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BIOMETHANE AS A FUEL FOR CITY TRANSPORT

Wojciech Gis, Andrzej Żółtowski, Paulina Luiza Grzelak

Motor Transport Institute
Environment Protection Centre
Jagiellońska Street 80, 03-301 Warsaw, Poland
tel.: +48 22 438 51 25, 438 55 18, 438 53 27, fax:+48 22 438 54 01
e-mail: wojciech.gis@its.waw.pl
andrzej.zoltowski@its.waw.pl, paulina.dziolak@its.waw.pl

Abstract

Depletion of fossil energy sources, and thus the prices increase of conventional fuels such as gasoline or diesel fuel, the energy security and dependence on imported fuels, as well as the deteriorating environment and global warming mean that there are more and more new technologies using renewable energy sources nowadays. In the medium- and long-term perspective a significant changes are needed regarding means of transport in ensuring "sustainable mobility", while the horizon of short-term solution is the implementation of biofuels, including biogas refined to form of biomethane, and renewable alternative fuels.

Biomethane is produced from waste organic matter. Directive 2009/28/EC indicates the benefits of using waste for the production of transport fuels, to decarbonisation of the energy sector and requires Member States of UE to use renewable fuels.

The paper presents possibilities for the biomethane production, as well as conditions to use it as fuel to power city buses. The level of current use of gaseous fuels in the national urban transport was specified, and also conducted an evaluation of benefits, especially ecological, to use these fuels for these applications.

Keywords*: biomethane, biogas, road transport, environmental protection, CNG, NGV*

1. Introduction

Raw biogas is the mixture of methane (app. 65%), carbon dioxide (app. 35%) and other additives. It is formed through the methane fermentation in anaerobic conditions. Possible substrates for biogas production are agricultural waste (biomass), municipal waste from landfills, industrial waste and sewage sludge from the sewage treatment plants [1].

Biogas can be used as a fuel to produce electricity and heat, and biomethane in its upgraded form, can be used as a fuel for internal combustion engines. Biomethane-fuelled engines have generally lower emissions of pollutants and greenhouse gases than diesel engines; taking into account, that biogas is a renewable fuel.

Biogas production is characterized by a high degree of dispersion. Optimization of the manufacturing process and increasing the kinds and quantities of substrates requires the solution of several fundamental problems, which can contribute to a significant increase of the production level and resource exploitation efficiency [1].

Increase of biogas production is not only the result of energy needs, but also it is a result of the administrative incentives systems, to promote using of renewable energy sources (RES) and environment protection.

European countries, such as Poland, Germany, Finland and Sweden, are characterized by high potential for biogas production. Amounts of biogas produced would let for covering demand for biogas as a fuel. Potential of biogas in countries mentioned above is presented in Tab. 1.

The result of growing interest in biogas production is a wide range of technological solutions, which should be applied with taking into account of resource potential in terms of quantity and

quality, climate and agricultural conditions, supply of raw materials and receiving energy etc. Lack of the above knowledge mentioned above can lead to low efficiency of biogas production processes, despite of high-investment.

Tab. 1 Potential for biogas production in Germany, Sweden, Poland, Finland

Country	Total potential for biogas production
	(bn Nm^3)
Germany	23-24
Sweden	2.3-2,8
Poland	2.9-6.4
Finland	1.2-3.0

2. Methods of biogas usage in Europe

Biogas is used primarily to produce electricity and heat in Europe. Obtained heat is often used in installations and other facilities. In many landfills, there is only partial use of biogas for their own needs. Unused part of biogas is burned in flares. Regardless of the technical difficulties arising from the complexity of connecting to the electric network of the local energy sources, it is known that each process of energy conversion is a lossy process, also by the entropy component, which is cumulated at each stage of processing.

Biogas is used to produce electricity. Produced energy is transmitted even over long distances. Energy transmission is a lossy process, so it is recommended to use biogas as transport fuel in its purified form. Thus, it is believed that the use of biomethane, as a direct energy source (for example in filling stations), is more advantageous and should be promoted. On the other hand, the upgrading process is a lossy process also. Promotion of the biomethane as a transport fuel, especially for city busses, will contribute to better environment protection in cities [1].

Connection of biogas plants, that producing upgraded biogas, to the gas grid is not a technical problem. Hence, the use of biomethane as a direct energy source is good technical solution too.

Therefore, the other methods of biogas use, among its use for electricity and heat production, can and should be the following application of biogas:

- as a fuel for internal combustion engines,
- for supplying gas micro turbines,
- for applications in fuel cells,
- as a fuel in polygeneration systems,
- as a carrier of energy in industrial and municipal applications by the gas grid.

Because of dispersion of biogas plants, the size of these installations, the absence of clear criteria for estimating the quantity and suitability of substrates for biogas production, as well as the process efficiency, lack of cumulative records of produced biogas quantity, there were met various data of biogas production and its estimated potential. Data on the composition of biogas and its basic chemical and physical parameters also vary depending on the source.

Countries on the south of the Baltic Sea are characterized by high agricultural potential of biogas production, while the countries on the north side of the Baltic Sea based on the potential derived from municipal waste and sewage sludge from the sewage treatment plants.

According to VTT Company in Finland, biogas used as a fuel in city buses is a good solution for improving air quality in cities. This is due to lower emission of particle matter. There is also negligible emission of nitrogen oxides (NO_x), especially nitrogen dioxide (NO_2). In comparison, new diesel technology causes an increase of NO_2 emission. Biogas buses also contribute to the lower noise emission [2].

3. Biogas buses in European Cities

The perfect example of using biomethane as a fuel for city buses with success is Stockholm in Sweden. Target for renewable energy sources in Stockholm was 40% of buses using renewable fuels in 2010 and 50% in 2011. According to forecasts, in 2025 there will be 100% of buses using renewable fuels in Stockholm [3].

Biogas in Stockholm is introduced stepwise and is delivered by three wastewater treatment plants, which produce about 8 million Nm^3 of biogas per year [4]. Biogas is transported by bottle-tracks, because of absence of well-developed gas network. Planned biogas infrastructure in the Stockholm area, connecting among the other the fuel-stations, biogas plants, bus depots, is presented on the figure below.

Fig. 1 Planned gas grid distribution of biogas in Stockholm [3]

The fuelling equipment is available at several bus depots. In the end of 2012 there will be about 230 buses running on biogas [3]. Biogas, used as a transport fuel, has an advantage over conventional fuels, especially in the global warming potential, acidification and particle matter emissions.

The environmental advantage of biogas is presented in Tab. 2.

Tab. 2 Environmental advantage of biogas [4]

Environmental impact per MJ fuel	Global warming potential	Acidification	Particle matter (PM)
	g CO_2 (equivalent)	mg SO_2 (equivalent)	mg
LIGHT VEHICLES			
Biogas	4.3	8.7	0.72
Gasoline	87.8	95.0	3.86
Reduction	95%	91%	81%
HEAVY VEHICLES			
Biogas	4.3	140	0.72
Diesel	83.0	410	7.1
Reduction	95%	66%	90%

Biogas is one of the cleanest fuels that contribute to the significant reduction of GHG emissions. Biogas can be produced locally, so the gas pipe infrastructure is not necessary for its transmission. It is suitable for local traffic, such as public buses, city taxis, etc. Use of biogas as a vehicle fuel requires suitable infrastructure. The infrastructure in the other Swedish City – Örebro, connected the biogas plant, wastewater treatment plant, bus depots, and fuelling stations is presented on the figure below.

Fig. 2 Biogas infrastructure in city of Örebro [5]

In Örebro there are 61 buses running on biogas. Those vehicles use about 6 million Nm^3 of biogas per year, and the daily fuel consumption of those buses is about 7000 – 8000 Nm^3. This means, that the annual demand for substrate for biogas production in this city is about 50000 Mg [5]. The substrate is delivered by two plants – municipal wastewater treatment plant and in biogas plant "Swedish Biogas" with capacities of 1.5 million Nm^3 and 6 million Nm^3 respectively. According to introduction of biogas buses in city of Örebro, it was reported a significant reduction of greenhouse gases and toxic compounds. The annual reduction of CO_2 was 14 000 Mg, NO_x – 21 Mg, SO_x – 4 Mg and PM – 2 Mg [5].

In Poland, there are about 300 CNG buses, which can be fuelled by purified biogas. Current potential for biogas production in Poland is sufficient enough for supplying bus fleets in every Polish city.

In the Hamburg Airport in Germany, are operating buses fuelled with biomethane, which carry airplane passengers. Plans for use biogas as a vehicle fuel also exist in Estonia. Authorities of Tartu City bought 4 CNG buses and built CNG fuelling station. They are planning to build the biogas plant now.

4. Conclusions

Biogas (biomethane) is a good and perspective gaseous-biofuel, possible for use in engines. High potential for biogas production and its suitable parameters are determining the profitability of its production and purification for use in internal combustion engines. The leading state in production of biogas as a fuel for transport is undoubtedly Sweden, where for example only fuels derived from renewable resources drive buses in public transport in the City of Stockholm, including biomethane.

Interest in biogas and its production is growing in European countries because of the possibility for municipal waste, sewage sludge and agricultural waste utilization and completion of the set in the Directive of the European Parliaments and of the Council 2009/28/EC of 23 April 2009 on the promotion of energy from renewable sources.

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