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Methane utilization as a resource-saving method inthe coal industry

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Abstract. Risks of partial or total loss of ecosystems and species due to climate change are currently increasing. Russia is the world's fourth largest emitter of greenhouse gases, which have a detrimental effect on ecosystems. The fuel and energy complex is the largest emitter of greenhouse gases; in this regard, it is precisely the reduction of greenhouse gas emissions in this area has the utmost significance.In addition, methane as one of the greenhouse gases is harmful not only for the ecosystem but also for industrial safety, and this is also a sphere of state regulation.Since methane, based on its forecast volumes, may well be mined as an independent mineral product, it is necessary to develop a rational method for its use, since today everything that is mined is emitted into the atmosphere.The report analyzes how coal mining companies are currently using coal-seam methane. The volumes of methane in coal seams in the Russian Federation and in coal basins are analyzed. The world experience in the extraction of coalbed methane as a separate mineral product is investigated. A project is proposed for the rational use of methane as a separate mineral product.The main purpose of the article is to show that resource-saving measures for the use of methane can have not only environmental but also economic effect.A financial model of the project is proposed, which allowed to prove the economic efficiency of the project for the use of methane as a fuel. The article is based on the case method, the method for constructing financial models, the method for assessing risks, the method for analyzing information, etc.

1 Introduction

Resource conservation is embedded in the context of the Sustainable Development Goals identified by the UN Commission on Sustainable Development in 2015.

This document concerns thegoal that secures responsible consumption and production(Resolution adopted by the General Assembly on September 25, 2015), which is relevant for the Russian Federation as a country with a resource-based economy.

Official statistics show that, for example, in the reduction of energy intensity, domestic production lags behind many industryleaders in the global market. For comparison: the volume of manufactured products in the United States is 4.6 times more than in

Russiawithinthe same period, while the volume of energy consumption differs by only 1.72 times. It shows the need to implement resource-saving technologies [1].

Russia is the world's fourth world largest emitter of greenhouse gases with a detrimental effect on ecosystems [2]. The main emitter of greenhouse gases in Russia is the fuel and energy complex, and the leaders in methane emissions are large coal companies [3].

At the same time, foreign experience shows that modern technologies allow not only to extract but also use methane as an alternative to traditional fuel, which meets the principles of responsible consumption of mineral resources.

Russian large coal companies have sufficient resources to introduce technologies that can effectively extract and use coalbed methane [4,5].

Therefore, the task of reducing methane emissions is one of the urgent tasks of resource conservation and achieving sustainable development goals.The purpose of this article is to prove the economic feasibility of a method for coalmethane, extraction,compression, and use as a motor gas fuel using the example of the Siberian Coal Company (SUEK).

2 Literature review

Global experience shows that the organization of the extraction of coalbed methane as a separate mineral allows us to provide gas to both industry itself and external consumers [6].

The leading coal reserves have Russia, the USA, China, and Australia, with reserves of 80 trillion m^3, 65 trillion m^3, 30 trillion m^3 and 25 trillion m^3, respectively [7].

According to experts, the global volume of methane is from 225 to 268 trillion m^3.. The countries with the richest reserves are Russia, the USA, Australia, and China. Among these countries, only in Russia industrial production and the use of methane as a mineral have not been not developed.

For example, in the United States, about 50 billionm^3 of mine methane is produced annually, while the production of coal bed methane is increasing every year. The specific methane content per tonne of coal ranges from 13 m^3 to 32 m^3 (in Russia the value is slightly higher).

The cost of production in Russia is lower than in other countries, which allows this industry to develop independently. About 200 companies engaged in the extraction of methane as a separate mineral resource work in this industry (International Energy Agency 2016).

In Australia, methane production technologies have been developed since the 1990s and these technologies are exported to other countries. In Australia itself, industrial methane production provides 80 percent of the region's gas demand [7].

According to forecasts ofthe Australian Department of Energy, with the current level of production of profitable reserves of coalbed methane, it will last for more than 100 years, and traditional gas for less than 60 years [8].

In China, the production of coalbed methane reaches approximately 5 billionm^3 per year. According to experts from the World Energy Agency (IEA), by 2040, out of 225 billion m^3 of all unconventional gas production in China, coal bed methane will account for about 30 billion m^3 [9, 10].

Bythe report of the World Energy Agency, coalbed methane production in these countries in 2000-2016 doubled, reaching 70 billion m^3 per year [9].Despiteall this, the further prospect of developing the field of methane use in these countries is rather ambiguous, since shale gas production is more profitable for companies [10,11].

The process of extraction of coalbed methane is activating in developing countries in Asia, e.g., in India and Indonesia.

In the Russian Federation, the forecasted methane resources in the main coal basins of Russia are estimated at 83.7 trillion m^3, which corresponds to about a third of the country's forecast natural gas resources. A special place among the coal basins of Russia belongs to Kuzbass, which can rightfully be considered the largest of the most studied methane coal basins in the world. Predicted methane resources in the Kuzbass coal basin are estimated at more than 13 trillion m^3, the depth of methane occurrence varies between 1200 and 1800 meters [12,13]. The articles present the most relevant information on the assessment of methane, unfortunately, it is dated 2015-2018.Consequently, methane reserves to date could have slightly decreased compared to the forecast values.

The proportions of the estimated methane resources in coal seams, reaching trillions of cubiq meters in the main coal basins of Russia, allows us to consider these basins (and primarily the Kuzbass coal basin) not only as a base for coal mining but also as a giant source of unconventional hydrocarbon geological material. Since almost all coal basins in the Russian Federation are remote to gas production areas, methane can provide additional gas for these areas [14].

Large-scale methane resources are a prerequisite for the creation of commercial coal and gas fields.Thus, the need and the possibility of organizing methane coal industries is due to the following factors:

- Resource conservation in accordance with the goals of sustainable development
- Presence of large forecast methane reserves located in the coal basins of the Russian Federation
- Availability of methane production technology and the experience of foreign countries, proving the possibility of effective extraction of coalbed methane
- Availability of investment and scientific potential among leading companies in the industry for implementing measures to introduce resource-saving technologies in the fields.

3 Research methodology

In this article, the case study method was used, and the single case was the project for the use of compressed methane extracted from SUEK's coal mines.Besides the case study method, the article used an analysis of the SUEK operation.

Based on the analysis, a financial and economic model of the project was created.Risk assessment is presented by NPV sensitivity analysis.

The Siberian Coal Energy Company is the leader of the Russianmarket among coal and energy companies. In terms of coal production, it ranks 1st and 6th in the Russian Federation and the world, respectively. The company has 8 traditional mines and 19 opencast mines.

In 2019, the company allocated more than USD 40 million for the implementation of environmental policy considered as an element of corporate social responsibility [15]. This amount of funding also providesfor the implementation of new projects for SUEK aimed at saving resources and increasing the competitiveness and sustainability of the coal company [16,17,18].

In the Russian Federation, companies often do not use any possible ways of using coalbed methane, e.g., electricity, pipeline gas, LNG, etc. [19]. This is due to special mining and geological conditions in which methane production is not profitable because of the low concentration of methane in most fields. Nevertheless, projects for the use of methane for power production have recently been implemented by SUEK at two mines.

The analysis of methane output volumes showed that SUEK's methane production volumes amounted to about USD 42.54 million in 2013 – 2019 [20-22]. According to the current standards governing payments for air emissions, the company's total payments to the budget for 7 years amounted to just over 3 million rubles [23]. However, the payments themselves are not a strong incentive to reduce methane volumes. The Paris Climate Agreement ratified by the Russian Federation in 2019, according to which companies must reduce their environmental impact, can be considered the main motivating argument. This can also be implemented by reducing methane emissions as its destructive effect on ecosystems has been proven a long while ago.

The international practice shows the following areas of methane use: fuel for generating electricity, pipeline gas, liquefied gas (LNG), compressed gas (CNG).

It is not advisable for Russian companies to supply methane to foreign markets as pipeline gas, since not all regions have a developed gas pipeline infrastructure, and the regulatory risk in this marketis high.

Compared to LNG, CNG has the advantage of being easier to store. LNG requires the maintenance of a special temperature regime, whichis not important for CNG. In this regard, LNG storage requires additional costs for maintaining the temperature.

The choice of method of use (CNG or power production) depends directly on the volume of methane. In this article, the CNG method was considered, due to the significant volumes of methane.

The essence of the method lies in the simultaneous extraction of coal and gas by conducting mine workings over the developed seam. Next, the gas is compressed at the plant and used for the needs of the enterprise.With this method, methane can be used as a motor fuel for mining equipment.

4 Results

The economic effect can be obtained both through the use of methane as a cheaper fuel for generating electricity (according to our estimates, it will amount to 143 million rubles), and as gas engine fuel (instead of diesel). To determine the use of methane as a gas engine fuel, it was taken into account that 8,529,006 liters of diesel fuel per year can provide 95 units of equipment based on the average mileage of 1 unit of equipment at the Kirov mine (110,000 km/year) and the average consumption of CNG per 100 km (75 m^3/year).

Major project investments include:

- Acquisition of a fleet of mining equipment in the amount of 95 units, the internal combustion engine of which runs on gas
- Construction of a methane compression plant
- Construction of a filling station for the equipment park
- Construction of a gas pipeline from wells to thecompression plant.

The calculation of the economic efficiency of the project is based on taking into account the additional effects obtained in the event of the project implementation and its abandonment (the principle “with and without theproject”).

Three pipelines will be connected to the methane compression plant: themain pipeline from the surface, transporting methane from the current degassing, and apipeline transporting methane from the worked-out area. The length of the gas pipelines is approximately 1000 meters. The cost of the plant is estimatedas 300 million rubles based on a similar project. The approximate number of employees is defined as 24 people:2 people service agas pipeline per shift, therefore, there are 6 of them per shift, 4 shifts per day. The service of the filling station is supposed to be carried out by the forces of the transport services available at the field, they also fill of the equipment.

The main indicators of the project are presented in Tables1-2.

Table 1. Basic macro parameters of the project

Index	Units	Value
Cost of G grade coal	rub/ton	3000
Diesel fuel cost	rub/liter	45
Income tax	%	20
Property tax	%	2.2
Mineral extraction tax for methane	%	Not subject to taxation
r	%	11.9
Discounting start date	-	01.01.2021
Methane Production	$3m$/year	7 884 000.00
CNG volume	l/year	8 529 006.09
Saving on diesel	million rubles/year	383.81
Capex	million rubles	643
OPEX (for the entire duration of the project)	million rubles	1962.38
NPV	million rubles	236.41
DPP	years	1.37
PI	unit	7.03
IRR	%	20.35

The discount rate is taken based on the calculation of the WACC of SUEK.

The extraction of coalbed methane is not taxed; however, the budgetary effects of the project will be more than a billion rubles for the entire duration of the project, namely 10 years.

According to the analysis of the sensitivity of the NPV project, the price of diesel fuel affects the project the most (Fig. 1). The price of diesel fuel tends to increase, and since the project involves its replacement, there is the prospect of increasing the NPV of the project.

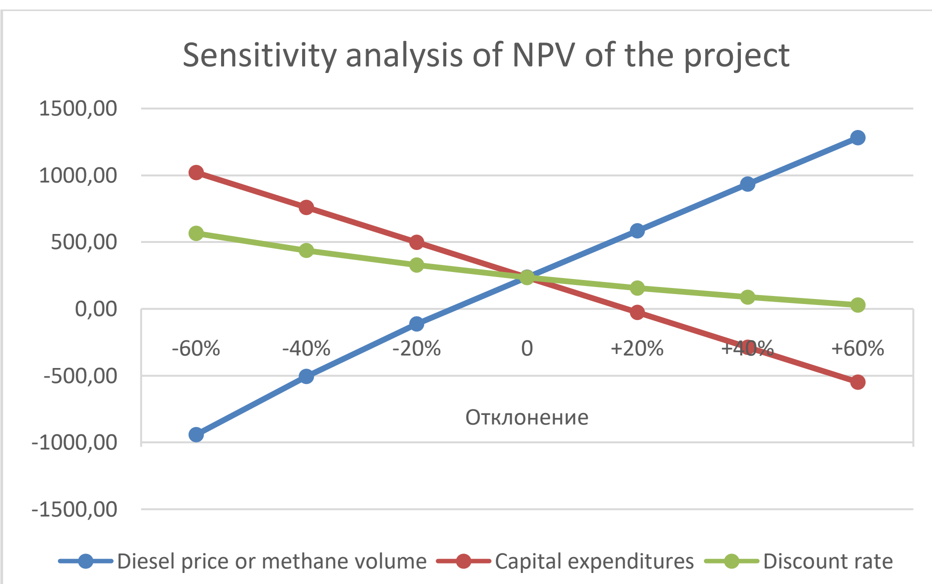

Fig. 1. Sensitivity analysis of NPV of theproject.

4 Conclusions

The existing methane production technology used at coal mines in the Russian Federation does not prevent the emission of methane into the atmosphere. This causes great harm to the ecosystem and does not meet the objectives of resource conservation, which determine, in particular, the achievement of sustainable development goals.

Predicted volumes of methane in coal seams allow us to consider it as an independent mineral product, especially since methane production has several advantages: 1) large forecast volumes (about a third of the natural gas reserves); 2) relatively small depth; 3) well-known technology for the further processing of methane.

The world experience in the extraction of coalbed methane allows us to consider methane production as a separate sphere, which can provide gas both to the mining industry and to external consumers.

The presented project involves the extraction of coalbed methane, its compression and further use as anengine gas instead of diesel fuel in mining equipment of the enterprises. The main economic effect is achieved due to the difference in the cost of purchased diesel and the cost of the by-product methane.

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