Methane Recovery and Utilization from Coal Seams in Russia. The Present State of Affairs

Puchcov L.A., Slastunov S.V. and Karkashadze G.G.

(Moscow State Mining University, Russia)

ABSTRACT

The paper deals with resources of coal methane in Russia. Information on emission of methane from potentially dangerous mines is provided. It is noted that Vorkuta coal deposit and Kuznetsk coal basin are the most abundant in methane. Conceptual approach to the problem of recovery and usage of the gas from Russian coalmines is described. The key element behind the concept used here is the problem of safety concerning methane and improved coal production. To this end recovery and further usage of coal methane at all stages of mine functioning are considered. Namely, from mine construction to the end of its development and after its closure. The paper also describes the promotion problems concerned with coal methane technologies in Russia. Here you can find information on investment projects to be realized, and the state of affairs with Russian technologies of preparation of methane-and-air mixtures to be used. According to the concept worked out here we suggest a radical way of solving the problem of coal methane recovery and usage in Russia - that is introduction of a law banning development of coal seams with methane content over 9 m^3/ton without preliminary degassing. It should be mentioned that this measure must be introduced gradually, for instance, for 15 years. Apart from that it is very important to introduce tax privileges for enterprises using methane as environmentally-friendly resource.

Key words: coal, methane, resource, safety, recovery and usage of methane, concept.

INTRODUCTION

Methane resource of Russian coal basins is 49Tcm (1Tcm=One Trillion cubic meters=10^{12} m^3) including Kuzbass – 13.085; Pechora – 1.942; Eastern Donbass – 0.097; South-Yakutia – 0.920; Ziryansk – 0.099; Tunguska – 20.0; Lensk – 6.0; Taymir – 5.5. The structure of gas-bearing mines and recovery units abundant in methane among Russian coal deposits are presented in table 1 [1].

Vorkuta and Kuznetsk basins are the most abundant in methane among Russian coal fields. Methane potential of these deposits is 11.6m^3/t (normal cubic meter per ton of coal).

Methane resources in Kuzbass coalbeds of up to 1800m deep are estimated to be ~13Tcm, while within coal mine fields they are estimated to be 210Bcm (1Bcm = One Billion cubic meters = $10^9 m^3$). Pechora coal basin contains ~ 2Tcm, while within coal mine fields

methane resources are estimated to be 26Bcm, 17Bcm of which are promising for recovery, with 56% being in workable seams. The fields of the «Vorkutinskaya», «Severnaya», «Komsomolskaya», and «Zapaliarnaya» mines are characterized as having the densest content of methane, with 380, 362, 292 and 298mmcm (1mmcm= One million cubic meters=10^6 m^3) per square kilometer respectively. These fields in Pechora coal basin are regarded as priority fields for methane recovery with prior (advanced) degassing.

The Russian Federation has 82 coalmines of potential methane hazard functioning now. Fifty mines are abundant in methane. Twenty two mines (44%) are in operation using degassing technology. The number includes 13 mines in Kuzbass, and 6 mines in Vorkuta. The working faces of those mines emit 710mmcm of methane per year; recovery units of Kuzbass mines produce 53mmcm of methane per year by degassing process. In Vorkuta it is 130mmcm per year. But not more than 37 – 40mmcm per year are used. The present state of recovery of Russian mines is presented in table 2. Table 3 shows the quantity of methane. Table 4 shows the volume of methane recovery at mine units in Russia.

Kuzbass mines have devised methods of degassing nearby seams and gobs through wells driven from the surface and connected with vacuum pump or vent installation [2].

Vorkuta mines have gained an experience of using methane captured by degassing in mine boilers, air-heating radiators and in drying at dressing plants. In Kuznetzk basin methane captured in mines is not used commercially. However, considering methane emission here, there are conditions of switching boilers to coal methane fuel for electricity generation and heating [3, 4].

Coefficient of methane recovery by degassing in Russian mines – 0.2; Kuzbass – 0.15; Vorkuta – 0.4. Energy producers in Russian are getting to understand the fact that coalbed methane outside coal fields can be of interest as a useful mineral in itself. However, considering rich resources of conventional gas available in Russian the problem is not of strategic importance as for the national energy security.

At present a conceptual approach to the problem of coal mine methane recovery and usage has been formulated in Russia. It does not present the problem in question as a key task of facing Russian coal mining industry. It is only of local importance and methane can be regarded as a by pass product or a way of reducing cost in coal production.

The problem in question can be solved only as a part of a whole complex of present day actual problems of coal methane [5, 6]:

1 Methane hazard free underground coal mining;

2 Better efficiency of coal recovery ensured by the safety of work in degassed areas;

3 Environmental problem concerned with methane emission reduction contributing to greenhouse effect;

4 Resource saving in development of coal deposits recovery and usage of extra raw material (methane) of coalbed.

Conceptual approach to the problem is based on the necessity of securing effective methane recovery at all stages of coal deposit development. It includes mine construction, production and its closure (see table 5).

The recent up date on the problem of coal methane recovery and usage in Russia is the following:

- mine methane recovery by degassing accounts for 20% of methane emission in coalmining;
- about 20% of methane remain intact in gobs;
- about 60% of methane goes out through vent flow.

Facts concerning mine methane usage:

- by vent flow – no;
- by degassing: Kuzbass – no; Vorkuta – up to 40%, mainly boilers, usage of methane concentration not less than 25% with the minimum debit of methane – 16m^3/min.

The areas of problems indicated boils down to the following:

a) absence of stable quality methane recovered by degassing;

b) scarce degassing. In particular, Kuzbass mines practice mainly degassing of gobs, while a number of mines use gas suction through gobs by flank wells of large diameter;

c) absence of preparation system as well as absence of stability of quality of the methane recovered;

d) absence of record for sources of methane emission (including shut down mines).

The outlook for methane recovery and usage in Russia are predetermined by the following factors:

- It is impossible to ensure effective workload for the working face (adequate level of coal production to ensure economically profitable coal production) without effective methods of degassing accompanying methane recovery from coal bearing strata;

The Russian Federation decree № 410, dated on July, 1, 2005.

- . It stipulates 1000 times higher fines for methane emissions (even now many coal mining companies are in heavy debt for this very reason);

- Ratification of Kyoto Protocol by Russia. Launching the Kyoto mechanism within the framework of Mutual Project Implementation.

At present in this field Russia has several investment projects set for realization. «Severnaya» mine project stipulates methane for electricity generation and heating using gas and piston instillations (ГПТЭА-1500 made by «Econeftegas» Company. Its minimum yield is 8.75m^3/min). Seven installations of this type can generate 10.5MW (1MW=One Million Watt) of electricity. They are to be connected to the «Komenergo» electricity grid, adhere to technical specifications.

Investment projects to recover and use methane from gobs of previously shut down mines of Kuzbass are set for realization in 2006 – 2007. They are «Kapitalnaya», «Baidaevskaya» and «Zirayanovskaya» mines. At present the Moscow State Mining University is carrying out research and design studies to this end. Preliminary estimates show that methane left behind in gobs of «Komsomolskaya» mine amounts to 120mmcm.

Studies carried out for alternative methane projects indicate that low cost of electricity in the region makes Kuzbass not prospective for use of methane for electricity generation. On the other hand considering low capital cost of boilers renovation it is more sensible to use Kuzbass methane as boiler fuel. Methane used in flares is also under consideration. Now Kuzbass has over 2000 coal fired operating boiler rooms. Only 15% switch over to combined type of fuel (gas and coal) can reduce annual emissions of: CH_4 by 675mt (1mt = One thousand ton = 10^3 t), CO_2 by 3780mt, SO_2 by 28,8mt, NO_x by 1.4mt, macro particles by 123mt.

International Centre for Coal and Methane of Russian Academy of Science (Siberian Department) in cooperation with ICF Consulting (USA) has been engaged on a project within the UN framework Development Programme «Russia - Eliminating Barriers in the Way of Mine Methane Recovery and Utilization».

The aim is the implementation of two large pilot projects of recovery and usage of Kuzbass mine methane. «SUEK» (Siberian Coal Power Company) coal company has prepared a business plan «The Usage of Methane Produced by Degassing at «Komsomolets» mine». The plan considers two versions of using the methane. One is to produce heat energy by burning methane in renovated boilers; the other is to produce electric power and heat at a generating power station. Each version has a technological solution considering conditions of «Komsomolets» mine. Technical equipment and its cost have been identified and calculated as well as feasibility studies done for the methane use technologies. The calculations take account of emission trade mechanism set by Kyoto Protocol. Investment costs for implementations require 7.9million rubles for boiler upgrade and in case of generating power station the costs total to 31.5million rubles. «Novosybirskteploenergoproect» LTD is taking part in the design of a new boiler room switched over to methane fuel.

Similar business-plan has been worked out for «Raspadskaya mine LTD». The boiler room of the mine consumes 40mt of coal annually. If 50% of fuel used now in the boiler were mine methane instead of coal the amount of coal saved in the process would be 20mt annually. Thus, a switch over to mine methane as a fuel for «Raspadskaya» boiler would allow for 15mmcm of methane (~29 m^3/min) being burn annually. In terms of 100% concentration it amounts to the heat efficiency of ~20mt of coal.

The annual amount of methane being consumed in a power generating unit is estimated at 2.4mmcm. In terms of 100% concentration by installing one «Caterpillar» unit with the capacity of 1 MW additional 10512Bcal (1Bcal=10^9Calories) of heat can be produced annually.

By implementing the project with the help of «Company for Recovery and Utilization of Mine Methane» set up in the framework of UN Development Programme «Russia. Eliminating Barriers in the Way of Methane Recovery and Utilization» economic benefits for «Raspadskaya» mine can be assured. The company shall provide $1645 thousand towards recovery costs. Capital expenditure of «Raspadskaya» mine will be $1162 thousand; the return on investment period will be reduced to 3.9 years.

Experimental work is being carried out in Kuzbass to begin commercial production of methane from coalbeds outside mine fields. In this case the focus is not greenhouse methane reduction but rather economically useful production of methane from unconventional source. The main target of that experiment is to develop methane recovery technology and turning coal methane resource into a commercially useful class of resources. At present we have four experimental wells driven with 18 coalseams worked by «Shlumberger» (US). The work is being carried out to perform well dewatering, evaluate the dynamics of gas flow from the wells, and ensure commercially useful debit.

The main technologies for utilization of coal methane developed in Russia are:

1 Combined burning of methane and coal in boiler furnaces;

2 Generating electricity and heat in Diesel, gas engines, and gas turbines;

3 «Chemical» technologies to produce fuel for engines, methanol, acetylene, black, aldehyde, octamix.

All technologies have been brought to working design and test operating stage. However, wide-scale introduction is hindered by incomplete technology for preparation of methane-air mixtures to be used in the above technologies, as well as by investment problems.

There have been created installations capable of ensuring higher level of methane concentration and achieving optimum concentration for each technology to be employed. They are based on membrane and vortex principles of new concepts use methane-air-mixtures to

produce fuel for engines (liquid or gaseous), methanol, black, athetylene, octamix and formaldehyde.

MSMU has created an industrial design while «PROMGAZ» has constructed a prototype of oxidation of methane to get methanol. The unit requires 3 – 4MPa pressure, 300 – 500^0C by either catalytic or non-catalytic way. Return on investment of 1t – $54.3, selling price $90 per ton. Installation to produce athetylene (designed by «ОАО ГИАП»-State Institute of Nitric Industry) features two main units for pyrolysis gas production and athetylene separation with annual production of 60t (36 athetylene cylinders per day). Gas consumption being ~6.8 m^3/min; 4.2m^3 cylinder costs – $6, athetylene cylinder selling price – $42.25, annual sales profits – $275thousand.

Direct conversion of methane into formaldehyde (designed by «ОАО ГИАП») is a promising method of methane-air-mixture processing. Only in case of formaldehyde production the utilization of low methane concentration is possible. Ventilation methane may be converted into formalin. Each million cubic meters of methane accounts for 60 – 100mt of potential aldehyde. Market demand for aldehyde is growing constantly, today 1t of the substance being sold at world markets at $5thousand.

MSMU in cooperation with «Metal Steel Temirtau» (Kazachstan) have been engaged in production of black from advanced methane degassing of coalbeds.

For utilization of coal methane (concentration of 95 – 98%) there have been designed and tested a pilot installation which decomposes methane into black and hydrogen. Reduction in methane and carbon dioxide emissions make that installation ecologically effective. Required volume of investment for the project – $138million.

A number of developments in «small» chemistry and electrical power engineering allows 90 – 95 % coalbed methane utilization. They all make use of Russian produced commercial type of equipment. These technologies can be used to produce chemical products to meet market demand and have its own value. They reduce emissions of harmful matter and gases contributing to greenhouse effect, thus improving environmental situation in coal producing regions.

Today, Federal Agency on Science and Innovations of the Russian Federation has commissioned a comprehensive project «Development of Technologies to Recover and Utilize Coalbed Methane Commercially». The main aim of the project is to develop highly-effective environmentally clean technologies to recover and use coalbed methane on the basis of fundamental and applied study results. It also aims at arranging a set of measures to launch Kyoto Protocol mechanism to draw-investments.

The work on the project will enable to conduct studies and give a well-grounded opinion on commercialization of the following enterprises and services:

- Commercial production of coalbed methane both outside acting mine area and within coal mine fields using technologically and ecologically clean raw materials of regional markets of energy resources and raw materials for chemical processing;
- Heat and electricity generation using coalbed methane of coal producing regions;
- Wide-range production of gas and chemicals (synthetic liquid fuel, oil, synthetic drying oil, black, etc.) on the basis of coalbed methane and mine methane processing.
- Production of special-type equipment and technical means for recovery and preparation for further use of coalbed methane, mine methane (surface and well equipment for construction completion and bringing to a commercial level installations for comprehensive gas preparation and equipment for mine methane preparation and vent gas preparation);
- Construction of small boiler rooms and heat generating stations to produce heat and electricity.

Services:

1 Advanced degassing of coalbeds using technologies designed and methane marketing;

2 Construction, completion and bringing to a commercial level of coal methane wells using stimulated liquid flow coalbeds;

3 Design inventor inspection and monitoring developments of coal methane deposits;

4 Gas supplying utilities to supply coalbed methane for communal and home consumers.

Despite high potential of the existing Russian coalbed methane technology now national coal companies take little interest in them, if at all. High starting cost of implementation and a long term of return on investments are the major prohibitive factors for those technologies. Thus, one can speak of a great risk of investments in those technological solutions.

At the same time it is clear that existing norms and regulations governing development of gas bearing coalbeds provide no adequate guarantee as for the safety against possible gas explosions or coal outbursts. The estimated gas hazardous limit is $9m^3/t$. Below that the risk goes down to zero.

For the reasons stated obligatory coal methane recovery can be enforced by governmental measure, in particular by improving existing mining low. Introduction of new regulations based on providing hazardous free development of gas bearing coal beds. At the same time it is very important to legislate new tax privileges for those producers that use environmentally clean coal methane.

In our view, a concept solution to ban all underground mining of coalbeds with 9m^3/t gas bearing content will be adequate enough measure to make coal companies carry out degassing, in case the above limit is surpassed.

The solution suggested will be for the benefits of all concerned:

- the state will be the better for it, as labour productivity of mines increases they will be able to provide additional tax;
- coal mines will have adequate safety levels thanks to degassing measures, higher labour productivity, additional profits for coal methane utilization, reduction of fines padded for methane emissions and potential of emission trade participation writhing Mutual Implementation Project;
- Environment will be the lifter for greenhouse gas emission reductions.

In order to soften the possible initial negative impact we suggest that the measure should be implemented gradually, for example within 15 years, as follows:

- 2006 – 2010 – preparation for degassing, setting up the necessary structure. No limitations as for the quantity of content.
- 2011 – 2015 – ban on beds development with gas bearing content above 14 m^3/t.
- 2016 – 2020 – ban on beds development with gas bearing content above 12 m^3/t.
- After 2021 – ban on beds development with gas bearing content above 9 m^3/t.

Thus, in case of implementation in 15 years Russian will have safe technologies of underground coal mining, higher profitability of coal mines due to higher labour productivity, coal methane utilization for energy, and finally greenhouse gas emissions reduction.

Apart from this legislation initiative it is highly desirable to introduce tax privileges for coalbed methane recovery and utilization operations, especially within allocated mine areas.

To promote this legislation initiative it is necessary to get support from authoritative experts of Methane to Market Partnership and also have feasibility studies and business plan based on internationally tested and approved standards ready. In our case, with regard to particular mine of high gas bearing content in Russia, the mine engaged in coal methane and utilization.

Reference

1 Ruban A.D. «The Technology of Coal Mine Methane Recovery and Utilization: Experience and Outlook» - II International Symposium on «Reduction of Methane Emissions» Novosibirsk, 2000, p. 503 – 574.

2 Ruban A.D., Zaburdiaev V.S. «The Problem of Safe Development of High Gas Concentration Coal Deposits» - Geotechnological Problems of Comprehensive Development of Earth Resources. Mining Research Institute/ Urals Department /Russian Academy of Science RAS – Issue 2 (92), Ekaterinburg, 2004, - p. 86 – 98.

3 «The Problems of Coalbed Minining Recovery and Utilization of Mine Methane in Pechora Basin». – M.: Mining Research Institute after A.A. Skochinski, 2002, p.350.

4 Durnin M.K. «Coalbed Methane: Degassing and Utilization» - Scientific Report / Mining Research Institute Center after A.A. Skochinski, M., 2003, - issue 324, - p.56 – 66.

5 Slastunov S.V., Kolikov K.S. «Recovery and Utilization of Mine Methane – Necessary Condition for Rational Development of Coal Deposits» - Research Institute Center after A.A. Skochinski, M., 2002, - issue 321, p.60 – 64.

6 Puchcov L.A., Slastunov S.V., Kolikov K.S. «Methane Recovery from Coalbed» M., M.S.M.U. publishing house, 2002, p.383 (Monograph).

7 Slastunov S.V., Advanced Degassing and Recovery of Methane in Coal Deposits». – M., M.S.M.U. publishing house, 1996 (Monograph).

Ours e-mail: slastunov@msmu.ru
karkash@msmu.ru

Table 1 – Gas Mine Structure and Methane Abundant Recovery Units in Russia

Coal Basins, Deposits, Regions	The Number of Gas Mines where Productive Mining is under Way		Recovery Units /number/					
			Gas Mines		Absolute Methane Content (m^3/min)			
	Total	Share	Total	Share	Less than 3	From 3 to 10	From 10 to 20	Over 20
Pechora	11	0.134	33	0.171	19	8	5	1
South Kuzbass	17	0.207	35	0.181	15	11	2	7
Prokopievsk – Kiselevsk	15	0.183	55	0.285	51	4	0	0
North and Central Kuzbass	19	0.232	35	0.181	19	9	4	3
Eastern Donbass	4	0.049	6	0.031	2	4	0	0
Urals	6	0.073	13	0.067	11	2	0	0
Far East	6	0.071	12	0.062	12	0	0	0
Sakhalin	4	0.047	4	0.021	0	1	3	0
Total	**82**	**1.0**	**193**	**1.0**	**129**	**39**	**14**	**11**

Table 2 – The State of Methane Recovery in Russia

Coal Basins, Deposits, Regions	Number of Units							Volumes of Methane Recovery, m^3/min
	Degassing Required	Using			Degassing of Opening	Gob Degassing	Gas Suction from Gobs	
		Degassing	Gas Suction	Degassing and Gas Suction				
Pechora	1	11	0	0	0	4	0	400
South Kuzbass	8	0	4	10	5	0	1	464
Prokopievsk – Kiselevsk	2	2	0	0	0	0	0	80.5
North and Central Kuzbass	9	1	8	3	2	0	1	297
Eastern Donbass	0	1	0	0	0	0	0	28.3
Urals	0	1	1	1	0	0	0	25.3
Far East	0	0	0	0	0	0	0	9.1
Sakhalin	4	0	0	0	0	0	0	4.,3
Total	**24**	**16**	**13**	**14**	**7**	**4**	**2**	**1349.6**

Table 3 – Methane Bearing Capacity of Mine Units in Russia (m^3/min)

Coal Basins, Deposits, Regions	Methane Bearing Capacity of Mine Units, m^3/min					
	Total			Ventilation Network		
	Total	Average/per Face	Per 1t of Coal	Ventilation	Average/per Face	Per 1t of Coal
Pechora	399.8	12.1	6.7	60.3	2.7	2,0
South Kuzbass	435.6	13.2	5.9	99.9	4.8	3,7
Prokopievsk – Kiselevsk	80.5	1.5	2.8	75.5	1.4	3,8
North and Central Kuzbass	297.4	8.5	4.1	36.3	1.6	1,6
Eastern Donbass	28.3	4.7	7.1	18.8	3.8	8,5
Urals	25.4	2.0	4.0	13.0	1.3	3,0
Far East	9.1	0.8	1.8	9.1	0.8	2,5
Sakhalin	45.3	11.3	11.6	45.3	11.3	16,7
Total	**1321.4**	**-**	**-**	**358.2**	**-**	**-**

Table 4 – Volumes of Methane Recovery at Mine Units in Russia, m^3/min

Coal Basins, Deposits, Unions	Methods of Methane Recovery at Units												
	Degassing				Gas Suction				Degassing and Gas Suction				
	Degas-sing	Ventila-tion	Average /per face	Per 1t of coal	Gas suction	Ventila-tion	Average /per face	Per 1t of coal	Degas-sing	Gas suction	Ventila-tion	Average /per face	Per 1t of coal
Pechora	237	102.8	30.9	30.0	-	-	-	-	-	-	-	-	-
South Kuzbass	-	-	-	-	80.9	9.4	22.6	11.5	38.2	168	67.0	27.3	14.2
Prokopievsk - Kiselevsk	0.35	4.6	25	20.4	-	-	-	-	-	-	-	-	-
North and Central Kuzbass	22.6	1.7	24.3	10.6	119.9	16.1	17.0	7.0	61.7	26.4	127	33.6	22.7
Eastern Donbass	24	7.1	9.5	16.7	-	-	-	-	-	-	-	-	-
Urals	0.7	2.3	3.0	28.8	0.9	1.8	2.7	-	1.7	1.2	3.8	6.7	27.6
Total	284.65	118.5	-	-	201.7	27	-	-	101.6	195.6	197.8	-	-

Table 5 – Stages of Coal Methane Recovery

Advanced			Accompanying			Following
Methane Recovery in Fields of Future Mines	Advanced Degassing	Preliminary Well Degassing from the Surface	Preliminary Coalbed Degassing from Underground Workings	Current Degassing	Degassing by Vent Streams	Gob Degassing
Stages, years						
Planning	Construction (mines, levels)		Development			Closure
∞ … 30	- 30 … - 5	- 5 … 0	0 … 50			50 … ∞
Strata Penetration Capacity Change						
Higher	Higher	<u>Higher</u> Without Increase	Without Increase		Ventilation	<u>Without Increase</u> Higher
Recovery Technology						
Wells from the Surface, Hydro treatment, Strata Processing			Beded wells from openings with /without/ strata processing	Wells, workings without strata processing	Ventilation	Wells from the surface with / without strata and gob processing