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THE ROLE OF OIL AND NATURAL GAS IN THE CONTEXT OF LOW-EMISSION TRANSPORT BY 2030

Jakub Prugar¹, Paweł Węgrzyn²

Abstract

Fossil fuels, mainly petroleum and natural gas, are dominant in the transport sector. The occurring climate changes, which are largely the result of exhaust emissions, must be slowed down. To achieve this, legal regulations have been introduced determining the development of alternative drives in transport while reducing the share of those present. The development of electromobility and clean gas technologies is a chance to reduce the share of diesel drives in the transport sector. The purpose of this article is to present the role of natural gas and crude oil in the perspective of 2030. Key words: natural gas, oil, low-emission transport.

Introduction

Oil and natural gas are the two most desirable fuels in the world. The history of these fossil fuels dates back to ancient times – a however, their true value was appreciated only in the mid-19th century. The discovery of oil and natural gas and their extraction from the world's first oil field started by Ignacy Łukasiewicz took place in 1854 in Bóbrka near Krośno (PGNiG 2017). Ignacy Łukasiewicz used oil as a fuel in a kerosene lamp, which was a milestone for the later oil sector. The great importance of that discovery is demonstrated by the fact that 160 years after that event, oil and natural gas underpin the functioning of global economies, because industry, transport, and electricity production are all based on these fuels (Fic 2015: 17). Along with global development, the demand for these fossil fuels is constantly increasing, and their extraction potential is limited. Apart from the fact that these resources are limited, the second important factor in analysing further perspectives of these fuels is emission from combustion, i.e. natural gas emits less combustion gas into the atmosphere than burning liquid minerals such as diesel oil or petrol (Sas et al. 2017: 38). It is a huge challenge for further development of the global transport sector still based on oil. Which direction will it take? Is this the end of the “black gold” era, to be supplanted by new gas technologies or electric propulsion?

The main aim of this article is to present the role of oil and natural gas in the transport sector in the context of the development of low-emission transport by 2030. With this aim in view, the authors have put forward the following hypotheses:

- the role of oil by 2030 will diminish in favour of other technological solutions;
- legal regulations effectively aim at reducing the number of combustion-engine vehicles in favour of those powered by “clean energy” by 2030;
- new gas technologies will play a leading role in individual and public transport.

In view of the above hypotheses, a few research questions which will be useful in studying the hypotheses must be formulated:

- is it possible to dethrone the leading role of oil in transport by 2030?
- how will the development of low-emission transport affect the position of oil?

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- are the assumptions of EU legal acts on climate change decreasing effectively the number of vehicles fuelled with liquid minerals?
- will electric and hybrid cars gain the passenger car market by 2030?
- how does the NGV market look in Europe and throughout the world?
- how is the infrastructure for CNG/LNG vehicles being developed in Poland?

Determinants of the development of low-emission transport

It is worth considering why low-emission transport is developing at an increasing pace and becoming so popular. There are a few factors, which mainly determine the development of this industry. The basic impulse for making the process of introducing low-emission transport more dynamic is the environment (Ministry of Energy 2016: 9). Global warming, caused by excessive emission of greenhouse gases, has had the result of passing legal regulations to prevent this problem. Countries which are members of economic and political organisations must enforce the provisions of the law, so that the problem of global warming can be dealt with globally. It seems that the European Union is a leading entity in this area, which through the national energy regulatory authorities, supervises the effects of the adopted assumptions.

Climate policy

There are three main strategies in the field of climate: *The Third Energy Package from 2007*, *Climate and Energy Policy Framework by 2030*, and *Low-carbon Economy in 2050* (European Commission 2017). There are three main assumptions resulting from the above mentioned strategies which, with further forecasts, will evolve appropriately. These include:

- **Limiting the emission of greenhouse gases**

The reduction of greenhouse gases, in particular water steam and carbon dioxide, is one of the main challenges of the European Union. The importance and negative influence of the problem was recognised at the beginning of the 21st century, but only in 2007 was attention drawn to the problem by the drawing up of a legal act - *The Third Energy Package*. The industrial and transport sectors are the main sources of these gas emissions (Motowidlak 2015: 176). Therefore, in subsequent points of the abovementioned legal acts, attention is paid to the production of clean energy and increased energy efficiency, which must partially face upcoming energy challenges (ibid.).

- **Improved energy efficiency**

Gradual improvement of energy efficiency by reducing losses and using intelligent systems, in connection with the newest technologies, allows the effects of energy production to be maximised (ibid.). In the strategy valid until 2030 efficiency is to be improved by 40% compared to the year 1990 (European Commission 2017).

- **Increased share of RES in the energy balance**

Using more advanced solutions makes it possible to increase every year the share of renewable energy sources in the total energy balance. Hydroelectric plants, wind farms, and

photovoltaic cells are all developing rapidly - the projects are mainly financed from EU funds. Taking into account the increasing demand for electricity, it is a very good signal in terms of meeting consumers' needs (*EUCO 169/14*: 1-5).

All the mentioned assumptions help directly or indirectly to increase interest in low-emission transport. Countries are forced to reduce greenhouse gases, including car exhaust fumes. Two types of low-emission vehicles are gas and electric vehicles. The latter works to meet the next assumption – that is, increasing the share of renewable energy sources in the total energy balance.

Natural gas as an alternative to oil

Natural gas is one of the three most caloric fuels in the world along with oil and hard coal. It is what many economic branches are based on – industry, transport, services, or households (Kaliski et al. 2010: 28). The main advantage over other energy sources is its low emissions – several times lower than hard coal or oil emission. It can take different forms. It can be purified and compressed (CNG-Compressed Natural Gas), liquefied (LNG-Liquefied Natural Gas), or in case of refinery waste produced during oil and natural gas (LPG) processing, change its physical state under pressure (WNP 2017). Imposed restrictions of exhaust gas emission makes all natural gas form a very good alternative to diesel oil or petrol.

Vehicles powered with different forms of natural gas are becoming more popular and year by year their number is growing. To encourage potential customers, certain tools should be used to cause a specific reaction, namely, introducing financial instruments to encourage the purchase of this technology, favourable fiscal policies, and clear legal regulations. Development strategies for low-emission transport depend on a number of elements: forecasts for the condition of the natural environment, profitability of infrastructure construction and maintenance, and the attractiveness of the natural gas unit price compared to other fuels (Sas et al. 2017: 13). It is appropriate here to present the emission of toxic compounds based on the example of buses powered with diesel oil and CNG (Table 1).

Table 1 Emission of toxic compounds of a city bus

Exhaust compound	Exhaust emission value [g/k Wh]	
	Diesel engine	CNG engine
Nitrogen oxides	13.4	2.9
Carbon oxide	4.6	0.3
Particles	0.3	0.06

Source: Monika Orzechowska, Dominik Kryzia, Polityka energetyczna – energy policy journal, Tom 17, Zeszyt 3, Kraków 2014, s. 323.

When analysing the presented data it can be definitely stated that natural gas is more friendly to the environment. Several times lower exhaust emissions should be an impetus for intensifying

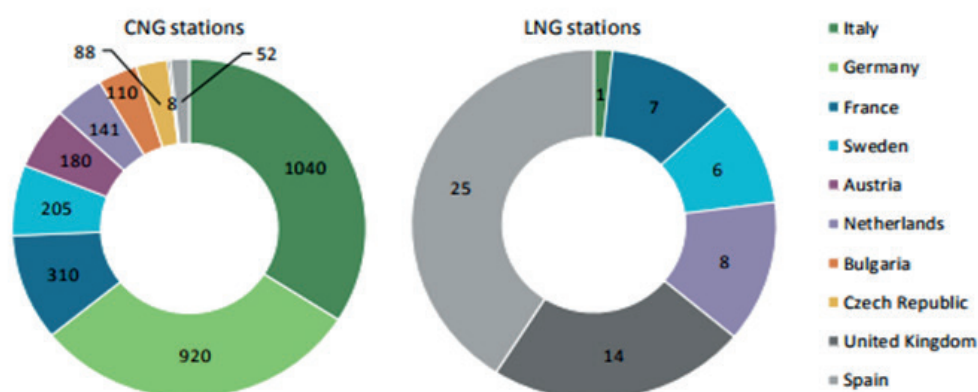
activities leading to the implementation of solutions based on natural gas. Favourable conditions – mainly of an economic nature - from the point of view of an individual customer would be a driving force for the market of clean gas technologies.

European NGV market

The European NGV market is less dynamic than the Asian or South American markets. This is the result of the policy of individual governments. Their recognition of CNG or LNG potential has resulted in domination of the market for vehicles powered with this fuel since 2009. Countries such as Iran, China, or Pakistan are leading in terms of the number of CNG cars. The largest percentage progress compared to previous years can be easily shown on the example of China, which during the last 7 years has increased its fleet almost 8-fold (ibid.). What is more, Southeast Asia has become the cradle of CNG vehicles production (CNG-LNG 2017). The trend is increasing (compared year-by-year), which is very good news from the point of view of the global development of low-emission transport, even in view of the proven technologies. In Europe, Italy is leading in terms of the quantity of vehicles and developed infrastructure. This phenomenon is determined by the base of CNG service stations opened even in the 1970's and 1980's. In the last decade the governmental programme for co-financing gas vehicles and lowering the excise on this fuel resulted in a substantial increase in the number of CNG cars by 51% (from 588,077 in 2009 to 885,300 in 2016). The top European countries are also: Ukraine, Germany, Sweden, and Bulgaria. However, the total number of vehicles in these countries does not exceed half of the Italian CNG fleet. As far as Poland is concerned, currently 3,590 CNG vehicles are in use, which can be refuelled at 27 stations. Throughout Europe 2 million CNG and LNG vehicles are being used.

The slow increase in CNG passenger cars in Europe and Poland seems to have been caused by the small number of passenger cars available on the market as well as expensive CNG systems, which has resulted in a lack of development of the infrastructure. It seems to be a vicious circle, where poor infrastructure results in the lack of production of CNG vehicles and vice versa. For instance, in Poland, taking into account the number of CNG service stations and the number of “ordinary” filling stations, the shortage of possibilities for refuelling a car means that customers are discouraged from purchasing such vehicles (number of CNG stations - 27; number of filling stations - 6624) (PGNiG 2017). The number of stations is a very reliable indicator, which shows how the CNG or LNG transport sector is developed (Chart 1).

The situation is better in the case of public transport, where more emphasis is put on ecological public transport buses. An excellent example is Rzeszów, where 70 CNG buses are in service, making it a leader among other cities. LNG buses, 35 of which were bought by MZA Warszawa in 2015, are unique in Europe (CNG-LNG 2017).

Chart 1 Chart presenting the number of CNG and LNG stations in selected European countries in 2016.

Source: www.iea.org

Conclusion

Among the areas mentioned in the analysis, the national natural gas market looks the least favourable in the context of individual transport. The lack of appropriate infrastructure, legal regulations, or state financial tools, has resulted in only a marginal increase in interest in alternative fuels among consumers. However, EU policy requires action in this matter. To achieve the objectives of the abovementioned policy a Low-Emission Transport Fund will be launched, whose purpose will be to extend the fleet of electric vehicles and develop electric, CNG and LNG vehicles infrastructure (PAP 2017). It is a chance for Poland to use the potential of drives based on natural gas.

The public transport market seems to be more favourable, especially urban transport, which in the last 10 years has been dominated by CNG and LNG buses. It should not be forgotten that electric buses, apart from gas fuels, are part of low-emission transport. What is more, a European tycoon of urban electric communication, Solaris Bus & Coach, is a Polish company. Electromobility and buses powered with alternative fuels are a chance for the Polish public transport industry (Transport Publiczny 2017).

The prospects regarding the European market seem to be encouraging. The countries with a significant number of vehicles powered with natural gas are constantly and consistently developing in this sector. New stations are being opened, facilities for the owners of such solutions are being introduced, and automotive companies are producing more and more passenger cars with factory gas systems. The trend is increasing, both in the development of infrastructure and the number of cars.

The development of low-emissions transport on current global trends is very interesting. Rapid growth in the number of CNG cars in the Middle East and in Southeast Asia can be noticed. The very high rate of growth is caused mainly by economic aspects - the price of natural gas constitutes 10-30% of the price of diesel oil or petrol; co-financing of the conversion of vehicles – up to 90% of the costs incurred – in for example Iran; abolished customs duties on the CNG system equipment between Pakistan and Bangladesh (Sas et al. 2017: 12). If the

current growth rate is maintained, the prospects for alternative fuels in Asia are encouraging. It can be an opportunity for European companies in the context of gaining a very ready market for modern technologies.

Currently, not many African countries have vehicles with such drives. The main users of gas vehicles are residents of Egypt and Mozambique (NGV journal 2017). It is the region with the least developed gas technologies. This is caused by their general development and economic situations, but it is possible that the condition of African economies will improve and they will become more open to innovative technologies. Today it is difficult to have any prospects for Africa.

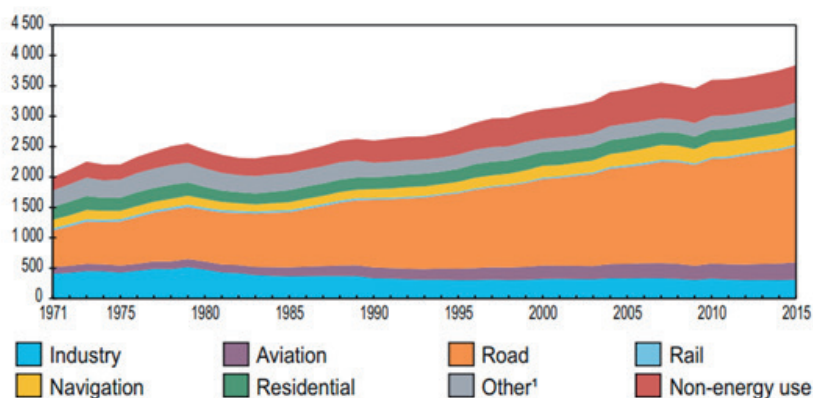
An exemplary continent with well-developed gas technologies can be South America. The number of cars powered with gas in South America constitutes about 24% of the total number of gas cars worldwide (22,335,773 pcs.) (ibid.). In the top ten countries with the most CNG vehicles, South American countries hold three places among 4 Asian countries and 1 European country.

As can be seen, the current global CNG situation is rapidly developing in two continents. Europe, after a few years of stagnation, is trying mightily to catch up and use the potential of clean gas technologies. The principles of free market and globalisation in the near future will result in natural gas becoming popular again and gas drives working in the whole world. Current trends and the rapid growth of fleets based on gas in those countries which have been developing such technologies for a long time, will drive the market. It is a very good direction taking into account current climate problems, security of supplies of other energy sources, and depletion of conventional sources.

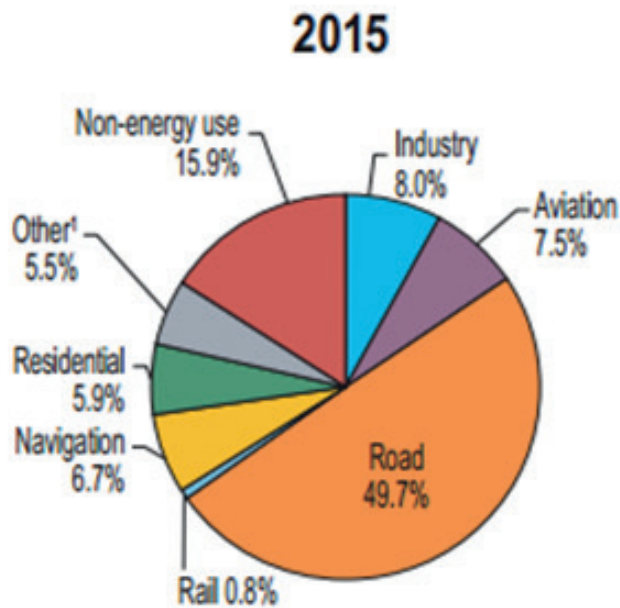
Current role of oil

Oil is a major, if not the most important energy source of the global economy, because it accounts for almost 33% of global primary energy (Sławomir Grzelak, *Państwo i społeczeństwo*: 137). It is of fundamental importance as an energy resource. It is very important for the chemical industry, but above all is used to produce fuels: in global terms the transport sector utilises about 60% of produced oil. It is worth mentioning data collected by the International Energy Agency:

Chart 2 Oil Total Final Consumption from 1971 to 2015 by sector



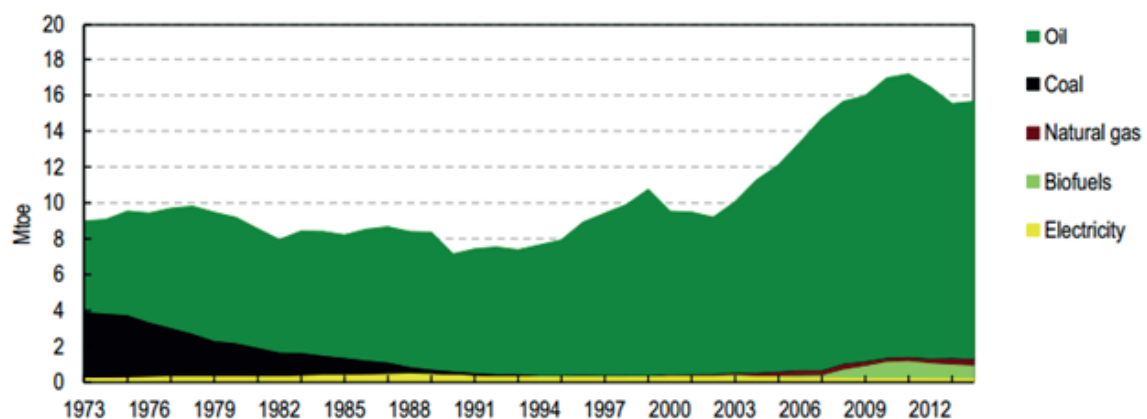
Source: IEA, *Key Word Energy Statistics 2017*, p.39

Chart 3 2015 shares of world oil consumption

Source: IEA, *Key Word Energy Statistics 2017*, p.39

The above charts clearly show how important oil is in the transport sector. Road transport itself utilizes almost 50% of global oil production; together with aviation they account for 57.2%. It is clear that oil is currently the main power source for vehicles, which makes it difficult to be replaced. Analysing the chart presenting total oil final consumption from 1971 to 2015 by sector, we can also notice an increasing trend in the consumption of this energy source. In that period oil consumption in transport more than doubled. To emphasise the current role of oil, the shares of energy sources in transport are presented below.

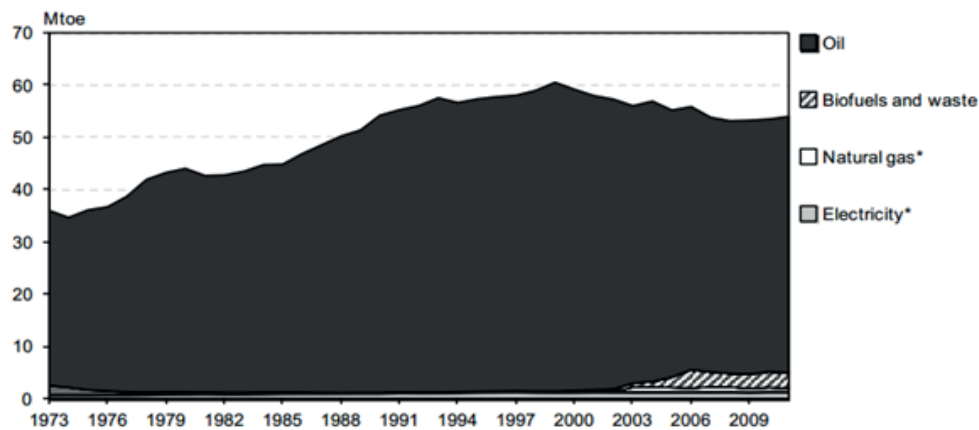
- In Poland - in 2014 the share of oil in transport was 64.3%, clearly seen in the chart below

Chart 4 TFC in the transport sector in Poland by source, 1973-2014

Source: IEA Poland 2016, p.55

- In Germany - oil is also dominant, but there are also other energy sources, e.g. REN

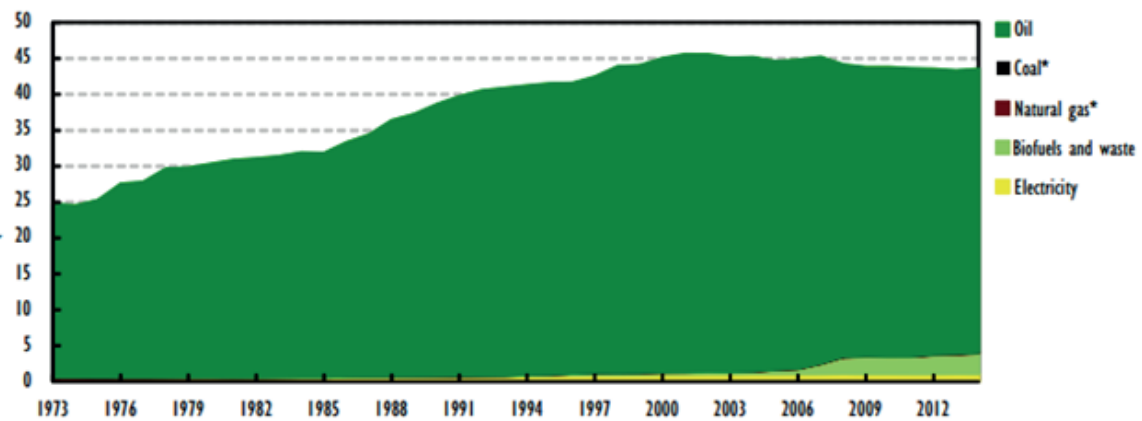
Chart 5 TFC in the transport sector in Germany by source, 1973-2014



Source: IEA, IEA Germany 2013, p.36

- In France - the sector is dominated by oil. Very slow growth of electricity in powering vehicles

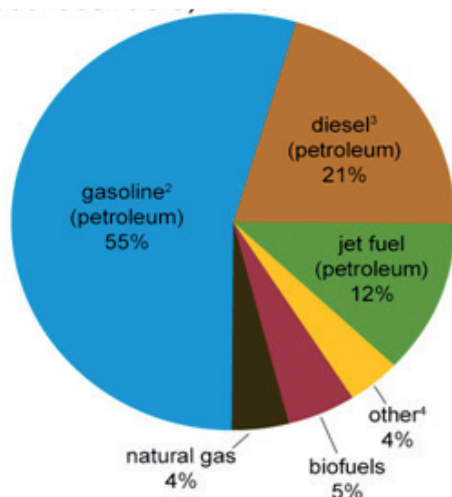
Chart 6 TFC in the transport sector by source - France



Source: IEA, IEA France 2016, p.52

- In the USA - the world's largest consumer of oil (Tomczonek 2013: 118).

Chart 7 TFC in the transport sector in the USA by source



Source: https://www.eia.gov/energyexplained/?page=us_energy_transportation

The role of oil in the context of low-emission transport by 2030 - forecasts.

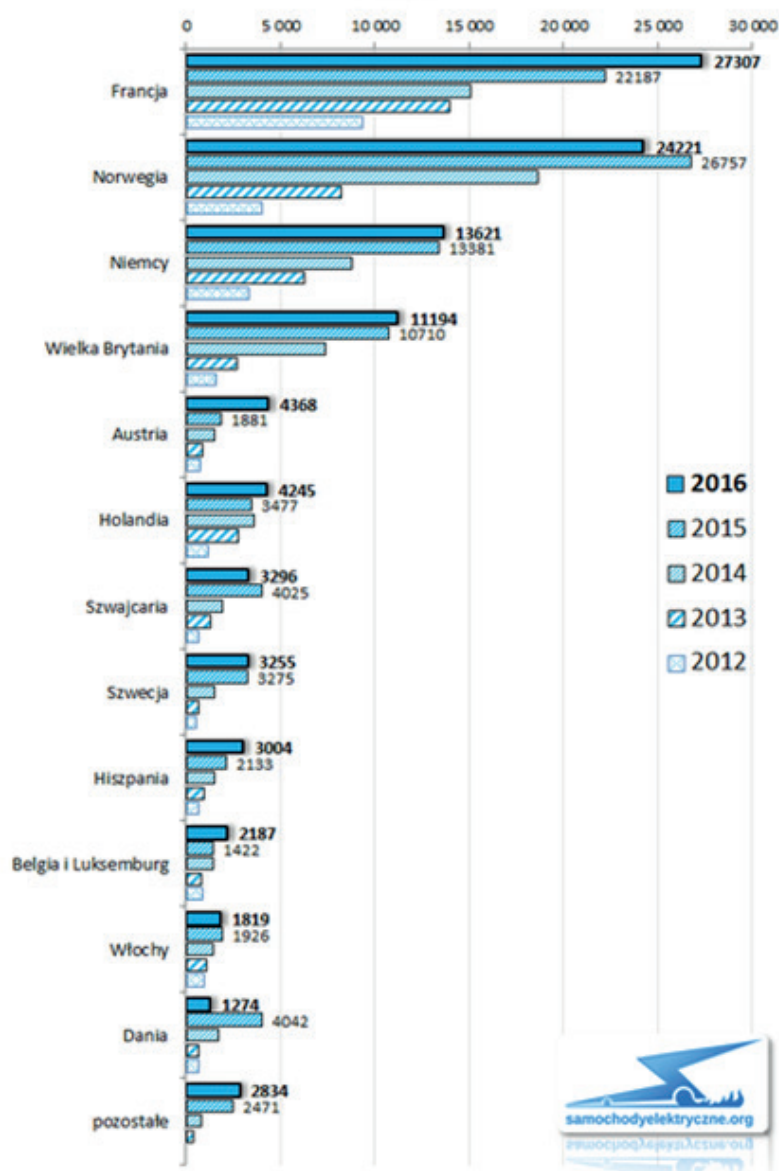
What will be the role of oil in the transport sector by 2030? This is a question asked by more and more people who study the transport sector and its related fuels. The main factor affecting directly the essence of using this material will be the pace of introducing electric vehicles onto the market. Although in the 1950's M. King Hubbert in his hypothesis on so-called peak oil predicted the decline of oil, developing production and discoveries of new reserves put this idea into question (Princeton 2017). A very accurate comment was formulated by a former minister of oil industry of Saudi Arabia, sheik Zaki Yamani: "The Stone Age did not come to an end because we had a lack of stones, and the oil age will not come to an end because we have a lack of oil" (Economist 2017). The above words clearly indicate that oil will lose its leading role in transport, but will it happen by 2030? It all depends whether another transformation will be carried out in transport. At present about 57% of global demand for oil is generated by the transport industry, and road transport itself needs 44% (Voxeu 2017). Therefore, two scenarios are presented below. The first one is based on dynamic development of electromobility and its effects on the role of oil in transport. The other one presents the role of oil when electric vehicles are slowly introduced onto the market.

Electromobility and hybrid vehicles

Electric and hybrid vehicles are also important in low-emission transport. It is safe to say that, consistently, we can see their age unfolding. Although the history of electric drives dates back to the 1830's, it is only in the 21st century that technological development has enabled such vehicles to be economically viable (Fic 2015: 55). Climate change and introduced legal norms are a catalyst for transport electrification. As a response to the transformation of this branch of the economy, many countries are preparing strategies and plans for the development of electromobility aimed at the development of infrastructure, co-financing of purchases, and fiscal policy for the owners of electric vehicles (ibid.: 16) .

In the third quarter of 2017, global sales of electric cars increased by 63% compared to the respective period of the previous year (Businessinsider 2017). According to data of the *International Energy Agency*, China is the market leader in terms of the number of electric cars. Chinese policy has created a situation where electric vehicles are almost 40% cheaper than combustion-engine cars, which is a great incentive to buy such cars. Other large markets include the USA and Europe. Despite double digit growth year-after-year in practically every market, electric cars account for about 0.2% of the total number of registered passenger and light commercial vehicles. Norway is a phenomenon on a world scale, where electric and hybrid cars account for almost 29% of all passenger cars (Obserwator finansowy 2018), and in 2017 the number of sold electric and hybrid cars constituted 51% of all vehicles sold. It is worth presenting statistical data on registration (sales) of electric cars in selected European countries in 2012-2016.

Chart 8 Registrations of electric cars in selected European countries in the last 5 years



Source: samochodelektryczne.org/wyniki_sprzedazy_aut_elektrycznych_w_europie_w_2016r_kraje_i_modele.htm

As can be seen in the chart above, registrations of electric cars are increasing. The increase in the number of cars is cyclical and stable. It can also be noticed that most registrations took place in the most developed countries with significant capabilities in the energy production sector. Both Norway and Germany are constantly developing renewable energy sources, which enables electromobility to be developed faster, because “clean energy” is to become the main power source of these vehicles. France, on the other hand, is leading in nuclear energy production. Capabilities connected with energy production using energy sources other than the traditional ones is contributing to the gradual decrease of the role of oil in transport.

The first issue that should be tackled here, is to answer the following question: what should happen to enable the quick introduction of electromobility? Where the production of

the car itself is not an important obstacle, the possibilities to “refuel” them seem to be more problematic. First of all, it is necessary to consider where the sufficient amount of energy to power vehicles can be obtained from. It is known that fossil fuels reserves are limited. Therefore, countries implementing electromobility put at the same time emphasis on the development of renewable energy sources, which are to be the main source of energy for vehicles. However, as is well known, electricity can be produced from oil, gas, coal, biomass, nuclear energy, or RES. This creates numerous possibilities and options. Generally with the prospect of limited reserves of fossil fuels, much emphasis is placed on energy produced from renewable energy sources, but such a prospect should not hamper the development of electric vehicles. De facto the energy obtained from fossil fuels, nuclear materials or RES is the same, and can be used to power electric vehicles without restrictions. This factor calls for the possibility of rapid development of electromobility even in countries where RES are not well developed, but which have reserves of coal or gas or a developed network of nuclear plants.

Another problem to solve is the charging of electric vehicles. In order to introduce electric cars, countries are forced to build appropriate infrastructure. This is a factor which can considerably slow down the introduction of this type of low-emission transport, because it requires appropriate funds and commitment on the part of the government.

Conclusion

The aim of the study was to present the role of oil and natural gas in the context of low-emission transport by 2030. Natural gas is a very promising alternative fuel. Compared to conventional fuels, it is a low-emission and more environment-friendly substance. An appropriate form to determine prospects for natural gas is their division into three areas: the national level, European, and the world. Due to huge disproportions in development of transport based on CNG or LNG, the evolution of natural gas as a fuel cannot be unambiguously and universally determined.

The vast majority of countries in the world base their communication system on oil technologies. 2030 seems to be too short a time to dethrone oil from its leading position in transport. Obviously, numerous requirements of environmental protection spur the moving away from conventional energy sources, something happening now, but such a process is systematic. It should also be taken into account that powering low-emission vehicles requires appropriate infrastructure, the construction of which requires time and financial resources. The social factor mentioned above is also important. In many countries the cost of purchasing an electric vehicle may be too high for an average citizen, which in turn will slow down the process. Only after a few years will people be able to buy second-hand electric vehicles, because their price will fall. Countries producing oil are also worth considering. Those countries will definitely not allow sudden supplanting of the material they offer, because it could mean colossal losses for them. Those countries will probably endeavour to slow down the process of supplanting oil. To sum up, the role of oil in the perspective of 2030 and low-emission transport may decrease but

not significantly. Oil will probably remain the most popular energy source in transport, but its market share may decrease by a few percentage points.

The prospects for developing the market of electric and hybrid vehicles are very encouraging. This is backed up by legal regulations which encourage the purchasing of e-cars. An additional factor stimulating this market are subsidies that allow cars to be purchased at a lower price, because part of the price is financed by external entities. An element which does not play a leading role but has its share, is social environmental awareness, because electric and hybrid cars are zero-emission vehicles. Apart from vehicles powered with clean gas technologies, electric and hybrid cars are becoming an important alternative to the combustion-engine cars still dominant on the market. By 2030 the market for passenger cars will probably not be dominated by alternative drives, but it is estimated that their number will constitute about 25% of the total number of cars (Ministry of Energy 2016: 5).

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