Oil Production by Polish Companies in Poland and Abroad

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Abstract

The article discusses a very important problem of oil production. Oil, recognized as a major source of economic development, is the main energy source of the modern world. Unfortunately, Poland has limited oil reserves. However, the production, which meets only about 4% of the demand, is carried out. Oil deposits in Poland are found in the Carpathians, in the Carpathian Foredeep, in the Polish Lowlands, and in the Polish Exclusive Economic Zone of the Baltic Sea. Initially, deposits in the Carpathians were of the greatest economic importance, but these are already depleted to a great extent. Currently, oil deposits in the Polish Lowlands are of the greatest economic importance. The largest deposit is BMB (Barnówko-Mostno-Buszewo) near Gorzów Wielkopolski. In total, in Poland oil resources amount to 23 598.46 thousand tons, of which 61.37% accounts for industrial resources (14 482.15 thousand tons). The article presents crude oil resources in Poland by regions, i.e. Polish Lowlands, the Carpathians, the Carpathian Foredeep, and the Polish Exclusive Economic Zone The resources were divided into anticipated economic, industrial, undeveloped resources and abandoned deposits. In addition, the three Polish companies involved in the extraction of oil, namely PGNiG S.A., the LOTOS Group S.A. and ORLEN Upstream sp. z o.o., were presented. The locations where exploitation is carried out and the volume of oil production in the last few years were discussed.

Keywords: *crude oil, resources, production*

Introduction

Crude oil, as the basic energy source, has become the subject of interest among global economic powers and the source of income for oil states over the last decades. The exploration, extraction, and processing industries are still growing dynamically despite the fact that numerous commercial banks have decided to cut their investments in fossil fuels. However, the abundance of resources is not always beneficial. The economically and militarily stronger countries put pressure on countries dependent on raw materials, forcing them to sell oil at the lowest possible prices. This often causes conflicts and leads to wars, while the raw material, instead of lifting the country out of crisis, becomes its curse. There are many examples, such as continuous armed conflicts in the Persian Gulf, Africa, or Central America. For this reason, it is extremely important to have own energy resources to avoid dependence on imports, which is always associated with supply interruption and price increase risks.

It is worth adding that at the beginning of the 20th century the province of Galicia in the eastern part of the Austro- Hungarian Empire (now Poland) was the center of the European petroleum industry.

On July 31, 1853, the first kerosene lamp designed by Ignacy Łukasiewicz was used in a hospital in Lviv; a year later, the oil mine in Bóbrka near Krosno was opened. By 1909, approximately 1.9 million tons of crude oil were produced in Borysław and the Galicia was an important region in the world in terms of oil production (Boiko O., Szurlej A. 2018). In 1909, the production in the Galicia amounted to 2.75 million tons. Currently, Poland has limited oil reserves, the reserves-to-production ratio (RPR or R/P) is 23 (BP 2018), which is why most of the crude oil (around 96%) must be imported from abroad. This is not a comfortable situation. Therefore, if large imports cannot be avoided, they must be diversified so as not to rely on raw material from only one supplier. Until recently, Poland imported crude oil only from the east; for example in 2014 the share of crude oil from Russia in supplies to domestic refineries amounted to 91%. In recent years, Poland started to reduce the dependence on supplies from Russia and imported oil from Iraq, Azerbaijan, Kazakhstan, Venezuela, Angola, the United States, the United Arab Emirates, and Nigeria. In 2018, the share of Russian oil decreased to 76% and should further decrease in 2019 in favor of, inter alia, supplies from Saudi Arabia (POPiHN (Polish Organization of Oil Industry and Trade) 2019)). Oil production is also carried out by Polish companies outside the country, mainly in Norway, but also in Lithuania and Canada.

Oil reserves in Poland

According to the data contained in the balance of mineral resources deposits in Poland as of December 31, 2017 (Bilans 2018), 86 oil fields were documented in Poland, including 29 deposits in the Carpathians, 12 in the Carpathian Foredeep, 43 in the Polish Lowlands, and 2 deposits in the Polish Exclusive Economic Zone. The oil deposits in the Carpathians, the oldest deposits in Poland, are now becoming depleted. The Carpathian crude oil deposits are mainly oil-gas deposits. The

Tab. 1. Oil resources in Poland by region, thousand tons. Source: Own work based on the balance of mineral resources deposits in Poland as of 31.12.2017
Tab. 1. Zasoby ropy naftowej w Polsce z podziałem na regiony, tys. ton

Region	Anticipated economic resources	Industrial resources
Polish Lowlands	15 360.17	8 130.53
The Carpathians	679.05	143.93
The Carpathian Foredeep	355.84	60.83
The Polish Exclusive Economic Zone	6 765.55	6 728.33
TOTAL	23 160.61	14 365.27

Tab. 2. Undeveloped resources, thousand tons. Source: Own work based on the balance of mineral resources deposits in Poland as of 31.12.2017
Tab. 2. Zasoby złóż niezagospodarowanych, tys. ton

Region	Anticipated economic resources	Industrial resources
Polish Lowlands	266.10	116.50
The Carpathian Foredeep	115.93	-
TOTAL	382.03	116.50

Tab. 3. Abandoned oil fields, thousand tons. Source: Own work based on the balance of mineral resources deposits in Poland as of 31.12.2017
Tab. 3. Zasoby złóż ropy naftowej, w których zaniechano eksploatacji, tys. ton

Region	Anticipated economic resources	Industrial resources
Polish Lowlands	49.74	0.38
The Carpathians	1.50	-
The Carpathian Foredeep	4.58	-
TOTAL	55.82	0.38

Tab. 4. Oil and natural gas mines in the PGNiG branches in Sanok and Zielona Góra. Source: Own work based on of the PGNiG report for the year 2017; 2018
Tab. 4. Kopalnie ropy naftowej i gazu ziemnego w oddziałach PGNiG w Sanoku i Zielonej Górze

The number of mines	Sanok	Zielona Góra
Oil mines	5	1
Oil and gas mines	13	7
Natural gas mines	18	10
TOTAL	36	18

Tab. 5. Oil production in Poland by the PGNiG (fractions, thousand tons). Source: Own work based on of the PGNiG report for the year 2017; 2018
Tab. 5. Wydobycie ropy naftowej w Polsce wraz z frakcjami przez PGNiG, tys. ton

Production site	Years				
	2013	2014	2015	2016	2017
The branch in Zielona Góra	766	742	719	719	747
The branch in Sanok	49	47	46	44	40
Total number in Poland	815	789	765	763	787
In Norway	283	418	664	555	470
TOTAL	1098	1207	1429	1318	1257

crude oil density ranges from 0.750 to 0.943 g/cm^3 while the paraffin content is in the range from 3.5 to 7.0%. These are sulfur-free deposits. The Carpathian oil deposits are limited, depending on the size and nature of the structures in which they occur. As a result of many years of exploitation, a significant depletion of resources in this area can be observed. The oils found in the Carpathian Foredeep are classified as light and medium oils (with a density in the range of 0.811–0.846 g/cm^3). The paraffin and sulfur contents range from 2.32 to 9.37% and from 0.45 to 0.85%, respectively.

Currently, oil fields in the Polish Lowlands are of the greatest economic importance. The paraffin and sulfur contents of these oils are between 4.3–7.4% and slightly above 1%, respectively. Their density is in the range 0.857–0.870 g/cm^3. These deposits occur in the Permian, Carboniferous, and Cambrian formations. The largest deposit is BMB (Barnówko-Mostno-Buszewo) near Gorzów Wielkopolski. The resources of this deposit were more than twice that of Poland. In total, in Poland oil resources amount to 23 598.46 thousand tons, of which 61.37% accounts for industrial resources (14 482.15 thousand tons). Table 1 presents oil resources in Poland in currently exploited deposits broken down into regions; tables 2 and 3 present the resources of undeveloped and abandoned deposits, respectively. Industrial resources that can be subject to economically viable and technically possible exploitation have been separated from anticipated economic resources. Crude oil resources also include oil condensate, whose share in total resources is 5.76%.

Crude oil production

In Poland, the production of hydrocarbons is carried out by the three companies. They include: PGNiG S. A., The LOTOS Group S. A., and Orlen Upstream sp. z o.o. However, it must be clearly emphasized that domestic extraction is not

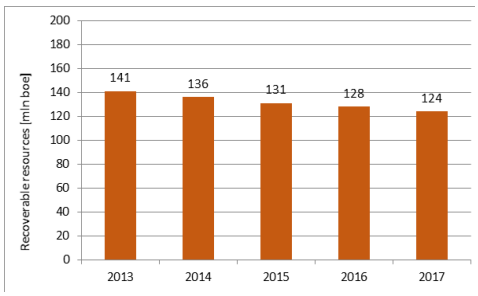

Fig. 1. The total exploitable resources (PGNiG data). Source: Own work based on the PGNiG report for the year 2017; 2018
Rys. 1. Zasoby wydobywalne ropy naftowej udokumentowane przez PGNiG

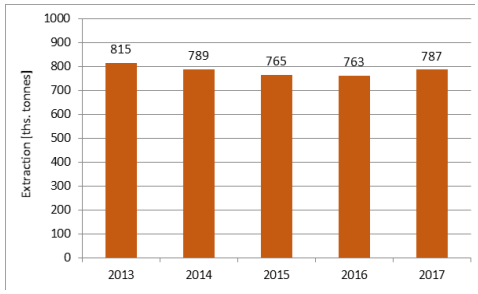

Fig. 2. The production of oil, condensate, and NLG by the PGNiG Group in Poland. Source: Own work based on the PGNiG report for the years 2017; 2018
Rys. 2. Wydobycie ropy naftowej, kondensatu i NLG w Grupie PGNiG w Polsce

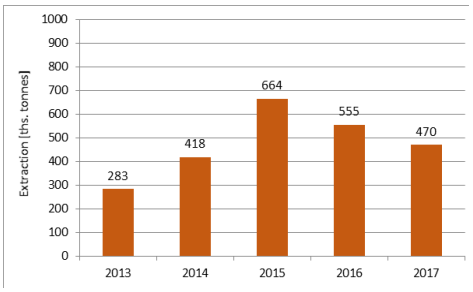

Fig. 3. The production of oil, condensate, and NLG by the PGNiG Group in Norway. Source: Own work based on of the PGNiG report for the year 2017; 2018
Rys. 3. Wydobycie ropy naftowej, kondensatu i NLG w Grupie PGNiG w Norwegii

able to meet domestic needs and the vast majority of crude oil must be imported from abroad.

PGNiG S. A.

PGNiG is one of the largest companies specializing in oil production in the country, in 2017 its production amounted to almost 800 thousand tons, which gives about 80% share in the domestic extraction. The company has even larger share, about 90%, in the production of natural gas. At the end of December 2017, PGNiG held 58 licenses for exploration and production of crude oil and natural gas (The PGNiG report for the year 2017; 2018). Table 4 shows the number of oil and gas mines owned by the PGNiG, while Table 5 shows the extraction of crude oil (including fractions) in Poland by this company.

PGNiG UN holds exploration and production licenses on the Norwegian Continental Shelf located in the Norwegian, North, and Barents Seas. The cooperation with partners in Norway involves the extraction of hydrocarbons from the Skarv, Morvin, Vilje, Vale, and Gina Krog fields, and the development of Ærfugl (formerly Snadd) and Skogul (former Storklakken) fields. The remaining licenses are exploration licenses. The most important is the Skarv field. In 2017, PGNiG UN extracted 470 thousand tons of crude oil (all fractions, per ton of oil equivalent) and 548 million m^3 of natural gas from the Skarv, Morvin, Vilje, Vale, and Gina Krog deposits. In 2017, an increase from 78 million boe to 83 million boe in the documented resources in Norway has been reported by the PGNiG UN (The PGNiG report for the year 2017; 2018).

Crude oil extracted in Norway is sold directly from deposits to Shell International Trading and Shipping Company Ltd (from Skarv, Vilje, Vale, and Gina Krog fields) and TOTSA Total Oil Trading SA (from the Morvin field). In the case of all fields, with the exception of Vilje, natural gas is also extracted along with oil; it is sent via gas pipeline to Germany, where it received by the PST. The main sales markets are Norway, Germany, and the United Kingdom.

PGNiG also conducts exploratory activities in Pakistan under a license for the exploration and exploitation of hydrocarbons in the Kirthar area, awarded on 18 May 2005 by the Pakistani government. Exploration activities in the Kirthar block are carried out jointly with Pakistan Petroleum Ltd. (PPL), according to the division of shares and costs (PGNiG (operator) – 70%, PPL – 30%). Two natural gas deposits, Reh-

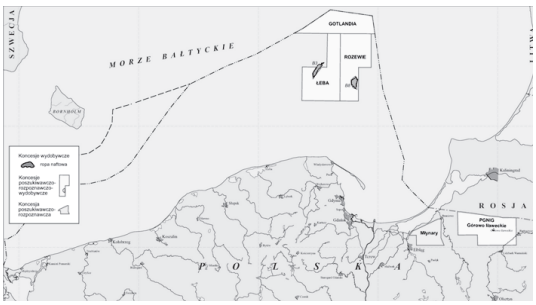

Fig. 4. The areas covered by exploration and production licenses in the sea and land areas of Poland. Source: http://www.lotos.pl/repository/49397/pl/
Rys. 4. Obszary objęte koncesjami poszukiwawczymi i wydobywczymi na obszarach morskich RP oraz na lądzie

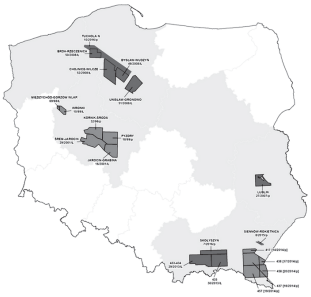

Fig. 5. The area of prospecting and exploration activities in Poland. Source: Projekty 2019
Rys. 5. Obszar działalności poszukiwawczo-wydobywczej w Polsce

man and Rizq, have been discovered in the course of previous exploration activities within the concession.

In addition, the PGNiG also conducted exploratory activities in Libya and Iran, but, due to the unstable political situation in these countries, these works were limited.

The PGNiG S.A. conducts intensive research work on the documentation of hydrocarbon resources. In the case of crude oil, the volume of documented exploitable resources (reserves) is gradually decreasing each year. And so, in 2013 they amounted to 141 million boe, and in 2017 only 124 million boe (Fig. 1).

When it comes to oil production, it is highly variable over the last five years. While the production in Poland is relatively stable, ranging from 763 thousand tons in 2016 to 815 thousand tons in 2013 (Fig. 2), the production of Norwegian deposits is highly variable. In 2013, it amounted to PLN 282 thousand tons and in just two years has increased to 664 thousand tons. In the next two years, however, it decreased to 555 thousand tons in 2016 and 470 thousand tons in 2017 (Fig. 3). Nevertheless, the Norwegian oil fields constitute an important element in the production of oil by PGNiG.

Taking into account the above data, it should be stated that the PGNiG S.A. is the most important Polish company involved in the exploration and extraction of both crude oil and natural gas.

The LOTOS Group S. A.

The LOTOS S.A. Group is another Polish entity involved in hydrocarbon extraction. The LOTOS Group consists of 17 companies and capital groups operating not only in Poland, but also in Norway and Lithuania. The group is focused on the exploration, extraction, production, trade, and services. It is the owner or co-owner of 33 sea licenses and 10 land concessions. It extracts oil in the Polish Exclusive Economic Zone, on the Norwegian Continental Shelf, in Poland, and Lithuania. In 2017, the total potential of the LOTOS 2P reserves amounted to 88.4 million barrels, while the output reached the level of 8.1 million barrels (Jednostkowy… 2018). To clarify, it is worth mentioning that, according to the international classification of resources (H-C) PRMS, 2P are probable reserves, i.e. determined on the basis of indirect, e.g. geophysical, analysis. They determine the size of the hydrocarbon trap but do not indicate the amount of resources.

In 2017, the LOTOS Upstream was established, which in December 2017 acquired its foreign assets from LOTOS Petrobaltic, i.e. LOTOS Norge and Geonafta. The aim of LOTOS Upstream was to manage international exploration and production activities. LOTOS Petrobaltic S.A. holds licenses for extracting crude oil and accompanying natural gas from the B3 field as well as a concession for oil extraction and co-occurring natural gas from the B8 field (B8 Sp. z o.o. BALTIC SKA). The company also holds 3 licenses for prospecting and exploration of crude oil and natural gas deposits and gas production from fields in the sea areas of Poland with a total area of 3177 km2 (LOTOS Petrobaltic Koncesje 2018).

Fig. 4. presents the areas covered by exploration and production licenses.

The newest land license is the prospecting and exploration license for oil and gas deposits in the Młynary area in the Warmian-Masurian Voivodeship. This was the first land license acquired by LOTOS Petrobaltic in September 2016.

LOTOS Exploration & Production Norge (LOTOS Norge 2018) is involved in hydrocarbon exploration and production on the Norwegian Continental Shelf. It belongs to the LOTOS Upstream Capital Group, in which it is responsible for implementing the strategy of the LOTOS extraction segment in the North Sea and the Norwegian Sea. At the end of 2017, LOTOS Norge held 26 licenses for prospecting, exploration

Tab. 6. Oil production by the LOTOS S.A. Group in Norway, Poland, and Lithuania, million boe. Source: Own work based on LOTOS S. A. 2019
Tab. 6. Wydobycie ropy naftowej przez Grupę LOTOS S.A. w Norwegii, w Polsce i na Litwie, mln boe

Production site	Year	
	2017	2018
Norway	6.2	5.5
Poland	1.8	1.6
Lithuania	0.4	0.3

Fig. 6. The main areas of activity of ORLEN Upstream in Canada. Source: Projekty 2019
Rys. 6. Główne obszary działalności ORLEN Upstrim w Kanadzie

and production of hydrocarbon deposits on the Norwegian Continental Shelf. Later on, the Norwegian authorities offered two new licenses, so their total number increased to 28. The output of LOTOS from Norwegian deposits in 2017 was at an average level of 17.0 thousand boe/day, which is 74% of the total volume of the segment. As at the end of 2017, the 2P reserves of Baltic deposits amounted to 39.3 million boe (including: 2.9 million tons of oil and 2.7 billion m33 of natural gas), which accounts for 45% of the total reserves (LOTOS Norge 2018). Key assets under the concessions held include: The Heimdal area, purchased in December 2013, including Atla (LEPN share: 20%), Skirne (30% share), Vale (share 25.8%), Heimdal (5% share) and the remaining fields in north from Heimdal: FriggGammaDelta, Langfjellet, Rind, Fulla, and Froy with an average share of the LOTOS Group at 10%. In 2017, in cooperation with the operator (AkerBP), LOTOS conducted an analysis of the optimal variant of development of deposits under the so-called Greater Heimdal project. The resource potential of the abovementioned deposits is about 34 million boe (LOTOS share).

The second is the Sleipner area purchased in December 2015 including the Sleipner Vest and Sleipner East fields, with the Gungne and Loke satellite fields. The exploitable resources of the Sleipner fields in the 2P category amount to 15,5 million boe as of 31.12.2017. The second deposit is the Utgard field, which is in the development phase, operated by Statoil. The exploitable resources of the Utgard deposit are 8.1 million boe (LOTOS share). The commercial production in the field is planned for the beginning of 2020. In the first five years of operation, an annual production volume of 4.000 boe/day is expected (the LOTOS share). In addition, LOTOS holds a 20% interest in the Yme field, which is being prepared for reuse and launch of oil production. The exploitable resources of the Yme field are 12.9 million bbl of crude oil (the LOTOS share). The commercial production in the field is scheduled for the first half of 2020 (LOTOS Norge 2018).

In addition, the LOTOS Group S.A. extracts oil in Lithuania. The AB LOTOS Geonafta, a company in the LOTOS Group and a daughter company to LOTOS Upstream, has carried out activities in Lithuania since 2000. As of today, crude oil is produced in land-based deposits, the potential of which has been greatly reduced over the years. It is necessary to conduct extraction at sea, which at the same time will increase Lithuania's energy security. Table 6 presents oil production by the LOTOS Group S.A. in Norway, Poland, and Lithuania in the last two years.

LOTOS strives to increase its activity in this country. The attention is focused on the possibility of exploration and extraction of oil from deposits located in Lithuanian territorial waters.

Orlen Upstream sp. z o.o.

The Orlen Upstream sp. z o.o. operates both in Poland and Canada. In total, in Poland and Canada, it has 153 million boe of reserves (Raport Zintegrowany2017). In Poland, the ORLEN Group is focused on exploration and production activities in the Greater Poland, Pomeranian, Podkarpackie, and Lesser Poland voivodships, the Lublin region, and Mazovia. At the end of 2017, the company's 2P reserves in Poland amounted to 11 million boe, while the production in the second quarter of 2018 reached 900 boe per day. The upstream segment holds 13 licenses for prospecting, exploration and production of hydrocarbon deposits in Poland; the next 13 licenses are held jointly with business partners. Formally, 8 concessions were granted by the Ministry of the Environment to ORLEN Upstream, while the next 5 were granted to FX Energy Poland, acquired by the ORLEN Group and integrated into the company's structures in 2015 (Projekty 2019).

The Orlen Upstream sp. z o.o. also cooperates with PGNiG S.A on the Sieraków, Płotki, Bieszczady, and Warszawa Południe projects. The areas of activity of the Orlen Group in Poland are shown in Fig. 5.

In North America, the Orlen Group has been operating since 2013. At the end of 2017, 2P reserves in Canada amounted to 141 million boe, while the average production in the second quarter of 2018 remained at 17 100 boe /d. The key Canadian assets of the group are located within the province of Alberta, in the following regions: Kakwa (Montney formation), Ferrier Strachan (Cardium formation), Lochend (Cardium formation), Pouce Coupe (Montney formation), and Kaybob (Dunvegan formation). The most important assets of Orlen Upstream in Canada (Projekty 2019) are described below:

Ferrier Strachan – one of the two main areas of activity of ORLEN Upstream Canada, very perspective for the development of coastal sandstones of the Cretaceous Cardium formation.

An interesting fact is a high variability of the extracted mineral – ranging from gas with a small amount of oil to crude oil with a relatively small amount of gas.

Kakwa – is one of the most promising regions in the Alberta region. The activities are carried out in the Lower Triassic Montney Formation. The main storage medium in the Kakwa region is gas with a high content of condensate.

Kaybob – the main reason for drillings in this region are the sandy delta deposits that were deposited during the Cretaceous period, forming part of the Dunvegan formation. They are distinguished by very good reservoir parameters and a high share of oil in the volume of extraction.

Lochend – An area just a few kilometers from the suburbs of Calgary is the foundation on which the ORLEN Upstream Canada project portfolio was built. In the area of several dozen square kilometers, the Upper Cretaceous Cardium Formation is perspective in at least two reservoir levels, from which light oil and gas are extracted.

Pouce Coupe – is one of the first three areas of activity of the ORLEN Upstream Canada. The extraction is carried out from mudstones of the Montney Triassic Formation. The main storage medium in the Pouce Coupe region is gas with a low liquid hydrocarbon content.

Stoney Creek – Stoney Creek in New Brunswick is one of the oldest discovered oil fields in this part of Canada. It was documented in 1909 within the assemblage of sandstones of the Dawson Settlement Member of the Carboniferous Albert Formation.

Goldboro LNG – ORLEN Upstream Canada has a 7.4% percent stake in the Pieridae Energy, which is responsible for the construction of the LNG terminal on the east coast of Canada. Preparatory works are underway on the basis of which an investment decision on the further direction of the project will be made.

Fig. 6 shows the main areas of ORLEN Upstream activity in Canada.

Conclusions

According to the Energy Policy of Poland until 2040 (PEP2040) (Projekt 2018), the demand for fuels in Poland will increase in the coming years, although this will be moderate due to the change in the structure of energy demand in the economy. When determining the future demand for oil in the transport sector, the use of alternative fuels, electricity, and biocomponents in transport must be taken into account. The draft states that the refining companies should focus on the production and trade of fuels, while the state is to take full control over the key assets of the energy security in the fields of pipeline transport and storage of oil and fuels. To maintain their position in the international market, the two largest entities in the fuel sector, i.e. ORLEN S.A. and LOTOS S.A. will be merged. Oil and gas exploratory projects will also be carried out, but the production will not be increased.

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Pozyskiwanie ropy naftowej przez polskie firmy wydobywcze na terenie kraju i poza jego granicami

W artykule poruszono bardzo ważny problem jakim jest pozyskiwanie ropy naftowej. Ropa jest podstawowym surowcem energetycznym w świecie i źródłem tak spektakularnego rozwoju gospodarczego jaki obserwujemy od czasu jest odkrycia. Polska jest niestety krajem ubogim w zasoby tego surowca, niemniej jednak prowadzone jest wydobycie, które zaspokaja zaledwie około 4% potrzeb. Zasoby ropy naftowej w Polsce znajdują się w Karpatach, w zapadlisku przedkarpackim, na Niżu Polskim oraz w polskiej strefie ekonomicznej Bałtyku. Początkowo największe znaczenie gospodarcze miały złoża w Karpatach, ale uległy one już w znacznym stopniu wyczerpaniu. Obecnie największe znaczenie mają złoża ropy występujące na Niżu Polskim. Największym złożem jest BMB (skrót od nazw miejscowości Barnówko-Mostno-Buszewo) koło Gorzowa Wielkopolskiego. Ogółem w Polsce zasoby ropy naftowej wynoszą 23 598,46 tys. ton, w tym zasoby przemysłowe 14 482,15 tys. ton, co stanowi 61,37% zasobów ogółem. W artykule przedstawiono zasoby ropy naftowej w Polsce z podziałem na regiony, tzn. Niż Polski, Karpaty, Zapadlisko przedkarpackie, oraz polską strefę ekonomiczną Bałtyku.

Zasoby podzielono na zasoby bilansowe, przemysłowe, niezagospodarowane oraz złoża, w których zaniechano eksploatacji. Przedstawiono również trzy polskie firmy, które zajmują się wydobyciem tego surowca, czyli PGNiG S.A., Grupę LOTOS S.A. oraz ORLEN Upstream sp. z o.o. Pokazano miejsca, w których prowadzona jest eksploatacja oraz jej wielkość w kilku ostatnich latach.

Słowa kluczowe: *ropa naftowa, zasoby, wydobycie*