

## Analysis of the market of LPG as an alternative vehicle fuel in Poland in 2005–2016

M. Buczaj<sup>1</sup>, A. Sumorek<sup>2</sup>

<sup>1</sup>*Institute of Electrical Engineering and Electrotechnologies, Lublin University of Technology*

*Nadbystrzycka 38A, 20-618 Lublin, Poland, e-mail: m.buczaj@pollub.pl*

<sup>2</sup>*Department of Structural Mechanics, Lublin University of Technology*

*Nadbystrzycka 40, 20-280 Lublin, Poland, e-mail: a.sumorek@pollub.pl*

*Received: April 28, 2017; Accepted: October 24, 2017*

**Abstract.** The Liquefied Petroleum Gas (LPG) is currently the only widespread and available alternative fuel used in Poland for motor vehicles equipped with spark-ignition engines. Until the end of the 1980s, the monopoly on the fuel market had belonged to petrol and diesel oils. In the 1990s this monopoly was broken by LPG. The important impulse causing increase of concern with using alternative driving fuels by drivers has always been economy issues. The Liquefied Petroleum Gas has been presented as an eco-friendly fuel, and with an attractive price it has also gained the title of an economical one. Over the last three decades, The Liquefied Petroleum Gas has become an important player in the fuel market. The article presents current trends observed in the fuel market (LPG fuel and gasoline U95) used to power motor vehicles equipped with spark ignition engines, and analysis of the price volatility of these fuels in the period 2005–2016.

**Key words:** alternative fuels, LPG fuel, petrol, fuel market, vehicles.

### INTRODUCTION

The main sources of energy used to power vehicles are gas oils and gasoline. All the other fuels are referred to as alternative fuels. The alternative fuels include LPG, CNG, hydrogen, electricity, and solar energy [7, 13, 14, 20, 24]. Of the alternative fuels currently available in Poland it is only in case of LPG that we can talk about the existence of a developed and fully formed market.

The emergence of the LPG market in Poland and its development over the last three decades has involved two main factors. The first factor was the economic aspect. LPG gas was and still is a much cheaper fuel. The cost-effectiveness ratio, which compares the cost of driving 1

km on U95 and LPG, was even above 3.0 (the end of the 20th century). At present, this factor has decreased to 1.5–1.7 [7, 9, 10]. The second factor contributing to the development of the LPG market is the availability of LPG distribution points. During the last few years, a dense LPG gas station network was established. Existing distribution infrastructure allows free access to the fuel. The network of distribution points largely coincides with the network of petroleum petrol stations. At present, the number of LPG distribution points in Poland is about 5.3–5.4 thousand [9, 10, 15, 16, 18]. The attractiveness of the LPG fuel market is evidenced by the fact that its main distributors include leading fuel companies in Poland (Orlen, BP, Lotos).

The article presents current trends on the LPG fuel market. For this purpose, it discusses the evolution of LPG and U95 fuel prices over the period 2005–2016, the cost-effectiveness of using LPG as an alternative fuel to U95 gasoline, and the changes in the availability of the LPG fuel distribution network and the volume of LPG fuel users (vehicles fitted with LPG installations) in the post-accession period of Poland to the European Union.

The main aim of the article is to highlight the periodic volatility of LPG and U95 fuel prices in particular months of the year and the existence of a characteristic seasonal factor in the evolution of LPG and U95 fuel prices. The results of the study will be presented for the period 2005–2016 and will be a comparative material to the previously presented results of LPG market analyses [7, 8, 9, 10].

### LPG FUEL

Liquefied Petroleum Gas (LPG) is a condensed hydrocarbon mixture whose main components are C<sub>3</sub>H<sub>8</sub> propane and C<sub>4</sub>H<sub>10</sub> butane (as n-butane and isobutane). In

addition to these basic ingredients it contains small amounts of other hydrocarbons (ethane) and impurities, mostly sulfur (not more than 50 mg/kg) [2]. During the year, the proportion of LPG propane and butane components is expected to change. The seasonality of this fuel (species B – winter and drought) is required by law. Normally, the composition of the mix should be such that, for the average ambient temperature, the vapour pressure is not less than 150 kPa [1, 13]. Due to the different boiling points of the basic components in the winter, the proportion of gases contained in the LPG fuel is adjusted to increase the propane content of the fuel [14, 17]. Detailed requirements concerning the composition and purity of LPG are regulated by the Polish Standard PN-EN 589 of 2009 [1]. Table 1 compares the basic characteristics of LPG and gasoline.

**Table 1.** The basic characteristics of LPG and gasoline [14]

Fuel characteristic	LPG		Gasoline U95
	Propane/Butane		
Calorific value [kJ/kg]	30/70	49 260	46 150
	40/60	49 340	
	50/50	49 420	
	60/40	49 500	
	70/30	49 590	
Calorific value [kJ/dm <sup>3</sup> ]	30/70	25 540	31 570
	40/60	25 150	
	50/50	24 885	
	60/40	24 620	
	70/30	24 360	
Octane number	100 ÷ 110		95
Density at t=15°C [kg/m <sup>3</sup> ]	0,52 ÷ 0,56		0,745
Flash point [K]	756		780
Theoretical air demand [kg/kg]	15,3 ÷ 15,7		14,5 ÷ 14,8

Source: Januła 1994 [14]

Comparing the data in Table 1, it can be seen that the calorific value expressed in mass units is higher for LPG compared to gasoline U95. On the other hand, the calorific value of LPG gas converted per unit volume is less than the net calorific value of gasoline U95. For both fuels the commercial unit is the dm<sup>3</sup>. It follows that, when determining the cost-effectiveness ratio, the differences arising from the different fuel values of LPG and U95

should be taken into account. The theoretical demand for LPG fuel resulting from differences in net calorific values expressed in unit volumes is higher than gasoline demand and ranges from 23% to 30%, depending on the type of LPG (propane/butane) component.

#### LPG FUEL MARKET IN POLAND

The use of LPG fuel in the world is not a new phenomenon. The first installations that enabled the LPG vehicles to be powered were built and used in the first half of the 20th century [17]. Interest in alternative fuels, including LPG, has always been greater in periods of oil crises (the 1940s, 1970s and now), when fuel was out of the market or its prices skyrocketed. In the world, the creation of a separate market related to the production and distribution of LPG fuel falls in the 1970s. In Poland, the establishment and development of the LPG market dates back to the mid-nineties. Earlier in Poland, LPG was used sporadically and had a small share in the fuel balance. Polish Central Statistical Office and Polish LPGA Association data show that the period from circa 1995 to 2005 is characterized by dynamic development (Table 2 and Table 3) of the LPG fuel market. In that period LPG market in Poland was the most dynamically developing market of LPG fuel in the world. Such rapid growth was influenced by the following factors: attractive price of LPG compared to U95 gasoline price, access to modern gas installations, and popularization of cars as private means of transport. The development of the LPG industry until 2005 and its subsequent stabilization have placed the LPG market in Poland among the world's leaders in terms of fuel sales and the number of vehicles adapted to this type of fuel.

The increase in the number of vehicles adapted to LPG supply and the domestic consumption of this fuel puts Poland in the strictest lead in the world. The LPG fuel market data in Poland during the last years are presented in Table 2 and Table 3. Table 4 shows the share of LPG fuel vehicles in the total number of passenger cars in 2005÷2015.

**Table 2.** LPG stations in Poland [according to Polish LPG Association] and their growth dynamics in Poland in the years 1998÷2016

Year	Number of LPG stations	Dynamics of growth up to			
		previous year	1998	2000	2005
		%	%	%	%
1998	1500	-	-	-	-
1999	1800	20,0	20,0	-	-
2000	2300	27,8	53,3	-	-
2001	2900	26,1	93,3	26,1	-
2002	3400	17,2	126,7	47,8	-
2003	4500	32,4	200,0	95,6	-
2004	5700	26,7	280,0	147,8	-
2005	6300	10,5	320,0	173,9	-
2006	6800	7,9	353,3	195,6	7,9
2007	6700	- 1,5	346,7	191,3	6,3
2008	6350	- 5,2	323,3	176,1	0,8
2009	6050	- 4,7	303,3	163,0	- 4,0
2010	5900	- 2,5	293,3	156,5	- 6,3
2011	5700	- 3,4	280,0	147,8	- 9,5
2012	5600	- 1,8	273,3	143,5	- 11,1
2013	5520	- 1,4	268,0	140,0	- 12,4
2014	5460	- 1,1	264,0	137,4	- 13,3
2015	5420	- 0,7	261,3	135,7	- 14,0
2016	5390	- 0,5	259,3	134,3	- 14,4

Source: Polish LPG Association [4, 6, 15, 18, 19]

**Table 3.** Sales of LPG autogas [according to the Polish LPG Association] and the dynamics of its sales in Poland in the years 1998÷2016

Year	Sales of LPG fuel 10 <sup>6</sup> kg	Dynamics of growth up to			
		previous year	1998	2000	2005
		%	%	%	%
1998	300	-	-	-	-
1999	395	31,7	31,7	-	-
2000	550	39,2	83,3	-	-
2001	700	27,3	133,3	27,3	-
2002	860	22,9	186,7	56,4	-
2003	1 070	24,4	256,7	94,5	-
2004	1 440	34,6	380,0	161,8	-
2005	1 775	23,3	491,7	222,7	-
2006	1 810	2,0	500,0	229,1	2,0
2007	1 830	1,1	510,0	232,7	3,1
2008	1 770	- 3,3	490,0	221,8	-0,3
2009	1 705	- 3,7	468,3	210,0	-3,9
2010	1 660	- 2,6	453,3	201,8	-6,5
2011	1 610	- 3,0	436,7	192,7	-9,3
2012	1 600	- 0,6	433,3	190,9	-9,9
2013	1 575	- 1,6	425,0	186,4	-11,3
2014	1 645	4,4	448,3	199,1	-7,3
2015	1 690	2,7	463,3	207,3	-4,8
2016	1 790	5,9	496,7	225,5	0,8

Source: Polish LPG Association [4, 5, 11, 12, 18]

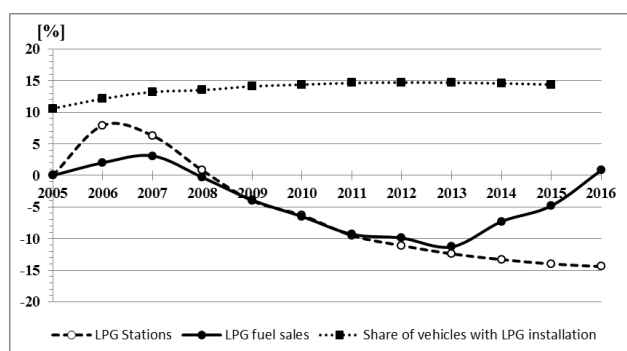
**Table 4.** Passenger cars powered by LPG in Poland [according to the Polish Central Statistical Office] in the years 2005÷2016

Year	Passenger cars powered by LPG	Passenger cars in general	Share
	in thousands	in thousands	in %
2005	1 306	12 339	10,58
2006	1 623	13 384	12,13
2007	1 927	14 589	13,21
2008	2 170	16 080	13,50
2009	2 326	16 495	14,10
2010	2 478	17 244	14,37
2011	2 651	18 125	14,63
2012	2 757	18 744	14,71
2013	2 847	19 389	14,68
2014	2 914	20 004	14,57
2015	2 977	20 723	14,37

Source: Polish Central Statistical Office [3, 21, 22, 23]

According to the Polish Central Statistical Office data (as at the end of 2015), Poland registered about 2 977 thousand Passenger cars adapted to LPG. The share of these vehicles in the total number of passenger cars is 14.37% and increased by about 4% as compared to 2005. This demonstrates the continued interest of vehicle users in this alternative power supply.

The trends of changes in the LPG fuel market and the share of vehicles with LPG installations in the total number of passenger cars in the years 2005÷2016 are presented in Figure 1.



**Fig. 1.** Growth dynamics of LPG sales points, the amount of LPG fuel to be pre-treated, and the share of vehicles with LPG in the total number of passenger cars in 2015÷2016 compared to 2005

The observed increase in the number of LPG vehicles does not translate into a visible increase in sales of LPG fuel during this period (2005÷2016). Compared with 2005, the fuel sales increased by approximately 1% in 2016. And in some years 2005÷2006 was lower than in 2005. This can be explained by the fact of the natural replacement of the vehicle fleet by users. Changing vehicles means that the installation of LPG is done in newer cars with lower fuel consumption. At the beginning of the 21st century, LPG was mainly used for older vehicles, with average fuel consumption of more than 10 dm<sup>3</sup> per 100 km (e.g. FSO Polonez). Manufacturers of new vehicles did not equip their cars with factory-installed LPG systems and often discouraged such installations. Currently, many global corporations are offering new vehicles equipped with factory LPG (e.g. Opel Astra, Škoda Fabia). Reducing the amount of fuel sold with the increase in the overall number of LPG cars fitted is likely to be a major driver of LPG installation in smaller vehicles considered urban ones (e.g. Honda Jazz, Citroen C3, Toyota Yaris) and owning more than one vehicle per household. This results in the reduced demand for fuel by vehicles and a reduction in the distance travelled by individual cars.

#### VARIABILITY OF LPG AND U95 FUEL IN THE PERIOD 2005÷2016

The basis for analyzing the market for LPG fuel and primary fuel (U95 petrol) as mutually alternative fuels for the supply of vehicles with a spark engine were the prices at Lublin petrol stations offering both types of fuel (LPG and U95 gasoline) in the period 2005÷2016. The data presented in Table 5 and in Table 6 reflect the indicative fuel prices of LPG and U95 gasoline occurring at selected stations in the given period.

**Table 5.** Fluctuation of LPG fuel prices in 2005÷2016

Price of LPG fuel in particular months in the period 2006÷2016													
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Aver.
	zł	zł	zł	zł	zł	zł	zł	zł	zł	zł	zł	zł	zł
<b>2005</b>	1,85	1,74	1,60	1,70	1,63	1,70	1,73	1,74	1,90	2,20	2,26	2,21	1,855
<b>2006</b>	2,17	2,12	2,08	1,99	1,94	1,90	1,95	2,02	2,09	2,15	2,15	2,15	2,059
<b>2007</b>	2,02	1,97	1,89	1,88	1,81	1,81	1,98	1,97	2,11	2,19	2,16	2,27	2,005
<b>2008</b>	2,17	2,18	2,16	2,13	2,15	2,13	2,07	2,20	2,20	2,19	2,19	2,14	2,159
<b>2009</b>	1,88	1,75	1,69	1,61	1,63	1,60	1,90	1,89	1,90	1,87	2,02	2,01	1,813
<b>2010</b>	2,03	2,05	2,14	2,14	2,12	2,14	2,11	2,11	2,14	2,22	2,39	2,49	2,173
<b>2011</b>	2,59	2,59	2,49	2,45	2,39	2,42	2,41	2,39	2,36	2,76	2,82	2,83	2,541
<b>2012</b>	2,82	2,84	2,79	2,76	2,77	2,75	2,69	2,69	2,69	2,67	2,63	2,64	2,278
<b>2013</b>	2,66	2,59	2,52	2,41	2,21	2,17	2,15	2,19	2,29	2,33	2,52	2,55	2,383
<b>2014</b>	2,55	2,57	2,51	2,39	2,36	2,29	2,32	2,53	2,59	2,49	2,45	2,42	2,456
<b>2015</b>	2,12	1,84	1,67	1,79	1,89	1,87	1,77	1,84	1,69	1,64	1,91	2,04	1,839
<b>2016</b>	1,82	1,59	1,52	1,46	1,51	1,52	1,56	1,54	1,83	1,88	1,95	2,25	1,703

Source: Own materials

**Table 6.** Fluctuation of U95 gasoline prices in 2005÷2016

Price of U95 gasoline in particular months in the period 2002÷2016													
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Aver.
	zł	zł	zł	zł	zł	zł	zł	zł	zł	zł	zł	zł	zł
<b>2005</b>	3,48	3,53	3,72	4,01	3,84	4,01	4,14	4,17	4,45	4,37	4,36	3,92	4,000
<b>2006</b>	3,59	3,60	3,52	3,59	4,01	4,05	4,19	4,32	4,34	4,19	4,09	3,89	3,948
<b>2007</b>	3,56	3,54	3,72	4,08	4,28	4,31	4,37	4,34	4,33	4,24	4,11	4,39	4,106
<b>2008</b>	4,11	4,12	4,09	4,17	4,18	4,55	4,56	4,49	4,39	4,29	4,13	3,63	4,226
<b>2009</b>	3,26	3,53	3,86	3,69	3,78	4,16	4,59	4,34	4,28	4,12	4,16	4,14	3,993
<b>2010</b>	4,14	4,19	4,24	4,39	4,49	4,63	4,73	4,72	4,69	4,65	4,69	4,79	4,529
<b>2011</b>	4,83	4,78	4,84	4,99	5,13	5,05	5,02	5,16	4,99	5,06	5,28	5,45	5,048
<b>2012</b>	5,42	5,54	5,72	5,84	5,79	5,75	5,49	5,61	5,73	5,79	5,63	5,41	5,463
<b>2013</b>	5,25	5,38	5,59	5,51	5,25	5,26	5,37	5,39	5,55	5,55	5,27	5,39	5,397
<b>2014</b>	5,12	5,12	5,14	5,19	5,24	5,19	5,39	5,27	5,19	5,07	4,95	4,69	5,130
<b>2015</b>	4,27	4,12	4,32	4,52	4,66	4,75	4,84	4,89	4,52	4,17	4,19	4,23	4,457
<b>2016</b>	4,05	3,89	3,77	3,99	4,19	4,37	4,39	4,13	4,22	4,21	4,35	4,39	4,163

Source: Own materials

Figure 2 shows a graph showing changes in the price of LPG and U95 fuel during the period considered (2005÷2016). The values refer to the first month of the period under consideration (January 2005). The graph shows fuel prices in the following months, starting January 2005 and ending December 2016 (144 reference periods). Both U95 gasoline and LPG gas are petroleum fuels. The graph (Figure 2) shows the effect of changes in world oil prices on the price of gasoline and auto-gas, in particular the increase in oil prices after 2009 and the fall in oil prices at the end of 2014.

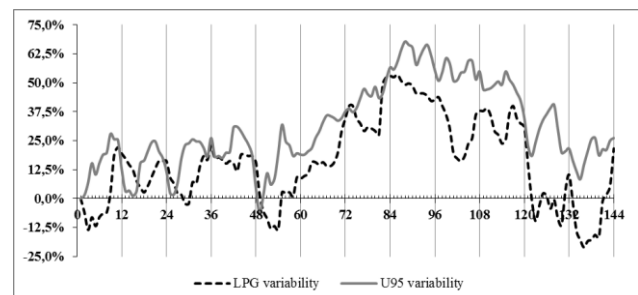
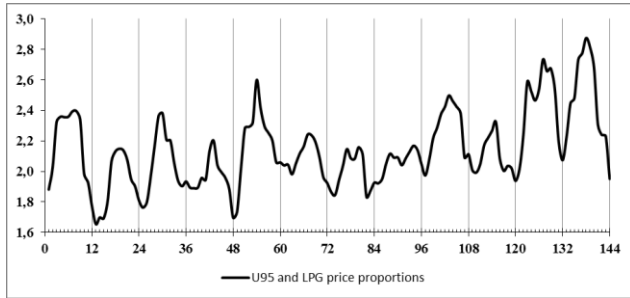
**Fig. 2.** Change in the prices of LPG and U95 fuel in 2005÷2016 relative to January 2005 at monthly intervals

Figure 3 shows the change in the price ratio between U95 gasoline and LPG gas in 2005÷2016. The chart illustrates the evolution of the price dependence between U95 and LPG during the period considered for mid-monthly values.



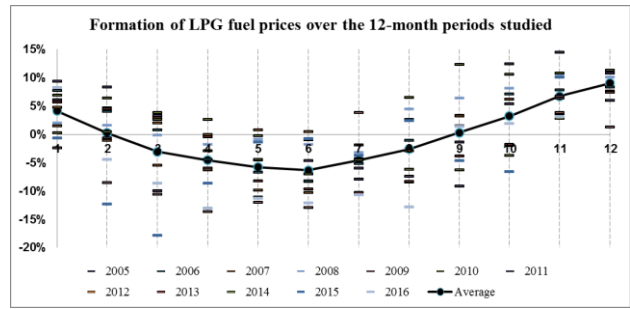
**Fig. 3.** Price ratios between U95 and LPG fuel in the years 2005÷2016 at monthly intervals

The analysis shows that the prices of LPG and gasoline are closely related. In the analyzed period (2005÷2016), the price ratios between LPG and LPG are similar, stable and oscillate around 2.0÷2.2, with a mean value of 2.15. Such price formation of fuels is characterized by a stabilized market with a definite distribution. Both fuels have reached a point of equilibrium and currently they do not compete, but complement the fuel market.

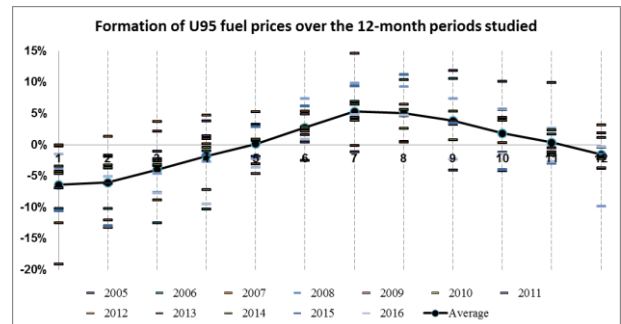
### EVALUATION OF LPG AND UN95 FUEL PRICES IN PARTICULAR IN THE MONTHS OF THE PERIOD 2005÷2016

In the graph of the price ratio of gasoline U95 to LPG gas in the years 2005÷2016 (Figure 3) it can be seen that fluctuations in the price of petrol to the price of LPG are seasonal, in winter the price ratios of U95 to LPG are lower, while in summer periods the ratio of U95 gasoline to LPG gas prices is higher. This may prove to be a seasonal variation in the attractiveness of a particular fuel for the user. In order to determine the observed seasonal dependencies, Figures 4 and 5 show data concerning price formation and their variability in particular months of the analyzed period (2005÷2016). Figure 6 shows the final analysis of the pricing and volatility analysis for the respective months of the year for U95 and LPG fuel during the period considered.

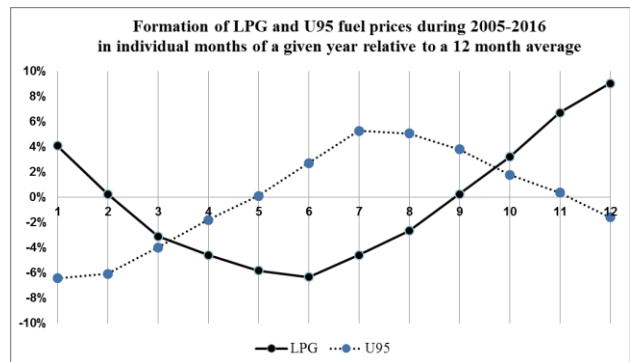
The relative prices for each month of the period considered (January 2005 – December 2016) were determined by referring the price of fuel in a given month to the average 12-month price including, in addition to the price for a particular month, prices from the 6 months preceding and 6 months following a given month of the analysed period.



**Fig. 4.** Graph of LPG fuel prices in particular months of a given year relative to the 12 month average



**Fig. 5.** Chart of U95 fuel prices in particular months of a given year relative to the 12 month average



**Fig. 6.** The formation of LPG and U95 fuel prices in individual months of a given year relative to the 12 month average

Figure 6 shows the final graph of the price and volatility analysis for each month of the year for LPG and U95. The graphs show clearly the seasonality of fuel prices in the year. Petrol has a favorable price relationship in winter, LPG in summer. In the analyzed period 2005÷2016 the annual fluctuations in average prices for individual months are higher for LPG (15.32%) than for gasoline U95 (11.70%). This may suggest that the petrol market is more stable than the LPG market.

## CONCLUSION

Enforcing the legal restrictions on exhaust emissions on vehicle manufacturers causes changes in the key paths in the development of the automotive market. First, manufacturers are constantly developing propulsion units. Second, there is a pursuit of the acquisition and use of new alternative and greener fuels. Third, emphasis is placed on structural changes in vehicles, allowing for reduced fuel consumption. Fourth, tax incentives stimulate the development of the alternative fuel market. Such premises were the basis for the establishment and development of the Polish market of LPG as an alternative fuel.

LPG market is the only developed alternative fuel market in Poland. The analyses presented in this paper suggest that the LPG market is a well-developed, accessible and well-formed market. This is evidenced by a steady price ratio in comparison to LPG alternatives to gasoline, fixed sales during the analyzed period, and a developed distribution network.

LPG as an alternative fuel, and having an opinion of an organic one, is further supported by appropriate legislation to maintain a constant price ratio relative to petrol.

By analyzing the characteristics of the price formation of U95 and LPG fuels in particular months of the period under consideration, one can observe a certain annual cyclicity in the changes in the prices of LPG and U95. Volatility of U95 and LPG fuel prices in individual months of the year does not coincide. This means that there are other seasonal factors influencing their price formation than just correlation with the price of crude oil.

## REFERENCES

1. **PN-EN 589:2009**. Automotive fuels - LPG - Requirements and test methods. PKN Publishing House, Warsaw 2009 (in Polish).
2. Minister of Economy Ordinance on quality requirements for liquefied petroleum gas (Dz.U. 2006 nr 251, poz. 1851), Warsaw 2006 (in Polish).
3. **Adach-Stankiewicz E., Rozkrut D. (editors) 2011**. Road Transport in Poland in the years 2005-2009. Polish Central Statistical Office (GUS) – Statistical Information and Elaborations. Department of Statistical Publishing, Warsaw (in Polish).
4. **Beszterda R., Gonet K., Olechowski A., Stępień R. 2009**. Annual Report 2008. Polish LGP Association (POGP), Warsaw.
5. **Beszterda R., Szozda M., Olechowski A. 2010**. Annual Report 2009. Polish LGP Association (POGP), Warsaw.
6. **Beszterda R., Szozda M., Olechowski A. 2011**. Annual Report 2010. Polish LGP Association (POGP), Warsaw.
7. **Buczaj M. 2006**. Application of alternative driving fuels in Poland under the new EU norms and directives. Motrol - Motorization and Power Industry in Agriculture, Vol. 8/2006, 12÷19, Lublin (in Polish).
8. **Buczaj M. 2006**. Profitability of using LPG fuel as an alternative fuel for vehicle feeding in the years 2002-2005. Motrol - Motorization and Power Industry in Agriculture, Vol. 8A/2006, 64÷73, Lublin (in Polish).
9. **Buczaj M., Pietrzyk W. 2012**. Profitability of use LPG fuel as an alternative fuel to feed car in the years 2002-2011. Motrol - Motorization and Power Industry in Agriculture, Vol. 14, nr 5/2012, 13÷17, Lublin (in Polish).
10. **Buczaj M. 2012**. The trend and variability of LPG petrol's price with U95 petrol in the years 2002-2011. TTS – Railway Transportation Technology Magazine, nr 9/2012, 1605-1702, Radom (in Polish).
11. **Gera K., Olechowski A., Szozda M. 2012**. Annual Report 2011. Polish LGP Association (POGP), Warsaw.
12. **Gera K., Olechowski A., Szozda M. 2013**. Annual Report 2012. Polish LGP Association (POGP), Warsaw.
13. **Górski W. 2010**. The state of the standardization LPG in Poland - The grade A whether B? Oil and Gas Institut - National Research Institute, Nafta-Gaz Magazine nr 2, Krakow.
14. **Januła J. 1994**. Selected aspects of power supply of engines with spark ignition by propane-butane gas. Conference Materials of CONCRETE'94. Krakow – Raba Nizna.
15. **Kwiecińska A., Olechowski A. 2016**. Annual Report 2015. Polish LGP Association (POGP), Warsaw.
16. **Kwiecińska A., Olechowski A., Walczak A. 2015**. Annual Report 2014. Polish LGP Association (POGP), Warsaw.
17. **Majerczyk A., Taubert S. 2003**. Power supply systems of propane-butane gas, WKiŁ Publishing Houses, Warsaw.
18. **Olechowski A., Piaścik M. 2017**. Annual Report 2016. Polish LGP Association (POGP), Warsaw.
19. **Olechowski A., Szozda M. 2014**. Annual Report 2013. Polish LGP Association (POGP), Warsaw.

20. **Olsza M. 2004.** Application of non-compulsory standards, And the LPG market ... grows from year to year, Materials of Energy Market Information Center (CIRE), Wroclaw (in Polish).
21. **Turek D., Rozkrut D. (editors) 2013.** Road Transport in Poland in the years 2010, 2011. Polish Central Statistical Office (GUS) – Statistical Information and Elaborations. Department of Statistical Publishing, Warsaw (in Polish).
22. **Turek D., Rozkrut D. (editors) 2015.** Road Transport in Poland in the years 2012, 2013. Polish Central Statistical Office (GUS) – Statistical Information and Elaborations. Department of Statistical Publishing, Warsaw (in Polish).
23. **Turek D., Wegner M. (editors) 2017.** Road Transport in Poland in the years 2014, 2015. Polish Central Statistical Office (GUS) – Statistical Information and Elaborations. Department of Statistical Publishing, Warsaw (in Polish).
24. **Wcislo G., Labak N. 2017.** Determination of the impact of the type of animal fat used for production of biofuels on the fractional composition of AME. *Econtechmod. An international quarterly journal* – Vol. 6, No.1, 111-117.