Why Lead Should be Removed From Gasoline

Lead impairs the mental and physical development of children even at low levels of exposure. The social benefits of removing lead from gasoline -- the major source of exposure in many urban areas -- vastly outweigh the costs. Political commitment and well designed policies play a key role in facilitating the lead phase-out process.

Why Should We Care About Lead?

Lead has long been recognized as a neurotoxin. However, its adverse effects on the brain development of children at lower concentrations were not understood until the 1970s, when scientific evidence showed that lead retarded the mental and physical development of children, causing reading and learning disabilities, hearing loss, hyperactivity, and reduced attention span even at low levels of exposure. A highly significant association has been found between the exposure of children to lead and their IQ. In adults, exposure of even low concentrations of lead has been demonstrated to result in elevated blood pressure and hypertension, leading to an increased risk of cardiovascular diseases. No threshold has been identified under which adverse health effects cannot be detected.

Ingestion is the main route of exposure to lead in children, who represent the highest risk group due to their propensity to ingest significant quantities of contaminated dust and soil; the high lead absorption rate of their digestive systems; and the susceptibility of their nervous systems to lead-induced disruptions. Adults are more susceptible to lead exposure through inhalation.

The Risks of Leaded Gasoline

The special properties of lead to improve auto engine performance by increasing the resistance of the internal combustion engine to early ignition (measured by the octane rating of gasoline) was discovered at the General Motors Research Laboratory in 1921, and lead additives
to gasoline have been widely used since the 1930s. By the 1970s, the worldwide use of lead as a gasoline additive reached 375,000 tons (Nriagu, 1992).

The main sources of human exposure to lead include leaded gasoline; industrial processes such as lead smelting and coal combustion; lead-based paint; and lead-containing pipes or lead-based solder in water supply systems. Most countries have already prohibited the use of many lead-containing products and have taken measures to abate emissions from large point sources.

Vehicular traffic, however, remains the single largest source of environmental lead pollution in most urban areas in developing countries, typically accounting for over 90 percent of all lead emissions into the atmosphere. Besides posing an immediate health risk through inhalation, vehicular lead emissions also accumulate in the soil, and enter the food chain, contributing to exposure through ingestion for long periods of time. High blood lead levels have been detected in urban areas where gasoline with high lead content is widely used (Figure 1), contributing to large public health costs. In Jakarta, for example, these costs were estimated between US$40 and 97 million in 1990.

A remarkably close relationship has been demonstrated in the U.S. between changes in the lead content of gasoline and blood lead levels (Figure 2).

**What Can Be Done?**

Various technological options are available to increase the octane of gasoline without using lead, by modifying the petroleum refining process. Complex (conversion) refineries have a wider range of technical options for octane enhancement than more simple (skimming) refineries. The refinery options of octane enhancement also determine the environmental effects of gasoline. While some of these options (e.g., increasing reformer severity) increase the aromatic content of gasoline, thus raising human health concerns, others—such as oxygenates—increase octane without significant health effects. Oxygenates—additives that contain oxygen—replace aromatics and also help fuels burn cleaner and more completely, thereby reducing the tailpipe emission of hydrocarbons, carbon monoxide and various air toxics. Therefore, the use of oxygenates, as well as other environmentally beneficial refining processes—such as isomerization, and alkylation—are preferred as a way of substituting lead.

**What Are the Costs?**

The cost of refinery modifications and, if required, of additives to increase octane levels or to provide lubrication rarely amount to more than US$0.01-0.02 per liter of gasoline. The cost of increasing unleaded gasoline octane by one RON (Research Octane Number) has been estimated around US$0.002 per liter (Thomas, 1995). Conversion refineries can typically substitute lead at a considerably lower cost than skimming refineries. In some cases—as a recent study of the Romanian refineries shows—a reduction in the lead content may even save money for the refining industry. Refining costs decrease over time as refineries adopt the new approach.

**What Are the Constraints?**

Besides enhancing engine performance by increasing the octane rating of gasoline, lead has also functioned as a lubricant of the exhaust valves. This allowed car manufacturers in the past to use low grade metals for the valves. Extensive studies and tests were carried out in the U.S. and elsewhere to assess the impacts of unleaded gasoline on these old engines.
**Box 1**

**Lead Trading and Banking in the U.S.**

A lead trading and banking program was introduced in the U.S. to allow refineries greater flexibility in adjusting to regulations aimed at phasing out lead from gasoline. Lead credits were created on the basis of existing standards and current production levels with average lead content. Inter-refinery trading of lead credits was permitted in 1982, while banking of lead credits was initiated in 1985. Refineries with lower costs of adjustment in refining, storage, transportation and distribution achieved higher than required lead reductions, earning credits to be sold to refineries with higher adjustment costs, or banked against future reduction requirements.

An active market developed for lead credits. The U.S. Environmental Protection Agency (EPA) estimated that savings due to the trading program reached $228 million. The monitoring of the lead content of gasoline, enforcement of compliance, and an agreement about basic environmental goals were critical factors in the successful implementation of the program.

These tests failed to show significant valve seat recession under normal driving conditions, while they demonstrated cost savings since lower maintenance costs were associated with unleaded gasoline due to less frequent oil change requirements, muffler and spark plug replacement, and reduced corrosion. In the U.S., these cost savings were estimated at 5 cents per liter.

Studies have demonstrated that a very low amount (0.02-0.05 gram per liter) of lead already provided sufficient protection to sensitive engines even under extreme driving conditions. Concerns about the protection of the soft valves of older cars can therefore be addressed by very low levels of lead in gasoline; intermittent fueling (using leaded gasoline only occasionally); or alternative gasoline additives (for example, potassium naphthenate) to provide lubrication of the valves in the absence of lead. Since the number of vehicles with soft valve seats is rapidly decreasing as auto manufacturers have increased the hardness of metal used for the valves, valve seat recession is a diminishing constraint of the total lead phase-out process.

**What is the Experience Worldwide?**

Countries around the world are at various stages of tackling the problem of human exposure to traffic-related lead emissions. Many countries have simultaneously reduced the lead content of gasoline and increased the market share of unleaded gasoline. In some countries (for example, the U.S.), the introduction of unleaded gasoline was initially driven by the intention of protecting the catalytic converters of new cars that were installed to reduce tailpipe emissions of various pollutants and required the use of unleaded gasoline. In others (for example, in the European Union), the regulation of lead levels in gasoline preceded the widespread use of catalytic converters. Lead has been totally phased out from gasoline in several countries including Austria, Brazil, Colombia, Japan, Slovakia, and Sweden. In a large number of developing countries, however, the use of gasoline with high lead content (frequently exceeding 0.8 grams per liter) is still standard practice, and unleaded gasoline has not been introduced yet (e.g., Bangladesh, Honduras, Lebanon, Uganda, Zimbabwe). Without significant changes in public policies, leaded gasoline can be expected to create large health damages in these countries as their urbanization and motorization increases.

**Conclusions and Policy Implications**

Large public health damages can be avoided at relatively low cost by phasing out leaded gasoline. According to estimates, the health benefits of phasing out leaded gasoline exceeded the costs by more than eleven times in the U.S. (U.S.EPA, 1985). Experience has shown that (i) public awareness of the health impacts of vehicular lead emissions coupled with strong political will to tackle the problem plays a decisive role in phasing out leaded gasoline; (ii) it is possible to achieve the total phase-out of leaded gasoline rapidly; (iii) leaded gasoline can be phased out independently from the introduction of catalytic converters; and (iv) policies, public programs, and market incentives that accelerate changes in consumer demand and the adjustment of gasoline supply, can be very effective in supporting direct regulations restricting the use of leaded gasoline.
Recommendations

The total phase-out of leaded gasoline is the recommended policy. Although the introduction of catalytic converters may be a necessary and cost-effective solution of protecting people from the adverse impacts of certain pollutants, the phase-out of leaded gasoline can and should be carried out independently from the commitment to adopt catalytic converters. The Bank can assist governments to design and implement policies that accelerate the phase-out of leaded gasoline. Measures should include:

- Differentiated gasoline taxation in favor of unleaded gasoline (creating a 5-10 percent price difference) to increase demand for unleaded gasoline;

- Public education to increase the awareness of the health benefits of eliminating lead from gasoline, and to address public misconceptions about the feasibility of using unleaded gasoline in cars without catalytic converters;

- Other incentive programs to facilitate the cost-effective phase-out of lead (Box 1);

- Fuel specifications to ensure that lead is not replaced by other harmful substances; and

- Training and education of technical staff to ensure the proper adjustment of vehicles.

If markets are allowed to function properly, the incremental cost of refinery investments and the production of unleaded gasoline are normally passed on to the consumers in the price of gasoline. Price liberalization or pricing policies, therefore, should ensure a reasonable financial return on oil refinery investments and on the distribution and retail of unleaded gasoline. Under the right incentives and policies, financing for capital investments are available from private sources. The implementation of leaded gasoline phase-out policy, therefore, should be part of the restructuring of the petroleum sector that is currently underway in most developing and transition economies. By facilitating the privatization and restructuring of the petroleum sector, the World Bank can also accelerate the phase-out of lead from gasoline.

References and Suggested Further Reading


Thomas, Valerie. 1995. The Elimination of Lead in Gasoline. CEES, Princeton University, Princeton, N.J.


Box 2
The World Bank's Assistance with Phasing Out Leaded Gasoline

The Bank has played a catalytic role in developing countries in (i) identifying the problem of lead exposure; (ii) designing and adopting an appropriate policy framework; and (iii) facilitating the implementation of the policy.

Several Bank studies have pointed out the danger of high lead exposures due to vehicular emission in Asia, Latin America, Africa, and in Central and Eastern Europe. Lead was identified as one of the most serious environmental hazards, for example, in most countries in Central and Eastern Europe.

The Bank has also facilitated the development of policies that include (i) tax incentives to change the structure of fuel demand; and (ii) price, market, and trade liberalization measures that facilitate supply-side adjustments to structural changes in fuel demand. In Thailand, for example, price and market liberalization measures have contributed to the implementation of environmental objectives, and improvements in productivity and increased participation of the private sector in the petroleum industry.

In addition, the Bank is supporting the restructuring of a petroleum refinery in Thailand to meet reformulated gasoline specifications. Projects are also under preparation in Bulgaria and Costa Rica to assist governments with the implementation of phasing out the production of leaded gasoline by refineries.