

Prospects of Alternative Energy and Shale revolution in Russia: Statistical Analysis

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Abstract—The Russian energy market is one of the most developed in the world; and Russia is one of the biggest oil and gas exporters. The market transition to alternative energy and shale oil is very slow and insignificant. The modernization of the energy market dictates the needs to change the national markets. In this regard, the discussion of the alternative energy and shale oil development in Russia is very important. The authors attempt to reveal the key factors, contributing to such a situation in Russia and to estimation of the economic effects of the implementation of the new energy sources on the country's energy market. The main finding of the paper is that the majority of energy consumers in Russia will suffer in terms of finances from the alternative energy development and shale oil extraction.

Keywords—alternative energy; shale oil; Russia; prospects; economic evaluation; LCOE

I. INTRODUCTION

The current situation on the global energy market dictates the necessity of search for new energy sources by all the countries. The hydrocarbons prices are volatile, the quantity of oil and gas left is hard to estimate, nuclear power is a dangerous technology quite often independent of humans (as in case of Fukushima), coal is an outdated resource, as it is less effective than oil or gas and produces much more pollution when consumed. Therefore, the risks of using traditional energy resources are growing.

The renewable energy sources are one of the alternatives to the massive use of hydrocarbons in the energy balance, but they are expensive and their effectiveness despite the steady growth still remains low. The alternative solution is shale oil and gas, but this solution is temporary, as it can cover all the needs of humanity for a limited period, after which the issue of new energy will rise again.

The named problems lead to the necessity to cut down the spending of hydrocarbons, especially by the countries, which possess the major reserves of oil and gas, as cutting down the supply on global scale will lead to the rise of prices on the oil products, leading to the shift in consumer demand for vehicles, recyclable materials and biodegradable products. At the moment, the leading oil and gas exporters do not follow this track, as the natural resources exploitation rent is extremely high.

The article reveals the possibilities of the development of alternative energy in Russia and the prospect of the Russian

shale oil of the Bazhenov suite [1]. The authors aim at proving the economic effectiveness or ineffectiveness of renewable resources development in Russia. In this regard, the economic estimation of the shale oil development is required

II. METHODOLOGY

The article follows the general methodology of researching the market conjuncture and comparison of economic effectiveness of the energy sources. The authors reveal the conditions of alternative energy development in Russia and give conclusions on the trends of further alternative energy production. In order to prove the theoretical trends, the authors calculate and compare the levelized cost of energy (LCOE) of the different energy sources in Russia by equation (1):

$$LCOE = 1 / (EP_{net} \cdot T) / (CC + MC + EG \cdot T) \quad (1)$$

where EP_{net} is the net energy production (energy produced minus energy consumed for the maintenance, in kW), T is the lifetime, CC is the cost of construction, MC is the maintenance cost, EG is the cost of the fuel.

Further, the authors assess the production of oil in Russia by the linear smoothing forecast using the data from the Ministry of Energy of Russia. At last, the economic effect of the structural change to the energy balance is assessed with the mathematical expectation formula (2):

$$M(x) = a \cdot A_s + b \cdot B_s + c \cdot C_s + \dots + z \cdot Z_s \quad (2)$$

where a, b, c, \dots, z are the costs of energy production by source, and $A_s, B_s, C_s, \dots, Z_s$ are the shares of each form of energy in energy balance

III. ALTERNATIVE ENERGY DEVELOPMENT IN RUSSIA

The alternative energy in Russia is a relatively new trend, which appeared massively in 2012 with the rise in efficiency of the technologies used in solar panels and wind generation and the decrease of costs of the needed equipment for their production. Russia produces a large volume of renewable energy (nearly 17 % of its energy balance); the main part of the production comes from the hydro-resources and lately from geothermal power plants [2]. In this aspect, Russia is one of the countries with relatively clean energy sector. In addition to that, the country has adopted a program of renewable energy development until 2030, stating that the share of alternative energy in energy balance should rise 400 %. It is

notable that most experts come to the conclusion that the legal basis for renewable energy in Russia is not well developed [3].

The key factors contributing to the slow development of alternative energy in Russia are:

- The abundance of traditional resources, which are easy to extract and use and already being distributed through existing infrastructure.
- The lobby, both abroad and in Russia, of the leading energy companies, such as Rosneft and Gazprom, which are the main taxpayers in Russia [4, 5].
- The uneven distribution of the population and industries in Russia: the majority of population lives in the European part of the country, where the energy demand from the private sector is the highest.
- The difficulty of alternative energy infrastructure construction due to the long distances to the main energy generation facilities and low effectiveness (caused by natural conditions) of solar and wind energy generation in the most populated regions.
- The low consumer density in the Siberian regions and lack of financial resources to build up a private renewable energy infrastructure [6].
- Severe climatic conditions in most of the country, causing the demand for the most reliable sources of heat and energy – characteristics that alternative energy lacks.

These factors lead to the following trends in alternative energy generation in Russia:

- The hydro-power plants supply the Siberian cities and the regional centers, which in turn, redistribute the energy resources to the local communities with significant energy losses (despite the fact that Russia has one of the most developed energy grids in the world, the distances and the high number of sub-suppliers lead to the efficiency losses).
- The geothermal plants prove to be effective on Kamchatka and are the primary source of alternative energy there (especially taking into account the transport hubs, situated on the peninsula and the overall higher population density than in Siberia).
- The solar and wind plants are more of a private initiative, still the latest research on their use in the southern regions of the country, especially on the Crimean Peninsula, demonstrates their potential capability to enlarge the quantity of alternative energy production in the southern regions of Russia.
- The central regions of Russia rely on conventional and nuclear energy, while the restructuring of energy production in the region can lead to a dramatic growth of biofuels in energy balance.
- The more exotic energy resources, such as tidal energy or human body thermal energy, etc. are not developed enough to discuss them in the context of this article and up to the 2030 horizon.

The brief analysis of energy sectors allows to conclude that the most reliable source of energy in Russia is still oil and gas, while the other energy resources tend to develop slowly. Furthermore, the economic estimation of the costs of use of such energy presented in Table 1 demonstrates the economic inefficiency of alternative energy in Russia.

TABLE I. THE ASSESSMENT OF 1 KW PRICE BY ENERGY SOURCES (BASED ON THE AUTHORS' CALCULATIONS AND [3, 7])

| Energy source | Lifetime (years) | Net capacity (MW) | Overnight capital cost (USD/kW) | Operation and maintenance cost (USD/kW/year) | LCOE (discount rate 10%) (USD/kWh) |
|---------------------------|------------------|-------------------|---------------------------------|----------------------------------------------|------------------------------------|
| Coal | 60 | 650 | 1800 | 73 | 0.05 |
| Natural gas | 30 | 650 | 800 | 43 | 0.04 |
| Solar PV of utility scale | 30 | 1 | 2425 | 51 | 0.25 |
| Wind | 30 | 10 | 2300 | 35 | 0.09 |
| Small hydro | 40 | 50 | 3040 | 61 | 0.11 |
| Geothermal | 50 | 60 | 2330 | 60 | 0.1 |

Table 1 allows to conclude that the cheapest energy source is natural gas (a predictable result, taking into account the reserves of the blue fuel in Russia), while among the alternative sources of energy the cheapest are wind and geothermal energy; nevertheless, their prices are twice as high as the prices for gas or coal energy generation.

The estimation of the biofuels effectiveness by the same method is much more complicated, as it includes many different potential sources of energy, so the authors use the data from [3], where the overnight capital costs of the energy source are estimated as the highest in comparison to natural gas, wind and solar energy.

IV. THE SHALE RESOURCES OF THE RUSSIAN FEDERATION

The shale oil in Russia had not been developed until 2018, when its extraction started on the Bazhenov suite – the biggest shale oil field by reserves in the world. The development of shale oil in the region is not active, and it seems to be a pilot project testing the technologies available in the Russian oil and gas industry.

The main sources of the Russian oil are situated in Siberia; the offshore oil extraction seems to be very prospective for the Russian energy sector, as the reserves of the Arctic Ocean shale oil are hard to estimate, but by the most accurate cautious forecasts they will account for at least 5% of oil production in 2030 [8]. In this regard, the main technological solutions that Russia seeks in the sphere of oil and gas industry are not the shale oil development technologies, but the offshore oil extraction solutions.

However, it is notable that the shift to shale oil development by the Russian companies began simultaneously with the EU sanctions, which cut down the capital flow to the Russian energy sector from the European banks and the technologies transfer. The general dynamic of the oil

extraction in Russia stays the same, as it was in the previous years (Fig. 1).

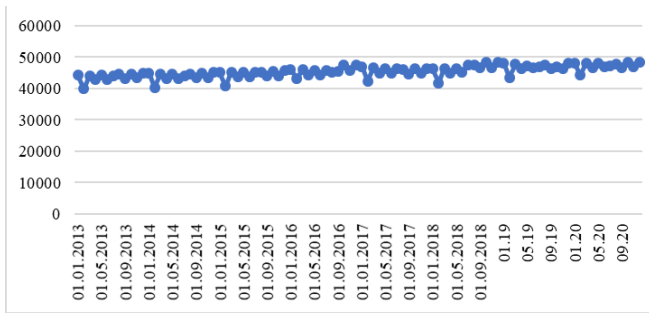


Fig. 1. The dynamic of oil extraction (thousands of tons) (forecasted by authors, based on [9]).

The seasonal component (February lows) may be missed in the discussion, as the drops do not play a significant role in the overall dynamics of the oil extraction in Russia. The growth trend is low, the 6-year growth was equal to 8,89 %, with a slight slowdown last year, so the shale oil development did not contribute much to the overall dynamic of the oil extraction in Russia. Unlike the US oil industry, the Russian one did not follow the trend of shale oil revolution for the following reasons:

- The US regulations on private natural resources development provide more opportunities for the entrepreneurs than the Russian ones [10].
- The US banks were eager to credit the industry, while the Russian banks due to the scarce external financial resources access are much more conservative in their credit strategies [11].
- The economic aspect of shale oil in the USA is significantly greater – the country became one of the major exporters of hydrocarbons from the main importer of fuels [12].
- The financial characteristics of the industries are different (Table 2). While the US industry is ready to bear high risks and costs of shale oil due to the unavailability of other potential oil resources, Russia has the rich conventional oil fields, which are much cheaper to develop and a new frontier for the industry development – the offshore oil.

TABLE II. TABLE 2. THE COMPARISON OF EXTRACTION COSTS OF OIL (DEVELOPED BY AUTHORS, BASED ON [13])

| Country | Type | Production cost (USD/barrel) |
|------------------------------|-----------------|------------------------------|
| Russia | Arctic offshore | 120 |
| | Onshore | 18 |
| The USA | Offshore | 57 |
| | Shale | 73 |
| <i>The average oil price</i> | | |
| Russia with shale oil | 24.2 | 5:93:2 |
| Russia without shale oil | 23.1 | 5:95 |
| The US | 66.4 | 41:69 |

The analysis of the average oil price (weighted average, the weights composition in the right column [14, 15]) allows to conclude that the delta for the introduction of 2 % of shale oil in the extraction balance of the country will increase the

average oil price by 4.76 %; therefore, the development of the industry in Russia promises negative return rates.

V. DISCUSSION

The alternative energy and the shale oil development in any country is an answer to the energy balance issues. The conventional energy sources are much easier and cheaper to exploit (at least for now and in the foreseen future). The discussed energy sources allow the country to develop green industry and to cut down costs on energy imports, which is not the case for Russia.

The Russian energy market is dominated by coal and gas, as they are the cheapest energy resources in the country, while the alternative energy allows to cut down the costs for the specific regions (Kamchatka, Siberia and southern regions, which are not the main energy consumers). The development of alternative energy in Russia is important for the future of the Russian energy market, as it will allow to change the national demand for hydrocarbons and consequently make the period of their abundance longer.

In order to do that, Russia has to implement costly reforms on the energy supply in the central regions of the country, stimulating the production of energy from biofuels and creating the possibilities for little hydro plants to sell electric energy to the nearby communities [2]. Still, this reform seems to be improbable because of the mighty lobby of the local energy sector oligopolists, which will not allow the competition on the market. At the same time, the stimulation of demand for alternative energy generation by the private sector may partially help to solve the problem – due to the low efficiency of solar energy in the region, the supply of energy to the regional grid will be very little, while demand for energy will be nearly the same, so the losses of the energy companies will be not that significant and may be compensated by tax cuts [16].

When speaking about the diversification of the oil sources in Russia, the prospects of shale oil in the country are very weak, especially taking into account the availability of offshore oil – the only option for the shale oil lies in the sphere of external effects: in case of further long-run sanctions, which are to last longer than 20 to 30 years, and the lack of technological development in the industry, shale oil will be the only variant for the reserves extension of the companies.

VI. CONCLUSION

The Russian energy sector is one of the most conservative in the world. Russia has a highly developed energy industry with mighty lobbies of energy companies, which contributes to the dominance of conventional energy sources and oligopoly competition on the energy market.

The economic aspect of alternative energy development is a very significant point, which slows down the dynamic of green energy implementation on the Russian energy market. The reason for it is quite simple – the majority of energy consumers live in the region, where the costs of alternative energy manufacturing are significantly higher, and the effectiveness of its production – consequently lower. However, the Siberian and the Kamchatka regions benefit from the abundance of alternative energy generation

possibilities, so these regions represent the main opportunities for the green energy development in Russia.

The shale oil, on the contrary, does not have any formed opportunities in the Russian energy market, as its production is much more expensive than the production of conventional oil. At the same time, a more expensive option – the extraction of offshore resources is a strategic task of the energy sector development in Russia and will be brought to life at any costs. Hence, on the current stage and in the nearest future the prospects of shale revolution in Russia are murky.

The economic benefits that Russia will gain from the development of the energy market by alternative paths are little, the social effects might be more significant (especially the ecological effects in the big cities in central Russia), but their estimation is not the focus of the article.

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