Removal of Lead from Gasoline

Human exposure to lead is a major environmental health hazard, a large part of which is attributed to the use of lead in gasoline. Experience has shown that significant reduction of present and future human exposure to lead can be achieved cost-effectively by removing lead from gasoline. This chapter provides guidance on implementation of programs to phase out lead from gasoline.

Impacts and Sources of Exposure to Lead

Lead is a highly toxic heavy metal that adversely affects the nervous, blood-forming, cardiovascular, renal, and reproductive systems. Of most concern are its effects on the nervous system of young children—reduced intelligence, attention deficit, and behavioral abnormalities—and its contribution to cardiovascular disease in adults. Such impacts occur even at low levels of exposure; there is no known lower threshold.

Human exposure to lead can be attributed to four types of sources: vehicular, when lead additives are used in gasoline; industrial emissions, largely from the mining, smelting, and processing of lead and lead-containing metal ores; waste disposal and processing of lead-containing substances through such means as incineration; and use of lead-containing products such as water pipes and solder, food-can solder, ceramic glazes, paint pigment, and batteries. Many of the uses of lead (for example, in paint) have been banned by most countries. As a result, vehicular traffic is often the largest source of human exposure, accounting for as much as 90% of all atmospheric lead emissions in many urban areas. A close connection has been discovered between the use of lead in gasoline and human health impacts (USEPA 1985). In addition to the immediate health exposures through inhalation, lead also accumulates in the soil, causing long-term exposure.

Rationale of Removing Lead from Gasoline

Since the 1930s, alkyl-lead compounds have been widely used to improve auto engine performance by increasing the resistance of the internal combustion engine to early ignition (measured by the octane rating of gasoline). The use of lead additives allowed car manufacturers to produce larger and more powerful engines, leading to rapid growth in the use and emission of lead from vehicular sources. Two major factors have brought about a decline in the use of lead in gasoline since the 1970s:

- The introduction of catalytic converters, designed to reduce tailpipe emissions of various pollutants, which required the introduction of unleaded gasoline to protect the converters.
- The recognition that health impacts occur even at low exposure levels, which induced measures to reduce the lead content of gasoline to minimize health impacts.

Because the social benefits of phasing out lead largely outweigh the costs, policies should facilitate the reduction of lead from gasoline in addition to and beyond the demands of changing car technology.

Worldwide Experience with Phasing Out Lead from Gasoline

Phase-out of lead is in different stages around the world. Argentina, Austria, Bermuda, Brazil,

Canada, Colombia, Costa Rica, Denmark, El Salvador, Finland, Germany, Guatemala, Honduras, Hong Kong (China), Japan, Nicaragua, the Slovak Republic, Sweden, Thailand, and the United States, among others, have completed a total phase-out. In some countries, such as the United States, the phase-out was initially driven by the desire to protect catalytic converters. In others (for example, EU member countries), the regulation of lead levels in gasoline preceded the widespread use of catalytic converters. Brazil and Colombia, among others, have introduced alternative fuels such as alcohol. Many developing countries, however, still use alarmingly high concentrations of lead in gasoline and have not yet introduced unleaded gasoline (see Table 1).

Technical Issues

Refinery Capacity to Produce Unleaded Gasoline

Gasoline-importing countries have greater flexibility in phasing out the use of lead in gasoline than do countries where domestic oil-refining capacity determines the options and cost of adjustment. Experience shows that the modifications required in refinery processes to reduce lead may be quite modest, depending on such factors as refinery complexity (more complex refineries adjust more easily), spare octane capacity, and the octane requirement of the car fleet. The additional cost of producing unleaded gasoline rarely exceeds US$0.01–$0.02 per liter of gasoline. The potential adverse

Table 1. Worldwide Use of Lead in Gasoline

Maximum allowed lead in gasoline	*Market share of unleaded gasoline (%)*		
	Low (0–30)	*Medium (30–70)*	*High (70–100)*
Low (< 0.15 g/l)	Cyprus, Greece, Ireland, Israel, Italy, Malaysia, Philippines, Poland, Portugal, Spain, Turkey	Belgium, Brunei, France, Hungary, Iceland, Luxembourg, Norway, Singapore, Switzerland, Taiwan (China), United Kingdom	Argentina, Austria, Bermuda, Brazil, Canada, Colombia, Costa Rica, Denmark, El Salvador, Finland, Germany, Guatemala, Honduras, Hong Kong (China), Japan, Netherlands, Nicaragua, Slovak Republic, Sweden, Thailand, United States
Medium (0.15–0.40 g/l)	Bahrain, Côte d'Ivoire, Egypt, Iran, Jordan, Kenya, Laos, Mauritania, Mauritius, Namibia, Paraguay, Qatar, Russian Federation, Saudi Arabia, Sri Lanka, South Africa, United Arab Emirates, Uruguay, Vietnam	Australia, Ecuador, Mexico	
High (> 0.40 g/l)	Algeria, Angola, Bangladesh, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Chad, China, Cuba, Ethiopia, Gabon, Ghana, India, Jamaica, Kuwait, Lebanon, Liberia, Libya, Madagascar, Malawi, Mali, New Zealand, Niger, Nigeria, Oman, Pakistan, Panama, Peru, Romania, Senegal, Syria, Venezuela, Yemen, Zimbabwe		

Note: Table is based on 1993–95 data; g/l, grams per liter.
Source: Lovei 1996.

environmental impacts of certain refinery processes should restrict the choice of technologies for replacing lead. Specifically, an increase in the aromatic (benzene) content of gasoline should be avoided by relying on isomerization, alkylation, and the use of oxygenates such as methyl-tertiary butyl ether (MTBE) to replace the octane-enhancing capacity of lead.

The Impact of Unleaded Gasoline on Cars Designed to Use Leaded Gasoline

Besides enhancing engine performance, lead lubricates the exhaust valves. In the past, this characteristic allowed car manufacturers to use soft, low-grade metals in the engine valves. The lubricating function of lead has become unnecessary in the new generation of cars; as most car manufacturers began using hard metals in valves during the last two decades. However, a significant share of the car fleets in many developing and transition economies may still consist of old cars with soft valves. The recession of these soft valves (especially the valve seats) caused by unleaded gasoline has been seen as an obstacle to the rapid phase-out of lead from gasoline in many countries. Tests and experience show, however, that (a) this problem is not as serious as is believed; (b) much lower lead concentrations than are found in most leaded gasolines still provide adequate protection to sensitive engines; (c) significant maintenance savings are associated with the switch from leaded to unleaded gasoline; and (d) valve seat recession can be avoided by adding lubricants to unleaded gasoline.

Policy Issues

Since the social benefits of removing lead from gasoline are large and the technical obstacles are relatively easy to deal with, the key to successful lead phase-out programs is the introduction of proper government policies. Recognition of the lead problem and political commitment to tackle it play a decisive role in initiating phase-out. The main areas on which government policies should focus are discussed below.

Public Awareness-Building and Education

Public awareness of the rationale of phasing out lead from gasoline plays an important role in changing consumer habits and demand. Public education should provide information on:

- The health impacts of lead
- The feasibility of using unleaded gasoline in various types of cars
- Recommended fueling practices
- Recommended maintenance requirements.

Consensus Building

A lead phase-out program requires the participation of various stakeholders whose consensus in the support and implementation of the program is essential. National programs should be designed with the participation of the main stakeholders including:

- The ministries of energy, industry, transport, environment, health, and finance
- Interest groups such as associations of car manufacturers and oil refineries
- Consumer groups such as auto clubs
- NGOs.

Fuel Specifications

Fuel specifications should provide clear requirements for scheduling the reduction and ultimate elimination of lead use in gasoline. To avoid the potential negative health impacts of certain refinery processes, fuel specifications should also limit the aromatics and benzene content of gasoline.

Regulations for Implementation

Government regulations should facilitate the cost-effective adjustment of gasoline supply to changing demand and requirements. In countries where a large number of refineries exist, the optimal timing and speed of adjustment at each refinery is likely to vary. Incentive regulations, such as lead trading among refineries (implemented, for example, in the United States) allow for flex-

ibility in the timing of compliance with changing fuel specifications.

Price Policies

Gasoline prices should enable domestic refineries to adjust. Liberalized price and market policies allow refineries to generate sufficient resources and returns to finance such adjustment. Controlled gasoline prices, however, can facilitate such adjustment only if prices are set at least at the level of prevailing international market prices. Gasoline price subsidies should be eliminated to encourage rapid supply-side adjustment.

Tax Policies

A tax rate that is higher for leaded than for unleaded gasoline is justified to reflect the social costs of negative health impacts caused by lead. Experience has shown that differentiated taxation which results in a 5–10% difference in favor of unleaded gasoline prices facilitates the rapid adjustment of consumer habits and demand. If revenue neutrality is an objective, the difference in tax rates will need to be adjusted over time as the market share of unleaded gasoline increases during the phase-out period.

Environmental Policies

Air pollution causes serious health damage, especially in densely populated urban areas. Traffic is generally a large and growing contributor to these pollution problems. In many cases, the requirement to install catalytic converters is justified to reduce the damage. Such regulations facilitate the shift in gasoline demand toward unleaded gasoline brands.

Import Policies

Import regulations and customs levied on imported cars on the basis of their age and environmental performance affect gasoline demand. Import policies should reflect the social cost of pollution generated by imported cars, using such proxies as presence of an emissions control device, typical emissions factors of the car model, and age of the vehicle.

Promotion and Training

Governments can accelerate the adjustment of markets to the wider use of unleaded gasoline by encouraging promotion of unleaded gasoline and by supporting the training of technicians and car mechanics in the proper maintenance and adjustment of the various types of vehicles to enable use of unleaded gasoline.

World Bank Experience

Policies

World Bank studies have pointed out the danger of lead exposure in, for example, Indonesia, Mexico, Thailand, the Middle East, and Central and Eastern Europe. Evidence of the adverse health impacts of lead has led to government action to address the problem and, with the assistance of the Bank, to design and implement lead phase-out programs and supporting policies in a number of countries, including Bulgaria, Mexico, the Philippines, and Thailand. Experience in Thailand has shown that rapid lead phase-out is possible if the government sets clear deadlines, gasoline prices are liberalized, and refineries respond to market changes and regulations. The lead phase-out program was severely hampered in Mexico, where price policies and market liberalization efforts failed to support the adjustment of refineries and of consumer behavior.

Implementation

The Bank has provided financial support for the restructuring of the Bangchak refinery in Thailand to enable the refinery to produce unleaded gasoline. The Bank's financing role has been largely catalytic, to attract the participation of commercial sources. As a result of government policies and rapid refinery adjustment, lead was completely phased out from gasoline by the end of 1995 in Thailand. A similar project, in preparation, will assist the main refinery in Bulgaria

to improve its technical capacity to increase the production of unleaded gasoline.

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