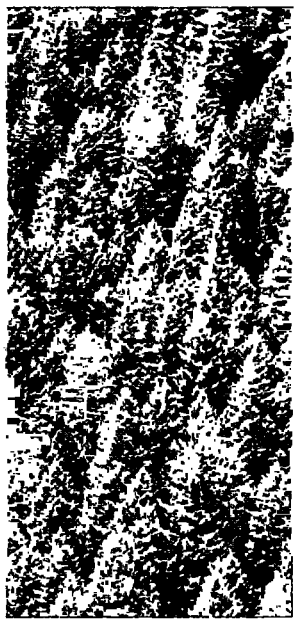
An Overnight Success:

Vietnam's Switch to Unleaded Gasoline

ESM257



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ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

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ESMAP Management"

Contents

Abbreviations

ASEAN	Association of Southeast Asian Nations
CIDA	Canadian International Development Agency
ESMAP	Energy Sector Management Assistance Program
EU	European Union
GoV	Government of Vietnam
HCMC	Ho Chi Minh City
LG/ULG	Leaded gasoline/unleaded gasoline
MOD	Ministry of Defense
MOH	Ministry of Health
MOI	Ministry of Industry
MOSTE	Ministry of Science, Technology, and Environment
MOT	Ministry of Transport and Communications
MOTr	Ministry of Trade
MPI	Ministry of Planning and Investment
MPS	Ministry of Public Security
PM	Prime Minister of Vietnam
RON	Research octane number
SIDA	Swedish International Development Cooperation Agency
TCVN	Vietnam Technical Standard
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
USAEP	United States–Asia Environmental Partnership
USEPA	United States Environmental Protection Agency
VND	Vietnamese dong (US$ 1 = 14,896 VND, as of 07/01/01)
VR	Vietnam Register
WB	The World Bank

Foreword

Of all the environmental issues that can be undertaken in developing countries, switching from leaded gasoline (LG) to unleaded gasoline (ULG) is one of the few that can have immediate results. On July 1, 2001 Vietnam took an important environmental step by switching to ULG virtually overnight. This report describes the process that led up to this important decision.

International studies have consistently shown that lead poses an extreme risk to urban populations, especially young children: even low exposure to lead is associated with behavioral problems, learning disabilities, and reduced intelligence. The risk of LG has been known for some time, and during the past 10 years the move to phase out LG has gained momentum. By eliminating lead from gasoline, countries can immediately reduce the risks of human exposure to lead.

Today, in addition to developed countries, many developing countries, including Bangladesh, India, Thailand, the Slovak Republic, El Salvador, and Nicaragua, have switched to ULG. As Vietnam has shown, for countries that do not have large petroleum refining sectors, the switch to ULG can be done quickly and at low cost. Countries that have eliminated LG have found that the technical difficulties are minor, and that the financial costs also have dropped as fewer countries use LG. Nonetheless, overcoming widely help perceptions about LG requires a high level of consensus-building and strong political support from key government agencies and senior leaders.

In switching to ULG, Vietnam has shown environmental leadership and concern for the health of its citizens. We particularly commend the Government of Vietnam for its commitment and for the expedience with which the switch was made. By its positive example, Vietnam can help persuade the countries that still use LG to make the switch to ULG and to remove one of the most serious, and truly avoidable, human health threats.

Andrew Steer
Country Director, Vietnam

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Sector Director for Environment and Social, East Asia and the Pacific

Acknowledgements

This report describes the results of a two-year effort by the Government of Vietnam between 1999 and 2001 to eliminate the use of leaded gasoline (LG). This effort was supported by an assistance project to Vietnam that was funded in part by a grant from the Energy Sector Management Assistance Programme (ESMAP), a joint program of the United Nations Development Programme (UNDP) and the World Bank. The financial assistance of the Government of the Netherlands through ESMAP is gratefully acknowledged. Other assistance for Vietnam's unleaded gasoline (ULG) program came from the Canadian International Development Agency (Cida), the Swedish International Development Cooperation Agency (Sida), the United States–Asian Environmental Partnership (USAEP), and the U.S. Environmental Protection Agency (USEPA).

The counterpart to the World Bank for the project was Vietnam's Ministry of Transport (MOT). Vice Minister La Ngoc Khue recognized the importance of the issue and gave the program his full support. The Vietnam Register (VR), under the MOT, was responsible for planning and carrying out Vietnam's switch to ULG. Within the VR, Director Nguyen Van Ban and Secretary Cao Xuan Vinh of the LG phaseout program were responsible for coordinating the program.

This report was prepared by Todd M. Johnson and Shane Rosenthal. Mr. Johnson was the task manager for the project, and is currently with the Environment Department of the World Bank. Mr. Rosenthal is an independent consultant and was the former program coordinator for environment with the World Bank in Hanoi. Special thanks go to Andrew Steer, Country Director for the World Bank in Vietnam, for his support and direction in pressing the ULG issue in Vietnam. Other Bank staff who provided valuable input to the project were Tran Thi Thanh Phuong (East Asia Environment and Social Unit (EASES), Vietnam Country Department), Sally Burningham (East Asia Transport Unit), Anil Malhotra (East Asia Energy and Mining, Vietnam Country Department), Masami Kojima (Oil, Gas, and Chemicals Department, Policy Division), Patchamuthu Illangovan (EASES), and Jitendra Shah (EASES).

Experts who attended the 1999 stakeholder workshop in Hanoi were Bebet Gozun (the Philippines), Allan Hong (Hong Kong), Li Pei (China), Supat Wangwongwatana (Thailand), and Ryangil Choi (South Korea). Piyasvasti Amranand, former secretary-general of Thailand's National Energy Policy Office, provided advice to Vietnam during a workshop in February 2001. Alan Troner of Asia Pacific Energy Consulting prepared information on Vietnam's petroleum product imports, and Nguyen Tien Vinh supported the collection of transport and fuel data in Vietnam.

Special thanks go to Nguyen Quynh Nga, Le Thanh Huong Giang, and Samson Kaber for administrative support for the project, and to Nguyen Van Ban, Cao Xuan Vinh, Tran Thi Thanh Phuong, Masami Kojima, and Magda Lovei for their review of and comments on the draft report.

Executive Summary

1. On July 1, 2001 Vietnam switched to unleaded gasoline (ULG). Vietnam thus reduced the health risk of its citizens by removing a major source of lead pollution in the environment. By making the switch to ULG essentially overnight, Vietnam avoided a lengthy and costly phaseout program. Vietnam was able to achieve an overnight switch through a combination of factors, including the commitment and leadership of key government agencies and officials.

2. Initial attempts to eliminate leaded gasoline (LG) in Vietnam began with the passage of transport-related environmental regulations in 1995. However, implementation was delayed due to concerns regarding the cost of the switch, and over fears that without significant modifications many vehicles in Vietnam would be unable to operate on ULG.

3. A workshop organized by the Ministry of Transport was held in Hanoi in December 1999 to discuss the issue of switching to ULG in Vietnam. Vietnamese participants included representatives from government, industry, the military and police, academic and research institutions, and the media. In addition, the meeting included experts from neighboring countries with recent experience in moving away from LG. The "South-South" dialogue between neighboring countries and Vietnamese stakeholders proved effective in overcoming many of the concerns and misperceptions that officials and citizens in Vietnam had about moving to ULG. A partnership of international donors, the GOV, and the business sector was established at the meeting, which proved effective over the following 18 months in supporting preparation for the switch to ULG. Domestic and international experts, including industry representatives, stressed that a gradual phaseout of LG was not necessary for Vietnam, and that an overnight switch would be both technically possible and much less costly than establishing a parallel distribution system for both LG and ULG. By the end of the three-day meeting, Vietnamese officials, who had previously indicated that the country planned to phase out the use of LG by 2005, had a much clearer vision of how to proceed with the phaseout and a much more ambitious schedule.

4. Following the workshop, the Government of Vietnam directed the Ministry of Transport and the Vehicle Register to begin building a consensus among concerned stakeholders in the country about how to move forward with the switch to ULG. The Ministry of Transport organized a steering committee and began preparation of an action plan for the switch that included an evaluation of Vietnam's vehicle fleet and of what measures, if any, would need to be taken for older vehicles; an estimation of the financial costs of switching to ULG; and the launching of a public education and awareness program on the benefits and process of switching to ULG.

5. There was particular concern in Vietnam that older vehicles, which accounted for about 10 percent of the automobile fleet, might be damaged if obliged to use fuel other than LG. Although experiences in countries with similar vehicle fleets had shown that older vehicles could use ULG without difficulty, the Vehicle Register

commissioned a series of lab tests to confirm that there would be no negative effects on existing automobiles or motorbikes in Vietnam.

6. Through discussions with the business community, Vietnamese officials became aware that not only were there few costs associated with a switch to ULG, but also that there were numerous benefits. Vehicle manufacturers reported that there would be significant benefits to vehicle owners in terms of a reduction in the maintenance and repair expenses associated with the corrosion of vehicle parts by lead. In addition, removing lead from gasoline would allow the use of catalytic converters for more advanced control of vehicle exhaust gases (lead permanently destroys catalytic converters).

7. In October 2000, the Prime Minister's office announced that Vietnam would switch to ULG nationwide beginning July 1, 2001. The government thus had less than nine months to finalize preparations for implementing the switch. The necessary preparations included the development of new gasoline standards; the finalization and dissemination of the results of vehicle tests; a national inventory of lead levels of imported gasoline at randomly selected gas stations; the monitoring of ambient lead levels prior to the switch; and a broad-based public outreach program, including radio and television announcements. Vietnam successfully implemented the switch to ULG on July 1, 2001 as planned, and all LG was banned in September 2001.

8. The Vietnamese experience is noteworthy because while numerous countries have eliminated LG over the past 10 years, few have moved as decisively and as rapidly as Vietnam. Vietnam was well-placed to eliminate LG quickly because of the country's lack of significant involvement in petroleum refining and the availability of high-quality ULG on international markets at prices comparable to those of LG. However, the government had to overcome widespread and strongly held perceptions that ULG would harm older vehicles in Vietnam. Vietnam deserves high praise for switching to ULG quickly, and serves as a positive example to other countries on how to eliminate the health and environmental hazards of LG.

1

Introduction and Background

1.1 One of the largest—and avoidable—sources of lead in the air is leaded gasoline (LG). Since the 1920s, lead has been used worldwide as a lubricant to protect engine parts made of soft metals and as an inexpensive additive for boosting the octane of gasoline. The threat to human health has been the primary driver of efforts worldwide to eliminate lead exposure in general, and to eliminate LG in particular. This report discusses the issues that Vietnam encountered as it proceeded to eliminate LG.

Health Impacts of Lead

1.2 Over the past 30 years the effect of lead on human health has been studied extensively internationally. Its negative impacts, especially on the development of children, have been well established. The removal of lead from gasoline has been directly associated with reduced blood-lead levels in humans and with the corresponding reductions in human health impacts from lead exposure.

1.3 Lead is a highly toxic heavy metal. Unlike other heavy metals, such as chromium, manganese, and nickel, low levels of which are essential nutrients to the human body, there are no known beneficial effects of lead for humans. Within the body, lead circulates in red blood cells and is found in soft tissue, such as the liver and kidney, and in bone, where it accumulates. Blood-lead concentrations are the most reliable indicator of recent lead exposure.

1.4 It has been known for centuries that exposure to high amounts of lead, as in the occupational exposure of miners and lead smelter workers, can have serious health effects. What had not been understood until the past several decades is that even at relatively low levels of exposure lead can have serious developmental impacts, and that children are especially vulnerable. Among the impacts of lead exposure are:

- immune system impairment
- anemia
- brain and nervous system damage (which can include permanent mental and motor retardation, and in extreme cases, death)
- kidney injury or failure
- injury to the gastrointestinal system and the heart

- damage to the reproductive system, including ovarian and testicular dysfunction
- impaired fetal blood synthesis, premature births, and other delivery complications

The U.S. Environmental Protection Agency (USEPA) and the International Agency for Research on Cancer have both classified lead as a probable human carcinogen.

1.5 The main sources of lead exposure for humans are the ingestion or inhalation of lead particles. Lead can be deposited on and accumulate in food and water, from sources such as lead plumbing, crops raised in lead-contaminated soil, leaded wastewater from industries, and lead-containing food containers. Another pathway is through ingestion of contaminated dirt or soil. While other sources exist—such as lead-based paint, mining, lead-soldered food and beverage cans, tobacco, combustion sources, and stationary sources, such as smelters—eliminating lead from gasoline is often one of the most effective ways to reduce human exposure and to prevent its accumulation in the environment. Unlike many other pollutants (hydrocarbons, for example), lead does not degrade and continues to accumulate in the environment unless it ceases to be added.[1]

1.6 There is no known threshold of exposure for many health impacts of lead,[2] and its absorption is not a linear function of intake. Rather, absorption depends on the chemical and physical state of the lead and on factors such as the age, nutritional condition, and physiological status of the individual. Evidence suggests that there is more lead absorption when dietary calcium, zinc, and iron are low, and lead absorption increases significantly when the stomach is empty. Additionally, the rate of absorption is higher for children than for adults. This has equity implications, since poor children will tend to have more dietary deficiencies than those that are less poor, and since they are also subject to higher risk of lead exposure due to unfavorable living conditions. In Vietnam, where a significant proportion of the population is under 18 and poor, there is a large population at risk for lead exposure of this type.

1.7 Evidence shows that even at low exposure levels (less than 10 micrograms per deciliter,<10μg/dl)[3] lead can affect the neurological development of young children. The impacts of children's exposure to lead have been well documented in various countries: urban and suburban children in Budapest, for example, have an IQ differential of 4 points (see Box 1.1).

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1 ESMAP (1997)
2 Lovei (1997)
3 CDC (1997).

***Box 1.1:* Lead and IQ**

In children, lead has been considered toxic at blood lead levels ≥ 10μg/dl. (This was the general definition of "lead poisoning" in humans.) Studies have strongly supported the existence of an inverse relationship between lead and children's IQ, or intelligence quotient, suggesting that an increase in blood-lead concentration from 10 μg/dl to 20μg/dl causes an average decrement of about 1 to 2 IQ points. Furthermore, at least two studies have supported the notion that there is an age of critical exposure, with IQ strongly and statistically negatively associated with blood-lead levels at age two. Unless the level of lead in blood is extremely high, the impact of lead on an individual's IQ may not be noticeable.

This is a serious concern for the community as a whole, since exposure to lead shifts the IQ distribution curve for the whole population and thereby indicates an overall reduction in average intelligence. Lead exposure results in losses of people with superior functions (highest IQ gradients) and increases the number of those with the poorest functions, such as children with mental retardation and adults with high existing risks of hypertension and strokes. This can also be costly in economic terms, with losses in productivity and the associated costs of remedial education and health care.

Source: Bellinger et al. (1992); Baghurst et al (1992)

1.8 Because exposure to even low lead levels is associated with behavioral problems, learning disabilities, and reduced intelligence in young children, the health benefits of removing lead from the environment can be very large. In countries where leaded gasoline has been used, switching to unleaded gasoline (ULG) can typically reduce ambient lead levels by 80–90 percent.

1.9 When eliminating lead from gasoline, it is important for health purposes to limit the levels of aromatics and benzene that are typically added to boost the octane level of gasoline to that previously provided by lead. Short-term exposure to benzene can cause drowsiness, dizziness, and unconsciousness, and long-term exposure can affect the bone marrow and cause anemia and leukemia. Health experts agree, however, that the risks posed by lead in gasoline are much greater than the risks posed by benzene. To minimize the risks associated with benzene exposure, health experts recommend that benzene concentrations in gasoline be limited to 5 percent, and total aromatics to 40–45 percent.

Lead Levels in Vietnam

1.10 In 1995, Vietnam established for the first time both maximum and daily average allowable levels for lead (TCVN 5937-1995). A 1995 study of lead in Vietnam examined lead levels on streets, at junctions, and in some urban residential areas. Results showed that while two streets had lead levels 1.2 times that allowed by Vietnam's standard and one junction had a level 1.8 times the standard, most points were below Vietnam's relatively high daily average standard for lead of 5 $\mu g/m^3$. Lead levels in Hanoi residential areas far from main traffic were low. It was reported that while the situation was not yet serious, lead poisoning was occurring on some roads and at some junctions. However, with traffic estimated to increase in Hanoi by 1.5–2.5 times between

2000 and 2020, with long periods of traffic congestion, the government expected lead pollution to become a serious health and developmental risk.[4]

1.11 Ho Chi Minh City (HCMC) has the highest population, traffic, and road densities in Vietnam. While lead is generated from two main sources (transportation and small-scale industry), ambient lead in the city is due mainly to vehicular exhaust. It was estimated that, in 1997, 787,000 tons of gasoline were consumed in the city, resulting in lead emissions totaling 98 tons/year.[5] Concentrations of suspended particulate matter exceeded the permissible standard by five to eight times, and lead levels reached the permissible standard. In 1999, air quality monitoring tests conducted at the crossroads and the city gateways with highest vehicle density showed that concentrations of lead did not exceed Vietnam's relatively high ambient lead standard, but did exceed some other countries' standards by two to five times.

1.12 In 1999, the Hanoi-based Institute of Laborers Health and Environmental Hygiene carried out a survey entitled "Lead Pollution Caused by Transport Emissions and Lead in the Hair of Hanoi Kindergarten Children."[6] The ambient lead level measured 2.94 $\mu g/m^3$ in Hanoi and 0.48 $\mu g/m^3$ in rural areas, and the average lead level in city dust was 85.34 $\mu g/g$, compared to only 1.4 $\mu g/g$ in the suburbs. The average lead level in children's hair was measured at 8.61 $\mu g/g$ in Hanoi and 6.34 $\mu g/g$ in rural areas.

1.13 While the ambient lead levels in Vietnamese cities are not extreme by some developing country standards, they are above World Health Organization-recommended levels. Elevated blood-lead levels have also been measured in children in Vietnam. What is most worrisome is that elevated ambient and blood-lead levels have been found in Vietnam despite the fact that Vietnam has one of the lowest per capita levels of motor vehicle ownership and gasoline consumption in the Asia region. By eliminating LG early in the development of the country's vehicle fleet, Vietnam could avoid the accumulation of lead in the environment and the associated health impacts.

Vehicle Fleet Growth

1.14 The rapid growth of Vietnam's automobile and motorcycle fleet from the late 1980s and throughout the 1990s increased the amount of lead emitted into the air in Vietnam. During the early 1990s, the number of automobiles in Vietnam increased by around 10 percent per year.[7] By the late 1990s, when the economy slowed considerably, the growth rate of cars and three-wheelers continued to increase by 7 percent (Table 1.1) Motorcycle ownership grew at around 18 percent per year between 1993 and 2000, rising from 2 million in 1993 to more than 6 million in 2000.

1.15 Motor vehicle ownership and use in Vietnam is heavily concentrated in the country's largest cities. HCMC, the country's major commercial hub, currently has

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4 Pham (1999).
5 Lam (1999).
6 Ha (1999).
7 World Bank (1994).

around one-third of all vehicles in Vietnam, and Hanoi one-fifth. As of 1997, the majority (85 percent) of passenger vehicles in Vietnam were publicly owned. Nearly all motorcycles were privately owned.

Table 1.1: Number of Registered Vehicles in Vietnam by Vehicle Type ('000s)

Vehicle type		*Registry year*					
		1996	1997	1998	1999	2000	2001*
Cars and three-wheelers	Quantity	372,000	417,700	443,000	465,000	486,000	546,000
	Annual growth rate	-	12%	6%	5%	5%	13%
Motorcycles	Quantity	4,022,683	4,827,219	5,300,000	5,585,000	6,479,000	8,000,000
	Annual growth rate	-	20%	10%	5%	13%	24%
Total	Quantity	4,394,683	5,244,919	5,743,000	6,050,000	6,965,000	8,546,000
	Annual growth rate	-	19%	10%	5%	15%	23%

Notes *2001 is estimate by MOT.
Source MOT (2002) [8]

Gasoline Consumption and Imports

1.16 Accompanying the growth in the vehicle fleet in Vietnam was a rapid increase in gasoline consumption. Gasoline consumption increased by 15 percent per year between 1985 and 1990 and by 13 percent per year between 1990 and 1995.[9] Although Vietnam's economy slowed considerably in the late 1990s, gasoline consumption continued to rise from 668 metric tons (mt) in 1995 to 980 mt in 2000, an annual increase of around 8 percent (Table 1.2). The Ministry of Trade has estimated that gasoline demand is likely to continue to grow by an average of 11 percent per year through 2006.

1.17 Despite the emergence of Vietnam over the past decade as a significant oil and gas producer, the country remains dependent on imports for virtually all of its gasoline. Vietnam has around 600 million barrels of proven oil reserves, and recent discoveries will raise this figure. Production of crude oil, as well as natural gas and liquefied petroleum gas (LPG), increased substantially in the latter half the 1990s. Crude oil production rose from an average of 175,000 barrels per day (bbl/d) in 1996 to 288,000 bbl/d in 2000, and production in the first nine months of 2001 averaged more than 350,000 bbl/d.[10] Given the lack of domestic oil refineries, Vietnam exports almost all of the crude oil it produces. Export markets include Japan (the largest importer of Vietnamese oil), Singapore, the United States, and the Republic of Korea.

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[8] Tables 1 1 – 1.3 were provided by the MOT directly to the World Bank in June 2002

[9] World Bank (1998).

[10] USDOE, Energy Information Agency: http.//www.eia.doe.gov/emeu/cabs/vietnam.html.

Table 1.2: Gasoline and Diesel for Civilian Transport Use ('000s metric tons)

Year	*Gasoline*	*Diesel*
1995	668	493
1996	677	600
1997	779	686
1998	845	741
1999	900	800
2000	980	870
2001*	1,200	1,000

*Notes: *2001 is an estimate*
Source MOT (2002)

1.18 Vietnam had net exports of around 133,000 bbl/d of oil in 2000, meaning that petroleum product imports were equivalent to around 155,000 bbl/d, or 7.75 million tons.[11] Of this amount, about 1.4 million tons were gasoline and 3.7 million tons diesel (Table 1.3). In recent years, most of Vietnam's gasoline imports have come from Singapore, which accounted for 75–80 percent of the country's supply in 2000. Indonesia has also been a regular supplier of gasoline to Vietnam, accounting for an additional 12–15 percent of gasoline imports. The remaining supplies of gasoline have come from small but regular shipments from Thailand, and occasional cargos of gasoline from the Philippines and Sarawak (Malaysia).

Table 1.3: Fuel Imports for Vietnam, 1995–2000 ('000s metric tons)

	Fuel Type				
Year	*Gasoline*	*Diesel*	*Fuel Oil*	*Kerosene*	*Aviation Fuel*
1995	905	2058	804	289	239
1996	926	2510	996	273	458
1997	1040	2871	1029	212	326
1998	1174	3082	1423	266	259
1999	1281	3081	1668	203	230
2000	1433	3703	2047	370	107

Source. MOT (2002).

1.19 A range of commercial and state companies are involved in the gasoline trade with Vietnam. Shell has traditionally had the largest share of the trade with

[11] USDOE (ibid). Note that 1 million metric tons (mmt) per year of crude oil is equivalent to around 20,000 bbl/d.

Vietnam, and also sells to Vietnam through Thailand, Malaysia, and the Philippines. Shell and BP Amoco have been regular suppliers from Singapore. As of late 1999, there were two primary grades of gasoline for sale in Vietnam: RON 83, accounting for about 70 percent of all sales, and RON 92,[12] comprising the remaining 30 percent. Both grades of gasoline were leaded, specifying a maximum lead content of 0.40 grams per liter (g/l) for RON 83 and 0.15 g/l for RON 92.

1.20 Since the mid-1990s, LG in Vietnam was sold primarily by "blenders," companies purchasing ULG and adding lead to it to meet Vietnam's specifications for gasoline. Storage companies and independent traders have tended to blend gasoline on special order for Vietnam. Two independent companies, Vitol and Hing Leong, have dominated the gasoline blending trade for Vietnam.[13]

1.21 Several government-owned companies are licensed to import gasoline in Vietnam. The major ones include Petrolimex and Petec (Ministry of Trade); the PetroVietnam Trading Company (Petechim), under PetroVietnam; SaigonPetro (Ho Chi Minh City People's Committee); and Vinapco (Vietnam Airlines). Petrolimex is the largest importer of petroleum products, accounting for approximately 70–80 percent of imports, and is solely a trading and distribution company. SaigonPetro is the third-largest importer of gasoline, is a major seller of LPG, and owns and operates a very small (800 bbl/d) refinery in Ho Chi Minh City, from which it produces and sells LG in the southern provinces.

Domestic Refining

1.22 Although Vietnam lacks domestic petroleum refining capacity, it is planning the construction of two refineries, both of which plan to produce only high-quality ULG (Table 1.4). These two refineries are slated to produce about 14 million tons per year of products—enough to satisfy the country's net petroleum product consumption for about a decade, based on current trends in petroleum product consumption.

1.23 Vietnam began planning the construction of its first refinery in the early 1990s. Following a series of negotiations with several international companies for a joint-venture refinery, the Ministry of Planning and Investment in early January 1998 granted approval for a US$ 1.3 billion oil refinery. The Dung Quat refinery project, located about 100 kilometers south of Danang in Quang Ngai province, is now a joint venture between PetroVietnam's Vietsovpetro (a Vietnam-Russia joint venture) and Russia's External Economic Federation (Zarubeznheft). The Dung Quat refinery, which is estimated to begin production in 2005, is expected to reach its production capacity of 6.5 million tons per year after four years. It will be capable of producing LPG, ULG, jet fuel, kerosene, diesel, and fuel oil, all meeting domestic and ASEAN (Association of Southeast Asian Nations) quality standards (see Annex 1).

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[12] RON stands for research octane number MON (motor octane number) is lower than RON, with the difference dependent on the composition of the gasoline. In the United States, the "anti-knock" index is posted at the pump, and is defined as (RON+MON)/2. In Europe, the RON is posted

[13] Asia Pacific Consulting (2001)

1.24 The government is planning a second refinery, with a capacity of 6 to 7 million tons per year. According to PetroVietnam, a memorandum of understanding was signed in 2001 with Mitsubishi and JGC Corporation, and construction could start by 2006.[14] The location under discussion for the second refinery is in Thanh Hoa province in the north of the country.

Table 1.4: Specifications for Unleaded Gasoline for Dung Quat Refinery

Density	0.74
RVP, kPa	60 0
RON	94 0
MON	83 0
Benzene, % volume	3.7
Aromatic, % volume	28 8
Olefin, % volume	30 0

Source: PetroVietnam (1999)

[14] USDOE, Energy Information Agency: http //www.eia.doe.gov/emeu/cabs/vietnam html

2

Initial Efforts and Constraints

2.1 Recognizing the serious human health impacts of lead, and facing the prospect of rapidly increasing motor vehicle usage and gasoline consumption, Vietnam passed environmental legislation in the early 1990s to restrict the use of leaded gasoline (LG). However, before Vietnam could proceed with eliminating LG, it had to overcome strongly held perceptions about potential technical problems and the financial costs of switching to unleaded gasoline (ULG).

Legislative Steps

2.2 Vietnam's initial attempt to introduce ULG coincided with the passage of extensive environmental legislation, beginning in the early 1990s. The centerpiece was the 1994 Law on the Environment, which was followed by numerous decrees needed to support its implementation.[15] One of these was Decree 36/CP, dated May 29, 1995, entitled "Regulations on Traffic Safety and Order of Road and Urban Transport,"[16] which banned the operation of "vehicles using leaded petrol or emitting black smoke causing environmental pollution." The law, requiring all automobiles to use ULG, was premature and not able to be implemented, since ULG was not yet available in the country. Nonetheless, the law established the legal and political basis for the elimination of LG.

2.3 Implementing the switch to ULG did not take place for several years, primarily because many government officials and the public believed that a switch would create technical and financial difficulties for the country. In addition, as Vietnam's economy developed during the early and mid-1990s, the government's transportation priorities were focused on other issues, such as improving road infrastructure and transport safety and developing a modern vehicle fleet. Just months after Decree 36/CP came into effect, the Ministry of Transport and Communications (MOT) and the Ministry of Science, Technology, and Environment (MOSTE) proposed that implementation of the lead phaseout program be postponed indefinitely.[17] The Prime Minister's office agreed, but assigned the MOT the responsibility of coordinating with other ministries research

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15 See: http://coombs.anu.edu.au/~vern/luat/english/Law-envir-protect.txt

16 See http://coombs anu.edu.au/~vern/luat/english/Gov-36CP-traffic.txt

17 MOT (1995).

into an eventual phaseout of LG, with studies to be completed by 2000.[18] Efforts were again stalled by the Asian economic crisis in 1997–99, which reduced foreign direct investments and the demand for Vietnamese products. Some government officials argued that requiring a move to ULG would put Vietnam at a further competitive disadvantage in attracting foreign investment.

2.4 Regional political and market trends helped to keep the unleaded issue on the agenda in Vietnam. Numerous governments in the region were moving to ULG, including those of Hong Kong, Thailand, Singapore, Malaysia, the Philippines, and China. At a gathering of ASEAN countries in 1998, transportation ministers signed an agreement that placed restrictions on the use of LG in commercial vehicles. In October 1998, the Vietnamese Prime Minister approved the agreement, which provided a legislative basis for Vietnam's gasoline use to be brought into line with the regional trend. Because China is a major importer and exporter of petroleum products in Asia, the announcement by the Chinese that they would introduce ULG nationwide in 2000 signaled a major change in the availability of LG in the Asian market.[19]

2.5 Despite the growing trend toward ULG in the international market (which also lowered the price differential between ULG and LG), Vietnamese officials believed that a significant portion of the vehicle stock in Vietnam would require LG for the foreseeable future.

Perceived Technical Constraints

2.6 At the end of the 1990s, Vietnam's vehicle stock included many older vehicles with engine exhaust valves made with soft metals. Figures provided by the MOT in late 1999 stated that of the 58 civilian makes of automobiles in Vietnam, only half could use ULG "without structural change."[20] As in other countries, there was concern that without the lubricating properties of LG there would be valve seat recession in engines with soft valves. There was also concern that the use of ULG had not been verified in a country with such a large fleet of motorcycles. In contrast to the predominant two-stroke motorcycle fleets in other Asian countries, the majority of motorcycles in Vietnam are four-stroke (two-stroke engines do not have valve seats and thus do not pose a valve seat recession problem). Transport officials recognized that the new vehicle stock of automobiles and motorcycles, primarily located in the major cities of Hanoi and HCMC, would not have difficulty using ULG. However, they were concerned about the thousands of older vehicles in the country's small towns and rural areas. There was also considerable apprehension about the switch to LG by the military and police in Vietnam, which possessed a large fleet of older vehicles from the Soviet Union, eastern European countries, and China.

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18 Government of Vietnam (1995).

19 In meetings with Vietnamese transport and energy agencies in February 2001, several officials cited China's decision to switch to unleaded gasoline as a key signal for Vietnam to move in the same direction.

20 MOT (1999).

2.7 The vehicle fleet in Vietnam as of the late 1990s was actually remarkably modern. While there certainly were old vehicles in Vietnam, their numbers were small, both in absolute numbers and in relationship to the entire vehicle fleet. Of the 6.5 million motorcycles in Vietnam in 2000, more than 80 percent had been added since 1990. The automobile fleet comprised only about 46,000 civilian cars in 1989, but nearly 160,000 by 1998. The vast majority of cars and four-stroke motorcycles added during the 1990s were specifically designed to operate on ULG.

2.8 An important question for policymakers was the effect that ULG would have on older vehicles with soft engine valves. Vietnamese officials were being presented with different information as to the ability of older vehicles to operate on ULG, and the effects on them if they did. Vehicle manufacturers typically said that older vehicles with soft engine valves were designed to run on LG, and that they needed the lead for lubrication. In reality, lubrication could be provided by other additives, and the amount of lead that was needed for lubrication was much lower than allowed in Vietnam's LG specifications. Aside from the lubrication properties of lead, lead was also added as a low-cost way to boost the octane level of gasoline. Vehicle manufacturers warned that their vehicles needed minimum octane levels to perform well, but this was often understood by Vietnamese officials to mean that it was the lead, rather than the octane level, that was required. The octane level could be raised by adding other high-octane blending components, such as oxygenates, alkylate, isomerate, fluidized catalytic cracking gasoline, and aromatics.

2.9 Studies from other countries had shown that the effects of ULG on soft engine valves were insignificant under all but extreme driving conditions (for example, at sustained high speeds or with heavy loads). However, this information was not widely available in Vietnam, and there had been no specific studies done for Vietnam. The MOT was thus wary of moving to ULG without clear and ample evidence that there would be no harm to the country's vehicles. The need to provide such evidence was made clear by the widespread opposition to ULG among most government agencies in Vietnam.

2.10 While fuel quality is certainly a concern when switching to ULG, this issue was less important in Vietnam's case. First, virtually all gasoline was imported in Vietnam, much of it from Singapore refineries that were producing high-quality ULG for a number of countries. As such, ULG available to Vietnam had low levels of benzene (<5 percent) and aromatics (<40 percent). Second, Vietnam had already decided to move to ULG in its two planned refineries. Both refineries were slated to produce only ULG with internationally acceptable levels of both benzene and aromatics (see Table 1.4).

2.11 An issue of considerable confusion among some agencies in Vietnam was the issue of catalytic converters. Since the 1970s, catalytic converters have been installed on vehicles in industrialized countries for advanced control of tailpipe emissions such as carbon monoxide, nitrous oxides, and volatile organic compounds. Because lead permanently destroys the emission reduction properties of catalytic converters, countries should not introduce vehicles with catalytic converters until unleaded fuel is available. The lead additive industry has argued (and apparently made this case to Vietnamese

officials) that it is necessary for all vehicles to possess catalytic converters before moving to ULG. The argument is that catalytic converters limit the emission of benzene in vehicle exhaust gas. Because of the potential health risks of benzene and aromatics, limits on how much should be added to gasoline have been used in the United States, Europe, and Japan, and these standards have been adopted by a number of countries in Asia. Nonetheless, some transport and environment officials in Vietnam believed that all vehicles in Vietnam would have to be equipped with catalytic converters before ULG could be introduced.

Perceived Cost Constraints

2.12 The potential cost of the switch to ULG was a central concern to Vietnamese officials, and most costs were closely related to the technical issues. Following the 1995 legislation calling for the elimination of LG, and again during the Asian financial crisis (1997–99), high costs were cited as the primary reason for delaying the introduction of ULG. In countries with petroleum refining capacity, the costs of upgrading refineries to produce ULG can be significant. However, as noted in the previous chapter, Vietnam lacked any major refining capacity that would need to be modified to produce ULG.[21] Nonetheless, there were a number of issues raised by Vietnamese officials between 1995 and 2000 that ultimately revolved around the financial cost of switching to ULG. These included:

- the cost of changes to vehicles and/or lead-replacement additives
- the additional expense of importing ULG
- the costs of establishing a dual distribution system associated with a gradual phaseout of LG
- the administrative costs of switching to ULG, including the design and issuance of new fuel and vehicle (imports and production) standards

Engine Modifications and Fuel Additives

2.13 As noted previously, many government officials in Vietnam believed that both old and new vehicles would have to be modified before they could use ULG. Although it does not appear that specific cost estimates had been undertaken, the prospect of replacing large numbers of vehicle engines and installing catalytic converters greatly concerned Vietnamese transport officials. Because many of the older vehicles were in small towns and rural areas, there was also concern that the costs of upgrading older vehicles would be borne by poorer parts of society. The military also regarded the switch to ULG as adversely affecting its vehicles, most of which were old, and publicly opposed the switch. To what extent these misperceptions were widely accepted in Vietnam is not

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[21] As will be discussed later, Vietnam's one small refinery (with capacity of just 350,000 tons per year) made a case for special consideration when the switch to ULG was announced. However, this did not present a major cost constraint nor inhibit the country moving forward with the unleaded program

known. However, key government agencies continued to voice concern over vehicle modifications, and the cost issue must have been foremost in their minds.

2.14 A secondary concern was the need for lubricants for older vehicles as a replacement for lead. The alternative to lead for lubrication is additives based on sodium, potassium, or phosphorous. While the cost of adding alternative lubricants to gasoline is generally low (US$ 0.01 per liter), expenditures for fuel additives became another perceived incremental cost to the government of the switch to ULG.

Costs of Importing ULG and LG

2.15 The changing relative prices of LG and ULG during the late 1990s made it easier for Vietnam to switch to LG. Since Vietnam imported virtually all of its gasoline, the fuel-related costs of switching to ULG were a function of the price difference with LG. As a growing number of countries worldwide have eliminated the use of LG, the demand for it internationally has declined. In contrast to the past, when lead was an inexpensive octane booster, by the late 1990s the cost advantage held by LG had largely disappeared.

2.16 Without specific import price figures from Vietnamese importers, it is difficult to calculate the actual cost differential between ULG and LG in the Asian petroleum market. As of the middle of 2001, the price of ULG was less than that of LG in other international markets. Although LG prices ceased to be published in the Asia region in the mid-1990s, the trend in the relative price of LG versus ULG has been observed in other international markets. As noted before, all LG shipments after 1995 were provided by blenders producing gasoline specific to Vietnamese gasoline specifications. While these blenders may earlier have enjoyed some cost advantages in selling LG to Vietnam, as the demand for LG declined so too did the price advantage. Furthermore, as of 2000, a premium was being charged on cargoes of LG to Vietnam from Singapore. The reason for the surcharge related to the need for shippers to clean their ships after transporting LG, since even small amounts of lead can result in subsequent cargoes being unable to meet unleaded standards. Shippers complained that it would take up to three cargoes of another clean fuel (such as gas oil) to remove all traces of lead from their tankers. The lead surcharge for Vietnam was reported to be as much as 10 percent over standard chartering rates.

A Dual Distribution System

2.17 When Vietnam began exploring the switch to ULG in the mid-1990s, it looked to the experiences of other countries. Most of the lessons that were available to Vietnam were from countries that had taken many years to phase out LG, such as the United States (22 years), Japan (14 years), and the EU (15 years, planned). While government officials in Vietnam recognized that the situation in their country was different, the presumption among many officials was that a transition period was necessary in which both LG and ULG were sold in the market at the same time.

2.18 Thailand has been a model for Vietnam in the environment field, and that country's experience with phasing out LG was of great interest to Vietnam. In Thailand, the switch to ULG took place over a five-year period between 1991 and 1995, and was very successful.[22] In Thailand, as in other countries, the primary reason for the transition period was to allow refineries time to restructure their equipment to produce ULG. Following a visit by Vietnamese officials to Thailand in 1999, the opinion was that the phaseout in Vietnam could proceed more quickly than in Thailand; the assumption nonetheless remained that there would need to be a phaseout period during which both LG and ULG would be sold. The concern among Vietnamese officials was that the establishment of a dual system for gasoline in Vietnam would cost a significant amount of money for storage tanks, supply trucks, and dispensing equipment. In Vietnam, establishing a dual distribution system posed more significant costs than it would in other countries because of the limited gasoline distribution infrastructure in the country. At most filling stations in Vietnam only two grades of gasoline were sold, due to the lack of storage and dispensing facilities. Adding ULG without eliminating one of the other grades would pose great difficulties for Vietnam's gasoline distribution system. As will be discussed in the next section, once the dual distribution system idea was dropped, one of the key cost impediments for Vietnam also disappeared.

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[22] See Sayeg (1998).

3

Government Leadership and Consensus Building

3.1 In addition to the technical and financial concerns outlined above, other barriers to switching to unleaded gasoline (ULG) in Vietnam included regulatory and administrative changes, and the need for public awareness. However, what was most lacking in Vietnam was a clear understanding among policymakers of the technical and cost issues involved in switching to ULG.

Informing Stakeholders and Policymakers

3.2 In November 1999 a workshop was held in Hanoi to discuss the outstanding issues constraining progress on the move to ULG. The MOT had indicated that it wanted to move forward on the issue earlier in the year, and had requested assistance from the World Bank. The workshop in 1999 was cosponsored by the MOT, the United States–Asia Environmental Partnership (USAEP), and the World Bank, and was the first broad-based effort to address the technical and cost implications of Vietnam moving to ULG. A partnership between international donors, the business sector, and the GOV was established at the workshop and proved valuable over the course of the next 18 months in supporting the VR address the information and preparation activities that were required for the switch to ULG. A range of stakeholders from Vietnam attended, including officials from the health, environment, transport, energy, and trade sectors, the military, the press, and from the municipal governments of Hanoi and Ho Chi Minh City. Foreign participants included representatives from neighboring countries that had completed or were in the process of phasing out LG (see Box 3.1).

3.3 It was clear from the introductory statements of Vietnamese officials that: (1) Vietnam was strongly committed to eliminating the use of leaded gasoline (LG); (2) there was a presumption that the switch to ULG should be gradual, extending over several years;[23] and (3) there were significant technical and financial issues to be resolved in the minds of key leaders and the public before ULG could be introduced.

[23] Reflecting the opinion of most Vietnamese officials that there would need to be a transition period in which unleaded gasoline was introduced and leaded gasoline was eliminated, the workshop was entitled the "National Workshop on Phasing Out Leaded Gasoline in Vietnam."

Box 3.1: Asian Experiences in Switching to Unleaded Gasoline

China

China adopted a rapid phaseout schedule to eliminate leaded gasoline (LG) prior to the introduction of catalytic converters. In 1992 only 30 percent of China's gasoline was unleaded; LG had a lead level of 0.4 g/l. By July 1997, 56 percent of all gasoline produced in China was unleaded, and when the country banned LG in Beijing, other major cities followed suit in October. By 2000, ULG had been introduced throughout the country, and older refineries were working toward a complete ban on the production of LG.

Hong Kong

Hong Kong began introducing ULG in 1991 by providing price incentives for ULG and through extensive public awareness campaigns. Although misperceptions about the use of ULG caused setbacks in sales during the first year of its introduction, sales of LG declined steadily throughout the 1990s. In January 1999 the government instituted a complete ban on sales of LG.

Republic of Korea

In 1987, the Korean government regulated that automakers install catalytic converters in all automobiles manufactured after that time. Simultaneously, the use of unleaded fuel became mandatory. After 1990, stricter emission standards were applied to all passenger cars, and in 1993 sales of LG were banned. Over a five-year period, oil refineries invested about US$ 1 billion to produce ULG.

The Philippines

The Philippine government mandated a reduction of lead in gasoline from 0.6 g/l to 0.15 g/l by 1994. The Clean Air Act required unleaded gasoline nationwide by the end of year 2000. Spot checks at gasoline filling stations are conducted to ensure compliance with the requirement.

Thailand

Unleaded gasoline was introduced in 1991, and LG was totally banned in 1995. In 1995, under pressure from vehicle owners, alternative lubricants were added to ULG, but this requirement was dropped in 1998 following extensive testing that showed that the lubricants were not needed.

3.4 Different government agencies had different visions of how long it would take to introduce ULG and to ban LG. Two government papers suggested it would take until 2006 for a complete phaseout, and a third outlined a three-stage switch that would be completed by 2008.[24] Still another plan called for a gradual phaseout, beginning first in major cities and extending to other areas based on the results of this experience.[25] The underlying belief was that while the newest vehicles in Vietnam could quickly move to using ULG, older vehicles could not make this switch so easily. It was assumed that a rapid switch would cause financial hardship for private vehicle owners, industry, and the state sector (including the military). As such, a transition period was assumed, in which high-octane ULG (RON 92) would be sold in urban areas and relatively low-octane LG

[24] MOT (1999).
[25] MOSTE (1999).

(RON 83) would continue to be sold everywhere else until the older vehicle stock was retired.

3.5 One of the unique features of the workshop was that experts from neighboring countries were invited to provide lessons to Vietnam from their experiences in eliminating LG Representatives from China, Hong Kong, the Republic of Korea, the Philippines, and Thailand provided Vietnamese participants with specific examples of the issues they encountered and how those issues were resolved. In Hong Kong, for example, drivers had complained that ULG provided less power; it was shown that this was because ULG had been introduced in the summer when drivers were also using their air conditioners more, and public awareness helped overcome the perception among drivers that ULG was to blame. Examples such as this, along with workshop discussions about Vietnam's specific situation, proved useful in separating the actual issues from the many misperceptions that people have about ULG. More so than lessons from advanced industrialized economies or international organizations, this "South-South" dialogue helped show Vietnamese officials that the technical and financial issues they faced were fewer than expected.

3.6 The experiences of Thailand and China in introducing ULG were especially useful in convincing Vietnam that their vehicle fleets could use ULG without problems. In Thailand, the government had offered compensation to any vehicle owner who sustained damage through the use of ULG; no one had come forward to report damage. The use of ULG in China, whose older automobile (and military vehicle) fleet was similar to Vietnam's, also resulted in no major problems, according to Chinese experts. Representatives from Thailand and China furthermore expressed the view that Vietnam had an additional advantage in that it had no existing oil refineries that would require modification.

3.7 Representatives from the private sector, including Vietnamese companies, were instrumental in dispelling many of the technical and financial concerns of Vietnamese stakeholders. A Ford Motor Company official stated that Ford had not manufactured a vehicle anywhere in the world since the 1980s that could not use ULG. Ford stated that it actively supported the switch to ULG in Vietnam so that catalytic converters could be introduced, thus reducing the emission of other air pollutants from motor vehicles. A representative from the U.S. Environmental Protection Agency's (USEPA's) vehicle research lab reported that the conditions under which older vehicles with soft engine valves could sustain damage using ULG were extreme, requiring sustained high speeds or heavy loads, and that such conditions would probably never be encountered in Vietnam. A representative from Petrolimex, Vietnam's largest importer of gasoline, said that so long as there was no need to establish a dual distribution system, his company would face little financial difficulty in switching to ULG overnight.

3.8 The neighboring country and company representatives helped strengthen the position that Vietnam did not need to have a gradual phaseout of LG but could move directly to ULG. Vehicle compatibility (i.e., whether or not older vehicles could use ULG) was especially important, because if there was not a need to continue selling LG to

protect older vehicles, Vietnam could avoid the costs and administrative difficulties of setting up and managing a dual distribution system.

3.9 Overall, the two-day workshop was successful in clarifying for policymakers the key concerns for Vietnam in eliminating LG. The false perception that catalytic converters were required to use ULG was corrected. Concerns about negative impacts on older vehicles had been greatly reduced, though not completely eliminated. There was greater understanding that all vehicles could use ULG, though the need or method of protecting older vehicles had yet to be fully worked out. Progress on the vehicle compatibility issue meant that it was possible to talk about an overnight switch to ULG rather than a gradual phaseout. While no Vietnamese official had raised the option of an "overnight" elimination of LG at the beginning of the workshop, by the end this was indeed a possibility, and was supported by all international experts, company representatives, and some Vietnamese government agencies.

3.10 A number of issues remained to be settled. Most important was the need to overcome the remaining concerns about the older vehicle fleet in Vietnam. The MOT proposed that a series of laboratory tests be carried out on Vietnamese vehicles. While some international experts maintained that such tests would be costly and ultimately inconclusive, from a practical perspective the MOT argued that such tests would be helpful in countering the concerns of the public and recalcitrant agencies over the use of ULG.

Lead Elimination Action Plan

3.11 In January 2000, the MOT established a steering committee to manage the switch to ULG. The international donors agreed to support the committee through the preparation of an action plan. Experts working under the direction of the steering committee were to develop the plan, and international donors were to provide financial assistance and technical inputs. The steering committee was to review and prepare the work program for introducing ULG and submit its recommendations to the prime minister.

3.12 The work was spearheaded by the MOT's Vietnam Register (VR) department, which had been charged with overseeing the program. Over the course of the next eight months, the VR sought input from the government ministries and state corporations responsible for industry, defense, environment, public health, and the import and distribution of petroleum products. A draft plan for introducing ULG was prepared by the VR, with input from the steering committee. This draft was used as the basis for discussion with other government agencies. In most cases, multiple meetings were held with each agency, soliciting their input and providing information to reduce any remaining doubts that the technical and financial issues of the plan were sound.

An Overnight Switch

3.14 By October 2000, the MOT had collected input from all relevant stakeholders, had convened meetings to discuss their concerns, and had prepared a draft

directive for the prime minister. In November 2000, Deputy Prime Minister Nguyen Tan Dzung issued the directive on "Switching to Unleaded Gasoline in Vietnam," which stated that ULG would cease to be used by July 1, 2001. What had previously been expected to be a gradual switch over several years had become an "overnight" switch.

Box 3.2: Highlights of Directive No.24/2000/CT-TTg: "Directive of the Prime Minister on Switching to Unleaded Gasoline in Vietnam"

Directive No. 24/2000/CT-TTg called for the MOT to be responsible for the following activities:

- Determine the effects of ULG on road transport vehicles, develop vehicle technical standards to specify vehicle types and suitable gasoline, and develop emission standards for each type of road transport vehicle.
- Establish systems of mobile source monitoring and vehicle emissions controls for the urban environment, focusing first on big cities.
- Coordinate with other ministries and sectors to develop a plan for phasing out LG and submit it to the prime minister for approval before January 31, 2001 (this occurred on March 30, 2001). The plan was to propose technical as well as economic, environmental, and social solutions for the ULG switch, based on information and the experience of other countries in the region.
- Coordinate with central agencies, mass organizations, and People's Committees of the provinces and centrally controlled cities to propagate and disseminate information regarding the purpose and process of the switch to ULG.
- Arrange cooperation with foreign agencies and international organizations to make use of external support to assist with projects and research activities related to the switch to ULG.

The Ministry of Trade was directed to:

- Study options for the importation, supply, and distribution system of ULG to ensure that the gasoline supply meets consumer needs during the switch.
- Coordinate with the MOT to list the types of vehicles running on LG that should not be imported, starting from January 1, 2001.

The Ministry of Science, Technology, and Environment was directed to:

- Develop and issue fuel standards for ULG.
- Develop a program and schedule to assess environmental quality before and after the switch.

3.15 The task of implementing the switch was assigned to the MOT. The three main ministries involved in preparing the groundwork for the switch were the MOT, the Ministry of Trade, and the Ministry of Science, Technology, and Environment (MOSTE) (see Box 3.2). The directive detailed the responsibilities of these and other agencies, and requested the People's Committees of central cities and provinces to assist with preparations for the switch. A month later, following the Hanoi Fuel Exhibition, the MOT called an interministerial meeting to agree on a plan to implement the Prime Minister's Directive. After consulting with the relevant ministries, the MOT submitted a plan to the prime minister[26] detailing how the switch would be implemented.

[26] MOT (2000).

4

Preparations for Implementation

4.1 Following the announcement by the prime minister, the government had nine months to complete plans for the overnight switch to unleaded gasoline (ULG). Among the key issues that still had to be resolved were: (1) the notification and education of the public on the benefits of eliminating leaded gasoline (LG), and of the practical steps involved in the switch; (2) the documentation for Vietnam of the technical feasibility of older vehicles (including four-stroke[27] motorcycles) moving to ULG, and the determination of whether fuel additives were needed; (3) a decision on the different grades of gasoline that would be sold in Vietnam and the issuance of new fuel standards; and (4) estimation of the financial costs of the switch and of its impacts on specific sectors or companies.

Public Outreach

4.2 From the earliest days of the ULG initiative in Vietnam, there was a keen awareness within the government of the need to inform and get input from the public on the switch. Government agencies were seriously concerned with the potential impact on the thousands of automobiles and millions of motorcycles, with concerns ranging from the impacts on engines, gas mileage, and health to the financial cost to citizens. Experience in other countries illustrated the importance of public awareness, since consumer misconceptions about unleaded fuel had often delayed or inhibited implementation.

4.3 With funding from the Canadian International Development Agency (Cida), 22 journalists and reporters from various national and local newspapers throughout Vietnam attended the stakeholder workshop in Hanoi in November 1999. In addition, a group of journalists was hired to produce a comprehensive set of public awareness materials for the workshop. News articles covered the gasoline situation in Vietnam, the experiences of neighboring countries that had eliminated LG, and a

[27] In contrast to the engines of four-stroke motorcycles, two-stroke motorcycle engines do not have valves, and therefore are not susceptible to valve seat recession through the use of ULG. While the use of ULG in two-stroke motorcycles is not an issue, many countries around the world have moved to limit or ban two-stroke motorcycles because of their significant contribution to local air pollutants (for example, in the form of particulate matter and carbon monoxide) The vast majority of motorcycles in Vietnam are four-stroke.

discussion of the various technical and financial issues associated with the switch to ULG. The story received coverage on radio and television, and was carried widely in leading newspapers and journals. The campaign also included the production and distribution of pamphlets and posters on switching to ULG.

4.4 To help with informing industry and commercial interests, both domestic and foreign, the Vietnam Register prepared and conducted a public awareness program in association with the International Automobile and Petroleum Exhibition and Conference in December 2000. A major publication was prepared for the exhibition, providing detailed technical information on the use of unleaded fuel and why it was important for Vietnam to proceed with eliminating LG.[28]

4.5 In the wake of the November 2000 announcement that the country would switch to unleaded fuel in less than a year, there was a new round of public discussion in the press, and a significant amount of opposition. The opposing viewpoints, aired in numerous newspaper articles and television reports, argued that with so many older vehicles Vietnam needed to introduce unleaded fuel over the course of several years, and could not switch overnight. Realizing that public opposition could sink the ULG program, a workshop was held in February 2001 to prepare a public information plan for Vietnam for the switch. Organized by the MOT and USAEP, the workshop was intended both for representatives of government agencies and for journalists. Along with a broad invitation to the media, individual invitations were issued to journalists who had been critical of the government's plan for an overnight switch to ULG. A key objective was to reaffirm that the switch to ULG was the right decision, especially from a national health perspective, that the switch would be carried out efficiently and expediently, and that there would be minimal negative impact on consumers.

4.6 The focus of the workshop again centered on the potential impacts, both technical and financial, of a switch to ULG. Vehicle manufacturers and fuel suppliers showed that not only could all vehicles in Vietnam use ULG, but also that there were cost savings to be achieved by not using LG. Vehicle experts estimated that unleaded fuel could cut vehicle maintenance costs in half by reducing the frequency of exhaust replacements, tune-ups, and other maintenance work associated with the corrosive properties of lead. A representative from the oil company Caltex assured Vietnamese participants that ULG could be used in older vehicles without the use of fuel additives, based on the experiences in Thailand. All of the industry representatives (Caltex, PetroVietnam, and Ford) supported a rapid switch to ULG.

4.7 With help from the USEPA, the Vietnam Register developed a public information program in early 2001 to inform consumers about a range of issues associated with ULG, including costs, health benefits, and vehicular compatibility. Because the government had already made the decision to switch to ULG, a limited and highly focused information campaign was carried out to inform people of the date of the

[28] Vietnam Register (2000).

switch and the reasons for it. Public information posters were prepared and distributed to inspection and gasoline stations in readiness for the July 1, 2001 switch.

Vehicle Fleet Compatibility

4.8 The most important issue that needed to be resolved in Vietnam was to confirm that vehicles could operate properly on ULG. Under the direction of the Vietnam Register, a series of surveys, vehicle tests, and studies were undertaken to evaluate the effects of a switch to ULG on Vietnam's vehicle fleet.

4.9 The MOT commissioned a vehicle fleet survey to identify vehicles with soft engine valves. The review found that there were about 39,000 civilian vehicles for which manufacturers had recommended the use of LG—approximately 8 percent of the country's vehicle fleet. Around 29,000 of these vehicles were Russian-built and manufactured before 1985 (see Table 4.1). Another 10,000 vehicles with soft engine valves were from China and Eastern Europe. Many of these countries had introduced ULG when they still had large fleets of vehicles designed to run on LG. In Slovakia, some 70 percent of the total vehicle fleet had soft engine valves when ULG was introduced. The corresponding figures for Slovenia and the Czech Republic were 25 and 40 percent, respectively. In the European Union, the fleet percentage with soft engine valves was estimated at less than 30 percent in 1993, and was estimated to decline to 20 percent by 1997.[29] Because all of these countries, plus China and the former Soviet Union, were moving to ULG without major technical difficulties, it was evident that the technical constraints for Vietnam would be minimal.

4.10 To provide further evidence specific to Vietnam, the MOT commissioned the Hanoi University of Technology to carry out tests on the impact of ULG on Vietnamese automobiles and four-stroke motorcycles. Results indicated that ULG did not affect the capacity, fuel consumption level, and other technical aspects of the test engines. Furthermore, the MOT announced in early 2001 that, since 2000, automobiles and motorbikes in the area from Danang in central Vietnam to north Vietnam had unknowingly been using what was essentially ULG (i.e., <0.013g/l lead) without problems.

4.11 To allay remaining concerns in Vietnam over the use of ULG in older Russian vehicles, the MOT organized a meeting in early April 2001 with the support of USAEP and Ford Vietnam. A Russian expert who had been involved in Moscow's LG phaseout provided detailed technical information confirming that older Russian vehicles could indeed use ULG without problems. In addition, with the support of the Swedish International Development Cooperation Agency (SIDA), a Swedish expert with considerable experience with Soviet-built vehicles and the use of ULG reviewed the vehicle fleet issue in Vietnam. The resultant report reiterated the position that Vietnam's older vehicle fleet could safely use ULG.[30]

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[29] Lovei (1997).
[30] SIDA (2001).

Table 4.1: Soviet-Made Vehicles in Vietnam (excludes military vehicles)

No	Type	Number
1.	GAT-69	15
2	GAT	651
3.	ZHIGULI	7
4.	LADA	3270
5	MOSKWICH	57
6	NIVA	410
7.	VOLGA	1712
8.	VOLGA M20	1
9.	UAZ	9895
10.	LATVIA	736
11.	PAZ	1696
12.	TRAIKA	1
13.	GAT-51	227
14.	GAT-53	21
15.	GAT-66	14
16.	ZIL 130	10561
17.	ZIL 131	22
18.	ZIL 157	7
19.	URAL	201
TOTAL		**29,303**

Source: Vietnam Register (2000).

4.12 Based on technical documents, questionnaires supplied by vehicle manufacturers, the results of local engine lab tests, and multiple vehicle studies, the conclusion was that the planned switch to ULG would have minimal impact on the relatively small number of vehicles in Vietnam designed for LG. In addition, the consensus was that it did not make sense to implement a dual distribution system to provide LG for the small remaining older vehicle fleet. In order to ensure that the vehicle fleet did not continue to add LG vehicles, the government issued a directive[31] that forbade the importation of older vehicles designed for leaded fuel. While consideration was given to marketing lubricant additives, eventually these were deemed unnecessary, given the experience of Thailand and information provided by fuel companies. In April 2001, the Vietnam Register presented the conclusions of its vehicle fleet compatibility analysis at a workshop entitled "Switching to Unleaded Gasoline in Vietnam," concluding with a press conference.

[31] Government of Vietnam (2001a).

Gasoline Grades

4.13 Developing appropriate grades of ULG and determining their specifications was an important matter that had to be resolved prior to the switch. The first issue was how many and what grades of ULG to introduce on July 1, 2001. Early on, MOSTE intended for there to be four new grades of ULG, all of which had relatively high octane levels (above 90 RON). In February 2001, the former head of Thailand's National Energy Planning Office, who had been instrumental in Thailand's LG phaseout, provided advice to Vietnamese officials on fuel standards, the fuel requirements of motorcycles, and the use of fuel lubricant additives. Based on Thailand's experience, he recommended that it would be better to have fewer high-octane grades and to continue with at least one lower-octane grade for lower-compression engines. This would simplify the distribution system and lower the distribution costs and the ultimate cost of gasoline to the consumer. The recommendation to limit the number of gasoline grades was heeded, but not the suggestion to maintain a lower-octane, lower-cost grade. The MOT subsequently proposed[32] in March 2001 that, after the switch, two types of gasoline would be available: ULG-90 and ULG-92. Vehicles that previously used LG 83 were to change to ULG-90, while the other 92-octane grade would be the same. The issue was that the price of ULG-90 was likely to be considerably higher than the former LG-83, not because it was unleaded. but because it was higher octane.[33]

4.14 The MOT was concerned that a higher price of ULG would create public criticism of the ULG program. The MOT argued that a change in fuel prices would not be in accordance with the prime minister's November 2000 directive for the switch, which stated that the "price of ULG should not be higher than the price of LG."[34] It also pointed out that if the government had to cover the difference there could be fiscal implications. It therefore proposed that unleaded ULG-83 and ULG-92 would replace the LG-83 and LG-92. Three grades of gasoline were proposed (RON 90, 92, and 95) in April 2001, but only RON 90, 92, 83 were offered for sale after the switch. The new lead-free RON 83 made its market debut on July 1, and MOSTE introduced a temporary regulation on technical requirements for this fuel. When the switch occurred, the price of ULG at the pump actually fell 100 VND per liter (about US$ 0.03 per gallon), compared to its leaded equivalent with the same octane number. In September 2001, sales of RON 83 gasoline (both leaded and unleaded) were ended; with only RON 90 and 95 remaining on the market.

SaigonPetro

4.15 When the switch to ULG was announced in November 2000, one of the few strong objections came from the SaigonPetro Company. SaigonPetro, which owned a small refinery producing only LG (RON 83), claimed that it would go bankrupt and have to lay off hundreds of workers if it had to replace lead with more costly imported octane

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32 MOT (2001b).

33 As of December 2000 the price of RON 92-octane gasoline was about US$ 5 higher per ton than RON 83-octane (about US$ 0.005 per liter)

34 Government of Vietnam (2001b)

enhancers. The company mobilized several key intellectuals in HCMC to argue for an extended phaseout of LG. Recognizing the problem, the MOT, with assistance from USAEP and Ford Vietnam, organized a meeting in April 2001 to address this and other concerns particular to southern Vietnam. Although SaigonPetro continued to question the government's program, the workshop concluded with an agreement that the switch to ULG would go forward as planned.

4.16 To overcome the issue with SaigonPetro, the company was given a short-term exemption on the import tax for high-octane blending components to allow it to produce ULG and sell it at what was the current market price for leaded RON 83. The tax reduction, it was argued, would have only small fiscal implications, since the quantity of gasoline produced by SaigonPetro was so small (10,000–15,000 tons per year). The MOT proposal was for an import tax reduction for a period of three years, beginning July 1, 2001. In return, SaigonPetro could not continue producing and selling LG after this date.

Final Steps and Implementation

4.17 At the end of March 2001, the MOT issued a proposal[35] to the prime minister (PM) that evaluated progress and outlined remaining issues. In the report, the MOT reaffirmed the PM's directive to switch to ULG on July 1, 2001, and offered a timetable of requisite steps. From May 1, 2001 there would be official public notification of the types of fuel to be imported and sold in Vietnam. From July 1, the importation of LG and additives for the production of LG would be prohibited. The switch to ULG took place as scheduled on July 1, 2001.

[35] MOT (2001a).

5

Lessons for Others

5.1 In Vietnam, a concerted effort at consensus building among government agencies, commercial interests, and the public allowed the switch to unleaded gasoline (ULG) to occur quickly and efficiently. A partnership of international donors, the private sector, and the GOV proved useful in directing assistance towards key issues, and helping the relevant agencies involved to address information and implementation issues. While each country's situation is unique, Vietnam's experience offers some valuable lessons for other countries that are considering switching to ULG.

Institutional/Political

5.2 A critical factor for the success of Vietnam's ULG program was that key government leaders supported the switch, even though at the outset they could not specify the exact details of how the switch would occur. Once the decision was made to proceed, the details were left to staff in the MOT and the Vietnam Register, which undertook the research primarily on its own. The partnership of donors and the business community was helpful in bringing in international experts to address specific issues, and of providing support for selected activities (e.g., workshops, public awareness campaign, technical studies).

5.3 The second characteristic of Vietnam's success was the concerted effort to involve interested government agencies, commercial interests, and the public. At times, international observers felt the program was in peril, given the delay in the issuance of the "Directive." However, the MOT staff was conducting a methodical, and at times trying, process of consensus building among the various stakeholders. In the end, the broad-based consultation that the MOT led helped pave the way for smooth implementation of the ULG program.

Technical

5.4 The widespread belief that older vehicles could not run on ULG has plagued lead elimination programs worldwide, and this was no different in Vietnam. Vehicle manufacturers had been partly responsible for this perception, by not being willing to say that older vehicles could use ULG under normal conditions. All vehicles, including motorcycles and older vehicles with soft engine valves, were proven to operate safely on ULG. By confirming that older vehicles could run on ULG, Vietnam was able

to avoid establishing a dual distribution system for gasoline. Even lubricating additives for older vehicle engines were shown to be unnecessary. What ultimately proved essential in Vietnam was that the country conduct its own lab tests with ULG on Vietnamese vehicles. Whether or not these tests add significantly to the international body of evidence that ULG can be used in vehicles with soft engine valves, the domestic tests were important politically.

5.5 The questions that arose about catalytic converters and whether they are needed for vehicles running on ULG were due to a lack of understanding on the part of Vietnamese officials and to an apparent attempt by the lead additive industry to forestall the move to ULG in Vietnam. While it is true that LG cannot be used with catalytic converters, since lead permanently destroys the catalysts, Vietnamese officials were told that all vehicles should be equipped with catalytic converters in order to run on ULG. In reality, catalytic converters on vehicles can provide advanced control of exhaust gases, but should only be introduced when and where the threat of LG contamination is low. Requiring that all vehicles be equipped with catalytic converters before the introduction of ULG would have ruined Vietnam's switch to ULG due to the costs that this would have entailed and due to the inability to enforce compliance. Catalytic converters can control the emission of high levels of aromatics, but high-quality ULG with acceptable levels of benzene and aromatics was available to Vietnam on the international market, and the gasoline quality standards for the country's planned refineries were well within international norms.

Financial

5.6 The resolution of the technical issues—fuel additives, catalytic converters, and engine renovation—all had financial implications that made it easier to move to ULG. The fact that Vietnam lacked significant petroleum refining capacity was the most important factor enabling the country to switch quickly to ULG. Other countries that do not have major refining industries, and that thus would not face the need for major refinery renovation, also should not delay in moving to ULG.

5.7 A second financial lesson from Vietnam is that establishing a dual distribution system for ULG and LG can be extremely costly. This is especially important for countries that, like Vietnam, have limited fuel distribution systems. By answering the question in the affirmative that older vehicles could run on ULG, Vietnam was able to avoid establishing a dual distribution system for gasoline.

5.8 The declining demand and declining production of LG in the Asian market has led to an increase in its price compared to ULG. This, combined with the premium that shippers were charging Vietnam for carrying "dirty" LG, made it more costly to import LG. This trend in leaded versus unleaded prices is now apparent worldwide, providing even less of a financial incentive to use LG.

Annex 1. Technical Specifications for ULG

Table A1.1: TCVN6776-2000: ULG Technical Specifications

ITEMS	ULG			TEST METHOD
	90	92	95	
1. Research octane number (RON), not less than	90	92	95	**ASTM D2699**
2. Lead content, not more than	0.013			TCVN 6704:2000 (ASTM D 5059)/ ASTM D 3237
3. Composition: - Initial boiling point, ^{o}C - 10% volume, ^{o}C not more than - 50% volume, ^{o}C not more than - 90% volume, ^{o}C not more than - Final boiling point, ^{o}C not more than - Distillation residue % volume, not more than	Report 70 120 190 215 2.0			ASTM D 86
4. Corrosion test of copper at 50 ^{o}C /3h, not more than	1			TCVN 2694: 2000 (ASTM D 130)
Existent gum mg/100 ml, not more than	5			TCVN 6593:2000 (ASTM D 381)
5. Immersion period, minutes, not less than	240			TCVN 6778:2000 (ASTM D 525)
6. Total sulfur % volume, not more than	0.15			ASTM D 1266
7. Vapor pressure (Reid) at 37.8 ^{o}C, kPa	43-80			TCVN 5731: 2000 (ASTM D 323)/ ASTM D 4953
8. Benzene concentration, % volume, not more than	5			TCVN 6703:2000 (ASTM D 3606)
9. Density (at 15 ^{o}C), kg/m^{3}	Report			TCVN 6594: 2000 (ASTM D 1298)
10. Color	Pure, without suspended particulate matter			Visual check

Source: Vietnam Register (2000).

Annex 2: Official Decrees

In 1991, Vietnam approved the National Plan for Environment and Sustainable Development. A Framework for Action. The plan provided a comprehensive framework for establishing the strategies, policies, institutions, laws, regulations, and programs needed to address environmental issues. In the energy sector, for example, it acknowledged that regulations and programs would be required for air pollution. The plan also recognized that administrative, financial, and intellectual resources were limited, and that some programs would need to be prioritized (World Bank, 1998).

The governing law for all these activities, the Law on Environmental Protection, was enacted in 1993. While the law did not make any specific reference to phasing out lead from gasoline, Article 22 of the law established a policy basis for addressing air pollution issues. The relevant piece of the legislation stated that "organizations and individuals operating means of water, air, road and rail transport must observe environmental standards and be subject to the supervision and periodic inspection for compliance with environmental standards by the relevant sectoral management agency and the State management agency for environmental protection. The operation of transport means failing to meet the stipulated environmental standards shall not be permitted."

To give guidance for the detailed implementation of the Environment Law, the government promulgated Decree No. 175/CP in 1994. Of particular relevance to leaded gasoline use was Item 3 Article 26, which regulated that transport means are not allowed to release hazardous emissions into the environment.

This was followed by two more regulations on May 29, 1995. The Government of Vietnam issued the Regulation on Road and Urban Transport Safety and the Observation of Traffic Order and Safety in Road and Urban Transport, which helped to further define the restrictions. Article 71 of the decree has the following provisions, which came into force on August 1, 1995.

1. "The prohibition of motor vehicles that use LG or emit black smoke that pollutes the environment.
2. "Motor vehicles when traveling along streets must maintain permissible levels of emissions and noise according to the standards set out by the MOSTE, and clean all dust and mud on the surface of car.
3. "The prohibition of the operation of motor vehicles that have no noise absorber."

Despite the enactment of such legislation, several factors continued to hamper Vietnam's efforts to adopt an effective environmental management strategy in the 1990s. Responsibilities for energy and environment issues were not clearly assigned, and there was limited awareness about certain environmental problems (such as the long-term effects associated with emissions of lead, volatile organic compounds, and nitrogen oxide). Few workers were familiar with many of the technologies involved (such as atmospheric pollution control), and there were limited funds for training, investment, and information gathering.

Annex 3: Timeline of Decisions and Events

Included provisions to prohibit release of hazardous exhaust emissions into the environment	12/27/199	Law on Protection of the Environment
Gave guidance to implementation of LPE, item 3 article 26 regarding transport exhaust emissions	10/18/199	Decree 175/CP
Banned vehicles using leaded gasoline	5/29/1995	Decree 36/CP Article 71 Provisi
MOT proposal for postponement of regulation (Article 71, Provision 1)	10/24/199	Circular3270/KHKT
PM assigns ministries assigned to conduct research on switch to unleaded, completed by 2000	11/24/199	Circular 6759/KGVS
Commercial vehicles must use ULG when operating in countries where UG has been phased out (ASEAN)	10/1998	Decision 195/1998/QD-TTg
Ministry officials visit Thailand to study phaseout process	8/1999	US-AEP EEP study visit
National Workshop on Phasing out Lead in Gasoline in Vietnam (Hanoi); public information campaign	11/1999	Stakeholder workshop
Proposal for LEAP developed based on outcome of stakeholder workshop	12/12	LEAP terms of reference
PM Directs July 1st 2001 as date of switch to ULG; assigned preparatory tasks to ministries	11/23/200	Directive 24/2000/CT-TTg
Vietnam Register provides exhibit and information on LG phaseout at Fuel Exhibition	12/6/2000	Int Auto & Petroleum Exhibitio
Submission by MOT of plan of ministries preparatory tasks for switch to ULG	12/2000	Circular 4306/2000-GTVT-KHC
Authorize MOT to co-ordinate with MoTR, Police, Customs to ban import of vehicles using LG	1/15/2001	Circular 223/VPCP-KG
International experience in raising public awareness for phasing out LG in Vietnam	2/16/2001	Stakeholder workshop
Guidance on prohibiting vehicles using leaded gasoline	2/23/2001	Circular 05/2001/TT/BTM
Vietnam Register's study reveals no negative effects on VN's vehicle fleet anticipated	3/1/2001	Vehicle Fleet Study
MOT maximum selling price of gasoline; price frame, gasoline import tax	3/20/2001	Proposal 0979/TM-CSTNN
MOT summary of ministries progress on Directive 24/2000/CT-TTg	3/30/2001	Proposal 965/GTVT-DK
Vietnam Register holds workshop "Switching to Unleaded Gasoline in Vietnam" (HCMC)	4/20/2001	Stakeholder workshop
Decision on import of ULG which indicated that selling price would not be higher than that for LG	4/27/2001	Decision 348/CP
Overnight switch to unleaded gasoline	7/1/2001	

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Joint UNDP/World Bank

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

LIST OF REPORTS ON COMPLETED ACTIVITIES

Region/Country	*Activity/Report Title*	*Date*	*Number*
	SUB-SAHARAN AFRICA (AFR)		
Africa Regional	Anglophone Africa Household Energy Workshop (English)	07/88	085/88
	Regional Power Seminar on Reducing Electric Power System Losses in Africa (English)	08/88	087/88
	Institutional Evaluation of EGL (English)	02/89	098/89
	Biomass Mapping Regional Workshops (English)	05/89	--
	Francophone Household Energy Workshop (French)	08/89	--
	Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development (English)	03/90	112/90
	Biomass Assessment and Mapping (English)	03/90	--
	Symposium on Power Sector Reform and Efficiency Improvement in Sub-Saharan Africa (English)	06/96	182/96
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	Africa Gas Initiative – Main Report. Volume I	02/01	240/01
	First World Bank Workshop on the Petroleum Products Sector in Sub-Saharan Africa	09/01	245/01
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	Power Rehabilitation and Technical Assistance (English)	10/91	142/91
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Botswana	Energy Assessment (English)	09/84	4998-BT
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	Review of Electricity Service Connection Policy (English)	07/87	071/87
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	Urban Household Energy Strategy Study (English)	05/91	132/91
Burkina Faso	Energy Assessment (English and French)	01/86	5730-BUR
	Technical Assistance Program (English)	03/86	052/86
	Urban Household Energy Strategy Study (English and French)	06/91	134/91
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	Improved Charcoal Cookstove Strategy (English and French)	09/85	042/85
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Cape Verde	Energy Assessment (English and Portuguese)	08/84	5073-CV
	Household Energy Strategy Study (English)	02/90	110/90
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Chad	Elements of Strategy for Urban Household Energy The Case of N'djamena (French)	12/93	160/94

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Comoros	Energy Assessment (English and French)	01/88	7104-COM
	In Search of Better Ways to Develop Solar Markets: The Case of Comoros	05/00	230/00
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	Power Development Plan (English and French)	03/90	106/90
	Africa Gas Initiative – Congo: Volume IV	02/01	240/01
Côte d'Ivoire	Energy Assessment (English and French)	04/85	5250-IVC
	Improved Biomass Utilization (English and French)	04/87	069/87
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	Power Sector Efficiency Study (French)	02/92	140/91
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	Bagasse Study (English)	12/86	063/86
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	Status Report (English)	05/84	016/84
	Coal Conversion Action Plan (English)	02/87	--
	Solar Water Heating Study (English)	02/87	066/87
	Peri-Urban Woodfuel Development (English)	10/87	076/87
	Power Master Plan (English)	11/87	--
	Power Loss Reduction Study (English)	09/96	186/96
	Implementation Manual: Financing Mechanisms for Solar Electric Equipment	07/00	231/00
Lesotho	Energy Assessment (English)	01/84	4676-LSO
Liberia	Energy Assessment (English)	12/84	5279-LBR
	Recommended Technical Assistance Projects (English)	06/85	038/85
	Power System Efficiency Study (English)	12/87	081/87
Madagascar	Energy Assessment (English)	01/87	5700-MAG
	Power System Efficiency Study (English and French)	12/87	075/87

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	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry (English)	11/83	009/83
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Mali	Energy Assessment (English and French)	11/91	8423-MLI
	Household Energy Strategy (English and French)	03/92	147/92
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	Household Energy Strategy Study (English and French)	07/90	123/90
Mauritius	Energy Assessment (English)	12/81	3510-MAS
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	Power System Efficiency Audit (English)	05/87	070/87
	Bagasse Power Potential (English)	10/87	077/87
	Energy Sector Review (English)	12/94	3643-MAS
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	Electricity Tariffs Study (English)	06/96	181/96
	Sample Survey of Low Voltage Electricity Customers	06/97	195/97
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Niger	Energy Assessment (French)	05/84	4642-NIR
	Status Report (English and French)	02/86	051/86
	Improved Stoves Project (English and French)	12/87	080/87
	Household Energy Conservation and Substitution (English and French)	01/88	082/88
Nigeria	Energy Assessment (English)	08/83	4440-UNI
	Energy Assessment (English)	07/93	11672-UNI
Rwanda	Energy Assessment (English)	06/82	3779-RW
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	Improved Charcoal Cookstove Strategy (English and French)	08/86	059/86
	Improved Charcoal Production Techniques (English and French)	02/87	065/87
	Energy Assessment (English and French)	07/91	8017-RW
	Commercialization of Improved Charcoal Stoves and Carbonization Techniques Mid-Term Progress Report (English and French)	12/91	141/91
SADC	SADC Regional Power Interconnection Study, Vols. I-IV (English)	12/93	-
SADCC	SADCC Regional Sector: Regional Capacity-Building Program for Energy Surveys and Policy Analysis (English)	11/91	-
Sao Tome and Principe	Energy Assessment (English)	10/85	5803-STP
Senegal	Energy Assessment (English)	07/83	4182-SE
	Status Report (English and French)	10/84	025/84
	Industrial Energy Conservation Study (English)	05/85	037/85
	Preparatory Assistance for Donor Meeting (English and French)	04/86	056/86
	Urban Household Energy Strategy (English)	02/89	096/89
	Industrial Energy Conservation Program (English)	05/94	165/94
Seychelles	Energy Assessment (English)	01/84	4693-SEY
	Electric Power System Efficiency Study (English)	08/84	021/84
Sierra Leone	Energy Assessment (English)	10/87	6597-SL
Somalia	Energy Assessment (English)	12/85	5796-SO
Republic of South Africa	Options for the Structure and Regulation of Natural Gas Industry (English)	05/95	172/95

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Sudan	Management Assistance to the Ministry of Energy and Mining	05/83	003/83
	Energy Assessment (English)	07/83	4511-SU
	Power System Efficiency Study (English)	06/84	018/84
	Status Report (English)	11/84	026/84
	Wood Energy/Forestry Feasibility (English)	07/87	073/87
Swaziland	Energy Assessment (English)	02/87	6262-SW
	Household Energy Strategy Study	10/97	198/97
Tanzania	Energy Assessment (English)	11/84	4969-TA
	Peri-Urban Woodfuels Feasibility Study (English)	08/88	086/88
	Tobacco Curing Efficiency Study (English)	05/89	102/89
	Remote Sensing and Mapping of Woodlands (English)	06/90	--
	Industrial Energy Efficiency Technical Assistance (English)	08/90	122/90
	Power Loss Reduction Volume 1: Transmission and Distribution SystemTechnical Loss Reduction and Network Development (English)	06/98	204A/98
	Power Loss Reduction Volume 2: Reduction of Non-Technical Losses (English)	06/98	204B/98
Togo	Energy Assessment (English)	06/85	5221-TO
	Wood Recovery in the Nangbeto Lake (English and French)	04/86	055/86
	Power Efficiency Improvement (English and French)	12/87	078/87
Uganda	Energy Assessment (English)	07/83	4453-UG
	Status Report (English)	08/84	020/84
	Institutional Review of the Energy Sector (English)	01/85	029/85
	Energy Efficiency in Tobacco Curing Industry (English)	02/86	049/86
	Fuelwood/Forestry Feasibility Study (English)	03/86	053/86
	Power System Efficiency Study (English)	12/88	092/88
	Energy Efficiency Improvement in the Brick and Tile Industry (English)	02/89	097/89
	Tobacco Curing Pilot Project (English)	03/89	UNDP Terminal Report
	Energy Assessment (English)	12/96	193/96
	Rural Electrification Strategy Study	09/99	221/99
Zaire	Energy Assessment (English)	05/86	5837-ZR
Zambia	Energy Assessment (English)	01/83	4110-ZA
	Status Report (English)	08/85	039/85
	Energy Sector Institutional Review (English)	11/86	060/86
	Power.Subsector Efficiency Study (English)	02/89	093/88
	Energy Strategy Study (English)	02/89	094/88
	Urban Household Energy Strategy Study (English)	08/90	121/90
Zimbabwe	Energy Assessment (English)	06/82	3765-ZIM
	Power System Efficiency Study (English)	06/83	005/83
	Status Report (English)	08/84	019/84
	Power Sector Management Assistance Project (English)	04/85	034/85
	Power Sector Management Institution Building (English)	09/89	--
	Petroleum Management Assistance (English)	12/89	109/89
	Charcoal Utilization Prefeasibility Study (English)	06/90	119/90
	Integrated Energy Strategy Evaluation (English)	01/92	8768-ZIM
	Energy Efficiency Technical Assistance Project: Strategic Framework for a National Energy Efficiency Improvement Program (English)	04/94	--
	Capacity Building for the National Energy Efficiency Improvement Programme (NEEIP) (English)	12/94	--

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Zimbabwe	Rural Electrification Study	03/00	228/00
	EAST ASIA AND PACIFIC (EAP)		
Asia Regional	Pacific Household and Rural Energy Seminar (English)	11/90	--
China	County-Level Rural Energy Assessments (English)	05/89	101/89
	Fuelwood Forestry Preinvestment Study (English)	12/89	105/89
	Strategic Options for Power Sector Reform in China (English)	07/93	156/93
	Energy Efficiency and Pollution Control in Township and Village Enterprises (TVE) Industry (English)	11/94	168/94
	Energy for Rural Development in China: An Assessment Based on a Joint Chinese/ESMAP Study in Six Counties (English)	06/96	183/96
	Improving the Technical Efficiency of Decentralized Power Companies	09/99	222/99
Fiji	Energy Assessment (English)	06/83	4462-FIJ
Indonesia	Energy Assessment (English)	11/81	3543-IND
	Status Report (English)	09/84	022/84
	Power Generation Efficiency Study (English)	02/86	050/86
	Energy Efficiency in the Brick, Tile and Lime Industries (English)	04/87	067/87
	Diesel Generating Plant Efficiency Study (English)	12/88	095/88
	Urban Household Energy Strategy Study (English)	02/90	107/90
	Biomass Gasifier Preinvestment Study Vols. I & II (English)	12/90	124/90
	Prospects for Biomass Power Generation with Emphasis on Palm Oil, Sugar, Rubberwood and Plywood Residues (English)	11/94	167/94
Lao PDR	Urban Electricity Demand Assessment Study (English)	03/93	154/93
	Institutional Development for Off-Grid Electrification	06/99	215/99
Malaysia	Sabah Power System Efficiency Study (English)	03/87	068/87
	Gas Utilization Study (English)	09/91	9645-MA
Mongolia	Energy Efficiency in the Electricity and District Heating Sectors	10/01	247/01
	Improved Space Heating Stoves for Ulaanbaatar	03/02	254/02
Myanmar	Energy Assessment (English)	06/85	5416-BA
Papua New Guinea	Energy Assessment (English)	06/82	3882-PNG
	Status Report (English)	07/83	006/83
	Institutional Review in the Energy Sector (English)	10/84	023/84
	Power Tariff Study (English)	10/84	024/84
Philippines	Commercial Potential for Power Production from Agricultural Residues (English)	12/93	157/93
	Energy Conservation Study (English)	08/94	--
	Strengthening the Non-Conventional and Rural Energy Development Program in the Philippines: A Policy Framework and Action Plan	08/01	243/01
	Rural Electrification and Development in the Philippines Measuring the Social and Economic Benefits	05/02	255/02
Solomon Islands	Energy Assessment (English)	06/83	4404-SOL
	Energy Assessment (English)	01/92	979-SOL
South Pacific	Petroleum Transport in the South Pacific (English)	05/86	--
Thailand	Energy Assessment (English)	09/85	5793-TH
	Rural Energy Issues and Options (English)	09/85	044/85

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Thailand	Accelerated Dissemination of Improved Stoves and Charcoal Kilns (English)	09/87	079/87
	Northeast Region Village Forestry and Woodfuels Preinvestment Study (English)	02/88	083/88
	Impact of Lower Oil Prices (English)	08/88	--
	Coal Development and Utilization Study (English)	10/89	--
Tonga	Energy Assessment (English)	06/85	5498-TON
Vanuatu	Energy Assessment (English)	06/85	5577-VA
Vietnam	Rural and Household Energy-Issues and Options (English)	01/94	161/94
	Power Sector Reform and Restructuring in Vietnam: Final Report to the Steering Committee (English and Vietnamese)	09/95	174/95
	Household Energy Technical Assistance: Improved Coal Briquetting and Commercialized Dissemination of Higher Efficiency Biomass and Coal Stoves (English)	01/96	178/96
	Petroleum Fiscal Issues and Policies for Fluctuating Oil Prices In Vietnam	02/01	236/01
	An Overnight Success. Vietnam's Switch to Unleaded Gasoline	08/02	257/02
Western Samoa	Energy Assessment (English)	06/85	5497-WSO
	SOUTH ASIA (SAS)		
Bangladesh	Energy Assessment (English)	10/82	3873-BD
	Priority Investment Program (English)	05/83	002/83
	Status Report (English)	04/84	015/84
	Power System Efficiency Study (English)	02/85	031/85
	Small Scale Uses of Gas Prefeasibility Study (English)	12/88	--
	Reducing Emissions from Baby-Taxis in Dhaka	01/02	253/02
India	Opportunities for Commercialization of Nonconventional Energy Systems (English)	11/88	091/88
	Maharashtra Bagasse Energy Efficiency Project (English)	07/90	120/90
	Mini-Hydro Development on Irrigation Dams and Canal Drops Vols I, II and III (English)	07/91	139/91
	WindFarm Pre-Investment Study (English)	12/92	150/92
	Power Sector Reform Seminar (English)	04/94	166/94
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	Environmental Issues in the Power Sector: Manual for Environmental Decision Making (English)	06/99	213/99
	Household Energy Strategies for Urban India: The Case of Hyderabad	06/99	214/99
	Greenhouse Gas Mitigation In the Power Sector: Case Studies From India	02/01	237/01
Nepal	Energy Assessment (English)	08/83	4474-NEP
	Status Report (English)	01/85	028/84
	Energy Efficiency & Fuel Substitution in Industries (English)	06/93	158/93
Pakistan	Household Energy Assessment (English)	05/88	--
	Assessment of Photovoltaic Programs, Applications, and Markets (English)	10/89	103/89
	National Household Energy Survey and Strategy Formulation Study: Project Terminal Report (English)	03/94	--
	Managing the Energy Transition (English)	10/94	--

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Pakistan	Lighting Efficiency Improvement Program Phase 1: Commercial Buildings Five Year Plan (English)	10/94	--
	Clean Fuels	10/01	246/01
Sri Lanka	Energy Assessment (English)	05/82	3792-CE
	Power System Loss Reduction Study (English)	07/83	007/83
	Status Report (English)	01/84	010/84
	Industrial Energy Conservation Study (English)	03/86	054/86
	EUROPE AND CENTRAL ASIA (ECA)		
Bulgaria	Natural Gas Policies and Issues (English)	10/96	188/96
Central Asia and The Caucasus	Cleaner Transport Fuels in Central Asia and the Caucasus	08/01	242/01
Central and Eastern Europe	Power Sector Reform in Selected Countries	07/97	196/97
	Increasing the Efficiency of Heating Systems in Central and Eastern Europe and the Former Soviet Union (English and Russian)	08/00	234/00
	The Future of Natural Gas in Eastern Europe (English)	08/92	149/92
Kazakhstan	Natural Gas Investment Study, Volumes 1, 2 & 3	12/97	199/97
Kazakhstan & Kyrgyzstan	Opportunities for Renewable Energy Development	11/97	16855-KAZ
Poland	Energy Sector Restructuring Program Vols. I-V (English)	01/93	153/93
	Natural Gas Upstream Policy (English and Polish)	08/98	206/98
	Energy Sector Restructuring Program: Establishing the Energy Regulation Authority	10/98	208/98
Portugal	Energy Assessment (English)	04/84	4824-PO
Romania	Natural Gas Development Strategy (English)	12/96	192/96
Slovenia	Workshop on Private Participation in the Power Sector (English)	02/99	211/99
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	Energy and the Environment: Issues and Options Paper	04/00	229/00
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Arab Republic of Egypt	Energy Assessment (English)	10/96	189/96
	Energy Assessment (English and French)	03/84	4157-MOR
	Status Report (English and French)	01/86	048/86
Morocco	Energy Sector Institutional Development Study (English and French)	07/95	173/95
	Natural Gas Pricing Study (French)	10/98	209/98
	Gas Development Plan Phase II (French)	02/99	210/99
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	Electric Power Efficiency Study (English)	09/88	089/88
	Energy Efficiency Improvement in the Cement Sector (English)	04/89	099/89
	Energy Efficiency Improvement in the Fertilizer Sector (English)	06/90	115/90
Tunisia	Fuel Substitution (English and French)	03/90	--
	Power Efficiency Study (English and French)	02/92	136/91
	Energy Management Strategy in the Residential and Tertiary Sectors (English)	04/92	146/92
	Renewable Energy Strategy Study, Volume I (French)	11/96	190A/96

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Tunisia	Renewable Energy Strategy Study, Volume II (French)	11/96	190B/96
Yemen	Energy Assessment (English)	12/84	4892-YAR
	Energy Investment Priorities (English)	02/87	6376-YAR
	Household Energy Strategy Study Phase I (English)	03/91	126/91
	LATIN AMERICA AND THE CARIBBEAN (LAC)		
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Bolivia	Energy Assessment (English)	04/83	4213-BO
	National Energy Plan (English)	12/87	--
	La Paz Private Power Technical Assistance (English)	11/90	111/90
	Prefeasibility Evaluation Rural Electrification and Demand Assessment (English and Spanish)	04/91	129/91
	National Energy Plan (Spanish)	08/91	131/91
	Private Power Generation and Transmission (English)	01/92	137/91
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	Household Rural Energy Strategy (English and Spanish)	01/94	162/94
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Colombia	Energy Strategy Paper (English)	12/86	--
	Power Sector Restructuring (English)	11/94	169/94
	Energy Efficiency Report for the Commercial and Public Sector (English)	06/96	184/96
Costa Rica	Energy Assessment (English and Spanish)	01/84	4655-CR
	Recommended Technical Assistance Projects (English)	11/84	027/84
	Forest Residues Utilization Study (English and Spanish)	02/90	108/90
Dominican Republic	Energy Assessment (English)	05/91	8234-DO
Ecuador	Energy Assessment (Spanish)	12/85	5865-EC
	Energy Strategy Phase I (Spanish)	07/88	--
	Energy Strategy (English)	04/91	--
	Private Minihydropower Development Study (English)	11/92	--

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Ecuador	Energy Pricing Subsidies and Interfuel Substitution (English)	08/94	11798-EC
	Energy Pricing, Poverty and Social Mitigation (English)	08/94	12831-EC
Guatemala	Issues and Options in the Energy Sector (English)	09/93	12160-GU
Haiti	Energy Assessment (English and French)	06/82	3672-HA
	Status Report (English and French)	08/85	041/85
	Household Energy Strategy (English and French)	12/91	143/91
Honduras	Energy Assessment (English)	08/87	6476-HO
	Petroleum Supply Management (English)	03/91	128/91
Jamaica	Energy Assessment (English)	04/85	5466-JM
	Petroleum Procurement, Refining, and Distribution Study (English)	11/86	061/86
	Energy Efficiency Building Code Phase I (English)	03/88	--
	Energy Efficiency Standards and Labels Phase I (English)	03/88	--
	Management Information System Phase I (English)	03/88	--
	Charcoal Production Project (English)	09/88	090/88
	FIDCO Sawmill Residues Utilization Study (English)	09/88	088/88
	Energy Sector Strategy and Investment Planning Study (English)	07/92	135/92
Mexico	Improved Charcoal Production Within Forest Management for the State of Veracruz (English and Spanish)	08/91	138/91
	Energy Efficiency Management Technical Assistance to the Comision Nacional para el Ahorro de Energia (CONAE) (English)	04/96	180/96
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	Recommended Technical Assistance Projects (English)	09/85	--
	Status Report (English and Spanish)	09/85	043/85
Peru	Energy Assessment (English)	01/84	4677-PE
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	Village Power 2000: Empowering People and Transforming Markets	10/01	251/01
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