. The Bank has completed numerous health studies dealing with exposure to lead in the region and has conducted assessments of the feasibility of phaseout of leaded gasoline in several countries. Bank assistance has contributed to a growing political commitment to action.

In 1996, the United Nations Economic Commission for Europe (UNECE) established a task force to prepare a pan-European strategy for phasing out lead in gasoline. The Bank, together with a large number of countries, actively participated in this two-year program. The strategy proposed by the task force set out the following objectives:

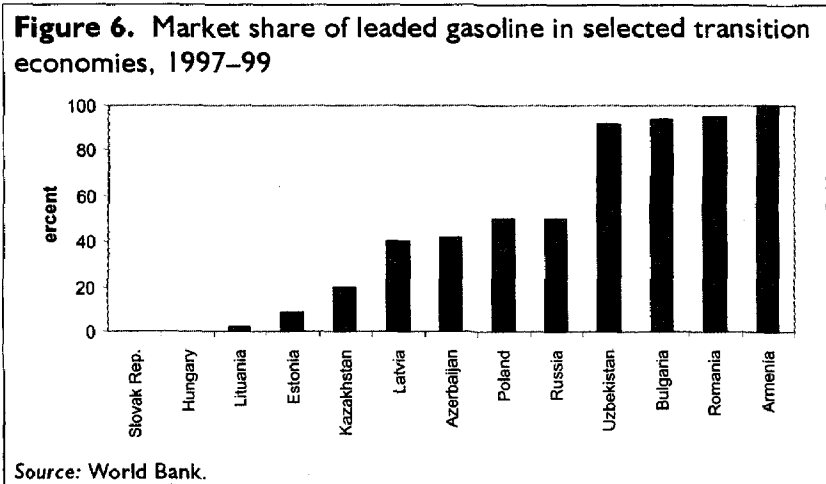
- By January 1, 2005, leaded gasoline will no longer be marketed in European countries.
- As intermediate targets, countries undertake to reach an 80 percent market share of unleaded gasoline by January 1, 2002, at the latest, and set a maximum limit for lead content in gasoline of 0.15 grams per liter (g/l) by January 1,

2000, at the latest. The lead content of unleaded gasoline is not to exceed 0.013 g/l.

The strategy was submitted to the Fourth Environment for Europe Ministerial Conference in Århus, Denmark, in June 1998. Thirty-three countries committed themselves to the objectives.

Central Asia and the Caucasus. During 1997–98 the Bank assisted Azerbaijan, Kazakhstan, and Uzbekistan with national commitment-building programs for phasing out leaded gasoline. Under the program, Azerbaijan and Kazakhstan made commitments to phase out leaded gasoline by 2005 and Uzbekistan, by 2008. National action plans were prepared and are currently being implemented.

In 1998 the Bank initiated a multiyear regional study on cleaner transport fuels to improve urban air quality in Central Asia and the Caucasus. The study, undertaken with the participation of the environment, energy, and transport sectors, has focused on Armenia, Azerbaijan, Georgia, Kazakhstan, the Kyrgyz Republic, Tajikistan,



Turkmenistan, and Uzbekistan. (See Figure 6 for recent data on the share of leaded gasoline.). The primary objective is to provide a framework for improving urban air quality by setting medium- and longer-term fuel quality objectives cost-effectively, improving air quality monitoring, and reducing vehicle emissions.

South Asia. In 1998, the George Foundation, with the support of the World Bank, the U.S. Centers for Disease Control and Prevention, and other bodies, organized a large international conference in India on prevention of lead poisoning. The objective was to raise awareness and develop a lead poisoning prevention strategy for India and other countries in the region. The phaseout of leaded gasoline is a key element of the proposed complex strategy, which includes measures in the health and environment area.

Bilateral assistance

In addition to regional programs, the Bank has been involved in bilateral support of national lead phaseout plans in several countries, including Bulgaria, Jamaica, Pakistan, Peru, Romania, Trinidad and Tobago, and Vietnam.

Box 3. Lead phaseout in Thailand's Clean Fuels Program

As part of a comprehensive program to address urban environmental concerns, the Bank provided analytical and policy support to the government in designing its clean fuel program and assisted in the introduction of clean fuel standards. Policy measures such as the deregulation of oil prices and removal of restrictions on private sector investments in the refinery sector facilitated the rapid adjustment of refineries to changing conditions. The Bank supported the successful restructuring of the Bangchak refinery and provided financing for the Clean Fuels and Environmental Improvement Project to help meet the government's fuel quality requirements. About a year after introduction of the program, the market share of unleaded gasoline had increased to about 18 percent. Within five years, leaded gasoline had been phased out completely.

Challenges ahead . . .

The World Bank, together with other multilateral and bilateral partners and NGOs, has succeeded in raising public awareness of the lead problem and in strengthening commitment in several regions to phase out leaded gasoline. However, in a number of countries (for example, Bangladesh, Cuba, Indonesia, Kenya, Lebanon, Nigeria, Pakistan, Romania, Syria, and Venezuela), unleaded gasoline has not yet been introduced or is used only in insignificant amounts; while high concentrations (0.6 to 0.8 g/l) of lead are added to gasoline in some cases. With the growth of traffic and urbanization, these countries will face increasing human health problems unless measures are taken to change the situation.

A challenge for the Bank is to strengthen political commitment in countries and regions where less progress has been made and to facilitate the implementation of lead phaseout plans in countries where strong commitment exists but assistance is needed. Among key areas for future efforts are the introduction of lead phaseout objectives into the policy dialogue and into operations in the transport, energy, urban development, and environment sectors, and closer collaboration with the IFC.

Further information

Abt Associates, Inc. 1995. "Reducing Lead in Gasoline: Refining Technology and Economics." Paper presented at the U.S.-hosted International Workshop on Phasing Lead Out of Gasoline, Washington, D.C., March 14–15.

ESMAP. (Energy Sector Management Assistance Program) 1997. "Elimination of Lead in Gasoline in Latin America and the Caribbean. Status Report, December 1997." Energy Sector Management Assistance Programme. Washington, D.C.: World Bank.

- Lovei, Magda. 1998. *Phasing out Lead from Gasoline: Worldwide Experience and Policy Implications*. World Bank Technical Paper 397. Washington, D.C.
- Lovei, Magda, editor. 1997. *Phasing Out Lead from Gasoline in Central and Eastern Europe. Health Issues, Feasibility, and Policies*. Implementing the Environmental Action Program for Central and Eastern Europe series. Washington, D.C.: World Bank.
- Sayeg, Philip. 1998. *Successful Conversion to Unleaded Gasoline in Thailand*. World Bank Technical Paper 410. Washington, D.C.
- USEPA (U.S. Environmental Protection Agency). 1985. "Costs and Benefits of Reducing Lead in Gasoline: Final Regulatory Impact Analysis". EPA-230-05-85-006. Office of Policy Analysis. Washington, D.C.



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