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FUEL QUALITY BEST PRACTICE OVERVIEW:

APPLICATION TO VIETNAM'S FUEL QUALITY STRATEGY

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This publication was produced for review by the United States Agency for International Development. It was prepared by Sandrine Dixson-Declève, IFQC, Director Europe & Africa and Hoang Thi Tinh Vietnam Standards Centre, STAMEQ

FUEL QUALITY BEST PRACTICE:
APPLICATION TO VIETNAM'S FUEL QUALITY STRATEGY

REPORT 1

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I. Background

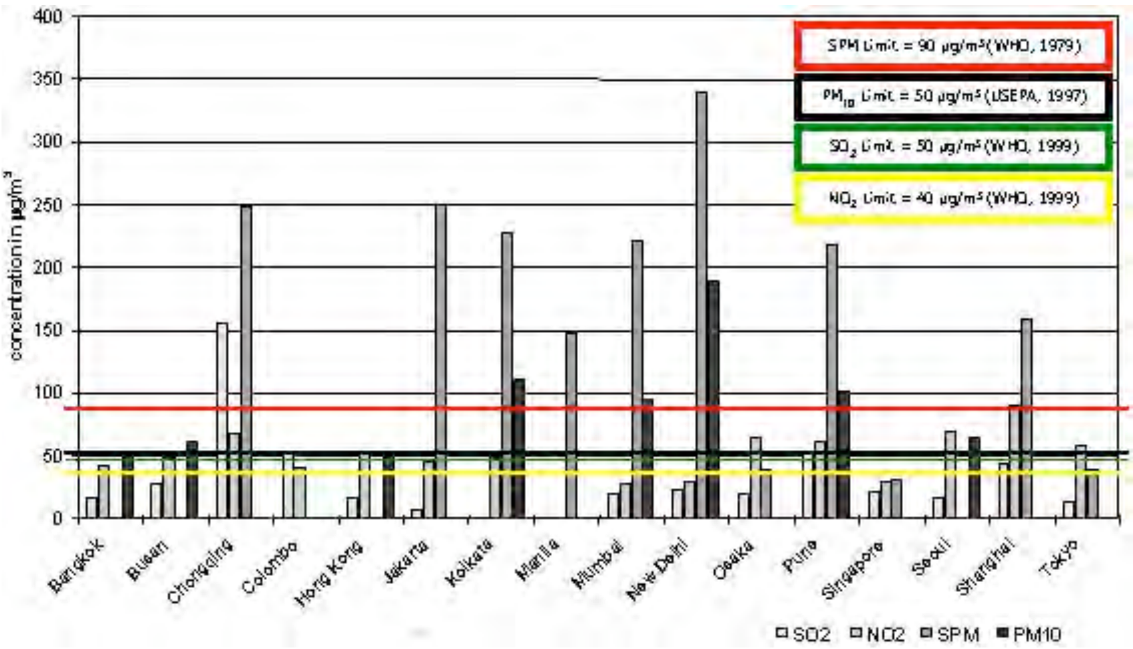
In October-November 2003, a training manual was developed by the International Fuel Quality Center (IFQC) in collaboration with CAI-Asia was developed as a comprehensive reference guide to support drafting national fuel quality strategies. This manual was developed to complement training sessions given to six Asian countries in the process of drafting solutions to air quality problems from mobile sources. Vietnam was one of the countries that participated in this workshop. This *Fuel Quality Best Practice Overview* is part of Vietnam's fuel quality standard development process. The material in this overview is largely founded on material and information from this workshop and the complementing manual, as well as from the IFQC's own benchmarking analysis of fuel quality standard development in the Asian region and Europe. This overview attempts to demonstrate the current globally accepted rational for setting fuel quality specifications and the best practice in doing so across the globe with a focus on the Asian region so as to demonstrate that Vietnam is amongst like minded countries in its efforts to set fuel quality standards.

Air Quality Issues and Costs

Multiple sources cause or contribute directly to air pollution. These include large stationary sources such as factories, power plants, smelters and refineries; smaller sources such as dry cleaners, fuelling facilities and degreasing operations; mobile sources such as cars, buses, planes, trucks, and trains; and natural sources such as wildfires, volcanoes and plants. Rapid urbanization, combined with a rapid growth in vehicle ownership and vehicle use has contributed to a situation in which most cities across the globe have some type of air quality problem. Asian cities suffer from the same plight. Figure 1 below provides an overview of the ambient levels of a number of key pollutants in major Asian cities. These key pollutants are sulfur dioxides (SO2), nitrogen oxides (NO2), suspended particulate matter (SPM), and particulate matter (PM). Air pollution in Asian cities comes from different sources such as mobile sources; stationary sources or from smaller area sources, such as home cooking and garbage burning. In many Asian cities, mobile sources are the most significant contributor to air pollution. This is especially so for PM, carbon monoxide (CO) and NOx, the pollutants most often found to exceed the ambient air quality standards.

While the growth in mobility in Asia is a strong positive indicator in Asian countries of their continued economic development, at the same time, this exacerbates their air quality situation. In many cases, air quality in Asian cities does not meet the standards set by World Health Organization (WHO). Pollution levels above the WHO standards mean that the health of people breathing the air is negatively affected. It is clearly documented in medical journals and governmental studies that poor air quality not only impacts the environment but also health in particular the respiratory system in the youngest and oldest population age groups, hospitalisation for heart or lung diseases, and even premature death. This results in considerable financial and economic costs for households and Asian economies.

Figure 1: Average Annual Pollution Concentrations for some Asians Cities (2000-2001)



Source: Asian Development Bank, 2004

Table 1 below provides a summary of the local and global impacts of all air pollutants, including the major human health, environmental, and climate change impacts.

Table 1: Summary of major pollutants from transportation sources

Pollutants	Local Impacts	Global Impacts	Comments
Lead	Impairs the normal intellectual development and learning ability of children	Ground water pollution and particulates in air	
CO	Aggravates existing cardiovascular diseases, impairs visual perception and dexterity	Indirect influence on warming through competition with methane for oxidation	Transportation can be responsible for up to 95% of CO emissions in urban areas. Globally distributed gas HC
HC	Range of health impacts including respiratory, neurological & carcinogenic Photochemical smog precursor	Class of compounds includes methane, a potent greenhouse gas Indirect warming influence through ozone formation	A range of natural and anthropogenic sources ensures that HC species are generally available as ozone precursors NOx

Pollutants	Local Impacts	Global Impacts	Comments
NOx	Respiratory irritant Visibility impairment Acid precursor Photochemical smog precursor	Indirect warming influence through ozone formation	Acid and ozone production impacts of NOx can be widely distributed through long-range transport of reservoir species O3
O3	Primary constituent of photochemical smog Severe respiratory impacts Material & crop damage	Global warming impacts due to increasing background concentrations	O3 has no direct emissions sources—NOx, HC, and sunlight are required for production SOx
SOx	Respiratory irritant Visibility impairment Acid precursor	Sulphate has some cooling impact due to light scattering	SO2 has a relatively long atmospheric lifetime leading to widespread acid impacts PM
Benzene	Classified as a human carcinogen (Group 1) by the International Agency for Research on Cancer		
PM	Cardiovascular & respiratory impacts Visibility impairment Includes acid species	Particles can influence warming or cooling, depending on carbon content & scattering abilities	Atmospheric lifetime varies with particle size GHG
GHG		Leading to global warming through long-term atmospheric accumulation	Transportation is a major source of CO2 but less important for methane & N2O

Source: ICCT and IFQC data, 2003

In addition, the estimated costs related to health issues from air pollution have been documented by national and international organisations. For example, the World Bank Environment Monitor Reports (2002) for the Philippines and Thailand show that health-related air pollution costs amounted to US$392 million for Metro Manila in 2001 and US$424 million for Bangkok in 2000. World Health Organization estimates of mortality indicate that on a yearly basis about 800,000 people die prematurely because of exposure to urban outdoor air pollution. Of these, about 500,000 are believed to be in Asia as seen in Table 2.2 below. The burden of disease expressed in Disability Adjusted Life Years (DALY) indicates that out of the 6.4 million affected, 3.8 million are in Asia. Air pollution can also significantly affect ecosystems. For example, ground-level ozone has been associated with reductions of agricultural and commercial forest yields, and airborne releases of NOx are one of the largest sources of nitrogen pollution in certain water bodies. Like health costs, such damage is also a cost burden on society.

Table 2: Mortality (premature deaths) in Asia

Environmental Risks	Global Estimate	Asian Estimate	Asia as a percent of Global
Unsafe water	1,730,000	730,000	42%
Urban Outdoor Air	799,000	487,000	61%
Indoor Air	1,619,000	1,025,000	63%
Lead	234,000	88,000	37%

Source: WHO, 2002

However, despite implementing the World Health Organization's (WHO) Air Quality Guidelines issued in 1999, many countries are not meeting their health-based standards for CO, NO2, sulfur dioxide and ozone, exceeding them in some cases by a factor of two. Although Sulfur dioxide (SO2) and nitrogen dioxide (NO2) ambient levels are dropping in many countries because of stationary and mobile source programs, ozone and particulate matter pollution are a serious problem around the world, even in developed countries that have taken aggressive action to reduce this kind of pollution. The countries that have phased out leaded gasoline have experienced a massive drop in lead emissions. Lead use is currently concentrated in just a few regions of the world, including Africa, Eastern Europe and parts of Asia. We expect the global lead phase out to be essentially complete (except for parts of Africa) by 2006. In addition, other key pollutants such as CO and HC have been reduced significantly in countries that have phased out lead and have introduced vehicle emission control equipment such as catalytic converters. In many cities across the globe, vehicles are the main source of air pollution, although there are differences with respect to the type of vehicles that are contributing the most to transport related air pollution. In some cases it is diesel-fuelled busses, while in other cases, especially in urban city centres, it is gasoline fuelled two-stroke vehicles.

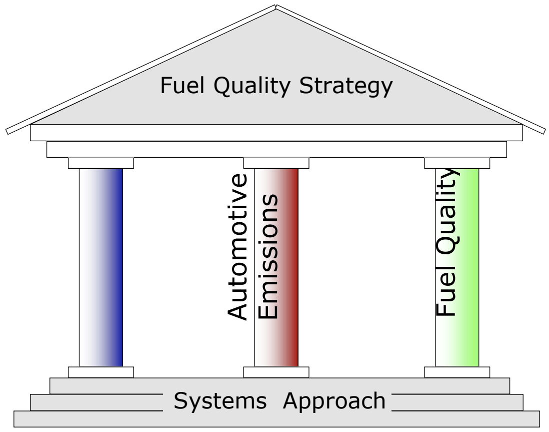
It is important to note that the way in which countries across the globe have reacted and will react in the future to mobile source related air pollution and urban air quality issues is context specific and is influenced by a variety of factors including:

- Key air pollutants
- Climate change
- Energy security issues
- The structure of their automotive and energy sectors
- Socio economic
- Political factors

II. The Systems Approach: A Best Practice Approach

Across the globe, comprehensive fuel quality strategies and ultimately the setting of fuel quality specifications are based upon the "systems approach". The "systems approach" was initially conceived and implemented in the United States but is now implemented across the world. This approach focuses on three main pillars as seen below in Figure 1.2.

Figure 2: The "Systems Approach"



Source: Sandrine Dixson-Decleve, International Fuel Quality Center (IFQC), 2003.

As shown above, it is these three pillars, based on the "systems approach", which are the foundation for a successful fuel quality strategy. Each pillar although a separate entity is dependent on the other to up-hold the resulting fuel quality strategy. The impact of a vehicle on air quality is directly linked to the type of engine and after treatment technology on that vehicle and the quality of the fuel used in the engine. Therefore, the development of a fuel quality strategy must first be based on meeting certain air quality objectives. Once these objectives are defined and source apportionment has occurred e.g. the actual impact of transport on urban air pollution has been calculated, determination can be made of which automotive emissions must be reduced and by how much. This in turn will determine engine technology needs and the quality of fuels necessary to enable the engine and/or after treatment technology to meet the emission requirements.

Asian countries are at different stages when it comes to setting and revising emission standards. Most Asian countries are either currently implementing or planning to implement the European standards for automotive emissions and fuel quality. As the Asian region has predominantly followed the European approach it is worthwhile to take a look at how the EU regulates automotive emissions.

In the EU, motor vehicle emissions are regulated by Directive 70/220/EEC (light vehicles) and 88/77/EC (heavy vehicles) and amendments to those directives. The first set of amendments through the 1980's and 1990's established the Euro 1-2 standards for light duty and heavy-duty vehicles. A series of amendments have been issued to gradually tighten the original Euro 1 and 2 standards, mainly as a result of the EU Auto-Oil Programme I and II findings. The Auto-Oil Programme also resulted in legislation on durability. That is that a manufacturer is responsible for emissions from light duty vehicles during the first five years or 80,000 kilometres (whichever occurs first) of use, providing the vehicle is properly maintained, and on the use of onboard diagnostic (OBD) systems.

Directive 98/69/EEC Relating To Measures to Be Taken Against Air Pollution from Motor Vehicles and Amending Council Directives 70/156/EEC and 70/220/EEC is the most important piece of legislation on vehicle emissions. Directive 98/69/EC went into effect in September 1999. Its promulgation was coordinated *with Directive 98/70/EC on Gasoline and Diesel Fuel Quality* (CEN standards EN228-1999 for gasoline and EN 590-1999 for diesel), which set stricter standards for fuel quality for 2000 and 2005. The 2005 fuel requirements were then amended by Directive 2003/17/EC calling for 10ppm sulfur availability in 2005 in both gasoline and diesel and 10ppm gasoline fuel Europe-wide by 2009 the diesel date left to be confirmed. These requirements were then translated into the European standards EN 228-2004 and EN 590-2004.

Directive 98/69/EC covers what is commonly known as Euro 3 and Euro 4 emission standards. Euro 3 regulates five vehicle classes: 1) passenger vehicles less than 2.5 tonnes; 2) passenger vehicles greater than 2.5 tonnes; 3) transport vehicles less than 3.5 tonnes; 4) transport vehicles greater than 3.5 tonnes but less than 12 tonnes; 5) transport vehicles greater than 12 tonnes.

Also, Directive 1999/96/EC amended Directive 88/77/EEC and went into effect in February 2000. This Directive set more stringent emission standards for heavy-duty vehicles and buses for 2000, 2005 and 2008. The European Commission estimates the 2000 limits will result in a 30% reduction over previous emission levels. Two new test cycles are included and limits for non-methane hydrocarbons and methane were introduced for gas engines. The limits for 2005 set even more stringent limits for particulate matter to push manufacturers into using particulate trap technology. In 2008, more stringent nitrogen oxide limits will be introduced.

The Euro emission standards are given in the tables below:

Table 3.1: EU Passenger Car Limits (type approval), 1970 -. All limits in either g/km or g/test as indicated.

Gasoline Cars							
Directive	Year	Euro ?	CO	HC	NOx	HC+NOx	Units
98/69	2005	Euro 4	1	0.1	0.08		g/km
98/69	2000	Euro 3	2.3	0.2	0.15		g/km
94/12	1996	Euro 2	2.2			0.5	g/km
							g/km
91/441	1991	Euro 1	2.72			0.97	g/km
88/436 (> 2.0 l)	1990		25		3.5	6.5	g/test
88/436 (1.4 - 2.0 l)	1990		30			8	g/test
88/436 (< 1.4 l)	1990		45		6	15	g/test
88/76 (> 2.0 l)	1988		25		3.5	6.5	g/test
88/76 (1.4 - 2.0 l)	1988		30			8	g/test
88/76 (< 1.4 l)	1988		45		6	15	g/test
83/351	1983		84			23.5	g/test

Source: International Fuel Quality Center (IFQC), from the European Commission 2002.

Table 3.2:. EU Passenger Car Limits (type approval), 1970 - . All limits in either g/km or g/test as indicated.

Diesel Cars								
Directive	year	Euro ?	CO	HC	NOx	HC+NOx	PM	Units
98/69	2005	Euro 4	0.5	0.05	0.25	0.3	0.025	g/km
98/69	2000	Euro 3	0.64	0.06	0.5	0.56	0.05	g/km
94/12 **DI**	1996	Euro 2	1			0.9	0.1	g/km
94/12 **IDI**	1996	Euro 2	1			0.7	0.08	g/km
91/441	1991	Euro 1	2.72			0.97	0.14	g/km
88/436 (> 2.0 l)	1990		25		3.5	6.5	1.1	g/test
88/436 (1.4 - 2.0 l)	1990		30			8	1.1	g/test
88/436 (< 1.4 l)	1990		45		6	15	1.1	g/test
88/76 (> 2.0 l)	1988		25			6.5		g/test
88/76 (1.4 - 2.0 l)	1988		30			8		g/test
88/76 (< 1.4 l)	1988		45			15		g/test
83/351	1983		84			23.5		g/test

Source: International Fuel Quality Center (IFQC), from the European Commission 2002.

Table 3.3: EU Heavy Duty Truck & Bus Limits (type approval), 1982 -. All limits in g/kWh.

HDV	Year	Euro	CO	HC	NMHC	CH4	NOx	PM	PM	Units	
Directive									<0,7 dm3 etc		Note
1999/96 C (EEV)	-	-	1.5	0.25	-	-	2	0.02	-	g/kWh	New cycle (ESC)
1999/96 C (EEV)	-	-	3	-	0.4	0.65	2	0.02	-	g/kWh	New cycle (ETC)
1999/96 B2	2008	Euro 5	1.5	0.46	-	-	2	0.02	-	g/kWh	New cycle (ESC)
1999/96 B2	2008	Euro 5	4	-	0.55	1.1	2	0.03	-	g/kWh	New cycle (ETC)
1999/96 B1	2005	Euro 4	1.5	0.46	-	-	3.5	0.02	-	g/kWh	New cycle (ESC)
1999/96 B1	2005	Euro 4	4	-	0.55	1.1	3.5	0.03	-	g/kWh	New cycle (ETC)
1999/96 A	2000	Euro 3	2.1	0.66	-	-	5	0.1	0.13	g/kWh	New cycle (ESC)
1999/96 A	2000	Euro 3	5.45	-	0.78	1.6	5	0.16	0.21	g/kWh	New cycle (ETC)
91/542 B	1996	Euro 2	4	1.1	-	-	7	0.15	0.25	g/kWh	13 mode cycle (and refer directive 96/1)
91/542 A	1991	Euro 1	4.5	1.1	-	-	8	0.36	0.61	g/kWh	13 mode cycle
88/77	1988	Euro 0	11.2	2.4	-	-	14.4	-	-	g/kWh	13 mode cycle
Reg 49	1980		14.2	2.5	-	-	18	-	-	g/kWh	13 mode cycle

Source: International Fuel Quality Center (IFQC), from the European Commission 2002.

Table 3.4: EU Light Commercial Vehicle Limits (type approval), 1991 -. All limits in g/km.

Gasoline light commercial vehicles							
Directive	Year	Euro ?	CO	HC	NOx	HC+NOx	Note
98/69 class I	2005	Euro 4	1	0.1	0.08		
98/69 class II		Euro 4	1.81	0.13	0.1		
98/69 class III		Euro 4	2.27	0.16	0.11		
98/69 class I	2000	Euro 3	2.3	0.2	0.15		
98/69 class II		Euro 3	4.17	0.25	0.18		
98/69 class III		Euro 3	5.22	0.29	0.21		
96/69 class I	1997	Euro 2	2.2			0.5	
96/69 class II	1997	Euro 2	4			0.6	
96/69 class III	1997	Euro 2	5			0.7	
93/59 class I	1991	Euro 1	2.72			0.97	
93/59 class II	1991	Euro 1	5.17			1.4	
93/59 class III	1991	Euro 1	6.9			1.7	
Class	Vehicle reference mass						
I	< 1250 kg						
II	1250 - 1700 kg						
II	> 1700 kg						

Source: International Fuel Quality Center (IFQC), from the European Commission 2002.

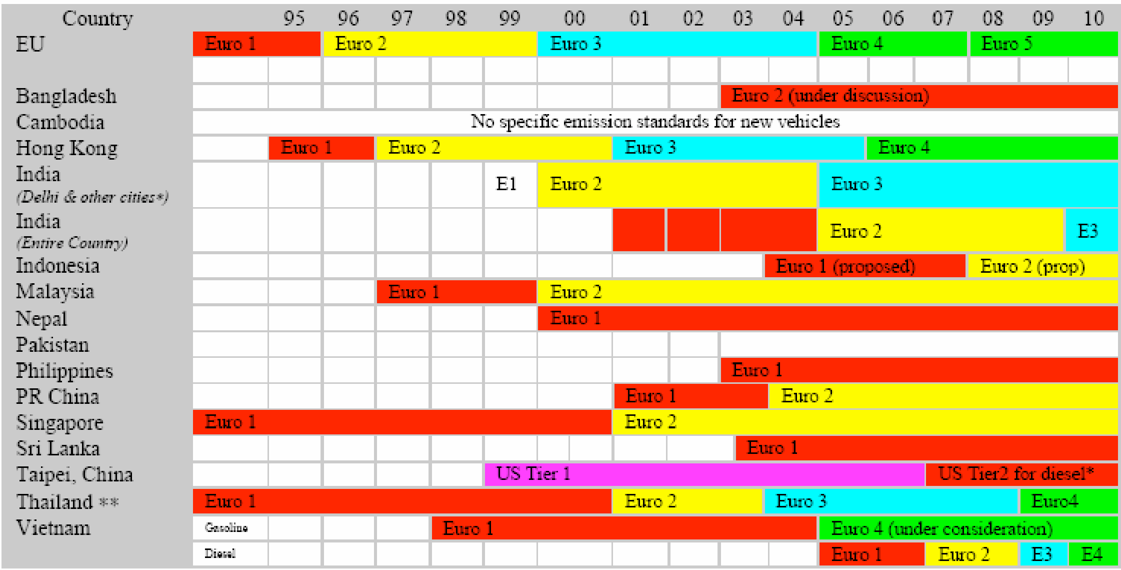
Table 3.5: EU Light Commercial Vehicle Limits (type approval), 1991 -. All limits in g/km

Diesel light commercial vehicles								
Directive	Year	Euro ?	CO	HC	NOx	HC+NOx	PM	Units
98/69 class I	2005	Euro 4	0.5		0.25	0.3	0.025	g/km
98/69 class II		Euro 4	0.63		0.33	0.39	0.04	g/km
98/69 class III		Euro 4	0.74		0.39	0.46	0.06	g/km
98/69 class I	2000	Euro 3	0.64		0.5	0.56	0.05	g/km
98/69 class II		Euro 3	0.8		0.65	0.72	0.07	g/km
98/69 class III		Euro 3	0.95		0.78	0.86	0.1	g/km
96/69 class I - IDI	1997	Euro 2	1			0.7	0.08	g/km
96/69 class I - DI	1997	Euro 2	1			0.9	0.1	g/km
96/69 class II - IDI	1997	Euro 2	1.25			1	0.12	g/km
96/69 class II - DI	1997	Euro 2	1.25			1.3	0.14	g/km
96/69 class III - IDI	1997	Euro 2	1.5			1.2	0.17	g/km
96/69 class III - DI	1997	Euro 2	1.5			1.6	0.2	g/km
93/59 class I	1991	Euro 1	2.72			0.97	0.14	g/km
93/59 class II	1991	Euro 1	5.17			1.4	0.19	g/km
93/59 class III	1991	Euro 1	6.9			1.7	0.25	g/km

Source: International Fuel Quality Center (IFQC), from the European Commission 2002.

As can be seen below in Figure 3, Asian countries are at various stages of applying the Euro standards. Although Japan's emission standards are of course among the most stringent in the world, Hong Kong also complies with Euro 3 emission standards, while most other Asian countries have adopted Euro I or 2, or U.S. Tier 0 standards. There are a few countries in the region such as Cambodia and Indonesia that have not set emission standards at all, although both countries are in the process of discussing the adoption of such standards.

Figure 3: Asia Pacific in Use Emission Standards for New Light-Duty Vehicles



Source: Asian Development Bank (ADB), 2003.

Note: * Gasoline vehicles under consideration. Euro 2 introduced in Mumbai, Kolkata and Chennai in 2001. Euro 2 in Bangalore, Hyderabad, Khampur, Pune and Ahmedabad in 2003, Euro 3 to be introduced in Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad and Ahmedabad in 2005. ** Heavy duty diesel standards: up to 1999: Euro 1, 2000 – 2005 Euro 2, 2006 onwards Euro 3

It is expected that during the next ten years there will be an annual GDP growth of 6%-7% in Vietnam, along with significant investments in infrastructure such as roads and bridges. Also expected is an annual vehicle growth rate of around 6%. This includes an increasing number of new vehicles, however at a lower growth rate than at present due to the importation of secondhand vehicles. As vehicle use increases so will emissions from transport.

Environmental Protection and Health

Protection of human health and the environment is the target for setting gasoline and diesel fuel quality standards. As the ownership of private vehicles and motorbikes increases in Vietnam the impact of their use on air quality and human health is also increasing. Therefore, the most effective way to reduce air pollution from vehicles is to implement vehicle emissions and fuel quality standards as the fuel and vehicle work together as a system. This is called the "systems approach" and aims to meet air quality goals. This approach has been successfully implemented in countries across the world including the USA, Europe and Asia.

It is well known that mobile source emissions are a significant cause of air pollution. Scientific research shows that vehicle emissions contribute to serious health and environmental effects. Besides lead pollution, emissions from gasoline powered vehicles include inorganic pollutants such as CO, CO2, NOx, O3, SO2 and carbon particulates, and other organic pollutants like benzene, aldehydes and PAH-based (polyaromatic hydrocarbon) substances, which do not disintegrate easily and are probable carcinogens. In addition, heavy metals like Cd and Mn can also exist in emissions. Some of these compounds, such as benzene and metals, are mixed in gasoline and emitted to the air, while others such as dust, PAH and aldehyde are formed in the incomplete burning process of gasoline. These pollutants can cause several diseases, including respiratory system disease (from dust, PM10, CO); nerve disorders; cancer (from benzene, PAH, Cd) and blood disease (from Pb). Their impacts on the environment are considerable, and include contributions to the greenhouse effect, acid rain (SO2, NOx), and dust pollution (TSP).

Such pollutant emissions are associated with gasoline or diesel composition, as well as the mechanism for (or level of) the fuel's complete burning in an engine. The contribution of emissions from different vehicle types in Hanoi are given in table 3 below:

Table 3: Air Pollution by Vehicle Type in Hanoi

Air Pollution Contribution by Vehicle Type, Hanoi

Pollutant	Motorcycle	Gasoline vehicle	Diesel vehicle
CO	54.5%	45.2%	0.3%
HC	54.1%	44.9%	1%
Pb	54.5%	45.5%	
Dust	43%	35.3%	22%

Source: Hanoi DOSTE.

The introduction of cleaner fuels has an immediate impact on both new and existing vehicles in the market place. For example, new cars with tighter emission standards can take some ten to 15 years or even longer before they are able to penetrate the market in sufficient numbers to be fully effective, whereas lowering lead levels in gasoline reduces lead emissions from all vehicles immediately. However, not all fuel quality changes have the same dramatic effect in lowering the emissions of older vehicles. The introduction of vehicles with more advanced emission control technologies has by far the greatest effect on lowering emissions. Lowering sulfur levels enables these technologies to function properly and to obtain necessary emission reductions.

In Asia, some countries, such as India and Hong Kong have already issued medium-term policies outlining fuel quality targets and emission reductions to be achieved by 2013. Others are in the process of setting fuel quality or emissions reduction goals such as Malaysia and Thailand. Today, fuels used in Vietnam are imported from China, Thailand, Singapore, so standards for fuels are mostly adapted to fuel quality in these countries with a view to harmonising Vietnamese standards with the region. However, Vietnam is also in a position of strength as we can ask for the quality of fuel we want to import and by producing cleaner fuel post 2008 we can also export.

Let us not forget that the principal driver for change to fuel quality standards is environment and health, that is the need to provide fuels that facilitate the adoption of emerging vehicle engine and emission control technologies to reach more stringent emission standards and meet air quality requirements. Such standards need to be consistent with engine development practices and provide reliable and long-life compliance. Typical fuel quality parameters for gasoline and diesel can be seen below in Table 4 showing EU, California and WWFC fuel quality legislation.

Table 4: The Main Gasoline and Diesel Fuel Properties Affecting Emissions

Diesel	EU			USA			WWFC	
	EN: 228 1993/97 "Euro 2"	Dir. 98/70/EC 2000 "Euro 3"	Dir. 2003/17/EC 2005 "Euro 4" (*)	Conventional 2004	Phase 2 RFG 2000/ 2004	CARB Phase 3 2005	Category 3 1998	Category 4 2002
Aromatics, vol%. max.	-	42	35	-	-	35	35	35
Olefins, vol%. max.	-	21 / 18	18	-	-	10	10	10
Benzene, vol%. max.	5.0	1.0	1.0	-	1.0	1.1	1.0	1.0
Oxygen, wt. %, max.	-	2.7	2.7		1.5 – 3.5 / 2.1 average	1.8 – 3.5	2.7	2.7
Sulfur, ppm, max.	2000/50 0	150	5 / 10	300 / 80	300 / 80	30	30	5 - 10
RVP@37.8°C, kPa, min-max (**)	35 - 100	60 / 70	60 / 70	44 - 75	44 - 69	44 - 50	45 - 105	45 - 105
Lead, g/l, max.	0.013	0.005	0.005	0.013	0.013	0.013	Not detectable	Not detectable

Diesel	EU			USA			WWFC	
	EN:590 1993/97 "Euro 2"	Dir. 98/70/EC 2000 "Euro 3"	Dir. 2003/17/EC 2005 "Euro 4" (*)	Automotive Diesel No2 1993	Automotive Diesel No2 2006	CARB 1993 / 2006	Category 3 1998	Category 4 2002
Total aromatics, vol%. max.	-	-	-	35	35	10 - 20	15	15
Polyaromatics, wt% max.	N/A	11	11	-	-	-	2	2
Sulfur, ppm max.	2000/500	350	50 / 10	500	15 (on road)	500 / 15 (LA)	30	5 - 10
Cetane number min.	49	51	51	40	40	-	55	55
Density @ 15°C, kg/m3, min-max.	820 - 860	845 max	845 max	-	-	-	820 - 840	820 - 840
Distillation, T95, °C, max.	360	360	360	-	-		340	340

****Review clause***: By end 2005 the European Commission will carry out a comprehensive review of the other non-sulfur parameters and alternative fuels and see if new specifications are necessary, the outcome of the various commitments with the auto-manufacturers to reduce fuel consumption and CO2 emissions of new passenger cars, the effect of metallic additives on new pollution abatement technologies, and the final date of on-road and non-road diesel 10ppm introduction.
2005 introduction of 10ppm sulphur – Fuel must be geographically available in an appropriately balanced manner

** depends on ambient temperature & season

Source: IFQC, 2005

III. Fuel Quality Developments in Vietnam

The secretariat of the Vietnamese standards body TCVN/TC28 "petroleum and petroleum products" has sent two diesel and gasoline draft standards for comment to all relevant stakeholders both private and public, and to external experts and organizations. It is hoped that the finalised standards will be published by mid 2005. Vietnam is looking to implement fuel quality changes in a similar time frame as countries in the region.

In addition, based on these discussions, and the planned launch of the two new Petro Vietnam refineries, the VSC would like to propose fuel quality specifications for gasoline (Annex I) and diesel (Annex II) for the next 5 year period. This will allow traders and Petro Vietnam to plan for the changes and make the proper investments or supply decisions. Confirmation of these standards and the exact date should be made after stakeholder workshops and internal government discussions in the near future.

Complementary to these fuel quality standards, and in respect of the "systems approach" the Vietnamese government 2004 plan on standardization includes the application of Euro regulations on vehicle emissions and stricter air quality targets. A road map for the adoption of Euro 2-4 is also in the process of being discussed.

Vietnam - Gasoline Fuel Quality Issues

In Vietnam 75% of passenger vehicles and all motorcycles use gasoline. There is a high fleet growth rate especially in the case of gasoline driven passenger cars and two and four stroke vehicles (cars: 7% , motorcycles: 15%). Today the following motorcycle types dominate the market: 9% Two-stroke; 91% Four-stroke.

Vietnam imports almost all its gasoline, and switched to unleaded gasoline on July 1st, 2000. Prior to the switch, the country consumed only two grades of gasoline, RON 83 and RON 92 and its quality was subject to TCVN 5690 (1998). Imports of unleaded gasoline now include RON 90, 92, and 95; the majority is RON 90 and 92, however imports of RON 83 will be maintained for the coming two to three years. The quality of imported unleaded gasoline is subject to: TCVN 6776:2000 where important criteria include (i) sulfur content of less than 0.15% weight, (ii) benzene content of less than 5% volume, and (iii) Pb content of less than 0.013 g/l. In addition, Petrolimex, the country's biggest importer of gasoline, ensures that the actual aromatics content is lower than 45% volume.

Vietnam - Diesel Fuel Quality Issues

In comparison with gasoline passenger car growth rates, only 25% of passenger vehicles are diesel driven. However, as diesel fuel sulfur content is rather high in Vietnam, the SO2 emitted by diesel burning engines can be also considerable. Pollutants caused by diesel vehicles are quite complicated and vary by type of oil, and include CO, CO2, hydrocarbons (benzene, toluene, alkybenzene, xylene, PAH, aldehyde), NOx, and sulfate.

Imported diesel oil is subject to TCVN 5689 2002, which specifies that the sulfur content in the 3 types of diesel fuel sold in Vietnam are equal or lower than 0.5% and to 0.25% weight respectively. While some companies continue to import diesel with a sulfur content of up to 1%, since 2001, Petrolimex has only imported diesel fuel with sulfur content equal or less than 0.5%.

Gasoline and Diesel Import Activities

Today, Vietnam has no large-scale oil refineries and has produced only a small amount of unleaded gasoline RON 83 therefore almost all gasoline and diesel consumed at present must be imported. Major sources of petroleum imports are Singapore, PRC and Kuwait, and importation continues to be conducted by state-owned enterprises.

However, as of 2008 Vietnam will have the capacity to produce low and ultra low sulfur fuels as PetroVietnam brings on line their first refinery in Don Quat (Central Vietnam). By 2013 their second refinery will be completed in the North of Vietnam at Nghi Son. Both refineries are aiming to produce low (Don Quat) and ultra low (Ngi Son) sulfur fuels. Taking this into consideration it is recommended that Vietnam set a schedule for the implementation of lower sulfur fuels to promote production for domestic use and export to the Japanese market currently the largest importer of Vietnamese oil. Japan is a net importer of clean fuels at present.

I.V. Main Gasoline Specification Changes:

Best Practice

Octane number RON and MON

Vehicles are designed and calibrated for a certain octane value. There are two methods for determining octane number: Research Octane Number (RON) and Motor Octane Number (MON). Octane number is measure of gasoline's ability to resist auto-ignition. Theoretically the higher octane number the better, but it must be met with the performance of each type of engine. MON is related to high-temperature knock conditions. RON is related to mild-knock conditions at low speed. RON values are typically higher than MON and the difference between these values is the sensitivity, which is usually controlled in the range 10-12, again for good anti-knock reasons. To extract high performance and low fuel consumption, it is necessary to use high compression ratios and high engine revolutions, these are factors that increase the need for high MON. An inadequate MON will lead to destructive knock at high engine speeds. All existing engines are currently calibrated on MON. The importance of MON for car makers is to protect engines against high-speed knock and breakage. Any drop in MON, even slight, will put the integrity of engines at risk under extreme operating conditions.

Based on compiled data and and surveys reported on at the August 2004 Workshop organised by STAMEQ. The new draft TCVN unleaded gasoline standard requires 3 levels of RON and MON:

- RON 90/92/95 and
- MON 80/82/85

For reference purposes, refer to Table 5 below:

Table 5 - Octane number of gasoline in legislation or under an industry standard in other Asian countries

	RON	MON	(RON + MON)/2
China	90/93/95	-	85/88/90
India	88/93/91/95	81/85 (for 91/95 RON)	84/88
Malaysia	92/97	-	-
Philipines	81/87/93/95	reported	-
Singapore	92/98	-	-
Thailand	91/95	80/84	-
Indonesia	88/94/95/98	-	-
Taiwan	92/95/98	-	-
Japan	89/96	-	-
Hong Kong	95	85	-

Source: IFQC – Status of leaded gasoline phase out & octane requirements Worldwide, May 2004 and Fuel Quality Specification Booklet, January 2005

Lead in Gasoline

Lead is a good octane component but it is one of the most important environmental fuel quality parameters due to its impact on health and the environment. There are also a variety of growing automotive issues with leaded fuel such as high combustion chamber deposits, spark plug fouling, etc.

Taking into account the health and environmental effects linked to lead and the fact that Vietnam has banned leaded gasoline, it is proposed to further reduce lead levels to 0.005 in a second and third lead reduction phase in 2008 and 2013 respectively. Refer to Annex I and II.

Aromatics and Benzene

Aromatics can be found in both gasoline and diesel. In general aromatics are a good octane component for gasoline however they can be a source of benzene, NOx and particulate emissions. Also, heavier aromatics have been linked to engine deposit formation, particularly combustion chamber deposits. In general, reducing aromatics and T90 can enable reductions in exhaust mass NMHC and CO emissions to be achieved. The fuel aromatic content affects combustion and the formation of particulate and PAH emissions. Of particular concern among the general family of compounds we describe as "aromatics" is benzene, which is a known human carcinogen. Numerous studies have shown that the benzene and aromatics strongly influence exhaust benzene emissions. Control of benzene concentration is recognized to be the most direct and cost-effective way to limit benzene emissions. Benzene limits in China India, Malaysia, The Philippines, Thailand, Japan are as follows:

Table 6: Current Benzene levels in Asia

	China	India	Malaysia	Philippines	Thailand	Japan
Benzene, % v/v, max	2,5 (10/2004)	1-3,0 (cities and metros) 5.0 (2005) (countrywide (2000)	5 (1993)	2 (2003)	3,5 (2004)	1 (2005)

Source: IFQC, fuel specification booklet 2005

Taking into account the health and environmental effects linked to aromatics and benzene, the new draft TCVN unleaded gasoline standard reduces benzene from 5%v/v to 2.5%v/v max in 2005. A second and third gasoline aromatics and benzene reduction phase is also recommended in 2008 and 2013 respectively. Refer to Annex I and II.

Olefins

Olefins in gasoline are good octane components however, they are found to be sources of evaporative emissions and also can cause gum formation and engine deposit. The US EPA has declared that "NOX emissions were lowered by reducing olefins, raised when T90 was reduced."

Taking into account the engine deposit issues and health and environmental effects linked to olefins, the new draft TCVN unleaded gasoline standard defined olefins of 38%v/v max in 2005, which is the same level as China. A second gasoline olefins reduction phase is also recommended in 2008 and 2013. Refer to Annex I and II.

Oxygen Content

The oxygen parameter refers to the oxygen content allowed in fuel. This oxygen comes from fuel compounds called oxygenates. Oxygenates are used as octane boosters and volume extenders and include MTBE, ethanol, methanol, ETBE, TBA, Iso propyl alcohol, Iso butyl alcohol to name but a few. They replace high-octane aromatic hydrocarbons and lead. The most well known oxygenates used today are MTBE, ethanol, ETBE (in Europe), Iso-octane/iso-octene and TBA. Adding oxygen carrying components to gasoline reduces the resultant fuel calorific value. For engines with non-sophisticated fuel metering systems, the mixture becomes leaner ensuring a more complete combustion and emissions reduction, whereas for engines with adaptive learning engine management systems, these will compensate thereby counter acting (neutralising) any effects of fuel composition.

Taking into account standard EU and US oxygen content levels and the high octane and good combustion properties of oxygenates, the new draft TCVN unleaded gasoline standard set a 2.7%wt max oxygen level in 2005.

Volatility: Distillation and Reid Vapour Pressure (RVP)

Distillation (or boiling range) is a reference to the volatility of the fuel. The distillation or boiling range of the fuel is a consequence of the chemical composition of the fuel meeting other fuel property requirements such as vapour pressure, viscosity, flash point, and density. Vehicle refuelling emissions are also strongly affected by fuel volatility.

Gasoline volatility indicates the ability of a fuel to vaporize either directly (through the measurement of vapour pressure at a particular temperature) or indirectly (through correlation with the distillation characteristics of the fuel). These distillation properties, along with the fuel's measured vapour pressure, are critical parameters in ensuring smooth engine starting, efficient fuel combustion and evaporative emission controls. In addition, the combination of correct vapour pressure and distillation characteristics is essential to prevent hot fuel handling problems such as vapour lock and carbon canister overload.

Reid Vapour Pressure (RVP) is identified as one of the most important parameters for evaporative emission (VOC) reductions contributing to low level ozone formation. RVP is directly impacted by the use of alcohols and thus an important parameter to look at when setting ethanol limits. RVP can be relaxed in cold climates as is the case under the EU Directive where arctic regions are allowed a higher RVP of 70 kPa, but not in warm regions where greater evaporative emissions occur in warm climates. In addition, as many Asian countries are considering the use of ethanol as an octane booster, it is important to note that ethanol is highly volatile when blended at lower levels to 10%.

Taking into account the volatility issues and thus VOC emissions linked to high RVP especially in warm climates such as Vietnam, it is hoped that the future roadmap will bring down maximum RVP allowances to a 60kPa summer and 70kPa winter maximum as in Europe and other Asian countries such as Hong Kong, Malaysia, Bangladesh, Indonesia, Philippines, Thailand and Taiwan. At present, the new draft TCVN unleaded gasoline standard sets RVP levels between 43-75kPa max as of 2005.

Sulfur Content

Sulfur naturally occurs in crude oil. Fuel sulfur affects the performance and durability of many exhaust treatment and on-board diagnostic systems on gasoline and diesel vehicles alike. For traditional vehicle technologies sulfur is one of the most important parameters for emission reductions especially for SO2, PM and NOx. Reducing fuel sulfur also cuts hydrocarbons and carbon monoxide from all vehicles. Emissions of ultra fine particles especially benzene, which are the focus of health concerns, are particularly sensitive to fuel sulfur content. Based on the US Auto/Oil study, it appears that NOx could go down about 3% per 100 ppm sulfur reduction. For future gasoline cars, EU Auto Oil II results show that sulfur free fuel will help ensure that significant reductions in CO2 emissions can be made without exceeding 2005 Euro 4 NOx emissions limits.

See the data collected in Table 7 below:

Table 7: Sulfur Effect on Emissions (According to World-wide Fuel charter 2002)

Study	Vehicle	Sulfur, ppm		Emissions reduction, % (From high to lows)		
		high	low	HC	CO	NOX
Air Quality 1989-1992 (AQIRP)	Tier 0	450	50	18	19	8
European Program on Emissions 1993-1995 (EPEFE)	Euro 2+	382	18	9(43*)	9(52*)	10(20*)
US Manufacturers Association 1998 (AAMA/AIAM)	Vehicle with low and super low emission (LEV & ULTRA LEV	600	30	32	55	48
Coordinating Research council (CRC)	Vehicle with low emissions (LEV)	630	30	32	46	61
Japan Auto Research Institute (JARI)	1978 regulations	197	21	55	51	77

* Reduction achieved during hot extra urban portion of test

Taking into account the health and environmental effects linked to sulfur, the new draft TCVN unleaded gasoline standard starts to reduce sulfur from 1,500ppm to 500 ppm max. It is recognised however that such a reduction does not achieve true health and environmental benefits until further reductions are implemented to lower and ultra low sulfur levels e.g. 150ppm, 50ppm and 10ppm respectively. Therefore, a second and third gasoline sulfur reduction phase is also recommended in 2008 and 2012 to come in line with the penetration of Euro 3 and Euro 4 vehicles. Refer to Annex I and II

Gasoline colour

This is one of the new requirements for gasoline in the reviewing draft. This requirement is based on decision of the trade ministry No 1273/2004 QDD. BTM which comes to in force 7 September 2004.

V. Main Automotive Diesel Specification Changes:

Best practice

The Draft TCVN Diesel standard replaces TCVN 5689:2002 setting fuel quality specifications for automotive diesel fuel, non-road diesel, and heating oil. The new draft is based on the Euro 2 standards EN590: 1993 for diesel. The main changes in comparison to TCVN 5689:2002 are detailed in table 10:

In looking at diesel fuel properties it is important to distinguish between diesel fuel used for automotive fuel purposes and diesel fuel used as non road fuel e.g. tractors, locomotives, construction equipment, boats; and as heating oil. In addition, it is important to note that marine fuel oil is also becoming regulated. In Europe and the United States, these fuel are becoming increasingly regulated separately from automotive diesel fuel. Specifications are therefore typically given for four categories of diesel fuel:

- On road automotive diesel,
- Non road or off road diesel
- Heating oil
- Marine/bunker fuel

In all four categories, efforts are being made to clean up the most polluting parameters and meet new engine requirements particularly with regard to sulfur. In fact in both the US and EU non road fuels are becoming aligned with non road fuels.

Vietnam currently has three grades of diesel including non-road diesel. In adopting its new TCVN standards, Vietnam has looked at other current diesel fuel quality developments in the region. For example in China, Thailand and Singapore as can be seen under table 8 below:

Table 8: Reference data on quality properties of Automotive Diesel Oil from other countries

Property	China to 2004/2005	Thailand (2004)	Taiwan (2002)	WWFC (class 2)
1. sulfur content, ppm, max	2000/500	350	350	300
2. Cetane number, max	45/49	47	-	53
3. Cetane index, max	–/46	47	48	50
4. Distillation at 90% v/v, °C, max	355	357	338	340
5. Flash point °C,, min	45-55	52	52	55
6. Viscosity at 40°C, cSt	2.5-8.0	1.8-4.1	1.9-4.1	2.0-4.0
7. Carbon residue 10%,m/m , max	0.3	0.05	0.1	0.3
8. Pour point, °C, max	–	10	-3	–
9. Ash content, % KL, max	0.01	0.01	0.01	0.01
10. Water and sediment, % v/v, max	–	0.05	0.05	0.02
11. Copper corrosion	–	–	–	1
12. Density at 15 °C, kg/m^3	Reported/810-850 (Beijing)	810-870	reported	820-850

Cetane Index and Cetane Number

Cetane number is a measure of the compression ignition behaviour of a fuel and auto-ignition quality; it influences cold startability, emissions and combustion noise. Cetane index is a cetane "natural" of the fuel, it can be calculated based on measured fuel properties. It can affect many different aspects of emissions. A higher number generally implies a better environmental performance. Incomplete combustion leads to white smoke emissions, especially for start-up. Dependent on the vehicle technology and the emission regulation, the world auto manufactures recommend cetane levels of around 45-50. For the Asian region the lowest cetane number is about 45, this is also the limit introduced in Vietnam's draft of Diesel Oil standard, although increasing the cetane number in future fuel quality standards is recommended so as to align the diesel fuel quality with Euro 3-4 engine needs.

Table 9: Global Diesel Cetane Numbers

2002	Cetane Number		Cetane Number
USA	40		
Canada	40	Egypt	55
Mexico	48	China	45
EU	51	India	48
S. Korea	45	Japan	50
Australia	46	WWFC	45/50/52/52

Source: International Fuel Quality Center (IFQC), 2003.

Taking into account the emissions impact linked to cetane number and index, the new draft TCVN automotive diesel oil standard increases the cetane index to 46 min. A second and third diesel oil phase is also recommended in 2008 and 2013 respectively based on the penetration of Euro 3 and Euro 4 vehicles. Refer to Annex I and II.

Sulfur content

Sulfur naturally occurs in crude oil. If the sulfur is not removed during the refining process it will contaminate vehicle fuel. It has been found that sulfur can have a significant effect on engine life. Diesel fuel sulfur also contributes significantly to fine particulate matter (PM) emissions, through the formation of sulphates both in the exhaust stream and, later in the atmosphere. Sulfur can lead to corrosion and wear in engine systems. Furthermore the efficiency of some exhaust after-treatment systems is reduced as fuel sulfur content is increased in the exhaust. In addition to its role as a technology enabler, low sulfur diesel fuel gives benefits in the form of reduced sulfur induced corrosion and slower acidification of engine lubricating oil, leading to longer maintenance intervals and lower maintenance costs. These benefits would apply to new vehicles and to the existing heavy-duty vehicle fleet beginning in 2006 when the fuel will be introduced. These benefits can offer significant cost savings to the vehicle owner without the need for purchasing any new technologies.

The current diesel oil standard defines 3 grades of diesel oil based on sulfur content. In this new draft TCVN automotive diesel oil standard only 2 grades are defined: DO 500 ppm mandatory use for vehicles to meet Euro 2 engine emission requirements and DO 2500 ppm , as follows in Table 8 below.

Taking into account the health and environmental effects linked to sulfur and the introduction of Euro 2 vehicle emission standards, the new draft TCVN diesel standard starts to reduce sulfur from 5,000ppm and 2,500ppm to 500 ppm max. It is recognised however that such a reduction does not achieve true health and environmental benefits until further reductions are implemented to lower and ultra low sulfur levels e.g. 50ppm and 10ppm respectively. Therefore, a second and third diesel sulfur reduction phase is also recommended in 2008 and 2012 to come in line with the penetration of Euro 3 and Euro 4 vehicles and PetroVietnam's production capabilities of 50ppm fuels. Refer to Annex I and II.

VI. Conclusions

Vietnam is concerned about its air quality and the impact of automotive emissions on poor air quality in its urban centers. As Vietnam is expected to continue its rapid economic growth over the coming years, the impact of road transport on air pollution is only expected to increase.

In this regard, Vietnam is following international experiences in the area of air quality, fuel quality and automotive emissions and is planning to tighten its fuel quality standards for automotive gasoline and diesel in 2005, with further tightening being discussed post 2008.

The proposed 2005 standards for gasoline and diesel (Tables 7 and 8 below) are the result of a major stakeholder process and several stakeholder meetings bringing together oil refiners such as Petro Vietnam, fuel traders, representatives of the standards body VN, and external international experts. We are therefore thankful to TAF, USAEP, VN and all of the stakeholders who actively participated in the drafting process of the standards.

Table 10: Draft TCVN 6776 : 2005 Gasoline Standard

Properties	Current standard unleaded gasoline TCVN 6776			Draft TCVN 6776 : 2005		
1. Octan number						
- RON, min	90	92	95	90	92	95
- MON, min.	-	-	-	***80***	***82***	***85***
2. lead, g/l, max	0,013			0,013		
3. Distillation :						
-Initial boiling point, °C, min	Reported			Reported		
-10% v/v, °C, max	70			70		
- 50% v/v, °C, max	120			120		
- 90% v/v, °C, max	190			190		
-Finish boiling point, °C, max	215			215		
- residuce, % v/v, max	2,0			2,0		
4. Copper corrosion, 50°C/3h,max	1			1		
5. existent gum, mg/100 ml, max	5			5		
6. Oxydation, min., min	240			480		
7. Sulfur, mg/kg, max	1500			***500***		
8. Vapour pressure, 37,8°C, kPa	43-80			43-75		
9. Benzene, % v/v, max	5			***2,5***		
10. Density, (at 15°C), kg/m³	Reported			reported		
11. Apperanee	Clear, no suspended matter			Clear, no suspended matter		
12. Aromatics, % v/v, max	40			40		
13. Olefins, % v/v , max	–			38		
14. Metal content (Fe, Mn, other)				Nondetectable*		
15. Oxygen, % KL, max	–			***2,7***		
16. Colour				Red	Green	No dye

As highlighted in table 7, the main changes to the gasoline fuel quality parameters are:

- The introduction of MON 80/82/85,
- Maintenance of lead at max 0,013 mg/kg, this limit may be reduced to 0,005 mg/kg in 2008
- Reduction of sulfur from 1,500 to 500ppm due to high sulfur impacts on health, environment and Euro 2/3 engine technologies
- Reduction in benzene from 5 to 2.5 % v/v, max as benzene is a class I carcinogen and very harmful to human health and the environment
- RVP has been slightly reduced from 80Kpa to 75kPa at the top end but this may need to be re-addressed in 2008 or later due to the increase in volatile emissions related to greater than 60kPa in warm climates
- Olefins have been set at 38% v/v

Table 11: Current and draft of standard TCVN 5689 Diesel Oil (DO)

Properties	TCVN 5689 : 2002			Draft TCVN 5689:2005
	DO 0,05 %	DO 0,25 %	DO 0,5 % S	
1. Cetane index, min	45	45	45	46
2. Sulfur, mg/kg, max	500	2500	5000	**500**
3. Distillation, °C, 90% v/v, max	370	370	370	360
4. Flash point, °C, min	50	50	50	55
5. Viscosity, 40°C, cSt (mm²/s)	1,6-5,5	1,6-5,5	1,6-5,5	**2-4,5**
6. Carbon residue, 10% distilled volume,% m/m, max	0,3	0,3	0,3	0,3
7. Pour point, °C, max	+ 9	+ 9	+ 9	+6
8. Ash, % m/m, max	0,01	0,01	0,01	0,01
9. water, % v/v, max	0,05	0,05	0,05	0,02
10. particulates, mg/l, max				**10**
11. Copper corrosion, 50°C, 3 h, max	1	1	1	1
12. Density, 15 °C, kg/m³	report	report	report	820-860
13. Lubricity, µm, max				**460**
14. Appearance				**Clear, bright**

As highlighted in table 8, the main changes to the automotive diesel fuel quality parameters are:

- Reduction of sulfur from 5,000 and 2,500 to 500ppm due to high sulfur impacts on health, environment and Euro 2 engine technologies penetrating the Vietnamese market

- Increase in the Cetane index from 45 to 46
- Reduction in the Distillation, ^{O}C, 90% v/v, max from 370 to 360
- Increase in flash point ^{O}C, min from 50 to 55
- Increase in Viscosity, 40^{O}C, cSt (mm^2/s) from 1,6-5,5 to 2-4,5
- Reduction in Pour point, ^{o}C, max from +9 to +6
- Reduction in water % v/v, max content from 0,05 to 0,02
- Insertion of fixed Density, 15 ^{o}C, kg/m^3 of 820-860
- Insertion of new parameters for particulates, mg/l, max value of 10, Lubricity, μm, max of 460, and appearance "clear, bright"

Vietnam has chosen to adopt the above fuel quality specifications for gasoline and diesel which are similar to Euro 2 "type" (the gasoline specifications are not exactly the same as Euro 2 fuels and in some cases do go towards Euro 3 fuels e.g. benzene, aromatics) fuels EN 228 and 590 – 1993, so as to match developments in the region e.g. china, Thailand, Singapore, Taiwan, and move towards cleaner fuels. Note: Euro 2 type fuels are not qualified as environmental fuels, as the only environmental parameter, which is strengthened is sulfur and the reduction in sulfur to 500ppm is not qualified as enough to have major environmental and health benefits. Therefore, these new standards are being implemented along with new Euro 2 vehicle emission requirements, and are only considered as the first step in a more comprehensive fuel quality and vehicle emissions strategy to be adopted in 2008 and in 2012.

Proposed future fuel quality changes will be laid out in a road-map identifying further changes in 2008 and 2012 (refer to Annex I and II) so as to allow the oil industry, traders and the automotive industry the necessary lead time to prepare themselves. Vietnam believes that it is necessary to further tighten its fuel quality standards, so that all fuel imports into Vietnam will be cleaner, and domestic production to come on line in 2008 matches international and regional clean fuel trends. As seen in this fuel quality overview, Asian countries except for Japan are behind Europe in the introduction of the Euro 3 and 4 type fuels, but most countries, plan to adopt similar standards around the 2010 timeframe. In this regard Vietnam will do the same, in order to reduce the growing impact of air pollution from transport on health and the environment. Vietnam is determined to move away from the consumption of less environmentally friendly fuels and not become Asia's dumping ground for high sulfur fuels still produced in the region. Due to the start up of the two new Petro Vietnam refineries it is recommended that a cost effective approach be undertaken immediately in the planning of low sulfur fuel production and thus Vietnam should leapfrog if possible from 500ppm max fuels to 50ppm fuels in line with Petro Vietnam's clean fuel production plans in 2008. This will incentivize Petro Vietnam and create a market advantage for domestic fuel over imports thus giving Petro Vietnam a swifter payback period for its initial investment in clean fuel production technologies.

In order to ensure stakeholder cooperation and acceptance of Vietnam's future fuel quality and vehicle emissions strategy and road map, the Vietnamese government and standards association VN will organize stakeholder meetings over the coming months. It is recommended that in addition to the fuel quality changes proposed, stakeholders discuss with the Government the necessity of a communications campaign on the new fuels so that the Vietnamese people are aware of the benefits and support the change (refer to Philippines Case Study 3 in Annex III), and the possibility of tax incentives use. The Vietnamese Government should address whether tax incentives may need to be envisaged in the second phase of the project e.g. 2008 in order to facilitate the implementation of these changes. Tax incentives have been successfully used in Europe to differentiate between cleaner fuels and other fuel qualities. This has assisted oil companies in the investment of cleaner fuel technologies and has facilitated the introduction of cleaner fuels on national markets by making the pump price lower for the consumer. This could be a useful tool for Vietnam in order to differentiate between 50ppm quality fuels and higher sulfur fuels and would also help PetroVietnam regain some of its investment in cleaner fuel technologies.

ANNEX I: PROPOSED UNLEADED GASOLINE REQUIREMENTS:

MAIN ENVIRONMENTAL PARAMETERS 2005, 2008 & 2012

	Unleaded Gasoline	Gasoline	
	2005 (July)	2008	2012
	Euro 2	Euro 3/Euro 4	Euro 4
RON, min	91/95/98	91/95/98	91/95/98
MON, min	82/85/88	82/85/88	82/85/88
RVP @37.8° kPA , max	43-75	43-70 (s)	43-70 (s)
Lead g/l, max	0.013	0.005	0.005
Aomatics vol%, max	40	40	35
Benzene vol%, max	2.5	1	1
Olefins vol%, max	35	18	18
Oxygen wt%, max	2.7%	2.7%	2.7%
Sulfur ppm, max	500	150 (50)*	50(10)

*Footnote *: The 2008 Period is seen as a transitory period to 2010. This is predominantly for imported fuel quality not domestically produced fuel. Due to the new technological investments made at the two PetroVietnam refineries around the 2008 period, it is recommended that the refineries directly invest in technology allowing them to produce 50ppm sulfur fuels and leapfrog directly to Euro 4 standards. This makes more economic sense.*

ANNEX II: PROPOSED AUTOMOTIVE DIESEL REQUIREMENTS:

MAIN ENVIRONMENTAL PARAMETERS 2005, 2008 & 2012

Diesel			
	2005 (July)	2008	2012
	Euro 2	Euro 3/4	Euro 4
Cetane #	49	51	51
Cetane Index	46	46	46
Density @ 15° C, kg/m3, min-max	820-860	820-845	820-845
Viscosity @ 37.8° C, csT, min-max	2.0-4.5	2.0-4.5	2.0-4.5
Distillation T90° C, min-max	350	350	350
PAH, wt% max	-	11	11
Sulfur ppm, max	500	350(50)*	50(10)

Footnote *: The 2008 Period is seen as a transitory period to 2010. This is predominantly for imported fuel quality not domestically produced fuel. Due to the new technological investments made at the two PetroVietnam refineries around the 2008 period, it is recommended that the refineries directly invest in technology allowing them to produce 50ppm sulfur fuels and leapfrog directly to Euro 4 standards. This makes more economic sense.

ANNEX III:
ASIAN BEST PRACTICE CASE STUDIES

Case Study 1: Japan - JCAP I and II

Background - The Japan Clean Air Program (JCAP) is a collaborative study undertaken by the automobile and the petroleum industries in Japan - similar to other countries, such as the current Auto Oil Program in the US and CAFÉ in Europe to develop automobile and fuel technologies to improve air quality. The first stage of the program, referred to as JCAP I, was carried out from 1997 to 2001.

Japan implements one of the most stringent automotive emission regulations in the world, further decrease in automotive emissions is required to achieve better air quality and environment. The U.S. and Europe, having similar problems to Japan, are carrying out air quality improvement programs by combining automotive and fuel technologies: the Air Quality Improvement Research in the U.S., and the Auto Oil Program (AOP) in Europe. To develop a similar program, suited to the specific Japanese context, the Petroleum Energy Center, in collaboration with automobile and oil industries in Japan, launched the Japan Clean Air program (JCAP) to estimate the future atmospheric environment and to investigate the most cost-effective combination of measures for the improvement of its air quality based on an analysis of the nation's unique social, industrial, geographical, and meteorological conditions.

Under a subsidy from the Ministry of Economy, Trade and Industry (METI), the Japan Petroleum Energy Center (JPEC) had the lead responsibility for JCAP. Since its inception in 1997, it has had the close cooperation of the Petroleum Association of Japan (PAJ) and the Japan Automobile Manufacturers Association (JAMA). JCAP I was a five-year effort running from 1997 to 2002.

Issue Focus - The objectives of JCAP I were:

(1) To evaluate the potential for improvements or modifications of fuel quality to reduce emissions, and
(2) To clarify the role of more advanced technologies for medium and longer-term emissions reductions.

The principal conclusions from JCAP I were as follows:

The sulfur content in gasoline had a great impact on emissions
The Reid Vapour Pressure of Gasoline had a great impact on evaporative emissions
Diesel fuel sulfur content had a great impact on exhaust emissions, and
Diesel Particulate Filters retrofitted to active use vehicles could not display sufficient capacity under urban driving conditions.

The results of JCAP I research were presented at the 3rd JCAP conference held on February 21-22, 2002 in Tokyo. The first program was able to create mutual understanding between the automobile and petroleum industries, release reliable data to the public, increase the number of technical opinions for making air quality policies, and discuss comprehensively on air quality improvement, energy and economical issues.

The second stage, JCAP II, has further been carried out starting 2002 and is expected to be completed by 2006. The objectives of JCAP II are divided into two studies:

1. Automobile and Fuel Technology Study

- Evaluate high technology for gasoline/diesel vehicles aiming at near zero emissions and fuel properties;
- Evaluate emissions and CO2 reduction potential;
- Examine fine particle measurement methods and evaluate high technology through high measurement methods.

2. Air Quality Model Study

- Build a real-world emission inventory simulation model;
- Build an integrated model of both urban and roadside air quality;
- Evaluate the integrated air quality model and case study.

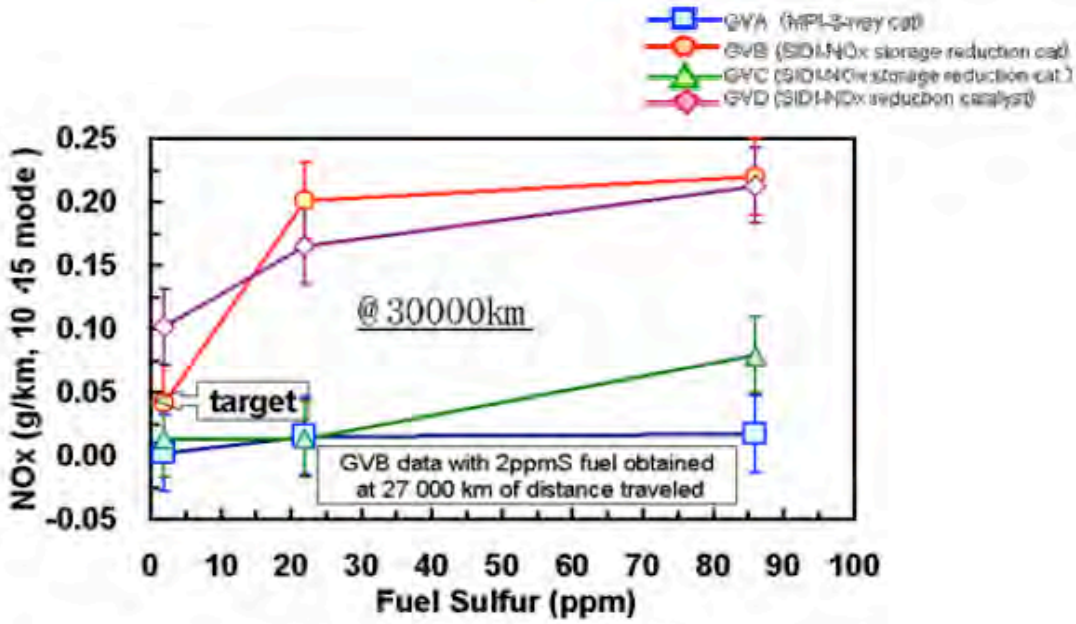
There are seven working groups (WG) under JCAP II, with the Gasoline WG studying the influence of fuel properties such as sulfur and RON on automobile emissions and fuel consumption, and the Diesel WG studying CO2 emission reduction potential with high diesel technologies and ideal fuels. The other WGs include Oil, Unregulated Material, Health Effects, CO2 Emission, and Air Quality Model.

The following is a summary of some of the JCAP II results relating to the effects of sulfur in gasoline and diesel on nitrogen oxide (NOX) emissions and fuel efficiency as well as particulate matter (PM) emissions. These results were recently presented at the 3rd Asian Petroleum Technology Symposium in Kuala Lumpur, Malaysia from March 2-4, 2005.

Effects of gasoline sulfur levels on NOX emissions:

The effects of sulfur on NOx emissions from Spark Ignition Direct Injection (SIDI) vehicles at 30,000 km of distance traveled can be seen in Figure 1 below. At near zero sulfur levels, NOx emissions are clearly lower for GVB, GVC and GVD vehicles than at sulfur levels around 20 ppm or 85 ppm. Similarly, also the World Wide Fuel Charter (WWFC) suggests the importance of very low sulfur levels for advanced technology vehicles; sulfur free gasoline is found necessary by the engine manufacturers to maximize the benefits of lean-burn, fuel efficient technology.

Figure 1. Sulfur Effect on NO_x Emissions



Source: Japan Petroleum Energy Center, March 2005

Effects of gasoline and diesel sulfur levels on fuel economy:

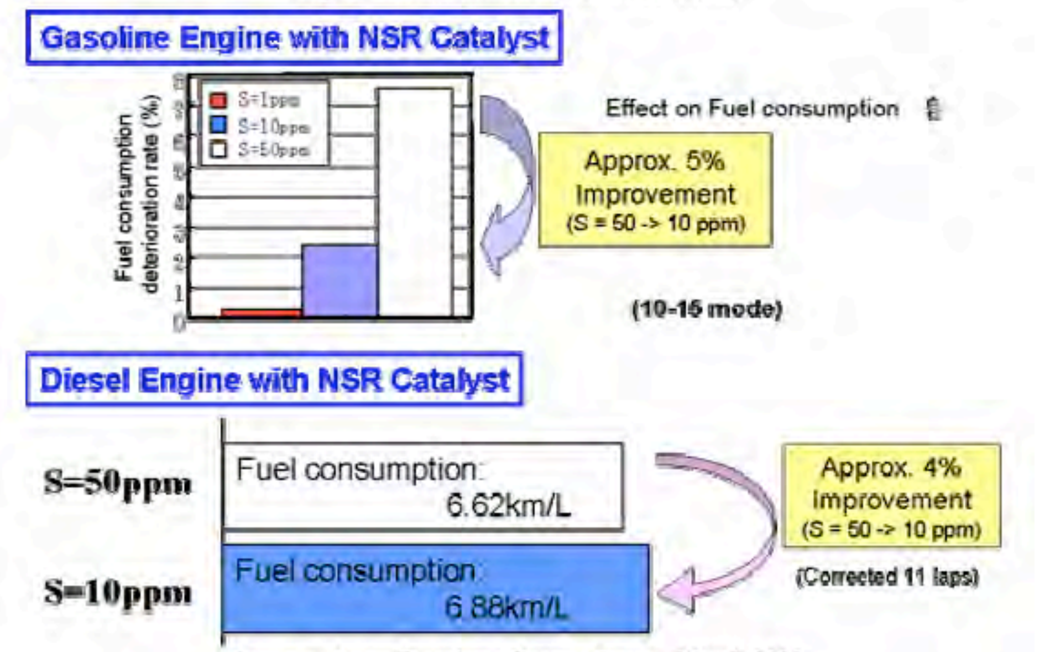
Figure 2 below shows the effects of sulfur on fuel economy in both gasoline and diesel engines fitted with NOx sulfur reduction (NSR) catalysts. The tests show that there is a 5% improvement in fuel consumption when 10 ppm sulfur gasoline is used compared to 50 ppm sulfur gasoline. Using the same scenario for diesel engines, fuel consumption is found to improve from 6.62 km/l to 6.88 km/l or about 4%.

According to the WWFC, it was predicted in the European Auto Oil program that a sulfur reduction from 500 ppm to 30 ppm in trucks will result in PM emission reductions of 7% from light duty diesel vehicles and 4% from heavy duty diesel trucks. A correction factor was later developed to take into account the absolute PM level or the fuel consumption to better reflect the relationship between PM and fuel sulfur levels. Effectively, the correction suggests that the real benefit from sulfur reductions will be even more significant. As a result, the Committee on Motor Vehicle Exhaust Emission, Petroleum Products Quality Sub-committee of Advisory Committee for Natural Resources and Energy and the Evaluation Committee of Diesel Vehicle Emission Control Technologies got together for a meeting and reflected the following air quality improvements in environment and energy policies:

- Mandate of 50 ppm sulfur fuels starting 2005 and 10 ppm sulfur gasoline and diesel from 2008 and 2007 respectively to reduce sulfur emissions
- Self-imposed control of RVP in gasoline due to significant evaporative emissions;
- Preparation of diesel vehicle emission regulations by the Tokyo Metropolitan Government due to inadequate retrofitting of DPF to in-use vehicles under urban driving conditions.

Generally, JCAP II is expected to continue co-operation between the automobile and petroleum industries, generate discussion with citizens and other industries, and release reliable data based on innovative technologies and air quality models. Evaluation of health effects in the real world and proposal of a socially optimal system using advanced automobile and fuel technologies are also expected to be carried out. The progress of JCAP II will be presented at the 4th JCAP conference to be held on June 1-2, 2005 in Tokyo (visit http://www.pecj.or.jp/japanese/index_j.html for more information).

Figure 2. Sulfur Effect on Fuel Economy



Source: Japan Petroleum Energy Center, March 2005

Analysis / Lessons Learned - JCAP I highlighted the important role that fuels can and will play as a central component of efforts to reduce motor vehicle pollution. Most important has been the focus on the role of sulfur in both gasoline and diesel fuel and as a result of this effort, aggressive efforts have been taken to introduce near zero sulfur (10 ppm) fuels in Japan. The JCAP program has also demonstrated the value of bringing vehicle manufacturers and oil industry together in one program to arrive at effective strategies for emission reduction control.

JCAP II will broaden the scope to focus on near zero emitting technologies as well as high fuel economy or low CO2 emissions. The benefits of low RVP fuels were also highlighted.

Source: ADB, 2003 and IFQC, 2005

Case Study 2: Malaysian Air Quality and Clear Fuels Initiatives

Background - The air quality problems faced by the government of Malaysia appear to be moderate. The main area of air pollution concern is the Klang Valley. The air quality data indicate that there are a significant number of days in the Valley when ozone concentrations are above the health standards and a number of days when the ambient PM10 concentrations are above health levels. The meteorological conditions, and the high concentration of mobile and other pollution sources in the Valley create conditions that are conducive to higher pollutant levels. It appears that the fuels and motor vehicles are the major contributing sources to pollution in the Valley.

Since there is a significant growth in motor vehicle population, the emissions from motor vehicles will continue to increase. Consequently air quality problems will become progressively worse unless measures are taken.

Issue Focus - The government of Malaysia is in the process of taking a preventive approach against air pollution through a series of measures. Among other actions:

Malaysia has established a governmental cooperation with GtZ. GtZ is providing the government of Malaysia with expert technical assistance on a number of areas where there is a lack of expertise. The assistance provided by GtZ to the government of Malaysia is critical in their efforts to implement an air quality strategy.
Malaysia is in the process of restructuring the environmental agency in order to allocate more resources and assign higher priority on air quality issues.
Malaysia has been expanding the air quality monitoring- network, and has been collecting an emissions inventory for both stationary and mobile sources in order to identify the contribution of various sources to the air quality problem.
Fuels and motor vehicles standards are an important component of the Malaysian strategy. The government of Malaysia has been evaluating the options of implementing standards for fuels and motor vehicles as a preventive means to emissions' reductions.

Table Comparison of Malaysian Gasoline Properties to CA, USEPA, EU, Thailand, MVMA:

Fuel Property	*Malaysia*	*Thailand*	*CA*	*USEPA*	*EU*	*MVMA*
RVP, psi	*10.0*	*9.0*	*7.0*	*7.2*	*7.0*	*Varies*
S, ppm	*1500*	*300*	*20*	*130*	*50*	*30, 200, 1000*
Aro. vol%	*40-45*	*35*	*25*	*25*	*35*	*35,40,50*
Benz.vol%	*3-5*	*3*	*0.8*	*1.0*	*1.0*	*1.0,2.5,5.0*
Ole. vol%	*18*	*18*	*6.0*	*8.5*	*18*	*10.0,20.0,-*
Ox. wt%	*---*	*0.4*	*2.0*	*2.0*	*---*	*2.7,2.7,2.7*
T90,deg F	*356*	*---*	*305*	*320*	*290*	*----**
	239	*---*	*213*	*210*	*200*	*----**

Currently the Malaysian government has established a dialogue with the oil industry, and it is considering the implementation of Euro 2, Euro 3, and Euro 4 fuel standards. Three potential approaches are being considered:

Approach A: Implementation of Euro 2, Euro 3, Euro 4 standards consecutively over a period of 10 years.

Approach B: Implementation of Euro 2 standards within a short time interval to be followed by Euro 4 implementation in a 4-6 years time frame.

Approach C: Implementation of Euro 2 and Euro 3 standards within a 4-6 years time frame. Evaluation of the air quality to determine the need for implementation of Euro 4 on a later date.

Analysis/Lessons Learned - The ability to recover the costs of compliance is a critical issue. Even when the air quality has not reached a critical stage, it is prudent to implement a fuels program as a preventive measure and to meet the needs of motor vehicles. Resources as well as infrastructure are needed in order to implement a fuels program A fuels program requires the cooperation of a number of governmental agencies.

Source: ADB, 2003Case study 3: Phase out of Leaded Gasoline in the Philippines

Background - When the Clean Air Act of the Philippines was signed into law in 1999, lead phase-out was identified as the first priority action because of its serious health effects. This prioritization was widely supported by civil society groups throughout the development and public consultations on the law. The Act mandated the elimination of leaded gasoline by January 1, 2001, but the major oil companies and the Department of Energy decided to advance the phase-out to April 1, 2000 in Metro Manila. The announcement of the early phase-out plans prompted a multi-sectoral group including government, business, civil society, and development institutions interested in the implementation of the Clean Air Act to meet. These stakeholders agreed and decide that the success of the phase out was hinged on public understanding and acceptance.
In February 2000, an ADB-US AEP (The United States-Asia Environmental Partnership) supported workshop with over 150 participants from government, non-government organizations (NGOs), civil society, and the private sector was conducted to educate these stakeholders about the issues involved in the phase-out of lead and to enlist the participants in planning and executing a campaign to educate the public about the phase-out. Participation was high because of the high profile and effective speakers and the momentum generated by the accelerated deadline for the Metro Manila phase-out. The workshop participants agreed to form the Lead-Free Coalition and launch a public awareness campaign with the following objectives:

Inform motorists that the lead phase-out will occur on April 1
Reassure motorists that their vehicle can safely use unleaded gasoline
Underscore the physical/health benefits
Explain the financial benefits from the use of unleaded gasoline

Issue Focus - The Lead-Free Coalition made effective use of a wide range of media and convinced the oil companies to include educational information in their print ads. The short time available and the small budget required the group to be creative and focused. The main challenge was the very short time frame to develop and implement the campaigns before phase-out dates. The group addressed this by quickly pulling together the right partners and implementing an intensive campaign that lasted for three weeks and included seminars/press media publicity, TV and radio spots, print ads, and distribution of flyers, stickers, and posters. Non-traditional media were also used, e.g., telephone hotlines, website, mailing inserts, and seminars. Some resistance was encountered from vehicle manufacturers and motorized tricycle operators. The opposition included concerns about the technical ability of all cars and motorcycles to safely switch to unleaded gas, and the higher cost of unleaded versus regular, low-octane gas. The federation of tricycle operators and drivers filed a temporary restraining order to stop the phase-out; however, the Coalition initiated an outreach effort and convinced the federation to drop the case. In Metro Manila, the decision-making process took place in several meetings with key partners before and after the February workshop, in which a large number of people from all concerned sectors were present and encouraged to give their opinion and get involved in the campaign. During the meetings, policy issues were discussed in an open, multi-sectoral forum that led to greater understanding and faster action.

After the Metro Manila phase-out, the focus was on the nation-wide phase-out scheduled for January 1, 2001. At this time the Coalition expanded its campaign to include cleaner diesel and renamed itself the Coalition for Cleaner Fuels. Nine regional dialogues were held to raise awareness, answer questions, and put fears at ease in regions across the country—environmental NGOs, the transport industry, and the agricultural and fishing communities were particularly involved at the regional level. This network of local contacts was used for materials dissemination, feedback, and, later, compliance monitoring. The group achieved its objective of a smooth phase-out of leaded gasoline. The group (now called the Partnership for Clean Air) reports on its performance during the yearly General Assembly and has set up an external evaluation committee to evaluate the group' s work twice a year.

Analysis / Lessons Learned – The lead phase-out campaign in Metro Manila and the provincial dialogues and campaigning were deemed successful because the lead phase-out took place without any major resistance. This was an important accomplishment given the poor image of oil companies and government (protests are regularly held when fuel prices are raised), short time and budget available. Because the passage of the Clean Air Act was very contentious, it was critical for the first action of the Act, which was the leaded gasoline phase-out, to be carried out in an inclusive manner with a great deal of two-way communication. The Coalition's efforts accomplished this. The Coalition also included cleaner diesel in its provincial campaign, ahead of the December 21, 2000 reduction of sulfur to 2 mg/litre. Eliminating lead from the air and reducing sulfur levels will have major impacts on the health of the population, especially the urban poor, and ecosystems. This effort also resulted in a sustainable, effective group that has evolved into the Partnership for Clean Air.

The group learned (and demonstrated) the value of multi-sectoral cooperation and strong partnerships to accomplishing a goal that involves many stakeholders. There were many naysayers and roadblocks during the initial meetings, and it was difficult to coordinate everyone's schedules and convince people who normally are at odds (NGOs vs. industry and one government department vs. another department) to work together on a common goal. But the momentum created by the February 2000 workshop and the success of the campaign convinced the group to continue working on other air pollution issues and to build on the foundation of the strong partnerships that were forged. The highly visible and important role played by the NGOs throughout the phase-out initiative was also recognized. The president of the lead NGO, Concerned Citizens Against Pollution, was a very credible and convincing spokesperson on many TV and radio talk shows and in meetings with oil company executives and top government officials.

Source: ADB, 2003