Montenegrin Journal of Economics

Vol. 15, No. 2 (2019), 165-179

Economic, Investment and Legal Paradigm of Shale Gas Development: World Experience and Prospects for Ukraine

ANDRII BUTYRSKYI[1], LIUDMYLA NIKOLENKO[2], BORYS POLIAKOV[3], NATALYA IVANYUTA[4], LESIA DONCHAK[5] and IRYNA BUTYRSKA[6]

[1] Professor, Yuriy Fedkovych Chernivtsi National University, Department of Private Law, Chernivtsi, Ukraine, e-mail: a.butyrskyi@chnu.edu.ua
[2] Professor, Donetsk Law Institute of the Ministry of Internal Affairs of Ukraine, Law Department, Mariupol, Ukraine, e-mail: nln2006@ukr.net
[3] Professor, Yaroslav Mudryi National Law University, Law and Management Institute, Kyiv, Ukraine, e-mail: doc.pol@ukr.net
[4] Associate Professor, Donetsk Law Institute of the Ministry of Internal Affairs of Ukraine, Law Department, Mariupol, Ukraine, e-mail: natalaivanuta9@gmail.com
[5] Associate Professor, Ternopil National Economic University, Department of economy of enterprises and corporations, Vinnytsia Research Institute of Economy, Vinnytsia, Ukraine, e-mail: l.donchak@tneu.edu.ua
[6] Ph.D, Yuriy Fedkovych Chernivtsi National University, Department of Procedural Law, Chernivtsi, Ukraine, e-mail: i.butyrska@chnu.edu.ua

ARTICLE INFO

Received February 02, 2019
Revised from February 28, 2019
Accepted May 25, 2019
Available online June 15, 2019

JEL classification:

L71, Q38, Q43

DOI: 10.14254/1800-5845/2019.15-2.13

Keywords:

shale gas,
investment,
Ukraine,
risks,
production

ABSTRACT

Nowadays, shale gas is becoming an increasingly promising alternative energy source. Taking into account the significant controversial problems on the issue of shale gas development, its economic efficiency, environmental consequences, the legislative framework, it is necessary to structure and systematize the problems identified, to find optimal solutions, especially for the development of this industry in Ukraine. The hypothesis of the study is the question of whether there is an economic feasibility of extracting shale gas in Ukraine. The purpose of the study is to analyze theoretical, practical, economic, investment and legal aspects of the development of shale gas production in the world and the prospects of Ukraine in this issue. The subject of the study is the economic, legal and environmental factors in the development of the shale gas industry in Ukraine. The methodological basis of the research consists of scientific works on the main aspects of shale gas development in the context of European integration. The economic and environmental aspects of shale gas development in the United States, the European Union and China have been examined. The economic, ecological and legal aspects and prospects of shale gas development in Ukraine on the Yuzivska and Oleska gas fields have been determined. A SWOT analysis of shale gas development prospects in Ukraine has been conducted, and the risks have been identified. It was concluded that the development of shale gas production for Ukraine is ambiguous, there are many contradictions, both economic, environmental and legal.

INTRODUCTION

Ukraine belongs to countries with economic development being significantly restrained by the lack of own energy resources. Therefore, Ukraine has recently become increasingly active in issues of energy diversification and energy investment. One of the components of this process is the active use of bioenergy technologies, the development of new deposits, particularly production of unconventional gas types. Natural gas and similar energy sources are the most convenient and economical fuel type. Ukraine produces in its territory a certain amount of gas at the level of 15.5-20.5 billion cubic meters annually. However, this number, according to state institutions of Ukraine, is not enough to meet the needs of the national economy. Ukraine still remains the country with the world's largest share of energy consumption, while this figure is 3-5 times higher than in developed countries. Due to the high energy intensity of many industries, particularly metallurgical and chemical ones, Ukraine needs to import additional 30 billion cubic meters annually. Considering the high and constantly rising cost of imported natural gas, there is a need for diversification both as a source of supply and for own production of the specified energy resource. This problem can be solved by either gas import or unconventional sources development. The latter include the so-called shale gas. However, despite the existing of some countries' experience of its development and production, the economic and environmental aspects of the application and adaptation of this technology remain virtually undeveloped, especially when it comes to Ukraine.

The structure of the global gas market has been changing rapidly in recent years. Thus, it is gradually turning from segmented into regional clusters to a global one. These changes are associated primarily with the growing role of the global market for liquefied natural gas as compared to regional markets for pipeline gas. The main catalyst of the upcoming global changes will be the “shale revolution”, which is already changing the world energy map. It is worth to be reminded that the term “shale revolution” refers to a breakthrough in the US in technologies for the extraction of gas and oil from shale deposits. The Shale Revolution has led to a collapse in gas prices in the US market, triggering a wave of structural changes in the global energy market.

The development of shale gas production has directly affected North America’s market and manifested itself in a sharp decline in domestic gas prices in the United States so far. As for other markets, shale gas production in the US has a rather psychological effect now. The reserves of this resource were found in many EU countries, such as Poland, Hungary, Ukraine and some others, which gave hope to the governments of these countries to obtain energy independence. The development of industrial production of shale gas in the United States serves as an example of the successful development of so-called non-conventional gas reserves. Therefore, the problems of shale gas production for Ukraine are now very relevant. The goal of this study is to find out if Ukraine needs to follow the “American model” for the shale gas production or accept the position of the European Union. To answer this question, it is necessary to study all the economic, legal and environmental issues of the possibility of shale gas production in Ukraine. The purpose of this study is to figure out whether it is necessary to invest in this industry or not.

1. LITERATURE REVIEW

It should be noted that the discussion of the prospect of shale gas production today takes one of the central places among the interests of international and Ukrainian entrepreneurs and experts in the field of energy and economic security. Although this is a quite new issue for the Ukrainian economy, many specialists in various fields of science are involved in its development, namely economists, technologists, ecologists, geophysicists, hydrogeologists, and others. Thus, A. Kalinichenko (2013) believes that it is necessary to closely study the experience of countries that have already dealt with shale gas developing (for example, the USA, Poland), particularly to study technologies and accompanying mechanisms of production, their primary and subsequent influence on agroecosystems. The increase in volumes of hydrocarbons of own production, the satisfaction of

the needs and financial interests of international gas corporations should not lead to ecological catastrophes and making it impossible for people to reside in the areas of gas production and adjacent ones. A. Galeeva & O. Gaziniva (2014) state that the prospects for shale gas production are certainly great, which underlines the importance of research on this topic. At the same time, the "shale revolution" has a great influence on the changing global gas market now. In the global meaning of shale gas production, attention should be paid to the conclusion of C. Chen (2015), who argues that shale gas is able to cause a change in the structure of natural gas production in the future, which will lead to a significant change in the elasticity of demand in all regional markets in the world.

E. Halina (2016) believes that the impact of the "shale revolution" on the development of unconventional hydrocarbon reserves was quite limited. Despite the efforts of the United States, supported by several European countries, shale gas production technologies are not widely used in the EU. At the same time, the indirect effects of the American "shale revolution" were very significant. The rapid growth of shale oil production was one of the reasons for the sharp drop in oil prices in 2014. J. Romm (2012) thinks that this is a potentially game-changing revelation for one of the fruitful energy policy choices of this decade, which lies in understanding how hard it is to push shale gas in the US and around the world. S. Balmasov (2014) has more pessimistic point of view on the issue, claiming that the "shale revolution" could be another information myth of the West. This statement is supported by an American scientist A. Berman (2012), who says: «*We suspect that the current euphoria about shale gas will follow the path of other energy panaceas including coal-bed methane and tight sandstone gas. Shale gas will remain an important part of the North American energy landscape, but its costs will almost certainly be higher, and its abundance less than many now believe. Producer behavior will be modified by the effect of changing perceptions on capital availability and the entry of new, more substantial players*». Another American scientist, L. Mattar (2008), on the contrary, mathematically proves that there is economic coherence in the development of shale deposits. Also, he models the process of shale gas extraction and makes it clear that investments in this production pay off within 3 years.

Q. Wang (2014) considers that the US shale gas revolution would be curbed, if the environmental risks posed by hydraulic fracturing are not managed effectively. The hydraulic fracturing is water intensive and can cause pollution in the marine environment, with implications for long-term environmental sustainability in several ways. Also, large amounts of methane, a powerful greenhouse gas, can be emitted during the shale gas exploration and production. Hydraulic fracturing also may induce earthquakes. These environmental risks need to be managed by good practices, which are not being applied by any producer in any location. Enforcing stronger regulations are necessary to minimize risk to the environment and human health. Robust regulatory oversight can however increase the cost of extraction, but stringent regulations can foster an historic opportunity to provide cheaper and cleaner gas to meet the consumer demand, as well as to usher in the future growth of the industry. Thomas C. Kinnaman (2011) claims: «*Recent advances in drilling technology have allowed for the profitable extraction of natural gas from deep underground shale rock formations. Several reports sponsored by the gas industry have estimated the economic effects of the shale gas extraction on incomes, employment, and tax revenues. None of these reports has been published in an economics journal and therefore have not been subjected to the peer review process. Yet these reports may be influential to the formation of public policy*».

Benjamin K. Sovacool (2014) notes that if implemented properly, shale gas development can enhance energy security and the availability of energy fuels, lower natural gas prices, offer a cleaner environmental footprint than some other fossil fuels, and enable local economic development. However, in case of poor implementation production can be prone to accidents and leakage, contribute to environmental degradation, induce earthquakes, and, when externalities are accounted for, produce more net economic losses than profits. Weiyao Zhu and Dongxu Ma (2018) based on the use of mathematical methods have proved the efficiency of shale gas production with minimal environmental hazards in the field of mining.

Jiehui Yuan et al. (2015) believe that shale gas, due to its clean-burning and efficient nature, is becoming an increasingly promising alternative energy resource. It is commonly held that promoting shale gas development will gradually play a significant role in meeting the energy needs of economic and social development as well as reducing harm to the environment. Considering the significant implications, many countries are pursuing shale gas opportunities. However, numerous concerns have been raised about the economics of shale gas development, as it is difficult to evaluate. Accurately evaluating the economic viability of shale gas development to reduce investment risks and increase investment opportunity is the key issue that needs to be urgently addressed. From the standpoint of legal support for shale gas development in Ukraine, the conclusions made by A. Macko should be considered (2014). He believes that Ukrainian legislation contains several gaps in regulation of shale gas development. At present, there are no mechanisms for waste water utilization, reclamation of land plots where drilling is carried out, indemnities for local residents for environmental damage, biodiversity conservation, etc. The lack of proper legislative regulation means the actual lack of access to justice for local communities. There is a risk of mass forced expropriation of land plots from members of these communities motivated by social necessity.

2. METHODOLOGY

The methodological basis of the research consists of scientific works on the main aspects of shale gas development in the context of European integration. Publications of domestic and foreign scientists in scientific journals and periodicals, legal acts that regulate the principles and technology of shale gas development in Ukraine, the EU countries and the United States, comprise the information and analytical basis of the study. The statistical base of the article has been prepared based on the official websites and reports of the State Statistics Service of Ukraine and reports of U.S. Energy Information Administration.

To achieve the goal of the study, the following general and specialized scientific methods and tools have been implemented: the abstract method, the logical method and the method of theoretical analysis have been used to determine the specifics of shale gas development; generalization method, system analysis, comparative analysis and abstraction have been applied to study the existing methodological approaches to determining the economic efficiency of shale gas development in Ukraine; graphical method has been implemented to illustrate the total reserves of shale gas in the world and to make the forecast of the possible production of shale gas at the Yuzovsky and Oleskaya fields; synthesis method, specification and analogy have been exploited for calculating the economic efficiency of shale gas development in Ukraine and also for conducting a SWOT analysis of the prospects for shale gas development in Ukraine, determining its environmental threats. To structure the results of the study, descriptive statistical analysis methods have been applied. The purpose of the study is to analyze theoretical, practical, economic, investment and legal aspects of the development of shale gas production in the world and the prospects of Ukraine in this issue.

3. RESULTS

A general definition of the category "shale gas" will be provided to support a detailed analysis of the problem. Shale gas is a natural gas (methane content is up to 95%) contained in small amounts (2-3% volumetric) in low-porous and poorly permeable clay-silty sedimentary rocks at depths of from 1 to 5-6 km. (U.S. Energy Information Administration, 2018). The shale gas with a methane as a main component is a pure, highly efficient energy and chemical raw material, which is mainly used as consumer gas, raw materials for urban heating, electricity supply, automotive fuel production and chemical industry. Horizontal drilling and hydraulic fracturing are used for the extraction of shale gas. Although shale gas is contained in small quantities (0.2-3.2 billion m^3 /

km²), a significant amount of it can be obtained through the opening of large areas. This is still the only economic way to extract shale gas at the present time. According to the American Information Energy Agency (2018), there was a total amount of 200 trillion m³ of shale gas in the world in the beginning of 2017 (Table 1). The table shows that the estimated shale gas reserves, according to a prospective estimate, were up to 50% of the conventional gas reserves in the world. This may indicate the prospects the development of this type of fuel.

Table 1. Conventional and shale gas reserves in the world, trillion m³

Region	Conventional natural gas reserves	Unconventional natural gas reserves			
		Gas of dense rocks	Shale gas	Coal methane	Total
Eastern Europe / Eurasia	144	11	12	20	44
Middle East	125	9	4	-	12
Asia-Pacific Region	43	21	57	16	94
America	47	11	47	9	67
Africa	49	10	30	0	40
Latin America	32	15	33	-	48
Europe	24	4	16	2	22
WORLD	462	81	200	47	328

Source: compiled by the authors based on U.S. Energy Information Administration, 2018

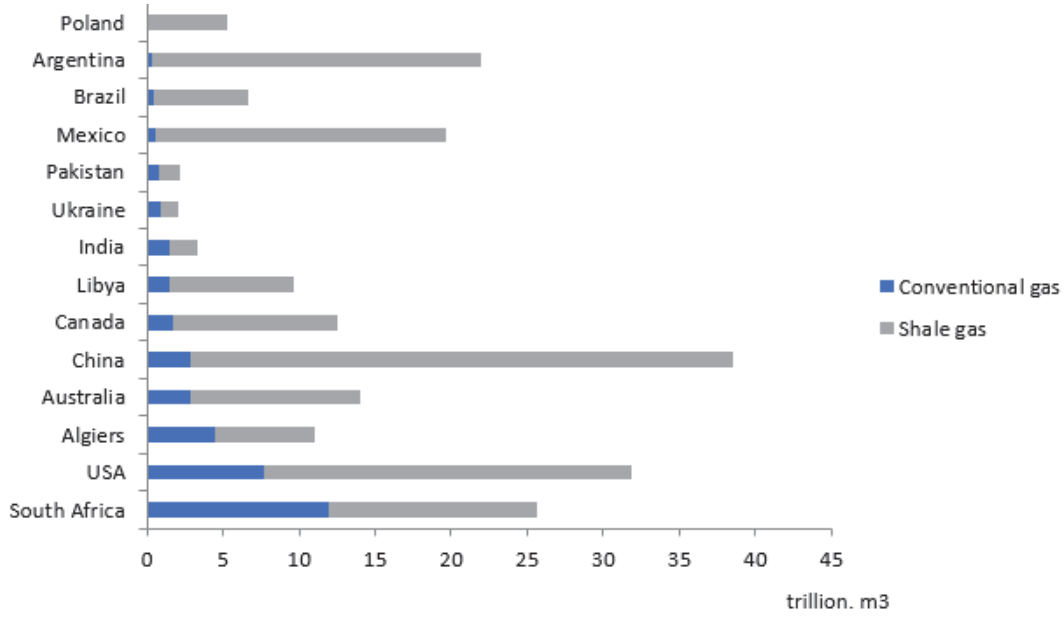

Figure 1. Convection and shale gas reserves in the world

Source: compiled by the authors based on report by National power company «Ukrenergo»

In April 2017, the United States Secretary of Energy released a report on estimation the natural shale gas reserves in the 14 regions of the world most promising for development. It was prepared by the US Energy Information Administration with the involvement of an independent consultant ARI (Advanced Resources International, Inc., 2018). According to the results of the report, world reserves of shale gas suitable for extraction are already equal to the reserves of a conventional one. The research of 48 basins in 32 countries showed that world geological resources of shale gas, excluding Russia, the Middle East, Central and South Asia, could reach 715 trillion m³.

Technically possible volumes for extraction, based on the average world production rate of 25%, are estimated at 187 trillion m³. An increasing number of regions and countries are becoming interested in the development of shale gas. As for the number of projects, the USA, Australia, Canada and China rank first, followed by India, Indonesia, Argentina, South Africa and several European countries, including Poland, Germany and Ukraine. In some countries with the largest deposits of this type of unconventional gas (USA, China, Argentina, Brazil, Mexico, Canada, Poland), its reserves considerably exceed the reserves of conventional gas, as seen from figure 1. In general, the issue of energy security is currently very relevant for Ukraine, primarily because of the high level of energy resources consumption in the country in comparison with other countries of the world and the average income level of the population. Evidences of this statement are provided in the table 2.

Table 2. The ratio of gas consumption and income of the population of Ukraine

Country	Gas consumption, trillion m³	Per capita income, thousands of US$
USA	683,4	42,2
Russian Federation	414,1	6,5
Japan	94,5	36,2
Germany	81,3	37,1
Ukraine	55,0	2,5
Poland	14,3	9,8

Source: compiled by the authors based on report by National Ecological center of Ukraine

Devon Energy launched a large-scale industrial shale gas development in the United States in the early 2000s, which was the start of the "shale revolution". The explored reserves of shale gas amount to 24 trillion m³ in the US (technically accessible for extraction - 3.6 trillion m³) (Technical Paper: Shale Gas Reservoir Characterization Using LWD in Real Time, 2010). The analysis of shale gas production (Figure 2-3) shows that the rate of shale gas development in the United States roughly reminds arithmetic progression, and the production rate increases from 40 to 80 billion m³ annually.

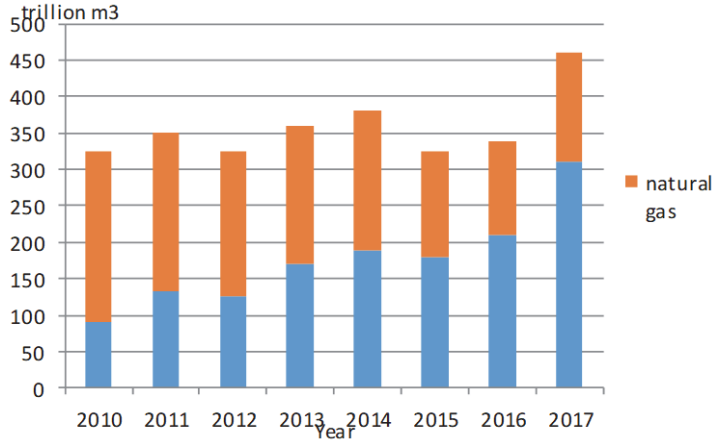

Figure. 2. Total volumes of natural gas production and shale gas production in the USA in 2010-2017

Source: compiled by the authors based on U.S. Energy Information Administration, 2018

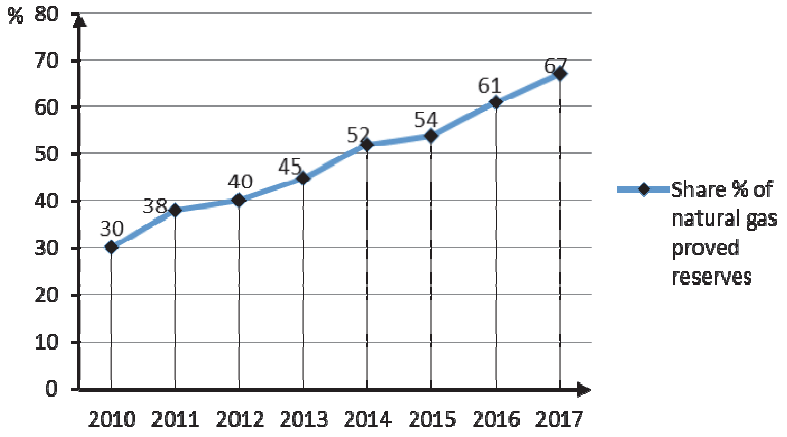

Fig. 3. Ratio of shale gas development to natural gas development in the USA in 2010-2017

Source: compiled by the authors based on U.S. Energy Information Administration, 2018

First, figures show the high level of shale gas development technologies, which have led to drop in prices. It should be noted that such a fall in natural gas prices took place when the costs of other energy sources were rising. In general, the further development of the shale gas industry in the United States will depend on the situation on the domestic energy market, the development of capacities for natural gas exports, the rates of drilling of new wells, their efficiency, regulatory framework development and other factors. The state of shale gas extraction in the EU countries is provided in the table 3, which shows that most EU countries have imposed a ban on shale gas extraction. The main reason for the prohibition is the ecological damage of shale gas extraction technology to the environment and public health.

Table 3. Shale gas development in EU countries

Country	Gas reserves, trillion m³	Industry state
UK	5,5	In 2011, activities suspended because of hydraulic fracturing and seismic shocks. In 2012, shale gas extraction resumed. By 2014, $12 billion have been invested in the industry
Poland	3,3	Since 2012, active production has been stopped due to the lack of economic attractiveness of test wells. In 2013, 46 wells were drilled. In 2014, a test well in the city of Lembork started operation (8 thousand m³ daily). It is planned to investment 12.5 billion euros by 2020
Romania	0,5	In 2010, exploration started. In 2012, a moratorium on the development of deposits was established. On 26.01.2013 the development of deposits began. On 17.10.2013, the development of deposits was stopped because of protest actions. Planned investments in deposits exploration for 4 years account for $ 80 million.
France	6,4	Development and extraction are prohibited. Causes: Environmental risks. High risk to human health and the environment.
Germany	2,3	
Spain	2,0	
Italy	1,4	
Czech Republic	0,9	
Bulgaria	0,4	
Netherlands	0,8	
Sweden	0,2	

Source: compiled by the authors based on report by Ministry of Finance Republic of Poland, 2018

Poland is the most active country to introduce shale gas extraction technology, but at present the results of extraction in Poland are not economically profitable and require significant investment. The shale gas extraction situation in China is worth being analyzed separately. Shale gas has become a new independent type of minerals, which has been recently approved by the State Council of China. China has the largest extractive reserves of shale gas in the world, which are several times larger than in the United States. The table 4 shows the amount of shale gas extraction in China. The first and the only case of attracting a foreign oil and gas company to shale gas production is a production-sharing agreement between the Chinese company CNPC and Shell, which was signed in 2011 and approved by the Chinese government in 2013 (The State Council of People's Republic of China, 2013). The Production Sharing Agreement supposes shale gas extraction in the Sichuan Basin on an area of about 3.5 thousand square kilometers. It should be noted that simultaneously with an increase in own development of shale gas, China signed a 30-year agreement with Russia on the purchase of natural gas, with a supply of up to 60 billion cubic meters per year. This can be interpreted as the uncertainty of China in the real possibility of shale gas extraction within the specified limits to cover its own needs. Conducted research of the economic aspects of shale gas development in the world allows to proceed to the analysis of prospects for shale gas development in Ukraine.

Table 4. Shale gas development in People's Republic of China

Year	Extraction volume	Investments in the industry
2012	50 million m³	By 01.02.2013 $1,14 billion had been invested in the industry. More than 80 wells had been drilled, including more than 20 horizontal ones.
2013	200 million m³	
2014 (planned)	1 billion m³	
2015 (planned)	3,2-6,5 billion m³	
2020 (planned)	30 billion m³	If the water supply problem is solved

Source: compiled by the authors based on report by Ministry of Natural Resources of the People's Republic of China, 2018

It should be noted that by 2018 shale gas development in Ukraine had been completely stopped. Experts provide several reasons to explain this. They include the military conflict in Donbass, the annexation of the Crimea and the crisis in Ukraine's domestic policy. The recovery of shale gas production in Ukraine should begin in 2020, but it is necessary to investigate the economic background of this issue in advance. The main areas of possible shale gas extraction in Ukraine are Yuzsvska gas field (Eastern Ukraine) and Oleska shale gas deposits (Western Ukraine).

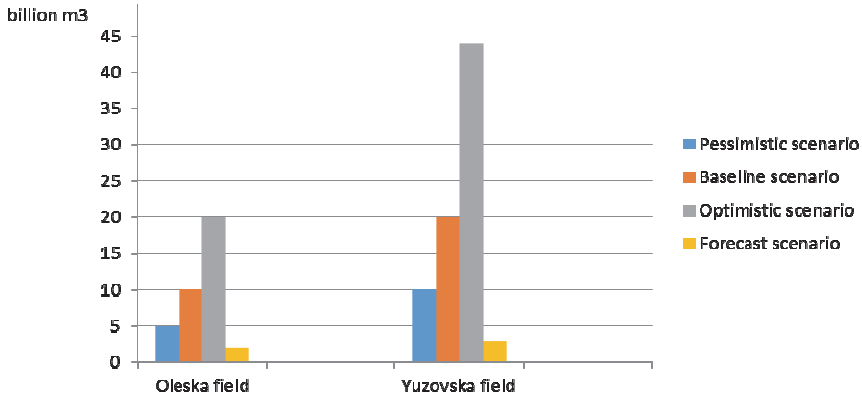

Figure 4. Forecast variants of annual shale gas development in Yuzivska and Oleska fields of Ukraine

Source: compiled by the authors based on report by National Institute for Strategic Studies, 2018

According to the research of various scientific institutions and public services, prospective volumes of shale gas reserves of Ukraine are ranging between 4 and 7 trillion m³. The results have been obtained empirically, based on generalized data on the geological structure of the region and typical indicators of gas content of shale and / or other natural gas containing rocks. Forecast variants of annual shale gas extraction in Yuzovska and Oleska fields are presented in figure 4.

In turn, real reserves assessments can only be conducted after detailed exploration work. Also, they should be primarily based on the results of exploratory drilling and analysis of samples of geological material. According to the pessimistic forecast, Ukraine could rank fourth in Europe by volumes of shale gas production right after Poland, France and Norway. According to the optimistic forecast, Ukraine may hold the first place.

In early 2013, Ukraine signed an agreement with the US company Shell, which was supposed to be engaged in the exploration and production of shale gas in Yuzovska field (the territory of Kharkiv and Donetsk regions). Its area was 7,886 km2. Extraction forecast stood at 8-10 billion m³. Probable reserves were estimated at 4.05 trillion m³. The investment parameters should have the following specifications: $200 million should be spend on exploration and $3.5 billion - on the development of the field. An agreement on product distribution has been signed for 50 years. The initial stage of geological study involves obtaining two-dimensional and three-dimensional seismic data and drilling 15 wells on the Yuzovska field. At the same time, at the initial stage, the Ukrainian party (the state and joint venture Nadra Yuzivska) will receive 35% of the extracted gas. In the future its share will reach 65%. However, Shell is insured: there is an item in the agreement that allows it to export gas to Europe (Unconventional gas in Ukraine, 2018). Conducted economic calculations are presented in table 5. Under the above-mentioned terms of the contract between Ukraine and Shell, a profit margin of $100 will allow Shell to fully return investments in 5 years, and then receive permanent income with the Ukrainian side at 50% for 45 years. It should be noted that is possible under pessimistic scenario.

Table 5. Economy of Shale Gas development on Yuzovska and Oleska Field in Ukraine

	Yuzovska Field		Oleska Field	
Initial conditions	Shell	Ukraine	Chevron	Ukraine
Annual production under pessimistic scenario	8 billion m^3		5,6 billion m^3	
Field development investments	$410 million	-	$350 million	-
Deposit development investments 50/50	$1,75 billion	$1,75 billion	$1 billion	$1 billion
Forecast cost under pessimistic scenario for 1 thousand m^3	200$ thousand m^3		200$ thousand m^3	
Selling price under pessimistic scenario for 1 thousand m^3	300$ thousand m^3		300$ thousand m^3	
Calculation of annual profit				
Total costs	$2,36 billion	$1,75 billion	$1,35 billion	$1 billion
Rate of return 100$ for 1 thousand m^3	8 billion m^3 * $100 for 1 thousand m^3 = $800 million		5,6 billion m^3 * $100 for 1 thousand m^3 = $560 million	
% according to the agreement	65%	35%	50%	50%
Payback period	Up to 5 years	Up to 7 years	Up to 5 years	Up to 5 years
Agreement term – 50 years (The work was suspended on 04.06.2014 due to a military conflict in Ukraine)				
Years	45	45	45	45
Profit distribution	50%	50%	50%	50%
Minimum profit from the deposit	$800 million per year		$560 million per year	
Profit (minimum level)	$400 million per year	$400 million per year	$280 million per year	$280 million per year

Source: compiled by the authors

Because of the military conflict in Ukraine in June 2014, Shell stopped exploration of shale gas fields in eastern Ukraine. According to the Ministry of Energy and Coal Industry of Ukraine, the first volumes of shale gas extraction will appear not earlier than in 3 years (Ministry of Energy and Coal Industry of Ukraine, 2018). Another area of potential shale gas production in Ukraine is Oleska area. On November 5, 2013, Ukraine and Chevron signed an agreement on gas extraction on the Oleska area, which is located within the Lviv, Ivano-Frankivsk and Ternopil regions. The investment parameters are supposed to be following: $350 million for the development and $2 billion to prepare the area for the initial drilling. An agreement on product distribution has been signed for 50 years. 13 exploratory wells are expected to be drilled at the stage of geological study (Unconventional gas in Ukraine, 2018). Conducted economic calculations are presented in table 5. Under the above-mentioned terms of the contract between Ukraine and Chevron, a profit margin of $100 will allow Chevron to fully return investments in 5 years, and then receive permanent income for 45 years. It should be noted that is possible under pessimistic scenario.

It should be emphasized that in order to reach the specified volumes of extraction, it is necessary to drill approximately 1000 wells, which will require about 200 sites with an area of from 1 to 3 hectares. By the way, considering that the drilling of one well takes 3 months, a creation of a given number of wells will require 20 modern drilling machines working for 12,5 years. In general, conducted economic calculations show that the issues of economic fairness of these agreements in the context of energy security for Ukraine remain open. It is worth noting that the Chevron project in Ukraine was also suspended in 2014 alike the Shell one. Suspension of shale gas production as well as other energy carriers, that are hard to extract, was not only Ukrainian but also a global trend in 2014. Resumption of production is possible due to the increase in the cost of "classical" energy sources, which is expected in the coming years. According to the (fi.news), shale gas extraction in Ukraine will be expedient when a natural gas price reaches $265-365. There is SWOT-analysis carried out in order to implement the program of shale gas extraction in Ukraine (table 6). The strengths of shale gas extraction for Ukraine are following: reduction of dependence of the country on imported gas; new workplaces creation; proximity to the sales markets; availability of own energy source.

Table 6. SWOT-analysis of prospects for shale gas development in Ukraine

Strengths	– reduction of dependence of the country on imported gas; – new workplaces creation; – proximity to the sales markets; – availability of own energy source; – opportunity to export gas.
Weaknesses	– climate change (environmental catastrophe) – water pollution; – air pollution; – removal of large land areas from economic use; – significant investments.
Opportunities	– country provision with own gas; – extraction of shale gas in the country will lead to savings on the money paid for imported gas; – opportunity for economic growth; – energy security.
Threats	– technological dependence on the USA; – need of significant investments; – hydraulic gap of layers; – greenhouse gases; – short operating period of wells; – earth surface deformation; – reduction of territory seismic stability.

Source: compiled by the authors

There are several main reasons for the lack of acceptance by the local population unconventional gas development in Ukraine (National Institute for Strategic Studies, 2018):

- high "politicization" of energy supply issues, which pushes interested parties to create "necessary public moods";
- insufficient transparency in the issues of technology development of individual companies - applicants, lack of operating experience in Ukraine;
- lack of information among the population and non-governmental organizations that are inclined to support propagandistic stereotypes;
- the lack of appropriate explanatory and scientific-experimental work on the unconventional gas problems by central authorities in work with local governments, institutions of the National Academy of Sciences, citizens and non-governmental organizations;
- the lack of adequate mass informing of the population in the places of potential development by companies claiming for subsoil use and official government structures.

Also, there is a significant disadvantage of shale gas production, which, in fact, pushed Europe to impose a moratorium on extraction. It is the threat to the ecology of Ukraine. A detailed analysis of the environmental risks of shale gas development in Ukraine is given in table 7 (V. Koziuk et al 2018; S. Kozlovskyi, 2010).

Table 7. Environmental aspects of shale gas development in Ukraine

Problems	Yuzovska Field	Oleska Deposits
Use and protection of water resources	1. Very large volumes of water are required. Its reserves are insufficient in this area (the river Siversky Donets provides drinking water to a large part of the population of Kharkiv, Donetsk and Luhansk regions). 2. The part of Kharkiv and Donetsk region that does not have enough water resources may lose its strategic groundwater reserves (about 10 kilometers separates the site of the first freaking drilling from the Krasnopavliv reservoir, from which one third of Kharkiv gets water).	1. Very large volumes of water are needed. Its reserves are insufficient in this area. 2. Absence of waste water discharge points. 3. Ukrainian legislation prohibits drilling of oil and gas wells and discharges of wastewater in the zones of sanitary protection of water intakes (the problem of providing water supply in Lviv and possible contamination of the mineral water deposit "Oleska").
The threat to the natural reserve fund of the Carpathians		The attractiveness of the tourist and recreation complexes of Western Ukraine will be lost (balneological resorts Slavyansk and Svetlogorsk will be destroyed; the village sanatorium "Salt Symphony" and the unique salt deposit of Soledar may also be destroyed).
Seismicity, geological stability	1. Landslide danger 2. Areas cannot stand seismic activity, used construction technologies and materials may not withstand the shocks that are formed in the earth during hydro-breakdown of the layers.	1. The areas are characterized by increased seismicity and significant tectonic disturbance. The use of fracking can unpredictably cause earthquakes. 2. Under above-mentioned conditions of tectonic disturbance application of fracking can lead to loss of screening properties of watertight strata and uncontrolled distribution of fracking liquids and gases in the geological environment.

Lack of Ukrainian environmental standards for most chemical reagents	Horizontal drilling and shale gas wells operation require toxic chemical reagents. In normative acts of most developed countries, which have not yet banned the use of fracking, companies are required to fully disclose the composition of fracking liquids. In Ukraine, there is no such requirement in the legislation, therefore, in case of an accident or deliberate pollution of the environment, it will be almost impossible to convict the companies that apply fracking.
Technogenic	Each gas well is an object of increased explosion and fire hazard. A fracking well also supposes additional chemical danger. If an accident occurs during hydraulic fracturing, several tons of fracking substance will be released to the air. The question of neutralization and liquidation of probable consequences is still open.
Transportation	Fracking liquid or its components are to be transported over long distances (in some countries, temporary pipelines were used for this in the past). Ukraine has no legislative restrictions on the transportation of fracking liquids or its components.
Methane losses	Hydraulic fracturing is an almost uncontrolled process that can only be calculated based on the theory of probability. At the same time, there is always a certain probability that the process will go the other way, that the structure of the underground rocks differs from the one calculated, etc. Consequently, some cracks in compacted sandstones can reach the upper boundary of their occurrence. These cracks may coincide with similar cracks in other rocks. Thus, natural gas gets to the surface not through the well, but through random openings, which creates the danger of fire and explosions, poisoning of people and animals.
Artesian waters pollution	Artesian waters are one of the greatest treasures of Ukraine. Shale wells are characterized by excessive depth: 3.5-5 kilometers. Thus, they will cross even the deepest aquifers for sure. This technology will destroy the reserves of Artesian waters of Ukraine.

Source: compiled by the authors

Finally, regarding the environmental problems of shale gas extraction in the EU, several countries have already imposed a moratorium on the use of hydraulic fracturing technology (fracking) for the extraction of non-conventional gases. Either they had witnessed the catastrophic consequences of this method or they are just aware of the high degree of risk. In September 2013, the Congress of the International Union for the Conservation of Nature adopted Resolution No. 118 (Ecologia ta pravo, 2018) encouraging states to suspend the issuance of licenses for the production of gas with hydraulic fracturing method and to prohibit its use near drinking water sources, in seismic hazardous areas, in areas with a shortage of water, near seismic faults and in protected areas. More than half of the existing reserves of conventional natural gas in Ukraine has already been extracted. In order to reduce the dependence on Russian fuel, the government is planning to produce shale gas. Due to the attraction of large foreign oil and gas companies to extraction of unconventional types of natural gas, Ukraine will become more energy and therefore politically independent. On the one hand, citizens are concerned about the danger of gas extraction technologies for their health and the environment, on the other hand, there is a willingness to become independent from Russian gas consumption at any cost. The hydraulic fracturing is a controversial method for extracting shale gas. It can be safe if implemented with careful security and proper process management.

At present, industrialists are seeking alternative methods of hydraulic rapturing to replace chemicals, which is caused by public protests. Thus, a group of Austrian scientists proposes to replace toxic substances under high pressure in gas-bearing layers on a mixture of starch, water, sand and corn. Such a study could be conducted, for example, in Ukraine or Poland, where shale gas development is a relevant issue. Unfortunately, today there is no hydraulic fracturing technology that does not require the use of chemicals. In order to study all the risks of such hydrocarbon production and changes in domestic legislation in accordance with the requirements of international environmental standards, it is necessary at least to create a joint commission of representatives of the extracting company, experts, local authorities, public organizations and all interested

parties. Such a commission would study the experience countries that are already producing hydrocarbons with the use of the fracking method. The commission would also create a relevant public agreement that would take into account Ukraine's specifics, wishes and suggestions of all interested parties and local communities in the extracting areas at the first place. After all, despite all the economic and political benefits of shale gas development (cheapening of gas, removing dependence on foreign supplies, etc.), its extraction can cause a significant violation of long-established ecosystem, violate the right of Ukraine's inhabitants to a safe environment, and become a factor of significant social shifts, migration processes, etc.

It is necessary to conduct an active proactive company of informing local communities about the advantages and risks of the process of exploration and extraction of shale gas. Local governments should receive complete and reliable information on this issue and, in accordance with the Laws of Ukraine "On the protection of the environment" of 1991, "On Local Self-Government in Ukraine" of 1997 and Decrees of the Cabinet of Ministers of Ukraine "On Approval of the Procedure for Involving the Public on the Issues of Decision Making that May Affect the State of the Environment" of 2011 to ensure the formation of a conscious position of local communities. Considering the high level of risk and the serious negative effects of extraction, as well as the lack of adequate regulation and protection mechanisms, the shale gas development in Ukraine requires a thorough research. Under conditions of associate membership in the EU, Ukraine has to comply with Articles 35-37 of the Charter of Fundamental Rights of the European Union, 2000.

CONCLUSION

According to the data of European Commission, fracking is a highly risky activity that affects people's health and the environment. Scientists from the EU have proved that the process of shale gas extraction is risky for the environment. The leak of methane and highly toxic carcinogenic chemicals is virtually inevitable and affects the quality of air, water and soil, creating serious threats to human health. Many of these effects are of a non-temporary nature and are manifested not only locally. They have impact at the regional level, and even globally. Also, in the case of water and air pollution, there is a threat to future generations.

Considering insufficient geological exploration of shale gas deposits in Ukraine, it is necessary to conduct in-depth research with the aim of clarifying the conditions of extraction and forecasting the consequences of extractive activities. For this purpose it is expedient to identify the areas of priority extracting works as experimental industrial sites, within which the following forward-looking research complex should be carried out: geophysical parameters of the gas-producing area; study of the gas-geochemical field, geochemical indicators of landscapes within the zone of potential impact of the polygon; analysis of materials of remote sensing of the Earth and determination of the presence of activity of geological structures; carrying out of high-frequency engineering-geodetic researches for estimation of possible changes of the explosions surface; estimate of the number of experimental industrial wells, the volume of energy use during hydraulic fracturing as a source of man-made earthquakes; determination of the structure and composition of the ecological monitoring systems of the landfill and zone of influence of shale gas extraction and its interaction with the existing system of eco-monitoring.

It is necessary to prepare the necessary infrastructure: if the industry development follows an optimistic scenario, there will be a need for the drilling of a large number of wells each year (several hundreds and more), the territorial displacement of extraction areas and engineering infrastructure (access roads, technological water pipelines, etc.), modernization of existing gas pipelines and new construction to meet local needs; access to water supply, drainage and water treatment systems, as well as construction and modernization of enterprises for cleaning and storage of waste with sufficient capacity. The first cubic meter of Ukrainian shale gas will be extracted not earlier than in 2021. Thus, considering the environmental threats and political battles, this problem

should be finally solved in future. Therefore, it is not necessary to speed up the process. It is crucial to analyze all the pros and cons and listen to unbiased scholars and experts. The future of the state and the welfare and health of its citizens depend on this issue, while every mistake or miscalculation can be fatal.

All in all, the shale gas extraction as an alternative to natural gas and the way of reaching political independence from Russia is a totally right decision. However, before starting this new and specific economic activity, all institutes of public administration in Ukraine must conduct a preparation in advance. It includes many years of making changes in domestic law. Now, after the signing of the relevant agreements, the main task for Ukraine is to improve and amend the national legislation, using more than 60 years of international experience of the USA on advanced technologies for successful shale gas extraction on the territory of Ukraine.

REFERENCES

Advanced Resources International, Inc. (n.d.) (2018), available at: https://www.adv-res.com

Balmasov, S. (2014), «Algerian Shale Revolution», available at: http://www.vz.ru/opinions/2014/6/20/692021.html (in Russian).

Benjamin K. Sovacool (2014), «Cornucopia or curse? Reviewing the costs and benefits of shale gas hydraulic fracturing (fracking)», *Renewable and Sustainable Energy Reviews*, Vol. 37, pp. 249-264, available at: https://doi.org/10.1016/j.rser.2014.04.068

Berman, A. E. (2012), «U.S. Shale Gas: A Different Perspective on Future Supply and Price», *Bulletin of the South Texas Geological Society,* Vol. 52, No. 6, pp. 19-44.

Chen, C. (2015). «Prospects for the "shale revolution" and the Russian-Chinese energy dialogue», *Bulletin of Peoples' Friendship University of Russia*, Vol. 3, pp. 90-98 (in Russian).

China Geological Survey. China Shale Gas Resources Survey Report (2014), available at: http://www.cgs.gov.cn/upload/201506/20150610/20150624093321310.pdf

Ecology right people (2018), available at: http://epl.org.ua (in Ukrainian).

Energy Information Administration (2018), available at: https://www.eia.gov/ natural-gas/crudeoilreserves/

Galeeva, A. R., Gaziniva, O. V. (2014), «Shale gas: a revolution in the global commodity market», *Bulletin of Kazan Technological University*, Vol. 12(17), pp. 157-161 (in Russian).

Halina, E. S. (2016), "The influence of the 'shale revolution' on the energy policy of the European Union and Russia at the beginning of the 21st century", *Vestnik RGGU*, Vol. 3, No. 5, pp. 83-93 (in Russian).

Jiehui, Y., Dongkun, L,, Lianyong, F, (2015), «A review of the technical and economic evaluation techniques for shale gas development», *Applied Energy*, Vol. 148, pp. 49-65, available at: https://doi.org/10.1016/j.apenergy.2015.03.040

Kaletnik, G. M., Zabolotnyi, G. M., Kozlovskyi, S. V. (2011), «Innovative models of strategic management economic potential within contemporary economic systems», *Actual Problems of Economics*, Vol. 4, No. 118, pp. 3-11.

Kalinichenko, A. V. (2013), "Environmental risks of shale gas extraction on gas fields of Ukraine", *Bulletin of the Poltava State Agrarian Academy*, Vol 2, pp. 127-131.

Kinnaman, T. C. (2011), «The economic impact of shale gas extraction: A review of existing studies», *Ecological Economics*, Vol. 70, No. 7, pp. 1243-1249. https://doi.org/10.1016/j.ecolecon.2011.02.005

Koziuk, V., Dluhopolskyi, O., Farion, A., Dluhopolska, T. (2018), «Crony sectors as a barrier to economic well-being and ecologization (case of Ukraine)», *Economics & Sociology*, Vol. 11, No. 3, pp. 113-132, https://doi.org/10.14254/2071-789X.2018/11-3/7

Kozlovskyi, S. V. (2010), "Economic policy as a basic element for the mechanism of managing development factors in contemporary economic systems", *Actual Problems of Economics*, Vol. 1, No. 103, pp. 13-20.

Kozlovsky, S., Fonitska, T. (2013), "Modern theoretical and methodological approaches to the budget management system forming", *Economic Annals-XXI*, Vol. 3-4, pp. 35-37.

Kozlovskyi, S. V., Gerasymenko, Y. V., Kozlovskyi, V. O. (2010), "Conceptual grounds for construction of support system for investment decision-making within agroindustrial complex of Ukraine", *Actual Problems of Economics*, Vol. 5, No. 107, pp. 263-275.

Kozlovskyi, S., Shaulska, L., Butyrskyi, A., Burkina, N., Popovskyi, Y. (2018), "The marketing strategy for making optimal managerial decisions by means of smart analytics", *Innovative Marketing*, Vol. 14, No. 4, pp. 1-18, https://doi.org/10.21511/im.14(4).2018.01

Koziuk, V., Dluhopolskyi, O., Hayda, Y., Shymanska, O. (2018). Typology of welfare states: quality criteri a for governance and ecology. Problems and Perspectives in Management, 16 (4), 235-245. https://doi.org/10.21511/ppm.16(4).2018.20

Law of Ukraine «*Charter of Fundamental Rights of the European Union*», No. 994_524, 07.12.2000, available at: https://zakon.rada.gov.ua/laws/show/994_524

Law of Ukraine «*About the protection of the environment*», No. 91, 1991, available at: http://zakon.rada.gov.ua/laws/show/1264-12

Law of Ukraine «On Local Self-Government in Ukraine», №24, 1997, available at: https://zakon.rada.gov.ua/laws/show/280/97-вр

Law of Ukraine (2011), «On Approval of the Procedure for Involving the Public on the Issues of Decision Making that May Affect the State of the Environment», No. 771, available at: https://zakon.rada.gov.ua/laws/show/771-2011-п (in Ukrainian).

Lee, W. J. (2010), "Gas Reserves Estimating in Resource Plays", *Paper SPE 130102, presented at the SPE Unconventional Gas Conference in Pittsburg*, February, 23-25.

Macko, A. S. (2014), "Legal regulation of shale gas extraction in Ukraine in the context of environmental protection", *Zovnishnia torgivlia: economica, finansi, parvo*, Vol. 4(75), pp. 34-45, available at: http://zt.knteu.kiev.ua/files/2014/4(75)/uazt_2014_4_5.pdf (in Ukrainian).

Mattar, L. (2008), 2Production Analysis and Forecasting of Shale Gas Reservoirs: Case History-Basd Approach", *Paper SPE 119897, presented at the Shale Gas Production Conference*, November, 16-18, available at: http://www.pe.tamu.edu/blasingame/ data/z_Rate_Time_Spreadsheet/z_References/SPE_119897_(Mattar)_Prd_Anl_y_Focst%20_Shale_Gas_Hist_Based_Ap_(wPres).pdf

Ministry of Natural Resources of the People's Republic of China, Official site, available at: http://www.mlr.gov.cn

Ministry of Energy and Coal Industry of Ukraine, Official site, available at: http://mpe.kmu.gov.ua

National power company «Ukrenergo», Official site, available at: https://ua.energy/wp-content/uploads/2018/01/4.-Osvoyennya-vydob_netr_gazu.pdf

National Institute for Strategic Studies, Official site, available at: http://www.niss.gov.ua/content/articles/files/slanets-19b15.pdf

Romm, J. (2012), "Bombshell Study: High Methane Emissions Measured over Gas Field "May offset Climate Benefits of Natural Gas", *ThinkProgress*, available at: https://thinkprogress.org/bombshell-study-high-methane-emissions-measured-over-gas-field-may-offset-climate-benefits-of-decf0bf388da/

Technical Paper: Shale Gas Reservoir Characterization Using LWD in Real Time (2010), *Schlumberger*, available at: https://www.slb.com/resources/ technical_papers/drilling/137607.aspx

The State Council the People's Rebublic of China (n.d.). Official site, available at: http://english.gov.cn/

United States Secretary of Energy, available at: www.doe.gov

Wang, Q., Chen, X., Jha, AN, Rogers, H. (2014), "Natural gas from shale formation – The evolution, evidences and challenges of shale gas revolution in United States2, *Renewable and Sustainable Energy*, Vol. 30, pp. 1-28, https://doi.org/10.1016/j.rser.2013.08.065

Weiyao, Z., Dongxu, M. (2018), "Effective stress characteristics in shale and its effect on shale gas productivity", *Journal of Natural Gas Geoscience*, Vol. 3, No. 6, pp. 339-346.