POLITYKA ENERGETYCZNA – ENERGY POLICY JOURNAL

2023 ✦ Volume 26 ✦ Issue 4 ✦ 209–220

DOI: 10.33223/epj/176767

Dominik Kryzia[1], Monika Pepłowska[2]

Assessment of the potential of using CNG to power up passenger cars in Poland

Abstract: This article presents the results of an assessment of the potential for the use of CNG in Poland as a fuel for passenger cars powered by an internal combustion engine fuelled by petrol or diesel. The basis for assessing the potential was an analysis of the economic efficiency of converting a passenger car fuelled by petrol or diesel to a dual-fuel vehicle by installing a CNG system. On the basis of available literature data, the vehicle structure was characterised using the following criteria: vehicle age, engine capacity, car-segment, type of fuel used and kerb weight. The average fuel consumption (petrol or diesel) of the vehicle before conversion was determined on the basis of specially developed statistical models. The conversion and operating costs of a vehicle fuelled with conventional fuel and with CNG (after vehicle conversion) were estimated on the basis of a stochastic simulation model using probability density distributions of vehicle parameters and the Monte Carlo method. The vehicle parameters were estimated so that the obtained set of vehicles reflected the actual structure of passenger cars in Poland. The estimated costs of vehicle conversion (purchase and installation of a CNG system) and its subsequent operating costs made it possible to assess the economic efficiency of the car conversion process. The potential use of CNG as a fuel for combustion cars was estimated by comparing the operating costs of a vehicle before conversion

✉ Corresponding Author: Monika Pepłowska; e-mail: monika@meeri.pl

[1] Mineral and Energy Economy Research Institute of the Polish Academy of Sciences, Poland; ORCID iD: 0000-0003-0639-3485; e-mail: kryzia@meeri.pl

[2] Mineral and Energy Economy Research Institute of the Polish Academy of Sciences, Poland; ORCID iD: 0000-0001-9150-7525; e-mail: monika@meeri.pl

and the operating costs of a vehicle after conversion, taking into account the costs of conversion. Analogous calculations were carried out for the conversion of a vehicle to run on LPG, i.e. the most important competitor to CNG.

Keywords: economic efficiency, Monte Carlo, LPG, CNG vehicles, alternative fuels

Introduction

In the face of an increasing number of vehicles, particularly passenger cars, modern methods of powering them are being developed. With the introduction of the Energy and Climate Package, European Union (EU) countries, including Poland, are required to comply with regulations limiting the emission of harmful substances into the atmosphere. Consequently, in every growing sector of the economy, EU residents are seeking new, environmentally friendly solutions aimed at reducing air pollution. This trend is moving towards lowering or completely replacing high-emission sources with cleaner alternatives.

The road transport sector, along with industry and households, is one of the main sources of pollution emissions in the country, mainly due to exhaust fumes. Therefore, various measures are being taken in this area. The increasing number of vehicles, especially in large cities, contributes to the rise in pollution emissions. Additionally, in recent years, there has been an increased import of used cars, that are often old and worn out. Interest in electric vehicles is lower than originally forecasted due to high prices and limited availability of charging infrastructure and the range of these vehicles. In the current situation, one of the solutions to reduce emissions seems to be the conversion of gasoline or diesel cars to dual-fuel vehicles by installing CNG (compressed natural gas) systems.

Natural gas, considered one of the most 'clean' fuels, can also be used to power vehicles. Although this fuel is mainly gaining popularity abroad, there is also interest in this type of fuel in Poland. In this country, it has mainly become known through its use in public transport vehicles (city buses). This ecological fuel is used in transport in two forms, namely in a compressed form, known as CNG, and in a liquefied form, known as LNG (liquefied natural gas). In terms of domestic consumption, the liquefied form is far less popular than the compressed form. The most common substitute used by today's users is LPG (liquefied petroleum gas); however, this is a mixture of propane and butane gases, not natural gas.

It should be noted that the use of a gaseous-fueled vehicle is determined by a number of factors, which include the availability of refueling stations, the price of gaseous fuel, the price of the vehicle, the public's mainly environmental awareness and a number of other factors.

The aim of this study was to determine the impact of the price relationship of fuels such as petrol, diesel, CNG and LPG on the choice of propulsion type for passenger cars in Poland and to estimate the potential for the demand of these fuels for powering passenger cars and to forecast the level of carbon dioxide emissions from the engines of these vehicles.

The authors explored the topic by publishing a number of papers, i.e. Pepłowska and Kryzia (2016), Orzechowska et al. (2014, 2016), Kryzia et al. (2015a, 2015b), Orzechowska and Kryzia (2014, 2015).

The paper is structured as follows: the paper begins with an introduction, the next section describes the mathematical model, the following section presents the results of the analysis and their interpretation, and the paper concludes with a summary and literature list.

1. Materials and methods

In Poland, the passenger car fleet consists mainly of vehicles equipped with spark-ignition or compression-ignition engines that run on liquid fuels such as petrol and diesel. Passenger car operators deciding to install alternative fuels, such as LPG and CNG, should perform an economic viability analysis, in which the key factors are the fuel consumption of the vehicle and the ratio between conventional and alternative fuels, as well as the costs of purchasing, installing and maintaining the system. The total cost of ownership depends on the characteristics of the vehicle, the way it is operated and the road and weather conditions.

The potential for the use of CNG in Poland for fueling passenger cars equipped with an internal combustion engine was estimated on the basis of a simulation conducted using a proprietary model of fuel consumption by a combustion engine. The model simulates a hypothetical vehicle by determining its key parameters. They are simulated in a random way (with correlations of the most important parameters – Tables 2 and 3) from empirical probability density distributions established in the course of the analysis of the parameters of the passenger car fleet in Poland. For each hypothetical vehicle simulated in this way, the petrol or diesel consumption per one hundred kilometers travelled by the vehicle was calculated. For this purpose, econometric models were developed using data made available on the Autocentrum portal (www.autocentrum.pl/spalanie). A full description of the econometric models used to estimate fuel consumption is provided in (Kryzia et al. 2015).

One of the assumptions made in the analysis is that forms of powering passenger cars such as electricity, LNG and hydrogen have been omitted. The authors considered that the share of cars powered by these types of fuels in the passenger car market in Poland was so small that they could be omitted from the analysisand, moreover, there is a great deal of uncertainty about their development.

The parameters characterizing the hypothetical vehicle were considered to be:

- the type of fuel supplying the vehicle (diesel or petrol),
- the carcass of the vehicle (values from 660 to 2180 kg),
- the vehicle engine displacement (values from 0.8 to 4.2 dm^3),
- the age of the vehicle (values from 0 to 31 years),
- the car segment to which the vehicle belongs (eight categories, namely smallest cars, small cars, lower middle class, middle class, vans, small SUVs, higher middle class, large SUVs).

Table 1 contains values of descriptive statistics of probability density distributions of parameters characterizing the passenger car fleet in Poland. The probability density distributions for the parameters indicated above were prepared on the basis of data obtained from the CEPIK database and PZPM reports.

Table 1. Descriptive statistics for a sample of the passenger car fleet in Poland

Tabela 1. Statystyki opisowe dla próbki floty samochodów osobowych w Polsce

Parameter	J.m.	Average	Median	Value min.	Value max.	Deviation standard	Coefficient of variation	Skewness	Kurtosis
Own weight	kg	1,546.0	1,540.0	780.0	2,675.0	257.4	0.167	0.597	1.405
Engine capacity	dm^3	1.53	1.48	0.8	4.2	0.54	0.35	1.69	7.50
Age	years	15.92	15	0	31	3.92	0.53	0.29	2.23
Car-segment	–	3.61	3	1	8	1.68	0.46	0.47	2.19

Source: own study.

Values for all the above-mentioned car paramaters have a stochastic character and were determined on the basis of available statistics on the number of diesel and spark ignition passenger cars registered in Poland. All vehicles for which the age exceeded thirty years were classified as thirty-one-year-old vehicles. This assumption does not affect the obtained results of the analysis, as it was assumed that vehicles over thirty years old are eligible for scrapping and their conversion is an economically inefficient undertaking. The useful life of a vehicle is calculated as the difference between the maximum vehicle life and its current age.

Sports and luxury cars were omitted from the analysis on the assumption that these types of vehicles would not be converted to run on alternative fuels.

As a result of the Monte Carlo simulation, sets of parameter values characterizing the hypothetical vehicles were obtained, creating a set of 17,618 elements, representing the existing passenger car fleet in Poland. In order to ensure that the combination of values of parameters characterizing the hypothetical vehicle reflected the combination of values occurring in reality, correlation coefficients characterizing relationships between parameters were included in the model. Their values were calculated from the empirical data and are presented in Tables 2 and 3.

The cost of operating a vehicle is calculated on the value of fuel consumption per hundred kilometers (the value from the statistical models described by formulae 1 and 2), the fuel price and the average value of the annual mileage of the vehicle. In the analysis, constant fuel prices of PLN 6.50 per dm3 of petrol and PLN 6.40 per dm3 of diesel were assumed. LPG and CNG prices did not change in the analyzed period; however, in order to illustrate the changes in the value of the CNG demand potential on the price of these fuels, different variants were analyzed, being a combination of LNG and CNG prices, the values of which were changed with a step of PLN 0.25 per unit volume of fuel. The value of the average annual vehicle mileage in kilometers was determined on the basis of collected statistical data. This value depends on the car-segment

TABLE 2. Values of correlation coefficients for parameters characterizing spark-ignition passenger cars

TABELA 2. Wartości współczynników korelacji dla parametrów charakteryzujących samochody osobowe z silnikiem iskrowym

Specification	Engine capacity	Own weight	Car-segment
Engine capacity	1.00	0.87	0.73
Own weight	0.87	1.00	0.78
Car-segment	0.73	0.78	1.00

Source: own study.

TABLE 3. Values of correlation coefficients for parameters characterizing diesel passenger cars

TABELA 3. Wartości współczynników korelacji dla parametrów charakteryzujących samochody osobowe z silnikiem wysokoprężnym

Specification	Engine capacity	Own weight	Car-segment
Engine capacity	1.00	0.83	0.72
Own weight	0.83	1.00	0.84
Car-segment	0.72	0.84	1.00

Source: own study.

to which the vehicle belongs and the type of fueling. The average annual mileage values adopted in the analysis are shown in Table 4.

TABLE 4. Annual average passenger car mileage values by fuel type and car-segment [km/year]

TABELA 4. Średnie roczne wartości przebiegów samochodów osobowych według rodzaju paliwa i autosegmentu [km/rok]

Car-segment	The smallest cars	Small cars	Lower middle class	Middle class	Vans	Small SUVs	Higher class	Large SUVs
Diesel-powered vehicle	12,000	12,000	20,500	20,800	20,800	22,000	23,100	21,600
Petrol-powered vehicle	10,000	10,000	13,800	16,000	16,000	14,500	17,200	16,700

Source: own study.

$$S_g = 0,1117 \cdot A_s - 0,0269 \cdot R_p + 2,4642 \cdot P_s + 0,0013 \cdot M_w + 56,0856 \tag{1}$$

$$S_d = 0,2864 A_s - 0,0084 \cdot R_p + 1,1688 \cdot P_s + 0,0019 \cdot M_w + 16,1199 \tag{2}$$

where:

S_g – value of the specific petrol consumption of the vehicle [dm/100 km^3],
S_d – value of the specific consumption of diesel by the vehicle [dm/100 km^3],
A_s – the car segment to which the vehicle belongs,
R_p – the year the vehicle started production,
P_s – engine capacity of the vehicle [dm^3],
M_w– unladen vehicle mass [kg].

The adjusted coefficient of determination R2, a measure of model fit, reached a value of 0.813 for the model of fuel consumption of diesel-fueled vehicles and 0.869 for the model of fuel consumption of petrol-fueled vehicles. This demonstrates a statistically good explanation of the fuel consumption values by the explanatory variables (vehicle parameters).

In addition to fuel consumption, the operating costs of a CNG vehicle consist of:

- the cost of the technical inspection, which is performed annually and is £69 more expensive than the inspection of a vehicle without the installation;
- the cost of legalization of the fuel tank, which is conducted every three years and amounts to PLN 150 per tank;
- the cost of carrying out a leak test of the installation and fuel tanks, which is performed every ten years and amounts to GBP 300 per tank.

The cost value of installing a CNG system is influenced by parameters such as the number and capacity of fuel tanks and the type of engine and number of cylinders. Table 5 summarizes the cost values for the installation of CNG systems. These data were obtained from consultations with service companies installing CNG systems and from officially available price lists.

TABLE 5. Costs of installing CNG systems

TABELA 5. Koszty montażu instalacji CNG

Specification	Unit	Values				
Engine displacement from	dm^3	0.6	0.8	1.0	2.5	4.0
Engine displacement up to	dm^3	1.0	1.4	3.0	5.0	4.2
Number of cylinders	pieces	2	3	4	6	8
Cost of installation including assembly	PLN	3,000	3,300	3,500	3,900	4,500

Source: own study.

The curb weight of the vehicle after conversion increases, which has an impact on the fuel consumption of the vehicle. The change in vehicle weight (but also the maximum range) is mainly determined by the number of CNG fuel tanks fitted to the vehicle. The increase in vehicle weight is limited by the permissible gross vehicle weight and the design parameters of the chassis. It has been assumed that one type of tank is used, namely a tank with a capacity of 75 dm^3 and a weight of approximately 75 kg, costing approximately PLN 1,300. It was assumed in the analysis that the number of tanks included in the model depends on the car segment to which the vehicle belongs (Table 6).

Table 6. Number of CNG tanks depending on the car segment the vehicle belongs to

Tabela 6. Liczba zbiorników CNG w zależności od autosegmentu, do którego należy pojazd

Car-segment	The smallest cars	Small cars	Lower middle class	Middle class	Vans	Small SUVs	Higher class	Large SUVs
Number of tanks	1	1	2	2	2	2	2	3

Source: own study.

It was assumed that the cost of installing a CNG system in a diesel vehicle is about 20% higher than installing one in a passenger car with a spark-ignition engine. The analysis assumes that, in the case of diesel engines, a mixture of natural gas and diesel is introduced into the combustion chamber at a ratio of 3:2. During the start-up phase, both types of engine with a CNG installation are (for about 5% of the total engine operating time) fueled with conventional fuel, until an adequate temperature is reached to protect the gas regulator from icing.

In the case of LPG installation, the costs of operating the vehicle consist of:

- the cost of the technical inspection, which is performed annually and is £69 more expensive than the inspection of a vehicle without the installation;
- the cost of conducting a leak test of the installation and fuel tanks, which is performed every ten years and amounts to £300 per tank.

The cost value of installing a CNG system is influenced by parameters such as the number and capacity of fuel tanks and the type of engine and the number of cylinders. Table 5 summarizes the cost values for the installation of LPG systems. This data was obtained during consultations with car services specializing in the installation of LPG systems and from officially available price lists.

Based on the data in Table 7, triangular probability density distributions of the cost of purchasing and installing an LPG system were constructed for each variant of the number of cylinders in the engine.

Based on an analysis of an article by Łyko et al. (2014), it was assumed that 20% of vehicle owners would choose not to install a CNG system even though it would make economic sense to do so. This is due to the discomfort that may be associated with the use of CNG vehicles caused by, among other factors, limited boot space and a limited number of refueling stations.

The model made it possible to indicate whether it made sense (from an economic point of view) to install a CNG system in a vehicle. For each of the hypothetical vehicles, the cost of fitting a CNG system and operating the vehicle on natural gas for its entire life was determined. Similarly, costs were calculated for the installation of an LPG system and the operation of an autogas vehicle over its lifetime. These values, discounted at a five percent discount rate, are compared with each other. If the value of the sum of the discounted operating costs

Table 7. Costs of installing LNG facilities

Tabela 7. Koszty montażu instalacji LNG

Specification	Unit	Values				
Engine displacement from	dm^3	0.6	0.8	1.0	2.5	4.0
Engine displacement up to	dm^3	1.0	1.4	3.0	5.0	4.2
Number of cylinders	pieces	2	3	4	6	8
Maximum cost of installation including assembly	PLN	2,465	3,081	3,081	4,062	4,788
Average cost of installation including assembly	PLN	2,465	3,081	3,081	4,062	4,788
Minimum cost of installation including assembly	PLN	1,600	2,000	2,000	2,800	3,500

Source: own study.

of a CNG vehicle is the lowest (i.e. lower than the value of the sum of the discounted operating costs of a vehicle with an engine that burns liquid fuel or LPG), the annual natural gas consumption of that vehicle is determined. The sum of CNG consumption determined as described above for a set of hypothetical vehicles has to be increased a thousand times. As a result, the annual potential for CNG consumption by passenger cars in Poland powered by conventional fuels is obtained. In order to obtain the value of the total potential, the value of natural gas consumption by vehicles that are currently already running on CNG was added to the value calculated above.

The number of passenger cars in which a CNG system can be installed is approximately 17.618 million units.

The Monte Carlo simulation was performed using the Crystal Ball version 11 Oracle software called.

2. Results and discussion

On the basis of simulation studies, the potential for natural gas use in passenger cars in Poland was estimated. The value of this potential depends on the price of CNG and the price of LPG – the most important competitor for CNG. Table 8 shows the potential demand for CNG to power passenger cars depending on the number of fuel prices.

On average, in 4% of the smallest cars, it makes economic sense to install a CNG system. In other car segments, the percentage values are: small cars – 12%, lower mid-range car – 20%, mid-range cars – 29%, vans – 31%, small SUVs – 39%, higher-range cars – 46% and large SUVs – 45%. Gasoline-powered spark-ignition cars dominate, generating almost 82% of the annual natural gas use potential.

TABLE 8. CNG demand potential to fuel passenger cars for option 26 CNG refueling stations [million m^3/year]

TABELA 8. Potencjał zapotrzebowania CNG do zasilania samochodów osobowych dla wariantu 26 stacji tankowania CNG [mln m^3/rok]

		CNG price [PLN]										
		3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50
LPG pric [PLN]	3.00	1,401.67	828.89	621.96	446.37	264.07	113.91	12.63	0.00	0.00	0.00	0.00
	3.25	2,367.56	1,528.18	824.85	527.73	362.61	185.71	63.74	5.08	0.00	0.00	0.00
	3.50	3,322.87	2,482.22	1,644.23	894.91	450.40	269.07	128.15	30.10	0.00	0.00	0.00
	3.75	4,150.09	3,391.17	2,613.20	1,756.96	954.01	393.93	178.21	89.10	6.66	0.00	0.00
	4.00	4,752.68	4,162.06	3,477.95	2,697.88	1,869.96	1,055.38	392.66	110.25	32.47	3.50	0.00
	4.25	5,209.33	4,694.34	4,144.61	3,481.04	2,733.37	1,955.45	1,167.09	458.23	74.97	6.66	0.00
	4.50	5,537.40	5,103.47	4,617.16	4,068.44	3,453.72	2,752.28	2,031.49	1,277.03	557.64	86.57	1.15
	4.75	5,752.83	5,358.65	4,957.52	4,458.97	3,903.13	3,332.84	2,708.27	2,047.11	1,359.83	698.48	185.71
	5.00	5,890.75	5,505.67	5,127.61	4,698.00	4,182.32	3,632.45	3,086.51	2,519.18	1,905.82	1,318.10	758.87
	5.25	5,928.89	5,548.88	5,159.45	4,739.75	4,241.58	3,704.90	3,159.41	2,600.76	2,011.58	1,437.39	895.54
	5.50	5,928.89	5,548.88	5,159.45	4,739.75	4,241.58	3,704.90	3,159.41	2,600.76	2,011.58	1,437.39	895.54

Source: own study.

As a result of using CNG as a vehicle fuel instead of conventional fuels such as petrol and diesel, there would be a reduction in carbon dioxide emissions of 19 to 22% and particulate emissions of more than 90%.

Conclusions

The European Union's policy is directed towards the application of pro-environmental solutions. The introduction of the so-called 3x20 package and emission reduction guidelines obliges member states to seek pro-environmental solutions in every sector of the economy, One of the sectors with high emissions and in which there are a number of opportunities to reduce pollution is the road transport sector.

The conducted research allows a number of conclusions to be drawn:

1. The performed simulation concluded that the price ratio of CNG relative to other fuels is of key importance for the economic viability of converting passenger cars to CNG fuel. At the current CNG fuel price of over PLN 9.50/m^3, the installation of a CNG system in passenger cars in Poland is not economically viable. Taking into account current fuel prices, the installation of a CNG system would start to be economically efficient for a small number of vehicles when the CNG price is PLN 4/m^3 lower than the current price.
2. The low share of CNG-installed vehicles in the passenger car structure in Poland may be due to the high price of natural gas and comfort concerns arising from the limited range, the small number of charging stations and the high initial costs associated with vehicle conversion.
3. Conversion most often has a positive economic effect when it takes place in cars with a petrol-fueled engine characterized by high fuel consumption and an average annual mileage of more than 20,000 kilometers. It makes particular sense to convert the power supply of a large SUV and higher-class passenger car.
4. As a result of using CNG as a vehicle fuel instead of conventional fuels such as petrol and diesel, there will be a reduction in carbon dioxide emissions of 19 to 22% and a reduction of particulate emissions of more than 90%.

This study was done within the statutory research of Mineral and Energy Economy Research Institute of the Polish Academy of Sciences.

References

Kryzia et al. 2015a – Kryzia, D., Kopacz, M. and Orzechowska, M. 2015. Estimation of carbon dioxide emissions and diesel fuel consumption in passenger cars (*Szacowanie emisji ditlenku węgla i zużycia oleju napędowego w samochodach osobowych*). *Zeszyty Naukowe Instytutu Gospodarki Surowcami Mineralnych i Energią PAN* 90 (*in Polish*).

Kryzia et al. 2015b – Kryzia, D., Orzechowska, M. and Kopacz, M. 2015. Causes of seasonal changes in fuel consumption in internal combustion engines of passenger cars (*Przyczyny sezonowych zmian zużycia paliwa w silnikach spalinowych samochodów osobowych*). *Logistics* 4(3) (*in Polish*).

Lorenc, A. 2012. Methodology for forecasting actual fuel consumption (*Metodyka prognozowania rzeczywistego zużycia paliwa*). *Mechanika. Czasopismo Techniczne – Technical Journal. Mechanics* 109(7-M), pp. 135–145 (*in Polish*).

Łyko et al. 2014 – Łyko, P., Śliwka, M. and Pomykała, R. 2014. Application of CNG and biomethane in transport – good practices from selected European Union countries (*Zastosowanie CNG i biometanu w transporcie – dobre praktyki z wybranych krajów Unii Europejskiej*). *Logistyka* 4(6), pp. 4628–4632 (*in Polish*).

Orzechowska, M. and Kryzia, D. 2014 SWOT analysis of the use of natural gas in road transport in Poland (*Analiza SWOT wykorzystania gazu ziemnego w transporcie drogowym w Polsce*). *Polityka Energetyczna – Energy Policy Journal* 17(3) (*in Polish*).

Orzechowska, M. and Kryzia, D. 2015. Estimation of the future demand for natural gas in road transport in Poland. *5th International Youth Conference on Energy (IYCE)*, Pisa, Italy, pp. 1–5, DOI: 10.1109/IYCE.2015.7360815.

Orzechowska et al. 2014 – Orzechowska, M., Szurlej, A. and Filip, M. 2014. Economic and environmental aspects of using CNG in urban public transport – based on the experience of MPK Rzeszów. *Logistyka* 4.

Orzechowska et al. 2016 – Orzechowska, M., Kryzia, D., Kopacz, M. and Roś, P. 2016. Energy security in the road transport sector in Poland (*Bezpieczeństwo energetyczne w sektorze transportu drogowego w Polsce*). *Energia i Paliwa* 2015, Kraków: Wydawnictwo Studenckiego Towarzystwa Naukowego (*in Polish*).

Pepłowska, M. and Kryzia, D. 2016. The assessment model of energy security in the road transport sector in Poland. *Humanities and Social Sciences* 21 (XXI) (23 (2)), pp. 169–176.

Resin, P. 2012. Modelling and simulation of fuel consumption and exhaust emissions in urban traffic (*Modelowanie i symulacja zużycia paliwa i emisji spalin w ruchu miejskim*). Master's thesis. Adam Mickiewicz University in Poznań [Online] http://min.wmi.amu.edu.pl/wp-content/uploads/2015/01/Praca_magisterska_informatyka.pdf [Accessed: 2023-10-20] (*in Polish*).

Siłka, W. 1994. Theory of car movement, energy intensity of movement and fuel consumption. Higher School of Engineering in Opole, Opole.

Ubysz, A. 2008. Forecasting the fuel consumption of a passenger car in real traffic (*Prognozowanie zużycia paliwa w samochodzie osobowym w ruchu rzeczywistym*). *Mechanika. Czasopismo Techniczne – Technical Journal. Mechanics* 105(6-M), pp. 209–217 (*in Polish*).

Dominik Kryzia, Monika Pepłowska

Ocena potencjału wykorzystania CNG do zasilania samochodów osobowych w Polsce

Streszczenie

Artykuł prezentuje wyniki oceny potencjału wykorzystania CNG w Polsce jako paliwa do zasilania samochodów osobowych napędzanych silnikiem spalinowym zasilanym beznyną lub olejem napędowym. Podstawą do oceny potencjału była analiza efektywności ekonomicznej konwersji samochodu osobowego zasilanego benzyną lub olejem napędowym na pojazd dwupaliwowy polegający na montażu instalcji CNG. Na podstawie dostępnych danych literaturowych scharakteryzowano strukturę pojazdów za pomocą następujących kryteriów: wiek pojazdu, pojemność silnika, autosegment, rodzaj stosowanego paliwa, masa własna. Średnie zużycie paliwa (benzyny lub oleju napędowego) przez pojazd przed konwersją zostało określone na podstawie specjalnie opracowanych modeli statystycznych. Koszty konwersji i eksploatacji pojazdu zasilanego paliwem konwencjonalnym oraz instalacja CNG (po konwersji pojazdu) oszacowano na podstawie stochastycznego modelu symulacyjnego wykorzystującego rozkłady gęstości prawdopodobieństwa parametrów pojazdów oraz metodę Monte Carlo. Parametry pojazdów estymowano tak, aby otrzymany zbiór pojazdów odzwierciedlał rzeczywistą strukturę samochodów osobowych w Polsce. Oszacowane koszty konwersji pojazdu (zakup i montaż instalacji CNG) oraz jego późniejszej koszty eksploatacji umożliwiły ocenę efektywności ekonomicznej procesu konwersji samochodu. Potencjał wykorzystania CNG jako paliwa dla samochodów spalinowych został oszacowany poprzez porównanie kosztów eksploatacji pojazdu przed konwersją i kosztów eksploatacji pojazdu po konwersji z uwzględnieniem kosztów jej przeprowadzenia. Analogiczne obliczenia prrzeprowadzono dla wariantu konwersji pojazdu na napęd zasilany LPG to jest paliwa będącego najważniejszym konkurentem dla CNG.

Słowa kluczowe: efektywność ekonomiczna, Monte Carlo, LPG, CNG, ICE