The gas sector of Ukraine:past and future

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Oksana Voytyuk
University of Bialystok
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Oksana Voytyuk

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Introduction

Ukraine is one of the largest countries in Europe not only in terms of territory, but also in terms of the energy resources it has. The Ukrainian gas sector has a long history. Ukraine ranks third in Europe in terms of gas potential. Regardless of such great potential, Ukraine still imports gas. There are three gas-bearing regions in Ukraine – Carpathian, Dnipro-Donetsk and Black sea region. Gas production began at the beginning of the 20th century. After the Second World War, Ukraine was the main exporter of gas from the USSR to Eastern Europe. Today, private companies provide the majority of gas production in Ukraine. This article examines the history of the development of the Ukrainian gas sector and its future. The main goal of the article is to show the dynamics of the development of the gas sector in Ukraine, analyze its gas potential and highlight the problems that the industry is facing at present, and indicate possible ways to solve them. The purpose of the article is to answer the following questions: can Ukraine be self-sufficient in the terms of gas supplies?, is there any chance for gas supplies from regions other than Russia?, can the expansion and modernization of Ukraine's gas infrastructure favor the construction of the Eastern European gas hub on the territory of Ukraine in the future? In preparing the article, the following methods were used: the historical method was used to describe the history of the development of the gas sector of Ukraine; comparative method was helpful in compiling and analyzing statistical data; moreover, in the article were used the method of analysis and synthesis.

History of the gas industry and the development of gas infrastructure in Ukraine

The Ukrainian history of natural gas extraction goes back to the beginning of the 20th century. At that time, Eastern Galicia, where the first gas deposits were discovered, was part of the Austro-Hungarian Empire. The first gas resources were discovered accidentally, while drilling wells for water, salt or oil. For the

first time, gas-bearing horizons were discovered around the city of Kalush during the process of drilling salt shafts in 1912. However, the discovered gas resources were small and did not have great industrial significance. In the years 1912–1913, natural gas began to appear while drilling the oil wells in the Boryslav oil field. At the same time, a gas field was discovered in the vicinity of Dashava.

At the beginning of the 20th century, there was no targeted search for gas deposits. The natural gas released during the extraction of oil was considered a non desirable phenomenon, as it hindered drilling, caused fires, and disturbed drilling of deeper wells[1]. It is believed that during the first 20 years of the 20th century, about 6 billion cubic meters (m^3) of natural gas were burned or vented[2]. The First World War stopped the process of searching for natural gas and oil deposits. The first industrial exploration of the raw materials began in the Carpathian Mountains only in the 1920s. The region found itself in a new political reality – under the rule of the newly created state – the Republic of Poland. In 1924, the industrial development of the Dashava gas field began.

The development of the gas sector in the region, now known as Western Ukraine, was slowed back then, as there was no industry in this region that could use natural gas. In addition, development of the deposits in the region, which at that time was called „Lesser Poland", was not in the interest of the Polish government. This region was considered as a raw-material appendage of Poland. In addition, the economic crisis of 1929–1933 stopped the development of the gas industry. In 1939, after joining western territories to the USSR, the gas industry of the Carpathian region was nationalized. In 1940, the Oparske gas field began to be developed, and gas production doubled from 198 million m^3 to 391 million m^3 compared to 1938[3]. The gas extraction stopped during World War II. Until 1950, the gas industry developed only in Transcarpathia.

In 1948, the largest gas deposit was discovered in the Carpathian region – Bilche-Volytske. As of 1950, four natural gas deposits were exploited in Ukraine in the Lviv region (Dashavske, Oparske, Kosivske, Ugerske). Gas from these deposits was supplied to gas pipelines. Two deposits were also exploited in the Ivano-Frankivsk region, however gas was used for the region's own needs. The oil production increased to 1,54 billion m^3 of gas annually. The production from the Carpathian fields increased at an enormous pace. In 1955, about 48% of the total gas production in the USSR was produced in western Ukraine. On 1 I 1962,

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1 В. Щербина, *Розвиток газової промисловості України у 1940-х–1980-х роках*, http://dspace.nbuv.gov.ua/bitstream/handle/123456789/32914/05-Scherbuna.pdf?sequence=1 (29 III 2020).

2 М. Білявський, *Історія одного відкриття. Газовій промисловості України – 90 років*, https://www.istpravda.com.ua/articles/54237349b9159/ (25 IV 2020).

3 *Невідома історія розвитку та занепаду газовидобування в Україні (графіки)*, https://carpatobserver.eu/невідома-історія-розвитку-та-занепад/ (26 IV 2020).

the industrial gas reserves in the western regions of the republic amounted to 111,2 billion m³ [4].

At the same time, the small deposits of natural gas were discovered in Pryazovia, not far from Melitopol. Drilling the wells began in 1929 and gas was used for local needs. In the 1950s, the Shebelynka gas field was discovered in eastern Ukraine (Kharkiv region). Its operation began in 1956 and had significant influence on the development of the gas sector in Ukraine.

In the 1960s new gas deposits were discovered both in the eastern part of the country (Kegychivske, Glynsko-Rozbyshivske, Chrestyshchenske, Sosnivske, Proletarske, Gadiatske and others) as well as in the west of the country in the Lviv and Ivano-Frankivsk oblasts (Pivnichno-Medynytske, Kavske, Kosmatske, Ivanykivske, Rosilnianske, Pynianske, Bohorodchanske). In the south, the development of the following gas deposits began: Glibivske (1966), Zadornenske (1970), Yankoyske (1970). A natural gas field has also been discovered near the village of Strilkove on the Arabat Spit, part of the deposit is located at the bottom of the Azov Sea. Since then, the need to solve the problem of natural gas extraction in the Azov and Black Sea basins has emerged for the first time. In 1970, about 43 gas fields were exploited. The extraction of natural gas and as well associated natural gas amounted to 62 billion m³ and continued to increase.

Interesting data can be found in the Statistical Yearbook of the USSR's National Economy: in 1940, Ukraine produced 495,1 million m³ of gas, and Russia – 209,9 million m³. The RSFSR overtook the USSR in gas production only after World War II[5]. Natural gas production reached its peak in 1975–1976 and amounted to 68 billion m³ (Figure 1)[6]. Along with the increase in natural gas production, exports also increased. In 1967, the First Secretary of the CPU Central Committee, Petro Shelest wrote to the CPSU Central Committee: *Despite the presence of an extensive gas pipeline network in Ukraine, many industrial centers, especially Kiev, Dnepropetrovsk, Zaporozhye, Kryvy Rig, Lviv and other cities of the western regions of Ukraine, have serious difficulties with gas supply in winter*[7].

According to chart 1, the peak of gas production in the USSR falls on 1973–1978, when production reached 68 billion m³. Gas was exported to socialist countries – Poland, Czechoslovakia and allied republics – Russia, Belarus, Lithuania and Latvia[8]. From that moment, gas production began to decline gradually. Ukraine has never returned to such high gas extraction rates.

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4 *Ibidem*.

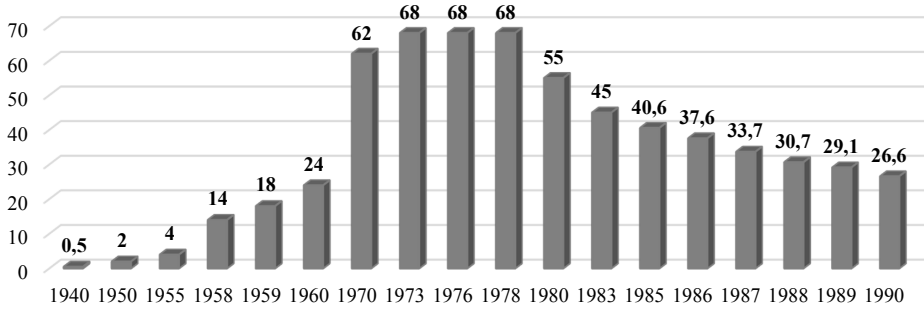
5 *Невідома історія розвитку та занепаду газовидобування в Україні (графіки)*, https://carpatobserver.eu/невідома-історія-розвитку-та-занепад/ (26 IV 2020).

6 *Нафтогазова галузь України: поступ і особистості*, ред. З. Осінчук, Київ 2013, p. 34.

7 *Країна глибокого буріння. Як українці добували газ для СРСР*, https://www.istpravda.com.ua/articles/2012/02/16/73445/ (26 IV 2020).

8 *Ibidem*.

Chart 1. The dynamics of natural gas production in the Ukrainian SSR in 1940–1989



Source: own study based on: *British Petroleum Statistical Review of World Energy*, http://www.bp.com/statisticalreview [20 V 2020]; *Невідома історія розвитку та занепаду газовидобування в Україні (графіки)*, https://carpatobserver.eu/невідома-історія-розвитку-та-занепад/ [26 IV 2020]; *Розвиток газового сектору України в контексті євроінтеграції*, http://razumkov.org.ua/upload/1392734130_file.pdf (26 IV 2020).

At the end of 2018 the documented natural gas reserves in Ukraine amounted to 1,1 trillion m^3[9]. According to BP statistics, they are the third largest confirmed resources in Europe. Ukraine is behind only Norway with 1,6 billion m^3 and Russia with 38,9 billion m^3[10]. Ukraine has sufficient resources to cover its own demand for natural gas. Taking into consideration the size of natural gas potential, the question arises: why does Ukraine by having the third largest gas potential in Europe depend on its import?

More than 120 gas deposits have been discovered on the territory of Ukraine. Gas resources are located in various parts of the country – in the east it is the Dniprovsko-Donetski Basin and the north-west of Donbass, in the west – the Volyn-Podilsk Plateau, the Carpathians and Transcarpathia, in the south the region of Black Sea coastal area, Crimea and the shelf of the Azov and Black seas[11]. Almost half of the undiscovered hydrocarbon resources are associated with the Dniprovsko-Donetski Basin. Scientists estimate that there can be at least 5 large, 20 medium and over 500 small natural gas deposits discovered[12].

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9 *British Petroleum Statistical Review of World Energy*, http://www.bp.com/statisticalreview (20 V 2020).

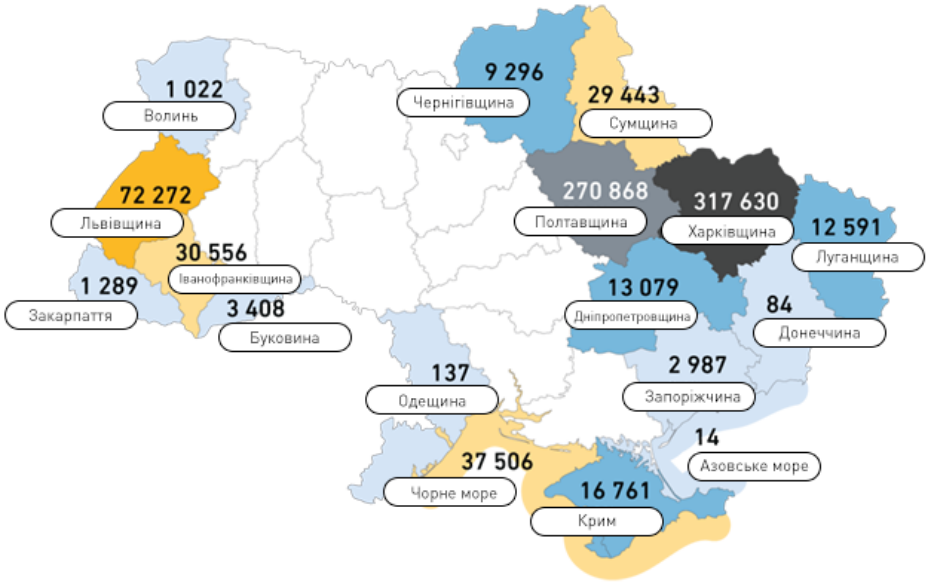
10 *Ibidem*.

11 І. Лещенко, О. Стогній, *Перспективи розвитку газовидобувної промисловості України*, „Проблеми загальної енергетики" 2015, вип. 3 (42), p. 5-12.

12 Я. Витвицький, І. Іванченко, *Економічні проблеми використання ресурсного потенціалу нафтовидобування в Україні*, http://dspace.nbuv.gov.ua/bitstream/handle/123456789/167061/5-Витвицький.pdf?sequence=1 (27 IV 2020).

According to the data in Figure 1, the Kherson Oblast has the largest natural gas resources with 317 630 million m^3, Lviv Oblast with 72 272 million m^3 came second, Odessa with 37 506 million m^3 is on the third place, the next one is Ivano-Frankivsk oblast with 30 556 million m^3, the top five leaders closes Sumy Oblast with 29 443 billion m^3.

Figure 1. The gas potential of individual regions of Ukraine

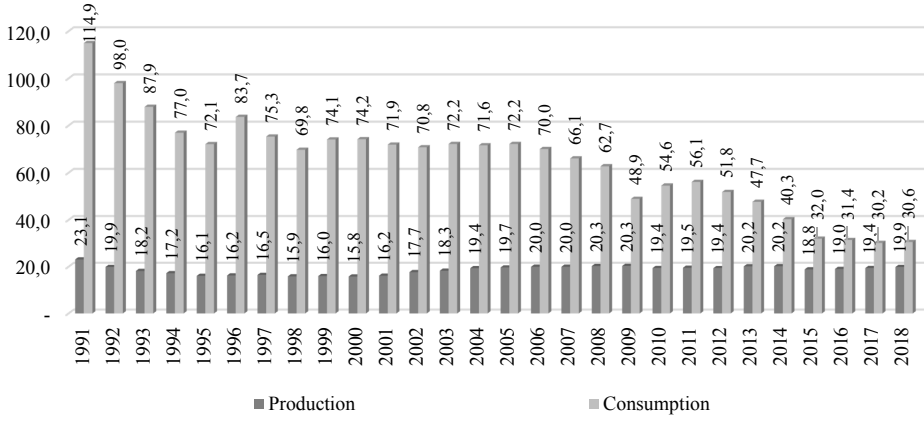


Source: *10 фактів про видобуток українського газу*, https://www.epravda.com.ua/projects/gazpravda/2019/09/5/650837/ (27 IV 2020).

According to British Petroleum statistics, natural gas production in the first years of Ukraine's independence fell from 23,1 billion m^3 in 1991 to 16,2 billion m^3 in 1996. Since then, natural gas production was fluctuated within 16,2-20,0 billion m^3 of gas per year (Chart 2)[13]. The decline in production is caused by the depletion of existing fields, lack of funds for exploration and production and lack of investment in the development of the energy sector. In addition, the annexation of Crimea has affected natural gas production. The Black Sea shelf has been appropriated by the Russian Federation, and the volatile situation in the east of the country is holding back investment in field development in this part of the country.

[13] *Ibidem*.

Chart 2. Dynamics of natural gas production and consumption in Ukraine in 1991–2018, billion m^3



Source: own study based on statistical data British Petroleum Statistical Review of World Energy, http://www.bp.com/statisticalreview (20 V 2020).

The simplest calculations show that with documented resources in 1,1 trlm m^3 of gas and consumption at 31 billion m^3 per year, gas will be enough for over 30 years. According to data from chart 2, Ukraine significantly reduced gas consumption, which is caused first of by all energy efficiency policies, closing unprofitable enterprises, high gas prices for households. In 1991, gas consumption amounted to 114,9 billion m^3, which is almost three times more than in 2019, when the consumption was at 30,6 billion m^3[14]. Fluctuations in gas production in the country result from the fact that gas tariffs for country's own production do not cover the costs of its extraction, which limits investments in the development of industry and limits upstream activity[15].

With consumption at the level of 2019, Ukraine's own gas resources will satisfy the demand until 2050. To extend this period certain steps are necessary to reduce gas consumption furtherly.

Firstly, the energy saving policy should be continued by increasing energy efficiency of households.

Secondly, it is necessary to develop plans for exploration and development of new deposits, attracting investments in the energy sector and re-evaluation of the energy strategy.

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[14] *Ibidem*.

[15] І. Лещенко, О. Стогній, *Перспективи розвитку газовидобувної промисловості України*, http://pge.org.ua/index.php?option=com_docman&task=art_details&mid=20153&gid=421&lang=ua (3 V 2020).

In 2019, Ukraine imported only 9,8 billion m^3 of natural gas from Europe, 0,2 billion m^3 of which was of Dutch origin, and the rest – 9,6 billion m^3 was gas mainly of Russian origin, which reached Ukraine through re-export[16].

Ukrainian natural gas resources have a number of features that significantly affect the conditions of production, and thus its cost. The vast majority of fields are old fields with a lifetime of 40-60 years. According to various estimates, 60-75% of gas production takes place under conditions of constant pressure drop in the wells. Gas resources are spread over many small (1-5 billion m^3) and very small (up to 1 billion m^3) deposits. The deposits are located at great depths, which hinders production and increases its value. The average depth of deposits is about 3500 m, and the maximum exceeds 6000 m. More than 15% of the explored resources belong to the hard-to-extract group, which requires the use of modern technologies[17].

The development of energy infrastructure began with the industrial development of the first gas fields in western Ukraine. The development of gas infrastructure can be divided into three stages:

- Stage I (1922–1964) construction of the necessary infrastructure;
- Stage II (1965–1990) apogee – construction of strategic pipelines;
- Stage III (1991–present) contemporary – reconstruction and modernization.

Stage I (1922–1965). In 1922, the first 14 km Dashava-Stryi gas pipeline was built[18]. In the years 1924–1925, the gas pipeline was extended to Drohobych and Stebnyk, and in 1929 to Lviv. Just before World War II, the Opara-Boryslav gas pipeline was built, and the Dashava-Kyiv gas pipeline (the largest in Europe at the time) was designed, with a length of 512 km. The construction of three gas processing factories was also planned, but the beginning of the war did not allow these plans to be implemented[19]. The gas pipeline was commissioned on 17 XI 1948. In 1951 it was extended to Moscow (Fig. 2)[20]. In addition, in 1962, gas pipelines from Ukraine were expanded to Minsk, Vilnius and Riga[21].

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16 *British Petroleum Statistical Review of World Energy*, http://www.bp.com/statisticalreview (20 V 2020).

17 I. Лещенко, O. Стогній, *op.cit.*

18 *Ibidem*.

19 *Газодобывающей промышленности Украины – 80 лет*, „Энергобизнес" 2004, nr 24, p. 16-20.

20 O. Малярчук, *Нафтогазовидобування західного регіону Української РСР – складова економічного потенціалу республіки*, [in:] *Україна-Європа-Світ. Міжнародний збірник наукових праць. Серія: Історія, міжнародні відносини*, 2016, vol. 18, p. 70-80, http://nbuv.gov.ua/UJRN/Ues_2016_18_11 (26 IV 2020).

21 *Ibidem*.

Figure 2. Pipeline route Moscow-Dashava

Source: *Історія одного відкриття. Газовій промисловості України – 90 років*, https://www.ist-pravda.com.ua/articles/54237349b9159/ (26 IV 2020).

Figure 3. Transit system of Ukraine

Source: *Russian gas transit through Ukraine after 2019: the options*, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2018/11/Russian-gas-transit-through-Ukraine-after-2019-Insight-41.pdf (2 V 2020).

II stage (1965–1990). In 1965, construction of the Brotherhood gas pipeline began, which supplied natural gas to Czechoslovakia at that time. The length of the gas pipeline was 540 km, of which 190 km ran through the territory of Ukraine.

At the end of the 1970s, several European countries asked the USSR government to increase gas exports to Germany, Italy, France, Austria, Belgium, the Netherlands, Switzerland and Greece. Regardless of the Cold War period, the USSR was reliable in gas supplies to Europe. At the end of the 1970s, the potential of Ukrainian gas deposits began to decline significantly, which could be explained primarily by the depletion of deposits. To meet the expectations of Western countries, it was necessary to expand the transit infrastructure and ensure gas supplies from other regions. Ukraine from a country exporting natural gas has become a transit state. And Western Siberia became the main place of extraction of natural gas. It was from here that the construction of the new Urengoy – Pomary – Uzhhorod export pipeline began. And when its construction was completed, a „contract of the century" was signed for gas supplies. Western countries granted long-term loans to the USSR, which provided for the purchase of pipes and necessary equipment. The pipeline was built at a record pace – in one year instead of three, and was commissioned on 25 VII 1983[22]. In 1988, the third Progres transit gas pipeline was commissioned (Fig. 3)[23].

Stage III (1991–present). At the beginning of the 21st century, the Ukrainian gas pipeline system was in excellent shape. Currently, the system amounts to 36,7 km^2 of gas pipelines. Gas transit via the territory of Ukraine was delivered to Germany, the Czech Republic, Slovakia, Romania and Poland. All gas transmission lines that run through Ukraine are fully automated.

The Orange Revolution of 2004 and the Revolution of Dignity 2014 brought significant changes to the functioning of the transit system of Ukraine and significantly changed the situation to the detriment of the state. Gradually, Ukraine began to lose the position of the main transit country (Chart 3).

The new energy strategy of the Russian Federation had an impact on reducing gas transit through the territory of Ukraine. The goal of the Russian Federation is to eliminate third countries from the gas supply process. The confirmation of this strategy was the construction of Nord Stream (2011), Nord Stream 2 (under construction), Blue Stream (2003) and TurkStream (2020). The commissioning of these gas pipelines will significantly reduce the volume of gas transit through Ukraine. In addition, gas disputes between Ukraine and Russia in 2006–2010 were to the detriment of Kiev. The LNG market also has an impact on reducing gas transit through Ukraine.

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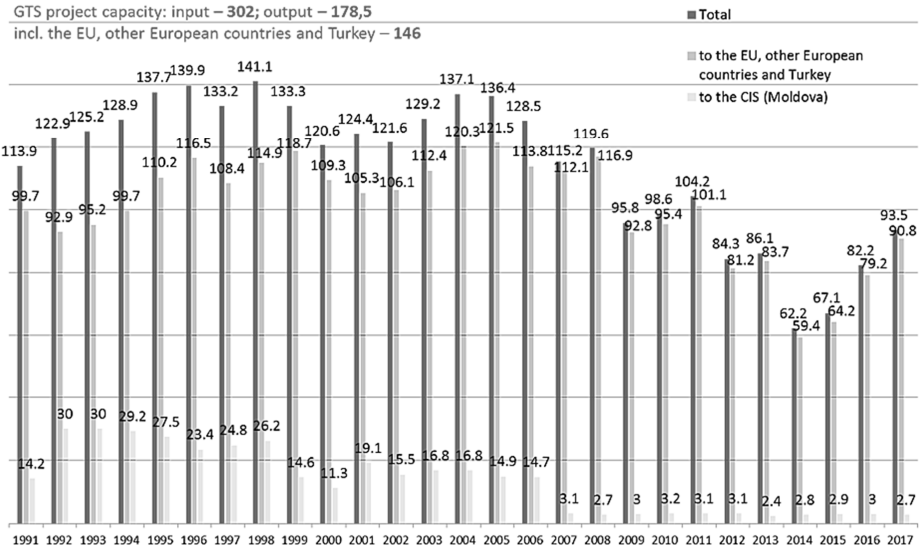
[22] *Ibidem*.

[23] *Газотранспортна система України: готовність до співпраці?* (Аналітична доповідь Центру Разумкова), „Національна безпека і оборона" 2004, nr 1 (49), p. 3.

Chart 3. Transit of natural gas through the territory of Ukraine in 1991–2017 (billion m^3)



Source: *Natural Gas Transit via Ukraine, 1991–2017*, http://www.naftogaz-europe.com/article/en/naturalgastransitviaukraine2017 (28 IV 2020).

Over the past 10 years, Ukraine has invested 4 billion UAH in the modernization of the gas pipeline system. Since the transit through the territory of Ukraine began to decline, the transit system has been reset (modernized) to the reverse regime. For the first time, Ukraine used the reverse in 2009, when the gas conflict with Russia began. After lasting and difficult negotiations, the parties reached an agreement and signed a ten-year contract for gas transit through the territory of Ukraine. This contract was very unfavorable for Ukraine, under this agreement Ukraine, according to various estimates, lost USD 10-20 billion and therefore submitted an application to Stockholm Arbitration with a request to re-review some points of the contract. The contract for gas transit ended on 31 XII 2019, and the signing of the new one was delayed because the parties could not agree on the terms and price of the transit (Tab. 1)[24].

Finally, the contract for gas transit through Ukraine was signed for a period of 5 years (2020–2024) with the possibility of its extension for another 10 years. Under the terms of the agreement, the minimum transit volume will be 65 bil-

[24] М. Топалов, *На порозі газової війни: що буде, якщо не вдасться підписати транзит з „Газпромом”*, https://www.epravda.com.ua/publications/2019/11/20/653912/ (28 IV 2020).

lion m³ in 2020 and 40 billion m³ in 2021–2024[25]. For the first time in the history of Ukraine, Gazprom has concluded a transit agreement based on the European „pump-or-pay" principle[26]. In addition to the gas transit agreement, Ukraine and Russia also signed a settlement agreement. Under this agreement, Gazprom completely ceases to appeal against the Stockholm arbitration decision[27].

Table 1. Requirements of Russia and Ukraine regarding the signing of a new gas transit agreement

Ukraine	Russian Federation
1) Key requirement: signing a ten-year contract based on European legislation, with a minimum transit volume of 60 billion m³ of gas per year. Another 30 billion USD is an additional option reserved for demand in the EU market. 2) Gazprom hopes that Ukraine will sign the agreement for direct gas supplies from Russia. Naftogaz's position is unchanging – yes, but on fair prices.	1) Key requirement: the agreement will be signed if Ukraine and Russia give up their mutual claims in international arbitration in Stockholm and terminate all court proceedings. 2) The Kremlin proposed to forget about the won arbitrations, the current arbitration (12 billion USD) and the fine of the Antimonopoly Committee of Ukraine, which is about the total amount to be reimbursed for Ukraine amounting to about 22 billion USD. 3) Harmonization of Ukrainian legislation with EU legislation and guaranteeing the independence of the regulator is also important for Ukraine.

Source: own study based on: М. Топалов, *На порозі газової війни: що буде, якщо не вдасться підписати транзит з „Газпромом"*, https://www.epravda.com.ua/publications/2019/11/20/653912/ (28 IV 2020).

Since the implementation of the Strategy, it has been possible to unbundle Naftogaz Ukraine. Unbundling of Naftogaz was a necessary condition for the conclusion of a new transit agreement and was one of the basic EU requirements for Ukraine. Until the commencement of the unbundling process, all functions related to the extraction, transport, storage and sale of gas belonged to Naftogaz and its subsidiary Ukrtransgaz. Under agreements with the European Energy Com-

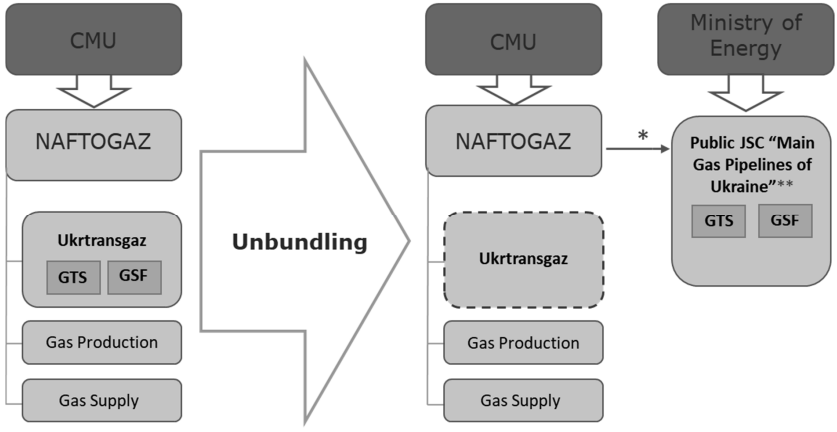
[25] *Украина подписала контракт на транзит газа на пять лет (обновлено)*, https://lb.ua/economics/2019/12/30/446200_ukraina_podpisala_kontrakt.html (28 IV 2020).

[26] „*Pump or pay* clause, meaning Russia must pay the minimum gas-transit fee even if it doesn't pump the contracted volumes through Ukraine". *Russia, Ukraine Reach Five-Year Gas-Transit Deal*, https://www.rferl.org/a/long-russia-ukraine-reach-five-year-gas-transit-deal/30353000.html (28 IV 2020).

[27] М. Топалов, *Нафтогаз vs Газпром: хто виграв битву під Стокгольмом*, https://www.epravda.com.ua/publications/2018/02/28/634557/ (28 IV 2020).

munity, Ukraine committed itself a few years ago to separate transport, storage, production and sale of gas, which was only achieved at the end of 2019 (Fig. 4)[28].

Figure 4. Property Division Model



Source: *Amendments introduced to Ukraine's unbundling plan*, https://www.cms-lawnow.com/ealerts/2019/06/amendments-introduced-to-ukraine-unbundling-plan (2 V 2020).

Status of implementation of unbundling in 4 main operation areas (as of 1 I 2020):
- Separation of the Storage System Operator of Ukraine Branch – 100%;
- Extension of the Gas Transmission Operator Branch – 100%;
- Legal unbundling of the Gas System Transmission Operator of Ukraine – 100%;
- Third Party actions to complete the unbundling process – 85%[29].

If Ukraine follows Eastern European countries, supporting the development of competition and protecting consumer rights, then it will be able to create a competitive market that will help reduce gas prices and improve the quality of services[30].

In the context of the analysis of the energy infrastructure, as well as its expansion and modernization at the present stage, Ukrainian gas storage facilities, the potential of which is one of the largest in Europe, are equally important.

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28 М. Топалов, *Ключові „газові" виклики для команди Зеленського*, https://www.epravda.com.ua/publications/2019/09/6/651347/ (2 V 2020).

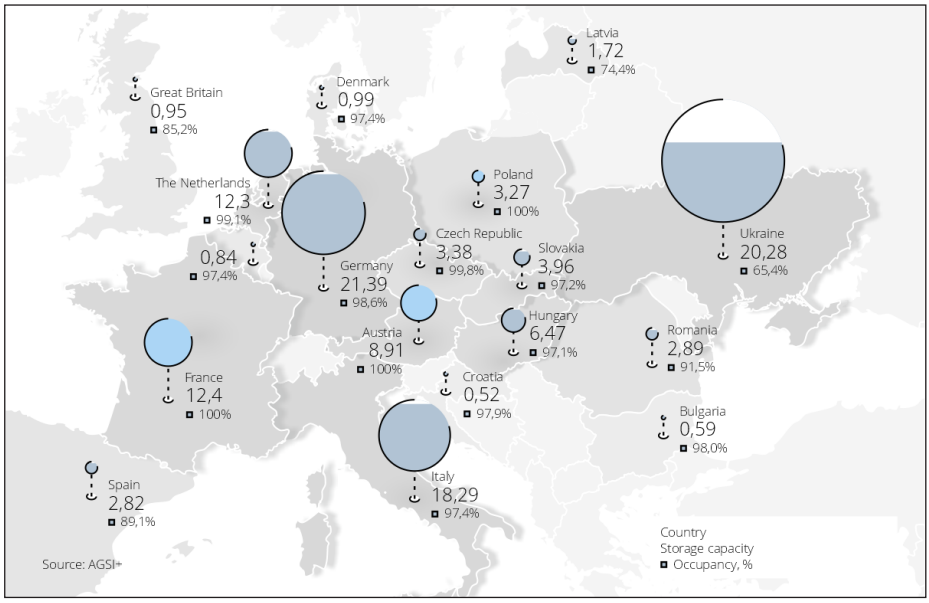
29 *Unbundling*, http://utg.ua/en/utg/company/unbundling/ (2 V 2020).

30 М. Топалов, *Відокремлення ГТС від „Нафтогазу": навіщо це робити і як це допоможе у війні з „Газпромом"*, https://www.epravda.com.ua/publications/2019/11/5/653341/#2 (2 V 2020).

The underground natural gas storage

The underground gas storage network is an indispensable and inseparable element of the Ukrainian gas pipeline system. Ukraine has one of the largest natural gas tanks in Europe (Fig. 5).

Figure 5. Potential of underground gas storage in Europe and Ukraine's place in it, billion m³ (October 2019)



Source: *Gas Reserves in European UGS Facilities on*, https://kosatka.media/en/category/gaz/analytics/zapasy-gaza-v-evropeyskih-phg-na-08-10-2019 (27 IV 2020).

Underground gas storage facilities in Ukraine have been built up for decades in parallel with the expansion of transit infrastructure. Underground gas storage facilities are used to ensure energy security in conditions of uneven supply and unequal demand for natural gas[31].

The history of the development of underground gas storage can be divided into four periods:

[31] А. Кожевников, А. Судаков, Б. Ратов, *100 років історії розвитку підземних сховищ газу. Огляд*, http://ir.nmu.org.ua/bitstream/handle/123456789/150608/7-15.pdf?sequence=1&isAllowed=y (28 V 2020).

- I period (1955–1970) construction of underground gas storage facilities based on aquifers for supplying gas to Kiev. The first gas tanks were built in Olyshivske and Chervonopartyzanske aquifers[32].
- In the second period (1971–1995), the construction of underground gas storage facilities on the basis of depleted gas fields began to ensure the reliability of gas supplies throughout the country and the beginning of gas exports to Europe. Underground gas storage facilities in Prykarpattia arose on the basis of depleted gas fields. In 1973, the construction of the Dashava underground storage facility on the basis of an exploited gas field began to regulate gas supplies to Lviv. In 1979, gas was pumped into the Oparske and Bohorodychanske underground storage facilities, and in 1983–1992 one of the largest underground storage facilities, Bilche-Volytske-Uherske, was established on the basis of depleted fields. In 1987, the Vergunske underground storage facility in the Donetsk region was built on the basis of the depleted field. In 1983, the Glibivske underground gas storage facility was established in the same way, and in 1986, the Proletarian underground gas storage facility was constructed in the Dnipropetrovsk region. Over time, underground gas storage facilities were built in the Kharkiv region (Kegychivske, 1988) and the Poltava region (Solokhivske, 1987) (Fig. 6)[33].
- III period (1996–2000) further extension of the underground gas storage network, modernization and technical re-equipment, gradual transition of underground gas storage facilities to operation in market conditions.
- IV period (2001–present) modern period of modernization of the underground gas storage network[34].

Underground gas storage facilities form a powerful underground gas storage system, which is an important technological link in the current national gas transport system, capable of solving many problems, the most important of which are:

- ability to manage uneven gas supply;
- compensation for seasonal irregularities in gas supplies;
- the possibility of additional gas supply to customers in case of extremely low temperatures (due to available gas reserves);
- ensuring the reliability of the transmission system by reserving gas in case of short-term failure of the gas pipeline;
- ensuring security of gas supply for export;
- creating long-term state gas reserves in case of unforeseen extreme situations[35].

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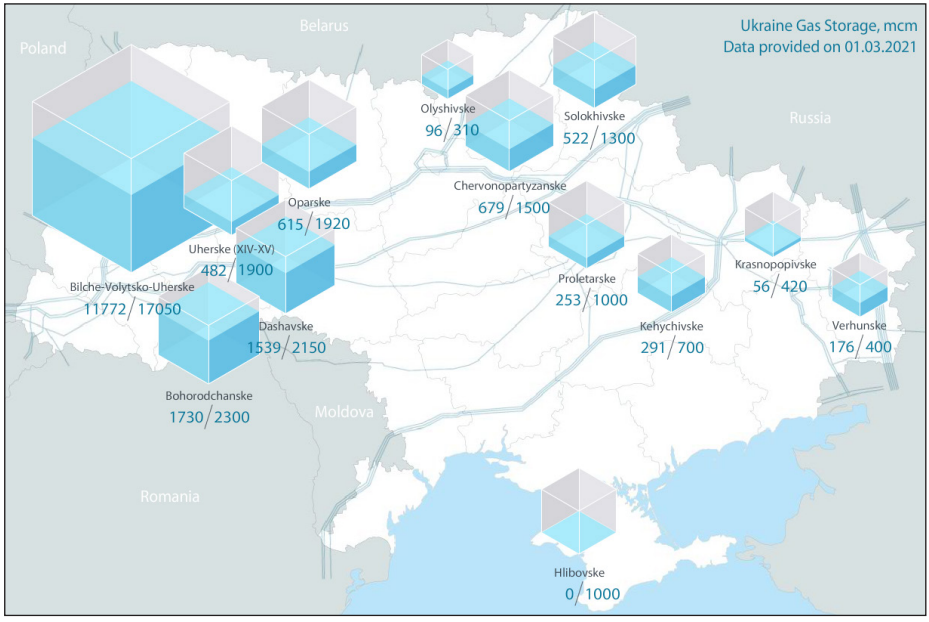
[32] *Ibidem*.

[33] *Нафтогазова галузь України: поступ і особистості*, ред З. П. Осінчук, Київ 2013, p. 42.

[34] Б. Савків, *Підземне зберігання газу в Україні*, Київ 2008, p. 12-13.

[35] О. Чернова, *Аналіз розвитку мережі підземних сховищ газу України*, http://mining.in.ua/articles/volume8_3/34.pdf (27 IV 2020).

Figure 6. Underground gas storage facilities and their potential



Source: *Gas Balances in Ukrainian Underground Storages*, https://naftogaz-europe.com/article/en/englstorage (27 IV 2020).

Underground gas storage is controlled by „Ukrtransgaz", the company operates 12 tanks – two of them based on aquifers (Chervonopartyzanske, Olyshivske), the rest based on depleted gas deposits (Fig. 6)[36].

The technological connection of underground gas storage facilities with major gas pipelines allows separating four strategic areas (according to their geographical position) for the deployment of underground gas storage facilities in Ukraine, including:

Western area. The western complex was created in the area of transition gas pipeline systems such as: the Orenburg – state border (Soyuz), Urengoy – Pomary – Uzhgorod, Ivacevychi – Dolyna, Kyiv – Western Ukraine, Dolyna – Uzhgorod, Yelets – Kremenchuk – Ananiev – Bogorodchany. This guarantees the reliability of Russian and Central Asian gas transit to Central and Western Europe and surrounding areas of Moldova and Belarus, as well as to the Balkans. This complex includes a group of underground gas storage facilities located in the Carpathian region – Dashavske, Uherske, Bogorodchanske and Bilche – Volytsko – Uherske.

[36] *Укртрансгаз*, http://www.utg.ua/uk/activities/underground-gas-storage/ (28 IV 2020).

North area. Underground gas storage facilities have a common goal: to ensure security of gas supply to the capital and Kyiv region. They are located in pairs with the gas supply system: two underground gas storage facilities (Kegychivske and Solokhivske) are connected with Shebelynka – Poltava – Kyiv and Yefremivka – Dykanka – Kyiv gas pipelines, which run west through the Kiev – Western Ukraine gas pipeline system. Next two underground gas storage facilities (Olishivske and Chervonopartyzanske) are connected with the Kyiv – Bryansk gas pipeline, the latter being connected to the Tula – Shostka – Kyiv gas pipeline.

South area. The southern complex is under construction, its main purpose is to ensure gas supplies to the southern regions of Ukraine and in the Balkan direction. The annexation of Crimea somewhat complicated the plans for the expansion of this complex and complicated the plans to expand the Hlibivske underground gas storage.

Eastern area. Chervonopopovske and Vergunske underground gas storage facilities have a local function in the reliability of gas supplies under the Donetsk gas transmission system. Its impact on the reliability of supply throughout Donetsk is insufficient. That is why it is important to search for new geological objects for gas storage in this region. Currently, this is not possible due to the war in the eastern part of the country[37].

Ukraine has all the necessary conditions to create the East European gas hub based on the existing gas storage system. To use underground gas storage as a hub successfully, a number of problems need to be resolved. One of them is the direct interaction between the operators of the Ukrainian transmission system and related systems in order to avoid problems during the transmission of natural gas to Ukraine and from Ukraine to other European countries. Ukraine has good predispositions to become a gas trading platform. In Europe, the largest gas exchanges are located at strategic gas transit nodes. This helps to manage gas distribution effectively. In Ukraine, underground gas storage facilities are located near the transit hubs, which allows gas importers to save money on transport to habs. The location of underground gas storage facilities near the EU border with a total capacity of around 25 billion m^3 of gas and the prospect of increasing it to 30 billion m^3 of gas mean that the interest of international energy companies in reverse delivery is growing. Ukraine's entry into the European competitive gas market will ensure the profitability of all transit gas pipelines in Ukraine, even taking into account the forecast of a minimum load on the Ukrainian gas transport system with imported Russian gas in 2020[38].

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[37] А. Кожевников, А. Судаков, Б. Ратов, *100 років історії розвитку підземних сховищ газу. Огляд*, http://ir.nmu.org.ua/bitstream/handle/123456789/150608/7-15.pdf?sequence=1&isAllowed=y (28 V 2020).

[38] С. Сторчак, В. Заєць, *Підземні сховища газу України – надійна основа для створення Східноєвропейського газового хабу*, http://elar.nung.edu.ua/bitstream/123456789/3870/1/5672p.pdf (3 V 2020).

In order to create an East European gas hub, Ukraine has already taken some steps, including:

- Completed the unbundling process;
- Modernized the gas pipeline system;
- Implemented the Third Energy Package.

The next steps on the way to creating Eastern European hub should be:

- Construction of the LNG terminal;
- Modernization of the underground gas storage management system[39];
- Synchronization of the operation of the gas transport system of Ukraine with the EU gas transport systems, primarily with its neighbors – Poland, Hungary, Slovakia and Romania;
- Providing a regulatory framework for work in Ukraine by foreign gas exploration and production companies[40].

In order to increase the importance of underground gas storage facilities and to create an Eastern European gas hub on the territory of Ukraine in the future, an in-depth reform of Ukraine's energy sector is necessary, which will ensure energy security for Ukraine, but also increase its credibility as a reliable partner.

The reform of the Ukraine energy sector and its future

Energy sector reforms are necessary to ensure Ukraine's energy security. On August 18, 2017, Ukraine's Energy Strategy was adopted for the period up to 2035[41]. The strategy's watchword is – security, energy efficiency and competitiveness.

The strategy has been divided into three stages:

- I Stage – Energy sector reform (2017–2020). As part of the first stage of reforms, the implementation of the third energy package is expected to be completed, this will support the creation of fully-fledged markets for natural gas and electricity in accordance with EU energy legislation. It is planned to complete the institutional integration of Ukraine with ENTSO-E, as well as carry out most of the activities related to the integration of the United Energy System of Ukraine with the ENTSO-E energy system. Reforming energy enterprises in accordance with the commitments of Ukraine under the Energy Community Treaty, the increase of gas

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[39] М. Войтів, *Газовий хаб: Україна ще цікава Європі*, https://www.epravda.com.ua/columns/2015/07/7/549534/ (3 V 2020).

[40] В. Рамазанов, *Газові „хаби" Європи. Створення Східноєвропейського газового хабу*, http://ua-ekonomist.com/archive/2014/11/Ramazanov.Pdf (3 V 2020).

[41] Кабінет Міністрів України. Розпорядження від 18 серпня 2017 р. № 605-р, Про схвалення Енергетичної стратегії України на період до 2035 року „Безпека, енергоефективність, конкурентоспроможність", https://zakon.rada.gov.ua/laws/show/605-2017-р (2 V 2020).

production, reducing the energy intensity of GDP and further development of renewable energy sources are key tasks.

- II Stage – Optimization and innovative development of energy infrastructure (2020–2025). The implementation of the Energy Strategy at this stage provides for:
  - Integration of the Ukrainian network with continental Europe as part of the European Network of Transmission System Operators for Electricity (ENTSO-E) in the service mode;
  - Full integration with the European gas transport system under the European Network of Transmission System Operators for Gas (ENTSO-G) and further deepening cooperation with Central European countries in order to increase the security of energy supplies;
  - It is expected that Ukraine will completely cover the domestic demand for natural gas from its own resources by increasing production, as well as optimizing the operation of the Ukrainian gas transport system in accordance with the expected scenarios of its loading.
- III Stage – Ensuring sustainable development (2025–2035). The main challenges for Ukraine's energy security will be:
  - Ensuring the growth of domestic gas production, including unconventional gas and production on the continental shelf and in the exclusive (maritime) economic zone of Ukraine;
  - Adaptation of the capacity of the Ukrainian gas transport system to the conditions of development of the pan-European natural gas market[42].

The first stage of the strategy implementation ended before 2020. Not much has been achieved. Along with the implementation of the Strategy in 2018, the company Ukrgasvydobuvannya presented the „20/20 Program" for increasing natural gas production in Ukraine.

The Ukrgasvydobuvannya 20/20 program envisaged a gradual increase in gas production. The company planned to achieve this goal by developing new fields and intensifying production in old fields. The company has implemented a gas extraction program from old fields with appropriate licenses through a significant increase in the number of drilling and fracturing operations. However, these activities were not enough, because the old deposits are exhausted by 80-90%, and they have less and less gas, which makes it difficult to get it out. In order to increase production, it is necessary to obtain new licenses and develop new fields. Ukrgasvydobuvannya suffers annual losses of 1 billion m^3 of gas due to blocking the license (Chart 4).

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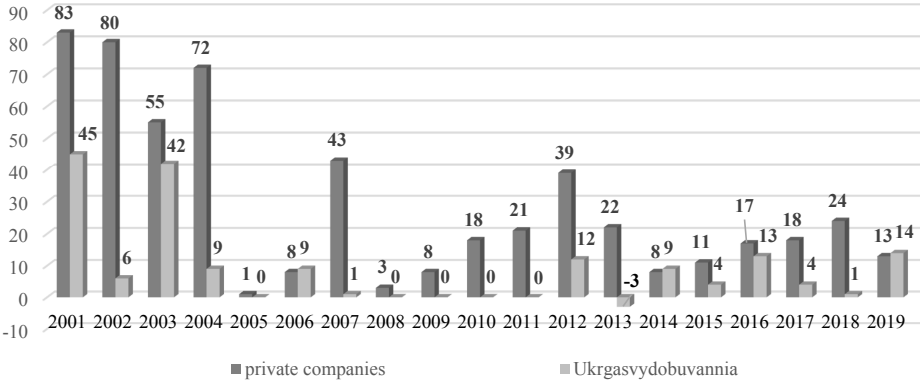
[42] Про схвалення Енергетичної стратегії України на період до 2035 року „Безпека, енергоефективність, конкурентоспроможність", https://zakon.rada.gov.ua/laws/show/605-2017-р (2 V 2020).

Chart 4. Number of licenses issued for exploration of new deposits and drilling of new wells in 2001–2018



Source: own study based on: http://agpu.org.ua/upload/files/14158210445759.pdf (2 V 2020); *Нафтогаз України – Naftogaz*, https://www.facebook.com/photo?fbid=2137258433020597&set=п рограма-укргазвидобування-2020-передбачала-поступове-збільшення-видобутку-газу- (2 V 2020).

Chart 3 data indicates that both private and state-owned companies operate on the Ukrainian gas market. There are currently 50 private companies operating on the Ukrainian gas market, six of them provide 90% of total gas extraction from private companies. Of these six, DTEK Oil and Gas and Burisma Holdings produce 65% of the gas[43]. The rest of license holders make a small contribution[44].

Private companies have licenses to develop the most attractive hydrocarbon fields. Over 100 companies in Ukraine have special permits to use mineral resources – for geological exploration or hydrocarbon production, but only 49 companies actually produce gas. This means that 51 licenses are not working[45].

As it results from chart 3 data, private companies have obtained the majority of licenses for exploration and extraction of gas in the last 18 years. In the years 2008–2011 Ukrgasvydobuvannia did not obtain any license. In 2013, three licenses for gas exploration and production were revoked. In this way, private companies in the period 2001–2019 obtained 544 licenses for exploration and

[43] The owner of DTEK Oil & Gas is Rinat Achmetov, and at Burisma Energy the company's directors are, among others Polish President (1995–2005), Aleksander Kwasniewski and son of US Vice President Joe Biden – Hunter Biden.

[44] Н. Прудка, *Газові ліцензії: приватна колекція. Як знищується державний сектор газовидобування*, https://glavcom.ua/publications/gazovi-licenziji-privatna-kolekciya-yak-znishchujetsya-derzhavniy-sektor-gazovidobuvannya-364634.html (2 V 2020).

[45] *Ibidem*.

extraction of gas in the area of 73,5 thousand km^2. The total number of licenses for Ukrgasvydobuvannia in this period was about 160 on an area of 22,3 thousand km^2.

Due to the failure to issue the appropriate number of licenses, the implementation of the „Program 20/20" failed. The main reason for this is corruption in the licensing process[46]. In addition, the natural gas production plan in 2019 was not implemented even in the fields that were licensed, due to the lack of investors. During the years of independence, Ukraine has still not developed an effective mechanism to attract investors and technologies.

After the revolution of dignity in 2014, the Ukrainian gas upstream was going through hard times. During the rule of President Viktor Yanukovych, the control over the issuing of licenses for exploration and gas production came under the strict control of the Party of Regions, ruling in 2010–2013. It deprived state-owned companies of numerous licenses for development of deposits (Fig. 3) and limited the operations of „Nadra Ukraine"[47]. The situation began to change in 2017. The Ministry of the Environment has taken a number of decisions aimed at renewing the licensing procedure[48].

The main changes concerned, among others:

- Improvement of the current land allocation practice, ensuring continuity of land development, giving the possibility to explore land under a contract with the landowner after the pilot industrial field development project and commissioning of fields for industrial use.
- Providing the possibility of using the servitut mechanism for the construction of oil and gas extraction installations and pipeline transport, which will allow the use of land without changing its purpose.
- To agree that removal and transfer of soil cover for drilling and equipment for oil and gas wells, construction and operation of pipelines can be carried out without a special permit and based on a working land management project[49].

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[46] *Уряд не давав нові дозволи на видобування газу через корупційні причини – Вітренко*, https://mind.ua/news/20206469-uryad-ne-davav-novi-dozvoli-na-vidobuvannya-gazu-cherez-korupcijni-prichini-vitrenko (2 V 2020).

[47] The national joint-stock company „Nadra Ukrainy" is one of the largest enterprises in Ukraine, which performs the whole complex of exploration works of various types of natural resources. *У України значні поклади газу на великій глибині – глава НАК Надра України*, https://nv.ua/ukr/biz/bizinterview/u-ukrajini-znachni-pokladi-gazu-na-velikiy-glibini-glava-nak-nadra-ukrajini-1808081.html (2 V 2020).

[48] *Проект Закону про внесення змін до деяких законодавчих актів України щодо спрощення деяких аспектів нафтогазової галузі*, http://w1.c1.rada.gov.ua/pls/zweb2/webproc4_1?pf3511=61900 (2 V 2020).

[49] *Рада приняла законопроект о дерегуляции добычи газа*, https://www.epravda.com.ua/rus/news/2017/12/19/632316/ (2 V 2020).

Currently, „Nadra Ukraine" is looking for potential investors for the development of deposits previously discovered and the search for new ones. However, to make this search more effective, it is necessary to reform the State Service of Geology and Natural Resources (Dezheonadra), which is responsible for issuing licenses for the exploitation of deposits and ensuring access to geological information. In addition, Ukraine should effectively manage the interior of the earth. The government has developed a law that will encourage the return of licenses. The idea of the project is that in the absence of exploration of resources, the company will pay taxes without receiving a profit. The government will set a monthly fee for licenses that were approved over 3 years ago. The exact cost will depend on the size of the area and the date when the the permition was issued. In the case of deliberate non-payment of long-term license will be suspended, and then canceled[50].

Conclusions

Since the discovery of gas resources in Ukraine, their development has been very intensive, which has led to the depletion of most of the fields in the western part of Ukraine. The annexation of Crimea in 2014 led to the loss of deposits on the Black Sea coast and deterioration of relations with the Russian Federation, which was the main supplier of gas to Ukraine. All this, on the one hand, had a negative impact on the energy balance of the state and energy security, but on the other hand, it became an impetus to search for new ways of supplying energy resources, to search for ways to develop own gas fields and to modernize the gas pipeline system and extension of its potential.

Ukraine has one of the largest gas potentials in Europe, an extensive system of gas pipelines and underground gas storage facilities. Systematic underfunding of industry is the main reason for the lack of large scale upstream activity. In addition, the opaque price formation system, corruption and unstable political situation discourage potential investors.

Since the implementation of the new Energy Strategy, Ukraine has taken the following steps:

- Modernized the gas pipeline system;
- Finished the unbundling process;
- The process of changing the format for issuing licenses for gas extraction has begun.

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[50] *Позбавляємося від „сплячих ліцензій" на видобуток нафти й газу*, – *Олексій Гончарук*, https://www.kmu.gov.ua/news/pozbavlyayemosya-vid-splyachih-licenzij-na-vidobutok-nafti-j-gazu-oleksij-goncharuk (2 V 2020).

There is still a lot to be done before Ukraine to ensure energy security and minimize dependence on external gas supplies. In the near future, Ukraine should focus on:

- Developing industry's competitiveness by increasing investment in the development of modern gas production technologies and reducing its consumption, which remains high;
- Solving environmental problems by increasing responsibility for pollution of areas where geological exploration is carried out;
- Increasing upstream activity and accelerating the industrial development of already discovered gas fields using the latest technologies and techniques;
- Increasing gas production by developing new deposits and regulating tax burdens;
- Regulation of property rights to the Ukrainian gas pipeline system by conducting periodic of market needs research in the field of gas transportation, ensuring the reliability of transport services. The diversification of sources of gas supply to Ukraine is important in this context, as well as preventing restrictions on the volume of gas transit through Ukraine;
- Reducing debt for gas by conducting an energy audit to determine the degree of gas production and consumption, adopting relevant legal acts regarding the implementation of energy saving policies;
- Integrating the national economy with the global energy infrastructure through regulations of the legal framework, participation in international projects and bringing the Ukrainian gas transport system to the level of technical reliability.

An analysis of the resource base of Ukraine has shown that the decrease in natural gas production in recent years is not caused by the depletion of these resources, but by the imbalance of the exploration process, which should have a clear sequence to ensure a steady increase in reserves and reproduction of the hydrocarbon resource base. One of the main reasons for this imbalance is the lack of investment in the gas industry[51].

The biggest threat is still the expansion of gas pipelines outside Ukraine, which in 4 years may significantly affect the energy security of the state. Ukraine has little time to ensure the reliability of supplies from other sources, maximize as much as possible its own production and integrate the gas transmission system with the European system, so that in case of complete cessation of gas transit from Russia, it can use the reverse gas pipeline system. Additionally, the construction of the LNG terminal could strengthen Ukraine's energy security.

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[51] І. Лещенко, О. Стогній, *op.cit.*

Abstract

Oksana Voytyuk

The gas sector of Ukraine: past and future

The Ukrainian gas sector has a long history. Ukraine ranks third in Europe in terms of gas potential. Regardless of such great potential, Ukraine still imports gas. There are three gas-bearing regions in Ukraine – Carpathian, Dnipro-Donetsk and Black sea region. Gas production began at the beginning of the 20th century. After the Second World War, Ukraine was the main exporter of gas from the USSR to Eastern Europe. Today, private companies provide the majority of gas production in Ukraine. Currently, the largest gas deposits are mature, and the newly discovered deposits require large investment outlays. The Ukrainian gas pipeline system has strategic importance and it is connected to underground gas storage facilities. Currently, the system works only on 50% of its own capacity due to the decrease in the volume of gas transit through Ukraine from Russia. The biggest problems in the gas sector are corruption related to the issuing of licenses for the development of new deposits and the lack of an appropriate pace of energy reforms. The proper implementation of the 2035 Energy Strategy may help improve the situation in this sector.

Keywords: Ukraine, Undreground Gas Storage facilities, supply system, transit

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Oksana Voytyuk – dr hab. politologii, adiunkt na Wydziale Historii i Stosunków Międzynarodowych Uniwersytetu w Białymstoku. ORCID: 0000-0001-6452-2893