

NATURAL GAS AS TRANSPORTATION FUEL – AN OFFER FOR MOUNTAINOUS RESORTS

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Summary

In this article the current state of development of the market of the CNG vehicles was described. Then, the economic and ecological aspects of using this fuel and the factors of its safe exploitation were characterized. Based on that, in the article were presented the current propositions of activities of the European Union administrative organs, which propagate using these alternative fuels for vehicles, including the natural gas.

Finally, the attention was paid to possibilities of using the natural gas as a fuel in vehicles used in mountain and spa resorts.

Keywords

CNG • fumes emission • natural gas • NGV • natural gas vehicles • ecological vehicles

1. Introduction

Natural gas has been used as car fuel since the third decade of the previous century. For this purpose natural gas can be used either in liquefied form (LNG) or in compressed form (CNG). In recent years, according to international standards, such gas is compressed to the pressure of 200–250 bars and then injected into the vehicle's tank. Vehicles powered by natural gas differ from the gasoline powered vehicles. They are equipped with a tank for compressed natural gas, an additional system supplying gas from the tank to the engine, and additional control systems. Modern vehicles powered by natural gas are in most cases bi-fuel vehicles (gasoline + natural gas). Buses are an exception from this trend, as they are powered by natural gas only. It should be noted that all the components of CNG and LNG systems are characterized by a high degree of safety.

Because of its properties and the way it is stored inside of a vehicle this fuel is considered to be safer than other, traditional vehicle fuels. Recently, many technical solutions have appeared, which allow using natural gas in diesel engines. Using natural gas as vehicle fuel is beneficial both ecologically and economically, which explains a dynamic increase of its use in many countries.

2. NGV in the world – current status

The ecological benefits of using natural gas as vehicle fuel (lower CO₂ and CO emissions, lower noise pollution and almost complete elimination of PM10 particulate matter when compared to traditional fuels), the energy security improvement as a result of fuel diversification and also the economic aspects have contributed to the NGV number increase being higher than new vehicle number increase in general.

Presently there are over 16 million NGVs in use [WorldWide NGVs & Refuelling Stations... 2013] over 1 million in Europe. The numbers related to NGVs and CNG stations are presented in Table 1 and in Figures 1 and 2.

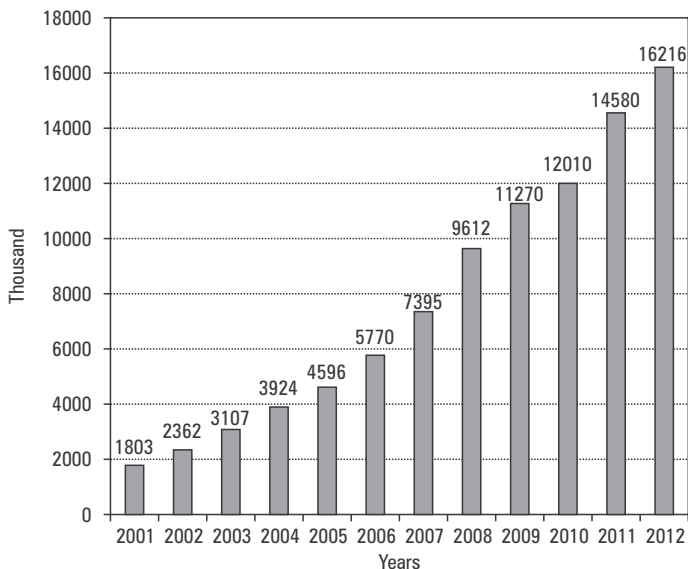
Table 1. NGVs and CNG stations in selected countries

Country	NGVs [thousands]		CNG stations
	2001	2012	2012
Pakistan	210	3100	3330
Iran	0.8	2900	1943
Argentina	756	2123	1916
Brazil	285	1719	1790
India	25	1500	724
China	36	1200	2500
Italy	328	747	903
Ukraine	n.d.	388	324
Germany	7	95	904
Russia	21	86	251
Bulgaria	0.1	61	103
Sweden	2	42	183
Poland	0.1	2,2	28
The world	1 793	16 216	21 027

Source: author's study based on WorldWide NGVs & Refuelling Stations

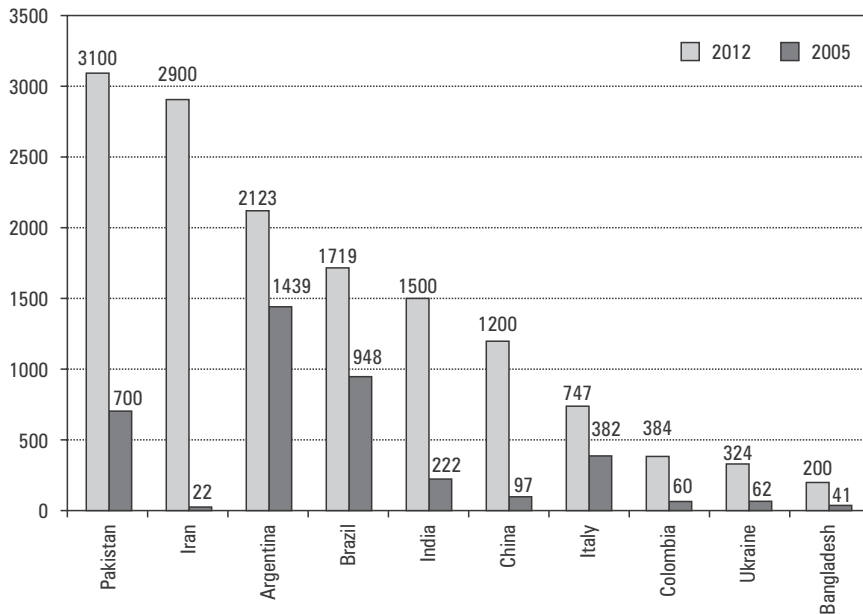
In this aspect, Poland definitely stands out from the leading countries. The percentage of NGVs worldwide is more than 1.5%, in Europe 0.5%, while in Poland it is only 0.01%, which is 50 times less than the European average value.

The numbers of NGVs in Poland in the years 2004–2012 and the locations of CNG stations are presented in Figures 3 and 4.



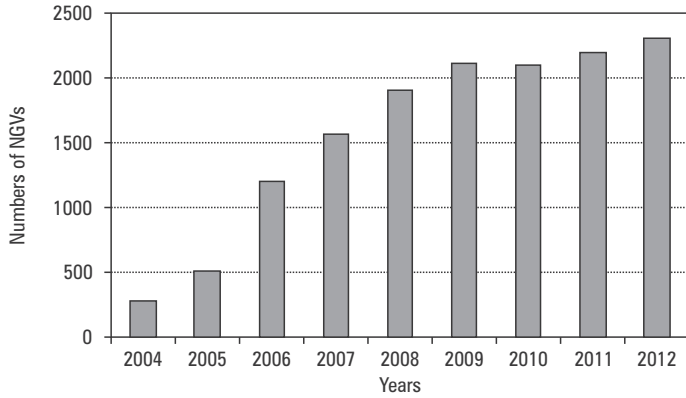
Source: author’s study based on Worldwide NGVs & Refuelling Stations

Fig. 1. Number of NGVs worldwide from 2001 to 2012



Source: author’s study on Worldwide NGVs & Refuelling Stations 2013

Fig. 2. Countries with the largest number of NGVs



Source: author's study

Fig. 3. Number of NGVs in Poland



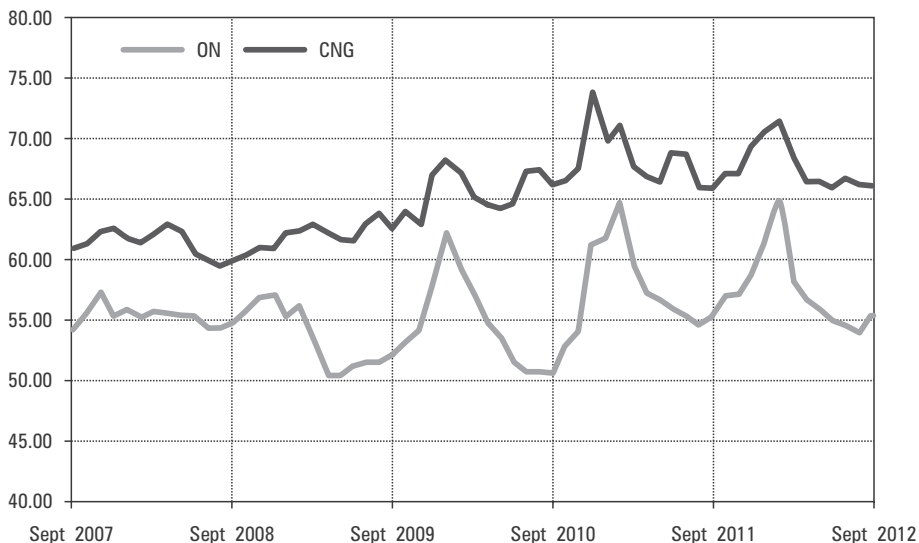
Source: authors' study

Fig. 4. Public CNG stations

3. Ecology, economy, safety

Using natural gas instead of traditional fuels (gasoline, diesel) is cost-effective. In modern vehicles CNG consumption, calculated in m³ is about 10% lower than gasoline consumption in liters. However, when compared to diesel, CNG consumption is about 15 to 20% higher, but its price is significantly lower. In Poland the price of CNG is about 55% the price of diesel. Such proportions allow saving a significant amount of money when using natural gas instead of gasoline or diesel.

On the other hand, NGVs are slightly more expensive than gasoline powered vehicles (by about 10%). However, these costs pay off after driving 20 000 to 30 000 kilometers for passenger cars, 30 000 to 40 000 kilometers for minibuses, and for city buses after 3 to 4 years. Credible fuel consumption data (diesel and CNG) for comparable city buses used on the same routes, in the same time are provided by PKM Gdynia [Galkiewicz 2013] (Figures 5 and 6).



Source: Galkiewicz 2013

Fig. 5. Average fuel consumption for diesel [liters] and CNG [m³] for 100 km in city buses, in the period of 09.2007–09.2012

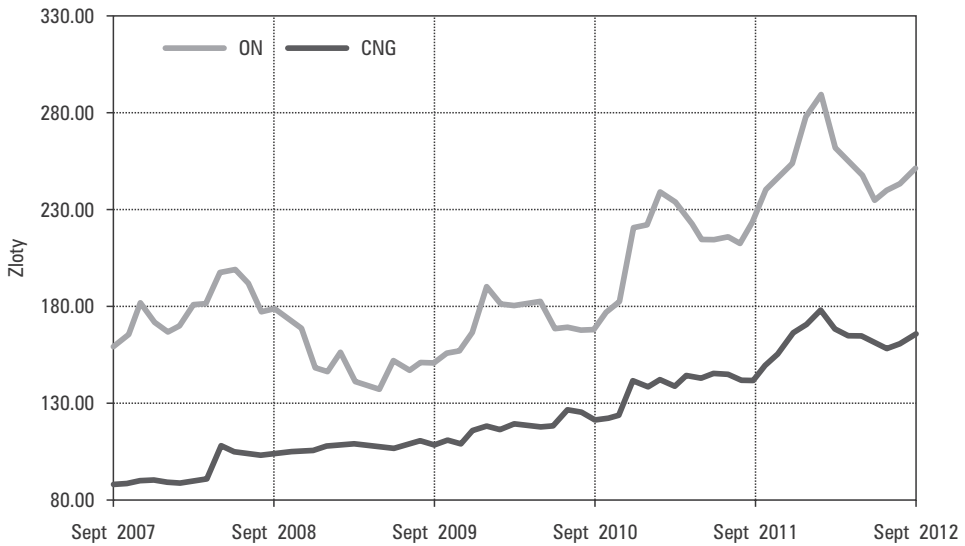
In the studied period the unit fuel savings in PKM Gdynia were equal 67.79 zloty for 100 km (costs of diesel/100 km – 193.01 zloty, costs of CNG/100 km – 123.22 zloty). Fuel savings were therefore equal 36.15%, which for 12 CNG buses gives 3 916 000 zloty of fuel savings.

Similar calculations can be made for other types of vehicles.

For the inhabitants of big cities, and, most of all, resorts, the ecological effects of CNG application will be very important. Such solution results in very positive changes,

whose scale depends on fuel type and modernity of gasoline or diesel engines. It can be assumed, that using natural gas instead of traditional fuels will result in:

- 99% decrease of particulate matter (PM10) emissions (compared to diesel),
- 50–80% decrease in NO_x emissions,
- about 20% decrease in CO₂ emissions,
- 60–80% decrease in CO emissions,
- 4–7% dB decrease in noise pollution.



Source: Galkiewicz 2013

Fig. 6. Average cost of a 100 km drive of city buses in the period of 09.2007–09.2012

The ecological benefits resulting from using natural gas as propulsion fuel are one of the main reasons for the EU institutions to promote natural gas as a very prospective alternative fuel.

Contrary to the popular opinion, natural gas is a safe fuel, as proved in the engine fuel comparison (Table 2). Natural gas has a low density ($0.716 \text{ kg} \cdot \text{m}^{-3}$) thanks to which it escapes very easily, which is very important in case of a leak in the gas tank. Natural gas is not toxic.

Safety requirements regarding natural gas application as vehicle fuel are determined in Rules No 110 [Regulamin nr 110... 2011] and technical standards for stations [ST-IGG-1601:2012a] and CNG refueling devices [ST-IGG-1601:2012b].

Table 2. Comparison of engine fuel properties

Property	Natural gas	LPG	Gasoline	Diesel
Ignition temperature [°C]	630÷650	500	550÷600	320÷360
Flammability limits [% of fuel volume in the air]	5÷15	1.8÷9.0	1.4÷7.6	0.6÷5.0

Source: author's study based on Molenda and Steczko 2000

4. EU policy regarding natural gas as an alternative fuel in transportation

The latest EU document regarding the European alternative fuels strategy [Komunikat Komisji... 2013] indicates, that fuel diversification is vital. Europe is too much oil dependent. According to data from the year 2010, 94% of energy used for transportation purposes was obtained from oil, and 84% of the oil used in Europe was imported [Komunikat Komisji... 2013]. Therefore, it is necessary to search for solutions, which will decrease Europe's oil-based fuel dependency.

Using petroleum fuels is also related to a significant emission of harmful fumes, including CO₂, which is related to climate warming. Therefore, the EU proposes to use alternative fuels. The full set of alternative fuels, presented in the document [Komunikat Komisji... 2013] includes: LPG, natural gas, liquid biofuels, hydrogen and electricity.

The present state of applicability of the aforementioned fuels is very diverse in different EU countries. E.g. Poland is the leading country when it comes to the number of LPG powered vehicles, while the leading European country in terms of the number of compressed natural gas (CNG) powered vehicles is Italy.

The diversity of legal regulations and technical requirements for installing such fuel systems in particular EU states, also when it comes to the fuel-related infrastructure, results from the lack of a common strategy and policy on the EU level.

This is about to change, as a result of implementation of the new European Parliament and Council directive, whose proposals has been submitted by the European Commission at the beginning of this year [Komunikat Komisji... 2013].

Analysis of these documents concludes unequivocally, that in the following years natural gas has the biggest chances of development. The least prospective fuel is hydrogen, as its mass application requires new technical solutions in terms of storage, and most of all a cost-efficient method of production.

Electricity is a "clean" energy at the moment of use, but the environmental consequences of its application depend on the way it is obtained. The capacity of the batteries used in electric vehicles is still too low to meet the expectations, and the vehicles are much more expensive when compared to similar vehicles powered by traditional fuels or natural gas.

Biofuels, due to the production costs, are not going to play a significant role in the future. Environmentally, LPG does not give as positive results as the rest of the alternative fuels. Besides, this fuel is obtained from crude oil processing. Considering all of

the above, everything seems to indicate, that in the near future, in the EU, a dynamic growth of natural gas application in transportation will occur.

The aforementioned directive [Komunikat Komisji... 2013] implicates the necessity to build infrastructure for natural gas refueling stations in Poland. To meet the requirements of the directive, at least seven LNG stations should be built along the roads of TEN-T network, and about 70 CNG stations should be operating (while 24 operate at the moment). According to the directive, this should be accomplished by the year 2020.

5. An offer for spas and resorts

Clean air in resorts is the object of constant concern of local governments in such places. While it was managed to decrease harmful industrial and communal air pollution in Poland, the car fumes emissions constantly grow along with the increase of the number of cars.

This applies not only to Poland, but also to most of the European countries. This is why it is especially important to use solutions, which will reduce these emissions. The actions taken by the EU institutions (even in the form of prepared and referred to in this study [Komunikat Komisji... 2013, Wniosek Dyrektywy... 2013] unequivocally indicate that alternative fuels will be promoted in the EU countries. From all the considered alternatives, the solutions using the natural gas as fuel for vehicles are fully implemented worldwide. There is also a wide range of NGVs to choose from.

Application of natural gas fuel (CNG or LNG) is environmentally friendly and cost-efficient as evidenced by the example of the city buses. In Poland however, this fuel is still not very popular and it is high time to change it. Currently, natural gas is delivered by trains to, among others, Krynica, Zakopane, Muszyna, Iwonicz, Rymanów and Horyniec. Therefore, there are no technical obstacles to deliver the gas in the form of LNG to e.g. Szczawnica, Piwniczna, Wysowa or Ustrzyki and thus provide a possibility to refuel vehicles with a much more ecological fuel, instead of the presently used petroleum fuels.

Application of natural gas also allows using biomethane, which can be mixed with natural gas. Such fuel can be used in buses operating in the resorts, as well as minibuses and passenger cars – including taxis and waste disposal service vehicles. There is no reason for the local fleets of vehicles not to have their own refueling devices (VRAs), without the need to build big CNG refueling stations. Whether or not the number of NGVs in resorts will increase, will depend not only on the government decisions (e.g. excise policy for natural gas fuel and NGVs) but also on the decisions of the local governments. Locally, restricted traffic zones can be established in terms of fumes and noise emissions. NGVs or hydrogen and electric cars could be released from the tax, due to their lower environmental impact. Tenders for transportation services could also use criteria regarding the air and noise pollution.

Hopefully, the popularization of natural gas usage, especially in resorts will be supported by the EU fund division criteria for the years 2014–2021.

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