

# THE CONVENIENCE OF USING COMPRESSED NATURAL GAS IN PUBLIC TRANSPORT OF PASSENGERS

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## INTRODUCTION

Tendency to reduce the emission of noxious products of diesel oil combustion in engines, treatment of the CNG as a fuel seems to be promising. It seems that in the future ecological aspects will matter more and more in Republic of Moldova with the UE adherence rules. So, considering ecological advantages of the CNG as a fuel, probably this technology will be more widespread. Obviously, the development of this technology requires the competitive price of the CNG with respect to the traditional fuels. The rapid increase of the number of vehicles can be observed. It is connected with undesirable phenomena: air pollution, soil pollution, water pollution and noise. It is estimated that the road transport is the main source of these effects. One of the methods of changing this situation is the replacement of the fuel type. The good alternative seems to be the utilization of the natural gas. It can be stored in a vehicle as Liquid Natural Gas (LNG) or Compressed Natural Gas (CNG). It also increases the level of fuel diversification in vehicles. It decreases economical dependency on the chosen fuel provider, what makes the company situation more secure. Utilization of natural gas as vehicle fuel bring not only the economical, abut also social and ecological benefits.

## 1. TECHNIQUE OF COMPRESSED NATURAL GAS USAGE

### 1.1. Gas fueling stations

In Republic of Moldova there are about 10 natural gas refueling stations – it is appreciably too less. Unfortunately the arrangement of the gas stations is very adverse. Most of them are located in Chisinau. An increase of the amount of cars fueled by CNG is possible only in the case of higher number of refueling stations. Employees working on the refueling stations have to be specially trained to serve the gas high-pressure facilities. The proper fire-fighting and flame-proof protection is also important.

### 1.2. Fuel tanks

Compressed natural fuel tanks have to be very refractory and leak proof. Gas pressure level is about 20 MPa, so it is necessary to use proper material for container wall. Nowadays, steel containers are widely used. Weight and huge dimensions are the main disadvantages. The container weight increases real vehicle weight which produce additional fuel consumption and decrease vehicle performance. For this reasons, new materials, as for example composites, are putted into commission. The composite containers durability is higher than the steel ones and their weight can be even three times lower. Internal side of this containers is made from aluminum and external from carbon fiber. The only disadvantage is the higher price of this containers comparing to the steel. On the other hand, lower weight causes lower consumption of the fuel.

According the requirements of the “Technical Inspection Agency”, CNG containers have to be periodically controlled. It is recommended to do this every three years.

### 1.3. Internal combustion engine

It is easier to adapt a gasoline engine. The problem is bigger in a diesel engine, widely used in buses and trucks. Removing fuel system and replacing it with the gas system is required. Engine supplied with the compressed natural gas (CNG) works similarly to a spark ignition engine. The engine needs construction changes like: decrease compression ratio, alternative form of chamber combustion and putting in the ignition system. Typical CNG fuel system is shown in Figure 1. Gas comes from a high pressure fuel tank (20 MPa). The gas pressure is decreased to the level of about 0,8 MPa in a three-stage reducer. This low pressure gas is mixed with the air and constitutes the combustible mixture, which is provided to combustion chamber.

To reduce nitric oxides, oxidize carbon monoxide and another hydrocarbons, the engine can be equipped with three-way catalyst. The three-way

catalyst works properly only with a stoichiometric coefficient of the air factor ( $\lambda$ ) from the range of 0,98-1,02. The only possibility to achieve this value is the application of a microprocessor engine control system. Important part of the engine control system uses lambda sensor which measures oxygen level in exhaust fumes. According to this value combustible mixture is prepared.



**Figure 1.** Wiring diagram of the CNG cars.

The start of the cold engine is trouble-free. The main advantage of the CNG is a high anti-knock index, which assures a non-detonation combustion and engine smoothness prolonging the durability of the engine.

Preparation of the combustible mixture is easier with gas than with gasoline. Good quantity of the gas fuel is obligated for the proper engine operation. EN ISO 15403: 2005 describes gas properties requirements for being used as a fuel in car engines.

## 2. ECOLOGY OF COMPRESSED NATURAL GAS ENGINES

Compressed natural gas is a mixture of light paraffinic hydrocarbons, for instance: methane (83-99%), ethane, propane or butane. Apart from desirable components, the compound is made of foulants like nitrogen, hydrogen sulfide or carbon dioxide. After proper processing, the natural gas is suitable for vehicle supply. There are many advantages of usage of this fuel instead of diesel oil or gasoline.

Transport of the natural gas is safer than of the liquid fuel. The density of the natural gas is lower than of the air. In case of container damage or non-hermetic insulation, gas quickly moves up and does not create flammable mixture. In the event of the road accident with liquid fuel tanker, the risk of soil, water or air pollution is higher than in case of the gas piping transport.

Derivatives of the oil combustion cause the huge emission of very dangerous pollution like dust, poly nuclear aromatic hydrocarbons or benzene. These substances are classified as carcinogenic substances entailing the increase of the cancer cells. Application of the compressed natural gas reduces drastically the quantity of these dangerous substances in fumes. Emission of other gaseous pollutants is also limited.

**Table 1.** Decrease of pollutant emission by the replacement of gasoline and diesel with CNG.

	Gasoline/GNC	Diesel/GNC
CO	60-80%	70-90%
NMHC	85%	40-60%
NO <sub>x</sub>	50-80%	80-90%
PM	-	99%
CO <sub>2</sub>	20%	25%
Noise	-	40%

The CNG usage as a fuel decreases CO<sub>2</sub> emission to the atmosphere even to 25% over gasoline or diesel fuels, which reduces the risk of greenhouse effect. NO<sub>x</sub> emission is also lower which influences the decrease of the risk of acid rains. Moreover, NO<sub>x</sub> is also a greenhouse gas, so the reduction of its emission decreases also the danger of the global warming. The CNG usage also reduces the non-methane hydrocarbons (NMHC) and particle matters (PM) emission too. These two substances influences the smog growing, especially in the cities. The PM emission reduction is near 100%. The CNG does not contain any sulfur compounds so its usage as vehicles fuel is more safe for buildings, especially old ones.

Buses propelled by the CNG fit all norms, even the most restrictive ones. Since October 2009, new acuter limits of emission of pollution have been enacted, nevertheless the CNG still fits all confines. Noise level generated by the CNG engines can be even with 40% lower than diesel engines, which is desirable effect in cities and in densely populated built-up grounds.

## 3. ECONOMIC OUTLOOK FOR DEVELOPING CARS POWERED BY COMPRESSED NATURAL GAS

For the society, economic efficiency determines cost-effectiveness of the investigated project. For commercial projects, financial aspects are the most important. For non-commercial projects very important are also non-financial benefits, like environmental impact. A project is economically efficient when investment outlays and

operating costs are less than social benefits. It means it is efficient in the apprehension absolute. Relatively, economic project takes it to satisfy one concrete requirement of the population which is implemented by least financial cost. For researching efficient economical analysis should be employed, which allows to evaluate both financial and social benefits. The main purpose of the economical analysis is the expression value of the projects. It is necessary for proper share of the public resources between competitive investment projects.

As it can be noticed, investment in compressed natural gas is cost-effective just in determined conditions. The difference between the CNG and gasoline /diesel price is very important. When the difference increases, the profitability of the CNG usage also increases. When the difference decreases, the profitability also decreases significantly. The price of the diesel fuel was much higher than of the CNG in previous years. Therefore, it is possible that many cities will introduce buses fuelled by the natural gas. On the fuel prices huge influence have taxes, especially excise duty. Currently, the natural gas price is lower than of the other fuels. Taking into account the increase of the natural gas prices, introduction period of the buses in urban transport companies can be inconvenient. It is possible that companies could not invest in more ecological but much expensive CNG buses due to the increase of the operating costs.

Important for the introducing of the CNG buses in the urban transport companies is its price. The CNG buses are much more expensive (in comparison with the diesel buses supply) by the fact that the CNG technology is new, permanently improvement and the quantity of production of the CNG vehicles is quite small. It is the reason why many companies are not able to buy CNG buses. Subsidies are the element which significantly redounds to distribute alternative fuels in the transportation.

Currently, there is a possibility to get it from the European Union and from the council funds. This is one of the aspects which leads to increase the usage of the gas fuel in public transportation in the last few years. However, the new technology on the market in the close future could be more profitable.

Vehicles supplied by Liquid Natural Gas (LNG) are used in many countries of Europe. The main advantage is smaller size of LNG storage, in comparison with the CNG. By dint of it, LNG could be real competitive for the buses supplied by compressed natural gas, diesel or gasoline.

Biogas can be also very useful. It is stored as compressed gas. So, buses fuelled by the natural gas can be directly fuelled by biogas. Experts said that in Republic of Moldova are many unused farm wastes which could be used for biogas production and which now are thrown out on landfill. The Main disadvantage of this technology is the small amount of refueling stations.

## CONCLUSIONS

In last few years, it can be observed a pronounced increase of interest regarding to the usage of the compressed natural gas as a fuel for the public transportation. Despite financial, economical and ecological advantages, the process of implementation of the natural gas in vehicles in Republic of Moldova is quite slow. One of the reasons is the necessity to invest in refueling stations. The unstable macroeconomic policy and the threat of excisable duty cause the increase of the gas price, which makes the investments very risky. On the other hand, small quantity of gas users makes project unprofitable. Only long-term, well-defined and green policy could bring on increase of interest for the CNG usage as engine fuel. Moreover, the main purpose of the big cities long-term policy should be the improvement of the passengers comfort in public transportation for which the inhabitants will pay. The increase of the overcrowding streets by vehicles will be a norm in the future extorting development of the public transportation, which is passenger-friendly. Natural gas vehicles should fit these conditions.

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