# Introduction

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**Abstract** The idea of shale gas production has appeared nearly two centuries ago. But only in the recent decades, the technologies of the shale gas extraction were developed which permit the commercial scale of shale gas production; thus, it became possible to speak about the "shale revolution." The pioneer in this field was the USA which achieved considerable success here. At the same time, other countries that launched the shale gas production project have not been as successful as the USA so far. Regardless of this fact, the shale gas production affected significantly the arrangement of forces in the global gas market forcing many countries to take into consideration this factor in evolving their energy strategies.

**Keywords** Ecology, Hydrocarbon resources, Production, Shale gas

## Contents



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# 1 Introduction

The history of the shale gas production dates back to the early nineteenth century when the first wells were drilled which demonstrated the possibility to extract gas from shale plays. However, that time the applied technologies were not sophisticated enough to ensure shale gas production in commercial scale [1].

Natural shale gas refers to unconventional hydrocarbons, and it is a variety of natural gas, one of the kinds of the so-called unconventional natural gas. This is a commercial term meaning natural gas trapped in clay shales, coalbed methane, and tight gas in dense sandstones, occurring at great depths under not high pressure in geological zones.

Shale gas is the hydrocarbons contained in shales being the parent rocks. Shales represent the sedimentary rocks with a high content of organic matter that is required for formation of oil and gas and mostly consists of methane. Apart from methane, the shale gas contains ethane, propane, butane, and non-hydrocarbon compounds. The specific feature of such gas plays is that hydrocarbons in them occur in very dense, nearly impermeable rocks.

High temperatures and high pressure are conducive to formation of new minerals. The organic matter turns into oil and gas. The shales are distinguished by low porosity and low permeability. Gas in shale rocks spreads evenly through the whole formation. The amount of the extracted gas depends on the thickness of formation and its density. The thickness of formations in some areas may be as large as 100 m. The depth of occurrence of formations varies widely: from several 100 m to several kilometers. The formation pressure in gas parent rocks may be often abnormally high. The formation temperatures depending on the depth of occurrence may range from 80 to 180°C. This requires specific technologies for gas recovery.

In the second half of the nineteenth century, the new technological solutions appeared that permitted to extract considerable volumes of shale gas. This stirred greater interest to the shale gas having made the search for new solutions of this gas production more energetic. In the USSR, the technologies of the shale gas production have been developed since the 1950s and in the USA since the 1970s.

These researches were conducted largely as experiments because the availability of immense natural gas resources made unattractive the development of shale plays. Nevertheless, the Soviet scientists paid much attention to the theoretical aspects of the shale gas production. The theory of the shale gas production was developed by Academician S. A. Khristianovich at the Institute of Oil of the USSR Academy of Sciences. That time it was proposed to pump pressurized fluid into a well; as a result, the formation was fractured. This technique referred mostly to the increase of oil production and was targeted to attaining the greater oil yield of formations.

Greater interest to the technology of shale gas production was shown in the USA. Unlike the USSR where shale play development was of experimental nature, the USA got down energetically to development of the technologies capable to increase the gas recovery from shale rocks. Quite revolutionary was application of hydraulic fracturing in the Klepper play in Kansas. This method for experimental purposes

was first applied in 1947 by Stanolind Oil and Gas Corporation (at present Amoco Corporation) and in 1949 by Company Halliburton. The fracking technology was tested in Oklahoma and Texas.

The hydraulic fracturing is applied to create the "web" of fractures by pumping quickly large amounts of fresh water and sand as proppant into rocks. This technique requires specific technological equipment permitting to create pressure above 100 MPa and to pump water at a rate more than 15 cu. m/min. This technology proved to be effective, and during several decades, the great number of hydraulic fracturing was done in the USA.

The solutions used in hydraulic fracturing (fracking) are usually water based. The additives ensure transportation of the proppant with water to the fractures. Water accounts for over 98% of the applied solution, and the rest fraction is various additive chemicals.

Beginning from the 1980s, the shale gas in the USA was treated as an alternative to the traditionally produced natural gas.

The insistent efforts in the USA to develop the shale gas production technology were successful – from the 2000s the USA initiated the commercial scale extraction of this gas having become the leader in production of this hydrocarbon resource.

At the turn of 2008–2009 when the USA due to application of new technologies achieved a quick surge in its production outrunning Russia in this field, the interest to the shale gas has enormously grown in different countries. The volume of the shale gas production was estimated in dozen billion cubic meters which was comparable to the volumes of production and consumption in some countries. This stirred animated discussions concerning the perspectives of this hydrocarbon resource. The politicians and experts in many countries started speaking about the end of the epoch of the traditional natural gas.

Many experts agree that gas recovery from shale rocks has led to breakthrough in technologies. The construction of single wells was substituted by horizontal drilling from one well into which the working solution is pumped. Breaking of walls of gas pockets by fracking allows for significant increase of the gas recovery that is pumped out via the vertical borehole. This technology makes unnecessary the construction of on-field gas pipelines and the drilling process proper becomes more accurate [2].

The USA success in shale gas production gave an impulse to extensive research to evaluate the shale gas reserves. In view of certain difficulties with evaluation of reserves, the obtained data may be treated only as rough estimates giving only preliminary information about the reserves of this hydrocarbon resource.

The more extensive researches revealed many cases of gas play occurrence and spreading in complicated, unusual, in other words, nontraditional conditions. By the end of the twentieth century, the hydrocarbon resources of some unconventional accumulations (gas hydrate, heavy oil, shale oil, methane hydrate, gas of dense reservoirs), including shale gas, exceeded much the resources of their traditional analogs, while the beginning of the twenty-first century was marked by transition to their wider application in many world countries.

The geological reserves are estimated at trillion cubic meters and represent the world's "reserve fund" of hydrocarbons. Regardless of the absence of accurate data about the shale gas reserves and availability of only tentative figures based on expert assessments, the published data on prospective reserves are quite impressive. In 2010 the US Department of Energy started calling the gas from unconventional sources as gas from low permeability reservoirs.

The new technologies of shale gas production, such as horizontal drilling of "intellectual" wells applying the innovative technique of seismic modeling 3D GEO, as well as technologies of multiple fracking have transformed the gas sector. New technologies have drawn greater attention to the shale gas of major petroleum and gas companies and different states that started viewing this gas as a new means to ensure their energy independence and industrial base development.

As a result, the shale gas changes very quickly the energy landscape of the gas market. And although many forecasts concerning the reserves and production level of this gas have not come true, still the factor of shale gas has produced a significant impact on the energy policy of many world countries. It is not accidental that in many countries the shale gas is considered as a resource and geopolitical factor. Initiation of the commercial scale production of shale gas has become the key factor that affected strongly the world gas market in the recent decades.

If further development of technologies ensures lowering of the costs of commercial production of shale gas, it is quite likely that already by 2020–2025 the North American shale gas might appear in the world market. At least, the permanent reduction of costs of shale gas production allows for such forecasts.

The shale gas production has become recently one of the key issues not only in the world energy, but in the world politics, too. The experience of the USA in this business that has boosted up rapidly the shale gas production seems rather tempting. Many countries have seen their opportunities to develop production of their own shale gas expecting in the future to alleviate their dependence or even to refuse completely from hydrocarbon import.

The "shale revolution" – the term actively used in mass media and in the popular science literature played its role in formation of the energy map of the world. First of all, the success in shale gas production has influenced the US energy policy – the import of natural gas was cut drastically, and the options of their own gas export to foreign markets were considered. So far the shale gas depends on the oil prices which drop in 2014 urged the oil and gas companies engaged in shale gas production to adjust their activities. Notwithstanding this, the USA remains the leader in shale gas production. In 2010–2014 the gas sale price in the USA has dropped from 210 to 70 dollars per 1,000 cu. m. Many American companies conduct operations on shale gas extraction at a loss keeping the license in the sole hope for growing prices in the future [3].

The growing production of shale gas in the USA has led to considerable increase of gas prices in the American market and abandoning one of the Russia's largest projects – development of the Shtokman gas field in the Barents Sea which reserves are estimated at 3.9 tcm of gas and 56.1 million tons of gas condensate.

At the same time, it should be noted that the first attempts of the "shale revolution" export ended in a failure. The experience of the USA that managed to improve its energy security due to development of shale gas plays has been of limited application elsewhere.

Taking into consideration the depletion of the traditional gas resources, the shale gas cannot as yet become the reliable alternative to the natural gas in the near future [4].

But nevertheless it should be said that the interest to development of the shale gas fields remains high, and, first of all, in the USA. It is not accidental that some researchers believe that by the mid-2020s the shale gas will account for nearly the half of the US gas balance [5].

In the recent years, numerous fundamental works investigating various aspects of shale gas prospecting, production, and transit have appeared.

Regardless of non-optimistic attitude to the future of shale gas, we, Russian Company Gazprom, considered all complicated issues related to its production. This problem was studied in the books *Shale Gas* [6] and *Shale Flash Mob: Technologies, Ecology, Politics* [7].

Springer Publishers have turned to this problem more than once. It is sufficient to name such publications as "Sedimentology of Shale. Study Guide and Reference Source" [8], "Economics of Unconventional Shale Gas Development (Case Studies and Impacts)" [9], "Integrative Understanding of Shale Gas Reservoirs" [10], and "The Global Impact of Unconventional Shale Gas Development. Economics, Policy and Interdependence" [11].

The leaders of many countries are directly involved in addressing the issues of hydrocarbon production and transit, including gas, focusing much attention on this problem.

The European countries keep the shale gas production in the focus of attention as they endeavor to diversify the hydrocarbon supply sources, including by development of own shale gas plays. And among the first who not only showed the scientific interest to the shale gas production but made the first steps in this direction were Britain, France, and Poland. But as soon as they started extraction of shale gas, they faced some problems. Apart from the lack of reliable data about the shale gas reserves (Fig. 1), these countries faced the powerful public movements against the techniques applied in shale gas production. Accordingly, these countries had to make adjustments in their plans and adopt tougher requirements to producing companies.

Following the European countries, some post-Soviet states also made attempts to organize development of this hydrocarbon resource. The most energetic here was Ukraine that started inviting foreign petroleum and gas companies to such business. Meanwhile, the shale gas production was manipulated for attaining some political goals, and this made difficult the assessment of the starter conditions and likely consequences for the public and natural environment that appear in the course of shale gas production.

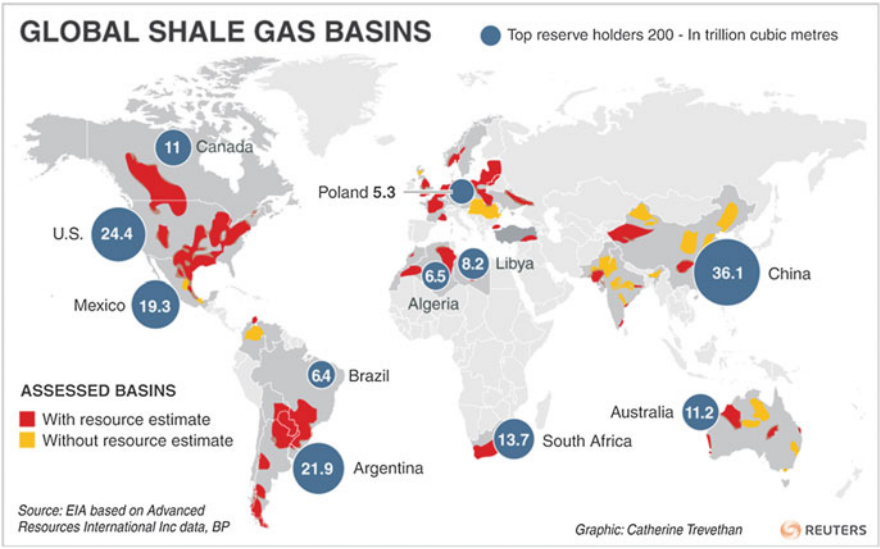


**Fig. 1** Global shale gas basins and resources (trillion $m^3$) (http://www.energy-without-carbon.org/sites/default/files/Shale-gas%20reserves.jpg)

Shale gas was in the focus of attention of the leadership in Kazakhstan and Moldova which started considering this hydrocarbon resource as a significant factor in implementation of the policy of hydrocarbon source diversification.

This "shale rush" appeared as a result of the coordinated information activities of US companies producing shale gas and state structures supporting them. Promoting the idea of energy independence, the USA was ready to get rid of the old equipment and technology and, at the same time, to obtain the multibillion orders for its petroleum companies operating in this business. Thus, still prior to launching the prospective drilling, the numerous speculations were circulating about enormous shale gas reserves in many world countries capable to ensure their energy independence. As a result, many countries not waiting even for rough estimates of the shale gas reserves rushed for their energy independence.

The "shale revolution" was not missed in Russia being one of the major suppliers of natural gas to the European market. In Russia the researches related to shale gas production have been conducted since the 1950s. Later on the shale gas was extracted in the USSR, but in insignificant quantities and, largely, for research purposes. Extraction of gas from shale plays was not vital for Russia in view of its enormous natural gas reserves, including in the Arctic seas. However, in the recent years, Russia had to take into consideration the shale factor in the global energy adjusting its price policy.

In 2014–2015, the experts and politicians continued their discussions concerning perspectives of development of the global gas market with regard to the shale gas factor (Fig. 2). This was facilitated by appearance of new technologies opening access to the previously inaccessible fields and also construction of terminals for


**Fig. 2** "Time" about future of shale gas (http://shalegas-europe.eu/wp-content/uploads/2014/02/TIME.jpg)

re-gasification of liquefied natural gas (LNG) and availability of the tanker fleet capable to bring it to different world regions.

The world financial crisis and growing hydrocarbon prices (till 2014) spurred the commercial development of unconventional oil and gas. In 2010 the world

production of shale gas amounted to 137 bcm. In the recent decade, the extraction of this hydrocarbon has increased 14-fold which, of course, has produced its psychological effect on the main players of the global hydrocarbon market. According to IEA, by 2035 the fraction of unconventional gas in the world production will reach 20% and of oil – around 10%.

The "shale revolution" stirred lively discussions of the environmental consequences of activities of the petroleum and gas companies. The reason for the ecology to be in the focus of attention was connected, primarily, with the negative environmental consequences of shale gas production. The hydraulic fracturing technology is detrimental for the natural environment causing irreparable damage to nature [12]. Ii should be added here that shale gas production requires enormous volumes of water and application of a wide range of chemicals.

In conclusion it should be stressed that shale gas influenced greatly the political and economic development of many countries, facilitated development of new technologies and affected the world gas market.

With further progress of technologies permitting to update the previous forecasts, the shale gas production has been given a new impulse. Many countries started treating the shale gas fields as the basis for their energy policy.

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