

# The Use of Liquefied Petroleum Gas (LPG) in the Republic of North Macedonia as a Sustainable Alternative Fuel: Regulation, Condition and Market Participants

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**Keywords:** LPG; Oil derivatives; Regulatory Commission for Energy and Water Services in Republic of North Macedonia; Legislative; Participants; Retail network

Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-Non-Commercial 4.0 License (https://creativecommons.org/licenses/by-nc/4.0/) which permits non-commercial use, reproduction and distribution of the work without further permission. **Abstract:** First and foremost, the main inspiration for a specific issue in this paper is the use of the Liquefied Petroleum Gas – "LPG" as a sustainable alternative fuel for transport in the Republic of North Macedonia. The questions that arise as a basis are: finding the reason why the progress in usage of alternative fuels is still slow and insufficient in the country and what are the advantages of the "LPG" as most available fuel of this type, including the reduction of harmful CO2 emissions- as the most important benefit. By summarizing in one place all the theoretical and empirical aspects, we are finding the answer by analyzing the legal framework, the condition and the participants in the market of oil and oil derivatives in the country for the analyzed period of three years (2017-2019). The results and conclusions of the research shall be achieved via comprehensive analysis, and by finding the answers to the posed questions through the: theoretical analysis, the inductive and deductive methods, as well as description methods, whereas the techniques utilized shall be questionnaires, interviews, observations.

The goal is achieved through: elaboration of legislation in the Republic of North Macedonia, emphasizing benefits of the LPG as alternative fuel and determination of the obstacles for its usage.

## 1. INTRODUCTION

The name liquefied petroleum gas ('LPG') has been used more recently, as a name for several types of hydrocarbons, such as propane, butane, iso-butane, and a mixture of propane butane in various ratios, unlike natural gas, which is composed of lighter methane. Propane and butane, as their most important representatives, are in a gaseous state at ambient temperature and atmospheric pressure. It is called liquefied because at a relatively low pressure it turns into a liquid and in such a state is transported and stored. The basic raw materials for its extraction are oil and gas fields.

In the English-speaking countries, it is denoted 'LPG' (liquefied petroleum gas), in French and Italian it is denoted by 'GPL' (Gas petrolier liquefiable or Gas di petrolio liquefatti) or just propane-butane, in Russian it is called 'сжиженни углеводородниј газ'.

LPG is a flammable hydrocarbon mixture used as a fuel for industry, households and vehicles (so-called «autogas»), and is also used in cooling technique to replace halogenated hydrocarbons (freons).

LPG has a typical specific calorific value of 46,1 MJ/kg compared to oil where it is 42,5 MJ/ kg as well as gasoline where it is 43,5 MJ/kg, but has an energy density per volume of 26 MJ/L which is lower than that of oil and gasoline because it has a lower relative density (about 0,5-

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0,58 compared to gasoline 0,71-0,77). LPG evaporates at atmospheric pressure and has a higher calorific value (94 MJ/m<sup>3</sup> equivalent to 26,1 kWh/m<sup>3</sup>) than natural gas (38 MJ/m<sup>3</sup> equivalent to 10,6 kWh/m<sup>3</sup>). This means that LPG cannot simply be replaced by natural gas, and in order to use the same burner and obtain the same combustion characteristics, LPG must be mixed with air to obtain synthetic natural gas (SNG).

Autogas fuel has been the most popular alternative fuel for vehicles on the Macedonian market for decades. The main advantage of autogas fuel is the lower price compared to other types of motor fuels, which allows a quick return on the invested assets for the installation of the device.

This is followed by a number of other benefits, from preserving the environment by reducing harmful combustion emissions in the engine, maintaining the cleanliness and technical integrity of the engine, to extending the life of the engine and the vehicle exhaust system. LPG has some disadvantages and difficulties for full market representation in the country, but they are minor in terms of the benefits of its use.

This paper elaborates the regulation, the situation and the participants in the market of oil derivatives for which the officially published data for the period (2017-2019) are analyzed.

The European Green Agreement envisions a 90 per cent reduction in greenhouse gas emissions by 2050, and to that end, the European Union is working to increase the availability of sustainable alternative transport fuels and predicts that by 2025 there will be around thirteen million vehicles with zero or low emissions on European roads. Alternative fuels as defined by the European Commission include electricity, hydrogen, biofuels, synthetic and paraffin fuels, natural gas (including biomethane), methane or compressed natural gas - CNG, liquefied natural gas (LNG) and liquefied petroleum gas (LPG)

### 2. LEGISLATION

The energy infrastructure in the oil sector in the Republic of North Macedonia enables import, export and transport of crude oil and oil derivatives, processing of crude oil, production of biofuel, distribution, transport and sale of oil derivatives.

The market with oil and oil derivatives in the Republic of Northern Macedonia, in addition to being regulated by the Law on Energy (Official Gazette of the Republic of Macedonia No. 96/2018, 96/2019) is also regulated by the following laws: The Law on Trade, the Law on Protection of Competition, the Law on Customs, the Law on Value Added Tax, the Law on Excises and the Law on Market Inspection.

In addition to these laws, the market with oil and oil derivatives is regulated by the Rulebook on quality of liquid fuels, the Rulebook on establishing the highest retail prices of certain oil derivatives and fuels for transport ('Official Gazette of RNM' No. 103/2019 and 212/2019), the technical regulations (storage and transport of oil derivatives, standards and similar), as well as the ratified international agreements: the Stabilization and Association Agreement with the European Union, the Energy Charter Agreement and the Energy Community Treaty.

Also, the relations in this market are influenced by our country's accession to the World Trade Organization.

According to the Law on Energy, activities in the field of crude oil, oil derivatives, biofuels and transport fuels are:

- processing of crude oil and production of oil derivatives;
- production of biofuels;
- production of fuels intended for transport by mixing fossil and biofuels;
- transport of crude oil through pipelines,
- transport of oil derivatives through product pipelines and
- wholesale of crude oil, oil derivatives, biofuels and transport fuels.

The transport of crude oil and oil derivatives through the pipeline takes place in accordance with regulated prices, but their transport through roads, railways and other ways - is at free prices.

The import, transit and *wholesale* trade of oil and oil derivatives as well as their storage is in accordance with free prices.

The refining of oil and the production of oil derivatives takes place by applying the Methodology for determining refinery prices.

*Retail* trade of oil derivatives (petrol stations) also takes place by applying the Methodology for determining the retail prices of oil derivatives and by making a decision by the Energy Regulatory Commission of RNM for the highest retail prices of certain oil derivatives and fuels for transport, and in terms of the provision of Article 149 of the Law on Energy.

The establishment and approval of the highest retail prices of individual oil derivatives by the Energy Regulatory Commission until the adoption of the relevant Rulebook, i.e. by May 23, 2019, was in accordance with the Methodology prescribed by Annex D of the Agreement for purchase and sale of shares and concession of Refinery AD 'OKTA' - Skopje, signed between the Government of the Republic of Macedonia and the joint-stock company 'EL.P.E.T. - Balkanike' as a strategic investor.

In accordance with the provisions of the '*Rulebook on the establishment of the highest retail prices of certain oil derivatives and transport fuels*', adopted in accordance with Article 24 and Article 28 of the Energy Law, the highest retail prices for certain oil derivatives are determined every seven days, for which are determined separately:

- the highest purchase prices (based on the stock exchange prices of oil products published on Platts European Marketscan (https://www.spglobal.com/platts/en/productsservices/oil/ european-marketscan), with parity FOB Med,
- wholesale and retail margin fees including transport costs from warehouse to petrol stations and final consumers,
- the values of specific excises, as well as other fees determined by laws and bylaws.

This approach enables stability and predictability in the formation of retail prices of oil derivatives and transport fuels, as well as transparency in the procedure for determining the retail prices of oil derivatives. The Rulebook reflects the functioning of the market for procurement and sale of oil products in our country and abroad by wholesalers of crude oil, petroleum products, biofuels and transport fuels. The adoption of the new Rulebook on the establishment of the highest retail prices of certain oil derivatives and transport fuels, which introduced a new and exact approach to the establishment of retail prices of certain oil derivatives was a significant event that marked 2019 on the market with crude oil, oil derivatives, biofuels and transport fuels in the Republic of North Macedonia.

With the mentioned Rulebook, for the first time after 20 years from the application of the Methodology for determining the highest prices of certain oil derivatives (defined in Annex D of the Purchase Agreement for shares and concessions for the OKTA refinery), a new Methodology is applied based on the real developments on the market with oil and oil derivatives in North Macedonia.

Furthermore, all the above activities can be performed by domestic and foreign persons on the basis of licenses issued by the Regulatory Commission for Energy and Water Services of the Republic of Northern Macedonia (https://www.erc.org.mk), who submit monthly and annual reports on their work.

The manner and conditions for sale of liquefied petroleum gas and compressed natural gas are regulated by the provision of Article 147 of the Law on Energy.

Pursuant to Article 147 paragraph 1) of the law, the wholesaler of crude oil, oil derivatives and transport fuels may fill and distribute pressure vessels with liquefied petroleum gas, i.e. compressed natural gas for single or multiple use, if it owns or has the right to use fillers for liquefied petroleum gas, i.e. compressed natural gas, which meet the prescribed conditions and standards for construction, maintenance and safe operation.

Paragraph 2) of the same Article 147 of the law stipulates that the company or part of the company of the trader must be displayed on each individual pressure vessel for liquefied petroleum gas and compressed natural gas.

The description of the type of facilities and storage conditions are determined in the provision of Article 148 of the Law on Energy. Pursuant to Article 148 of the Law, a facility for storage of crude oil, oil derivatives, biofuels or fuels for transport is a technical-technological and functional unit intended for storage consisting of tanks and auxiliary plants, which should meet the prescribed conditions for construction, maintenance, fire protection, environmental protection, as well as the conditions for recording the quantities and the required capacity, and the Minister with a rulebook prescribes the conditions for recording the quantities and the required capacity of these facilities.

Furthermore, in terms of the provision of Article 150 paragraph 1) and paragraph 2) of the Energy Law, the Government, at the proposal of the Ministry, adopts - Decree on the quality of liquid fuels which must be adhered to by the participants in the liquid fuel market, and which in particular regulates:

- 1) the type of liquid fuels that can be placed on the market as well as their characteristics,
- 2) the manner of determining the quality of liquid fuels,
- 3) the manner and procedure for monitoring the quality of liquid fuels,
- 4) the rights and obligations of the participants in the market of crude oil, oil derivatives and fuels for transport; and
- 5) the rights and obligations of the market participants and the state bodies in the transitional period necessary for replacement of the reserves of the mixtures of oil derivatives and biofuels for transport.

Paragraph 3) of Article 150 of the law, stipulates that the quality of oil derivatives and fuels for transport is confirmed by a Statement of Conformity wholesalers of derivative or transport fuel, retailers of fuels, as well as consumers who procure oil derivatives, biofuels and fuels for transport from abroad are provided by legal entities accredited in accordance with the standard MKS EN ISO/IEC 17020 based on a report for examination of the quality of the derivative or fuel for transport by laboratories accredited in accordance with the standard MKS EN ISO/IEC 17020.

Paragraph 4) of Article 150 of the law contains an explicit ban on import and trade on the market with crude oil, oil derivatives, biofuels and / or transport fuels if the previously described - Statement of Conformity has not been issued for those products.

## 3. SITUATION AND PARTICIPANTS IN THE MARKET FOR OIL, OIL DERIVATIVES AND TRANSPORT FUELS AND THE LATEST OFFICIAL STATISTICS

## 3.1. LPG Production

The main raw materials for the production of LPG are natural gas and oil. Almost the total world production of LPG, according to the Analysis - 'Gasification systems', part 1 of the Faculty of Mechanical Engineering Skopje, Republic of North Macedonia, is realized through two main sources:

- plants for LPG extraction from natural gas (through methods of absorption, low-temperature separation and adsorption).
- Oil refineries as a by-product (by decomposition of oil into fractions, through distillation): light gasoline, petroleum, heating oil and heavy residues. Additional processing of distillation products, especially heavy gasoline and distillation residues, is performed through the following thermochemical methods: cracking, reforming and hydration. In order to complete the previously started refining process with LPG, it is necessary to list the processes in which LPG is used as a raw material, as follows: Polymerization and Alkylation.

## 3.2. Transport and Retail Network

The transport of LPG from the producer to the industrial and other major consumers is done by using all types of transport, by special means of transport (tankers, wagons, water transport tankers) as well as through special pipelines that directly connect the producers with the LPG consumers.

There are currently about 371 gas stations in the Republic of North Macedonia.

Despite the fact that today the ownership structure in the retail sector has changed significantly, Makpetrol AD Skopje owns the largest number of gas stations, 127, followed by Lukoil Macedonia DOOEL Skopje with 31 gas stations, OKTA Brand with 27 gas stations, while the remaining (about 186) gas stations are privately owned by several domestic small companies. Some of the companies that own gas stations, in addition to their main activity to sell fuels at their gas stations, also appear as wholesalers, i.e. they do not sell some of the purchased liquid fuels through gas stations but directly to the final consumers. 5<sup>th</sup> International Scientific Conference ITEMA 2021 Conference Proceedings

## 3.3. Storage Capacities of Oil And Oil Derivatives

The total capacity of the tanks for oil and oil products in the Republic of North Macedonia is about 382 thousand m<sup>3</sup>. The reservoir capacities in the Republic of North Macedonia are sufficient for 90 days of current average consumption of each type of oil products. OKTA Oil Refinery AD Skopje, Makpetrol AD Skopje, Lukoil Macedonia DOOEL Skopje, State Commodity Reserves of the Republic of North Macedonia, as well as other smaller private and state joint stock companies, have their own reservoir warehouses, and all of them together constitute the reservoir capacities in the Republic of North Macedonia.

The establishment, storage, renewal and use of the mandatory reserves of oil and oil products are regulated in accordance with the Law on Mandatory Reserves of Oil and Petroleum Products and the Directives of the European Union.

According to the technical analysis and according to Bahadori, A., Nwaoha. C., Clark. M.W. (2013), the capacity of the storage tanks depends on the size of the consumers and the distance of the refinery from the station. Depending on the type of liquefied gas (propane, butane or propane-butane mixture), as well as the size of the storage space, the solution of the tank space is usually performed in two variants, as horizontal cylindrical tanks or as ball tanks. The choice of ball tanks for storage of large quantities has usually proved to be the most economically justified because there are large savings in the weight of the material compared to cylindrical tanks. It is clear that in the case of ball (ball tanks), the pressure distribution is most favorable.

## 3.4. Situation and Participants in the Oil and Oil Derivatives Market

### 3.4.1. Participants in the Oil and Oil Derivatives Market

There are several participants in the oil and oil derivatives market, i.e. performers of energy activities and there is a balance between supply and demand, although there are dominant participants in certain market segments.

The OKTA refinery started operating in 1982 and is designed as a hydroskimming refinery with a projected capacity of 2,5 million tons per year, or 5480 bbl/per day and has the capacity to produce: unleaded motor gasoline (95 octane) - Euro V, unleaded motor gasoline (98 octane) - Euro V, diesel fuel with 10 ppm sulfur - Euro V, fuel for jet engines - JET A-1, liquefied petroleum gas (LPG) - propane-butane mixture gas and commercial butane.

In 2019, crude oil was not imported into the country by OKTA Oil Refinery AD Skopje, and for that reason during 2019 on the domestic market there was no processing of crude oil and production of oil derivatives.

The procurement and sale of oil derivatives in the Republic of North Macedonia, during 2019, were *actively* performed by 27 legal entities - licensed for wholesale trade in crude oil, oil derivatives, biofuels and transport fuels, and their share is shown in Figure 1. The Regulatory Commission for Energy and Water Services, in the period from 2004 to December 31, 2019, has issued a total of 60 licenses in the field of crude oil and oil derivatives, of which at the end of 2019 - 37 are active and valid licenses, of which even 33 licenses are for wholesale trade in crude oil, oil derivatives, biofuels and transport fuels.



Figure 1. Total purchase and sale of oil derivatives in the country by traders in 2019 Source: Annual Report for 2019 of the Regulatory Commission for Energy and Water Services of the Republic of North Macedonia https://www.erc.org.mk

## 3.4.2. Import of Oil Derivatives

Total imported quantities of oil derivatives in the Republic of Northern Macedonia in 2019 (for which there was the latest official data during the preparation of this paper) amount to 1.143.276 tons, which is 15.76% more compared to the imported quantities of oil derivatives in 2018 (987,662 tons).

The largest importer in 2019 is OKTA Oil Refinery AD Skopje which participates with 68.85%, followed by Lukoil Macedonia DOOEL – Skopje with 10,06%, Super Trade Skopje with 7,19%, OM Petrol Skopje with 3,04% and other traders with about 10% share in the total import of oil derivatives in 2019.

In 2019, diesel fuel was mostly imported, i.e. 63.82% of the total import, followed by motor gasoline with 12.31%, mazut with 8.21%, propane-butane (LPG) with 6.67%, extra light fuel (EL-1) with 3.95%, jet fuel with 5.04% and a small percentage of biofuel imports.





Source: Annual Report for 2019 of the Regulatory Commission for Energy and Water Services of the Republic of North Macedonia https://www.erc.org.mk

From the chart above it can be seen that the import of oil derivatives in 2019 has increased significantly compared to the previous two years. There is increase in gasoline imports by 24.5% compared to 2018, while imports of diesel fuel in 2019 are increased by 11.9% compared to the previous (2018) year.

Significant increase of as much as 41.8% is registered with the import of mazut in 2019, compared to 2018, while with LPG there is an increase of 4.5%.





Source: Annual Report for 2019 of the Regulatory Commission for Energy and Water Services of the Republic of North Macedonia https://www.erc.org.mk

During 2019, the wholesalers of crude oil, oil derivatives, biofuels and transport fuels, has performed the import of oil derivatives in the Republic of North Macedonia from 13 countries, with most oil derivatives imported from neighboring countries, namely from Greece with 79.75%, then from Bulgaria with 10.82%, Serbia with 2.91%, Bosnia and Herzegovina with 2.60%, Albania with 2.06%, Romania 1.02% and a small percentage of imports from other countries.

## 3.4.3. Export of Oil Derivatives

The export of oil derivatives in 2019 amounted to 194.417 tons, and the same compared to 2018 (140.445 tons) has increased by 38,43%. The largest exporter of oil derivatives in 2019 is OKTA Oil Refinery AD Skopje with 81.90%, Makpetrol AD - Skopje with 13.31%, OM Petrol Skopje with 3.13% and the remaining export of 1.66% was realized by other traders.

## 3.4.4. Sale of Oil Derivatives

The sale of oil derivatives on the domestic market in 2019 amounted to 938,356 tons, which is an increase of 10.17% compared to the sale of oil derivatives in 2018 (851,770 tons).





Thereby, the sale of diesel fuels in 2019 has increased by 12.4% compared to the previous 2018, while the consumption of gasoline has increased by 2.7% compared to the previous year, i.e. the consumption of gasoline is approximately at the same level as 2017.

Significant increase in consumption in 2019 is also recorded in fuel oil, whose sales are 20% higher than sales in 2018, and sales of other oil derivatives are at approximately the same level as in 2018, i.e. 2017. The consumption of oil derivatives on the domestic market in 2019 is dominated by diesel fuels with 68.50%, unleaded gasoline with a share of 11.02%, mazut with 7.70% and liquefied petroleum gas with 7.80%, followed by extra light oil (EL-1) with 4.73%, biofuel with 0.19% and jet fuel with 0.06%.

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The dominant share in the total sales had OKTA Oil Refinery AD Skopje, followed by Makpetrol AD Skopje, Lukoil, Supertrade, Dadi Oil, Crna Reka Petrol, Detoil, Pucko Petrol and the remaining smaller wholesalers of oil derivatives. Wholesale trade is dominated by OKTA with 92.5%, and retail trade is dominated by Makpetrol with 33.28%, followed by Supertrade with 10.77% and Lukoil with 10.69% and these three companies together have over 54.73 % of retail trade.

Type of oil and oil derivative	Status of stock / reserves at the beginning of year	PURCHASE			TOTAL Available	SALE					Status of stock / reserves at the end of year
		In the country		TOTAL Purchase	(2+5)	In the country TOTAL			EXPORT	TOTAL Sale	
		OKTA Refinery Production.	IMPORT	(3+4)		Gas Stations	End Consumers	(7+8)		(9+10)	(6-11)
1	2	3	4	5	6	7	8	9	10	11	12
Crude oil	-	-		-	-	-	-	-	-	-	-
Unleaded petrol	4.060	-	140.747	140.747	144.807	99.916	3.486	103.402	36.491	139.893	4.914
Diesel Fuels	14.106	-	729.598	729.598	743.704	453.661	189.082	642.742	81.126	723.868	19.836
Extra Light 1 (EL - 1)	2.379	-	45.115	45.115	47.494	7.748	36.682	44.431	-	44.431	3.063
Mazut (Fuel oil) M1-HS	1.756	-	93.887	93.887	95.643	-	72.240	72.240	20.146	92.386	3.257
Propane – Butane (TNG)	2.698	-	76.234	76.234	78.932	57.837	15.364	73.201	3.242	76.443	2.489
Jet fuel	2.161	-	57.617	57.617	59.778	-	896	896	56.413	57.309	2.469
Biodiesel	2.106	-	-	-	2.106	1.497	122	1.619	-	1.619	487
FAME	145	-	78	78	223	99	-	99	-	99	124

Figure 6. Overview of crude oil supply, supply and sale of oil derivatives in 2019, in tons Source: Annual Report for 2019 of the Regulatory Commission for Energy and Water Services of the Republic of North Macedonia https://www.erc.org.mk

## 4. CONCLUSION

Of all the alternative fuels currently available on the market, liquefied petroleum gas - LPG is the best and most reasonable short-term solution for converting the existing fleet of light vehicles, it is available in our market and is expected to be widely used until electric vehicles become more accessible to our citizens, as stated in the Strategy for Energy Development of the Republic of North Macedonia until 2040. In our country, a satisfactory network of gas stations and services for installation and maintenance of LPG vehicles has already been established. But, there are still many reasons for insufficient use of liquefied petroleum gas (LPG) both in our country and in other countries. Those reasons according to the Analysis - 'Gasification Systems', part 1 of the Faculty of Mechanical Engineering Skopje, RN Macedonia, come down to the following:

- insufficient knowledge of LPG, its advantages and disadvantages,
- relatively low production of LPG in refineries,
- lack of domestic manufacturers of special equipment for LPG,
- lack of accurate calculations for the price of energy consumed, either in households or in industry,
- fear of accidents, related to technical primitivism, etc.

In the developed world there is no hesitation in the use of LPG, and the main consumers are:

- households,
- commercial heating (via central heating system),
- cooling technique,
- food industry (ovens, dryers),
- glass and ceramics industry,
- textile industry,
- as fuel in SVS engines of various vehicles,
- agricultural forms (drying, heating, burning),
- synthetic materials industry,
- for city gas production.

Hence it is concluded that wherever heat, air conditioning, power and cooling are required, the use of LPG is possible. Lately, LPG has become more widely used in petrochemistry where it is used to produce synthetic resins and synthetic fibers.

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Strategy for Energy Development of the Republic of North Macedonia until 2040