FUEL QUALITY ROADMAP FOR ARAB STATES

Centre for Environment and Development in the Arab Region and Europe

(CEDARE)

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ACRONYM	DESCRIPTION
ADB	Asian Development Bank
CAMRE	Council of Arab Ministers Responsible for the Environment
CEDARE	Center for Environment and Development for the Arab Region and Europe
CO	Carbon Monoxide
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GNI	Gross National Income
HC	Hydro Carbons
IARC	International Agency for Research on Cancer
LAS	League of Arab States
BPD	Barrels Per Day
MEWA	Middle East and West Asia
NO_x	Nitrogen Oxides
OAPEC	Organization of Arab Petroleum Exporting Countries
OECD	Organization for Economic Cooperation and Development
PCFV	Partnership for Cleaner Fuels and Vehicles
PCFV	Partnership for Cleaner Fuels and Vehicles
PM	Particle Matter
ppm	Parts Per Million
SO_2	Sulphur Dioxide
ULSD	Ultra-low Sulphur Diesel
UNEP	United National Environmental Programme
USEPA	United States Environmental Protection Agency
WEC	World Energy Council
WHO	World Health Organization

Executive Summary

This report aims to provide possible alternative routes for improving fuel quality in the Arab countries. The Council of Arab Ministers Responsible for the Environment (CAMRE) requested from the United Nations Environment Programme (UNEP) and the Centre for Environment and Development for the Arab Region and Europe (CEDARE) to work on introducing cleaner fuels in the region. This document proposes a roadmap to reduce sulphur concentration in fuel to have cleaner fuel and better air quality based on the available information from respective Arab countries. High levels of sulphur in vehicle fuels result in harmful emissions of sulphur oxides that threaten public health and ambient air quality.

The report focuses on diesel fuel since sulphur content in diesel fuel is significantly higher than gasoline fuel in most Arab countries. Notably, the countries of the Gulf Cooperation Council (GCC) are pursuing ambitious upgrade plans to reach top European fuel quality standards. Top fuel quality refinery products have been historically export-oriented in Bahrain and Qatar. Arab countries that depend mainly on imported fuels have fewer challenges with the introduction of cleaner fuels. Whereas Arab countries that meet domestic demand through a mix of local production and imports have greater challenges since upgrading current refineries is costly. However, the impact on improved health and environment as well as meeting the fuel standards needed for optimal performance of most modern cleaner vehicles must be taken into account.

The report provides information about current predominant diesel sulphur levels, along with the associated standards, the refineries' ownership structure and the fuel quality development history. The gathered information has been analyzed in order to provide predictions about fuel quality developments taking in consideration confirmed facts about refineries expansions and upgrades. Environmental awareness, export needs as well as standards for vehicle emissions and fuel quality are factors driving improvements with varying degrees throughout the region. It has been highlighted that environmental standards alone cannot achieve the desired fuel quality.

The report classifies the Arab countries in three categorizes according to (1) the existence of local refineries, (2) the capacity to produce low-sulphur diesel fuel, and (3) the share of imported fuels. For every category a roadmap framework has been recommended to assist in the reduction of sulphur content in the fuel distributed in the local market. The roadmap framework promotes ultra-low-sulphur-diesel (ULSD) fuel imports; investment in upgrading refinery units; setting the institutional arrangements for planning the transition; capacity building in key competences; a public awareness and outreach campaign according to the category.

Furthermore, for improved refinement of national and regional strategies for fuel quality improvement, it is highly recommended to promote availability of updated information on the status of clean fuels and relevant national policies (and national strategies if any) so that progress is continuously shared between Arab countries in order to facilitate joint efforts in this respect.

1 Background

In Arab countries, vehicle numbers are increasing exponentially, and high sulphur fuels continue to be the norm and inhibit the introduction of emission control technologies. By introducing policies to lower sulphur levels and setting strict emissions standards, Arab countries can mitigate a great amount of the air pollution caused by vehicle exhaust and also save energy since cleaner vehicles generally have better fuel economy.

In recognition of these pressing issues, a resolution was made by the Council of Arab Ministers Responsible for the Environment (CAMRE) in its 22nd meeting in November 2010, to take solid steps towards effecting the introduction of cleaner fuels and vehicles policies (CFV policies) in the Arab Region (CAMRE, 2010). The decision explicitly provides that actions is required through the United Nations Environmental Programme (UNEP) and the Center for Environment and Development in the Arab Region and Europe (CEDARE) in cooperation with national and international stakeholders to jointly develop strategies for cleaner fuels and vehicles for the Arab region. This comes mainly as a result of the impact of the successful preceding event of the *Middle East Cleaner Fuels and Vehicles Air Policy Forum* held in Egypt in 2010, which provided recommendations to CAMRE to act toward CFV policies.

The present report is part of the studies being conducted by CEDARE in partnership with UNEP's Partnership for Cleaner Fuels and Vehicles (PCFV), the League of Arab States and relevant national stakeholders. It focuses on improving fuel quality through reducing sulphur content, a measure that has much potential to improve air quality and public health. The report also comes as a step in addressing the sustainability of the transportation sector in the region where unsustainable trends are exacerbated by the fact that urban population in the Arab world is higher than the world average. And that's why policy makers in the region are laying an increasing emphasis on policies and visions for creating a more sustainable transportation system.

With growing concern globally over environmental sustainability and public health, more attention every day is given to the refining industry and its role in reducing vehicle emissions by improving quality of the most common vehicles fuels: gasoline and diesel. The focus of this report is on these two fuels and their use in vehicles, which often pose the most threat on the health of citizens in the city since the majority of roadside air pollution is often attributed to vehicle emissions. For this purpose, most countries have embarked on fuel quality improvement programs at different levels of progress (see Table 12, p.28)

Earlier significant changes in the refining industry globally had addressed certain improvement in fuel quality such as production of unleaded reformulated gasoline, and then incorporated to reduce the proportion of aromatics and olefins to very low levels with significant reduction in sulphur content in various types of gasoline and sulphur. Sulphur has become a key indicator of cleaner fuels.

Today, the challenge facing the refining industry depends highly on the availability of refinery conversion units that can achieve profitability for the refining industry. Building necessary conversion units is an expensive investment required to produce cleaner fuels and comply with emission standards. It is necessary to establish processing units and sulphur recovery units to deal with the very harmful acidic gases emitted from the sulphur removal process. Another challenge is that fuels in most Arab countries are still highly subsidized, and there is little indication of commitment to phase-out subsidies. Popular resistance is the main

barrier facing subsidy reform policies. Political uncertainties following the Arab spring exacerbate the effects of this barrier. Meeting fuel demand is increasingly difficult for the Arab countries due to fuel adulteration and smuggling operations to neighboring countries causing economic losses, especially in countries of high subsidies (e.g. Saudi Arabia, Egypt and Libya).

In the Arab countries, the total cost of production of different grades of cleaner fuels (of the same type) is higher than the international market price for the respective grade. This is because most are topping and simple refineries and conversion refineries of low complexity indices.

The Arab refineries configuration in 2012 are still predominantly topping and simple refineries with 31 of such refineries out of the total 61 available. These types of refineries are concentrated among the Arab countries that have been subject to socio-political and economic problems, as is the case in Egypt, Iraq, Algeria, Libya, Sudan, Yemen, and Mauritania. This may partly explains the delay in the Arab region in the implementation of cleaner fuel projects.

The current ability of some Arab countries' refineries to produce cleaner fuels that would comply with the Euro 2 and Euro 3 standards are therefore very limited (e.g., Egypt, Iraq, Algeria, Libya, Sudan, Yemen, and Mauritania) with the exception of a small number of refineries. However, a number of refineries in the GCC countries, and Morocco have the capacity to produce Euro 3 and Euro 4 equivalent fuels. In the GCC countries, where Euro 4 and Euro 5 equivalent levels are mostly for export purposes, enacted plans for expansions are promising the proliferation of Ultra-Low-Sulphur fuels.

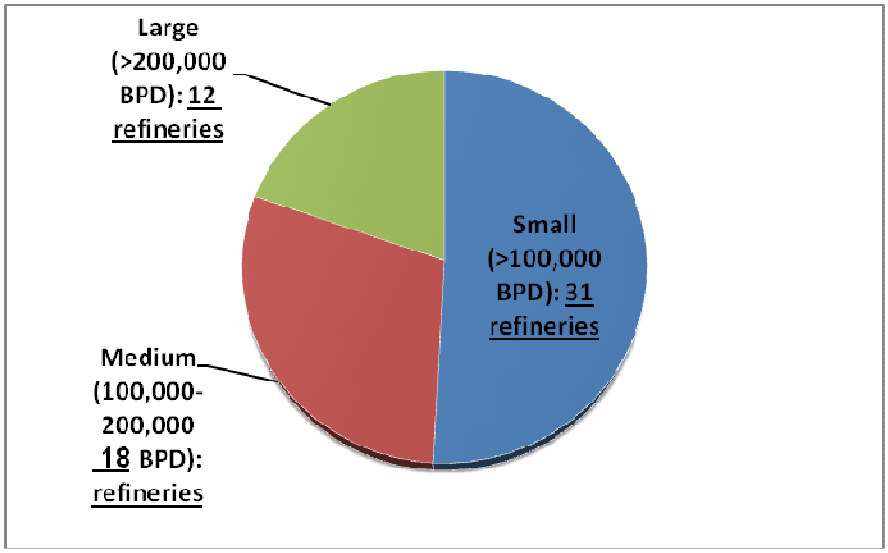

Figure 1: Size distribution of refineries in the OAPEC countries (OAPEC, 2013)

In response to fuel quality regulations and policies, the petroleum industries in leading industrialized countries have progressed rapidly in producing large varieties of petroleum products with the very strict specifications. The USA, Canada, European Union countries and Japan led the development of regulations and policies, later followed by most of Latin America, many Asian countries and certain countries in the Middle East following the same trend as awareness about environmental and health hazards of fuels slowly matured throughout the world.

Arab countries, many of which are among the largest oil producers worldwide, have also progressed rapidly in their refining industries to respond to the requirements of the international markets aiming to meet the evolving international fuel specifications. Some of the Arab countries, until 2012, have even exceeded the capacities on average of European countries' hydro-treating units for sulphur removal and naphtha reforming for producing high quality gasoline. Such countries include Oman, Morocco and Qatar.

There are many Arab countries that have developed ambitious investment plans in the refining industry to meet international clean fuel standards. In terms of such investment plans, the most committed countries are Saudi Arabia, United Arab Emirates, Qatar, Bahrain, Kuwait, Algeria and Iraq.

As a result of the recent events of the Arab spring, the development plans with respect to oil refinery modernization have been affected by events in several Arab countries, such as Syria, Libya, Tunisia, Yemen and Egypt.

The total number of refineries in the Arab countries in 2012 was 61 with a total capacity of 7922,000 BPD compared with 55 refineries in 2000 with total capacity of 6847,000 BPD. The total conversion process capacity in 2012 was 1536,000 BPD or 14% of the total refinery capacity, a modest change when compared to the average conversion process capacity of European refineries of 37% (OAPEC 2013).Refineries in the Arab region are mostly under governmental control in various forms. These forms include direct ownership by national oil companies or through subsidiaries and joint ventures with international companies; else the refineries are run by independent government owned oil companies.

Diesel consumption of Arab countries has increased by substantial amounts in the last 11 years (OAPEC, 2013). Figure 1 and Figure 2 illustrate the production and consumption of Gasoline and Diesel fuels for Arab countries in the year 2011. Note that the consumption excedes production even in some oil rich countries since the figures are not showing the net oil production but rather the production of the two specific products of Diesel and Gasoline which do not necessarily have the same balance as of the net flows of oil.

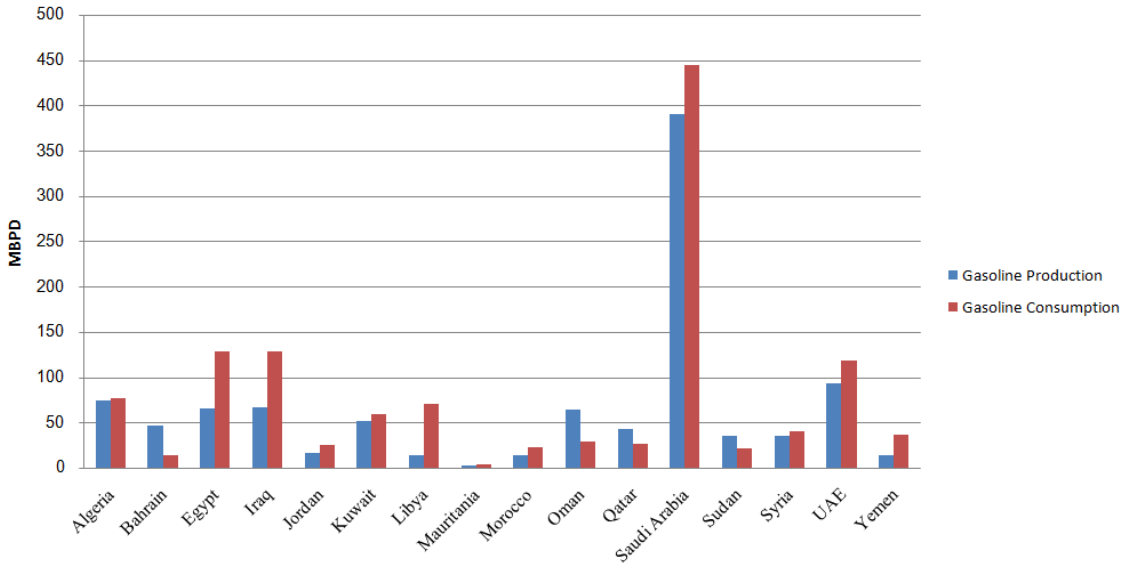

Figure 1: Gasoline Production and Consumption in the Arab Region in 2011 (OAPEC 2013)

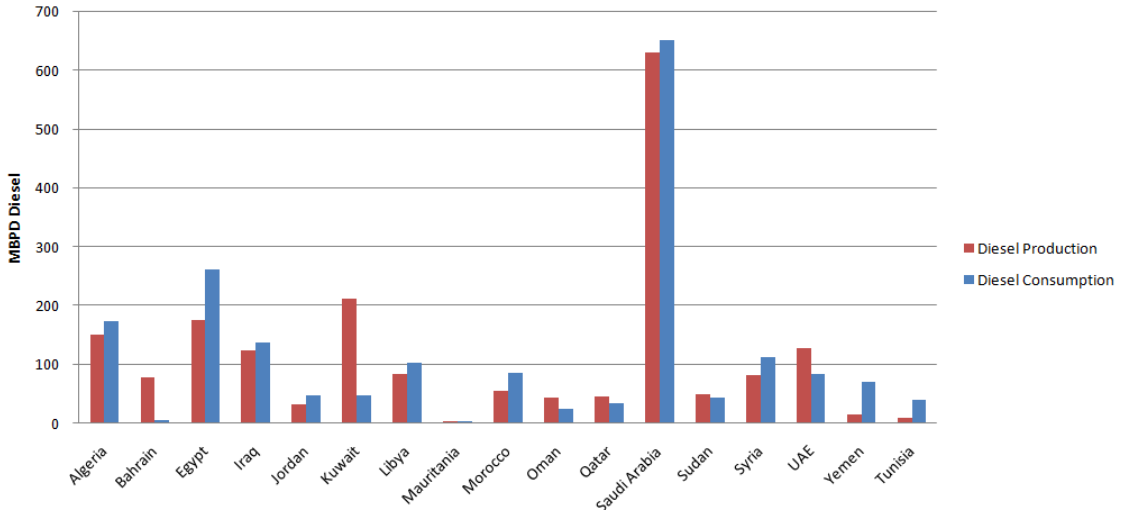

Figure 2: Diesel Production and Consumption in Arab Countries in 2011 (OAPEC, 2013)

Sulphur is a natural component in crude oil that ends up in gasoline and diesel unless removed. Sulphur in gasoline and diesel impairs the effectiveness of control systems and contributes to air pollution. High levels of sulphur in fuels are harmful for the environment because they prevent the use of emission control technologies to control diesel particulate emissions, considered a significant source of atmospheric soot and fine particles, which were recently classified as carcinogenic to humans, contributing to premature deaths, largely due to cardiovascular diseases, lung cancer and other health and environmental impacts (IARC, 2013).

Sulphur in the fuel is oxidized during combustion, producing sulphur dioxide and trioxide, which in presence of water rapidly converts to sulphuric acid causing acid rain. Reducing the sulphur content in gasoline and diesel enables advanced emission controls and reduces air pollution. Furthermore, improving fuels allows the introduction of more advanced vehicle technology with improved the fuel economy. Reducing sulphur levels in fuels is especially important in reducing the smallest particles and can reduce vehicle emissions in two ways:

1. Reducing sulphur in fuels reduces direct emissions of both sulphur dioxide and sulfate particulate matter from all vehicles, old and new. Sulphur dioxide (SO2) emissions from diesel and petrol vehicles and particulate matter from diesel vehicles tend to increase in direct proportion to the amount of sulphur in the fuel (UNEP, 2009).

2. Sulphur poisons or reduces the effectiveness of vehicle emission control technologies for petrol and diesel vehicles, resulting in increased vehicle emissions of CO, hydrocarbon (HC), nitrogen oxide (NOx), and PM. It also poisons or reduces the effectiveness of new types of emission control devices such as advanced catalytic converters and diesel particle traps, which can further reduce NOx, HC and PM emissions. For petrol vehicles, studies show that lowering sulphur enhances three-way catalyst operation and reduces HC, CO, and NOx emissions (UNEP, 2009)

The present report aims to draft a fuel quality roadmap for the League of Arab States (LAS) with timelines, a recommended approach and policy options. These will include an overview of existing national fuel quality regulations or proposals in the Arab region, a review of the existing status of sulphur content in vehicle fuels, and suggestion of relevant incentives needed to promote low sulphur fuels in the Arab region.

1.1 Impact of Sulphur on Vehicle Emissions

Achieving cleaner fuels and vehicles requires treating fuels and vehicles as a system, where lower sulphur fuels are paired with appropriate vehicle emission control technologies. This approach has proven to be more effective than treating fuels, engines, or emission controls separately. (UNEP, 2009)

Sulphur in fuels has both direct and indirect adverse effects on vehicle emissions. Blumberg et al. (2003) summarized the impact of different levels of sulphur in fuels as follows:

Reduced Sulphur fuel: (150ppm sulphur content) Reduced sulphur fuel decreases emissions of Carbon monoxide (CO), Hydrocarbon (HC), and nitrogen oxide (NOx) from catalyst-equipped gasoline vehicles and Particulate Matter (PM) emissions from diesel vehicles, with and without oxidation catalysts. These benefits increase as vehicles are designed to meet higher emission standards and sulphur levels are reduced further.

Low Sulphur fuel: (50ppm sulphur content) Diesel particulate filters can be used with low sulphur fuel but only achieve approximately 50% control efficiency. Selective catalytic reduction can be used for over 80% control of NOx emissions.

Near-Zero-Sulphur fuel: (10ppm sulphur content) enables more fuel-efficient engine designs, which are incompatible with current emissions control systems. Particulate filters achieve the maximum efficiency with near zero-Sulphur fuels, approaching 100% control of PM.

For pre-Euro2 vehicles, lowering sulphur will tend to lower SO_2 and PM emissions, but it is not directly linked to diesel technology. If stringent control of NO_x and PM is needed, sulphur levels would need to be reduced to 50ppm (Euro 4 fuel standards) or less so that they are compatible with Euro 4 vehicles.

It is important to note as well that catalytic convertors also require the elimination of lead from gasoline. This change occurred throughout almost all of the Arab countries, and resulted in substantial reduction in ambient lead levels in the air. Other gasoline properties that can be adjusted to reduce emissions include; vapor pressure, distillation, light olefin content, and aromatics content.

2 Refineries in the Arab Countries

The refining industry was initiated in the Arab countries with the establishment of the first refinery in Egypt in Suez in 1913, followed by another refinery in northern Iraq in 1927, Bahrain in 1936, Saudi Arabia in 1945 and Kuwait in 1949. In the fifties Arab governments started establishing refineries with foreign partners in order to meet the growing demand for petroleum products in the local markets. The refining industry continued to grow during the sixties and seventies to keep pace with the rapid economic developments witnessed by the Arab states in that period, especially in the petroleum-exporting countries of the Gulf region.

The rate of increase in total refining capacity in the Arab world during the sixties reached about 135% over the decade, and then continued to increase at a lower rate during the seventies at 76%, and in the eighties at 62% (OAPEC 2013). The rate did not rise significantly during the nineties, growing only 10% over the decade, but it rose more quickly during the first years of the twenty-first century. Most recently, the refinery capacity in 2012 was found to be 16% of what it was in 2000 (OAPEC 2013).

A host of reasons explain the development and expansion of refining capacity in the Arab countries. They include ambition to diversify exported oil products; long-term maximization of the economics of fuel products, and achieving a level of energy security. With time, the focus on building capacity of local human resources and institutional capacity enabled the expansion in local production of fuel products and total oil exports increased from 7% in 1980 to 23% in 1990, despite the decline in demand for petroleum products in the international markets during that period. Furthermore, certain large exporters, such as Kuwait, Saudi Arabia, Bahrain and the United Arab Emirates, acquired refining facilities and transmission and distribution markets in Europe and the United States, to secure foreign markets for their products.

The prominent organization overseeing the operation and progress of major oil producing countries in the Arab Region today is the Organization of Arab Petroleum Exporting Countries (OAPEC). It was established in 1968 concerned with the development and prosperity of the world petroleum industry by fostering close and fruitful cooperation among its members. OAPEC is based in Kuwait and led by a Ministerial council.

Members of OAPEC were originally countries whose oil constituted their major source of revenue. Later in 1972 additional oil exporting countries in the region were admitted. By 1982 the membership of the Organization increased to eleven Arab oil exporting countries namely: Algeria (1970), Bahrain (1970), Egypt (1973), Iraq (1972), Kuwait (1968), Libya (1968), Qatar (1970), Kingdom of Saudi Arabia (1968), Syria (1972), Tunisia (1982) and the United Arab Emirates (1970) (OAPEC 2012).

2.1 Production Performance to Oil Refineries during the 80's and 90's

Specifications for petroleum products improved in the Arab refineries during the 1980's to keep pace with the requirements of export to the markets in Europe and USA. Hydro-treating capacity increased at a rate almost three times the level it was in the seventies. It has risen from 513,000 BPD (13% of the crude oil distillation capacity) in 1980 to 1,312,000 BPD (21% of the crude oil distillation capacity) in 1990. The catalytic reforming capacity increased from 377,000 BPD (10% distillation capacity) to 669,000 BPD (11% of distillation capacity) in 1990 (OAPEC 2013).

In earlier years, in the Arab countries, the catalytic reforming operations capacities were not enough to improve the octane number of gasoline sufficiently to phase-out tetraethyl lead. Later, most of them adopted policies to expand the catalytic reforming/isomerization capacities in response to growing health and environmental concerns. To date, countries that still have lead in vehicle fuels however are Algeria, Yemen, and Iraq. Conversion processes capacities have increased in total in the Arab countries to 320,000 barrels/day equivalent to 10% of the oil distillation capacity in 1990.

2.2 Automotive fuels consumption and production in the Arab countries

The growth in demand for the Automotive fuels continued in the Arab countries at the beginning of the twenty-first century, raising the consumption of the automotive fuels from 1,745,000 BPD in year 2000 to 3,150,000 in 2011.Table 1 shows the evolution of consumption of automotive fuels in the Arab countries.

Table 1: Fuel consumption in Arab countries ('000 BPD) (OAPEC 2013)

Fuel type	1990	2000	2011
Gasoline	495	694	1287
Diesel& Gas Oil*	869	1051	1863

***Gas Oil in Arab countries is mainly used in vehicles and is used interchangeably as Diesel.**

Table 2 shows diesel and gasoline production structure in all Arab countries over the past three decades.

Table 2: Fuel production in Arab countries ('000 BPD) (OAPEC2013)

Fuel type	1990	2000	2011
Gasoline	600	820	1011
Diesel & Gas Oil*	1478	1699	1894

***Gas Oil in Arab countries is mainly used in vehicles and is used interchangeably with Diesel.**

As shown in Tables 1 and 2, consumption and production of automotive fuels is rapidly increasing. Gasoline consumption increased from 694,000 BPD in 2000 to 1,287,000 BPD in 2011, while the diesel fuel and gas oil increased from 1,051,000 BPD to 1,863,000 BPD over the same time period.-

Tables 1 and 2 demonstrate a long-term sustained trend for increasing consumption of fuel products due to population increase and economic growth. The local production is also increasing to cope with increasing consumption. An overall trend in Arab region is the incapacity of production to meet local demand with the exception of GCC countries which sometimes import limited amounts of refined products.

This trend is best exemplified by Egypt, which used to be a gasoline exporter until 2007, and is now a net importer of gasoline; it exports the gasoline precursor (naphtha). Other countries dependant on import are the non-oil-exporting countries like Jordan, Tunisia and Morocco.

This trend is bearing on Arab fuel products exports which comprise(d) some share of national revenues for several countries in the region. Arab countries had to import the 176,000 BPD of gasoline deficit to meet their domestic consumption in 2011, while in 2000 the Arab refineries exported 126,000 BPD of gasoline. For diesel, the Arab refineries exported 648,000

BPD of diesel fuels in 2000 but the exported quantity dropped to only 31,000 BPD of diesel in 2011.

2.3 Status of Refineries and Level of Complexity

In 1980 there were 43 refineries of varying process configurations and sizes in operation in 17 countries, growing in number to 61 in 2012. Table 3 summarizes these and indicates their distillation capacities and the expansion of the sector.

Table 3: Numbers of Refineries in the Arab countries 1980-2012 (OAPEC, 2013)

Country	No. of refineries 1980	Crude Distillation Capacity('000 BPD)	No. of refineries 2012	Crude Distillation Capacity ('000 BPD)
Saudi Arabia	5	760	7	2107
Kuwait	3	563	3	936
Iraq	8	352	12	860
Egypt	6	390	8	770
U.A.E	1	15	4	690
Algeria	5	518	5	583
Libya	2	127	5	380
Qatar	1	12	2	283
Bahrain	1	280	1	267
Syria	2	240	2	240
Oman	0	0	2	222
Morocco	2	10	2	155
Sudan	1	30	3	140
Yemen	1	100	2	140
Jordan	1	98	1	90
Tunisia	1	34	1	34
Mauritania	0	0	1	25
Lebanon	2	52	0	0
Somalia	1	10	0	0
Total	43	3591	61	7922

'000 BPD=Thousand barrels per day

Refineries can be classified into four main categories according to levels of complexity in their configuration: Topping refineries, Hydro skimming refineries, and two types of Complex refineries.

1- Topping refinery

A topping refinery is the simplest refinery configuration; a small facility that relies exclusively on crude oil distillation for producing various distillate components. The topping refineries are highly dependent on the quality of crude oil used. They do not have any processes such as catalytic cracking, and they may import blending components to meet fuel specifications. Given their small size, it is unlikely that it would be feasible to install new process units or modify the refinery or the production of clean fuels (ADB 2008).

In a number of Arab countries, where topping refineries represent an important part of fuel production such as in Sudan and Iraq, and where the fuel supply significantly relies on the fuel production from the topping refineries, the issue of clean fuels availability and supply

would require massive investments in refineries upgrades and new more complex refineries which in turn would place an extra pressure on the already burdensome subsidies.

2- Simple (Hydro-skimming) refinery

A hydro-skimming refinery is usually a mid-sized facility that, in addition to distillation processes, includes processes for catalytic reforming of some of the distillation streams such as hydro-treating. A hydro-skimming refinery is less dependent on crude quality to meet the product specifications. Some of these refineries might be able to produce clean fuels (ADB 2008). Depending upon the types of crude oils that these facilities run, they might be able to produce gasoline that nearly meets Euro 4 standards. However, their clean diesel capacity is more limited (ADB 2008)

Hydro-skimming refineries operate in some Arab countries and are able to produce cleaner fuels, because of readily available hydrogen, a side product from the Naphtha Catalytic Reformer process in these refineries.

Complex refineries can be classified into two configurations:

- **Conversion Refineries:** Refineries that have any type of cracking of residual; do not fully convert the residual oil.
- **Deep Conversion Refineries:** Refineries equipped to fully convert residual oil to light distillates

3- Complex Refineries (Conversion and Deep Conversion Refineries)

A complex refinery is a larger facility that has a wide range of processing capabilities to alter product yields and quality. The measure of the secondary conversion capacity relative to primary production capacity of a refinery is indicated by the Nelson complexity index. The higher the index, the more complex the refinery and the greater the upgrade investment costs and value of its products.

Further to the capabilities of topping and hydro-skimming refineries, complex refineries are able to crack heavy fuels, and may have additional processes that produce clean gasoline components such as alkylation, isomerization, and polymerization. Complex refineries can therefore convert low-value residual products to higher value gasoline or diesel, or very light streams into gasoline, and may already employ processes that would be useful in the production of clean fuels.

Complex refineries in Arab countries have a similar concentration of clean gasoline blend-stocks plants with processes such as alkylation, isomerization, or hydro-treating as the complex refineries in Europe or the United States. Examples are:

- BAPCO Bapco plans to upgrade the Sitra refineries in Bahrain in 2015,
- MIDOR refinery in Egypt,
- RAS-LAFFAN in Qatar,
- Mina Al-Ahmadi and Mina-Abdullah refineries in Kuwait,
- AL-RUWAIS refinery in UAE,
- AL-GUBIAL refinery and YANBU refinery in Saudi Arabia,
- BANIAS refinery in Syria, SALAH AL-DEEN refinery in Iraq,

- ZARQA refinery in Jordan,
- SOHAR refinery in Oman,
- MOHAMMEDIA refinery in Morocco.

However, the relative production of cleaner fuels in comparison with crude oil production capacity is a small ratio in the Arab region compared to refineries in Europe and the United States. Thus, increasing the production of clean fuels in Arab countries from current production levels would require significant additional capital investments and modifications of refinery operations to meet standards such as sulphur content limits of10/50ppm. Even when existing hydro-treating units are in place, it may be necessary to retrofit or rebuild them so as to produce fuels with such low sulphur content. Additional auxiliary units such as hydrogen production units or sulphur recovery units may also be required. Although the simple or hydro-skimming refineries are still a considerable number, they produce a limited amount of all transport fuels in Arab countries.

Figure 4 shows a comparison between Arab countries and European countries in terms of relative production of upgraded products indicated by the reforming capacity, hydro-treating capacity and conversion capacity in 2012. The figure illustrates the gap between the potential of the Arab countries compared to the European Union countries for the production of cleaner fuels, especially with regards to the capabilities of the hydro-treating capacity, associated with the production of the diesel fuels with the required environmental specification. However, utmost care must be taken on comparisons due to the differences in policy environment and ownership structures, as private involvement is the norm in the U.S. In this setting the government assumes the role of the regulator accounting for interests of all stakeholders.

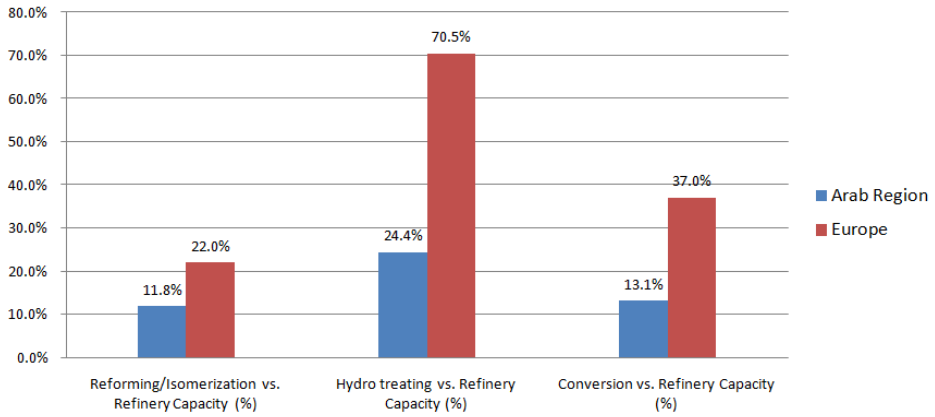

Figure 4: Comparison of Arab and European countries refineries capabilities(OAPEC 2013)

The reforming/isomerization vs. refinery capacity indicates ability to produce gasoline, the hydro-treating vs. refinery capacity indicates the ability to produce cleaner diesel fuel, while the conversion vs. refinery capacity indicates the ability to mass production of cleaner fuels from heavier fractions (bottom-of-barrel).

It is worth noting that the historical trend toward producing cleaner fuels in Europe and the US were greatly driven by regulations that gradually introduced stricter fuel and vehicle standards with time to reach the capabilities that are seen today.

Another measurement of the Arab countries industry lies in the comparison of the

refineries' sizes (70,190 BPD as input feedstock).

As a general rule, the 65,000 barrels per day crude throughput differentiates small refineries from medium and large ones. Figure 4can be taken as an indication the level of complexity of Arab refineries. It indicates that the capacity of producing gasoline is about 50% maximum of total refineries since the presence of reforming and isomerization units is the minimum requirement for producing gasoline of quality up to Euro 2 standards.

The use of additives along with reformation and isomerization can produce gasoline compatible with Euro 4/5standards; however that option would entail permanent costs for the purchase of expensive metallic additives. The hydro-treating capacity is 24.4% of crude capacity, which is lower than the 70.5% seen in European refineries. This indicates a relatively low capacity in the Arab Region to produce low-Sulphur diesel compared to Europe. It is worth noting, however, that hydro-treating capacity growth in Europe and the US was driven by stringent fuel quality standards.

2.4 Challenges of small refineries in Arab countries

With much similarity to the sector in Asia and most of the world, small refineries in the Arab Region also tend to be older and inefficient and therefore having low production rates. They are mostly topping plants with a few hydro-skimming plants and they are often the first to close as regulations on fuel quality become stricter. The impact of closing down smaller refineries on fuel supply therefore must be put into consideration when enforcing new regulations related to fuel quality. In the USA as an example, a gradual transition with interim standards was introduced to safeguard small refineries despite the foreseen delay in the implementation schedule of introducing cleaner fuels (ADB 2008).

Table 4: Summary of Arab refineries by country and process capacity (OAPEC 2013)

Country	No. of refineries	Crude Distillation Capacity('000 BPD[1])	Naphtha Hydro-treatingcapacity[2]('000 BPD)	HYDRO-Treating capacity[3]('000 BPD)	Conversion Capacity ('000 BPD)
Iraq	12	860	109	281	70
Egypt	8	770	114	201	108
Saudi Arabia	7	2107	238	797	655
Libya	5	380	21	41	0
Algeria	5	583	100	83	6
U.A.E	4	690	94	215	93
Kuwait	3	936	61	478	223
Sudan	3	140	10	23	0
Morocco	2	155	25	61	0
Syria	2	240	45	105	84
Qatar	2	283	71	145	80
Yemen	2	140	15	3	0
Oman	2	222	49	50	75
Tunisia	1	34	6	8	0
Jordan	1	90	10	17	10

Bahrain	1	267	18	163	116
Mauritania	1	25	6	6	0
Lebanon	0	0	0	0	0
Somalia	0	0	0	0	0
Total	**61**	**7922**	**992**	**2677**	**1520**

[1]'000 BPD= Thousands of barrels per day
[2]To reduce sulphur and avoid poisoning of catalytic reforming catalyst for gasoline production.
[3]Middle distillate (kerosene, gas oil) hydro-treating unit to remove Sulphur.

Table 5:Comparison between Refinery Configurations in different regions (OAPEC 2013)

	Refining Capacities MBPD		**Reforming Capacity/ Refining Capacity[1] %2012**			**HDS Capacity[2] /Refining Capacity % 2012**			**Conversion Capacity[3]/ Refining Capacity% 2012**	
	2000	**2012**		**Euro**	**World**		**Euro**	**World**		**Euro**
United Arab Emirates	430	690	13.85%	21.97%	12.48%	31.66%	70.52%	51.54%	10%	37%
Bahrain	267	267	7.22%	21.97%	12.48%	61.04%	70.52%	51.54%	39.7%	37%
Tunisia	34	34	16.70%	21.97%	12.48%	22.56%	70.52%	51.54%	0%	37%
Algeria	570	582.9	15.61%	21.97%	12.48%	14.18%	70.52%	51.54%	1.03%	37%
Saudi Arabia	1952	2107	12.60%	21.97%	12.48%	37.73%	70.52%	51.54%	25.9%	37%
Syria	240	240	18.78%	21.97%	12.48%	43.88%	70.52%	51.54%	35.1%	37%
Iraq	790	860	10.64%	21.97%	12.48%	32.67%	70.52%	51.54%	8.14%	37%
Qatar	65	283	24.98%	21.97%	12.48%	51.24%	70.52%	51.54%	28.3%	37%
Kuwait	936	936	6.96%	21.97%	12.48%	51.07%	70.52%	51.54%	25.2%	37%
Libya	380	380	5.66%	21.97%	12.48%	10.84%	70.52%	51.54%	0%	37%
Egypt	669.8	769.8	14.9%	21.97%	12.48%	25.6%	70.52%	51.54%	14%	37%
Jordan	90.4	90.4	11.39%	21.97%	12.48%	19.14%	70.52%	51.54%	10.9%	37%
Sudan	41	140	7.1%	21.97%	12.48%	16.1%	70.52%	51.54%	0%	37%
Oman	62	222	22.07%	21.97%	12.48%	22.52%	70.52%	51.54%	33.8%	37%
Lebanon	0	0	0	0	0	0	0	0	0	0
Morocco	154.7	154.7	39.10%	21.97%	12.48%	39.10%	70.52%	51.54%	26.5%	37%
Mauretania	25	25	22%	21.97%	12.48%	22%	70.52%	51.54%	0%	37%
Yemen	250	140	1.79%	21.97	12.48	1.79%	70.52	51.54	0%	37%
Somalia	0	0	-	-	-	-	-	-	-	-

Table 5 shows ability of Arab Countries to produce cleaner gasoline and cleaner diesel fuel in comparison with Europe and the World average.

2.5 Foreseen Refinery expansions in the Arab countries

Investments in most Arab countries in refining are foreseen to be for upgrading or expanding existing refineries, or building new complex refineries. The projects currently planned are 24 refineries in 13 Arab countries detailed in

Table 6 with total capacities of 5,285,000 BPD over the existing capacities. Some of these refineries are planned to start in 2014 and most of the others will start up in 2018. For comparison, no new refineries are being built in the US, it is considered too difficult to get permits to do so]

Table 6:Arab Countries Refinery Project up to 2018 (OAPEC 2013)

Country	Project	Refinery Capacity ('000 BPD)	Start-up Period
United Arab Emirates	Ruwais	517	2014
	Fujairah	200	2016
Algeria	Pescra	100	2017
	Gordaaa	100	2017
	Tiaret	100	2017
	Hassi Massaoud	100	2017
Saudi Arabia	SATORP (Jubail)	400	2014
	YASREF (Yanbu)	400	2015
	Ras -Tanura	400	2017
	Jizan	400	2018
Syria	Al-Frekls	140	2018
Iraq	Nasiriyah	300	2021
	Maysan	150	2019
	Karbala	140	2019
	Kirkuk	150	2019
Qatar	Ras-Laffan	146	2016
Kuwait	Al-Zour	615	2018
	Mina-Al-Ahmadi	460	
	Mina Abdullah	270	
Libya	Mellita	200	2017
Egypt	Ain-Soukhna	130	2017
Oman	Sohar-2	187	2016
Sudan	Port Sudan	100	2016
Morocco	Jafar Al-Asfar	200	2018
Yemen	Ras-Easa	50	2018
	Hadramout	60	2018
Bahrain	Sitra	360	2019

Furthermore, the refineries capacities and configurations indicate the capability to produce clean gasoline and diesel, which is illustrated in Table 7.

Table 7: Planned Refineries Capacities and Configurations in Arab Countries until 2018 (OAPEC 2013)

	Refinery Capacity (MBPD) 2012-		Refinery /Isomerization vs. Refinery Capacity (%) 2012-		Hydro treating vs. Refinery Capacity (%) 2012-2018		Conversion vs. Refinery Capacity (%) 2012-	
United Arab Emirates [1]	690	1307	13.85%	N.A	31.66%	N.A	10.0%	N.A
Bahrain [2]	26	360	7.22%	N.A	61.04%	N.A	39.7%	N.A
Tunisia	34	34	16.7%	16.7%	22.56%	22.56%	0.0%	0.0%
Algeria [3]	58	1395	15.61%	N.A	14.18%	N.A	1.03%	N.A
Saudi Arabia [4]	21	3707	12.60%	20.6%*	37.73%	48%	25.91%	42.5%
Syria [5]	24	380	18.78%	N.A	43.88%	N.A	35.1%	N.A
Iraq [6]	86	1660	10.64%	N.A	32.07%	N.A	8.14%	N.A
Qatar [7]	28	429	24.98%	N.A	51.24%	N.A	28.27%	N.A
Kuwait [8]	93	1615	6.96%	N.A	51.07%	N.A	25.20%	N.A
Libya[9]	38	580	5.66%	N.A	10.84%	N.A	0%	N.A
Egypt[10]	76	900	14.9%	N.A	25.6%	N.A	14.0%	N.A
Jordan[11]	90	90.4	11.39%	N.A	19.14%	N.A	10.9%	N.A

Sudan[12]	14	370	7.70%	N.A	16.10%	N.A	0%	N.A
Oman[13]	22	372	22.97%	23.0%*	22.52%	58.9%*	33%	60.3%
Lebanon	0	0	0	0	0	0	0	0
Morocco[14]	15	355	39.10%	N.A	39.10%	N.A	26.5%	N.A
Mauritania	25	25	22.0%	N.A	22.0%	N.A	0%	N.A
Yemen	14	250	1.79%	N.A	1.79%	N.A	0%	N.A
Somalia	0	0	0	0	0	0	0	0

1- UAE will build a new complexrefinery of 400,000 BPD in Ruwais Area and new one in Al- Fujairah of 200,000 BPD.
2- Bahrain will expandSitraRefinery to reach 360,000 BPD.
3- Algeria will build 4 new Refineries, each of 100,000 BPD in Pescra, Gordaaa, Tiret and Hassi Massaoud.
4- Saudi Arabia will build 4 new deep conversion Refineries each 400,000 BPD in Jubail ,Yanbu , Ras-Tanura and Jizan- the configuration of 2018 is made based on YASREF Refinery configuration in Yanbu.
5- Syria has a plan to build a new Refinery in Al-Zour Area of 140 MBDP.
6- Iraq plans to build 4 new Refineries in Nasiriyah, Maysan, Karbala and Kirkuk with 300,150,150,140 thousand BPD respectively, in addition to upgrades in other refineries.
7- Qatar plans to expand Ras-Laffan Refinery by duplicate the capacity in 2016.
8- Kuwait plans to build new complex Refinery in Al-Zour of 615,000 BPD, Start up 2018- With upgrading all the existing Refineries to produce cleaner fuels according to stricter specifications (not specified).
9- Libya plans to build new conversion Refinery, capacity 200,000 BPD, Start up 2017, with an upgrading for the existing 5 Refineries.
10- A refinery at Ain Sokhna with 130,000 BPD to be start in 2017. There is also a new deep conversion complex, Egyptian Refining Company (ERC), that is integrated with one of the existing refineries (Cairo Oil Refining Company) who supply residual oil as feedstock. ERC is planned to have a capacity of 96,000 BPD residual oil.
11- The Jordanian oil refinery plans is currently planning its fourth expansion project.
12- Upgrading / extension Khartoum Refinery to 200,000 BPD. New conversion Refinery startup in 2018 with capacity of 130,000 BPD at Port-Sudan.
13- Oman plans to extend and upgrade Sohar Refinery to 187,000 BPD and build new refinery at Dokum AREA With 150,000 BPD to start up at 2016 (calculation based on upgrading Sohar Configuration).
14- Morocco building a new conversion Refinery at Gafr Al-Asfar, capacity of 200,000 BPD startup 2018

In future plans, it is evident that production of clean fuels at very high standards is on the way in the foreseeable future for a number of Arab countries, and large capacities are also planned, implying surplus that will cater to the international market and its high requirements. The ongoing and planned expansions in existing refineries as well asthe building of new will increase the yield of top-standard gasoline and diesel.

The increased yield of conversion and deep-conversion refineries generates economies of scale which, along with the increasing environmental awareness in GCC countries, is leading to a justifiable increase in the share of quality fuel products. Bahrain is planning expansions in Sitra refinery, scheduled for operation in 2019. These new, expanded, or upgraded refineries can reduce the overall costs or incremental time to meet Euro 4/5fuel specifications without a need for metallic additives. Furthermore, there are three plants under operation in Qatar to produce ultra-low sulphur diesel fuel, which allows flexibility to match with any international diesel specifications. It is not clear however to what extent the cleaner fuel is considered for local consumption.

3 Air Quality and Fuel Quality in the Arab Countries

Gasoline and diesel motor vehicles emit large quantities of CO, HC, NOx, PM, dioxide (CO_2), sulphur Oxides (SOx) and toxic substances such as benzene, acetaldehyde, 1,3-butadiene, and lead. Along with the creation of secondary byproducts emitted pollutants, such as ozone from NOx, all of these can seriously harm human and the environment. A growing vehicle population and the high emission levels of these vehicles, contribute to the serious air pollution and health problems increasingly common in the cities of developing countries, including those in Arab countries (see map).According to IHS.inc, a leading global source of critical information, the Middle-Eastern automotive sector will grow twice as fast as that of Western Europe and the U.S between 2012 and 2020 (IHS, 2014).

Table 8 demonstrates a trend of more road congestion in some Arab countries.

Table 8: Vehicles per 1000 Km of road for some Arab countries (World Bank, 2014)

Country	2009	2010	2011
Algeria	34	36	-
Bahrain	103	108	112
Tunisia	64	68	71
Jordan	131	143	152
Kuwait	209	218	217
Morocco	44	47	50

Air pollution is a growing concern in these growing economies, for example, exposure to As shown in figure 5 exposure to fine particulate matter in urban areas in Egypt, GCC countries, and Mashreq countries, and Tunisia are substantially above global average levels (WHO, 2014).

Most Arab countries have planned their vehicle emission control programs with reference to the European requirements. These specifications can usefully be described in terms of four classes: Euro 2, 3,4 and 5. The Euro 2 fuel sulphur level was set at 500ppm to improve the performance of the catalytic converters used on gasoline vehicles. Specifications for the Euro 3 and 4 standards have been set with particular attention to stricter limits for sulphur to improve the performance or, in some cases, allow the use of advanced pollution control technologies (ADB 2008).

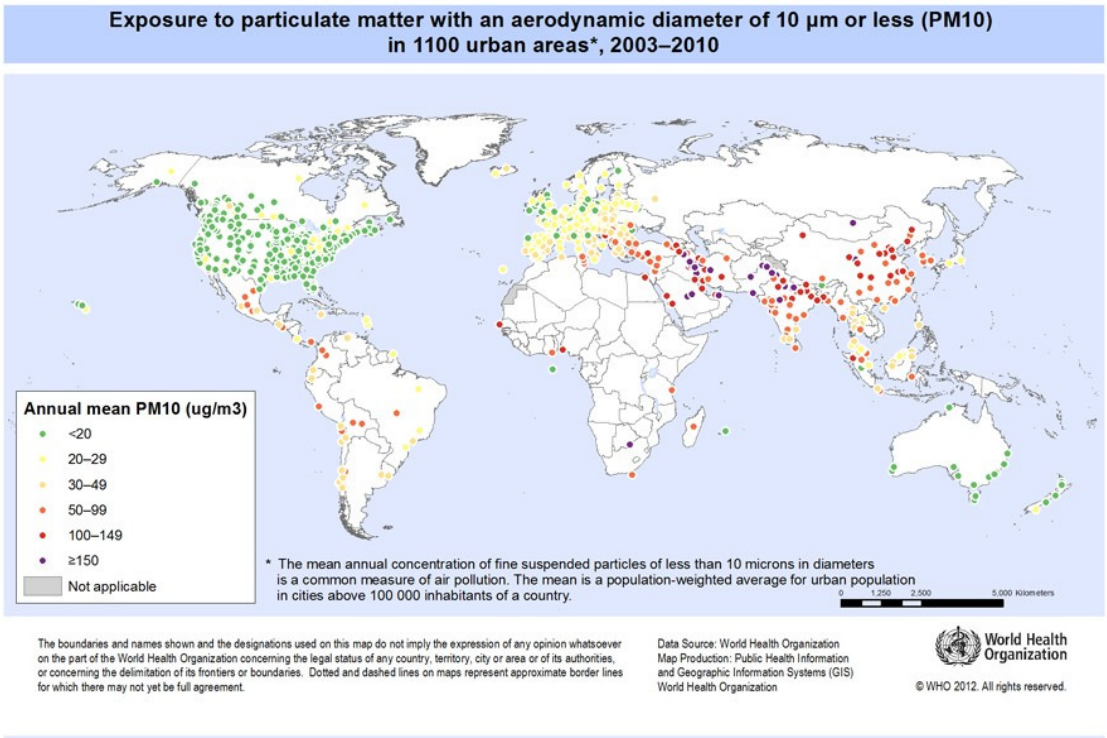

Figure 5: Exposure to PM_{10} in major world cities (WHO, 2014)

Table 9 details the specifications for the key environmental parameters of Euro 3, 4 and 5. The only change in the specifications for Euro 4 diesel was to establish the sulphur content at 50ppm. While the maximum sulphur limit of 50ppm applied to all gasoline and diesel fuel sold in the EU in 2005, fuels with a maximum limit of 10ppm were to be widely available by that year (ADB 2008). The introduction of the Euro 5 emission standard in 2009 further lowered sulphur levels in both gasoline and diesel to 10ppm and lower olefins in gasoline to 13% and polyaromatics in diesel to 6%.

Table 9: EU Gasoline and Diesel Fuel Quality Specifications (Directive 98/70/EC)

Petrol/Gasoline	Euro 3	Euro 4	Euro 5[a]	Diesel	Euro 3	Euro 4	Euro 5[b]
	2000	2005	2009		2000	2005	2009
RVP summer kPa, max.	60	60	60	Cetane number, min.	51	51	52
Aromatics, % by vol. max.	42	35	35	Density 15 °C Kg/m, max.	845	845	837
Benzene, % by vol. max.	1	1	1	Distillation 95% by vol. °C, max.	360	360	350
Olefins, % by vol. max.	18	18	13	Polyaromatics, % by vol., max.	11	11	6
Oxygen, % by mass max.	2.7	2.7	2.7				
Sulphur, ppm	150	50	10	Sulphur, ppm max.	350	50	10

°C = degrees Celsius, EU = European Union, kg/m; = Kilograms per cubic meter, kPa = Kilopascals, where 1 atmosphere of pressure equals about 100 kPa, max. = maximum, min = minimum, ppm = parts per million, RVP = Reid vapor pressure, vol. = volume.

[a]Ethanol mix minimum of 4.7% by volume and maximum of 5.3% by volume.
[b]TAME mix Minimum of 4.5% by volume and maximum of 5.5% by volume.

3.1 Current and proposed sulphur content

A natural result of the lack of the technical capabilities in many Arab countries is the inability to produce low sulphur content automotive fuels, especially for diesel fuel that can meet the European and U.S specifications. This is clearly observed from the inability of the Arab refineries keep up with the recent specifications and with the inability of some Arab countries to catch up with the Euro 2 gasoline specification such as Yemen, Somalia, Mauritania, Syria and Iraq. In the meantime, several other countries continue to only produce Euro 2 gasoline, such as Egypt, Kuwait, Saudi Arabia and United Arab Emirates. Bahrain and Qatar have both recently achieved the technical capabilities to produce Euro 3 automotive fuels.

Table 11 shows the diesel fuel specifications of the Arab countries of the Organization of Arab Petroleum Exporting Countries (OAPEC).

Table 10: Current fuel quality status in Arab countries

Country	Fuel					Vehicles (Light Duty Passenger)	
	Leaded Gasoline		Diesel sulphur				
	Current status	Comments	Predominant sulphur levels in the market (ppm)	Standard levels (ppm)	Comments	Vehicle emission standards	Enforcement
Algeria	Phasing out leaded gasoline	Algeria will have been 100% unleaded by the end of the present year, pending refinery upgrades	900 max (USEPA 2012)	1500 (OAPEC 2005)		Euro2 and Euro3 standards for both gasoline and diesel	A sample of imported new vehicles is examined by engineers to ensure compliance. Old vehicles are all checked regularly every two years
Bahrain	Unleaded		500 (Focal point)	500 (Focal point)	Adopted a low sulphur fuels strategies. In 2010 the country produced fuels with 10ppm sulphur concentration but for exports. up to 2014, there have still been no standards for sulphur in Diesel in Bahrain	Available vehicle emission standards	No update regarding the status of enforcement. Strict enforcement during licensing is most probable since this is the case in other Gulf countries where passenger cars cross borders without additional licensing
Djibouti	unleaded		-	5000 (PCFV,2008)	No further updates	No information available	No information available

Egypt	Unleaded		6000-7000 (Expert analysis)	10,000 (Focal point; OAPEC 2005)	Super Diesel (never introduced in the market) with sulphur limits set to 2,000ppm	For vehicles manufactured before 2003: HC: 900ppm Co: 4.5% of volume. Opacity: 30% For vehicles manufactured starting from2003 HC: 600 ppm CO: 2.5% of volume Opacity:30%	More work is needed in the enforcement issue
Iraq	Leaded	Gradual phase-out of Lead is in course and to be complete d by the end of 2015 (Ministry of Environm ent of Iraq)[1]	10,000 for Gas Oil, and 13,000 ppm for Diesel (Ministry of Environment of Iraq)[1]	10,000 (Ministry of Environment of Iraq)[1]	Ministry of petroleum has a strategy for upgrading several refineries to produce ULSD and lead-free gasoline	No information available	No information available
Jordan	Unleaded		9,300 (focal point)	12,000 (PCFV,2008)	Produced & imported 350ppm as a better level (the international standard 14596).	Environmental law stipulates issuing ministerial instructions to curb vehicle emissions. No information regarding those instructions	Regular mobile campaigns are launched to inspect vehicle emissions. No information regarding emissions inspection during licensing
Kuwait	Unleaded		500 (Kuwaiti national oil company)	5000 (PCFV,2008)		Vehicle emission standards exist	Campaigns to inspect vehicles in parking lots and stops.Fines for violators. No confirmed information regarding inspections during licensing

[1] Direct communication with the Ministry of Environment of Iraq.

Libya	Unleaded		1000 (PCFV, 2008)	1000 (Center of Standards Specifications of Libya, 2013)	Introduced 350ppm and 50ppm on limited bases (60KT) since 2007	Environmental law 15 stipulates that vehicles must pass internal combustion and fuel quality tests. The general authority for the environment set the following limits for emissions from all sorts of vehicles: ***Gasoline*** hydrocarbons: 900 ppm for vehicles manufactured before 2003 and 600 ppm for those manufactured after 2003. Co: 4.5% for pre 2003 vehicles and 2.5% for after 2003 vehicles ***Diesel*** *Opacity:30%*	Road eligibility tests are conducted during licensing. No exhaust gas tests are performed
Morocco	Unleaded		50 (expert analysis)	50 (PCFV Forum 2010, PCFV 2008, USEPA 2012)		Vehicle emissions standards exist. 4.5% for Co 70% for opacity	Vehicle inspection centers are found in many parts of Morocco for enforcing compliance on vehicles5 years or older. Inspection is not obligatory for new vehicles
Oman	Unleaded		50-500 (USEPA 2012)	No information available		No updates	No updates are available. Oman has a defacto special status in GCC . It might be different from the rest of the GCC countries regarding enforcement
Palestine	Unleaded		10,000-5,000 (PCFV forum, 2008; expert analysis)	No standards	Fuel is mostly imported from Jordan	No standards (dependant on fuel from Jordan)	

Qatar			500 max (USEPA 2012)	10 (USEPA 2012)		Vehicle emission standards exist	Standards are enforced during licensing
Saudi Arabia	Unleaded		-	50 (USEPA 2012)	Standards are being updated to reach Euro5 sulphur levels in all the kingdom's refineries	Vehicle emission standards exist	Compliance is enforced during licensing
Sudan	Unleaded		11,000 (PCFV,2008)	No information available			
Syria	Unleaded		6500 (PCFV, 2008)	7000 (PCFV,2008)		No information	No enforcement
Tunisia	Unleaded		50 (Focal point)	There are specifications for 10ppm Sulphur for the future reference but not used yet (focal point)		Standards for CO and opacity exist	Inspection is done during licensing on annual basis for new cars and half-annually for old ones
UAE	Unleaded		50-350 (USEPA; expert analysis)	5000 (OAPEC 2005)	currently being updated to Euro 5 levels	Vehicle emission standards exist	Very strict enforcement during licensing
Yemen	10%or more unleaded		500 (expert analysis)	No information available	Mostly imported from GCC countries; Euro2-Euro4	Regulation stipulates compliance with environmental requirements	More work is needed on enacting enforcement

Table 11: Development of gasoline quality in Arab countries* (OAPEC 2013, and Expert Analysis)

	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18
Algeria								Euro 4						
Bahrain	Euro 3				Euro 4			Euro 5						
Egypt	Euro 2													
Iraq														
Jordan	Euro 2													
Kuwait	Euro 2													Euro5
Lebanon														
Libya							Euro 2							
Mauritania														
Morocco														
Oman	Euro 2					Euro 3								Euro5
Qatar	Euro 2					Euro 3		Euro 4						
Saudi Arabia	Euro 2							Euro2/Euro3						Euro 5
Somalia														
Sudan	Euro 2													
Syria														
Tunisia														
United Arab Emirates	Euro 2			Euro 3			Euro 4							Euro5
Yemen														

***This table indicates the Euro Fuel standards with regards to sulphur only (however, most or all other parameters are also complying).**

Table 12: Diesel fuel quality developments in the Arab region (OAPEC 2013, Expert analysis)

Country	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18
Algeria	Non-compliant with Euro standards													
Bahrain	Euro 2													Euro5
Egypt	Non-compliant with Euro standards													
Iraq														
Jordan	Non-compliant with Euro standards													Euro 4
Kuwait	Non-compliant with Euro standards				Euro2									Euro5
Lebanon														
Libya														
Mauritania														
Morocco	Euro3/Non- compliant				Euro4									Euro5
Oman														
Qatar	Euro 2													Euro 5
Saudi Arabia[2]	Non-compliant with Euro standards													Euro 5
Somalia														
Sudan														
Syria														
Tunisia	Non-compliant with Euro standards		Euro3			Euro4								Euro5
United Arab Emirates	Non- compliant with Euro standards		Euro 2						Euro3/Euro4					Euro5
Yemen														

*This table indicates the Euro Fuel standards with regards to sulphur only (however, most or all other parameters are also complying).

[2] There are announced plans for switching to Euro 5 standards by 2016. The study team has put back the date to 2018 in order to account for contingencies.

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brazil*	3500	2000				1800-500 transition				500						
China*	2000						350				50			10		
EU-27	50				10											
India*	500					350										
Japan	50		10													
Russia	500								350		50	10				
Thailand	150							50								
USA	500	15														
South Africa	3000	500 (50 in some markets)											10			

*Brazil, India, and China have sub-national regulations requiring higher quality fuels in key cities and regions. This table show nationwide regulations only.

Figure 6:Nationwide Diesel sulphur levels[3](Transport policy, 2014)

Table 11 and Table 12 contain timeframes for fuel quality developments in Arab countries representing different geographic and socio-economic categories as well as prognoses for future developments. The information presented in them is based on data from various sources including, but not limited to, OAPEC publications, national oil companies, UNEP, and international new agencies. They refer to the predominant sulphur levels over the period 2005-2018. The study team and a top Arab oil expert have analyzed that Information in order to construct the presented timetable. The timeframe prediction might slightly differ from those presented by some specialized publications and newsletters because the study team has taken a conservative approach in making predictions due to hands-on and expert experience in regional institutional dynamics.

Some countries like Oman have introduced cleaner fuels such as diesel with 50ppm of sulphur, it is not clear if it is applied at a national scale. In the GCC countries plans are taking course to reach mostly Euro 5 sulphur levels. A constellation of factors drive the trend; relaxed economic conditions and the presence of a sovereign wealth fund; increasing levels of environmental awareness; changes in global refining industry, which is shifting towards the Middle-East and Asia, all combine to drive the upgrades.

Egypt, the largest and most populous and industrialized Arab country, does not comply with any of the diesel Euro standards and does not have current plans for addressing the issue. A wider scope is needed to explain the Egypt case, one which encompasses the crippling subsidy system, and the need to place investments in fuel quality upgrades in the context of expanding the production of medium and light distillates to increase the refineries' profitability

In Morocco, as part of promoting a low-sulphur strategy, the government introduced 50ppm fuels nationally in 2010. Additionally, as cited by the African Refiners Association, the country has set a good example of government efforts encouraging the development of operating refineries producing EURO 4 diesel and gasoline. Another corresponding policy is a decree in 2010 setting vehicle emissions limits. By 2010 Morocco introduced the use of Gasoil 50ppm (EURO 4) and unleaded fuel (EURO 3), reducing emissions of sulphur levels by 55.000 tons/year and lead levels by 760 tons/year (PCFV Forum, 2010). Morocco has a total of 2.6 million vehicles. Strategies adopted for air quality improvement include improving public transport networks and vehicle fleets (EURO 3 compliant); improving air quality monitoring systems and monitoring stations (10 new stations operating starting 2010); developing strategies

[3] In some cities and regions of Brazil, India and China, sub-national regulations exist for fuel quality higher than the national regulations.

for implementing national emissions standards, and developing programs for implementing clean fuels and vehicles.

It has to be emphasized, however, that the success of command and control regulation- vehicle emission standards combined with national fuel standards has been a success due to number of factors specific to Morocco, distinct from the rest of the Arab region. Since private sector is active in local refineries and wholesale distribution of fuel products, environmentally oriented regulation doesn't bear significantly on the national budget. One reason is that a large portion of marketed diesel and gasoline is imported, while international price differentials between low sulphur and high sulphur diesel are not high. Consequently, the government does not have to bear the capital costs of refinery upgrades. The fact that the number of conversion, reforming and hydro-treating units are relatively high for the region, further contributes to the success of regulation.

Besides, private sector involvement and a relatively less intense subsidy system make room for markets to respond to environmental regulation in the most economical way. The fact the Morocco relies for its domestic consumption on local refining of imported crude provides the required economics of scale, mentioned earlier, to refinery upgrades.

Tunisia also greatly relies on imported fuel products. The aggressive pursuit of top-standard fuel quality improvements is attributed to a state-level strategic orientation to streamline its markets with the Euro region, greening the country's image and good level of environmental awareness.

Algeria, although of the same socio-economic category of Morocco and Tunisia, is still lagging behind in fuel quality levels and no updates are available for fuel quality improvements. This is in spite of the fact that Algeria entertains abundant oil resources and a local refining industry. Further exploration is thereby needed for the Algerian case.

Just as Tunisia, Jordan relies on imports, yet the local production meets a larger portion of domestic demand than Tunisia. It is lagging in fuel quality upgrades despite of announced plans of upgrading the country's refinery. It seems that refining industry in Jordan is facing some difficulties relating to its organizational and technological competences. However, the country's overall technical and human resource base is excellent with regional standards which accordingly make the study's prediction with regards to Jordan's upgrade to ultra-low-sulphur levels quite realistic. Another factor at play is the need to avoid disparate duplicate market standards in countries, which rely on both imports and local production as imports are usually streamlined with local production quality.

No reliable updates have been obtained from Syria, but it is nevertheless self-evident that political conditions place political constraints on upgrade plans. In Iraq, despite of the presence of two complex refineries in Al-Dawra and Basra, the national capacity to produce low sulphur diesel is limited due to the predominance of topping refineries. Ongoing upgrade plans focus on expansions in isomerization and naphtha hydro-treating to sort out the pressing leaded gasoline problem. The drastic political upheavals over the last decade have been a factor in the lack of low sulphur goals. On the other hand, the fact that Iraq has cut down subsidies significantly point to the presence of other needs that have to be addressed in order to achieve ULSD targets.

A general observation is that in comparing Arab countries in general with emerging economy countries, such as Brazil and china, it becomes obvious that more work needs to be done in order to catch up. The GCC countries are an exception as most of them are upgrading to match top European quality standards

It is clear from Table 11 and Table 12 that the Arab countries are faring much better in gasoline quality than diesel. Technical considerations, discussed in later sections and throughout the report, render improving fuel gasoline quality more socio-economically feasible.

4 Barriers to Cleaner Automotive Fuels in the Arab Countries

Several barriers pose challenges to the refining industries in Arab countries in pursuing options for sulphur reduction. First there are the high investment costs often required (especially burdensome for the lower-middle-income and lower-income countries),which cannot be justifiable under the current energy pricing system across the Arab world. Political instability and potential social resistance in some Arab countries have further exacerbated the investment risk.

This is not a moot point however in GCC countries since the oil industry constitutes the bulk of its economic activities. Capitalizing on global trends in refining industry mentioned earlier would maximize the return on its oil resource by increasing the added value through expansions in the production of fuel products which must meet the increasingly stringent global fuel quality trends.

The desired outcome is to internalize externalities as much as possible, whereby users pay the true price of the fuel and its impacts. However, the approach and pace to reach this ultimate goal with least resistance will likely vary from one country or region to the other.

The second barrier is a massive energy and fuel subsidies system in the Arab region. This is a key barrier to fuel quality investments in non-oil exporting countries with a local refining industry that cover a considerable share of its domestic demand. Investing in refinery upgrades to improve fuel quality is thus too costly under these conditions and would require long payback periods to pay off. Restructuring subsidies to ensure that it benefits the vulnerable segments of society only is a necessary condition.

It is worth mentioning in this context that studies reveal that benefits of sulphur reduction far outweigh the cost; the U.S. EPA found human health and environmental benefits due to sulphur reduction were ten times higher than the costs (Blumberg et. al, 2003). Other studies in Europe showed that near-zero sulphur in fuel reduces total costs as a result of improved fuel economy (ADB 2008). This justifies investment in programs and schemes that push for cleaner fuels

Despite of the distorted pricing system that stems mainly from the subsidies system, the Arab countries have scored significant successes in phasing out lead in gasoline. However, this has raised the issue of health risks associated with using other octane-enhancing metallic additives and oxygenates in gasoline. The use of additives is subject to debate as to its environmental impacts and must be considered in environmental impact assessment studies.

Putting aside economic factors and global trends in refining industry, catering for the environmental concerns requires that fuels and vehicles should be dealt with as parts of an integrated air quality system since vehicle emissions are ultimately a function of engine technology, pollution control devices, such as diesel particulate filters and catalytic converters, and the quality of the used fuel.

Air quality is also affected by other sources of emissions, road congestion levels, weather and climatic conditions and urban patterns. The specific air quality context in a country or city can influence detailed formulation and implementation of cleaner fuel regulations paired with corresponding vehicle emission standards. This is done by coupling the prospects of the refining industry in a specific country with local conditions of the vehicle fleets and the severity of the pollution problem. Gradual introduction of realistic targets of vehicle emissions standards must be synchronized with plans for fuel quality upgrades so that optimum results with regards to air pollution levels are reached.

The main barrier to this integrated approach is the absence of detailed emission inventories and source-attribution studies that are delaying the recognition of the pressing environmental pressures. This nonetheless should not delay the response with countermeasures.

Again, the GCC countries are unique in that matter since a modern vehicle fleet, economic conditions, and strict enforcement of vehicle emission standards are contributing together to pollution reductions. Tunisia and Morocco have, on the one hand, done good work with the enforcement of vehicle emission standards, although they still need to be expanded. On the other hand they have made strides in fuel quality improvements.

In parallel with implementing agreed upon fuel road maps, Arab countries should continue to strive to improve the frequency and quality of detailed emission inventory and source-attribution studies. This will help to further refine the planning and implementation of integrated vehicle emission reduction strategies.

A third barrier is the lack of institutional capacity for the production of adequate plans, and, in some cases, for following an integrated approach towards sustainable transportation where fuel quality problems are tackled in a wider sustainability context.

5 Fuel quality policy environment

Arab countries can benefit from the experiences of the EU and other parts of the world and can base their decision making on fuel quality research and refinery advances implemented in the EU, Japan and the United States. Extensive research has been conducted in support of the development of fuel quality standards. The development of vehicle emission and fuel standards is based not only on emission reduction potential but also, as discussed in the previous section, on issues pertaining to the local vehicle fleet and the air quality system. Arab countries have indicated a preference for Euro emission standards.

However, they have not always implemented all fuel parameters as defined in the fuel specifications of the various Euro emission standards. Also the data gathered in the report shows that more often than not the marketed fuel is of better quality than standards as mentioned earlier. This is due to the level of complexity engulfing the energy sector and its policy environment. This dynamic has been run over in the barriers section and will be further unraveled throughout the present section and the later ones.

Pricing, Taxation and other incentives for cleaner fuels

On a global level, the USA, China, and the EU are among many regions and countries designing and implementing a variety of fiscally and economically actionable instruments in order to gravitate towards a cleaner fuel-based economy and sustainable development.

As distinct from the command and control regulation of strict enforced standards, a large kit of market-based tool sis available and used all over the world to implement fuel quality polices. The tools used vary across the globe as per the objectives and conditions specific to different conditions of specific countries. It includes taxation, financial penalties on vehicle manufacturers and assemblers in case of failure to comply with set regulations and standards, credit programs and rebates for purchasing efficient vehicle models. Also, some countries use other approaches such as taxation on engine specs, taxing vehicle CO2 emissions, lower trade

tariffs on imported green vehicles and related components while others penalize certain vehicle models.

In most Arab countries the utilization of such tools would be unrealistic under the current ownership structure of refineries and the large level of state involvement where governments in many cases assume the roles of owner, operator and regulator of the various components of the fuel production value chain. These instruments could be viable in Countries where the lion's share of its fuel products comes from imports; especially that private sector has a considerable presence in wholesaling and distribution.

Yet, even in countries within the region that have taken serious steps to mainstream the use of lower sulphur fuels such as Morocco and Tunisia the extent of utilizing market-based tools to reinforce cleaner fuel standards and lower sulphur concentrations in the Arab Region, especially fuel taxation, has been notably limited compared to Europe. This is because of the lower energy footprint in these countries, less mature refining industry and which is small in terms of scale compared to the U.S and Europe. Lack of coordination and institutional capacity pose a significant challenge in designing and implementing effective instruments. This is especially pertinent to taxation and pricing regimes which require close and continuous cooperation between different line-ministries such as the ministries of environment and ministries of finance, as well as between the government and the private sector.

Moreover, policy makers in the region have not yet tailored locally suitable fiscal instruments that take into consideration relevant country specific socio-economic events. Currently, many governments within the region also face challenges in adopting fuel taxation and other relevant measures due to overriding economic and political instabilities derived from prevalent income disparities, high unemployment, security breaches and poverty. There are 10 out of 22 Arab countries that are rated as low income and lower-middle income countries according to the World Bank country classification[4].

A country like Egypt is currently facing substantial challenges to pay for imported fuels due to international oil price volatility, lack of foreign currency and an increasing budget deficit.

The Arab Region however is distinctly characterized by predominance of high fuel subsidies, which must be taken into consideration before discussing taxation policies that might be premature in most cases. Furthermore, higher fuel pricing is often associated with higher quality fuel, whereas fuels of lower quality and lower octane numbers are often cheaper. This means that the public might perceive incentives for higher quality fuels as favoring the richer classes who can afford to pay more for use of cleaner fuels for their vehicles, unless associated with innovative financing schemes.

To address public resistance due to increased fuel prices, a larger systems approach in tackling fuel quality, where sustainable transportation trends are encouraged is mandated. Enabling conditions for sustainability in transportation are enhanced and created through, inter alia, expansion in mass-transit; road systems favorable to un-motorized transportation and bus rapid transit; policies and incentives that lower city congestion; mobilizing resources towards efficient, inclusive and aesthetic urban planning.

The incremental costs of compliance with the sulphur content limits of ULSD(Euro 4/5) have been found to be on average about 0.3-1US cents/ liter for gasoline (ADB, 2008).Those costs can reach down to about two cents/ liter, on average, for diesel; International price differences between Ultra low sulphur Diesel (ULSD) and 0.1 gas oil (1000 PPM sulphur) can reach down to only two cents per liter according to the spot markets price lists (Platts, 2014).For example in

[4] The World Bank's classification is based on GNI per capita for the year 2012. Low income countries are of $1,035 or less. Lower middle income countries are of $1036-$4085

2011, Tunisian diesel imports amounted to 26 MBD. Importing 1000 ppm sulphur saved only $ 82, 6321,133, which may not be an essential saving for the economy, especially given the expected external health and environmental costs. A holistic cost-benefit analysis would better evaluate this status when drafting a national plan..However, the case is totally different when cost of upgrading topping refineries is included. For example, upgrading the Tanta topping refinery in Egypt to produce ultra-low-sulphur diesel would cost around $750,000 adding about 70 U.S cents to the cost of one liter using simple payback method. These upgrades are for adding sulphur reduction units, but they cannot alter product mix considerably as is the case to upgrading to conversion refineries with cracking units.

Taking a more holistic approach makes the incremental costs associated with producing low sulphur fuels relatively small compared to the health care costs averted and environmental benefits. Alas, it is not yet common practice to internalize external environmental costs in assessing economic impact of policies in the Arab region. Furthermore, the low subsidized fuel prices in the Arab Region casts excess pressure on the economic feasibility of this approach.

Many countries including Egypt and the Gulf Cooperation Council Countries(GCC) are still governed by stringent fuel subsidy systems that underestimate the actual costing of producing or acquiring fuels. As a result the domestic market pricing of fuels does not even cover the actual cost.

However, the incremental costs of introducing cleaner fuels differ between each country and must be assessed for each nation separately in order to have a more accurate understanding of the associated costs, and preferably to include the externality costs of environmental and health impacts. Generally and before recent events in the region, the possibility of eliminating subsidies leading to price increases has almost always been met with resistance, as seen in Jordan and more recently in Egypt. However the superseding economic recession faced by many countries of the region are currently forcing the governments' hands into phasing out fuel subsidies due to alarmingly escalating budget deficits and the need to liberalize markets.

In several cases, there are non-fuel-producing countries in the region that are being compelled to revise and perhaps completely remove subsidies on fuels for pressing economic reasons. Oil-exporting rich countries might not face similar conditions to cause them to reconsider subsidies. However their long to medium economic development plans with steadfast liberalization, increased industrialization, promoting of energy efficiency policies and a growing GDP are all factors that will also drive their government to at the very least introduce a gradual lifting of subsidies.

Given the context of the region, removing fuel subsidies [subsidizing cleaner fuels] can be seen as a short-term first step in promoting fuel efficiency, energy savings and boosting the sales of more efficient vehicle models in the transportation sector. An interim step could be associating clean fuels with better quality fuels (higher octane) and charging for a premium price on the top-standard fuels while testing the waters and consistently reiterating to perfect the plans serving a strategy for an expansion in clean fuel production.

This may be particularly suitable for countries like Egypt, for investments in upgrading simple and topping refineries can only pay off via economies of scale achieved through expansions in light and medium distillates production.

Meanwhile, a communicable and transparent public outreach campaign must be adequately synchronized with the aforementioned plans to educate the public on the realities of the economic and energy situations, and to diligently inform the people about the benefits of lower sulphur fuels and the emissions benefits of cleaner fuels, as well as the externality costs of pollution. A prerequisite for the success of the outreach is political transparency which should

proliferate among the public a general mood of trust by redirecting the saved resources towards creating job and investment opportunities and better public services.

Ghana provides a good example of the success of the outreach campaign in uprooting the initial fierce public resistance to subsidies reform. While in Ethiopia the public understanding of the dire conditions facing the country from draught years facilitated public acceptance of energy subsidy cuts. Taking concrete steps towards promoting sustainable transportation trends discussed earlier would lend credibility to the public outreach campaign and mitigate the resistance stemming from rising fuel prices.

The final step would be the removal of fuel subsidies and substituting it with cash transfer schemes, which many economists argue are the most effective policy in that regard. Such a policy development will complement existing efforts in the region for setting fuel standards with lower sulphur concentrations and related savings measures. Leadership of the richer countries is fundamental; 6 out of the 22 Arab countries are high-income countries that are more likely to have the capacity to lead this shift towards clean fuel policies in the region.

The previously discussed subsidies reform is a precondition for the economic success of upgrade plans- though it has to be emphasized that it is not the only condition. The magical word for creating the right policy environment for refineries upgrade is enhancing the institutional capacity for effective integrated planning that furnishes a landscape which can contain the repercussions of the inevitable fuel price increases associated with refinery upgrades. This is done through sound planning of refinery upgrades and providing solutions for decreasing the reliance on fuel. The fact that several Arab countries have cut down subsidies significantly while they are still lagging behind in fuel quality, such as Jordan and Iraq substantiates the argument.

5.1 Timing the Introduction of Cleaner Fuels

To introduce cleaner fuels, governments usually introduce Euro 4 and Euro 5 fuel quality standards. These standards will drive the timing of and investments needed for the installation of existing technologies for new process units and expansion of existing units- which would be required in most of the older refineries in Arab countries. Nonetheless, an advantage of the delayed introduction of these technologies in the Arab Region is that they are now well established and can be applied in Arab countries with minimal risk.

Given the ownership structure of refineries in the region which has been mentioned earlier, relying on the introduction of clean fuel standards would not be the right tool, unlike other places like the U.S where private sector controls the energy market and the government assumes the role of the regulator and rule setter. This is not the case for countries which rely, mostly, on fuel imports since the government can influence the choices of wholesalers and distributors through fuel quality standards.

Building new refineries takes 4 to 5 years while upgrading an existing one may take up to 3 years. Finance and engineering would take one or two years raising the total up to7yearsfor building new ones, and 4-5 years for upgrading an existing one. In the meantime, vehicle emissions and engine fuel efficiency standards for new vehicles can be worked on and introduced well within the time required to establish or modify refineries, along with plans for modernizing the local pool of vehicles, in order to tie progress in cleaner fuel standards with the introduction of cleaner vehicles or retrofitting existing fleets where feasible.

5.2 Facilitating the Introduction of Cleaner Fuels in Arab countries

Ideally the extra cost for producing cleaner fuels should be passed on to the consumer. However, controlled pricing regimes in many Arab countries tend to prevent opportunities to pass higher costs of cleaner fuels onto consumers. Governments of Arab countries have borne the costs for producing cleaner fuels so far; fuel in Saudi Arabia is a prime example, and it is the cheapest in the Arab region and among the cheapest worldwide.

Nevertheless, high international oil prices in recent years, and increased local demand are forcing many governments to begin dismantling fuel subsidies and price controls, such as in Morocco, Sudan, Tunisia, Jordan, and Egypt, as well as Lebanon, which today sells fuel at its actual cost plus taxes. This is putting more pressure with time on mostly the net importers of oil to improve their subsidy- and fuel-pricing policies.

In order to facilitate introduction of cleaner fuels, the policy environment must be set for a host of policies engineered to be best fit for the local conditions in the Arab countries. In light of the data analyzed throughout the report and the particularities of the policy environment of the fuel regime in the Arab region, the following measures recommended to be taken by Arab governments in coordination with civil-society and development organizations that may offer technical and/or financial support:

- Intensifying awareness-raising about cleaner fuels, air pollution, and relevant externality costs from the impact on health and the environment as well as indirect impact on energy conservation on public and job creation by channeling financial resources to investments incentives in different sectors. For, the awareness campaign to be sustainable, it has to be highlighted in school curriculums and university discourse. The state media can play a significant role, especially in communicating with the disenfranchised portions of populations. The political mobility, which the region has been witnessing in the aftermath of the recent political upheavals, should be perceived as an asset in this campaign. This is through the engagement of credible civil society organizations and serious political parties and communicating effectively to them realities of the energy situation as well as the associated aspirations and policies. A liberalized energy market presents looming prospects for private sector actors with an eye on strategic investments; thereby, an inclusive process of planning that accounts for potential stakeholders can provide extra financial resources for the awareness campaign to be discharged through the widely spread and popular digital media outlets.

- Ensuring availability of local scientific analyses of air quality, health, and fuel and a strong role for civil society to improve the political feasibility of adjusting fuel pricing.

- Enhancing inter-institutional and inter-ministerial coordination and the harmonization of their activities.

- Within the framework of the holistic systems approach discussed in the previous section, planning for high-quality fuels requires the work of energy, environment finance, transportation, education, health and scientific research ministries as well as private sector stakeholders, civil society actors and erudite academics. Accordingly, shortcutting the bureaucratic obstacles to such an encompassing huge mission while ensuring the best possible performance for a sustainable transportation system would require a cross-functioning, inter-disciplinary policy and research committee. Hedging there commendations and findings of the committee against freezing and slipping into the backburner calls for the generation of specialized, lean task forces to execute the integrated plans across the different components of the transportation system;

- The outcome of this inter-institutional work should be a set of master plans and subordinate ones for subsidy reform, refinery upgrades, fuel import policies, pollution inventories, standards-setting, and the development of sustainable transportation trends. The task forces, on the other hand, would assume detailed planning and execution.

- Benchmarking against successful international experiences of countries of similar socio-economic conditions that have undergone subsidy reform and development of air quality standards and fuel quality improvement.

The fundamental prerequisite to these measures is ensuring the political will to prioritize the vision for cleaner fuels and to act upon it.

6 Recommended Approach and Policy Options

In order to succeed in improving fuel quality in the Arab Region, all measures should be taken in tandem with other efforts to phase out (or rationalize) fuel subsidies and efforts to improve vehicle emission control and vehicle technologies. Furthermore, with regards to sulphur, concern over quality of Diesel fuel is of higher priority due to the commonly high sulphur content compared to gasoline. Accordingly, SO_2 emissions from diesel are much higher than gasoline, turning diesel sulphur into an environmental hotspot.

Moreover, upgrading existing topping refineries to lower gasoline sulphur content is less capital intense than to lower diesel's. A reforming and an isomerization unit are sufficient to produce gasoline up to Euro 2 standards. On the other hand, to reduce sulphur content for diesel ina refinery with a reforming unit requires investments in an Amine plant, a sulphur reduction unit and a tail gas treatment unit which in turn curbs investments in diesel fuel quality upgrades and hence a higher level of policy intervention is needed in case of diesel.

For gasoline, on the other hand, the emissions of aromatics are more potent carcinogens, which mandate prioritized action that is facilitated by higher capacity of Arab refineries to produce better quality gasoline as indicated in the introductory sections. Regarding the more complex refineries, more capacity is dedicated to the production of cleaner gasoline for the exact same reasons and demand factors. As shown in **Error! Reference source not found.**, diesel fuel consumption is close to gasoline in the Middle East which further justifies the emphasis laid in the study on diesel fuel.

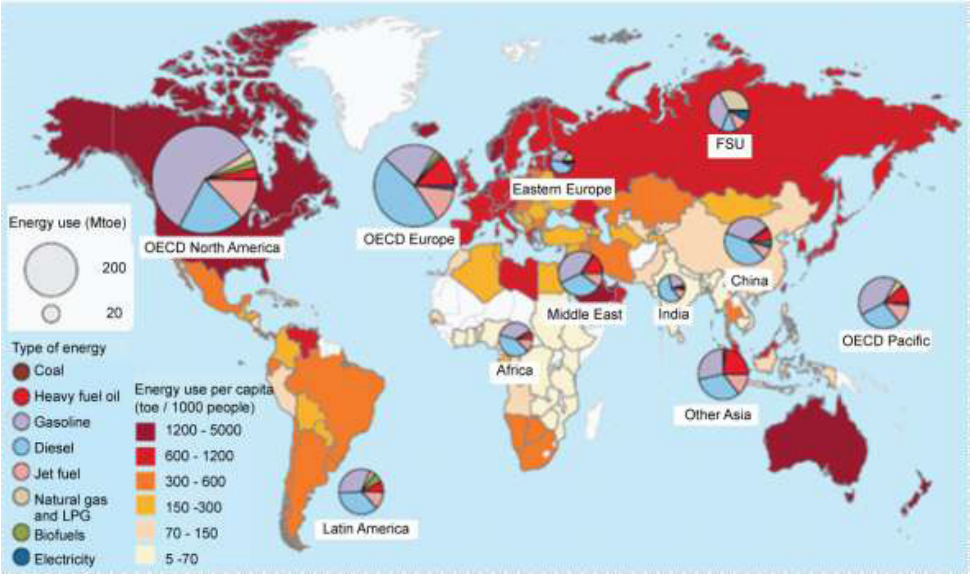

Figure 3: Transport Energy use by region in 2007 (WEC, 2011)

A number of Arab governments have announced investments for the production of the cleaner diesel and have scheduled targets for Euro3 or Euro 4 or Euro 5 standards (GCC countries, Jordan, Morocco and Tunisia). An expansion of the existing refining capacity, which is now becoming more likely after a long period of stable refining capacity in the Arab region, can be expected to increase the volume of cleaner fuels produced. The governments can set cleaner fuel production targets by evaluating the impact on regional fuel supply, evaluating special characteristics of the refining industry in each country, and considering a matrix of investment alternatives and their correspondent cost benefit analyses as well as compliance flexibility options for fuel quality parameters, which means prioritizing those quality parameters that represent environmental hotspots, especially in countries with no export potential.

For properties where there is potential for deviation from the Euro 4 & Euro 5 standards (RVP, olefins, aromatics), experts should evaluate those standards and alternatives to determine the emissions increases and the air quality penalties associated with the relaxation of the standards. In that regard they are not really exceptional as the approach is similar to that in Australia and the United States, where, when industry proposes a modification of the standards, an evaluation is performed to determine the optimal path (ADB 2008).

There might be circumstances, however, where the implementation of such a comprehensive set of fuel properties would significantly delay the introduction of cleaner fuels. In such cases, decision makers will have to balance the benefits of, for example, reducing sulphur levels with the costs of not addressing other fuel properties at the same time.

Recommendations for the Arab region to improve fuel quality are listed hereunder. On considering this set of recommendations care must be given to the contextual differences across the region:

- **Benchmarking and compliance flexibility:** Most of the Arab countries are benchmarking their progress in cleaner fuels and vehicles against European standards, so the combined cleaner fuels and vehicles approach can succeed to provide a clear road map that links to vehicles emissions standard with optimal cleaner fuel parameters. In the meantime, deviation from the standards for certain parameters (other than key contaminants such as sulphur) due to local conditions may be allowed so that locally-tailored standards may be used to facilitate feasibility. Compliance flexibility or flexibility in fuel quality parameters may provide significant reductions in operating costs and reduce market volatility. Attention should be paid, however, to common industry guidelines, to ensure fuels meet international standards, e.g. UNECE Working Party on pollution on environment (WP29).

- **Partial introduction of cleaner fuels:** Partial introduction of low-sulphur fuels is possible in Arab countries that already produce high-quality fuel in some of their refineries. This can be implemented in cities or for certain fleets, such as city buses that are less likely to exit the city premises.

- **Addressing diesel vehicles first:** Certain types of retrofit strategies are technically feasible for gasoline fueled vehicles, but they have not been as successful as diesel retrofits in other regions such as in Asia, and a similar situation is expected in the Arab region since sulphur emission concerns are more eminent from Diesel-powered vehicles.

- **Reforming and rationalizing subsidies:** Most of the Arab country refineries are topping and simple refineries without any conversion units. This calls for a substantial number of projects needed for installation of new process units for producing Euro4 or 5 with significant capital investment. The willingness of refiners to invest in the production of cleaner fuels is a function of their ability to recover expenditures through price adjustments, which will only be facilitated as the subsidy schemes are restructured or phased-out appropriately or redistributed rationalized to target those who most need them. International experiences in innovative subsidy schemes should be extrapolated and modified to suit the receptive contexts. The Brazilian experience in targeted subsidies offers a good few points for inspiring the locally tailored schemes.

- **Supporting the introduction of cleaner fuels:** Until fuel subsidies can be addressed, as an interim step, Arab countries can give precedence to cleaner fuels in government projects and mandating the use of clean fuels in all government related tenders. Government subsidies to public transportation must be linked to the use of cleaner diesel in countries where different diesel quality varieties exist.

- **Parallel measures for promotion of cleaner vehicles: A preference for ULSD: Countries with limited refining industry need only t**o introduce partial subsidy reforms to make ends meet in imported ULSD. Countries which rely on imports partially should prioritize the use of ULSD in all governmental transactions and means of transportation
-

- **Setting sound economic guidelines for the planning of refinery upgrades:** expansions in refineries capacity and upgrades must ensure the generation of economics of scale by ramping up the production of light and medium distillates. Reliable forecasts for the increase in energy and fuel demand and are prerequisite for the economic success of these investments which would require a longer payback period to offset the excess costs incurred during the interim period of subsidies phase-down and elimination.

- **Foreseeing future market requirements:** Today, there is roughly an overall balance of consumption and production of vehicle fuels in the Arab region, and after the construction of the new refineries by 2018, there will be a substantial surplus for net export to the rest of world. This prospective world market has strict automotive fuels standards, which is expected to be one of the main motivations for the Arab refineries to aspire to such high standards in their future plans and export quality fuels must be put into consideration if planning any compliance flexibility measures in national strategies.

- **Improving fuel economy and efficiency of vehicles:** Clean vehicle technology with appropriate emission control is interrelated with the often-prerequisite fuel quality improvement, and both must proceed in tandem and are mutually beneficial for the automotive industry and the refining industry.
- **Taking advantage of pending expansions:** Arab countries' future mix of fuel products will be more diversified, with alternative fuels such as CNG (biodiesel and other alternative fuels still under study), which is gaining a larger market share such as in Egypt and Algeria. Such alternative fuels can play an important role in reducing air pollution caused by the transport sector. However, experts see that gasoline and diesel will continue to constitute the bulk of transportation fuels, particularly in Arab cities, over the next 10-15 years. Thus it is important that policy makers develop and agree upon future standards for gasoline and diesel. Following a period in which no new refining capacity was created in Arab countries, the surging demand for transportation fuels has resulted in additional demand, which can no longer be met by existing refineries. This provides fuel regulators with a window of opportunity to shape the future refining structure in Arab countries.

- Integrated **planning and** policymaking: planning for fuel quality upgrades must synchronize and synergize with a whole set of policies designed for enhancing the sustainability of the entire transportation sector. This is a necessary condition for particularly the countries with a less complex refining industry that supplies a considerable share of domestic demand. The pressing economic conditions and the popular resistance to fuel quality upgrades necessitates the treading of multiple routes simultaneously in order to mitigate the social and economic repercussions of increased fuel prices

7 Roadmap for sulphur Phase-Down in the Arab Region

The 22 countries of the Arab region vary significantly in terms of their oil resources, maturity of the refining industry, investment capabilities, and priorities, although one common factor in most countries is that there are expensive subsidy policies in place. However, in order to best draw actionable conclusions from the findings of this report, and in consideration of the context of each Arab country, a general framework for a roadmap for the region is proposed.

The roadmap addresses as a priority the impact of poor fuel quality on air quality and human health. The roadmap focuses on diesel fuels for reasons elaborated in the previous section. This, combined with the high vehicle density in large cities affecting air quality, health and environment, is the reason diesel fuel quality requires immediate attention.

In Egypt for example, new public busses meeting Euro-III standards have been introduced, yet the sulphur content in Diesel remains at 6000/7000ppm, which inhibits the low-emission performance of the bus. From the viewpoint of climate change mitigation, there is a preference for diesel due to the higher combustion efficiency of diesel and the resulting lower CO_2 emissions raising the interest of some countries in increasing the deployment of more efficient diesel vehicles to decrease oil imports as part of an energy security strategy. However, these climate benefits may be lost if the diesel fuels and vehicles are substandard, since other local pollutants will be emitted at high rates, such as black carbon.

Furthermore, local pollutants would then be a major concern as well as the vehicles fuel economy since fuel specifications influence drivability, engine-wear, and the fuel efficiency, which is important in terms of impact on greenhouse gas emissions, energy saving, and fiscal burdens on the governments subsidizing the fuel.

Some countries in the Arab region, such as the GCC countries and Morocco, have already developed the capacity to produce Diesel fuel of 10 and 50 ppm sulphur, even without the formal requirement to do so.

On the other hand, other countries with a modest refining industry that comprises mainly topping and simple refineries have more challenging investment decisions to make considering the foreseen returns on investment as well as the socio-political impacts of transferring costs to consumers as discussed earlier. Whereas countries that totally rely on fuel imports are positioned to improve the quality of its domestic supply as the price differentials between ULSD and high sulphur diesel are not large.

With much care to the social impact and impact on small or older refineries, the study concludes with a proposed roadmap framework for ensuring better fuel quality in different categories of countries. Table 13 classifies the Arab countries according to the availability of a local refining industry, its technological level, share of domestic consumption, and availability of crude

Table 13: Classification of Arab countries

Group	Local refineries share of domestic consumption > 50%	Capacity of ULSD production	Share of imports in marketed fuel >10%	Countries
1			X	Lebanon, Tunisia, Somalia, Mauritania, Djibouti, Yemen, Palestine
2	X		X	Jordan, Sudan, Egypt, Iraq, Algeria, Lybia, Morocco
3	X	X		Saudi Arabia, Kuwait, UAE, Bahrain, Qatar, Oman

Group 1: This group has a good prospect for improving diesel quality as it relies on imports where international pricing patterns for diesel fuels of different quality demonstrate small differences. However, in case of pressing other economic priorities, only a partial reform of the subsidy system, which is relatively small, would suffice for offsetting the relatively small increases in fuel prices associated with importing ULSD.

The initial target is capacity building in international markets forecast to secure the best possible import arrangements and contractual terms. Planning for imports should go hand in hand with capacity building to make the whole process reiterative then the next step would be finalizing the plans. Finally the group should proceed with imports. The time frame of the whole process would be in the range of one or two years depending on factors indigenous to each country in the group.

To reach the target of ULSD for those countries, several targets have to be properly synchronized compromising a roadmap to fuel quality improvement. They come as follows:

- **Target 1:**capacity building in global fuel markets forecast and procurement to guarantee optimum prices and terms for fuel imports. It is important to arrive at scientific estimates of the global fuel market and oil industry futuristic trends.

- **Target2**:Planning the imports of ULSD. The plan should include prospective and alternative exporters, a set of favorable contractual terms, and the required resources

- **Target3**: Importing ULSD

Table 14: Recommended roadmap framework for Group 1

Recommended Road Map for Group 1	Steps			
	1	2	3	4
Capacity building in global fuel markets forecast and procurement				
Planning the imports of ULSD				
Importing ULSD				

Group 2: A mid-term solution is refinery upgrades. Public acceptance for the associated arrangements is necessary for the success of refinery upgrade plans. Preference in imports should be given to ULSD, which is a quick, easy to implement, cost-effective solution. The initial target is enhancing the institutional capacity for comprehensive all- encompassing planning of refinery upgrades. Assuming proper level of mobilization, the timeframe of this target should be less than a year.

Planning for importing ULSD is the second target, which starts and finishes with the first target. After plans for ULSD imports have been laid, Importing ULSD can be initiated. Planning and initiating the import of ULSD is a one or two-year endeavor.

Adequate planning for refinery upgrades is a crucial target that must be executed effectively and integrated into wider plans for enhancing the sustainability of the transportation sector and communication with a wide circle of stakeholders. Time frame for this target is a year or two depending on the level of the plan's integration into wider sustainability planning. Upgrading the refineries is the last target and would be executed in a 3-6 years according to the political resources dedicated to fuel quality improvements. Morocco has set an example in upgrading its refineries, and is planning to build new refineries capable of producing ULSD.

The roadmap targets come as follows:

- **Target 1:**Enhancing the institutional capacity for comprehensive planning of refinery upgrades
- **Target 2**:Planning for switching in imported share to ULSD
- **Target 3:**Preparingrefineryupgrade plans
- **Target 4**: Importing ULSD
- **Target 5:** Upgrading refineries

Table 15: Recommended roadmap framework for group 2

Recommended Road Map for Group 2	Steps						
	1	2	3	4	5	6	7
Enhancing the institutional capacity for comprehensive planning of refinery upgrades							
Planning for switching in imported share to ULSD							
Preparing refinery upgrade plans							
Importing ULSD							
Upgrading refineries							

Group 3: For, the GCC countries refinery upgrades are being rapidly pursued. Investments are being made in hydro-desulphurization and conversion units. Some short-term solution can be pursued to propagate ULSD while the refinery upgrades are taking place. The institutional capacity and planning resources are well positioned for immediate action on switching to ULSD imports.

- **Target:** Giving preference to ULSD imports until the ongoing refinery upgrades are completed.

Table 16: Recommended roadmap framework for group 3 countries

Recommended Road Map for Group 3	Steps						
	1	2	3	4	5	6	7
Giving preference to ULSD imports							
Ongoing Refinery upgrades							

In this context, meeting Euro4and Euro 5 standards is a matter of national priorities, which may not be possible for all Arab countries under the current refining industry expansion plans in the foreseeable future. This report therefore comes as a tool to be utilized by policy makers for exploring the routes to the prioritized transition. Some Arab countries, however, are showing excellence in cleaner fuel production that in some cases may exceed standards of advanced complex refineries in Europe, which also shows an opportunity for the Arab region to show leadership in producing cleaner fuels.

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