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REDUCING THE ENVIRONMENTAL POLLUTION ON TRANSPORT IN CITIES

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Abstract: P According to recent estimates, transport accounts the quarter of the world's energy demand, thus contributes significantly to the release of greenhouse gases. Most of it comes from fossil fuels, and therefore it is important that governments support the users to choose one of the environmentally friendly modes of transport. One of the main causes of air pollution is primarily the amount of gases emitted by gasoline and diesel engines. The air pollution of road traffic is determined by the number of vehicles, their modernity, technical condition and the type of used fuel. The legal and technical measures created to reduce the environmental pollution include tightening the regulation of vehicle entry, propagating new generation of vehicles that meet environmental requirements and mandating an environmental review. The goal of the research is to sum up the causes of air pollution in large cities, focusing on the traffic loads. In the research the writer will evaluate and quantify the environmental impact of the use of CNG in transport based on statistical analyses and description of the related technologies.

1 Introduction - World energy use

Primary energy sources are those energy sources that can be found in nature. The tremendous amount of informational, technological and industrial development that has taken place over the past decades, as well as massive population growth, is constantly increasing the energy demand of the Earth. As a source of energy, coal is still significant nowadays, despite the fact that around the world people are trying to limit the incineration of coal. Furthermore, significant fossil fuels are crude oil and natural gas. As the number of revealed hydrocarbon stocks will increase over the years as well as the technologies that enable the use of natural gas will be significant, there will be an increasing role for the use of natural gas. Combustion of natural gas has a lower environmental impact than the combustion of oil, for example in combined cycle gas turbine power plants case too. It can be noticed that the use of renewable energy has increased in the last 15 years, although it still hasn't got as significant role as the fossil energy sources. For example, subsidies in Europe have an important role in wind and solar power, and biomass-based power generation is also having a continuous development.

From the available data, a table has been made to show how much energy has been spent in different parts of the world in recent years.

Figure 1 shows the percentage composition of world energy consumption for 2006. According to the data, Asia accounts for the largest share of total energy demand, that is 35%, and Asia accounts for nearly half of its total energy demand from coal burning. Another major proportion still has North America, Europe and Eurasia. The least amount of energy was consumed by Africa.

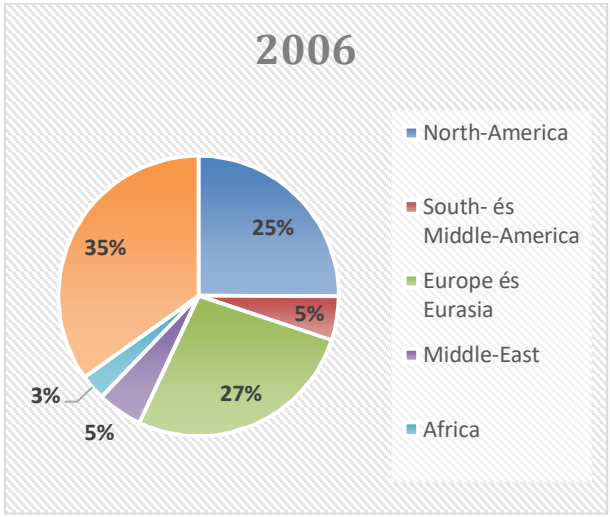

Figure 1 Percentage Distribution of Energy Consumption in 2006, Source: www.bp.com, Own modification

In Figure 2, the data has been summarized for 2016. Total energy consumption increased by around 15% in 10 years, but in Europe and Africa there is also a declining trend in the share of energy use. There was a 5% decline in Europe and 2% in Africa, although according to statistics Africa basically consumes very little energy compared to the rest of the world. The largest consumer in 2016 can also be named Asia by 42%. With a 7% increase over 10 years, practically Asia makes up for almost half of Earth's total energy consumption.

Figure 3 shows the energy consumption by fuels from 2000 to 2040. It can be seen that in the last 20 years, energy use from transport has increased steadily. The plan is to reduce the intensity of consumption in the coming decades, and to gain space for other fuel types alongside oil.

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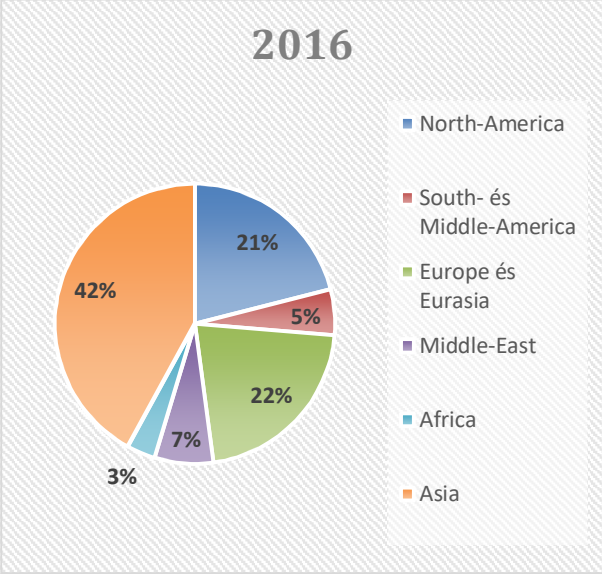

Figure 2 Percentage Distribution of Energy Consumption in 2016, Source: www.bp.com, Own modification

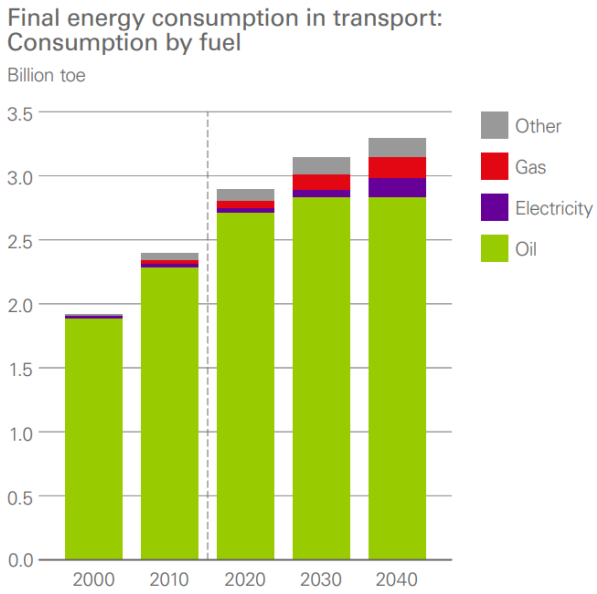

Figure 3 Final energy consumption in transport: Consumption by fuel, Source: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/transport-energy-consumption-by-fuel-eo19-p44-l.pdf

So taking into account the data, the world's energy needs have continued to grow, and will likely increase. Although the role of renewable energy sources is even bigger year by year, it still does not have the same role as fossil fuels. This essentially means that much of the world's energy needs will continue to be generated from fossil fuels, which will increase the environmental burden [1].

2 Presentation of air pollutants

Materials are considered to be air pollutants, which are completely independent of origin and state of the environment in such a way as to harm, negatively affect, and cause material damage to people's lives.

Pollutants from our atmosphere can come from natural and artificial sources, the latter being called anthropogenic pollutants. Anthropogenic pollutants consist of three main areas: transport, energy production and industry. The most important source is burning fossil fuels in these sectors. Examples of natural air pollutants include volcanoes (with sulphur oxides and powders), forest fires (carbon monoxide, carbon dioxide, nitrogen oxides and powders), wind storms (dust), live plants (hydrocarbons, pollen) (methane, hydrogen sulphide), soils (viruses, dust) and the sea (salt).

Air pollutants may come from pointy and diffuse sources. The sources where the concentration and the volume flow can be clearly determined are the exact ones. Diffusion (or surface) is the source where indirect measurements and calculations can be used to determine the amount of substance entering the environment.

The process of air pollution can be characterized by the following parameters:

- emissions,
- transmission,
- immission.

The amount of pollutants released into the atmosphere is called emission, the unit of measure is kg/h. Transmission is the spread of these materials, while the ambient air quality of a given space can be characterized by the term "immission".

Pollutants in the environment may be gases, dusts, fog or smoke. One of the groups of powders:

- the sediment dust (1000-10 mm),
- the floating dust (10-0.1 mm).

Some significant air pollutants:

- Carbon monoxide: It comes mainly from the transport industry into the air (or mining, combustion), it can reduce concentration and even cause death.
- Sulphur oxides: Due to the burning of fossil fuels and the industry (production of sulphuric acid, mining, ore preparation, cellulose production), they can cause respiratory diseases.
- Nitrogen oxides: Nitrogen oxides are produced in the production of nitrogen fertilizers, nitric acid production, transport, and energy production. They primarily damage the mucous membrane of the eye. Nitrogen dioxide forms in the atmosphere with oxygen and water to form nitric acid, causing acid sedimentation.
- Powders: Powders of varying particle size (from industry, especially mining, cement industry, combustion of fuels, etc.) can cause respiratory and cancerous diseases.
- Flue gas: Flue gas from services and households, or mainly from combustion processes, contains carbon monoxide, carbon dioxide, water vapour, carbon black, sulphur dioxide, nitrogen oxides, methane, hydrocarbons, etc. [2].

2.1 Analysing world CO2 emissions

Figure 4 and figure 5 shows CO2 emission data for the continents of the world. According to the data, it can be stated that CO2 emissions are increasing globally despite the fact that there is a steady decline in some areas. The main reason for this is the high carbon dioxide emissions from Asian areas. There has been no increase in CO2 emissions so much as there, between 2006 and 2016, it was 26%.

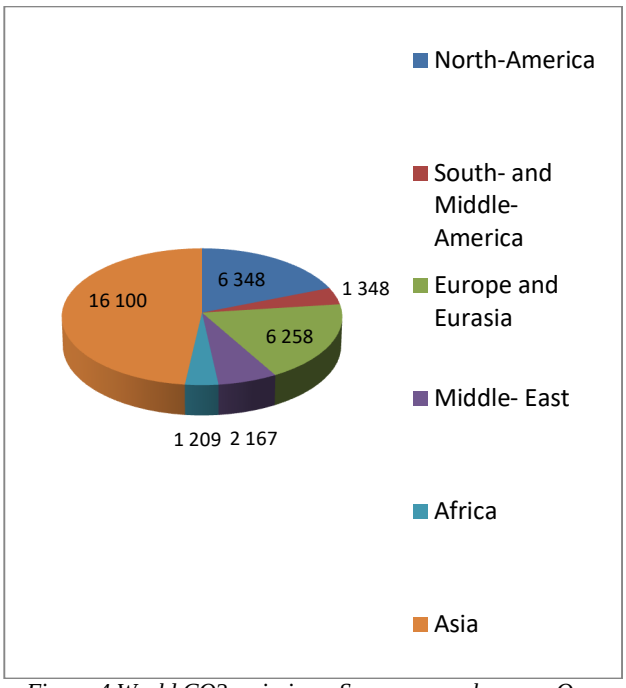

Figure 4 World CO2 emissions, Source: www.bp.com, Own modification

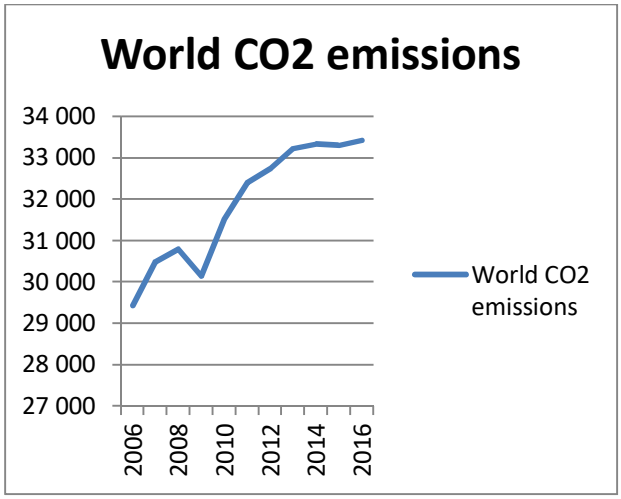

Figure 5 World CO2 emissions, Source: www.bp.com, Own modification

2.1.1 Presentation of the adverse effects of transport on the airspace

The main cause of greenhouse gas emissions is the burning of fossil fuels. Harmful emissions can be derived from a variety of sources:

- Industry;
- Energy industry;
- Transport;
- Households.

According to recent data, most pollutants released from transport directly after the energy industry, so a detailed analysis of the exact amount of environmental burden on today's motor vehicles has done and presented why it is extremely important that professionals search for alternative technologies, the most efficient way to ensure the cleanest possible traffic, especially in urban terms.

The recent smog alarms have also pointed out that the environmental classification of motor vehicles is poorly performed by specialists assigned to this task. In this case, our country has taken over the EU guidelines that have been causing various problems in Germany, France, the United Kingdom, even in developed western countries.

Smog is made up of tiny, invisible or visible particles (smoke) that, when inhaled into our body, can cause cancer, lung disease or death. This is because these particles contain heavy metals and other toxic substances.

There are two types of smog:

- London-type smog: This type is typical in the winter months due to low temperature. Since air movement is small, concentrations of pollutants are mostly caused by carbon burning, including carbon particles in the atmosphere.
- Los-Angeles smog: It is typical in the summer months, it is caused by car traffic, the sunshine produce ozone from the materials released, which is also harmful for humans.

In 1952, in London, for a 5-day smog, many people died. The number of deaths was estimated at 4 to 12 000.

Comparison of old and new types of diesel vehicles

Old diesel-powered vehicles were characterized by huge smoke streaks that were generated by the operation of diesel engines. This type of carbon black is made up of larger particles so that it cannot penetrate to the bloodstream through the lungs as the mucous membrane of the lung absorbs these particles. Carbons enter the atmosphere, which can cause chronic bronchitis, lung damage, allergies and asthma.

The new types of diesel cars apparently do not emit smoke. Particulate Filters (DPFs) (Fig. 6) have been released that thoroughly filter out the generated smoke, reducing nitrogen oxide emissions. So they seem like an environmentally-friendly vehicle, but it must also be taken

into account that carbon dioxide emissions and carbon black particles less than 2.5 microns are significantly increased. These ultra-small particles are now invisible, so it does not seem to emit smoke from modern diesel vehicles. However, these particles pass through the lung mucus without problems: they immediately get into the blood and poison the human body more intensely than their old type counterparts.

Figure 6 Particulate Filters, Source: http://dpf-szuro-tisztitas.hu/

In addition, particles smaller than 2.5 microns are much more active, attracting much more heavy metals and other toxic substances from the atmosphere, which are already heavily carcinogenic and toxic.

Number of fatalities

According to the official annual report of the European Union, the number of fatalities due to smoke having a particle size smaller than 2.5 microns in 2016 is summarized in Table 1.

Table 1 Number of fatalities

Germany	73 400
France	45 120
Italy	66 630
Romania	25 330
England	37 930
Hungary	12 890
Slovakia	5 620
Austria	6 960

Source: http://kifogasokvilaga.hu/miert-karosabb-modern-dizel-auto-mint-regi-csotrogany/

It is clear from the data that the largest number is in Germany and in the larger European countries, which in my opinion may be due to the intensity of the spread of more modern diesel cars in the developed countries compared to the less developed countries. If we look at the numbers in Hungary, it can seem that we are in a better position compared to other countries, but in this case I did not take into account the size of the countries in the question.

Population data:
- Germany: 82 million;
- France: 61 million;
- Italy: 59 million;
- Romania: 21 million;
- England: 61 million;
- Hungary: 10 million;
- Slovakia: 5 million;
- Austria: 8 million.

In the case that these data are also taken into account and proportioned to the number of population, we get the following numbers:

The number of deaths per 10 000 people:
- Germany: 9.1;
- France: 7.0;
- Italy: 11.1;
- Romania: 12.6;
- England: 5.9;
- **Hungary: 13.0;**
- Slovakia: 10.3;
- Austria: 8.2.

It turns out that the worst situation of the countries surveyed is in Hungary, while in England there is the least number of deaths due to air pollution [3].

Based on the data presented, it is clear that it is vital for professionals to develop alternative technologies that minimize the pollution of the atmosphere. One of these solutions can be provided by CNG technology.

3 The CNG technology

3.1 Features of CNG

CNG is an English abbreviation, meaning Compressed Natural Gas. This new and promising fuel type is rapidly expanding in transport and vehicle industry. A CNG vehicles (Fig. 7) fuel tank is capable of storing about 16 to 20 kg of fuel, making it capable of an average of 3-400 km. (This applies to passenger cars.) The most important element of CNG is methane. Contrary to fossil fuels, CNG is less likely to burden our environment, as methane burns far less harmful to the atmosphere than other fuels. In fact, since it is a gaseous fuel due to rapid combustion in the chamber, higher efficiency combustion occurs. Benefits of CNG powered vehicles:
- Carbon dioxide emissions are approx. 10% lower than diesel engines and 25% lower than petrol engines.
- Emission of solid particles is virtually impossible.
- Nitrogen oxide emission does not exceed the limit of EURO 6 norm [4-6].

Fuels used by motor vehicles with internal combustion engines must meet certain conditions, namely:
- High energy density;
- Easy handling;
- Provide the right quantity;
- The combustion product should have the least harmful effects on humans and the environment [6,7].

The last point of environmental protection is becoming more and more emphasized today, but this condition is not consistent with gasoline and diesel. The most important element of fuels is energy density, which is also related to volume and weight. The price of gasoline and diesel oil by volume, CNG price is determined by weight. The energy density per mass is important because of storage.

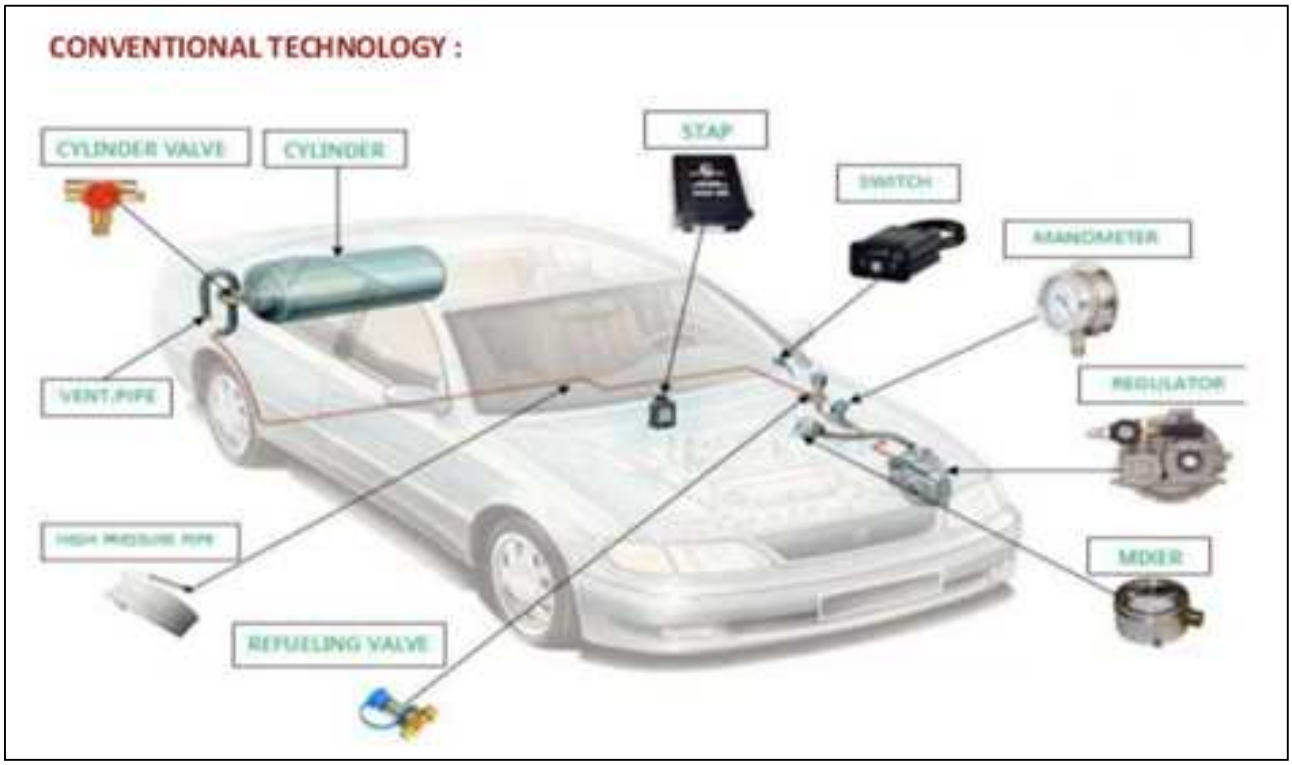

Figure 7 CNG fuelled car fuel system, Source: https://www.slideshare.net/rubel2012/vehicle-cng-conversion-technology

1 kg of CNG contains about as much energy as 1.5 litres of gasoline or diesel oil. In these vehicles there are cylindrical containers with high pressure cylindrical steel or composite material located. Depending on what kind of material the containers are made of, their weight can be 30 to 80 kg and their capacity is 90 to 150 litres. Their maximum permissible pressure will always depend on their size and country of the production [4-6].

3.2 The role and structure of filling stations

One of the most important elements of the implementation of natural gas transport is the design, construction and operation and maintenance of the filling stations. The construction of the filling station and the refuelling process itself are more complicated than for other fuels.

Figure 8 shows the structure of a CNG filling station. Compressed natural gas is produced by compressor technology in the filling station area. One typical feature of the compressor stations is the charge capacity Nm3/h, which is the typical amount of charge capacity within the vehicle for 1 hour. (Natural gas at 15 °C and ambient pressure). Based on this, we distinguish two types of filling stations:

- Slow Chargers: These stations have a capacity of less than 100 Nm^3/h, which is about 2-3 hours for cars.
- Fast chargers: Stations with a capacity of 100 Nm3/h or higher, with a charge time of 3-8 minutes, depending on the volume of the tank to be charged [4].

Charging starts from the minimum pressure buffer, and in principle it continues until the pressure in the container is equalized by pressing the buffer tank. In the case the flow rate of the natural gas flowing into the tank does not exceed the specified limit; the system will switch to the higher pressure tank. If the pressure in the buffer tank reaches a pre-set threshold, the compressor starts, and begins filling the vehicle fuel cylinders and the buffer storage at a nominal pressure [6].

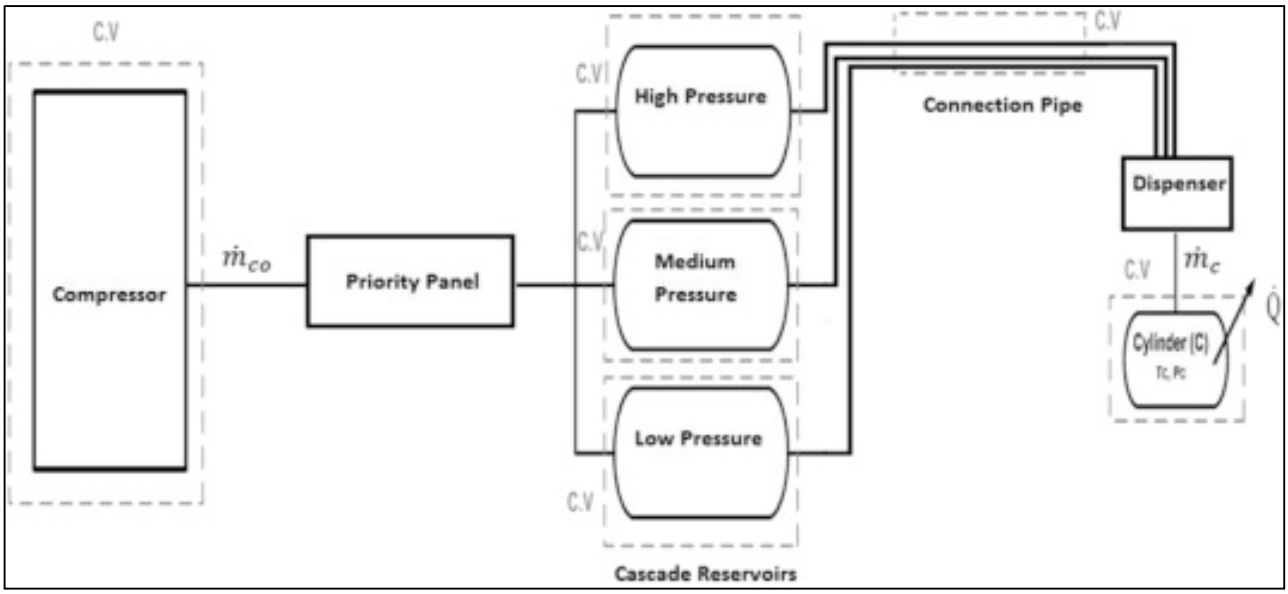

Figure 8 CNG refuelling station, Source: https://www.sciencedirect.com/science/article/pii/S1875510016300270

4 International outsourcing

The propagation of CNG vehicles is mainly influenced by the nature of pipeline gas supply in the area. The spread of CNG-powered vehicles in the world is different, due to different energy options and different political views. In 2014, the world's total CNG vehicle fleet was 22.3 million, which covered 2% of all vehicles. Countries with the largest natural gas station are listed in Table 2.

Table 2 Countries with the largest CNG vehicle fleet

Country	Fleet
Iran	4.0 million
China	4.0 million
Pakistan	3.7 million
Argentina	2.5 million
Brazil	1.8 million
India	1.8 million
Italy	900 thousand
Columbia	500 thousand
Uzbekistan	450 thousand
Thailand	462 thousand
Ukraine	388 thousand
Armenia	244 thousand

Source: www.cngport.hu

CNG has grown into one of the most important fuels in the other Asian countries mentioned in table 2. In many places in India, public transport is also use CNG based buses. According to the decision of the Government of Pakistan, in the most populous province, every bus in 2007 had to change to CNG plant. In China, 3700 CNG stations have been installed in 2014, but the propulsion of vehicles is not fully in line with the number of filling stations. Due to the regulation of the 12th Five Year Plan and the possibility of subsidies, the spread of CNG buses and trucks has been increasing in recent years [4,8].

In Africa and in the Middle East the best performing country is Egypt, with 63 000 gas-powered vehicles and 95 filling stations [9].

In Canada, gas mining is significant, and natural gas is sold at a favourable price in the form of CNG. In addition, it has many fuelling stations that serve the more than 12 000 CNG vehicle fleet. In the United States, the situation is similar, there is plenty of natural gas available. There are 873 filling stations and 114 000 vehicles in the country [10,11].

Gas-fuelled transport in the South American countries is very popular. The stock is mainly made up of the taxi fleet of major cities that are concentrated in Brazil and Argentina.

Just as Figure 9 shows, when we look at CNG technology at European level, there are big differences. In the first place, Italy has 1 173 filling stations, 1 million cars and 3 000 buses.

Germany stands at second place with 921 stations and their numbers are growing at a high rate. The fuel used is largely biomethane from renewable energy sources.

The gas-fuelled traffic in Hungary has a decade-long history, currently about 2 000 CNG vehicles are on the roads. The year 2010 was a low point for the gas transport, but since then, continuous development has begun. A total of 60 waste trucks and 240 buses run on the roads. In Hungary there are currently 9 filling stations operating publicly [4].

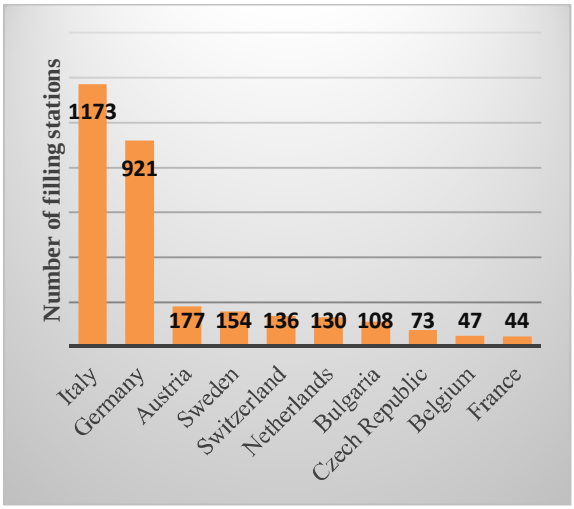

Figure 9 European countries with filling stations, Source: www.cngport.hu

4.1 The role of CNG in Hungary

Since 2010, CNG consumption in Hungary has been rising steadily, according to the latest data, the consumption was 8 million cubic meters in 2015, and in 2016 it was 12 million. This is still a significant amount despite we know that 50 million cubic meters of natural gas per month in Italy are used for transport, so there is still room for improvement. In the framework of the Clean Mobility Strategy, the European Union has set out the directives that set the legal basis for supporting renewable energy production, the use of clean and energy efficient vehicles, the deployment of alternative fuels and the development of the necessary infrastructure. The EU expects that the charging infrastructure for alternative-driven vehicles will be set up on TEN-T routes (M1-M5 motorway, M7-M3 motorway and Danube route). The European Network Development Fund receives 3 aid projects for Hungary. Within the framework of the PAN-LNG project, five LNG-L-CNG filling stations and a mini liquefying plants, which are completely independent of the gas pipeline network, are going to build. During the implementation of the PAN-LNG 4 DANUBE project, an LNG filling and transfer station will be set up at the Csepel Free Port, where the vehicles of three transport sectors - ships, lorries and trains - will be served with liquefied natural gas. The CLEAN FUEL BOX project includes the construction of 39 L-CNG filling points, which do not require a gas pipeline to operate.

CNG and LNG drives have a number of advantages, both for heavy vehicles and buses. The Hungarian Post has completed a 2-month test with the Iveco CNG tractor, with a spectacular result: the vehicle achieved fuel savings of 3.5 million forints per 100 000 kilometres. Such a tractor runs on an average of 120-160 thousand kilometres, so it is about to return its price over its useful life of five years. In Hungary, CNG-powered buses are typically used in local public transport, such as in Kaposvár, Miskolc. These vehicles have the same maintenance demand as conventional diesel engines, ranging from 400 to 500 kilometres, ideal for serving local passenger needs. On the other hand, CNG buses for inter-use are available on the market, such as Scania Interlink or Iveco [12]. A total of 60 waste trucks and 240 buses run on the roads, 80 of them in Miskolc, 71 in Budapest, 40 in Kaposvár, 39 in Szeged and 10 in Zalaegerszeg. In Hungary there are currently 9 filling stations operating publicly [4].

Seven capital companies decided in 2009 to sign a letter of intent aimed at promoting the infrastructure of the CNG vehicle use infrastructure. Under the contract, each signatory undertook to continuously update its own fleet of vehicles with natural gas vehicles, and the gas supply company in Budapest undertook to set up filling stations themselves. [6]

The mission of the City Transport of Miskolc is to "Pass passengers in a predictable, safe and environmentally responsible way. Reducing the emission of exhaust gas from vehicles in the case of environmentally friendly transport." This can be accomplished by maintaining the vehicles and constantly updating them. The City Transport of Miskolc is paying more attention to environmental protection, which shows that recently, 75 new CNG buses were sold to Miskolc. A compressed gas powered bus is much more environmentally friendly than a diesel one, and can be operated at 25-40% cheaper. Although the purchase price is 8-15 million forints higher, the investment will return relatively quickly. Based on the calculations, fuel savings are approximately 30-40 HUF per miles compared to diesel vehicles, so after 250-300 thousand kilometres the bus fleet will pay off and after that operation is much cheaper than the diesel engine.

The buses in Miskolc with CNG technology comply with the strictest Euro 6 environmental protection standards, and the emission levels almost equal to zero. The environmental impact of CNG and diesel vehicles in Hungary was first measured in Miskolc in March 2016 under real operating conditions. During the measurements, Neoplan (diesel, Euro IV engine) and the new MAN (compressed-air Euro VI motor) buses were performed on three Miskolc lines. The comparative measurements were made for 90 passengers. On the basis of the final results it can be stated, that from the CNG buses 98.0-98.5% less nitrogen oxides (NOx) are released into the atmosphere than from the diesel engines. Noise pollution is also significantly reduced due to new buses because the noise level of the CNG engine is much lower than that of similar power diesel vehicles.

Figure 10 shows the CNG filling station in Miskolc, which is the only station in Northern Hungary. In addition to the company's buses, it is open to individuals and companies throughout the day, it has an automated payment system, allowing you to pay for a card and also provide an invoice [13].

Figure 10 CNG fuelling station in Miskolc, Source: http://mvkzrt.hu/mvk-cng-toltoallomas

5 Conclusion

The purpose of the research was to sum up the causes of air pollution in large cities and to demonstrate how air pollution is continuously reduced due to the development of CNG traffic. In the research based on statistical analyses and description of the related technologies, the environmental impact of the use of gas-based motor fuels has been evaluated. Based on data series of the recent years, it was shown how the intensity of the emission of pollutants changed as a result of the introduction of environmentally-friendly CNG buses in several major European cities. Based on the data, although many countries show a decline in the emission of pollutants, if we look at the problem at global level, there is still a sustained increase in this area. So it can be said that the emission of pollutants is too high in order to reduce it globally with the current CNG vehicle fleet.

In my opinion, it would be important to carry out tests where the operation of diesel buses would be stopped in a given city, and instead of that they should put CNG vehicles in service during that period, and measure the quality of that air every day. By evaluating the data from these studies, it could be concluded with certainty what could be the perspective of designing and operating a CNG-based vehicle fleet and how much this can reduce the air pollution in cities.

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Review process
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