

**COAL MINE METHANE EMISSIONS REDUCTION
PROJECTS IN KUZBASS:
SELECTION OF METHANE UTILIZATION OPTIONS,
ECONOMICAL EFFICIENCY
ASSESSMENTS AND FINANCE SOURCES**

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ABSTRACT

Coal mine methane resources of Kuznetsk coal basin in Russia amounts to over 13 trillion cubic meters. Presently 47 coal mines operate in the region and emit 216 million cubic meters of methane per year but unfortunately none of them attempt to utilize drained methane. Development of coal mine methane recovery and utilization is of great technological, economical and ecological importance for Kuzbass.

One of the main challenges in monitoring methane recovery and utilization projects and generated Emission Reduction Units trading under the framework of Kyoto Protocol mechanisms becomes a selection of successful methane utilization options. Each separate coal enterprise features certain peculiarities that impact the decision adoption. Dominating role here is played by the existing thermal and electrical power market and emission reduction units market price.

Application of a mathematical tools based on game theory may serve as one of the means in addressing this issue. The method implies a financial-economic model plotting, where the main players are the "coal mine" and the "emission reduction units market".

A practical magnitude of results analysis of shaped models implies the development and the definition of the best effective scenario for economic system development with regard of regional and business peculiarities and the elaboration of recommendations for specific coal mining entities of Kuzbass region.

INTRODUCTION

Methane is a greenhouse gas, which is extracted from coal-beds by drainage facilities. It exceeds carbon dioxide in 21 times by its affective influence on warming the climate. Methane emissions constitute ten percent from all anthropogenic sources in a cycle coal - fuel.

Methane emissions take danger for the deep mining. At the same time coal mine methane is of great value as energy resource, which can be used for generating thermal energy, electrical energy, motor fuel and chemical products.

SELECTION OF METHANE UTILIZATION OPTIONS

One of the main solutions to manage complex coal mine methane recovery and utilization projects and emission reduction units trading under the framework of Kyoto Protocol is the selection of methane utilization options. For the substantiation of the solution in conditions of incomplete information the mathematical game theory was received a wide application.

On the basis of coal mines of Kuznetsky coal basin the financial and economic model has been built, where the main players are “coal mine” and “emission reduction market”. The coal mines acts in conditions of information deficiency on “emission reduction market” that leads to the income losses. The coal mine makes a decision S_i about realization of the project on extraction and utilization of coal mine methane and expects to receive income at the rate of s_{ij} at realization of N_j situation in the market. The advantage is lies in generalized making decisions model and is determined as:

$$NPV_{ij} = \sum_{t=0}^T \frac{F_i(x) - e_i(x)}{(1+d)^t} + \frac{L_j \times V_i(x)}{(1+d)^t} - x \quad (1)$$

with limitation of methane in volume $V_i(x) \leq V_{lim}$.

Here NPV_{ij} - net present value or general financial project outcome, describing a possible gain in coal mine economical potential; L_j - market price of emission reduction unit; x - investment outlays; $F_i(x)$ - the function of the guaranteed income, depending on methane utilization options; $V_i(x)$ - function of received methane emission reduction units in terms of CO_2 equivalent; $e_i(x)$ - function of operational costs (costs of installations maintenance and technological equipment); $i = (1,3)$ - methane utilization options ($i = 1$ - “electric power generator”; $i = 2$ - “firing methane and coal in boiler”; $i = 3$ - “producing of motor fuel”); t - year of the project development; T - project life; d - discount rate.

The research of model is carried out on the basis of the data of Komsomolets, Raspadskaya, Lenina, Usinskaya and Pervomayskaya coal mines in Kuznetsky coal basin, information of the coal mine methane utilization equipment and price information about the greenhouse gases emission reduction units market.

The selection of alternative methane utilization options for example for Raspadskaya was implemented in conditions of uncertainty of the information and active counteraction of the emission reduction units market. The solution of the game has allowed to receive optimal strategies for coal mines on the basis of Minimax criteria, Savage criteria and updated Savage criteria (table 1).

The selected policies of implementation of the coal mine methane utilization projects are shown in table 2.

Table 1

Selection of coal mine methane utilization options for Raspadskaya coal mine in conditions of uncertainty and counteraction of the emission reduction units market at capital investments making x million dollars

| ? | Criteria | $x = 0,18$ | $x = 0,8$ | $x = 2$ | $x = 5$ |
|---|-------------------------|--------------|--------------|------------|------------------------|
| 1 | Minimax | Boiler house | Boiler house | Generator | Generator/Boiler house |
| 2 | Savage | Boiler house | Boiler house | Motor fuel | Generator/Boiler house |
| 3 | Updated Savage criteria | Boiler house | Boiler house | Motor fuel | Generator/Boiler house |

Table 2

Selection of coal mine methane utilization options for coal mines at capital investments making x million dollars

| ? | Coal mine | $x = 0,18$ | $x = 0,8$ | $x = 2$ | $x = 5$ |
|---|----------------------|--------------|----------------------|------------------------|------------------------|
| 1 | Raspadskaya | Boiler house | Boiler house | Generator | Generator/Boiler house |
| 2 | Komsomolets | Generator | Generator/Motor fuel | Generator/Motor fuel | Generator/Motor fuel |
| 3 | Lenina and Usinskaya | Boiler house | Boiler house | Generator/Boiler house | Generator/Boiler house |
| 4 | Pervomayskaya | Boiler house | Boiler house | Boiler house | Generator/Boiler house |

Results of models analysis allow to define the effective development scripts of economical systems considering industry and regional specificity. It helps to elaborate the recommendations for specific Kuzbass coal mines.

As a whole, firing methane and coal in boiler is the most effective for coal mines, which are participants of the emission reduction units market and electric power generator is for coal mines which are not the participants.

E?ONOMICAL EFFICIENCY ASSESSMENTS

Not-for-profit organization “International Coal & Methane Research Center – “Ugletan” has prepared a several of coal mine methane projects in Kuzbass. Economical efficiency assessments and risk evaluation showed good returns of the coal mine methane extraction and utilization projects (tables 3 and 4).

When international agreements on climate change abatement come into force, Kuzbass may receive up to 1.9 million USD investments annually for coal mine methane projects realization.

Table 3

Methane recovery and use project opportunity at the Kirov mine

| ? | Description | Total Costs, 000 USD |
|---|----------------------------|-------------------------|
| 1 | Total Gas Recovering Costs | 905 |
| 2 | Total Gas Use Costs | 180 |
| 3 | Other Costs | 462 |
| 4 | Total Project Costs | 1547 |
| 5 | NPV | 2586 |

Table 4

Drained methane use at the Rapsadskaya mine

| ? | Description | Total Costs, 000 USD |
|---|----------------------------|-------------------------|
| 1 | Total Gas Recovering Costs | 2670 |
| 2 | Boiler Conversion Costs | 180 |
| 3 | Other Costs | 808 |
| 4 | Total Project Costs | 3658 |
| 5 | NPV | 5227 |

FINANCE SOURCES

The basic financial source for coal mine methane recovery and utilization projects implementation is coal mines own capital. However, the projects directed on creation of new or expansion of coal mine existing production are more profitable under existing conditions in Kuzbass, than coal mine methane projects. It is connected with internal prices disbalance for coal and gas. At present the coal mines are more interested in addressing methane problem from the view point of coal mining safety rather than in its use as power resource.

Other financial source involves capital of both domestic and foreign investors aimed for the delivery of their equipment and technology or for getting interests from the credit. First of all, attractiveness and efficiency of the project for investors depends on project income stability sources, security of market output under the project.

The main source of the project income is an effective consumption of coal mine methane utilization products (the electric power, thermal energy, motor fuel, chemical products etc.) by the coal mine or the sale to external consumers. This source is estimated by three factors: prices of power resources, requirements of coal mine or external enterprises for these resources and a geographical arrangement of coal mine (for example, vicinity

of settlements or industrial factories). Various branches of region's industry are in the position to consume coal mine methane utilization-produced products. Local coal mines, industrial and social infrastructure enterprises may be direct consumers [3]. Electric power consumption by all sectors of region's economy is 21,343 MkWh; thermal power consumption is 31,113 Tcal; natural gas consumption is 3,010 Mm³. The current energy and fuel prices in the region are: for 1 kWh electric power for industrial entities makes 0.544 RUR (about 2 cents); coal price is between 280-310 RUR without VAT per tonne; natural gas price – 550 RUR VAT free for 1,000 m³ (exchange rate 1 USD = 30-31 RUR).

Other source of project incomes which can essentially influence coal mine methane recovery and utilization projects payback period is the sale of emission reduction units on the international market. At present reduction cost of the coal mine methane emissions unit is within the limits of 0,5 - 1,5 USD and depends on the selection of methane utilization technology and volume of investment capital. The basic problem faced by Russian Federation is the imperfection of acts and mechanisms for emission reduction units registration. The international funds and organizations working in the field of the environment protection on the climate change mitigation can support coal mine methane related projects.

Ugletetan and ICF Consulting Ltd. have jointly developed UNDP/GEF project “Russian Federation – Removing Barriers for Coal Mine Methane Recovery & Utilization”, which has been already approved by Ministry of Energy of Russian Federation that is assigned as an Executive Agency for project's realization. The expected financing will amount to about 8,3 million USD. The project will mitigate greenhouse gas emissions by removing barriers to the implementation and financing of coal mine methane recovery and utilization projects in Russia. In order to reach this goal, the project will strengthen the institutional and financial framework for the promotion of coal mine methane projects and facilitate the implementation of selected demonstration projects so as to provide a basis for the wide scale replication of similar projects in the future. The initial focus of the project will be on the Kuzbass region, with further replication potential in other coal producing areas in Russia and elsewhere.

Methane industry development support of local administration, which is concerned, first of all about coal mining safety has essential influence. Support can be not only political, but also financial, expressed in tax credits provision. Some regions adopt their own laws to facilitate the investments into methane industry development. Laws incorporating a tax credits provision to investors were passed by the Kemerovo Regional Administration [3]. One law establishes benefits to juridical persons, who undertake the above cited activities of a geological profile in relation to experimental – industrial methane recovery from coal seams with respect to the taxes paid to the budget of Russian Federation Subject (Kemerovo region) and aimed for a 2001-2003 years period. This law relates to such taxes as income tax, property tax and land tax. Other law is in compliance with Tax Code of Russian Federation and with other standard legal documents of Russian Federation and Kemerovo region, establishing tax credits to subjects that receive investments in a form of capital inputs on the territory of Kemerovo region. This law relates to the income tax and property tax.

CONCLUSIONS

Coal mine methane recovery and utilization projects on Kuzbass coal mines are necessary and economical expediency. Participation in the international emission reduction market attracts additional investment resources.

The successful development of coal mine methane projects in Russia could be stimulated by additional factors, including ratification of Kyoto Protocol by Russia, realization of the international projects and changing a disproportion in gas/coal prices. The proposed mathematical models based on the games theory could be used as effective tools for selection rational coal mine methane utilization options on specific coal mines.

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