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U.S. and Mexico Sponsored International Workshop on Phasing Lead out of Gasoline

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Summary Proceedings of the
International Workshop
on
Phasing Lead Out of Gasoline

March 14, 15, 1995
Washington, D.C.

Co-hosts:
The United States Environmental Protection Agency
The Mexican Secretariat of Environment, Natural Resources, and Fisheries

Sponsors:
The World Bank
The Pan-American Health Organization

Introduction

On March 14 and 15, 1995, the United States Environmental Protection Agency (USEPA) and the Mexican Secretariat of Environment, Natural Resources and Fisheries (SEMARNAP) co-hosted an International Workshop on Phasing Lead Out of Gasoline. The development of this workshop dates back to the 1994 meeting of the United Nations Commission on Sustainable Development (CSD), where USEPA Administrator Carol Browner called for a global phase out of lead in gasoline. At the Summit of the Americas held in December, 1994, heads of state committed to develop action plans to phase lead out of gasoline in the Western Hemisphere. As a follow-up to these high-level commitments, in March, 1995, USEPA and SEMARNAP hosted this workshop.

More than 80 representatives from more than 25 nations, international organizations, industry associations and universities participated in the workshop. Participants discussed rationales and incentives to encourage the phaseout of lead in gasoline, identified national commitments required and highlighted available technologies and techniques. Administrator Carol Browner and Minister Julia Carabias opened the workshop with remarks, and Kyaw Kyaw Shane spoke on behalf of Dr. Klaus Toepfer, chairman of the Commission on Sustainable Development. The speakers emphasized the need for cooperation among industry, government and the public and requested due consideration of technical and fiscal issues facing developing countries as they strive to eliminate lead from gasoline.

The opening session concluded with an international status report on lead phaseout from Dr. Valerie Thomas of the Center for Energy and Environmental Studies, Princeton University, who pointed out that lead use in gasoline has been declining by about seven percent a year and that, with the exception of one small plant in Russia and another in Germany, Octel is the sole remaining producer of tetraethyl lead. Thomas reviewed the history of lead phaseout in various nations and concluded that many of the technical and practical problems they faced can provide valuable insights for other nations.

At the conclusion of the workshop, the participants agreed that the workshop's two major goals had been met. First, the workshop provided a valuable forum for exchanging views and sharing information and experiences regarding the phaseout of lead from gasoline. Second, workshop discussions outlined the steps needed at national levels to remove lead from gasoline, identified key obstacles to achieving a phaseout and described mechanisms that can be used to overcome these obstacles.

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International Workshop on Phasing Lead out of Gasoline

Workshop sessions began with a discussion of the health effects of exposure to lead and the benefits of removing it. Dr. Lynn Goldman, Assistant Administrator for Pollution Prevention, Pesticides and Toxic Substances, U. S. Environmental Protection Agency (USEPA), stated that lead exposure reduces intelligence in children, who are generally more vulnerable than adults, and that the effects are irreversible. Goldman described U.S. success in reducing lead exposure through both regulatory and voluntary measures.

Health Effects of Lead Exposure

Dr. Ellen Silbergeld, Department of Epidemiology, University of Maryland Medical School, reviewed the data on the health effects of exposure to lead. She stated that lead poisoning is prevalent but preventable and that children are especially vulnerable because their brains are still developing. Children absorb lead three to ten times more easily than do adults, so a given exposure can be much more injurious to children. In addition, since they explore the physical environment with their hands and mouths, infants and toddlers are more exposed to lead from all sources.

Lead in gasoline is also a 'multiplier,' meaning that its widespread dispersion and deposition guarantee many exposure pathways. Lead levels are high in urban air and soil, particularly in heavy-traffic neighborhoods. Indeed, the close correlation between leaded gasoline and serum lead is undeniable in the light of 'fingerprinting' techniques.

Silbergeld presented evidence of the detrimental effects of lead on children's cognitive development, academic performance, and attention span. Such effects appear even at relatively low exposures. There does not appear to be a 'safe' level of lead exposure. In adults, lead can cause high blood pressure, perinatal injury to the fetus, and kidney disease. Levels of lead in the blood of women rises markedly at menopause, suggesting mobilization of lead reserves in bone. The phenomenon may also appear during pregnancy and lactation, with the concomitant risk of transferring the lead to fetuses and infants.

The toxicity of lead appears to be independent of its chemical form, being generated by the lead cation itself. As increasing evidence of lead toxicity has emerged, the Centers for Disease Control has continued to lower the level at which medical intervention is recommended from 70 ug/dl before 1986 to 25 ug/dl in 1986 and again down to 10 ug/dl in 1991. Death occurs at about 100 ug/dl.

Suggesting removal of lead from all major exposure pathways, Silbergeld reminded her audience that: lead is ubiquitous and can't be detoxified; lead provides no known biological benefit; lead health effects are irreversible; and lead remains toxic indefinitely in humans.

Benefits versus Costs

Prof. Joel Schwartz of the Harvard School of Public Health discussed the costs and benefits of phasing out lead in gasoline in the United States. The costs include changes in refining and fuel distribution, plus the abiding concern over damage to engine valve seats. In the mid-1980's, a refinery optimization model indicated that unleaded gasoline requirements in the U.S added three to four cents per gallon to the cost of gasoline. Similar cost estimates have also been reported for OECD nations. Distribution costs will rise only where the distribution system has to accommodate both leaded and unleaded fuel at the same time.

With regard to concerns regarding valve seat damage to older vehicles run on unleaded gasoline, there is little or no evidence that this is a real, as opposed to a theoretical, problem. Studies indicate that valve seat damage can be a problem under extreme conditions -- during extended driving at high engine speeds and/or pulling heavy loads. However, in 1973 the U.S. Army tested unleaded gasoline on a fleet of 5000 vehicles under varying conditions and found no valve seat damage.

Benefits include far lower vehicle maintenance costs and dramatic health benefits for children and adults. Gasoline traditionally accounts for about half of exposure to lead in developed societies. A major benefit to consumers of removing lead from gasoline is fewer engine and exhaust system repairs. Lead additives cause corrosion and require more frequent oil changes and replacement of mufflers, exhaust pipes and spark plugs. In the United States in the 1980's, studies of large fleets of vehicles showed a savings in maintenance costs of about 18 cents per gallon[1]. Removing lead from gasoline was justifiable on the basis of savings in car maintenance costs alone.

In adult U.S. men, lead boosts blood pressure by one mm of mercury for each five ug/dl rise in blood lead levels—an increase that can increase strokes, infarctions and deaths. A comparable one ug/dl reduction in blood lead produces health benefits valued at $57 per year.

The benefits associated with avoiding the adverse health effects of lead exposure in children have been quantified in two areas: a reduction in measured Intelligence Quotient (IQ,) and lower educational attainment. Children exposed to lead have lower IQ's and grow into adults who earn less and are at greater risk of unemployment.

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[1] *Since the early 1980's, the use of upgraded steel for the exhaust systems of new U.S. cars has provided more corrosion-resistance than was previously the case. This would lower the cost savings slightly for newer cars, but a high percentage of cars in third world countries are pre-1980 models.*

In the United States, a one ug/dl increase in blood lead level for the first six years of life was estimated in 1988 to reduce an individual's potential earnings by about $1,300 (present value). A one point increase in IQ is associated with an increase of approximately one percent in lifetime earnings. Lead exposure also is associated with lower educational attainment because of inattention and behavior disorders. Lead exposure in children can also induce hearing loss and ancillary effects which have not yet been quantified in dollar terms.

Measured serum levels in U.S. children prior to phaseout were about nine ug/dl. Considering only the health effects of lower IQ 's of children[2] in the United States as a result of exposure to lead in gasoline, the health benefits to society of eliminating lead from gasoline are as high as 45 cents per gallon. This figure was calculated assuming that there is no 'safe' exposure threshold.

Schwartz noted that one concern about lead phaseout is the potential increase in aromatics, particularly benzene emissions, as refiners seek the least-cost approach ('reforming' process) to compensate for lost octane. But in the United States today, refiners replace the octane by using alternative processes that, though more costly, limit increases in aromatics and benzene. Moreover, where lead phaseout is accomplished in concert with the introduction of catalyst-equipped vehicles, 90 to 95 percent of any unburned aromatics and benzene are oxidized as they pass through the exhaust system catalyst. Catalysts also cut emissions of ozone precursors.

Even without catalyst-equipped vehicles, the adverse health effects from potential increases in the aromatic of greatest concern, benzene, are minor compared with the health effects associated with exposure to lead in gasoline. The USEPA's Carcinogen Assessment Group estimated that, in 1976, one of the early years of lead phasedown, automobile emissions of benzene were responsible for 47 cases of leukemia in the United States. By comparison, for white males age 40 to 59 can expect 5,000 deaths per year from high blood pressure and 6,000 first-time strokes and heart attacks per year due to lead in gasoline. These estimates were based on maintaining lead in gasoline at 0.5 gr/gal in the mid-1980s (USEPA's *1985 Regulatory Impact Analysis*). Thus, the health benefits from gasoline lead reduction far outweigh the adverse health effects from any increase in benzene emissions.

Characterizing the Problem

Mexico: Dr. Isabelle Romieu, of the Pan American Health Organization, analyzed the distribution and extent of lead exposure from gasoline in Mexico. She found that children, especially in industrial areas, are at high risk of lead exposure and that airborne lead from gasoline is a major contributor to exposure (other sources, such as lead glazes in ceramics, are also important). Romieu also discussed findings of greater cumulative exposure with longer residence, as measured in the bones of women. This has implications for transfer of lead contamination from mother to fetus and infant.

There is a substantial number of Mexican children and adults with elevated blood lead levels. In Mexico City, an estimated 25,000 children have blood lead levels greater than 25 ug/dl, and 800,000 women have blood lead levels greater than 15 ug/dl. Romieu highlighted the need for epidemiological studies to monitor changes in lead levels, because governments are more likely to intervene when they can see a significant impact. She also discussed the need in Latin America for more technical capability to test blood for lead and emphasized the importance of educating the population about the health effects of lead from gasoline and other exposure pathways.

Egypt: Dr. Yasser Sherif of the Cabinet of Ministers, Egyptian Environmental Affairs Agency, indicated that the Egyptian government believes that current scientific information justifies reducing exposure to lead and that benefits outweigh costs. The government is pursuing several lines of activity to reduce airborne lead exposure. First, to reduce exposure from private smelters, a major source of airborne lead, the government is using a cooperative approach to relocate industry outside Cairo to a less populous region and to introduce cleaner technologies. Second, the government will phase out leaded gasoline in Cairo and Alexandria, where rates of gasoline consumption are highest. The government has moved to boost production of reduced-lead fuel, improve transportation between Suez (where more refining production capacity exists) and Cairo, and build an isomerization plant. Emissions requirements for new vehicles have been tightened. Also, the government intends to reduce exposure by constructing a "ring road" to shift traffic to the Cairo outskirts.

Sources of Lead Exposure

Dr. George Alleyne, director of the Pan American Health Organization, introduced a panel lead by Assistant Administrator Dr. Lynn Goldman of USEPA's Office of Prevention, Pesticides and Toxic Substances. The panel discussed other sources of lead exposure. Panelists included Dr. Isabelle Romieu of the Pan American Health Organization and Dr. John Buccini from Environment Canada. Panelists identified alternative lead exposure pathways including pottery glazes, can solder, house paint, toys, water pipes, sports equipment, crystal, and industrial sources and processes. The panel surveyed current and planned actions, including progress in the OECD Chemicals Group, to address all sources of lead exposure. They concluded that a combination of mandatory and voluntary programs is necessary to reduce overall risk.

[2] *These figures also assume that, on average, four million children in the United States turn six each year and that approximately 100 billion gallons of gasoline are consumed each year.*

Obstacles and Successes

Assistant Administrator Mary Nichols of USEPA's Office of Air and Radiation, recounted the United States' experience of phasing lead out of gasoline, including the obstacles encountered. Unleaded gasoline was initially required in the U. S. so that cars could meet new vehicle emissions standards established to reduce smog. Lead in gasoline 'poisons' (disables) catalytic converters. During the phasedown transition period, both leaded and unleaded gasoline were sold. Thus, policymakers confronted the dual problems of preventing contamination of supplies of unleaded gasoline with leaded gasoline and of misfueling catalytic converter-equipped cars with leaded gasoline.

The problem of misfueling was exacerbated by the higher market price of unleaded gasoline. After her presentation, Nichols moderated presentations by five countries that focused on obstacles encountered and successes realized in lead phaseout programs.

Turkey: Fulya Somunkiranoglu, Turkish Ministry of Environment, stated that as motor vehicle use has risen in Turkey, so has air pollution. Turkey has approached the problem of lead in gasoline by revising gasoline standards, investing in unleaded refining technology, using economic incentives, and educating the public. Specific measures were: adoption of the EU standard of 0.15 g/l for leaded gasoline in 1988; investment in technologies for producing unleaded gasoline; reduction of the price of unleaded gasoline through decreased taxes; introduction of new cars with catalytic converters and imposition of higher taxes on cars not meeting EU emission standards.

South Africa: Dr. G. P. Venter, South African Department of Minerals and Energy Affairs, stated that in Capetown blood lead levels are estimated to be low -- between five and seven ug/dl. There are no requirements for lead phaseout. Nevertheless, a voluntary phaseout of lead in gasoline is underway due to technical and economic concerns of the auto industry as well as for environmental reasons. To encourage the use of unleaded gasoline, a fuel tax to create a price differential between leaded and unleaded gasoline has been considered. Of concern is the fact that such a tax would fall inordinately on the poor since the poor drive older cars that are thought to need leaded gasoline. In general, it is believed that costs should be borne by consumers and cost-benefit criteria should be established for installing catalytic converters on automobiles.

Sweden: Jan Karlsson, of the Swedish Environmental Protection Agency, stated that Sweden began limiting the lead content of gasoline in 1970. Since then, voluntary standards, economic incentives, and mandatory requirements have been used to convert the vehicle fleet to catalytic converters and to boost the use of unleaded gasoline. Tax differentials and information programs have been used to encourage the use of unleaded fuel. Lead will be completely phased out of gasoline in 1995. The Swedish experience indicates that cooperation with industry is important, alternative octane enhancers must be available, distribution costs can be cut by opening up a large market for unleaded gasoline, and quality control is vital as long as both leaded and unleaded are sold.

Bulgaria: Dr. Jontcho Pelovski, of the Bulgarian Ministry of Environment, stated that in Bulgaria emissions from the transportation sector and power plants account for approximately 80 percent of the country's air pollution. In 1983, Bulgaria reduced the lead content in gasoline from 1.2 gr/l to 0.15 gr/l. In 1985, refineries began to produce unleaded gasoline. However, unleaded accounts for only five percent of gasoline production today. The major problem with implementing lead phaseout is the prohibitive cost of upgrading the country's two refineries. In addition, there is a concern that older vehicles, which comprise a large share of the vehicle fleet, cannot use unleaded gasoline.

Russia: Vladimir Prozorov, chairman of the Dzerzhinsk City Committee on Nature Protection, stated that in 1992 Russia began a program to reduce lead in gasoline. Several cities, including Moscow and St. Petersburg, prohibit the sale of leaded gasoline. However, such programs have had limited success. Russia has one of the few plants in the world that still produces tetraethyl lead and officials have been unsuccessful in persuading the plant even to reduce emissions. Fiscal conditions make progress difficult. Further, the question of whether old cars can operate on unleaded fuel has not been resolved.

Gaining Support for Unleaded Gasoline

David Gardiner, Assistant Administrator for Policy, Planning, and Evaluation, USEPA, emphasized that reducing lead poisoning is a major sustainable development issue. He indicated that eliminating lead from gasoline has been one of the most successful regulatory efforts in the United States, and that the benefits have far exceeded the costs. Furthermore, phaseout and 'reformulated' gasoline have revolutionized U. S. refining technology. New production processes, utilizing pollution prevention technology, have been installed in the last few years. Gardiner also described the USEPA's *Environmental Technology Initiative*, which facilitates sharing information on clean technologies.

Lead Reduction Technologies & Costs

A presentation by David Hirshfeld and Dr. Jeffrey Kolb of Abt Associates examined refinery technology and the economic impacts of lead phasedown on third-world refineries. Hirshfeld pointed out that lead is a relatively inexpensive way to boost octane ratings by 12 to 15 points and that replacement-process options vary in cost and emissions consequences.

In an overview of petroleum refining processes and refinery types, Hirshfeld classified refineries (in increasing order of complexity) as: topping, hydroskimming, coking,

cat cracking, and deep conversion. As the complexity of a refinery increases, so does the range of process options available to phase down lead in gasoline. About 90 percent of refining capacity resides in 'conversion' refineries, which produce most of the gasoline sold in the world.

The least-cost option for refineries to replace lost octane is 'reforming', however, this process raises the aromatic and benzene content of gasoline. Higher cost processes that limit these and other pollutants include alkylation, pen/hex isomerization, and MTBE production.

A planning analysis was presented that addressed the cost of phasing out lead with process configurations typical of Latin American, Asian, and Pacific Rim areas. Using a refining optimization model and imposing the constraint that pollutant emissions were limited, Hirshfeld indicated that, for deep conversion refineries, the refining cost of removing lead from gasoline in developing countries is about six cents/gal[3]. When reforming processes alone are used and emissions are allowed to rise, refinery costs are about five cents/gal. The small additional cost to ensure emissions do not increase suggests that employing the more sophisticated processes constitute a cost-effective strategy.

Infrastructure and Vehicle Issues

U.S. Petroleum Industry: Ronald Jones, a vice-president of the American Petroleum Institute, spoke of why lead should be removed from gasoline, how it should be done, and what the U.S. has done thus far. In the U.S. there were two reasons for removing lead from gasoline. The first was to allow catalytic converters to be used to reduce carbon monoxide, hydrocarbon, and nitrogen oxide emissions. The second was to reduce lead emissions and health risks.

The phaseout was accomplished from 1974 to 1995 by introducing catalysts for cars and lowering, and eventually banning, lead content in gasoline. Service stations were required to sell unleaded fuel, misfueling was prohibited, refiners had to report lead usage, and vehicle emissions inspection and maintenance were required. As for infrastructure changes, refineries had to be rebuilt, storage systems were revamped and refineries, pipelines, terminals and service stations were cleaned up.

Initially, refiners were skeptical of claims by regulators that removing lead from gasoline would have significant economic benefits for automobile maintenance. By reducing the lead in gasoline, the life of exhaust systems and spark plugs was found to increase. As to valve seat problems, there was some evidence that valve seat life would be reduced in older cars fueled with unleaded gasoline. However, this turned out not to be a problem in the United States. In fact, for many years, Amoco marketed an unleaded premium gasoline for vehicles that also used leaded premium gasoline, without creating valve seat problems.

Jones pointed out that developing countries should learn from the mistakes made during the protracted U.S. program. In particular, he noted that certain gasoline properties with adverse environmental effects, such as gasoline volatility and aromatics content, increased during the lead phaseout period. This, in turn, required the imposition of new rounds of regulations controlling these gasoline properties. He emphasized that refiners should have flexibility in responding to lead phaseout and that countries should plan for lead phasedown in the context of an integrated air pollution control strategy.

U.S. Automobile Industry: Loren Beard of the Chrysler Corporation, representing the American Automobile Manufacturers Association, explained that there is an inherent relationship between the design of automotive engines and emission control technology and fuel. Further, fuel quality must match expectations for vehicle performance. Vehicles without catalytic converters have much higher pollutant emissions: twenty times higher for hydrocarbons and carbon monoxide and six times higher for nitrogen oxides. Unleaded gasoline allows the use of catalysts and other on-board emissions control systems.

Beard said the U.S. experience demonstrated that leaded gasoline aggravated tailpipe and muffler corrosion, shortened sparkplug life, and facilitated carbon deposits and oil contamination in engines. Lead also poisons catalysts, disables oxygen sensors, degrades cold-start performance in newer engines by causing intake valve and intake port deposits, and requires more frequent oil changes.

Pollution control technology is such an integral part of motor vehicles today that changes have to be made to modern cars to adapt them for sale in leaded gasoline markets. It is less expensive to produce vehicles designed to run on unleaded gasoline and then disable or remove emission control systems for sale in markets which allow leaded gasoline than it is to make vehicles without emission control systems in the first place. For such markets, Chrysler produces vehicles with pollution control systems, removes the catalysts and oxygen sensors, and disables closed loop controls, adaptive learning, and on-board diagnostics.

The issue of valve seat recession is not a problem in the United States. The use of hard valve seats in modern vehicles is now required. However, even with older valve seats, countries should not experience difficulties, because it is likely that lead levels would be maintained at low levels (such as 0.1 gr/gal) for several years, even in an aggressive lead phaseout program. Countries do, however, need to deal with possible misfueling during any period when leaded and unleaded gasoline are both available.

[3] *For less sophisticated refineries, e.g. hydroskimming refineries, limiting the aromatics and benzene content (and other emissions increases) of unleaded gasoline requires the addition of more expensive processes. The refining cost is roughly ten cents per gallon. Only a small proportion of total gasoline consumed in developing countries is produced in such refineries.*

Technology Issues and Approaches

William Nitze, Assistant Administrator for International Activities, USEPA, introduced speakers from India, Japan, and the Netherlands and moderated the discussion.

India: Dr. T. Chandini, Joint Director, Ministry of Environment and Forests, stated that a dramatic increase in the number of vehicles, coupled with weak emissions standards and enforcement, led India to introduce catalytic converters in 1995. The primary goal is to reduce air pollution in general, and the secondary goal is to reduce lead exposure. While India has no studies on costs of health effects related to automobile pollutants, it is estimated that at least one member of every family in metropolitan areas is suffering from a respiratory disease, particularly asthma.

In 1994, a lead phaseout initiative was launched that includes: upgrading existing refineries (only one or two out of 12 could produce unleaded gas as of 1991); introducing stricter emission standards; developing quality specifications for reformulated gasoline and diesel fuel; introducing unleaded gasoline for cars; and developing specifications for the nozzle size of fuel dispensers and tank heads.

Catalytic converters are imported duty-free; however, cars equipped with catalysts are still more expensive than cars without catalysts. The government wants the car industry to cross-subsidize catalyst-fitted cars with charges imposed on the others, but industry objects. Another problem is the increased use of highly-polluting two- and three-wheeled vehicles.

Japan: Takeshi Miki, of the Petroleum Department, MITI, and Shigeo Yamagishi, Deputy Director of the Environment Agency/Automobile Pollution, presented the Japanese experience with lead gasoline phaseout. Unleaded gasoline was introduced in Japan to prevent airborne emissions of lead and to ensure the durability of catalysts installed to reduce emissions of ozone precursors.

From 1972 to 1987, Japan tightened emissions standards, introduced catalytic converters, and set up refineries to produce unleaded gasoline. Between 1970 and 1974, the mean concentration of atmospheric lead along Tokyo's roadsides was reduced from 3.19 ug/cubic meter to 0.73 ug/cubic meter. Today, the level is 0.1 ug/cubic meter.

Four prominent issues surfaced in Japan's lead phaseout program. First, to address the potential valve seat recession problem, Japan required hardened valve seats and a dual fuel system (one-third leaded and two-thirds unleaded). In actuality, Japan did not experience a significant valve seat problems even for cars with unhardened valve seats using unleaded gasoline. Second, lead phasedown caused octane levels in gasoline to drop by two or three octane numbers in Japan's low-grade gasoline. Japan was able to increase gasoline octane to 90-92 without using MTBE by increased refinery processing. Third, to avoid a potential lead contamination problem in the distribution system, Japan required separate pipelines and trucks for leaded and unleaded gasoline and conducted periodic gasoline quality checks. Fourth, to prevent misfueling, Japan required different fuel dispensers in service stations for unleaded and for leaded gasoline and fuel-specific tank caps on cars requiring unleaded gasoline. Service station workers were trained and consumers informed of potential problems.

Netherlands: Jan Jrupp de Graeff of the Dutch Environmental Protection Agency, stated that in the late 1980's, prompted by political pressures and environmentally conscious consumers, Dutch industry reversed its uncooperative position towards the Dutch government's spending on environmental issues. This change opened the door to cooperation between industry and government.

The most significant form of this cooperation is the voluntary agreement, which has resulted in increased support for both environmental and industrial policies. For a voluntary agreement to be effective, there must be political or market pressure to motivate the industry, clear and achievable targets, a recognition of mutual benefits between industry and government, and legal measures and licensing to guard against 'free-riders.'

Agreements can be enforced in court, but that's unlikely to be needed. It is difficult for industries to enter into an agreement and not fulfill it, since there are future repercussions, such as problems obtaining government licenses. To date, 50 voluntary agreements have been drawn up.

Policy Reform & Financing

William Nitze of USEPA moderated this session on international financial institutions and industry perspectives.

The World Bank: The World Bank assists governments of developing countries by identifying problems; providing analysis and support to policymakers; helping to build commitments among such policymakers; playing a catalytic role in mobilizing finance from a variety of sources; and providing financing for specific projects. Dr. Andrew Steer, Director of the World Bank's Environment Department and Dr. Richard Ackermann, Principal Analyst in the Environment Department, discussed the World Bank's role in assisting developing countries.

Dr. Steer stated that, in the World Bank's view, there is no question that removing lead from gasoline is an appropriate public policy, since the benefits far exceed the costs. Further, he emphasized that the issue of introducing catalytic converters on cars as a pollution control measure is separate and distinct from the issue of removing lead from gasoline—that is, there is no reason to delay removing lead from gasoline. Failure to reduce the lead content of gasoline, given projections of substantial growth in consumption, would result in a large increase in lead emissions in developing countries where many children already suffer from high serum lead levels.

Steer and Ackermann outlined the methods typically used by the World Bank to promote projects in developing countries: direct loans and loan guarantees to governments; loan, equity, and guarantees to the private sector; coordination of donor financing; and policy analysis and dialogue at the global, regional, and country levels.

Steer indicated that obtaining financing for investments to phase out lead in gasoline should not be an impediment as long as countries establish appropriate production incentives for refineries, regardless of whether state-owned or privately held. Such incentives enable the investment to be commercially viable and make possible the conditions for the private sector or the government to provide financing. The World Bank may fund pre-loan studies, but it will not usually fund detailed engineering studies on refinery conversion projects by the private sector.

Steer and Ackermann identified several key policy issues: gasoline prices should be allowed to rise to international market levels, providing proper incentives to refineries and users and facilitating market supply adjustments; gasoline taxes should be used to make unleaded gasoline five to ten percent (revenue neutral) less expensive than leaded gasoline during the phasedown period to encourage a shift in demand to low-lead or unleaded; institutions and regulations must be developed to ensure an appropriately-paced phaseout that does not replace lead with other harmful substitutes; public education and outreach must be used to convey the health impacts of exposure to lead, the higher maintenance costs of leaded gasoline, that use of unleaded gasoline does not require catalytic converters, and other information to gain consumer support.

The World Bank supports several projects that address phasing lead out of gasoline, including work with Thailand, Bulgaria, Indonesia, and Costa Rica. Also, Mexico was highlighted for its pursuit of lead reduction in the context of an integrated, cost-effective pollution control strategy.

Inter-American Development Bank: Antonio Vives, Chief of the Infrastructure and Financial Markets Division at the Inter-American Development Bank (IDB), explained that the bank works with both governments and the private sector in Latin American countries. The IDB functions much as does the World Bank, except that the IDB tends to work more directly with the private sector. Loans to private sector companies are set at international market interest rates. Loans to the public sector have lower rates.

The IDB can provide financing for lead phaseout in the following ways: direct loans and equity to firms for development projects at refineries and/or introduction of additives that increase octane; loans through IDB's subsidiary Inter-American Investment Corporation; direct loans to local banks, which then allocate funds to the local private sector; and technical support to governments on issues such as air quality monitoring, enforcement mechanisms, and drafting of legislation and regulations.

Private industry: Paul Brochu of Wright Killen & Co. emphasized that when developing countries design phaseout programs, they should first determine the full set of properties they want their unleaded gasoline to have. This is important because it will guide how refineries respond to lead removal and can reduce the need for later changes in gasoline standards and, thus, for additional investments in refining processes.

Costa Rica: Mauricio Castro explained that, in October of 1994, coincident with the *Summit of the Americas*, Costa Rica and the other Central American countries signed an *Agreement on Sustainable Development*, under which they are committed to phase out lead in gasoline.

Juan Felix Martinez spoke about how Costa Rica is promoting the use of unleaded gasoline. Leaded gasoline is scheduled to be banned by 1997. However, refinery estimates indicate this may not be possible because Costa Rica largely depends upon imports (e.g., MTBE) to produce unleaded gasoline. Currently, unleaded gasoline comprises 80 percent of all gasoline sold, and there is a price differential of ten percent between super unleaded and regular leaded gasoline. A Costa Rican survey indicated that consumers are willing to pay eight percent more per gallon for unleaded gasoline. In 1990, the regulated lead content of gasoline was 0.84 gr/l. It dropped to 0.4 gr/l in 1993 and then to the present level of 0.2 g/l. There is a campaign to encourage the public to use unleaded gasoline.

David Pierce indicated that the President of Costa Rica has very actively pursued lead phaseout. Costa Rica has passed a law requiring that as of January, 1995, all cars entering Costa Rica must have catalytic converters. Several obstacles must be overcome: only 56 percent of service stations can handle three grades of fuel (diesel, low-octane gasoline, high-octane gasoline); refiners may not be able to meet demands for unleaded gasoline; and a recent fiscal crisis has forced a moratorium on expenditures.

Philippines: Maria Ana C. Corpuz, Chief of the Environmental Protection and Monitoring Division, and Zenaida Ygnacio Monsada, Chief of the Energy Resources Supply Administration Division, discussed gasoline lead phasedown in the Philippines. The oil industry in the Philippines is heavily regulated. The government is considering a lead phaseout program and is moving to deregulate the industry by 1997. Oil companies are filing petitions to upgrade and refurbish a number of refineries. Thus, the government needs to determine lead reduction goals soon.

Air pollution in the Philippines is largely due to vehicular emissions. Gasoline can contain up to 65 percent aromatics content. It is difficult to justify reducing lead content when gasoline comprises only 14 percent and diesel fuel comprises 40 percent of the total demand for petroleum products. Furthermore, the diesel fuel has a high sulfur content, which should be reduced.

The Philippine government thinks a switch from diesel to regular gasoline must precede a shift from leaded to unleaded. Other issues, such as the lack of multiple grade pumps at service stations; concerns over misfueling and valve seat recession problems; questions regarding the viability of MTBE as a safe octane enhancer; concern over the ability of refineries to produce low-aromatic unleaded gasoline; and whether to mandate the use of catalytic converters for both old and new automobiles, need to be resolved before a shift to unleaded gasoline will be made.

Thailand: Apichai Chvajarernpun, Minister-Counselor for Science and Technology, stated that in 1990 some 51 percent of all Thailand's energy consumption occurred in Bangkok, and 75 percent of this was for land transportation. A lead phaseout scheduled for 1984 to 1996 has included gasoline lead level reductions to 0.15 gr/l in 1992. Leaded gasoline will be completely banned in 1996. In 1993, all cars in Thailand were required to be equipped with catalytic converters. This increased the price of cars, but the increase was offset by government tax incentives for installing the catalysts. Both grades of unleaded gasoline in Thailand have a lower price than leaded. At this stage of the lead phaseout program, ambient lead levels in Bangkok have decreased from 0.5 ug/m^3 in 1987 to 0.1 ug/m^3 in 1994.

United States: Marc Hillson, Chief of the Mobile Source Enforcement Branch, USEPA, spoke about three key implementation issues: keeping track of the actual lead content of gasoline; assuring a sufficient supply of uncontaminated, unleaded gasoline to fuel catalyst-equipped cars; and eliminating the misfueling of unleaded vehicles with leaded fuel.

Each year, Federal inspections for contamination and misfueling were carried out for 10,000 of the 150,000-200,000 retail gas stations in the United States. There were state inspections also. Wholesale purchasers of gasoline, distributors and terminals were inspected. Where uncovered, it was determined that contamination of unleaded gasoline was generally unintentional and caused by sloppy operations.

In some cases, higher prices charged for unleaded gasoline led to some fraudulent sales of leaded gasoline labeled as unleaded. In response, the United States changed the gasoline pump nozzle size and filler inlet size of unleaded vehicles, which was only partially successful due to vehicle tampering. USEPA also required reports from both refiners and lead producers to track lead use and ensure compliance with lead content standards.

Beginning in the early 1980's, USEPA instituted a lead credit trading system that allowed refiners to trade unused lead credits (credits were earned by producing gasoline with lower than allowed lead content), which were worth about five cents a gram. In 1985, the rule that reduced the lead standard from 1.1 to 0.1 gr/gal allowed a refiner to bank lead credits for use in later years. The credits could also be sold to other refiners. On-site audits of refiners revealed that some companies had greatly overstated their gasoline volume and had falsely indicated compliance with the lead standard. Other audits showed the misreporting of imports to disguise leaded gasoline use. Hillson concluded by stating that where there is a financial incentive against compliance oversight is necessary.

Conclusion and Next Steps

There was general agreement among workshop participants that serious and irreversible health effects result from exposure to lead and that no level of exposure should be considered 'safe'. Current data does not permit establishing a clear threshold for adverse effects. Participants agreed that the savings to consumers and human health benefits of lead gasoline phaseout far exceed the costs imposed on refiners. The favorable benefit/cost ratio provides a strong rationale for lead phaseout. Participants supported expanded worldwide efforts to phase out gasoline lead. The key points include:

The technology exists to eliminate lead from gasoline.

Lead phase-out planning should be part of an integrated air quality program, and should take into account a nation's economic, energy, and environmental goals.

If gasoline prices are set at international market levels, and an effective policy framework is developed, the capital necessary for upgrading refineries should be available.

An effective policy-making framework means government willingness to commit to: enacting regulations to define and institutionalize lead phaseout; enforcement of the program, starting with proper monitoring and reporting; ensuring that the phaseout fits into a larger, comprehensive environmental and energy strategy; ensuring that the phased reductions are achievable; elimination of energy subsidies and the use of economic incentives, such as taxes, to ensure unleaded is not priced above leaded; and launching of a public awareness and education program.

The concern over valve seat damage in older cars from unleaded gasoline is not justified. Experiments and experience show that it only occurs under fairly heavy engine loads. For farm and construction vehicles, alternative additives are available. Lead additives can corrode and damage mufflers, exhaust valves and pipes, and spark plugs.

Aromatic and benzene increases concomitant with lead removal can be limited. At some cost, alternative refinery processing can replace octane while limiting increases in aromatics or benzene content. Also, where catalytic converters are installed on motor vehicles, 90 to 95 percent of unburned benzene in gasoline is oxidized. Most importantly, the health effects from exposure to lead are far more serious than those from exposure to benzene.

Follow-Up Activities

The USEPA will distribute a summary of Workshop proceedings to all participants.

The Center for Sustainable Development (CSD), at their April, 1995 meeting, formally supported the results of the workshop by endorsing efforts to reduce the use of lead in gasoline and urging countries to develop action plans o meet this goal.

The United States and Mexico will recommend that an appropriate organization consider developing an information network and/or clearinghouse on phasing lead out of gasoline to allow for dissemination of technical information assist countries in converting to unleaded gasoline.

During May, 1995, the U.S. National Academy of Sciences, in cooperation with the Instituto Nacional de Salud Publica and the Academia Nacional de Medicina of Mexico, held an International Symposium and Workshop series, *Lead in the Americas: Strategies for Disease Prevention*, in Cuernavaca, Mexico.The Symposium developed a framework and action plan to reduce the pathogenic burden of environmental and occupational lead throughout the Western Hemisphere.

In September of 1995, pursuant to commitments made at the 1994 *Summit of the Americas*, Puerto Rico will host technical experts from the Western Hemisphere. Their task will be to establish clear priorities under the *Pollution Prevention Partnership Program*, including gasoline lead phaseout.

Through its bilateral and multilateral programs USEPA will provide technical guidance to help others choose the most cost-effective courses of action to achieve phaseout.