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Investigating the future trend of factors affecting energy efficiency in the road transport sector

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ABSTRACT

Transportation is one of the major sectors of energy consumption, and its developments have a great impact on the oil market. Statistics show that the transportation sector accounts for an increasing share of oil consumption. An examination of the trend of oil consumption per vehicle (OPV) shows the trend of energy efficiency in the road transport sector. Continuous improvement in the field of motor and non-motor technologies in commercial and passenger vehicles, changes related to changes in fuel composition including the use of alternative fuels and increasing the share of gas in the form of CNG in this sector and reducing the average vehicle miles traveled (VMT), affected by personal income and fuel prices, demographic change and increased access to public transportation have all led to increased fuel efficiency in this sector. This article examined the future developments of the above factors that will lead to increased fuel efficiency in the road transport sector, as well as their impact on the fuel market.
Key words: Electric cars, alternative fuels, LNG, energy efficiency, commercial vehicles, passenger cars

Introduction

The transportation sector is one of the largest consumers of energy and the main consumer of petroleum products, the consumption of which is growing. Besides, the transportation sector is growing faster than other sectors in the world. As a result, improving energy efficiency in the transportation sector is one of the fundamental and vital issues.

In addition to the positive effects of transportation on the economy, there is a range of negative effects in this sector. The combustion of fossil fuels causes greenhouse gas emissions and environmental problems in the region and the world. With the enactment of emission laws on vehicles in many countries around the world[1], the negative environmental impacts of fossil fuel combustion have been dramatically reduced over the past two decades. CO2 label affixing is a practical way to inform the consumer about the environmental standards of new cars. Attaching this label may increase awareness of the environmental impact of cars, and in combination with tax incentives may help change consumer decisions to buy environmentally friendly cars. The use of biofuels is considered as a fundamental way to reduce greenhouse gases in transportation as well as limit the effect of rising prices and improve supply security.

Given that the policy of countries around the world is focused on reducing crude oil consumption due to the goals of reducing greenhouse gas emissions, saving, and diversifying the fuels used, many changes in the future consumption of oil per vehicle (OPV) in the transport sector, especially in road transport, affect passengers. These developments are related to changes in the composition of fuels (biofuels, natural gas,

[1] Globally, the share of carbon dioxide (CO2) and other greenhouse gases is increasing.

electricity, hydrogen, etc.) and technology (efficiency of cars, self-driving cars, etc.) or cultural change (car sharing). These developments indicate an increase in the share of consumption of gas, electricity, and alternative fuels in this sector and its replacement with crude oil.

Current situation of energy consumption in the transportation sector in the world

The share of the transportation sector in total oil consumption in 1973 was 45.4%, which increased by about 19% in 2017 to 64.8%.

Due to the expansion of gas production and environmental policies, an increase in gas consumption in the transportation sector is visible. For example, because carbon dioxide emissions through natural gas consumption are one-third that of coal, policymakers prefer to substitute gas for coal to reduce carbon dioxide emissions. For this reason, gas replacement is seen in most sectors, including transportation. The share of natural gas consumption in this sector has increased from 2.7% in 1973 to 7% in 2017.

Also, the decrease in the share of coal consumption in the transportation sector is due to the policy of decarbonization with structural modification. For this reason, countries have pursued programs to reduce coal use to reduce carbon dioxide.

Despite the increase in the improvement of the technology used in the field of transportation, which will expand the use of electricity in this sector, pursuing the goals of the decarbonization policy by reforming the structure will lead to the development of programs in the transport sector to expand the production of electric vehicles (for example, the German government has entered into contracts with some car companies, such as Volkswagen, Daimler, and BMW, to produce more electric cars).

Future developments in the transport sector and its effect on the composition of the energy portfolio

There will be many changes in the future of energy consumption in the transportation sector, especially passenger road transportation[2]. These developments are related to changes in the composition of fuels (biofuels, natural gas, electricity, hydrogen, etc.) and technology (vehicle efficiency, self-driving cars, etc.) or cultural change (car sharing). In the following, we will examine each of the following factors separately.

Investigating the impact of technology trends on the composition of the energy portfolio in the transportation sector

According to the OPEC reference scenario in the 2016 vision of this reference, there is a growing trend of technology in various sectors, which has always had a great impact on the intensity of energy consumption. Also, the role of technology (production of high-efficiency cars and low fuel consumption, production of electric and hybrid cars, etc.) in the transportation sector will be much more colorful than now, as from the past until now, technological changes have had very important effects on the construction and development of car engines. According to OPEC forecasts in the future, car engines will be such that gasoline and diesel consumption will be less than now. Production of electric and hybrid vehicles will increase significantly and the use of these vehicles will be further expanded in urban areas. In the reference scenario, it is assumed that the costs related to the batteries of these cars will decrease faster than in the past.

The electrification of light vehicles is one of the drivers of energy saving in the transportation sector. Much of the energy savings in the future, as well as productivity investments, are related to increasing the market share of electric vehicles[3] (EVs) in light vehicle travel (LDVs). In 2015, EVs inventory (which includes direct-charge hybrid vehicles (PHEVs) and battery-powered electric vehicles (BEVs)) increased by more than 1 million to 1.26 million. Statistics show that sales of electric vehicles in 2015 resulted in more than 33 million barrels of oil savings over the life of the fleet. Fuel savings through EVs sales in 2015 accounted for 0.01% of global crude oil consumption in the transportation sector this year. However, electric vehicles are still an important and vital technology for reducing greenhouse gas emissions.

[2] According to the IEA, three-quarters of the energy savings that will be generated from productivity in 2040 are related to road transport, 80% of which is related to cars and trucks.

[3] More than 550,000 electric vehicles were sold in 2015.

According to the IEA scenario, 140 million electric vehicles will be needed for ground transportation to achieve the greenhouse gas reduction target by 2030.

In addition to electrifying passenger cars, which is one of the most important developments in increasing fuel efficiency in the road transport sector, the technology of piston engines has remained unchanged for a long time since the boom of road transport, while in recent years, the exhaust gas recirculation (EGR) and the reduction in the size of gasoline engines have led to the technology of gasoline engines to move to a generation of engines that control the flow of gasoline.

In the field of car production, the OPEC reference scenario assumes that in the future cars will be lighter than they are now, which will lead to a reduction in fuel consumption. It is also assumed that the roads will have higher standards, which will help reduce energy consumption in cars. However, a large and rapid increase in traffic, which is the result of faster development of countries, will affect the improvement of technology in the construction of cars and roads.

Because the major growth in energy consumption in the transportation sector is related to heavy-duty vehicles (HDVs) and also the increase in HDV efficiency compared to mobile travel LDVs is negligible. Recently, there has been a lot of focus on improving performance in HDVs[4].

In the OPEC reference scenario, a slight improvement in the efficiency of large commercial vehicles is assumed and the improvement in the performance of large commercial vehicles is expected to be limited. The reason for this assumption is that in the past, there was a 45% efficiency for diesel engines used in large commercial vehicles. At present, the diesel engine used in these large and heavy vehicles is much better than in the past, and there is no hope for further development in the future. Improvements in passenger cars and small commercial vehicles, meanwhile, have averaged 30 to 40 percent. As a result, in large commercial vehicles, unlike small commercial vehicles and passenger cars, efficiency is very close to its saturation point.

Investigating the impact of changes in regulations on the composition of the energy portfolio in the transport sector

The transportation sector accounts for a little over a quarter of final energy consumption, of which more than 90% is in the form of oil. Since 1990, energy consumption in transportation has increased at an annual rate of 2.2%. Without the further strengthening of the fuel standards outlined in the new IEA policy scenario, the annual growth of energy demand in transportation by 2040 will be 2.1%. Three-quarters of the energy savings in 2040 will come from road transportation, with 80 percent coming from cars and trucks.

The road transport sector is heavily influenced by strict laws. About three-quarters of existing vehicles are equipped with economical fuel standards, and policymakers are increasingly pushing for the rules for heavy vehicles. These measures will have long-term effects on crude oil consumption. In the new IEA policy scenario, for example, the average fuel consumption of new passenger cars will be around 4 liters per 100 kilometers in 2040. This is one third less than consumption in 2015. Since mid-2014, the market for cars that consume less fuel has increased.

Investing in vehicle engine technologies has a significant impact on global fuel demand[5]. According to the IEA forecast, the fuel efficiency standard will cover nearly 70% of road vehicles by 2021 (fuel consumption standards for heavy vehicles are less widespread).

Policies are a major factor in the growth of electric car sales. In general, policies in this area include incentive policies for consumers so that they find electric vehicles more affordable and manufacturers see the sale of non-electric vehicles as less profitable. The Netherlands, for example, offers tax exemptions for owners of electric vehicles.

Economic fuel standards are an important tool for achieving energy efficiency in the transportation sector. The standard covers more than 50 million vehicles sold in 2011. These standards will also be a guide for the market to expand the technologies and services needed to increase efficiency.

[4] The United States, Japan, and Korea have implemented standards to increase productivity in this sector.

[5] The increase in fuel efficiency in the car will be almost four times faster than in the last ten years.

Over the past ten years, through economic fuel standards, the average efficiency level of light-duty vehicles (LDVs) has increased from 20% to 25% among countries. These standards have only led to the obsolescence of vehicles that do not consume fuel economically. Also, the fleet of new vehicles that comply with 2015 standards will be only 33% as efficient as a fleet (BAT). However, vehicles with the best available technologies (BATs) are not necessarily available in every market, and market conditions such as low fuel prices and high vehicle costs can still limit the increase in the number of efficient vehicles.

Investigating the effect of alternative fuels on the composition of the energy basket in the transportation sector

The second reason for the reduction in the intensity of oil in road transport is the use of alternative fuels in this sector. For example, the supply of biofuels to use some of these fuels to combine in the final product has led to a reduction in the intensity of oil in this sector. Of course, the future of this fuel market is highly dependent on government protection policies. In the new IEA policy scenario, it is assumed that the government will continue to support biofuels. Therefore, in 2040, biofuels are expected to replace more than 4 million barrels of crude oil equivalent per day (mboe/d), which is 1.5 million barrels of crude oil equivalent higher than in 2015 today.

Based on the OPEC reference scenario in the 2016 vision, it is assumed that the role of renewable energy and electricity in the transport sector will increase in the future.

Also, according to OPEC, the use of hydrogen in the transportation sector will be further expanded. At present, all the required hydrogen used in this part is obtained from natural gas, and it is predicted that in the future, it will be obtained from renewable energies, especially wind and solar energy. The technology needed to store hydrogen in liquid and solid form is expected to improve significantly in the future[6].

According to the IEA forecast in the transport sector, in the new policy scenario, the share of renewable energy will increase from 3% in 2016 to 7% in 2040. According to the new IEA policy scenario in the transport sector, the use of liquid biofuels will reach 3.6 million barrels per day, and in policy 450 to 9 million barrels per day in 2040.

Electric cars (EVs) are also expected to make up one-tenth of passenger cars sold worldwide, and about 40 percent of the energy used in these vehicles will come from renewable fuels. Of course, in the field of renewable energy development policies in the road transport sector, the growth rate is slow. The reason for this is the high cost of its infrastructure and the production of vehicles that can use these fuels.

Other fuels used in transportation, such as electricity (e.g. EVs) or natural gas, are supported either by subsidies or by entering a competitive market. The fastest-growing rates of natural gas consumption in the transport sector are in the form of compressed gas (for passenger cars) and LNG (for trucks and maritime transport). In the road transport sector, we are witnessing the widespread use of natural gas, so that we will face a 5% annual growth in the use of natural gas. This rapid growth is observed in countries that pursue policies to promote and develop infrastructure or to buy and sell gas-powered vehicles to improve air quality and oil security.

The latest available statistics show that the number of vehicles that use natural gas fuel is increasing. In 2013, there were more than 22 million gas-powered vehicles. However, in some countries and large markets, such as the United States and China, in response to falling crude oil prices, we have seen a decline in the growth rate of these vehicles. According to OPEC, the share of gas in energy consumption in the road transport sector will almost triple by 2040. The bulk of the increase is due to the widespread use of gas in passenger cars, including buses and trucks, such as trucks, which is growing at a rate of about 6.3 percent per year.

According to the IEA, gas demand in the transport sector will increase by 160 billion cubic meters to 280 billion cubic meters in 2040. 90% of this increase in gas is related to the road transport sector. After

[6] Hydrogen is burned in internal combustion engines. Hydrogen fuel cells have been considered as a way to generate potentially cheap and pollution-free power. In the past, hydrogen used in gas transportation was obtained, but now hydrogen is generated from electricity generated from renewable sources such as wind, solar, geothermal, etc., and can be used in the transportation industry after being stored and transported to places of consumption.

that, the maritime transport sector has the largest share in this increase, in which the role of LNG is increasing rapidly. The United States has the largest increase in gas consumption in road transport, with the United States accounting for 30% of global demand growth by 2040. China is next with 21% and India with 14%.

According to the EIA, the share of natural gas in the transport sector will increase from 3% in 2012 to 11% in 2040 (in 2012, 66% of the gas consumed in the transport sector used in the pipeline and 28% in Light vehicles and 4% were used in buses). In the EIA reference scenario, it is predicted that the largest increase in the share of gas will be related to large trucks, in which the share of gas will increase from 1% in 2012 to 15% in 2040.

The most important factor of uncertainty about the future of the role of gas in the transportation sector is to provide the necessary infrastructure to benefit from this energy carrier in this sector. One of the challenges ahead is the investment risk to build natural gas pumps. This has made the development of gas vehicles and their mass production stage less clear.

According to the EIA forecast, by 2040, gas will account for 50 percent of bus fuel consumption, 17 percent of rail freight fuel, 7 percent of light vehicle fuel, and 6 percent of domestic ship fuel.

In the new IEA policy scenario, the share of biofuels, electricity, and gas is expected to increase by 2040 in road passenger transport (Figure 2). However, in road freight transport, there is an increase in the share of biofuels and gas, which is much less than passenger road transport. In the rail transport sector, the share of coal in this sector is expected to disappear and a significant increase in the share of electricity. In the maritime transport sector, the increase in the share of gas will be very evident.

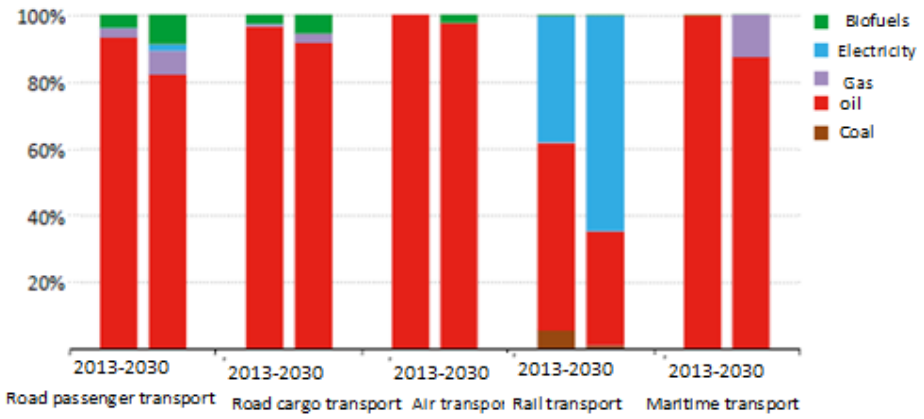

Figure 1. The share of final energy consumption based on transportation and fuel sub-sectors in the new policy scenario until 2040.

Source: IEA world energy outlook, 2017

1. Energy efficiency indicators

There are three types of indicators to measure changes in energy efficiency between countries and different regions of the world. These indicators are economic rate, technical-economic rate, and greenhouse gas emission index.

The economic rate refers to "energy intensity", which is the energy consumption per unit of energy - a tonne of oil equivalent (toe) on the indicators of economic activity (GDP, value added, etc.) in the currency at constant prices.

The technical-economic rate is obtained from the ratio of energy consumption to the activity index measured in physical conditions (tons of steel, number of kilometers of passengers, etc.) or a unit of consumption (e.g. car, residential, etc.). This ratio is also called specific energy consumption.

The GHG index seeks to examine the market penetration of energy-efficient technologies (share of electric steel, installation level of solar water heaters) and performance and practices (e.g. per capita displacement by rail transport).

2. Efficiency in the field of road transportation

Energy efficiency in the transportation sector can be measured as the average energy required to move a person or a ton of goods per kilometer, in just one area. This approach is related to the fact that different modes of transport have different technical efficiencies because changing the type of transportation can change the total energy consumption and is one of the ways to improve energy efficiency in the transportation sector.

The amount of energy consumption in the transportation sector depends not only on its sub-sector but also on how this sub-sector is used (driving patterns[7] and consumption efficiency). The size, power, and energy consumption characteristics of the car have a great impact on fuel efficiency. Of course, there is also evidence that consumer preferences for easier, not necessarily more efficient, transportation have changed somewhat. This change in taste in some countries, such as the United States, has led to increased consumption and reduced fuel efficiency.

According to the IEA, energy efficiency accounts for 30% of total energy consumption worldwide. This level of efficiency is not only due to laws enacted around the world, but also alternative or complementary methods and regulation of energy prices are other effective factors (increasing energy taxes and imposing prices on CO2 production) in this field. Although mandatory regulations have a significant impact on reducing energy consumption and savings (according to the IEA forecast, due to technological advances as well as mandatory regulations, we expect to see an annual growth of 2% efficiency in the global transport fleet), the real impact of the rules will not be seen unless the price of energy is such that it does not force consumers to reduce consumption.

Therefore, the effect of energy prices on its efficiency should not be ignored. As a result, the policy package to increase energy efficiency typically includes pricing and regulatory elements. Low energy prices, despite the expansion of efficiency due to the lack of economic attractiveness to invest to increase energy efficiency, will lead to reduced productivity.

However, on the other hand, the price signal alone is not enough to achieve efficient consumption. In addition to the price role of market policies, it will create the right conditions to provide energy-efficient equipment and services and allow consumers to make less costly decisions.

Most OECD countries have higher levels of energy taxes than the United States. This has increased the incentive to buy more efficient cars in these countries. Even in the absence of strict regulations and such taxes, the general trend has been to select more efficient vehicles, such as vehicles with state-of-the-art engine technology. Traffic problems as well as lack of parking have led to increased demand for smaller and more efficient cars.

In non-OECD countries, forecasts indicate stable performance in these countries.

3. Technological changes in the road transport sector

An examination of the trend of oil consumption in each vehicle, or OPV, shows the trend of energy efficiency in the road transport sector. As a result of technological changes that result in OPV changes in this sector, energy efficiency changes. To calculate this index, the average energy efficiency of vehicles, average distance traveled by each vehicle with a certain amount of fuel, and the average number of vehicles that use alternative fuels such as natural gas, electricity, and renewable energy, are used. OPV changes are estimated by improving energy efficiency and changing vehicle miles traveled (VMT) and expanding alternative fuels.

[7] Traveling in high-traffic areas, for example, requires more fuel than traveling on a secluded highway. Driving at high speeds increases fuel consumption. Sequential accelerating and braking, especially at high speeds, lead to higher fuel consumption. Starting a car with a cold engine consumes more fuel than starting with a warm engine.

The average VMT is affected by a wide range of factors, the most important of which are: personal income and fuel prices. These two factors limit drivers' budgets and therefore mileage. Other factors, such as demographic and aging population changes, increased access to public transportation, and changing employment levels, may also have some effect on VMTs.

Improving fuel efficiency in internal combustion engines has been a major source of OPV reduction. In general, continuous improvements in engine and non-engine technologies such as improved driving, better aerodynamics, and weight loss have led to increased fuel efficiency. While fuel efficiency improves for all vehicles, average vehicle fuel efficiency is also affected by changes in vehicle composition.

The development of some vehicles that run on alternative fuels will reduce the share of vehicles that use oil-based fuels, resulting in a reduction in OPV. Natural gas - in the form of CNG for passenger cars and commercial vehicles and LNG for commercial vehicles - is one of the alternative fuels. In some countries, there is widespread development of the market for vehicles that run on natural gas. It is expected that in other parts of the world, the share of this type of vehicle will gradually grow. However, the development of vehicles powered by electric fuel and electric batteries is currently subject to certain limitations, which will be discussed below.

- **Technological changes in passenger cars:**

The development of alternative technologies in the passenger car market is more challenging than commercial vehicles. Consumer tendencies, habits, laws, infrastructure, and convenience issues are often combined with economic and social considerations and influence the final decision to buy a car. As a result, when buying a new car, more criteria with different weights are usually considered in the decision-making process. This becomes more complicated when people are not always thinking about efficient transportation, but also about improving their social status.

General considerations such as the initial purchase price and the issue of convenience and facilities are of interest to all owners of private cars. As a result, battery-operated electric vehicles (BEVs)[8] are not expected to have a significant market share in the future. In addition to the high price of these cars, there are serious challenges with the facilities available in these vehicles (such as limitations of distance traveled based on car charge and poor battery performance in very hot or cold weather - exactly when higher efficiency is required for cooling or heating - as well as recharging costs) which requires a major investment in this area.

Even if the cost of the battery used in battery-powered electric vehicles is low, most consumers will not be eager to use these vehicles because of the challenges involved. Of course, to solve the above problem, a battery-electric vehicle equipped with an internal combustion engine to charge the batteries (REV) is recommended. However, due to the fact that these cars require high technology, which leads to increased costs. The development of the electric vehicle battery has slowed down.

Because of the challenges, vehicle electrification is limited to different levels of hybridization[9], including plug-in hybrid electric vehicle (PHEV)[10] and start-stop technology[11], especially in developed and urban

[8] A car is said to use a battery for propulsion instead of an internal combustion engine. In these cars, the engine is located under the body. The advantages of the electric car over the combustion car include a significant reduction in local air pollution, a reduction in greenhouse gases and a reduction in dependence on oil.

[9] *A hybrid car is a car that uses a combination of two or more separate power sources to move. In most cases, the name is used to refer to a dual electric vehicle in which the propulsion system has an internal combustion engine (usually gasoline) next to one or more electric motors, and the vehicle has the ability to use only one of these sources. Use energy or both together. There are other types of hybrid vehicles that use other fuels such as propane, hydrogen or solar energy. The type of technology used to make these cars depends on the purpose of the car designers; whether the hybrid vehicle is designed for higher fuel efficiency, more power, longer mileage with one refueling or reduced emissions. These cars are also known as green cars.*

[10] *It is a dual-burner vehicle with rechargeable batteries that can be fully charged by connecting to an external source. A PHEV has an electric motor and an internal combustion engine that features both a conventional dual-burner electric vehicle and an all-electric vehicle, and can also be connected to the mains. Most PHEVs are now passenger cars, but there are also PHEV commercial models, including vans, trucks, buses, trains, motorcycles, scooters, and military vehicles.*

[11] *It is a system in which the internal combustion engine is switched on and off automatically to reduce fuel consumption and greenhouse gas emissions. This technology is suitable for vehicles that spend a lot of time in traffic.*

areas where technology and costs have increased will be offset, leading to significant fuel efficiency improvements without the challenges that BEV vehicles face.

Hybrid vehicle technology in the passenger transport sector has the highest energy efficiency. These vehicles show a significant reduction in fuel consumption and pollution compared to conventional vehicles. Today, hybrid vehicles are used in developed countries such as the United States, the European Union, and Japan, specifically in urban areas to reduce pollution.

Although there is a lot of advertising pressure to expand fuel cell vehicles, high purchase costs will result in a lack of hydrogen refueling infrastructure, as well as relatively expensive hydrogen fuel. Therefore, the global development of this advanced technology for passenger vehicles is likely to be low in the future.

Other technological developments in the transportation sector include the gradual increase in the share of natural gas in the form of CNG as an alternative fuel in passenger cars. Most new CNG cars have the ability to dual fuel with gasoline. Mass production of these models has significantly reduced their price compared to diesel cars. As the number of CNG stations increases, vehicles that use only CNG as fuel will expand in the future, which will reduce purchase prices and improve their efficiency and performance.

The future growth rate of CNG vehicles technology in end-consumer markets will depend not only on the purchase price but also on the difference between the price of CNG and gasoline or diesel, as well as the availability of CNG stations. In Italy, for example, the Fiat Company, as a national automobile manufacturer, offers CNG vehicles at very competitive prices, and existing CNG stations guarantee that they are reasonably priced. The share of CNG vehicles of this factory in 2015 is 5% of its new cars, and this trend is growing.

Latin America, India, and China are expected to achieve the highest growth rates of CNG passenger cars due to government support for the development of necessary infrastructure and tax incentives for consumers.

Figure 2 shows the decline in the share of gasoline-burning cars from 81% in 2013 to 56% in 2040. The share of diesel cars in this period is expected to increase from 14% to 21%.

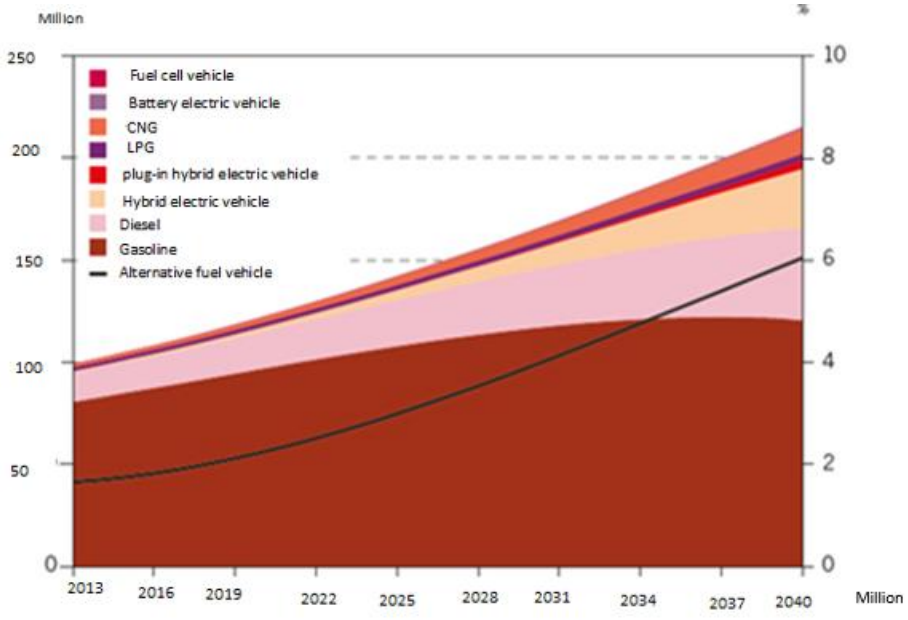

Figure 2: Composition of the fleet of passenger cars based on technology

Source: OPEC World Energy Outlook, 2017

The share of electric hybrid vehicles in the world is also expected to increase, leading to an overall decline in OPV. Forecasts show that the share of hybrid electric vehicles in the period 2040-2013 will increase from 1% to 14%. Due to the relatively high share of taxi stops-starts in cities, which leads to fuel

waste, the hybridization of vehicles to save energy is important. By hybridizing taxis, it is possible to save up to 30% on fuel for hybrid vehicles compared to conventional and older models. The share of these cars in the world is expected to increase from 2% in 2013 to 6% in 2040.

As can be seen in Figure 2, the number of BEVs and fuel cell vehicles in the world will also increase. However, due to the low share of these cars in the market, its growth is insignificant and its share will remain below 1% in 2040.

According to OPEC forecasts, there is an improvement in fuel efficiency in internal combustion engines, and this improvement is the main source of OPV reduction. To continuously improve fuel efficiency in passenger cars, standards, and fuel efficiency goals are being pursued worldwide. In addition to these set standards and goals, car companies are also looking to make their cars more efficient in a competitive environment.

As mentioned, the VMT variable affects the OPV and will decrease over time, as urbanization rates and traffic congestion problems along with public transport policies lead to further VMT reductions. As a result, OPV in passenger cars is expected to decrease due to improved fuel efficiency, reduced VMTs, and increased vehicles with alternative fuels.

As can be seen, between 2014 and 2040, OPV will show the highest decline in India, China, the United States, and OPEC and OECD countries, while it will be the lowest in Latin America and other Eurasian countries. The main factor of increasing fuel efficiency and decreasing OPV is increasing fuel efficiency in internal combustion engines and electric hybridization. An increase in the share of CNG-powered gas-powered cars, which account for the market share of gasoline-powered cars, will also lead to a decrease in OPV. Forecasts show that due to the proliferation of CNG cars in China and India, the reduction in OPV will be due to the replacement of CNG cars in these countries (Figure 3).

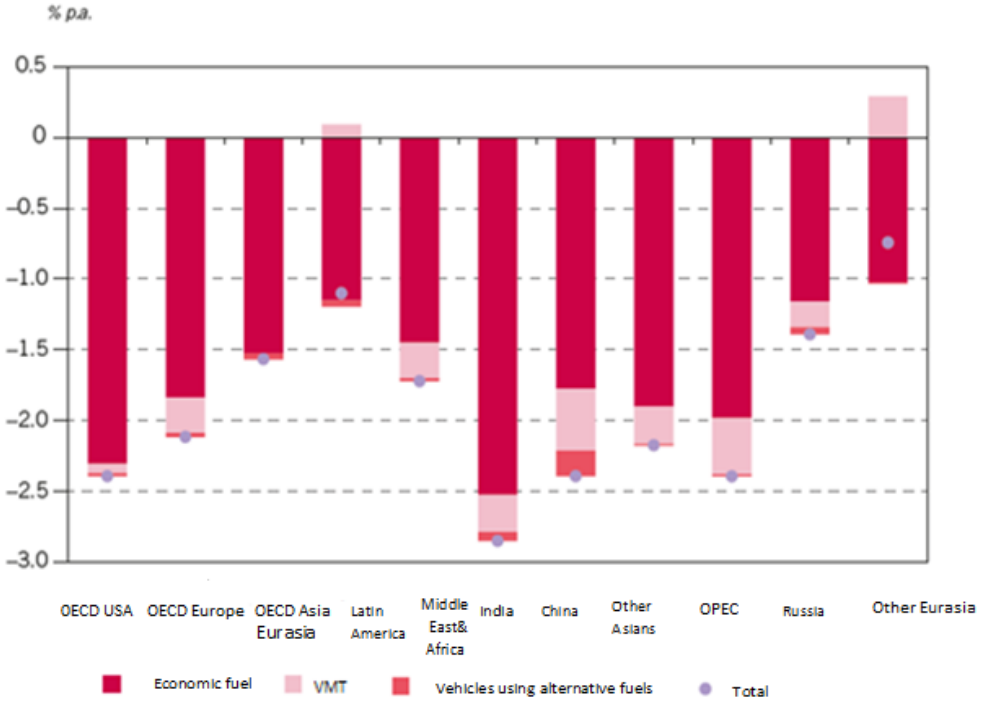

Figure 3: The relative contribution of OPV changes in fuel efficiency improvement, VMT and growth of vehicles to alternative fuels for passenger cars (2040-2014) in different countries

Source: OPEC World Energy Outlook, 2017

Inadequate road infrastructure increases fuel consumption and neutralizes vehicle fuel efficiency improvements. In the current trends, the improvement of road infrastructure in the transportation sector is visible, which has led to a reduction in energy consumption.

Other factors that have led to a reduction in fuel consumption in the road transport sector include weight loss in the new generation of vehicles, which has been effective in increasing energy efficiency. Also, the existing programs in the field of reducing traffic lead to reducing fuel consumption and improving efficiency in this sector. Another way to reduce energy consumption is to promote car sharing to reduce the use of private cars and thus reduce traffic.

- **Technological changes in commercial vehicles**

Diesel engines have traditionally been used as a cost-effective technology for commercial road transport, as diesel produces more energy based on the volume it consumes. On the other hand, over the past hundred years, the thermal efficiency of diesel engines has increased by about 50%.[12]

Because high-quality alternative technologies for trucks, such as BEVs or fuel cell electric vehicles (FCEVs), are underdeveloped due to the high cost of these technologies as well as the occupancy of cargo space by the batteries of these vehicles. As a result, the attractiveness of these technologies has diminished.

The use of BEVs in the commercial transport sector is mainly limited to electric city buses. These cars are widespread in China and are expanding in the United States and Europe. Although the use of these buses is associated with a reduction in greenhouse gas emissions, the cost of purchasing these buses is higher than its diesel models. Due to the lack of hydrogen refueling infrastructure and the high cost of purchasing this type of vehicle, there is a decrease in the tendency to buy trucks and buses with fuel cells.

Gas burners come in two forms, CNG and LNG[13]. These cars are no different in terms of engine and driving from cars that run on gasoline and diesel fuel, and the only difference is their fuel system. These gas-powered cars are 15 percent more efficient than similar diesel cars. Of course, for countries where the price of natural gas is significantly different from diesel fuel, there is a commercial alternative to CNG and LNG. However, so far, high costs and weak fuel networks have led to the limitation of this technology in the road transport sector.

Due to the low cost of CNG investment and the possibility of connecting it to the existing gas pipeline, it will be easier to build a CNG refueling network than LNG. Therefore, the penetration and expansion of CNG and LNG technologies in the commercial road transport sector strongly depend on the characteristics of that country, including access to that fuel, its price difference with liquefied fuels, the additional cost of natural gas vehicles (NGV), subsidies and the development of a dense refueling network. In some countries, such as Pakistan, Argentina, and Iran, due to the favorable conditions for the development of this technology, there is a penetration rate of 20 to 40 percent for commercial gas vehicles. As shown in Figure 4, globally, with the increase in natural gas supply and cheaper and more accessible technology, the gradual increase in the share of LNG and CNG in commercial vehicles is expected to be achieved by 2040.

[12] The share of diesel commercial vehicles is about 70% and is expected to remain around the same level until 2040.

[13] As an alternative to diesel fuel, LNG requires approximately 2.5 times the space for the fuel system, which is five times that of CNG. For this reason, LNG is used for long trucks and buses with high transport capacity. Thus cheaper CNG technology will be suitable for vehicles traveling long and medium distances as well as taxis and city buses and other municipal services such as garbage trucks.

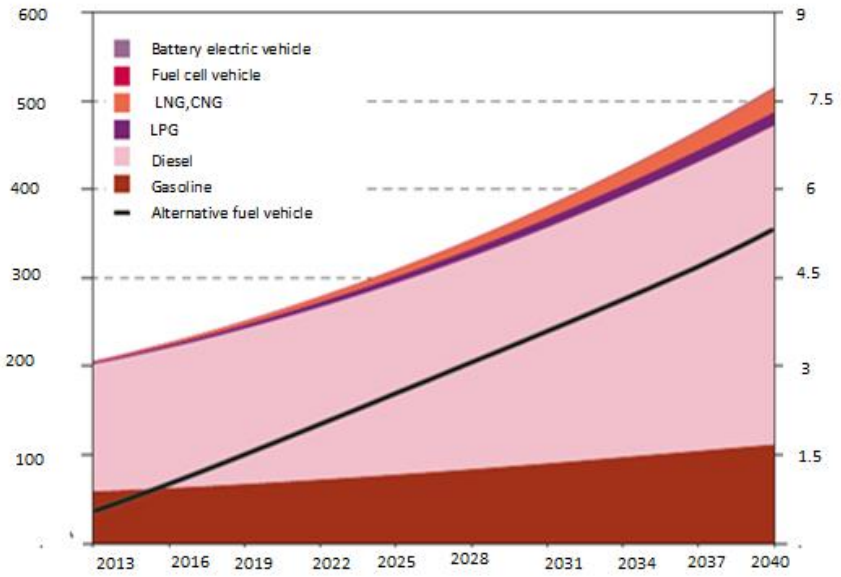

Figure 4. The combined inventory of commercial vehicles based on technology

Source: OPEC World Energy Outlook, 2017

The penetration and development of gas-powered commercial vehicles in the OECD countries of the United States, China, and Latin America is relatively higher than in other regions. China currently has the largest share of commercial gas vehicles compared to other regions and is expected to continue to have this high share in the future. It is predicted that due to the significant increase in CNG and LNG fuel stations that will be available to the public by 2020, the growth of gas-powered commercial vehicles in the OECD countries of the United States will be strengthened.

In China, India, and Latin America, NGVs' inventory growth is relatively high due to incentive policies to increase the use of gas as a fuel in cars. There is also an increase in LNG consumption in long trucks in the United States.

As can be seen in Figure 4, in the world of gasoline and diesel, it has a high share in commercial road transport and will continue to do so until 2040. The share of gas is also expected to increase by 2040. According to OPEC forecast, the share of gasoline consumption in commercial vehicles will decrease from about 29% in 2013 to 22% in 2040.

The global market share of gas-powered commercial vehicles in 2013 will increase from less than 1% to 5% in 2040. The share of commercial vehicles using alternative fuels will increase from less than 1% in 2013 to 5.3% by 2040 (Figure 4).

Because the fuel consumption of trucks is significant due to their long distances. The intrusion of commercial vehicles that use natural gas as fuel leads to fuel savings in these vehicles. In other words, natural gas is more economical than diesel over long distances traveled by road vehicles.

In the commercial road transport sector, forecasts show that if the economic use of fuel improves (in the commercial road transport sector, the focus of policies is more on environmental issues and reducing greenhouse gas emissions than the economic use of fuels), the average OPV reduction for trucks will be 1.8 percent by 2040 through aerodynamics and engine optimization.

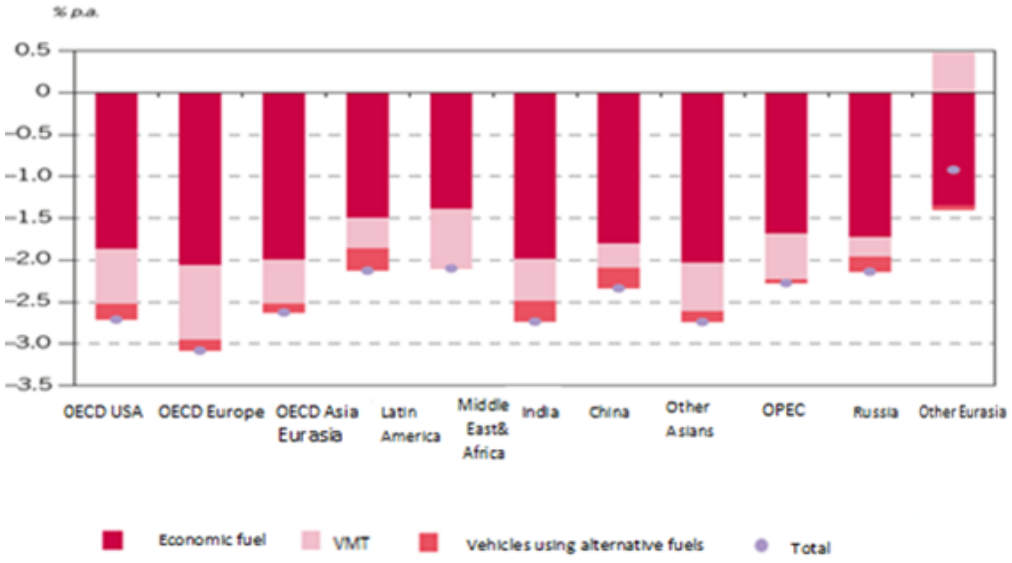

Figure 5: The relative contribution of OPV changes in fuel efficiency improvement, VMT, and growth of vehicles to alternative fuels for commercial cars (2040-2014) in different countries.

Source: OPEC World Energy Outlook, 2017

As shown in Figure 5, the OECD region, India, and other countries in Asia are expected to have the highest rates of OPV reduction in commercial vehicles among other countries and regions. The countries of the European OECD region have the largest share of performance improvement, followed by the OECD of the United States and Asia-Pacific, India, and other countries in the Asian region.

Conclusion

As shown, fuel consumption forecasts in the road transport sector are affected by several factors that have affected the future of fossil fuels in this sector.

Equipping about three-quarters of the world's cars with economical fuel standards and enforcing strict rules on heavy vehicles have a significant impact on energy consumption in this sector. Another influential factor in reducing fossil fuel consumption is the use of alternative fuels in the road transport sector. Despite the slow growth of consumption of these fuels, the reason is the high cost of its infrastructure and the production of cars that can use these fuels. The growing trend of technology through the production of high-performance vehicles and the production of electric and hybrid vehicles are other effective factors. Changes in the technology of piston engines and exhaust gas recirculation (EGR) and reducing the size of gasoline engines are another development in the road transport sector to reduce fossil fuel consumption. Lighter cars as well as higher road standards have also led to a reduction in fuel consumption in this sector. Also in the road transport sector, the widespread use of natural gas is seen following the policies of promoting and developing infrastructure or buying and selling gas-burning vehicles to improve air quality and oil security. The bulk of the increase is due to the widespread use of gas in passenger cars, including buses and trucks, such as trucks.

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