



POLICY BRIEF

Cleaner Fuels for Cleaner Air

Towards cleaner, low-sulfur Diesel Fuel



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الملخص التنفيذي

في ظل توجهات الدولة للتركيز على تطوير الصحة والتعليم في الفترة المقبلة وتوافقاً مع استراتيجية التنمية المستدامة (مصر ٢٠٣٠)، أعد مركز البيئة والتنمية للإقليم العربي وأوروبا (سيداري) - في إطار التعاون المستمر مع وزارة البيئة وبالتعاون مع برنامج الأمم المتحدة للبيئة - دراسة تناول قضية ذات أولوية ملحة تتعلق بمجابهة تلوث الهواء في مصر وتتلخص في النقاط التالية:

● تستمر الدولة في إنجازاتها للوصول إلى الاكتفاء الذاتي من احتياجات الوقود بحلول ٢٠٣٠ بفضل مجهودات وزارة البترول والجهات المعنية الأخرى ساعين إلى الانتهاء من عدة مشروعات واعدة في الفترة المقبلة.

● تتوجه الجهات المعنية بالبيئة والصحة إلى لفت الانتباه إلى فجوة هامة جداً فيما يخص الحفاظ على الصحة العامة ونوعية الهواء في مصر في ظل تلك التطورات - وهذا لما تم رصده من تأثيرات خطيرة بسبب الوضع الحالي الخاص بنوعية وقود الديزل (السولار) حيث أن نسبة الكبريت به لا زالت (وستظل حتى ٢٠٣٠ وفقاً للدراسات) أكثر من مائة ضعف الحد الآمن المتعارف عليه عالمياً... وهذا:

(١) لما يمثله تحسين جودة هذا الوقود من أولوية في مجابهة النسبة الأكبر من ملوثات الهواء في مصر ومسببات الأمراض الصدرية والسرطان وتأثيرات بيئية وصحية أخرى وتدهور آثار مصر،

(٢) حيث تتسبب نسبة الكبريت العالية (المتوسط ٢٦٠٠ وقد تصل إلى ٥٠٠٠ جزء في المليون - أكثر من عشرة أضعاف الحد الآمن، ومائة ضعف المعايير الأوروبية الحالية) تتسبب في انعدام فاعلية أجهزة علاج العوادم في جميع المركبات التي تعمل بالديزل في مصر، وهو ما أكدته القياسات الفعلية،

(٣) حيث تمثل تكاليف التأثير على الصحة بسبب تلوث الهواء أكثر من 2.5 مليار دولار، منها الثلث ناجم عن قطاع النقل وحده بسبب الديزل في المقام الأول.

● توصي الدراسة بتنسيق الجهود مع وزارة البيئة لوضع خطة العمل لتطبيق معايير (اليورو ٥) للديزل كأولوية للمحافظة على الصحة العامة، وتدعو الجهات المعنية للتشاور حول التوصيات التالية والتي توصلت إليها الدراسة الأولية إلى إمكانية تطبيقها:

(١) فرض معايير (اليورو-٥) في الديزل على مستوى القاهرة الكبرى كمرحلة أولى (نظراً لتوافر الكميات اللازمة حالياً والتي تنتجها معامل التكرير المتقدمة) - ومن ثم إعداد مواصفة قياسية مصرية لوقود الديزل المتداول في منطقة القاهرة الكبرى.

(٢) تعميم ذلك على الدولة فور اكتمال توفير الكميات الكافية (من خلال معامل التكرير الجديدة + إزالة الكبريت من منتج المعامل القديمة + منع استيراد الوقود الملوث) - علماً بأن تكاليف التأثير على الصحة والبيئة أكثر من تكاليف إجراءات الحد من الكبريت (Desulphurization) وفقاً للدراسات الدولية (وتوصلت دراسة "سيداري" إلى تقييم الاستثمارات اللازمة لإزالة الكبريت في مصر بـ ٥٠٨ - ٦٦٠ مليون دولار فقط).

(٣) إدراج التكلفة الناجمة عن تدهور الصحة والبيئة في منظومة صنع السياسات، حيث أشارت دراسات البنك الدولي إلى فقدان الدولة قرابة الـ ١% من إجمالي الدخل القومي بسبب تدهور نوعية الهواء وتأثيرها على الصحة، وقد تزيد تلك النسبة إذا ما أضفنا إليها التأثير على السياحة والزراعة والمباني الأثرية والتغيرات المناخية، وجودة الحياة بشكل عام، علماً بأن انبعاثات المركبات هي أكبر مصدر لتلوث الهواء.

توصي الدراسة بأهمية مشاركة وزارة البترول في الدراسات والفعاليات البيئية ذات الصلة بالتعاون مع وزارة البيئة ومركز البيئة والتنمية للإقليم العربي وأوروبا "سيداري" لمواجهة هذا التحدي واتخاذ الإجراءات اللازمة الموصى بها أعلاه وفرض التزامات على الشركات بإصدار تقارير دورية عن نسبة الكبريت في الوقود في الإنتاج الفعلي لرصد التطورات وتمكين وزارة البيئة من القيام بمهامها.

EXECUTIVE SUMMARY

In accordance with the agenda of the government of Egypt focusing on the advancement of education and health in the coming period, and in alignment with the Egyptian Sustainable Development Strategy (Egypt Vision 2030), the Center for Environment and Development for the Arab Region and Europe (CEDARE), in light of continued cooperation with the Ministry of Environment of Egypt and the United Nations Environment Program (UN Environment), conducted a study addressing an issue of *pressing* priority to mitigate air pollution in Egypt, with outcomes summarized in this policy brief. The highlights are as follows:

- The nation is continuing its achievements in approaching self-sufficiency in local production of fuel products to reduce import dependence by 2030, thanks to the efforts of the Ministry of Petroleum and the relevant authorities and stakeholders advancing the sector towards numerous promising projects to boost local production of high-quality products.
- Stakeholders concerned with environmental and health factors however draw attention to a very important gap associated with improve public health and air quality in Egypt in light of these developments in the refining sector. The current quality of Diesel fuel (the fuel colloquially referred to as “Soular”), currently has a content of Sulphur being far more than 100 times than the limits allowed in common international standards, and has been observed to cause substantial health and environmental damage, and it will continue to be so without additional interventions. It has been estimated to remain at dangerous levels even with ongoing expansions of production (it will still be >100 times more than target quality beyond 2030), with consideration of the following points:
 - 1) Improving the quality of diesel fuel is identified as a priority in addressing the largest contributor to air pollution in Egypt; transport.
 - 2) High contents of Sulphur (average 2100ppm and may reach 5000 ppm, a hundred times higher than acceptable levels) results in inhibiting the performance of the vehicle emission control devices in all diesel fueled vehicles in Egypt, confirmed by studies indicating high pollutant concentrations attributed to vehicle emissions in ambient air. Current specifications allow up to 10,000ppm.
 - 3) Costs of health damage exceed USD 2.5 Billion attributed to air pollution, of which a third is caused by the transport sector, primarily due to Egypt’s inferior diesel fuel quality and high consumption.
- The study recommends coordinating efforts with the Ministry of Environment to develop the action plan for introducing Euro-5 diesel fuel standards as a priority for addressing public health and environmental concerns, and invites relevant stakeholders

to cooperate in pursuing the following recommendations based on the preliminary study on the topic, which assured the viability of implementation:

- 1) **Enforcing Euro-5 diesel fuel standards in Greater Cairo** as a first phase (given the availability of Euro-5 diesel fuel quantities today produced by advanced refineries) and establishing a new low-Sulphur standard for diesel fuel.
- 2) **Nation-wide Euro-5 diesel standards** enforcement throughout all Egypt upon availability of sufficient quantities (i.e. through new refinery projects + desulphurization (Sulphur removal treatment) of the products of old refineries + prohibiting import of high-Sulphur diesel fuel). Notably, costs of health and environmental damage are greater than the costs of desulphurization measures according to international studies (while CEDARE's analysis for Egypt indicated that investment needs are modest, in the range of 508-660 MUS\$ for all desulphurization needs).
- 3) **Incorporating costs of damage to health and environmental degradation into policy development processes.** The World Bank studies on the damage costs of air pollution (sector note of 2013) indicated that Egypt incurs substantial costs due to damage to health from air pollution, reaching approx. 1% of GDP. This valuation would further increase if additionally considering impact on tourism, agriculture, historical monuments, climate change, and the quality of life in general, whereas vehicle emissions alone contribute to about one third of air pollution in Egypt.

Accordingly, the study stresses the importance of the role of the Ministry of Petroleum in effective participation in environmental studies and associated consultation events in cooperation with the Ministry of Environment and the Center for Environment and Development for the Arab Region and Europe (CEDARE) to effectively address this challenge and implement the recommended roadmap and interventions herein and further recommends enforcing periodic reporting of status of sulfur quality in diesel fuel produced by each refinery to enable the Ministry of Environment to plan for the urgently needed emission control policies and measures.

Contents

1	THE OPPORTUNITY.....	7
2	SUSTAINABLE TRANSPORT IN EGYPT: electric vehicles tomorrow, but fuel quality today!	8
3	ENVIRONMENTAL AND HEALTH DAMAGE DUE TO AIR POLLUTION	9
3.1	Environmental and Health Damage Costs in Egypt	9
3.2	Local Pollutants and Short-lived Climate Pollutants (SLCPs)	12
3.3	Impact of Sulphur on emission control technologies	13
3.4	Global estimates of costs and benefits	14
4	HOW DO WE COMPARE TO GLOBAL STANDARDS?	15
4.1	Status of diesel fuel and quality standards in Egypt	15
5	THE CONTEXT	17
5.1	Overview	17
5.2	Phasing out subsidies and ensuring self-sufficiency	17
5.3	Egypt's Oil and Gas Modernization Project	17
5.4	Key stakeholders	18
5.4.1	Committee for Fuels and Vehicle Emissions	19
6	ORIENTATION FOR NON-EXPERTS	19
6.1	Refinery classification	19
6.2	Producing Low- and Ultra-low Sulphur diesel.....	20
6.3	Understanding cost-saving opportunities.....	21
7	ROADMAP TO PHASE OUT SULPHUR FROM DIESEL FUEL	22
7.1	Foreseeable Scenarios	22
7.2	Will current and foreseeable projects and upgrades be enough?	23
8	POLICY RECOMMENDATIONS	25
9	NEXT STEPS AND FURTHER TECHNICAL COOPERATION NEEDED	26
10	REFERENCES	27

1 THE OPPORTUNITY

The Egyptian Environmental Affairs Agency (EEAA) and the Center for Environment and Development for the Arab Region and Europe (CEDARE) have been active in promoting fuel quality and efficiency in the transport sector through the Global Fuel Economy Initiative (GFEI) and Partnership for Cleaner Fuels and Vehicles (PCFV) in partnership with UN Environment and a large network of sustainable mobility stakeholders around the globe, including leading players in policy and technical assistance such as the African Refineries Association (ARA), the global oil and gas industry association IPIECA, African Cleaner Fuels Association (ACFA), among others.

In 2019, in continuation of cooperation with UN Environment, through its affiliated **Climate and Clean Air Coalition (CCAC)**, a situation analysis of the refining industry has been conducted, and prospects for low-Sulphur diesel fuel have been studied to explore options for a roadmap. The activity aims to propose a roadmap for the refining industry to achieve low-Sulphur diesel fuel for the sake of implied environmental and health benefits, as well as contribution to the competitiveness of the sector.

Accordingly, this policy brief provides a summary of the outcomes of the study on the refining industry and a proposed roadmap from the perspective of the competent authorities responsible for the environment and public health. It aims to support decision makers in addressing one of the most significant causes of air pollution in Egypt's cities: Low-quality fuel.

The main question is: Can Egypt leapfrog directly to international standards of diesel fuel quality?

WHY SULPHUR REDUCTION?

According to the **World Health Organization (WHO)**, approximately one in eight global deaths in 2012 were a result of air pollution exposure, making this the world's single largest environmental health risk.

The **International Agency for Research on Cancer** has classified diesel engine exhaust as carcinogenic to humans (Class 1). Nearly half of these early mortalities are associated with outdoor air pollution. The main cause is fine particles (PM_{2.5}). Vehicles are significant sources of PM_{2.5} and in many cities the major source.

To reduce PM_{2.5} emissions from vehicles there is an urgent need to introduce low-Sulphur fuels – fuels with no more than 50 parts per million (ppm) Sulphur, and ideally ultra-low 10 or 15 ppm Sulphur. Low-Sulphur fuels are also necessary for the introduction and effective operation of cleaner vehicles and emission control technology. This combination of cleaner fuels and vehicles will have major health benefits and deliver substantial climate benefits through the reduction of short-lived climate pollutants (i.e. black carbon).

Source: CCAC 2016, Global Strategy to Introduce Low-Sulphur Fuels and Cleaner Diesel

This question of potential leapfrogging is a question of estimating costs involved on one hand, and the benefits to the sector and *society* on the other hand. This involves valuation of externalities of

pollution (e.g. eliminated costs of health deterioration, environmental degradation, impact on tourism, etc).

2 SUSTAINABLE TRANSPORT IN EGYPT: electric vehicles tomorrow, but fuel quality today!

In 2018 the Ministry of Environment in cooperation with CEDARE and the Friedrich Ebert Foundation (FES Egypt) set a milestone on the road towards rolling out electric vehicle technologies and enabling policies in Egypt¹. The main outcomes included the finalization of a policy brief based on extensive stakeholders' consultations addressing EVs (*future vehicles*), in addition to a recommendation to conduct parallel interventions to address fuel quality (*existing vehicles*) for a holistic approach.

Focus on *existing* vehicles and fuels is due to the following fact:

Current trends show that the slow penetration rate of electric vehicles in Egypt will not be sufficient *alone* to improve air quality in the coming years if there are no parallel measures to improve emissions from *existing* vehicles as well.

In this respect, there are indeed many challenges in reducing emissions from vehicles in Egypt, but the **primary priority is addressing diesel fuel quality** in specific (colloquially known as “Soular”), which was found to be contaminated with very high levels of Sulphur, more than 100 times international standards. Furthermore, the rate of increase in demand is substantial, almost doubling since 1999. The Cairo Transit Authority (CTA) alone in Cairo doubled its fuel consumption over a period of 10 years as indicated in Figure 1 below. Therefore, the introduction of cleaner technologies (electric vehicles or even natural gas-powered vehicles) are likely to be insufficient to reduce Egypt’s overall emissions, since the penetration rates of the cleaner technologies must exceed this “moving target”. Hence the urgent need to improve diesel fuel quality, even with foreseen slow penetration of natural gas vehicles and EVs among other emerging solutions.

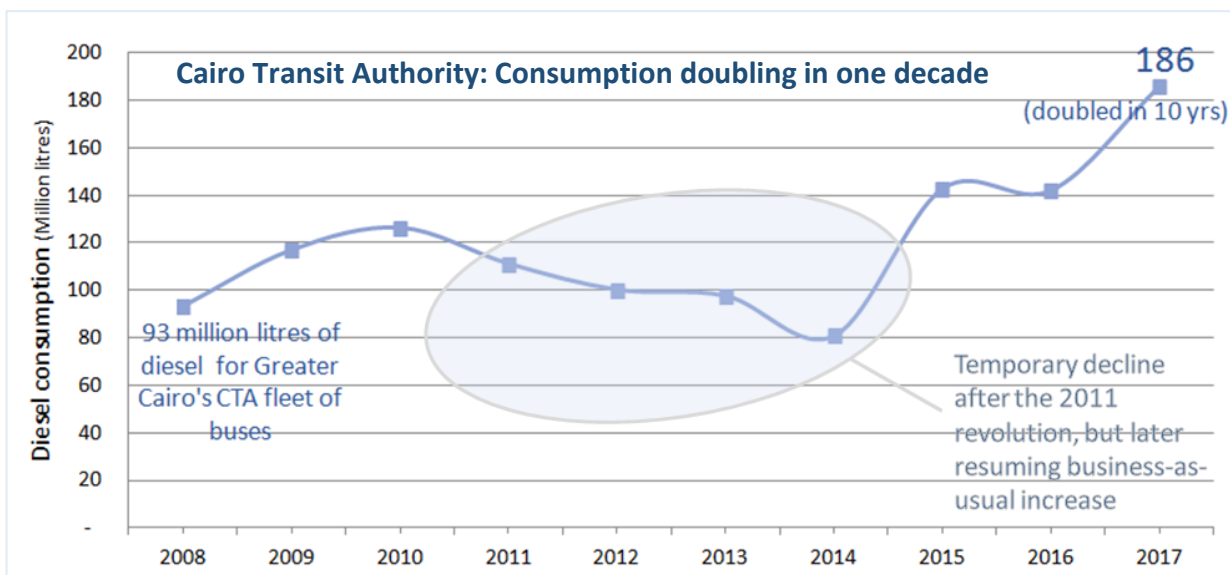


Figure 1: Diesel consumption of the Cairo Transit Authority (CTA) fleet (source: 2018 data, Ministry of Finance)

The broader discussion of sustainable transport advanced by the Ministry of Environment and its partners further covers the wide range of topics under the “Avoid-Shift-Improve” paradigm, ranging from promotion of cycling and walking (pedestrianization), to modal shift toward public transport, electrification, connectivity solutions, and intelligent transport systems infrastructure, and

promotion of transport-demand-management (TDM) interventions, along with advancing emission control policies, regulations, and enforcement.

3 ENVIRONMENTAL AND HEALTH DAMAGE DUE TO AIR POLLUTION

It must be noted that in order to assess the feasibility of projects addressing pollution abatement, the social benefits (*external benefits*) must be considered (*positive externalities*), as well as any external costs (*negative externalities*) incurred by society as a whole. Otherwise, private costs are often exceeding the private benefits in pollution abatement interventions

Similar examples include measures to phase out transformer oils containing carcinogenic Polychlorinated Biphenyls (PCBs) in waste streams, or installing dust filters at Cement Plants, or treating industrial wastewater to eliminate hazardous chemicals, etc.

Social and environmental costs and benefits must therefore be internalized in the evaluation of investments, especially when the impact is of such a magnitude; fuels distributed throughout the vast road network of the nation.

In the case of phasing out Sulphur in diesel fuels, the external benefits consist of the impact on health and environment, including not only results of reduction of Sulphur Oxides (SO_x) but also the impact of reducing carbon monoxide (CO), Black Carbon (BC), Hydrocarbon (HC), Particulate Matter (PM), Nitrogen Oxides (NO_x) among other pollutants that are reduced once vehicles are able to operate emission control devices with acceptable performance.

The costs incurred by the government (or society as a whole) are mainly associated with the loss of productivity, degradation of resources, and impact on tourism (both due to the nuisance of air pollution as well as the degradation of historical monuments), among other impacts.

3.1 Environmental and Health Damage Costs in Egypt

Information of environmental impact of air pollution (and pollution in general) in Egypt is scarce. However, the topic is gradually gaining more presence among both academics and public authorities with increased interest in positioning Egypt at higher rankings in terms of sustainable development goals.

Furthermore, the pressing environmental issues are also increasingly becoming more salient among the general public, most notably in the cases of waste management and air pollution due to their immediate relevance to the urban life.

Due to the difficulty of quantification these various external costs and benefits, a common approach is to focus on a specific cost category and specific context that is seen as largely representative of the main external costs. Examples are studies that may specifically focus on PM10 in ambient air, or focus on impact of PM2.5 and black carbon from tailpipe emissions.

Impacts of air pollution highlighted by the World Environment Organization, UN Environment, and its affiliated Climate and Clean Air Coalition (CCAC) are illustrated in the following page.

A list of key references that attempted to support the valuation of the damage of air pollution in Egypt are enlisted as follows:

- WB (2002) study, highlighting air pollution as the highest contributor to damage costs in Egypt among all environmental pressures².
- WB (2013) study, calculating health and environmental degradation costs attributed to air pollution in Greater Cairo to be an average of 1.03% of GDP over the period of 1999-2009³.
- Lowenthal et al. (2014), Source Apportionment Study indicating that 21% - 37% of air pollution is attributed to Motor Vehicles⁴.
- WHO (2016) data, estimating air pollution costs equivalent to 2,162 DALYs/1000 inhabitants, globally ranked in the lowest quartile of countries with highest estimations of DALYs (*Disability Adjusted Life Years*, a metric used to estimate the equivalent years of a “healthy” life lost due to the burden of disease, further explained later in this section).

Notably, such damage costs are conservative since they have not taken into consideration other impacts such as global warming attributed to emissions of Black Carbon (BC).

BC is a highly potent Short-Lived Climate Pollutant (SLCP) and not only a local pollutant, while other impacts have also not been considered, such as impact on aesthetics, real estate value, degradation of historical monuments, etc.

The fact that BC carbon is both a local pollutant and an SLCP implies that it addresses both challenges simultaneously and should also be eligible for climate financing schemes and any mitigation support programs.

This further coincides with Egypt’s needs to reduce dependence on diesel fuel and investigating potential fleet renewal programs aiming to mainstream cleaner diesel buses (when possible) and electric vehicles (currently expected to have very slow penetration rates), and CNG buses (leveraging existing know-how and foreseen abundant supply of locally produced natural gas).

THE **INVISIBLE KILLER**

Air pollution may not always be visible, but it can be deadly.



29%

OF DEATHS FROM
LUNG CANCER



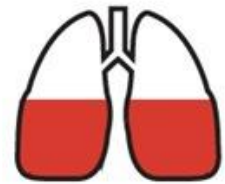
24%

OF DEATHS FROM
STROKE



25%

OF DEATHS FROM
HEART DISEASE



43%

OF DEATHS FROM
LUNG DISEASE

BREATHELIFE.
Clean Air. Healthy Future.



World Health
Organization

UN
environment



CLIMATE &
CLEAN AIR
COALITION
TO REDUCE SHORT-LIVED
CLIMATE POLLUTANTS

Figure 2: Impact of air pollution on health communicated through science-based infographics widely used in 2019, as the theme of World Environment Day (WED 2019) is "Air Pollution"

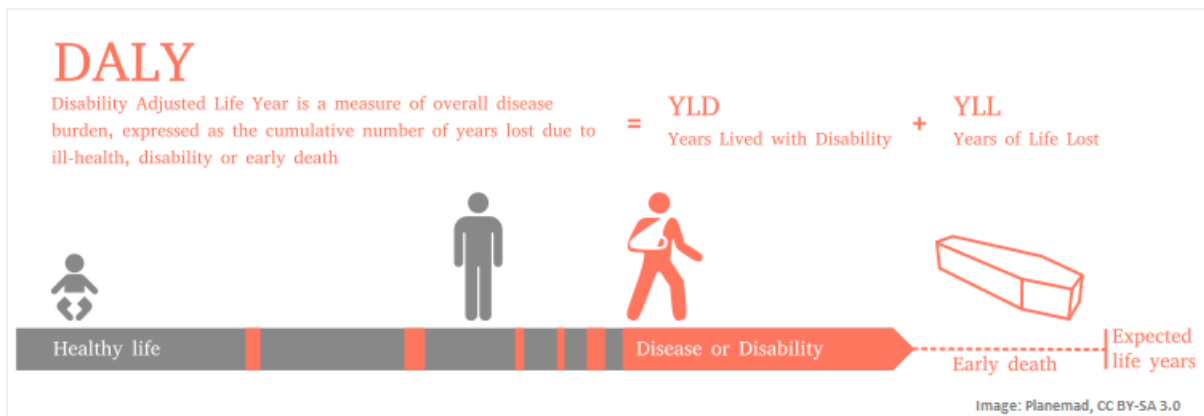


Figure 3: Disability Adjusted Life Years, a common measure of disease burden capturing both premature mortality and prevalence and severity of ill health, i.e. one year lost of a “healthy life”.

Egypt’s ranking in terms of impact of air pollution on health, where impact in Greater Cairo alone is estimated to exceed 1% of GDP³, while further informative studies indicate that approximately *one third* of air pollution is caused by motor vehicles, all indicating a substantial opportunity:

There are major implied cost savings for the national economy and contribution to welfare through the clear target of reducing Sulphur content in diesel fuel, positioning this as the priority intervention in the transport sector today.

3.2 Local Pollutants and Short-lived Climate Pollutants (SLCPs)

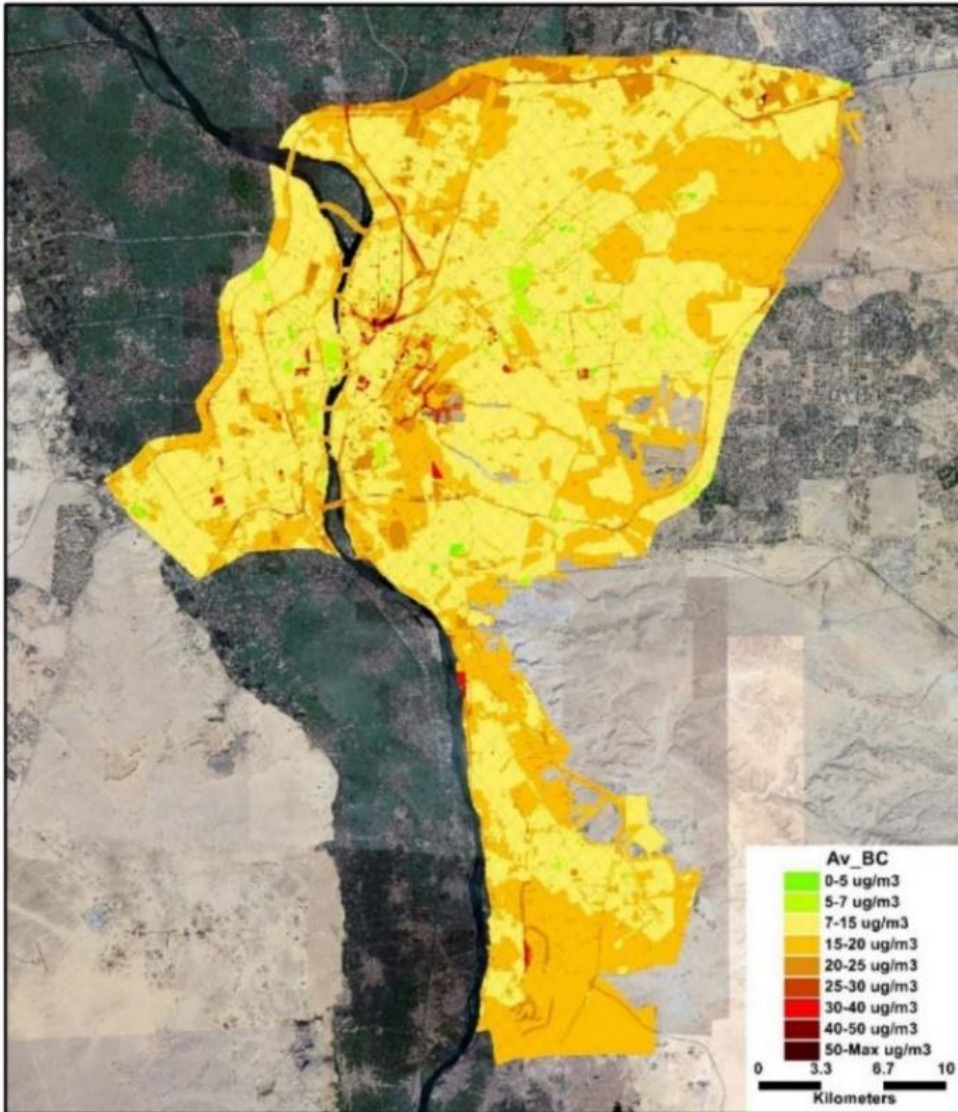
Short-lived Climate Pollutants (SLCPs) are climate pollutants that remain in the atmosphere for a shorter time than CO₂ but can have a much higher global warming potential. The most important SLCPs are four:

- Black carbon,
- Methane,
- Tropospheric ozone,
- Hydrofluorocarbons.

The four major SLCPs are responsible for up to 45% of current global warming⁵. Accordingly, a pollutant such as black carbon, associated with *local* air pollution, is likewise of major concern to global warming as well. A proxy to indicate black carbon emissions is PM_{2.5} from vehicle exhaust, which contains black carbon among other pollutants.

Studies in Egypt have indeed confirmed correlation of diesel fuel vehicles hotspots with higher exposures to Black Carbon (BC), a potent SLCP and a major contributor to the deterioration of the quality of life and impact on building surfaces and aesthetics of the built environment.

Figure 4 illustrates the results of a measurement campaign in 2017 covering a total of 525 km of roads covering Greater Cairo (3,300 km travelled for measurements for various times of the day). The reported average BC values were in the vicinity of 20µg/m³, which has been reported as “alarmingly an order of magnitude value (greater)” than maximum reported values in similar studies⁶.



source: T. Hoda, Abdelgawad, H., Hatzapoulou, M., 2018

Figure 4: Black Carbon concentration measurements in Greater Cairo

This only indicates BC, a fraction of pollutants present in fine particulate matter (PM_{2.5}). The PM_{2.5} emitted by diesel engines contains various pollutants, within a solid fraction (*black carbon* and ash), soluble organic fraction (including unburnt fuel and oil), and Sulfate particles.

The black carbon content varies widely depending on context but can typically be around 40% of all PM_{2.5} in a heavy-duty vehicle operating with high-Sulphur (500ppm) fuel⁷.

3.3 Impact of Sulphur on emission control technologies

Sulphur is a catalyst poison, and greatly impacts the performance of emission control devices in vehicles, which compromises the control of the following exhaust emissions of concern:

- Particulate Matter (PM), a complex diversity of suspended pollutants
- Hydrocarbons (HC)
- Nitrogen Oxides (NOx)
- Sulphur Oxides (SOx)
- Ozone (O₃) (due to the reaction of NOx and HCs under sunlight)

- Carbon Monoxide (CO)

Two common and widely diffused emission control devices for diesel vehicles are **Diesel Oxidation Catalysts (DOC)** and **Diesel Particulate Filters (DPF)**.

- **Achieving 500ppm for DOCs:** Sulphur levels of 500ppm and below enables the introduction of vehicles equipped with **Diesel Oxidation Catalysts (DOC)**, which can also be used as a retrofit solution for older vehicles. It is the most commonly used emission control technology after Exhaust Gas Recirculation (EGR). DOCs oxidize carbon monoxide (CO), gaseous and aerosol hydrocarbons (HCs) into carbon dioxide and water, and improve combustion of the soluble organic part of carbon particles that comprise soot and smoke. A DOC can achieve a 20-50% reduction in total PM, and over 90% reduction in CO and HC⁸. Lower Sulphur is necessary for optimal performance.
- **Achieving 50ppm for DPFs:** Sulphur levels below 50ppm enable **Diesel Particulate Filters (DPF)** to be introduced and can also be a convenient retrofit option, but not for older vehicles. This level is needed to avoid damage to emission control systems in Euro-IV vehicles and above. Euro-IV vehicles however generally are not equipped with particulate filters. Euro-VI on the other hand, are 'filter-forcing' standards, i.e. require particulate filters^{8,9}.

Many cities have indeed resorted to retrofit options together with improved fuel quality mandates, such as Mexico City, Santiago de Chile, and Hong Kong, among others⁸.

3.4 Global estimates of costs and benefits

In recognition of the health and environmental impact caused directly and indirectly by Sulphur content in fuels, the UN Environment has placed Sulphur-reduction in fuels among its priority areas for activity. Diesel fuel in specific is of most concern as 85% of road transportation globally is powered by diesel Engines, and many countries to date still use high-Sulphur fuels⁹.

Accordingly, a *Global Strategy to Introduce Low-Sulphur Fuels and Cleaner Diesel Vehicles* was developed in 2016 by the Climate and Clean Air Coalition (CCAC) Heavy Duty Vehicles Initiative, to provide global guidance. The global strategy, which is based on studies on countries that have not yet established 50ppm fuel Sulphur standards, found that the benefits of desulphurization by far outweigh the costs:

Desulphurization of on-road fuels by 2050 would results in global benefits that outweigh costs by a ratio of around 16:1, clearly justifying any government investments necessary⁹.

The global strategy categorizes countries (or regions) as '**importers**', '**refiners**', '**vehicle standards**' and '**cities first**'. The category of 'refiners' (like Egypt) are often the most difficult due to the time and financing needed for upgrades, especially in the cases where fuel subsidies are also in place. In the meantime, the 'cities first' category has been also suggested in recognition of countries that have introduced more stringent fuel standards in cities (or certain transit corridors) first, ensuring local availability of cleaner fuels as a first step before rolling out the standard to the rest of the nation.

Countries that started with a 'cities first' approach include Argentina, Brazil, and Peru, among others, focusing on highly populated/dense areas first.

4 HOW DO WE COMPARE TO GLOBAL STANDARDS?

The priority in terms of quality improvement needs is diesel fuel since gasoline generally meets high quality standards acceptable from the perspective of environmental authorities and is not as much of a concern from the health perspective at the moment. To compare with international standards, the levels of Sulphur pursued in the European Union are significantly less. In the EU, since 2009, diesel and gasoline have been limited to 10 ppm Sulphur for on-road vehicles. Non-road vehicles have been subject to the same limit since 2011, along with the other mandatory specifications for other fuel parameters.

The common benchmark in Egypt is the European Standard, which has set limits to Sulphur content in diesel fuel at 50ppm since 2005, and 10ppm (Euro 5) for the past decade as noted in Table 1 below.

Table 1: The evolution of EU fuel specifications for Sulphur content¹⁰

Implementation Date	Name	EU Directive	Sulphur Limit (ppm)
October 1994	n/a	–	2000
October 1996	Euro 2	93/12/EEC	500 (diesel)
January 2000	Euro 3	93/12/EEC	350 (diesel); 150 (gasoline)
January 2005	Euro 4	98/70/EC	50*
January 2009	Euro 5	2003/17/EC	10, 10**

* 10ppm fuel must be available

** nonroad fuels limit

4.1 Status of diesel fuel and quality standards in Egypt

Diesel fuel in Egypt remains with very high levels of Sulphur content and is not subject to safe limits by regulations yet (currently allowing up to 10,000 ppm, i.e. 1% by weight) and is about 5000ppm in the actual domestic supply (see Figure 5 indicating the country differences globally).

The challenge remains that Sulphur content in diesel fuel in Egypt is more than 100 times greater than common global standards found acceptable for public health.

However, there are many promising advancements and improvements in Egypt's refining industry, and the aim of this policy brief is to outline the dimension of public health and environment to add to the agenda of this progress, and to confirm if the new refineries and upgrades will be sufficient to improve the overall quality.



Diesel Fuel Sulphur Levels: Global Status February 2019

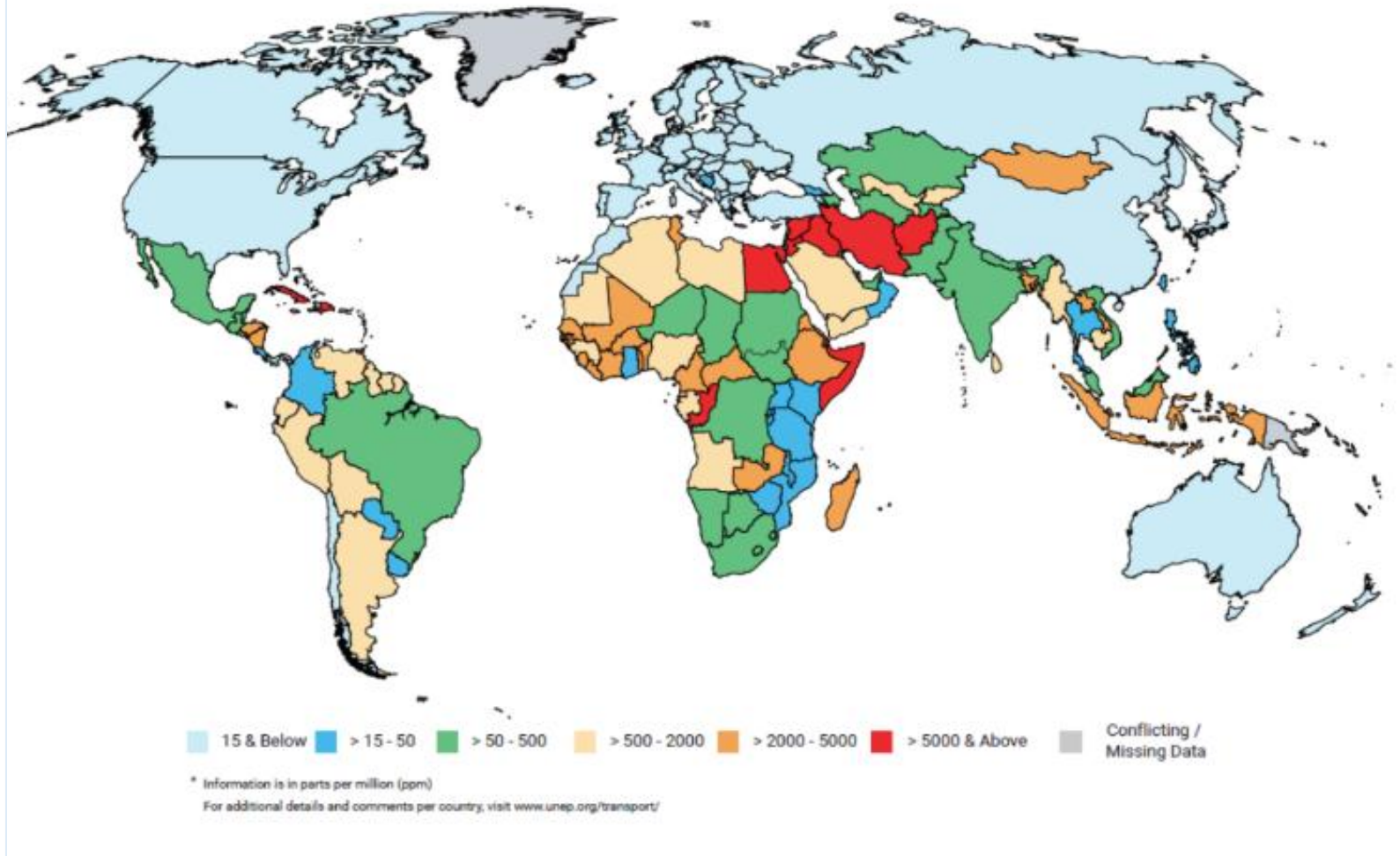


Figure 5: Global status of Sulphur levels in diesel fuel

5 THE CONTEXT

In the Arab region, the refining industry was initiated with the establishment of the first refinery in Egypt in Suez in 1913, still in operation today. This early start characterizes the challenges faced in much of the refining industry in Egypt, where old technology is still in operation, although much progress has been in process over the past decade.

Other than the challenge of old technology, the context also involves the partial imports of fuels along with provision of fuel subsidies, challenging cost recovery in the sector, as well as a long overdue need for structural reform, which is currently in process.

5.1 Overview

Domestic demand for final products in Egypt is partially met by imports, while local production is provided through 12 refining establishments: 8 refineries, and 4 processing plants (the latter is also referred to as *refineries* in popular media for the sake of simplification for the public, or otherwise ‘companies’), while substantial expansions and upgrades are also in process¹². The installed refining capacity is approx. 770,000 bpd. However, due to old technologies (e.g. the oldest refinery being Nasr Petroleum Company, established in 1913) and due to limited investment in upgrades, among other factors, much of the final products do not meet common international quality standards. Furthermore, specific petroleum products are highly subsidized while also being partially imported at international prices to meet the local demand of Egypt’s growing economy.

Both gasoline and diesel fuels are net-imported, however, the import of diesel fuel in specific is much higher (e.g. imports in 2014/2015 reached approx. 40% of consumption¹³). Current total consumption of diesel fuel is about 14 million tons/year.

5.2 Phasing out subsidies and ensuring self-sufficiency

In fiscal year 2017/2018, EGP 110 billion were allocated to subsidize petroleum products, about a third of all state subsidies for that year¹⁴. However, plans are in place to gradually phase out fuel subsidies and to substitute imports with increased local production to achieve the government’s target of self-sufficiency in production of road transport fuels by 2030.

Furthermore, in recent developments, a policy to shift to a cheaper option of transportation fuel, natural gas, has been initiated (or rather ‘revived’) through policies to enforce fuel-switching in public transport vehicles to operate on Compressed Natural Gas (CNG). However, forecasts for the extent of market uptake and assessment of impact of CNG vehicle penetration is yet to be studied.

5.3 Egypt’s Oil and Gas Modernization Project

In 2016, the Ministry of Petroleum initiated *Egypt’s Oil and Gas Modernization Project* to modernize the sector, promising transformational change to eventually position Egypt as a regional energy hub¹⁵. It includes fundamental structural reform to segregate roles and responsibilities in terms of policy making (the Ministry), executing (state corporations), and regulating (an independent body), which is seen as an underlying challenge to the progress of the sector in the past years. The five-year plan (2017 - 2021) aims to boost oil and gas reserves and production, expand gas connections to more households, secure meeting local demand for natural gas and petroleum products, and develop the petrochemical industry. Its seven programs and respective objectives are detailed in Figure 6.

In terms of downstream industry, objectives involve improvement in asset utilization and efficiency, and achieving globally competitive cost performance.

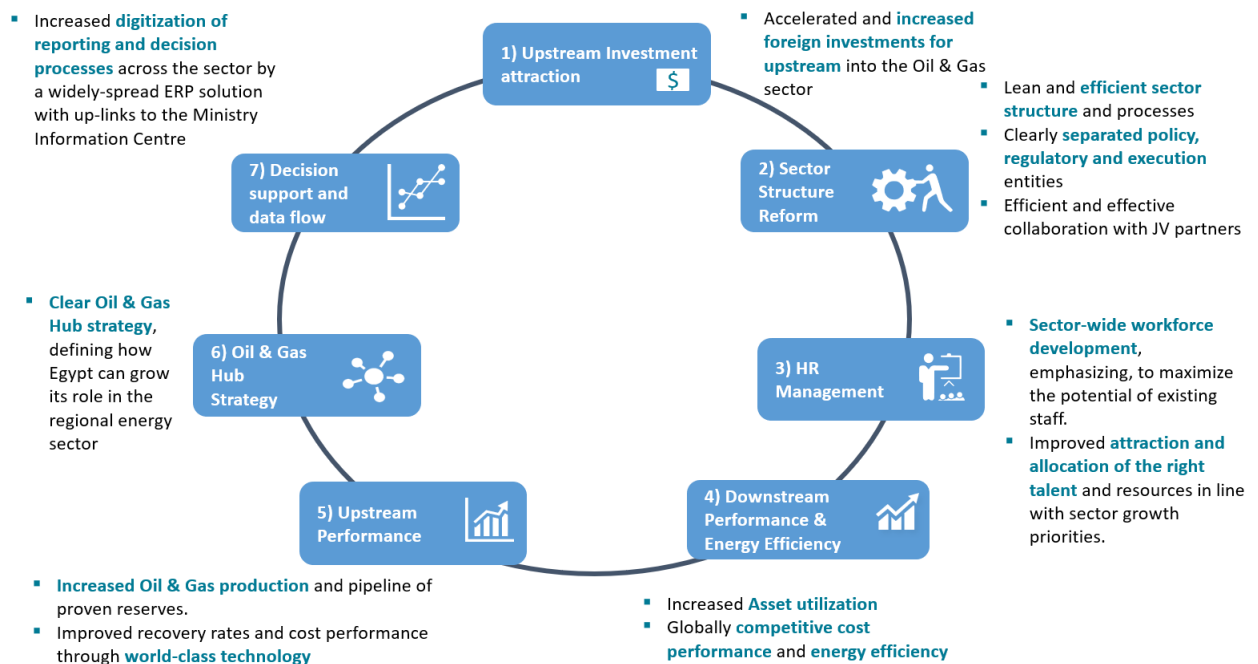


Figure 6: The objectives of the seven programs of Egypt's Oil and Gas Modernization Project¹⁵.

An important role for environmental authorities is apparent here in the fourth program. The implied impact of this plan on improvement of transportation fuel quality is an opportunity for parallel implementation of necessary environmental policies (e.g. mandatory regulations for cleaner fuels and vehicles) as well as revision of fuel quality standards to address the air quality challenges faced in major cities and impact on public health.

5.4 Key stakeholders

The Egyptian General Petroleum Corporation (EGPC) is the state-owned company affiliated to the Ministry of Petroleum mandated to develop the oil and gas sector in Egypt, including setting strategy for product quality. Through its affiliated companies, its activities are exploration, development, production, refining, processing, transportation, distribution, drilling, engineering, construction, fabrication, maintenance, and training.

The Quality Control Department (QCD) within EGPC is the authority responsible for setting standard for crudes and products produced locally, imported, or exported by EGPC, and for monitoring quality. Mandates include a wide range of QA/QC activities, from supporting equipping refinery laboratories to meet latest standards (ISO, ASTM, and IP), to auditing and inspection of fuel quality at fuel stations¹⁶.

The other organization responsible for setting standards across all sectors is the Egyptian Organization for Standardization (EOS) affiliated to the Ministry of Trade and Industry, while specific committees are established to coordinate setting standards. Committees include the relevant

stakeholders for consultation and to assess the implications of enforcement; in the case of fuel quality and vehicle emissions, the relevant committee is led by the Ministry of Environment.

5.4.1 Committee for Fuels and Vehicle Emissions

The discussion of fuel quality from the environmental and public health perspective is led by the Ministry of Environment (MoE) through its executive arm, the Egyptian Environmental Affairs Agency (EEAA). In this respect, a ministerial decree was issued in 2017 to establish a committee for the study of reduction of emissions from domestic consumption of petroleum products across sectors. The committee is chaired by the Central Department for Air Quality and Noise of EEAA, and includes the EGPC and Egyptian Organization for Standardization as well as other key stakeholders including the Ministry of Transport (MoT) and public transport authorities' representatives, the Federation of Egyptian Industries (FEI), Federation of Egyptian Chambers of Commers (FEDCOC), and the Industrial Development Agency (IDA), Ministry of Finance (MoF), Ministry of Health and Population (MoHP), Ministry of Local Development (MLD), Ministry of Interior (Mol), and Cairo University.

6 ORIENTATION FOR NON-EXPERTS

Each refinery is unique in terms of its physical configuration, operating characteristics, and economics, which are associated with location, age, availability of funds for capital investment, available crudes and nature of demand and product quality requirements.

6.1 Refinery classification

To facilitate describing and comparing refineries, complexity and configuration are widely-used:

- **Complexity** indicates the extent, capability, and capital intensity of the refining processes downstream of the crude distillation unit. The distillation unit alone by definition has a complexity score of 1.0. Two refineries with the same configuration (e.g. conversion refineries) can have different levels of complexity. This indicates capability to add value to crude oil by converting more of the heavy fractions to higher-value light products, as well as meeting higher quality specifications such as ultra-low Sulphur fuels.
- **Configuration** refers to the specific set of refining process units in a given refinery, the size/capacity of units, main technical characteristics, and the flow patterns between them. A key characteristic is involvement of *conversion* units which enable altering the natural yields by converting heavier fractions to lighter ones (typically Fluid Catalytic Cracking, Hydrocracking, Coking, and more recently, Visbreaking). The configurations can be classified as follows:
 - **Topping refineries**, limited to crude distillation and basic operations.
 - **Hydroskimming refineries**, which further involve catalytic *reforming* (which produces valuable by-product hydrogen as well), various *hydrotreating* units, and product blending. This enables upgrading naphtha to gasoline and controlling Sulphur content of refined products. They have no capability to alter natural yield patterns.
 - **Conversion (or cracking) refineries** further involve *catalytic cracking* and/or *hydrocracking* (in this case enabling Sulphur reduction to <100ppm¹⁷), which

transform heavy fractions (mainly gas oils) to lighter products. They still however inevitably produce heavy low-value products (e.g. residual fuel and asphalt).

- **Deep conversion (or coking) refineries** further involve *coking* which converts residue feed, the heaviest fraction, into lighter streams, which in turn feed into other conversion and upgrading processes.

Table 2 below indicates that various configurations of refineries in Egypt, noting prevalence of simple refineries (the topping refineries and one hydroskimming refinery).

Table 2: Refineries configurations in Egypt (and processing plants indicated in bold)

Location	Name of Refinery / Processing plant (by 2022*)	Configuratin/type
Alexandria	Middle East Oil Refinery (MIDOR)	Deep conversion
	Alexandria Petroleum Company (APC)	Conversion
	Alexandria Minerals and Oils Company (AMOC)	[Conversion processes]
	Alex National Refining and Petrochem. Company (ANRPC)	[Conversion processes]
	Amreya Petroleum Refining Company (APRC)	Conversion
Tanta	Tanta - Cairo Oil Refining Company (CORC)	Topping
Cairo	Mostorod - Cairo Oil Refining Company (CORC)	Hydroskimming
	Egyptian Refining Company (ERC)	[Deep conversion processes]
Suez	Nasr Petroleum Company (NPC)	Topping
	Suez Oil Processing Company (SOPC)	Conversion
Assiut	Assiut Oil Refining Company (ASORC)	Topping
	Assiut National Oil Production Company (ANOPC).	[Deep conversion processes]

Due to the sophistication of refinery processes, complex mathematical models of refinery operations are fundamental to plan any changes to respond to the market and specifications requirements. This ensures reaching technically feasible and economically optimized solutions.

6.2 Producing Low- and Ultra-low Sulphur diesel

In conversion processes, fluid catalytic cracking (FCC), hydrocracking, and coking, produce the main blend stocks for gasoline and diesel. Untreated FCC and coking products are primary sources of Sulphur in both gasoline and diesel pools¹⁷.

Diesel fuel typically involves 2-5 refinery-produced blend stocks, which can be blended differently. These include crude distillation products (straight run kerosene and distillates), and conversion unit products (FCC light cycle oil, coker distillate, hydrocracked distillate). The raw streams contain varying levels of Sulphur content (the highest contributor being the FCC light cycle oil). Reducing Sulphur is met at various degrees through processes that are for either (1) *yield improvement* or (2) *specifically dedicated* for meeting low-Sulphur requirements as follows:

Hydrocracking and FCC feed hydrotreating for yield improvement: Hydrocracking *coincidentally* reduces Sulphur content (i.e. is a *contributor* to reduction) but hydrocracking is rather pursued for the purpose of *yield improvement*, and is not sufficient for ultra-low Sulphur diesel (ULSD) requirements. FCC *feed* hydrotreating indirectly improves yield as well, since Sulphur inhibits FCC performance (poisons the catalyst). Hydrocracking might be suitable for countries/refineries in a transitional phase of fuel quality improvement (coinciding with yield improvement), but is high in costs.

Dedicated desulphurization: For the production of ULSD however, severe desulphurization of the blendstocks, primarily through *distillate hydrotreating*, is required (for example, blending all streams and deSulphurizing in one hydrotreater). Dedicated *Sulphur control* processes are necessary, which can be classified as follows, of which various combinations can be sought:

- **Adding new processes (e.g. distillate hydrotreating for ULSD),**
- **Expanding existing capacity for Sulphur control,**
- **Retrofitting existing units to improve Sulphur control.**

The consequent costs are mainly the capital investment costs in process capacity and support facilities as well as the costs of hydrogen supply.

Other influencing factors include local economic factors, such as refinery ownership, labor costs, construction lead times, and currency exchange rate. Therefore, careful consideration of the local context is fundamental for understanding the viable strategies for Sulphur reduction.

6.3 Understanding cost-saving opportunities

An example of basic components necessary in estimating preliminary desulphurization investment needs is indicated in Figure 7.

In this respect, opportunities of cost savings can be identified based on context.

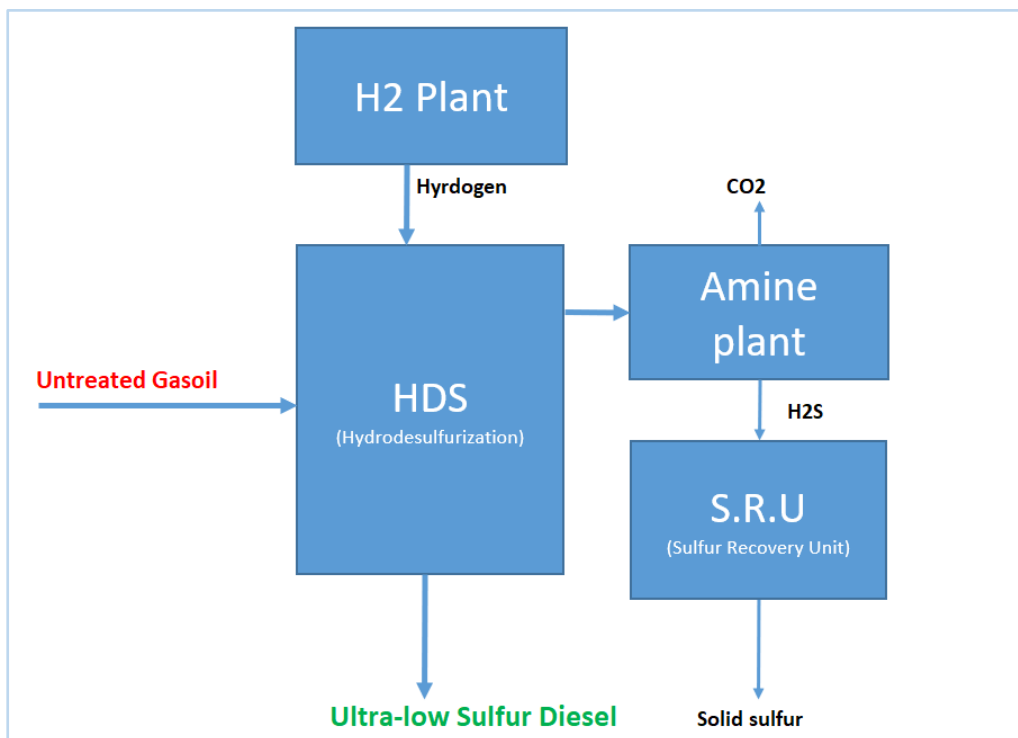


Figure 7: Simplified illustration of common components of desulphurization for preliminary cost estimates

Hypothetical cost-savings examples are as follows:

- **Example-1:** Refinery-1 and 2 producing low-quality diesel.
 - **Cost saving:** Combine flows of untreated gasoil in one desulphurization facility.

- **Example-2:** Refinery-1 and 2 producing low-quality diesel, but are next to Processing Plant (Plant-X) that has existing hydrogen supply.
 - **Cost saving:** Gas oil produced from both refineries will be treated by treating both flows of untreated gasoil using excess hydrogen available at Plant-X.
- **Example-3:** Refinery-1 and 2 producing low-quality diesel, but Refinery-1 has existing underutilized hydrogen production and Sulphur recovery units with available capacity.
 - **Cost saving:** Localized hydrodesulphurization of gas oil produced by both refineries to be located together at Refinery-2, saving costs of an Amine plant, Sulphur Recovery Unit, and a hydrogen production plant.
- **Example-4:** Refinery producing low-quality diesel, but having Hydrogen-rich gas available from a new Continuous Catalytic Reforming (CCR) unit.
 - **Cost saving:** Hydrodesulphurization of the Refinery's untreated product by using hydrogen-rich gas produced from the new CCR to reduce the costs of a hydrogen plant.

7 ROADMAP TO PHASE OUT SULPHUR FROM DIESEL FUEL

To lay the foundations for the discussions of a roadmap for Sulphur-reduction, a situation analysis of diesel quality in Egypt was developed, with consideration of likely future projects coming into operation as well as forecast increase in demand up to 2030.

This preliminary analysis was developed through a process of initial review of annual reports of relevant organizations and authorities, media sources and public information, as well as stakeholders and experts' consultations, and final expert evaluation and analysis of existing refineries and capabilities. This was followed by the development of scenarios for desulphurization.

7.1 Foreseeable Scenarios

Estimates of diesel production quantities and respective quality from each producer (and imports) were therefore derived, and foreseen upgrades and new refineries/facilities were assessed. Based on the results of the situation analysis and Business-As-Usual (BAU) expected, two alternative scenarios were developed and evaluated to provide perspective for policy-makers on the impact of different measures and to initiate the process toward desulphurization. Accordingly, three scenarios have been developed for discussion and evaluation.

- 1) **No-Action: Business-As-Usual (BAU)** with currently planned (and ongoing) upgrades, expansions, and new facilities, as well as decreasing import trends and moderate increase in demand.
- 2) **Greater Cairo First by 2020: A low-/no-cost 'cities-first' scenario** (logistical intervention for redistribution) where priority for cleaner fuel supplies is given to the most exposed urban area (Greater Cairo).
- 3) **Nation-wide Euro-5 by 2030: A desulphurization scenario**, imposing context-specific desulphurization interventions to achieve Euro-5 diesel fuel standards throughout Egypt.

7.2 Will current and foreseeable projects and upgrades be enough?

There are indeed various important upgrades and expansions in the refining industry that shall enhance local production as enlisted below (key projects), however, the impact has been found to be mainly on reducing import-dependence (i.e. replacing relatively good quality imports with new good quality domestic production).

This will have a limited impact on the overall quality of the diesel 'pool' in Egypt since the primary purpose of the additional domestic supply is to reduce imports, rather than to substitute the local lower-quality diesel products of the older refineries.

Notable projects are as follows:

- **MIDOR:** Upgrading in Midor Refinery in Alexandria, boosting capacity, substantially increasing diesel fuel production with Euro 5 standards. It shall meet approx. 19% of national needsⁱ.
- **ERC:** Egyptian Refining Company (ERC) in Cairoⁱⁱ. It shall meet approx. 15% of national needs when in operation together with expansions of MIDOR and operation of ANOPC.
- **ANOPC:** Assiut National Oil Production Company in operation, providing approx. 11% of national needs when in operation.

This indicates that refineries in operation in the coming years that have disclosed that diesel fuel shall meet Euro-5 standard shall provide less than *half* of all market needs. This eliminates prospects of reaching low-Sulphur specifications in diesel fuel by 2030, unless further interventions are introduced.

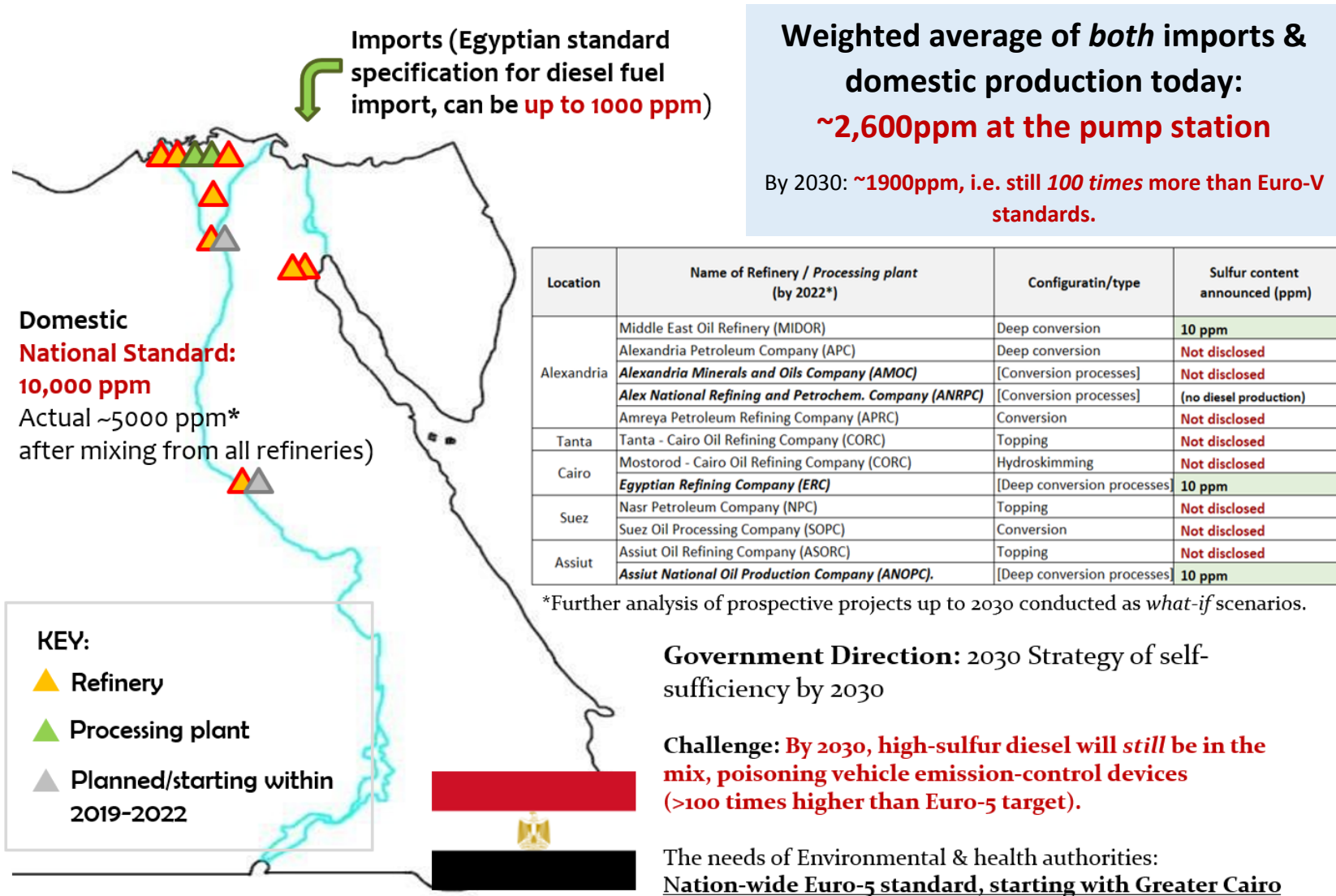
Furthermore, throughout the 2020-2030, there are numerous other prospects being planned, indicating additional production of high-quality products, such as the following projects in consideration, taken as *hypothetical* examples of prospects for further production within the target period:

- **New Alamein Complex Project** in Matrouh¹⁸.
- **Suez Hydrocracking Complex** in Suez¹⁹.

Situation analysis results have shown however that due to the focus on domestic production replacing imports (and meeting increased demand), the overall quality will not change significantly towards low-Sulphur diesel. This is summarized in the illustrative infograph on the next page.

ⁱ CEDARE analysis based on operation of all three planned projects and total consumption needs that are supplied both by domestic production and imports, including consideration of conservative increments in demand up to 2022.

ⁱⁱ Note that this may imply that Mostorod refinery of Cairo Oil Refining Company (CORC) shall moderately increase production to meet ERC's needs of residual oil, thus implying increased production of Mostorod's low-quality diesel fuel.



*Sources: UN Environment/PCFV Global Status and CEDARE survey and analysis

Figure 8: Infograph of the situation analysis showing that the Business-As-Usual with ongoing projects/upgrades coming into operation up to 2030 will not be enough to meet the target quality standards when mixing the good quality and low quality products.

Furthermore, gaps in information for further detailed analysis were assessed and follow up studies suggested. The Business-As-Usual scenario indicates that target quality will not be reached *even* with optimistic consideration of planned projects coming into operation within the period 2019-2030, whether those planned or announced as likely projects under discussion. This is mainly due to the fact that new domestic production of Euro-5 shall not significantly replace the lowest-quality fuel products, but rather replace imported diesel fuel.

Results indeed show a foreseen prospect of significantly approaching self-sufficiency in diesel fuel production by 2030 in terms of *quantity*. However, a further intervention is needed, as proposed herein, to also secure *quality* for the sake of today's pressing public health and environmental concerns.

Accordingly, initial cost estimation of investment needs of approximately 508-660 MUSD was concluded for the scenario for achieving *Nation-Wide Euro-5 Diesel*, based on estimates of untreated gasoil production quantities and a number of identified likely opportunities for cost-savings as noted in Section 6.3. Likely investment needs are dwarfed by the magnitude of costs of health and environmental damage as detailed in Section 3 indicating costs of health deterioration and environmental impact. Accordingly, the recommended next step is to conduct further detailed assessment with validation by EGPC in order to finalize the decision to introduce a roadmap for phasing out Sulphur from diesel fuel.

8 POLICY RECOMMENDATIONS

In conclusion, a situation analysis of the sector today and foreseeable future, despite foreseen increases in local production of high-quality (Euro-5) diesel fuel, shows that the quality of diesel will still suffer high content of Sulphur, implying content levels still two orders of magnitude higher than acceptably safe levels. This is mainly due to remaining large quantities of high-Sulphur fuels in old refineries among other reasons detailed in this policy brief.

The Business-As-Usual prospect for diesel quality improvement throughout Egypt (and implied prospects for better air quality and *health*) by 2030 will *not* be achieved without additional intervention in the form of imposed standards and investments in desulphurization.

Accordingly, the following recommendations are concluded and shared with stakeholders for consultation and engagement, stressing the importance of coordination between the Ministry of Petroleum and the Ministry of Environment and concerned stakeholders and authorities to develop an action plan for introducing Euro-5 diesel fuel standards as a priority for addressing public health and environmental concerns. Relevant stakeholders are thereby invited to cooperate in pursuing the following recommendations based on the preliminary study on the topic, which assured the viability of implementation:

- 1) **2020: Enforcing Euro-5 diesel fuel standards in Greater Cairo** as a first phase (given the availability of Euro-5 diesel fuel quantities today produced by advanced refineries).
- 2) **2020-2030: Nation-wide Euro-5 diesel standards** enforcement throughout Egypt upon availability of sufficient quantities (i.e. through new refinery projects + desulphurization (Sulphur removal treatment) of the products of old refineries + prohibiting import of high-

Sulphur diesel fuel). Notably, costs of health and environmental damage are greater than the costs of desulphurization measures according to international studies^{8,9}, while CEDARE's analysis for Egypt indicated that investment needs are modest, in the range of 508-660 MUSD for all desulphurization needs.

- 3) **Incorporating costs of damage to health and environmental degradation into policy development processes.** The World Bank studies on the damage costs of air pollution (sector note of 2013) indicated that Egypt incurs substantial costs due to damage to health from air pollution, reaching approx. 1% of GDP. This valuation would further increase if additionally considering impact on tourism, agriculture, historical monuments, climate change, and the quality of life in general, whereas vehicle emissions alone contribute to about one third of air pollution in Egypt.

Accordingly, the study stresses the importance of the role of the Ministry of Petroleum in effective participation in environmental studies and associated consultation events in cooperation with the Ministry of Environment and the Center for Environment and Development for the Arab Region and Europe (CEDARE) to effectively address this challenge of meeting sustainable development targets of 2030 and effectively addressing this identified priority and “quick-win” for mitigating air pollution in Egypt.

9 NEXT STEPS AND FURTHER TECHNICAL COOPERATION NEEDED

Emission standards for heavy duty vehicles in preparation for cleaner fuels: The Ministry of Environment will need to initiate parallel preparations for implementation of new emission standards that should be enforced upon completion of the fuel quality roadmap interventions. This shall be part of a policy mix along with promotion of EVs and CNG vehicles. It will also involve assessment of introduction of emission control technologies (DOCs and DPFs) in Egypt.

Logistics of city-specific standards: A key challenge identified in the final stakeholder consultation event (international seminar of STE-2019: *Cleaner Fuels for Cleaner Air*, June 18-19, 2019) was to conduct a deeper investigation of the risks and challenges in the *logistics* of the stocks and flows of diesel fuel when implementing the proposed *Cities-first* (Greater Cairo) phase. This would also include mapping out sector-specific implications (consideration of flows of diesel fuel to different sectors; tourism, transport, agriculture, etc), as well as consideration of implications to the *flexibility* of logistics operations necessary for crisis management.

Cleaner fleet schemes and quantification of climate benefits: Among the challenges faced by the Ministry of Environment and transport authorities is the quantification of climate benefits (carbon reduction) from energy efficiency and from SLCP reduction (CO₂ equivalent), which would together help building the case for carbon-reduction projects and therefore help in accessing climate funding or accessing other financial facilities supporting carbon-reduction interventions.

Bus technologies comparison (priority topic) and assessment of impact of cleaner fuels on existing technologies: Parallel schemes for introducing different *low-emission buses* (and vehicles in general) are needed, together with analysis to compare different technologies and technical approaches that environmental authorities are promoting (i.e. potential low-emission diesel vehicles, emission control retrofitting, CNG vehicles, and electric vehicles) in order to map out possible parallel schemes that can be implemented for overall improvement of high-mileage vehicles used in cities.

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