Vlada S. Markovska[1]

SHALE GAS MARKET IN NORTH AMERICA COUNTRIES

The article demonstrates the leading role of the energy sector in North America economies. Possible ways of the energy market diversification are presented, especially due to the shale gas extraction. A thorough analysis of valid deposits in the USA and Canada is performed.
Keywords: *energy sector; diversification; shale gas; North America.*
JEL Classification: F14.

Влада С. Марковська

РИНОК СЛАНЦЕВОГО ГАЗУ В КРАЇНАХ ПІВНІЧНОЇ АМЕРИКИ

У статті відзначено високу роль енергетичного сектору в економіках Північної Америки. Велику частину статті присвячено можливим шляхам диверсифікації енергетичного ринку, особливо завдяки видобутку сланцевого газу. Проведено ґрунтовний аналіз родовищ США та Канади.
Ключові слова: *енергетичний сектор; диверсифікація; сланцевий газ; Південна Америка.*
Літ. 16.

Влада С. Марковская

РЫНОК СЛАНЦЕВОГО ГАЗА В СТРАНАХ СЕВЕРНОЙ АМЕРИКИ

В статье отмечена высокая роль энергетического сектора в государствах Северной Америки. Большая часть статьи посвящена возможным способам диверсификации энергетического рынка, особенно добыче сланцевого газа. Проведен фундаментальный анализ месторождений США и Канады.
Ключевые слова: *энергетический сектор; диверсификация; сланцевый газ; Северная Америка.*

Problem setting: In order to protect the national interests, pulling the economy out of the consequences of the crisis and ensuring energy security it is necessary to find new strategic ways for possible energy market diversification. One of the most effective way for North America in particular is the unconventional gas extraction, for example, shale gas.

Latest researches and publications analysis. The essence of energy security and shale gas was explored by domestic and foreign scientists, in particular, by Geller and Melnikova (2010), Boyer, Kieschnick, Suarez-Rivera, Lewis and Walter (2006), Ambrose, Potter and Briceno (2008) etc.

The research objective is to determine the peculiarities of the North America energy market and find possible ways for its further diversification. Consequently, to provide a solid analysis of unconventional shale gas field in North America.

Key research findings. Production of natural gas from shale formations, rich in hydrocarbons compounds, and known as "shale gas", is one of those trends that are most rapidly developing today in Americas. Thus, in some areas it has brought capacity to develop energy sector where this has never happened in the past. New oil and gas development have brought changes to social and economic environments, particularly, in the areas where the development of the gas industry brought in new activities. Therefore, consideration of this vector, with all its features, is especially important.

[1] Institute of World Economy and International Relations of the National Academy of Sciences of Ukraine, Kyiv, Ukraine.

So, it is necessary firstly to explain the role of the traditional (natural) gas market as such and proceed later to the explanation of the shale gas market as an unconventional one.

In the United States and Canada the role of the former is valuable, because it is satisfying the big share of demand for energy resources. Thus, in the aggregate for natural resources, including oil, coal and natural gas, supply is 85%, in which the share of natural gas is 22% (International Energy Agency, 2008). Interestingly in marked areas percentage contribution of natural gas in energy supply is expected to be stable over the next 20 years.

So, considering, for example, the United States of America, it is worth noting that there are concentrated emergency supplies of energy resources. According to the International Energy Agency, the share of natural gas is 49,38 trln m^3 of technically extracted gas, including 5,975 trln m^3 of the proved reserves, in which the share of unconventional gas (shale gas, tight gas reservoirs, coal bed methane) is approximately 60% (International Energy Agency, 2008). According to specialists within the industry, these stocks will last for another 90 years. However, it is not possible to ignore the fact that historically the number of stocks is variable, because there are always new technologies to get resources. An example of such fast developing trend is unconventional gas resources trend, shale gas including.

In general, natural gas is supplied for almost all sectors of the economy, providing them with sustainable development. Thus, households account here for 20%, industry – 35%, electricity – 29% and commercial area – 13% (International Energy Agency, 2008).

So, given the vital importance of this resource, it is necessary to understand its essence. Natural gas is a combination hydrocarbon gas consisting mainly of methane (CH4) and smaller particles – butane, ethane, propane and other gases (Lapidus, Krylova and Tonkonogov, 2000: 82–88; www.naturalgas.org, 2012). It does not smell, and when lights, provides a significant share of energy. Companies in mining are carefully studying its deposits, using a sophisticated technology to detect natural gas clusters in order to meet the needs of the population and industry. This raises the question: why natural gas, rather than any other resource?

Thus, in the 1800s and early 1900s, natural gas was mainly used to light streets and homes occasionally. However, with the rapid change of technologies, supply chain, the rapid development of its usage was gained in this sphere (Energy Information Agency Department, 2012).

There were several reasons for this: its reliability (84% of the natural gas consumed on the territory of both Americas is also produced there); in the process of natural gas combustion the amount of harmful substances is the least among other fuels (www.naturalgas.org, 2012).

However, not looking to the positive aspects of the natural gas usage, it is worth mentioning that the above fuel consumption of those type economies exceed their ability to extract them in their own territories. And there is a tendency to increase this gap (Energy Information Agency Department, 2012). For example, half of the natural gas consumed in the United States today is produced from wells that were drilled 4 years ago (Independent Petroleum Association of Mountain States, 2010). And, despite the high level of resources possession, natural gas requires constant replenish-

ment. It was calculated that the level of the gap between domestic demand and consumption will increase by almost 0,25 bln m^3 in 2025 (Ambrose et al., 2008). In addition, the world market of this resource is increasing every day more and more, prices are rising, so the possibility of increasing its own energy security appears highly relevant. So, given all the above mentioned factors, we should refer to the detailed consideration of the unconventional gas sector.

According to the reports in the United States in the period from 1970 to 2011 gas reserves increased by almost 10%. This increase, at constant consumption, indicates improving technology for the extraction and transfer of resources of economically disadvantageous and failed to the category of proven reserves (North American Natural Gas Association, 2008). The biggest infusion to the total volume of proven gas reserves was made by unconventional gas: shale gas, tight gas reservoirs, coal bed methane fields, especially since 2008. So the growing trend for unconventional gas resources is indeed the case. That is the reason why it is necessary to elaborate on the factors that have contributed to this revival.

The first and the most fundamental factor is that technology has greatly progressed on the American continent, and therefore things such as horizontal drilling, are no longer something new. Second is the technological one: for shale gas extraction hydraulic fracturing should be used, which was impossible to implement. And finally, the third factor – the steady upward trend in prices and the growing demand, which both cause the desire to reduce dependence on these factors for sustainable energy security in the region.

However, before reaching economic profits, this field should be fundamentally explored, including the characteristics of the resources and their location. As it was already noted, shale gas is the natural gas extracted from shale formations. Mostly, these formations serve as reservoirs and sources of natural gas. In terms of chemical terminology, shale gas is typically dry type gas that consists of more than 90% of methane while some formations are producing wet gas. The US examples of such deposits are Antrim and New Albany (Boyer et al., 2006).

In general, shale is a sedimentary rock composed mostly of consolidated clay particles, its location is in the deposits with low power characteristics. During the process of penetration dirt organic nature can also be formed: algae, particles of animal or vegetable origin. However, all this creates flat sedimentary clay rocks, which have limited horizontal penetration and more limited vertical one (Freeze and Cherry, 1979).

Poor availability of this resource leads to naming it "unconventional gas resources". However, there are several other factors that distinguish this group separately.

Traditional gas accumulation can be described as following: in the wells from which traditional gas is produced, those is accumulated from such sands and carbonates (limestone and dolomite) containing gas in porous interconnected planes. In addition, these planes in their structure are similar to a kitchen sponge as gas moves through the narrow mouth of one season to another, creating flow throughout the tank.

Instead in unconventional formations generation process and production looks different: gas extracted from dense rocks, such as gas tight reservoirs, carbonate,

shale, coal, forming a separate thread. However, to achieve this, it is necessary to resort to incentives, such as hydraulic fracturing in the case of shale gas.

After all of the abovementioned, it is also worth paying attention to the basic parameters that characterize every single play – the same type built deposits, exploration of which is made with the identical methods and technical means.

So shale play is characterized by the following parameters: clay content (up to 50%); soil organic matter (less than 1%); maturity of organic matter in the shale rocks (values less than 1); porosity (not less than 3%); depth location; area of distribution; productivity (measured in flow rate – the amount of extracted methane reserves per well) (Energy Information Agency Department, 2012).

Field development begins immediately after expert verification of the abovementioned characteristics.

In North America countries first fundamental steps in this direction were undertaken about 20 years ago, but that does not mean that by this time shale gas was unknown. The first gas well in production of this fuel was discovered in 1821 near Fredoniya, NY (Harper, 2008). Gas from it was used for street lighting. The extraction was carried out with small holes that do not require sophisticated technology of drilling, or places where natural gas was seeping through to the earth's surface. Volume of gas allocated in this way was extremely low, however, played a role in lighting cities.

Later, other wells began to appear, such as large sand quarry in Kentucky in the 1920's. Now this play is experiencing a new period of rapid development, and reaches its area of about 7772 km^2. Another deposit is the Barnett Shale one. There in 1986, for the first time the hydraulic fracturing technology was used. Just as the first horizontal well was drilled in the same play in 1992. Development of other deposits was caused by the development of similar and more complex technologies: the Earth's surface multi-fracturing, 3-D GEO seismic modeling etc. which provoked a breakthrough in this field (Energy Information Agency Department, 2012).

So, today on the territory of the US shale gas is represented in 48 states. The most actively developed are the following plays: Barnett Shale, the Haynesville / Bossier Shale, the Fayetteville Shale, the Antrim Shale, the Marcellus Shale and the New Albany Shale. Each has its own unique characteristics and features. For example, the deposit of the Antrim Shale is at the stage of the development and production of gas produces there extremely large amounts of water; others possess also interesting features (Energy Information Agency Department, 2012).

As mentioned above, the first largest modern play is the Barnett Shale, located in Fort Worth Basin in north-central Texas. This deposit is at the depth from 1983 to 2593 m (Frantz and Jochen, 2005). On both sides it is surrounded by limestone savings: Marble Falls and Chappel. Despite the fact that in this play as far it was drilled more than 10,000 wells, it remains one of the most prominent and promising. The area occupied by this field is 12955 km^2, besides saturation gas extracted from it is one of the largest, and that entails a high level of activity in this area (Railway Texas Commission, 2009).

Next play, deserving thorough consideration, is Fayetteville Shale. It is located in the basin of Arkoma, northern Arkansas and eastern Oklahoma. Depth ranges from 300 to 2134 m. on the one hand, it is surrounded by sediment deposits of limestone,

and on the other, by the residue of sandstone: Pitkin and Batesville. The development of this play was launched in 2000, because that was the moment when scientists and energy industry experts have found similarity in geological characteristics of Barnett Shale and Fayetteville Shale, provoking its rapid development: every year the number of new wells ranged from 13 to 600 pieces. For its size Fayetteville Shale significantly outpaced Barnett Shale, because of the total area of almost 2 times more – 23318 km^2. However, by gas filling, this area is still far from Barnett Shale: the volume of shale gas extracted here from 1699 to 6230 m^3 per ton, which is 8495–9911 m^3 per ton less (Energy Information Agency Department, 2012).

Another interesting place is the Haynesville field or, as it is called, the Haynesville/Bossier Shale. It is located in the Salt Basin of northern Louisiana and eastern Texas. Depth resource: from 3200 to 4115 m, this is narrower than the previous two fields and deep enough. As in the case with other fields, its territory is surrounded by limestone and sand princes: Cotton Valley Group and Smackover Formation. The Haynesville has an area approximately 23318 km^2, which is a rectangle that is almost 100 m in length and 60 m in width. To date, technically extracted amount of resources is at the level of 7108 m^3, however, the total is 20,303 m^3 (Energy Information Agency Department, 2012).

Marcellus Shale is the most extensive shale gas play, because the area stretches here in 6 northeastern states (National Oil and Gas Assessment, 2008). Its area is 246,136 km^2. It should be noted, that after the increase of gas prices caused by the Act in Gas Policy (1978), the development of this field has experienced a positive trend, especially in the early 1980s. However, after gas prices started declining, the huge number of wells drilling has become uneconomical. After a pause, in 2003 the revival of this territory began. But the first results of this field were only in 2005. For today there are about 400 wells on its territory. Experts estimate that the total potential shale gas from this play, can reach almost 50000 m^3 (National Oil and Gas Assessment, 2008).

Another field worth mentioning is called The Woodford Shale. It is located in south-central Oklahoma, the depth of the resource varies from 1829 to 3353 m. It is deep enough for this type of fuel. On the one hand, there is the calcareous sediment, and on the other – undifferentiated formation. Development of this area began relatively recently – in 2003–2004, but it is interesting that the vertical drilling is used there instead of the horizontal one. The total area of this play is approximately 28500 km^2. It is important to note that this field is one of the most successful in setting the saturation gas: yet, it is removed from 5663 m^3 of gas per ton to 8,495 m^3 per ton, which is quite high (Energy Information Agency Department, 2012).

One of the most advanced and well-studied field is The Antrim Shale. Its location is Upper Peninsula of Michigan, located in the Michigan basin. Like other fields, it is surrounded by limestone sediment on one side, and by shale formations on the other: Squaw Bay and Bedford. The depth of shale gas ranges from 183 to 671 m. The area of the field is more than 30000 km^2. It is necessary to pay attention here to the fact that due to its characteristics, this play is fundamentally different from the others: it has a shallow depth of resources, small stratigraphic thickness and extremely

large volumes of water removed during drilling (Hayden and Pursell, 2004). Gas filling in this field is at the level of 1133 m^3 per ton to 2,832 m^3 per ton, which is a pretty good indicator (Energy Information Agency Department, 2012).

And finally, the last play in the United States, known to date, is The New Albany Shale. It is located in the Illinois Basin, in particular in the part of southeastern Illinois, southwestern Indiana and northwestern Kentucky. In all the parameters that play has similar characteristics with the Antrim Shale. The depth resources are ranging from 152 to 607 m. On both sides of this play there are calcareous sedimentary rocks: Rockford and North Vernon. As previously mentioned in The Antrim Shale description, here specialists receive additional bonus in the form of large amounts of water. On its size, it is necessary to point out that it is one of the largest – 112704 km^2. According to experts, the average extraction of useful substance is from 1,133 m^3 per ton to 2,267 m^3 per ton, which is not the highest rate to date, especially in comparison with other fields (Energy Information Agency Department, 2012).

The next group of fields are located in Canada. Among the main it is necessary to mention the following: Maritimes, Muskwa, Cordova, St. Lawrence Lowlands, Horn River, Montney, Colorado Group.

In general, there should be noted that the development of unconventional gas in this country is not a new issue. For quite a long period tight gas reservoirs, gas hydrates, shale gas, carbonates and coal bed methane gas deposits were explored.

Towards the shale gas there is a significant recovery. Just as on the territory of the United States, this situation is caused by the rise of technology of this resource extraction: seismic modeling 3D GEO, appearance settings that allow horizontal drilling – all of them played a key role.

Looking to another side, it is necessary to point out the Horn River Basin deposit and Cordova Embayment. Here it would be better to focus on the fact that, although it belongs to the recently opened, the total potential reserves, estimated by specialists, are at 9,000 bln m^3. However, there are some difficulties that arise with the development of this play. Due to high occurrence of shale gas extraction and the difficulty caused by density layers, the costs of shale gas are very high. Among the key players engaged in the development and those, who continue to introduce new ways to reduce costs are the following: Encana (one of the largest gas companies in Canada, providing 95% of gas production throughout the country) and Apache. Their total production is carried out in the area of 1417 km^2. Also, a large proportion is taken by Nexen – 498 km^2 and the company EOG – 567 km^2. Among other players whose role is significant are the world's top companies: Exxon Mobil/Imperial Oil, Devon, Quicksilver and Stone Mountain (Northeast Energy and Commerce Association Fuels Conference, 2008).

Another area for shale gas extraction is Montney and Doig Pley, located in northeast British Columbia. The main characteristics of this area are the following: from 1000 to 7079 m^3 of gas extracted from the play, called Upper Montney and from 700 to 4644 m^3 of gas is extracted from the play called Doig (Northeast Energy and Commerce Association Fuels Conference, 2008). Besides, shale gas extraction is not the only activity on these lands, as the company is also engaged in gas tight reservoirs

– gas from rocks that were previously considered economically viable and unable to extract energy resources. The main players in this field appear Encana, ARC Resources, Murphy and Shell.

Colorado Group has on its territory the many areas of fuel extraction, but the key is the First and Second White Specks, Base Fish Scales and others. Extraction of shale gas is expensive here, not in the operating room, either in their regular units. This situation is because due to its characteristics, this play is completely different from the previous two. Companies engaged in the development of this area are also different: Stealth and Panterra.

Also in Canada there is one more play, called Utica, located near one of the most famous cities – Quebec. The parameters that mark this deposit are: the depth of shale gas is about 701 to 1829 m (for comparison, this indicator on the territory of The Barnett Shale is almost 2–3 times deeper), the content of clay compounds is 15–26%. Companies engaged in the development here are the following: Talisman, Forest and several small businesses (Northeast Energy and Commerce Association Fuels Conference, 2008).

Constantly specialists are looking for new territories on which it would be possible to extract shale gas. Among the latest findings is the deposit in Nova Scotia. Activity in this area is warranted. So, with its arsenal of the latest technologies and highly skilled professionals, Canada does not neglect the ability to increase their level of energy and, consequently, economic security.

Other countries, such as Mexico, Argentina, Bolivia, Venezuela, Columbia, Uruguay, Peru, Chile, Ecuador and others are not engaged in such projects. This is due to the fact that the economies of many countries in the above list does not allow diverting funds for such matters, and in the countries where they exist, such as Venezuela, there is still sufficient conventional natural gas, which fully can satisfy the domestic needs.

To sum up all the facts, it is necessary to concentrate on the following points: total number of shale gas, located on the American continent is 168. In addition in the countries of this continent half of the resources are 100% proven reserves, which is a high level of research output.

Conclusion. Such a situation exists in North America due to the next factors: itself the oil and gas sector in Americas is independent; gas transportation infrastructure is highly developed (any gas producer, regardless the place of drilling, can be sure that within 10–20 km one can easily be connected to the existing gas pipeline); bearing strata occur at relatively shallow depths, which simplifies their removal; the degree of geological knowledge of the area is high, which significantly simplifies the search of locations for drilling wells; the market is free which allows sales success; tax regime for the extraction of shale gas is simplified, allowing even small businesses operate freely at this market; general legislation on subsoil is liberal, the right to develop mineral resources have even private enterprises; the level of understanding of the needs to protect energy security is the highest, which is reflected in the huge number of programs to stimulate this activity (Geller and Melnikova, 2010: 24–33).

So, after the analysis of unconventional shale gas fields in North America it is possible to point out that except all the above mentioned factors, we should emphasize the level of national consciousness, revealing in the following argument: despite

the present stability, availability of resources to meet the domestic demand, such countries as the USA and Canada are peeping in the future and seeking possible ways to reduce the unstable world markets dependence, increasing the level of national security.

References:

Геллер Е., Мельникова С. Зона неопределенности // ТЭК. Стратегии развития.– 2010.– №2. – С. 24–33.

Ambrose, W.A., Potter, E.C., Briceno, R. (2008). An Unconventional Future for Natural Gas in the United States oils. Geotimes: Earth, Energy and Environment News, Vol. 2 // www.geotimes.org.

Boyer, C., Kieschnick, J., Suarez-Rivera, R., Lewis, R., Walter, G. (2006). Producing Gas from Its Source and oils. Oilfield Review, 2006, // www.slb.com.

Canadian Society for Unconventional Gas (2008). Shale Gas in North America Emerging Supply Opportunity: Northeast Energy and Commerce Association Fuels Conference. Canada. 20 p.

Frantz, J.K., Jochen, V. (2005). Shale Gas White Paper // Oilfield Review, 2005, Autumn // www.slb.com.

Freeze, A.R., Cherry, J.A. (1979). Groundwater. USA: Prentice hall. 604 p.

Harper, J. (2008). The Marcellus Shale – An Old "New" Gas Reservoir in Pennsylvania. Topographic and Geologic Survey Bureau Department of Conservation and Natural Resources, 38(1), Spring // www.dcnr.state.pa.us.

Hayden, J., Pursell, D. (2004). The Barnett Shale: Visitor's Guide to the Hottest Gas Play in the US. Official site of group of property and mineral rights owners North Keller Neighbors // www.nknt.org.

International Energy Agency (2008). International Energy Agency Energy market statistics report 2008–2030 Prospect // www.iea.doe.gov.

Lapidus, A.L., Krylova, A.Y., Tonkonogov, B.P. (2000). Gas chemistry: status and prospects for development. Chemistry and technology of fuels and oils, 36(2): 82–88.

National Oil and Gas Assessment (2008). US Geologic Survey Energy resources program, 2008, Autumn // certmapper.cr.usgs.gov.

Natural Gas Basic Statistics. USA Energy field information database // www.eia.gov.

Newark, East (Barnett Shale) Field Paper (2009). Notice to oil and gas well operators of Railroad Commission of Texas Oil and Gas division, 2009, Spring // www.rrc.state.tx.us.

North American Natural Gas Supply Assessment (2008). US Clear Sky Fund Energy Field Report // www.afdc.energy.gov.

Overview of natural gas. Background // www.naturalgas.org.

Producing Today's Clean Energy, Ensuring Tomorrow's Innovation. Independent Petroleum Association of Mountain States (IPAMS). America's Independent Natural Gas Producers // www.ipams.org.

Стаття надійшли до редакції 1.04.2013.