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Fact Sheet: Natural Gas Vehicle in Transportation in the Arab Region

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I. Introduction

Transport is a key sector for a country's economic growth and social development. The transport sector, however, has an extensive impact on the environment, such as air, water and land pollution, as well as contributing to climate change and global warming, noise pollution, congestion and a wide range of public health problems. This vital sector has one of the highest growth rates of carbon dioxide (CO_2) emissions, highlighting the significant role natural gas can play in enhancing the sustainability of transport and the promotion of cleaner fuels.

Natural gas is the cleanest of the fossil fuels given that its CO_2 emissions are approximately 24%[1] of those from liquid-petroleum products. Although these are still the main source of fuel used in transport, the use of natural gas in the transport sector has been evolving globally since the 1990s, aided by technology advancements, the abundance of natural gas following the shale revolution and governments' efforts to mitigate the impacts of climate change.

All outlooks have stressed that the growth of natural gas for transport will be concentrated in regions with an abundant gas supply and policy support and where air quality is set to be a major issue. Furthermore, outlooks are in agreement that major natural-gas use and potential in transport will be seen in commercial transport. Consequently, in addition to the fact that the Arab region is expected to see a large expansion in commercial transport, a study of the prospect and policy instruments that could motivate natural-gas use as a fuel in the region proves to be of great importance.

Indeed, one of the most important, yet perhaps most overlooked, sector in the context of the future Arab energy transition is transport. The experience of Arab countries in the use of natural gas as a transport fuel remains limited, confined mainly to Algeria, Egypt, Tunisia, the United Arab Emirates (UAE) and, more recently, Qatar. There could, however, be scope for a potential increase in the use of gas in this region's transport sector, especially since it has one of the fastest growth rates of vehicle fleets in the world with an energy-intensive transport sector. This is due mainly to rapid urbanization rates and heavily subsidized liquid transport fuels and the lack of adequate policies, regulations and standards that would mitigate the ever-increasing consumption of polluting fuels.
Adequate domestic energy-pricing policies, investments in the required gas-distribution infrastructure and refuelling stations, the promotion of public transport and clean environment regulations are all necessary and compelling key drivers for the sustainable development of natural gas as a transport fuel. Replacing liquid-petroleum fuels with natural gas would not only have environmental advantages through reduced pollution, but would also benefit the countries' economic and fiscal strength.

[1] UN ESCWA *Policies and Measures to Promote the Sustainable Use of Energy in the Transport Sector in the ESCWA Region:* https://www.unescwa.org/ar/node/14873

II. Energy mix in the transport sector

Liquid-fuel products continue to dominate the global transport fuel mix

Energy consumption in the transport sector is projected to increase globally by an annual average rate of 1.1% between 2015 and 2050[2]. While fossil-fuel liquid products continue to be the dominant type of fuel used in transport, the *International Energy Outlook 2017* of the United States Energy Information Administration (EIA) foresees natural gas and electricity to grow the fastest among energy sources, with consumption of each almost tripling between 2015 and 2040 (Figure 1). Annual average growth of natural-gas consumption in transport is expected to increase by almost 5% between 2015 and 2050 while that of electricity by 4.4%[3]. Both sources currently represent roughly 5% of the energy mix in the transport sector.

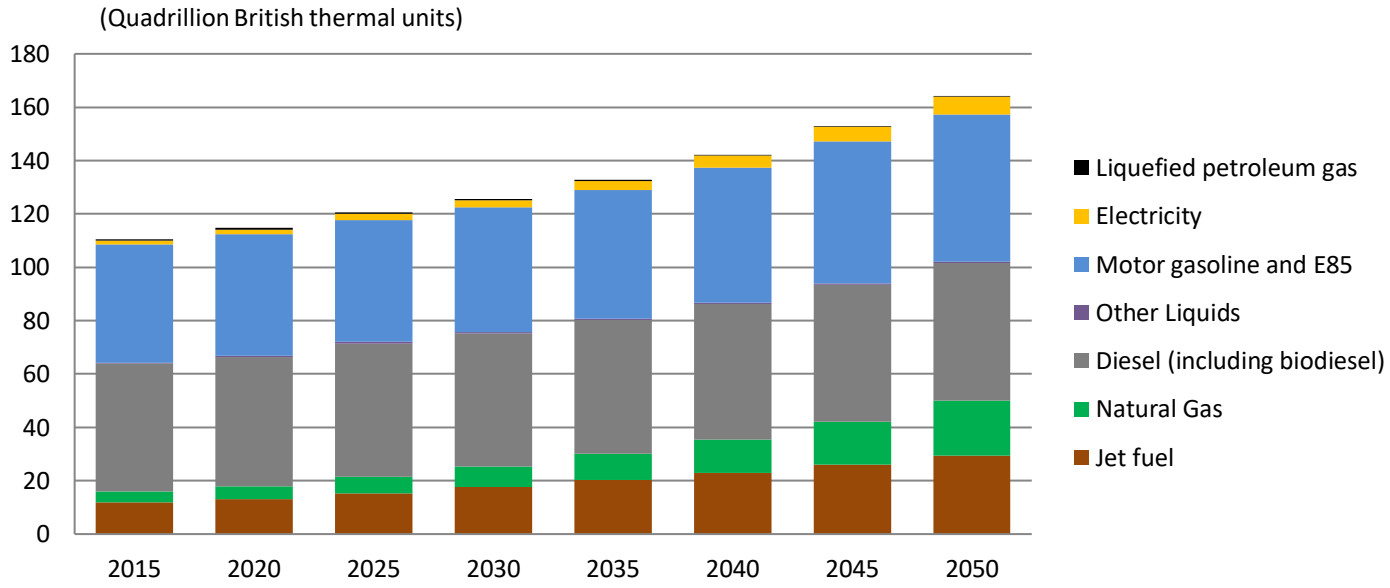

Figure 1. Energy mix in the global transport sector
Source: EIA: International Energy Outlook 2017

Oil consumption dominates the Arab region's growing transport sector

The transport sector accounts for nearly one-third of final energy consumption in the Arab region, a factor that falls frequently outside the classical focus of energy-efficiency

[2] EIA, *International Energy Outlook 2017*
[3] EIA, *International Energy Outlook 2017*

policies. Indeed, the region has one of the fastest growth rates of vehicle fleets in the world with an energy-intensive transport sector. According to the International Organization of Motor Vehicle Manufacturers, the compounded annual growth rate of the sales of new vehicles (all types) increased by about 2% over the period 2005–2015 in the Arab region, second to Asia (8.2%) and Central and South America (2.5%)[4]. This is due mainly to rapid urbanization rates and heavily subsidized liquid transport fuels. The Arab countries' urban population levels have increased by an alarming factor of four between the 1970s and the early 2010s and could more than double between 2010 and 2050.[5]

The transport fuel scene in the Arab region is dominated by the consumption of liquid-petroleum products (Figure 2) where alternative fuels cover only a very small share of total consumption. Natural gas in the form of compressed natural gas (CNG) has been introduced as a fuel for vehicles in the region, but its share of total transport fuels consumed remains extremely low, around 1%. Electricity is used in rail transport, but only in a few North African countries (Algeria, Egypt, Morocco and Tunisia)[6].

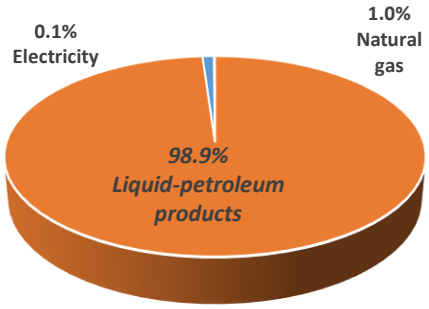

Figure 2. Shares of fuel (energy) use in the transport sector – Arab countries, 2012
Source: Organization of Arab Petroleum Exporting Countries (OAPEC, 2015)

Current fuel patterns in the Arab region

The main liquid petroleum products consumed as transport fuels are gasoline, diesel and jet fuel. Consumption of gasoline and diesel in the Arab countries increased substantially over the last 25 years. Between 1990 and 2015, gasoline and diesel use rose on average by a factor of almost three (Figure 3). This rapid fuel-consumption growth is unlikely to go unabated in the future unless the right policies, regulations and incentives are put in place.

[4] Arab region excludes Mauritania: http://www.oica.net/category/sales-statistics/
[5] UN ESCWA (2015): Urbanization and Sustainable Development in the Arab Region, *Social Development Bulletin*, 5:
[6] IEA (2017): World energy statistics, IEA World Energy Statistics and Balances (database)

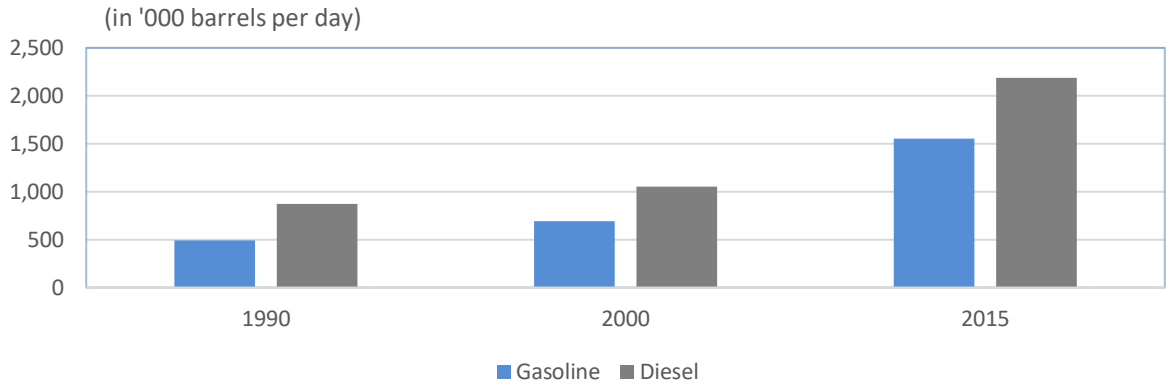

Figure 3. Fuel consumption in Arab countries,1990–2015
Source: OAPEC, 2016

In the Arab region, social and behavioural factors vary from one country or area to another. In high-income countries and to a lesser extent in other countries, large gasoline-fuelled sport utility vehicles (SUVs) and luxury cars constitute a relatively significant share of a country's vehicle fleet. The 2015 total sales of SUVs in the Gulf Cooperation Council (GCC) area was nine for every 1,000 GGC residents compared to an average of three for the rest of the world[7]. A particular feature of the consumption of liquid-petroleum products in some Arab countries is the high and rising level of diesel use (especially in Algeria, Egypt, Morocco and Saudi Arabia), compared to gasoline use (Figure 4). Diesel has a much higher sulfur content than gasoline, which worsens the environmental damage already caused by these liquid transport fuels.

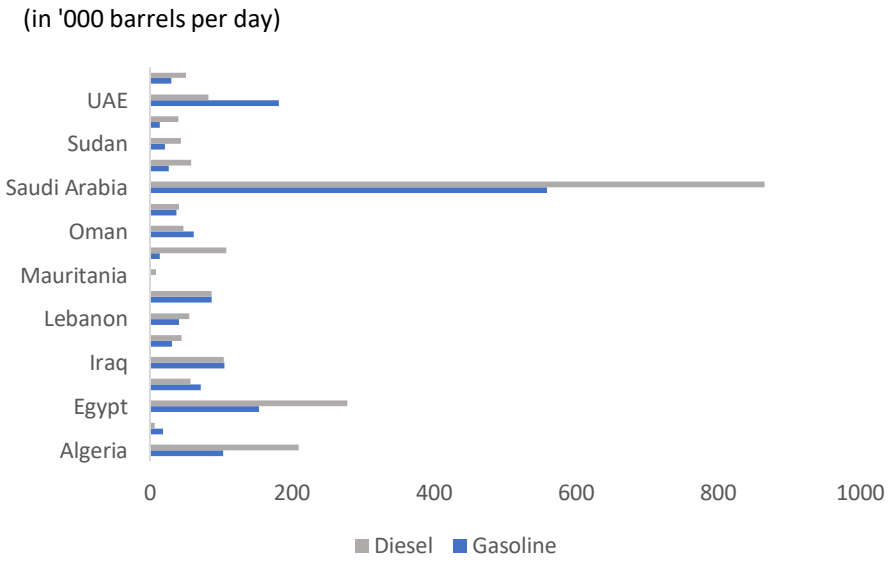

Figure 4. Gasoline and diesel consumption in Arab countries, 2015
Source: OAPEC, 2016

[7] Strategy& (2016): Tech-enabled transport: building smarter transportation networks in the GCC

III. Sustainable development and sustainable transport

Sustainable transport provides the necessary needs of the population in a safe and secure manner without causing any health or environmental damage for future generations. Sustainable transport should be the safest, least polluting, most efficient in terms of fuel consumption, the least costly for citizens and widely spread across urban and rural areas[8]. Moreover, sustainable transport should be harmonious with sustainable economic and social development.

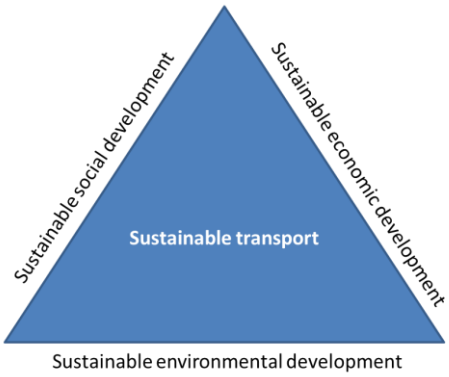

Figure 5. Sustainable transport
Source: UN ESCWA: *Policies and Measures to Promote the Sustainable Use of Energy in the Transport Sector in the ESCWA Region*

The identification of the key drivers for the sustainable development of transport in Arab countries will need to address energy access, renewable energy and energy efficiency in order to be consistent with the United Nations Sustainable Development Goal (SDG) 7. One of the means of implementing SDG 7 targets and to meet the Paris Agreement is to facilitate access to, and use of, cleaner transport fuels, such as natural gas.

Transport is a key emitter of carbon dioxide

According to the IEA, the consumption of oil products by the transport sector in all Arab countries resulted, in 2014, in a total of 395 million tons of CO_2 emitted or more than 20% of total CO_2 emissions globally. Most national quality standards of transport fuels currently consumed in Arab countries are well above acceptable international standards and guidelines. This has a major adverse impact on countries' air quality, especially in heavily populated urban centres. Figure 6 shows the upward trend of total CO_2 emissions from fuel combustion from the transport sector in the Arab region.

[8] UN ESCWA: *Policies and Measures to Promote the Sustainable Use of Energy in the Transport Sector in the ESCWA Region* https://www.unescwa.org/ar/node/14873

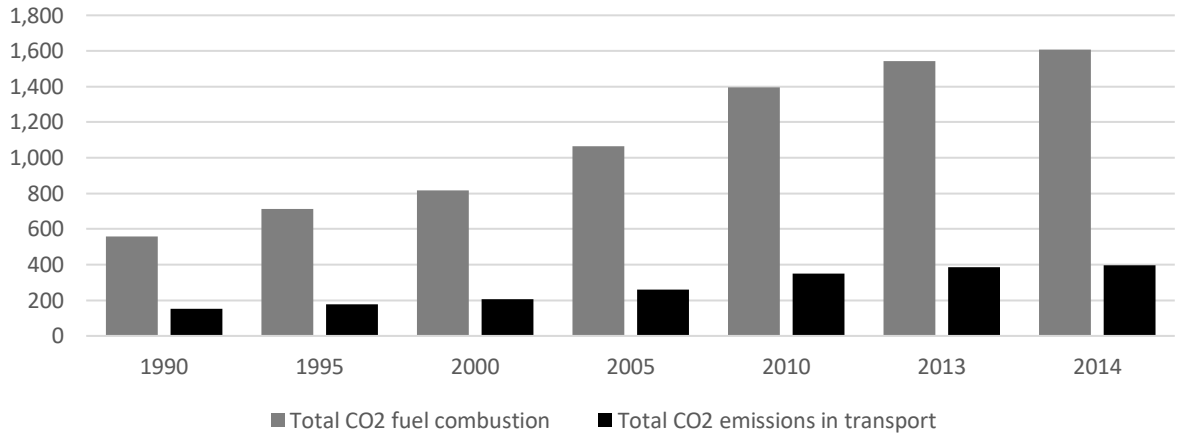

Figure 6. Evolution of CO_2 emissions from fuel combustion and transport in the Arab region (excluding Palestine and Mauritania)
Source: IEA (2017): CO_2 emissions by product and flow

Natural gas is the cleanest fossil fuel for the transport sector

According to the International Association of Natural Gas Vehicles (NGV Global): "Gas engines meet the highest safety standards, systems are tight and robust. Optimized gas engines (using direct injection and higher compression ratios) will become as energy efficient as diesel engines, meaning another 10%–20% of CO_2 savings can be achieved."[9] Other emission reductions achieved by using natural gas in road transport compared to the combustion of gasoline and diesel are: the reduction of nitrogen oxides (NOx) by 75% to 95% and of carbon monoxide (CO) from 70% to 90%.[10] The use of natural gas as a fuel in road transport can also reduce particulate matter (PM) by up to 95%, compared to PM caused by diesel combustion.
In marine transport, natural gas can be used as a fuel in the form of liquified natural gas (LNG) to allow the shipping industry to fulfil the emission requirements of the International Maritime Organization (IMO) to reduce sulfur oxides (SOx) emissions by 100% and NOx emissions by 90%, again compared to liquid-petroleum fuels.[11]
According to the World Health Organization (WHO), the worst annual air-pollution levels recorded are in cities in the eastern Mediterranean (including several Arab countries) and parts of South-East Asia, where they often exceed five to ten times the WHO limits.

[9] https://www.ngva.eu/co2-and-air-quality
[10] https://www.igu.org/global-natural-gas-insights
[11] Idem

IV. Role of natural gas in the transport sector

Overview of natural gas in the global transport sector

Technology advancements and governments' incentives to mitigate air pollution have led to the wider use of natural gas for transport. According to NGV Global, natural gas can be used in all types of vehicles and these cover a range of NGVs, such as motorcycles, cars, vans, light- and heavy-duty trucks, buses, lift trucks, locomotives, ships and ferries.[12] Compared to liquid-petroleum products, natural-gas products require more volume to produce an equivalent amount of energy and need to be compressed or liquified to allow for its economically effective use in transport. Natural gas can therefore be used and stored as a fuel in road and – more recently – maritime transport, as well as rail transport in two forms: CNG and LNG. Both CNG and LNG can be used as an alternative fuel to gasoline, diesel and bunker fuel. CNG in road transport is currently, however, by far the largest natural-gas application in the transport sector.

Compressed natural gas is compressed to a pressure of between 200 hPa and 250 hPa. This process compresses natural gas to less than 1% of its volume at standard atmospheric pressure. Also, natural gas can be liquified by cooling it at –162 °C. This reduces its volume significantly, while one cubic metre of LNG produced contains 600 m^3 of natural gas in its gaseous form. In terms of energy density, the autonomy equivalence of one litre of diesel is five litres of CNG. Whilst only 1.8 litre of LNG would be required to have the same autonomy as one litre of diesel.[13] This favours the use of CNG for short-distance road transport, mainly in urban centres, especially for public transport fleets, and LNG as a fuel for medium- to long-distance transport applications, such as road trucking and shipping.

The rising interest in natural gas as a fuel in maritime transport is driven by the recent emission regulations issued by IMO. IMO began in the first instance by the designation of SOx Emission Control Areas (ECAs): ships trading in these areas have had to use fuel oil with a 0.10% sulfur content since January 2015 against a previous 1% content. IMO then set up a global sulfur cap of 0.5% for all marine fuels to become effective by 2020. Outside the ECAs, the current limit for the sulfur content of fuel oil is 3.50%. More recent IMO measures have designated two ECAs (North Sea and Baltic Sea) as ECAs for NOx, taking effect in January 2021.[14]

[12] NGV Global (2017): Natural Gas Vehicles, http://www.iangv.org/natural-gas-vehicles/

[13] Natural Gas for Vehicles: IGU and UN Economic Commission for Europe Joint report, June 2012: https://www.ngva.eu/downloads/news/2012%20Final%20IGU%20UN%20ECE%20NGV%20Report%202012.pdf

[14] International Maritime Organization), 2017: www.imo.org

High natural gas vehicle penetration in West Asia and South America

As of July 2017, there was globally a total of 24.5 million NGVs, up from 850,400 NGVs in 1996[15]. The table below shows the top 10 countries with most NGVs and the level of penetration in each.

Table. Top 10 countries with highest natural gas vehicle penetration

Country	NGV population	NGV as % total vehicle population
Armenia	244,000	56%
Pakistan	3,000,000	33%
Bolivia	360,000	30%
Uzbekistan	450,000	23%
Iran	4,000,000	15%
Bangladesh	220,000	11%
Argentina	2,295,000	10%
Georgia	80,600	8%
Colombia	556,548	6%
Peru	224,035	5%
Subtotal	**11,430,183**	

Source: NGV Global, 2017

Key factors behind the development of natural-gas vehicles

The overview of the experiences of selected countries that have or have had large NGV fleets and high market-penetration levels show that the introduction of natural gas in the transport sector was not primarily driven by environmental factors. Although it is widely acknowledged that the use of natural gas in large urban centres has a significant pollution-abatement impact and its cleaner fuel properties are always put forward to promote its use, it is not the main driver. Other factors play a key role in consumers' behaviour to switch from liquid-petroleum fuels to natural gas.

[15] NGV Global (2017): http://www.iangv.org/current-ngv-stats/

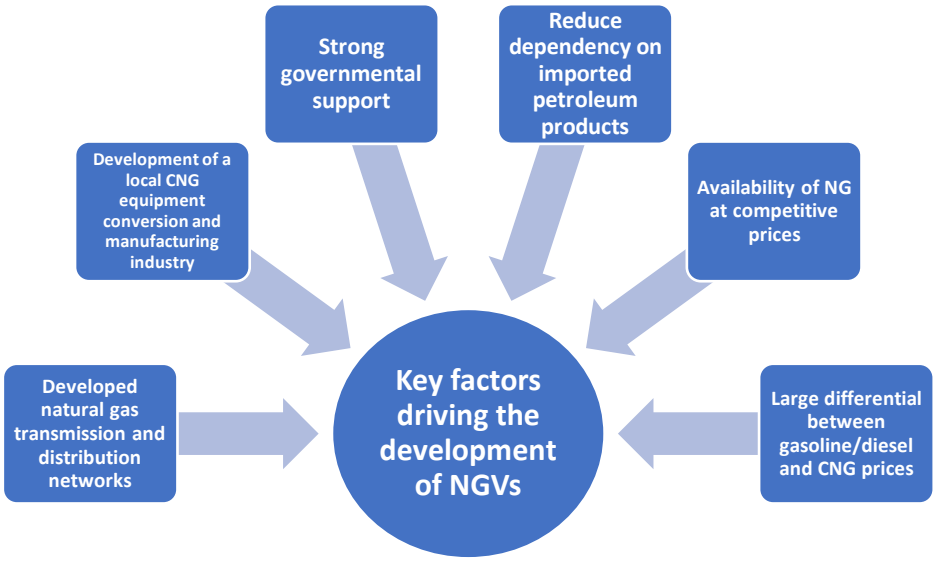

Figure 7. Key factors behind the development of natural-gas vehicles

Case study: Armenia

In the case of Armenia, which tops the list of countries with highest NGV penetration, there is no direct government support for the NGV industry or for the use of natural gas as a transport fuel. Until the collapse of the price of oil in mid-2014, the main driver of high natural-gas use in transport was the relatively cheap supplies of natural gas procured from the Russian Federation through a "strategic partnership" between the two countries. The future use of natural gas in Armenia's transport sector will very much depend on how cost-competitive the flow of imported Russian gas supplies will continue to be and whether new non-Russian gas imports could become available and be priced competitively compared not only to Russian gas, but also to liquid-petroleum products. Furthermore, the state of Armenia's CNG infrastructure and inadequate related regulations have raised safety concerns.

Case study: Pakistan

Pakistan has the world's second highest rate of NGV penetration after Armenia, although the magnitude of fleet sizes in the two countries is quite different. The introduction of natural gas in transport started in the 1990s and was initially driven by strong support of the Government (price subsidies, funding of gas infrastructure, fiscal incentives), which was keen to reduce its petroleum-products import bill and address a severe urban pollution problem. Another key driver was the presence of a natural-gas transport infrastructure with extensive transmission and distribution networks. CNG prices were regulated until December 2016 in order to maintain the cost-competitiveness of gas and were capped at 50% gasoline price equivalent. NGV growth slowed down, however, as the country was short of gas and started importing LNG in 2015.[16] This led the Government to cease the regulation of CNG prices and expose it to open-market dynamics. By January/February 2017, deregulated CNG prices rose by 8% but this does not seem to have affected CNG demand growth. According to the All Pakistan CNG

[16] Qatargas sells first LNG cargo to Pakistan, *The Peninsula*, 5 April 2015

Association, a gasoline and natural-gas price differential of over 30% will continue to fuel the demand for CNG growth. The differential in 2017 was just over 30%. The evolution of natural-gas use in Pakistan's transport sector started with the Government providing all kinds of support and incentives. This is no longer financially sustainable and future growth will be determined by market conditions, especially the competitiveness of imported gas supplies with liquid-petroleum fuels in the transport sector.

IV. Potential use of natural gas in the transport sector in the Arab region

Overview of natural gas for transport in the Arab region

The present contribution of natural gas as a transport fuel in Arab countries is still very small, although the region is considered to be generously endowed with natural-gas resources. Oil and gas reserves are not spread evenly throughout the region, however, with some countries being net exporters of oil and gas (Algeria, Qatar, Saudi Arabia, UAE) while others are net importers (Jordan, Lebanon, Palestine). The top 10 Arab countries with the largest known gas reserves include a wide range of reserve levels, as shown in Figure 8. A combination of declining natural- gas production in some Arab countries, slow upstream developments in others and a rapid natural-gas consumption growth rate in all countries that have been fuelled by heavy price subsidies has turned some Arab countries into gas importers.

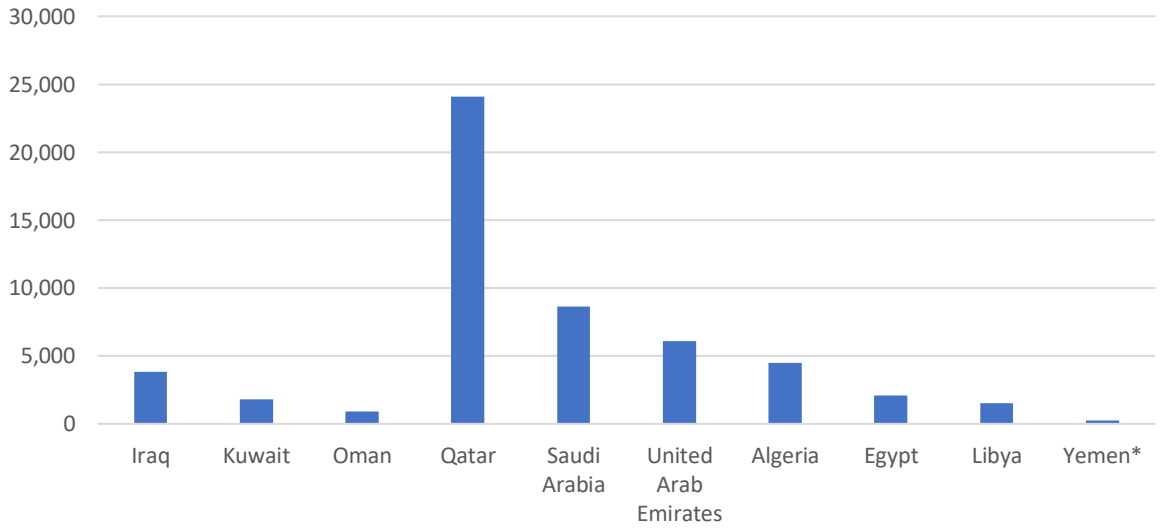

Figure 8. Top 10 natural gas reserve holders in the Arab region (billions of cubic metres), 2016
*Yemen is sourced from BP annual statistical report, 2017
Source: Organization of the Petroleum Exporting Countries (OPEC) and BP, 2017)

In early April 2017, Qatar Petroleum announced that it was lifting its 12-year moratorium on the development of its giant North Field with the potential to increase its production level by some 10%.[17] This potential increased output could provide additional gas supplies for exports within and outside the Arab region.
Egypt and the UAE are the two Arab countries so far to have promoted and introduced the use of natural gas as a transport fuel. Pilot schemes of different sizes have been launched in Algeria and Tunisia and, more recently, Qatar.

Drivers behind some of the Arab countries' use of natural gas in transport

Egypt was the first Arab country to use natural gas in the transport sector and has one of the longest experiences in the world in this area of gas utilization. The relatively successful penetration of NGVs has been driven essentially by the price differential between CNG and gasoline prices and the resulting savings that favour conversion to CNG use, especially for taxis. Financing facilitation to repay the incurred conversion costs in monthly instalments through a system of smart cards also played a key role in boosting conversion to CNG. The price advantage is supported by the subsidized price of natural gas supplies for the CNG market. While this is feasible, given low gas volumes currently consumed and current low international gas prices, it may not be sustainable in the longer term, giving rise to the need for different fiscal incentives, including a carbon-pricing mechanism.

CNG was first introduced through a taxi replacement programme to reduce air pollution. Despite the significant efforts by the Government, the percentage of vehicles converted to CNG remains low: estimated to be between 3% and 5% of Egypt's total vehicle fleet. According to Gastec, some 230,000 NGVS in Egypt are supported by 183 CNG stations and 72 CNG conversion centres. For a country that is suffering from severe urban pollution in densely populated centres, there is clearly a need to accelerate the use of cleaner transport fuels, such as natural gas.[18]

The Government's decision to develop the use of natural gas in the transport sector was based on a number of factors. These included:

- Need to diversify the range of fuels consumed in transport, a sector that accounts for 50% of the country's total consumption of petroleum products;
- Reduction of imports of liquid-petroleum products;
- Lowering of the financial burden resulting from the price subsidies for liquid-petroleum products;
- Reduction of liquid-petroleum product emissions to improve the environment, especially in densely populated cities such as Cairo.

[17] Qatar Petroleum (2017): Qatar Petroleum Announces Plan to Increase Qatar's Gas Production Capacity by 2 Billion Cubic Feet Per Day. *Qatar Petroleum News*, 3 April 2017.

[18] Osama Kamal (2011): CNG Role in Protecting the Environment: Egypt Case Study. EGAS, Cairo, Egypt.

The existing relatively large natural-gas transport grid in Egypt and the Government's efforts to increase the number and geographical coverage of CNG refuelling stations around the country's main cities contributed to the increased use of CNG.
Egypt's recent natural-gas supply crisis, which led to the urgent need to import LNG supplies through two floating storage and regasification units to meet its gas demand is unlikely to have affected the use of gas in the transport sector. Although no recent disaggregated data on this sector's natural-gas use are publicly available, the volume of natural gas used in transport is too small to be subjected to rationing or a cut in supplies. With new gas supplies coming on stream in the near future (e.g. Zhor field), the low demand level of the transport sector can easily be accommodated. Nevertheless, the significant increase in CNG price since 2014 has reduced the potential savings resulting from a switch to natural gas which could affect the potential growth of its use in the transport sector, unless some supportive regulatory framework is put in place to promote the use of cleaner fuels, at least in highly polluted urban areas.

In the **United Arab Emirates**, the introduction of natural gas as a transport fuel has been driven by environmental factors aiming to reduce pollution. The UAE's focus is on a more elaborate approach, however, that promotes not only the use of a cleaner transport fuel such as natural gas, but also the use of green technologies covering all the associated facilities, such as CNG refuelling stations. The key lesson to draw from the UAE experience, although still in its infancy, is the all-encompassing sustainable approach adopted which is part of the implementation of a broader sustainable energy policy.
The introduction of natural gas in the transport sector was led by Abu Dhabi, which has the UAE's largest natural-gas endowment, mainly in the form of associated gas. The UAE's main objective was focused on reducing air pollution caused by vehicle exhaust emissions: an objective reflecting Abu Dhabi's Economic Vision 2030 to reduce carbon emissions.

Abu Dhabi's national oil and gas company, ADNOC, led the introduction of an alternative transport fuel through the Natural Gas for Vehicles project with the support of other government stakeholders. Switching-to-gas efforts have been concentrated on government and public transport fleets (including taxis).[19] According to ADNOC's Distribution subsidiary company, air and noise pollution have decreased significantly in Abu Dhabi since CNG was introduced. In addition to Abu Dhabi City, CNG has been introduced in Al Ain and Sharjah. The next phases of the NGV project will include the western region's industrial area of Ruwais. Abu Dhabi's objective is to attain a share of 25% of government vehicles to be fuelled with low-emission natural gas in line with Abu Dhabi's Economic Vision 2030.[20]

The UAE's second largest emirate, Dubai, has also developed an NGV programme to reduce increasing air pollution from vehicles. Dubai's drive to NGV is conducted by the Emirates National Oil Company (ENOC). ENOC envisages increasing significantly its network of CNG service stations for the creation of a "smart and sustainable city" in Dubai

[19] ADNOC Distribution website: https://adnocdistribution.ae/en/corporate/ngv/

[20] NGV Global (2017): ADNOC Prepares Arabian Gulf's Largest CNG Filling Station, 30 June 2017

and other UAE emirates.[21] Dubai's Roads and Transport Authority is planning to convert 50% of taxis into hybrid CNG/gasoline vehicles by 2020. At present, Dubai's natural-gas-fuelled vehicle fleet is much smaller (less than 1,000 vehicles) than Abu Dhabi's, which is estimated at about 6,000 vehicles.[22]

In both Abu Dhabi and Dubai, CNG stations have been developed and/or renovated to be "green" stations, using sustainable technologies such as solar panels to generate electricity and the construction and operation of the stations adhere to the "highest international standards". A greater emphasis is put on the concept of sustainability in the two emirates' NGV programmes. It is interesting to note that Dubai, in line with its Dubai Plan 2021[23] "to make Dubai a smart, integrated and connected city that uses its resources sustainably" and to reduce carbon emissions by 16% by 2021, also launched the region's first electric vehicles project in 2015.

Overall, the current share of natural gas in the UAE's transport sector is extremely low. Natural-gas-fuelled vehicles account for less than 0.5% of the UAE's total vehicle fleet. Given the UAE's strong commitment to reduce air pollution and promote clean and sustainable transport fuels and transport solutions, NGVs are expected to increase their share of the total.

Besides, under the current energy-price reform conducted by the UAE Government, whereby subsidies for liquid-petroleum product prices have been removed and linked to international prices, there is an economic incentive to switch to natural gas. This is due to the lower price of CNG compared to gasoline and diesel on an energy-equivalence basis.

Two other Arab countries have introduced the use of natural gas as a transport fuel: Algeria and, to a much lesser extent, Tunisia but the current size of these two countries' natural-gas-fuelled fleets are significantly smaller than those of Egypt and the UAE.[24] A third Arab country, Qatar, has recently launched a small road NGV project.
In **Algeria**, the focus has been on LPG as an alternative cleaner and cheaper fuel. Algeria's NGV experience remains inconclusive and the main lesson from this attempt to introduce natural gas in the transport sector is the need for a clear government policy regarding alternative cleaner transport fuels supported by an overall energy sector policy that will sustainably address the critical issue of heavily subsidized liquid-petroleum products. In the case of Algeria, the drivers for this switch are not only environmental, but also financial, to reduce imports and potentially release more products for export.

Barriers to natural-gas use in the transport sector

21 ENOC (2016): ENOC Retail Eyes 40 Percent Growth in Network Capacity Until 2020, 25 February 2016: http://www.ngvglobal.com/blog/enoc-retail-eyes-40-percent-growth-in-network-capacity-until-2020-0225

22 NGV Global (2017): ADNOC Prepares Arabian Gulf's Largest CNG Filling Station, 30 June 2017: http://www.ngvglobal.com/blog/adnoc-prepares-arabian-gulfs-largest-cng-filling-station-0630

23 https://www.dubaiplan2021.ae/dubai-plan-2021/

24 NGV Global, 2017: Natural Gas Vehicle Knowledge Base: http://www.iangv.org/

Several Arab countries have taken courageous measures to adopt policies to promote and invest in the production and use of cleaner fuels (for domestic and export markets). But at the overall regional level, efforts are still needed to move towards a more sustainable path of clean transport fuel consumption, such as the use of natural gas and other clean alternatives.

Heavily subsidized liquid-petroleum products

Domestic energy-pricing policies and the issue of inter-fuel substitution and competitiveness affect directly the introduction and growth of natural-gas use in transport. The current highly inefficient use of heavily subsidized liquid-petroleum products in the transport sector of Arab countries presents a major barrier to the use of a cleaner transport fuel such as natural gas (unless the gas price is also highly subsidized). As long as the domestic prices of more polluting liquid-petroleum fuels are heavily subsidized and not constrained by strict environmental regulations to use cleaner fuels, consumers will continue to use liquid fuels in a highly inefficient way. This distorting fuel-pricing policy is not only environmentally detrimental to these countries' economies, given that "energy efficiency measures are among the most cost-effective means of reducing a country's carbon footprint",[25] but also a major financial burden on the countries' treasuries.

The oil-price collapse has finally forced some Arab producing countries to revisit their costly energy-price subsidy policies in order to balance their budgets and stem the increasing fund withdrawal from their wealth and stabilization funds. Over the last few years, countries have had to increase the prices of their liquid-petroleum products and, in some cases, the price of natural gas. But these have been increased from a very low price base.[26] With the exception of Jordan, Mauritania, Morocco and Palestine, the average prices for petroleum-fuel products in the Arab region are way below the global average as is evident in Figure 9.

[25] Idem

[26] Moerenhout, T, *Harnessing Social Safety in a Context of Changing Social Interactions: Compensation Schemes & Subsidy Reforms in the GCC*, OIES Paper, Oxford Institute for Energy Studies, Oxford, United Kingdom, August 2017

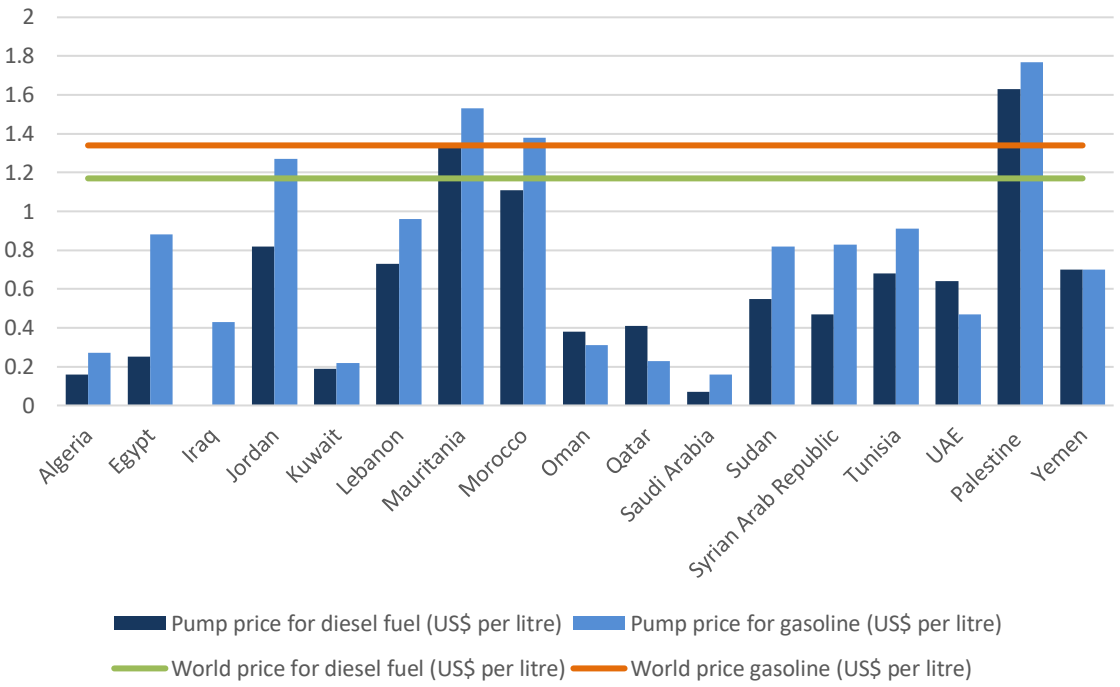

Figure 9. Fuel-pump prices in the Arab region, 2014
Source: World Bank, 2016

Competitiveness of natural gas with fuels in transport

The analysis of the competitiveness of natural gas as a fuel in transport requires more than just an assessment of the prices of competing fuels, which at present are mainly gasoline and diesel in the case of Arab countries. The factors that need to be considered for the introduction of natural gas in transport include a number of direct and other costs. The key direct costs that an individual user (private vehicles) or entity (taxis, buses, etc.) would face are as follows:

- **Conversion costs** or the incremental cost of a gas-fuelled vehicle from the original equipment manufacturer (OEM) compared to a vehicle with a gasoline- or diesel-fuelled engine. In a number of countries, the costs of conversion have been subsidized by the State. For example, in Egypt, the Government has provided a range of incentives (grants and subsidies) to encourage the initial switch to natural gas. But in the medium to long term, this is unlikely to be sustainable, due to financing constraints confronting the State. Although this issue of financing is more acute in the case of Egypt compared to other Arab countries, it remains a serious constraint, especially for large-scale developments of natural-gas-fuelled fleets.
- **Fuel cost savings** by using natural gas compared to gasoline or diesel: in some cases, this cost element could be a relatively small percentage of the total retail price of gas for transport. For example, in the United States, in 2015, natural gas accounted for only 20% of the total retail price of CNG, whilst distribution and compression costs plus marketing costs accounted for almost 70% of the retail price. Taxes represented only 13% of CNG retail price. It should be stressed, however, that the retail price structure can differ considerably from one region of the world to another.
- **Level of taxation of natural gas as a transport fuel compared to gasoline and diesel**: when low tax levels and subsidies (negative taxes) exist to encourage the use of natural gas,

it is important to establish how long these subsidies would be in place. This is important for motorists in considering the costs they will or will not face and how this would affect the savings they may or may not realize. In general, relying on such fiscal incentives, especially large subsidies, is not sustainable in the long term.

- **Difference in maintenance costs that may result from the conversion to natural gas:** it is reported that gas-fuelled engines have lower maintenance costs than gasoline-fuelled engines.

In the case of Arab countries, we note that, except for Egypt and, to a certain extent, the UAE, there is no local conversion industry in the Arab region. Moreover, most originally manufactured vehicles that run on natural gas are not manufactured in the Arab region and would need to be imported.

Gas infrastructure availability and coverage

The level of existing and future gas-infrastructure availability and coverage is a major driving factor in the penetration of natural-gas use in transport in Arab countries, especially in highly populated countries affected by severe air pollution (e.g. Egypt). The reference to infrastructure when looking at the NGV industry tends to be focused on the end segment of the chain, i.e. CNG refuelling stations. This would be an adequate approach in countries with fully developed natural-gas networks covering a wide range of localities but this is far from being the case in the Arab region.

Starting with the CNG refuelling stations, a very limited number exist in Arab countries.[27] This reflects the fact that the NGV industry in this region is still in its infancy. Further down the chain, few Arab countries (Algeria and Egypt) have developed natural-gas transport (transmission and distribution) networks that cover a large area of their territory. Investing in such capital-intensive gas-infrastructure projects takes time and significant financing that would be challenging to mobilize in less developed Arab economies and even in wealthier Arab oil- and gas-producing economies under current economic conditions.

Technology availability and role of the private sector

The issues of investing in CNG conversion capabilities, CNG-equipment manufacturing and the development of a local OEM industry in Arab countries will need to be commercially viable. This is the only sustainable condition for the private sector to engage and invest in such activities since, in most countries, the government is unlikely to be able to continue financing. The formulation and implementation of enabling sustainable energy and environmental policies (including industry standards and codes) are critical for the growth of natural gas in the transport industry in Arab countries.

[27] There are some 200 stations in the region (almost all of them in Egypt) against a worldwide total of about 30,000 stations.

V. Conclusions and recommendations

The availability of natural-gas supplies and a developed natural-gas infrastructure are the critical elements of any consideration to introduce natural gas as a potential transport fuel in any country. This is not sufficient, however, to drive gas market penetration unless governments implement key policies to promote the sustainability of natural gas in the transport sector. Key recommendations for relevant policy stakeholders are:

Sector reform and adequate domestic energy pricing policies, *whereby* the formulation and implementation of such pricing policies from one Arab country to another range from ad hoc fiscal adjustments to more effective price reforms. In countries that have removed price subsidies (or are gradually removing them) and that rely on imports to meet most or all of their domestic fuel needs, the move to cleaner fuels would in theory be much easier. But adequate policies and enforceable fuel standards would need to be in place to support this transition to a cleaner fuel environment.

Adequate domestic energy-pricing policies need to be accompanied by ***consistent environmental and climate change mitigation policies and regulations*** to enable the sustainable penetration of natural-gas use in transport. In this area, policies vary among Arab countries in terms of details, effectiveness and implementation. This category of policies and regulations, which is often overlooked, not implemented or enforced even if they exist, is another critical key driver for all alternative clean transport fuels. One of the major issues that affect this consistency concept in the Arab region is the fact that a number of policy decisions seem to be taken on an ad hoc basis and could not be sustainable.

The presence or development of a ***local conversion and manufacturing industry*** that would support the faster introduction of natural-gas vehicles. In the case of Arab countries, apart from the conversion to CNG capabilities and some equipment that is manufactured locally, much NGV equipment continues to be imported. This is due mainly to the lack of commercial incentives for the private sector to develop such an industry.

Regional cooperation and integration among Arab countries would greatly support and create synergies for the use of natural gas as a transport fuel. At present, the most relevant experience in other regions of the world would be the LNG Blue Corridors project launched in 2013 by a group of companies that are members of the NGVA in Europe and co-funded by the European Commission. Focused on LNG as a transport fuel for long distances, it provides interesting regional cooperation and integration features. Gas trading and joint regional financial funding among Arab countries could be another form of cooperation that would benefit the growth of natural gas in the region's transport sector.

Natural gas vehicle as the solution for taxis and public transport systems in the densely populated urban centres of the Arab region that suffer from air-pollution should be a key focus for governments. The promotion of new, modern, cost-effective public transport systems and investment in adequate transport infrastructure is key to promoting a safer and more efficient transport sector in the Arab region and could represent the easiest way to promote natural gas. The financial strength of the public sector is prerequisite to ensure adequate investments in the necessary infrastructure.

Other policies include providing incentives for regular vehicle fleet renewals, regulating vehicle ownership and implementing user-friendly enforcements to use other cleaner modes of transport. More important, however, is the effort made by the government to enhance the cultural and behavioural approach of individual citizens towards the use of more efficient and cleaner transport.