International Energy Agency

COAL MINE METHANE IN RUSSIA

Capturing the safety and environmental benefits

INFORMATION PAPER

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INTERNATIONAL ENERGY AGENCY

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International Energy Agency

International Energy Agency
9 rue de la Fédération
75739 Paris Cedex 15, France

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Acknowledgements

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The principal authors of this report are Nataliia Denysenko and Isabel Murray of the IEA's Directorate of Global Energy Dialogue (GED), under the guidance of Tom Kerr (Directorate of Sustainable Energy Policy and Technology) and Ann Eggington (GED).

The project was initiated by our IEA colleague Ellina Levina (now with the Center for Clean Air Policy (CCAP)). The paper draws extensively on detailed technical input from Russian expert consultants Anatoly Dmitrievich Ruban and Victor Semenovich Zaburdyaev of Research Institute of Comprehensive Exploitation of Mineral Resources of the Russian Academy of Science (IPKON RAN).

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For any questions or comments please contact:

Tom Kerr
Energy Analyst
Directorate of Sustainable Energy Policy and Technology
tel: +33 1 40 57 67 84 Email: tom.kerr@iea.org

or

Isabel Murray
Russia Programme Manager
Directorate of Global Energy Dialogue
Tel: +33 1 40 57 65 89 Email: isabel.murray@iea.org

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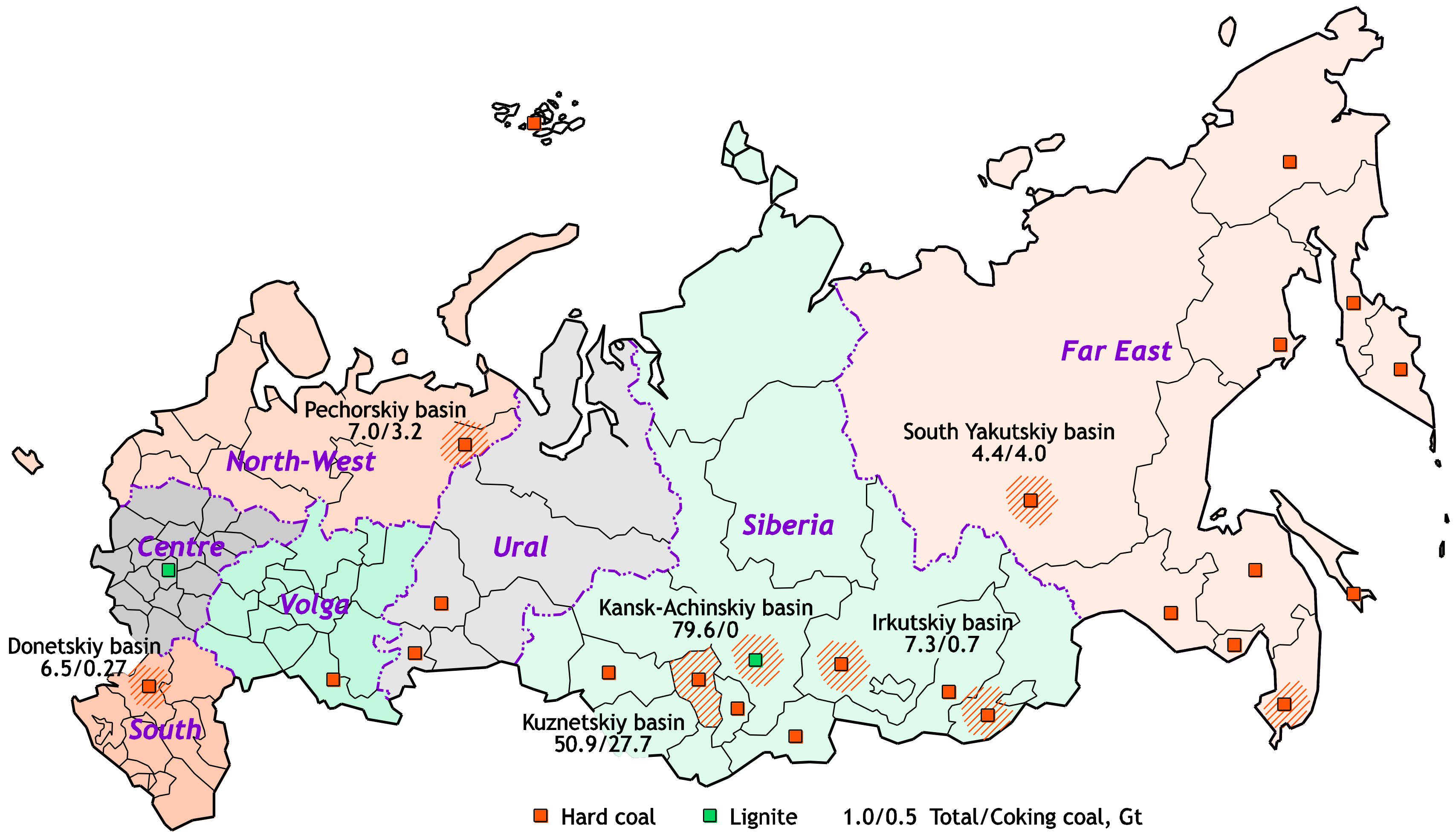
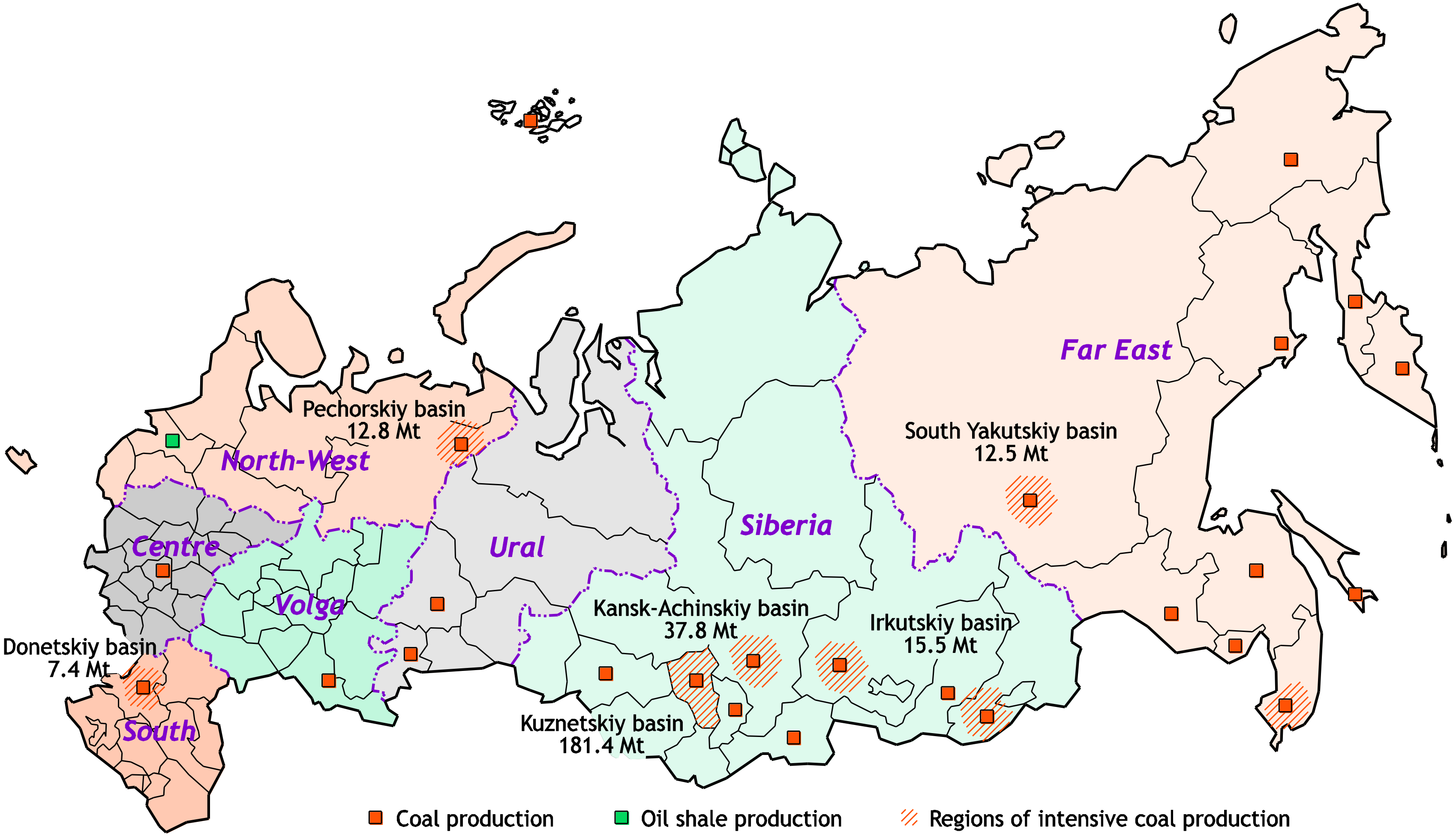
Map 1: Russian coal reserves



Note: The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

Source: IEA CCC, 2008.

Map 2: Russian coal production in 2007



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Source: IEA CCC, 2008.

Executive Summary

Coal mine methane (CMM) is emitted during the process of underground mining. It is both a safety hazard and a greenhouse gas that contributes to global warming. On the other hand, it has the potential benefit of use as a fuel. This paper discusses coal mine methane emissions in the Russian Federation, (the world's third largest emitter of CMM) and the potential for their productive utilisation.

The report is one of a series of Information Papers by the International Energy Agency (IEA) designed to highlight specific opportunities for cost-effective reductions of CMM from oil and natural gas facilities, coal mines and landfills, with the aim of improving knowledge about effective policy approaches. In recent years, there has been considerable international interest in the recovery and use of methane, which has been the major focus of the multilateral Methane to Markets Partnership (M2M).[1]

In Russia, coal mine methane is a safety problem...

Coal mine methane emissions need to be distinguished from coal bed methane: coal mine methane is the gas that is released immediately prior to, during, or subsequent to coal mining activities,[2] and thus has climate change impacts; coal bed methane is exploited as a natural gas resource. This paper discusses the former.[3]

Coal mine methane is a serious safety hazard in coal mining operations. Around the world, thousands of miners lose their lives each year in underground explosions, principally due to inadequate methane control. In 2007, two catastrophic coal mine explosions in Russia killed 150 miners. The RosTechNadzor (2007a, 2007b, 2007c), Russia's state safety regulator, pointed to excessive levels of CMM resulting from violations of ventilation requirements as the key cause of these explosions.

The largest global emitters of CMM in order of magnitude are China, the United States, Russia and Ukraine. Russia accounts for an estimated 6% of global CMM emissions, releasing almost 2 billion cubic metres (bcm) into the atmosphere each year (US EPA, 2006).

...and CMM emissions are expected to grow

Current official projections suggest that Russian coal production will grow from 323 Mt in 2008 up to 325-400 Mt in 2020 (Makarov, 2009), (although the current global economic crisis increases the uncertainty in this projection). Moreover, the outlook in Russia is for an increasing share of that coal production to come from deeper underground mines with higher and higher methane release. Hence, the increase in coal mine methane emissions could be even greater than the proportional increase in underground coal production. Russian experts project CMM emissions to grow as much

[1] The Methane to Markets Partnership is a public-private partnership of 29 national governments and over 900 private organisations working to advance the methane capture and use projects in the coal, agriculture, landfill, and oil and gas sectors in Partner countries. For more information see www.methanetomarkets.org.

[2] Note that there are emissions from surface mines but these are usually lower per tonne of coal produced. Figures in this report do not include emissions from surface mines.

[3] For a glossary of international terms see www.unece.org/energy/se/cmm.html.

as 4% per year, if no action is taken to enhance CMM recovery and use in Russia. This raises a range of issues related to mine safety (Ruban and Zabourdyaev, 2008).

CMM also contributes to global warming

Moreover, methane is also a powerful greenhouse gas (GHG), 21 times more potent than carbon dioxide (CO_2) over a 100-year period. In 2000, methane accounted for 16% of all human-induced greenhouse gas emissions globally, and coal mining contributed 8% of the total methane emissions that year (US EPA, 2006).

Currently in Russia only limited amounts of CMM are recovered and used

In 2006, 1.9 bcm of methane was released from Russian mines. However, only about 317 Mm^3 was recovered by degasification or methane drainage systems in 2008. The volume of methane that is actually used at the mine site or for local electricity and heat generation is much smaller, totalling only 40 Mm^3 per year (Ruban *et al*., 2005). Despite the fact that degasification allows an increase in the output from coal faces[4] and thus enhances the economics of coal production, only 25% of active mines in Russia have installed degasification systems. This is especially a concern given the relatively high methane content of Russian coal compared to coal mined elsewhere around the world.

Currently, leading edge technologies for CMM recovery and use are installed in only a few mines by coal companies in Russia. A major project at the Kirova mine in the Kuznetskiy basin is, however, being developed to increase the rate of methane drained and utilised.

Better CMM recovery would bring benefits, particularly improved mine safety

In Russia, the key driver for methane recovery is the safety of underground mining. Improved safety would in turn lead to improved labour and mine productivity. Methane-related accidents at coal mines in Russia are principally due to non-compliance with safety regulations. The high level of methane release at Russian mines increases the risk of accidents. Mine productivity is affected by this – accidents clearly reduce productivity and, indeed, mine operations must be shut down when the methane content in ventilation air is above a certain prescribed level. Major mine explosions have heightened the focus on mining safety in Russia and led to new coal mine methane limits and safety regulations being established. The key to ensuring mine safety in Russia is the effective adherence to these mine safety regulations.

Secondary drivers for CMM recovery are the interest in reducing greenhouse gas emissions and bringing additional clean fuel into the local fuel mix.

The high methane content of coal in Russian mines should make them attractive hosts for projects focused on methane recovery and use. If all of the 1.9 bcm of CMM emissions released annually in Russia could be recovered and used, there would be a potential value of about USD 130 million at 2008 regulated wholesale natural gas prices in Russia[5]. That said, the improvement of mine productivity from safe methane recovery would remain an even stronger economic driver.

[4] A coal face is the exposed seam of coal that is worked in a mine.

[5] The average USD/RUB exchange rate for 2008 (RUB 24.87 to the USD) was used for this calculation. Were carbon credits to be tied to the 1.9 bcm (28.5 Mt CO_2 eq) of methane released annually in Russia, then another USD 570 million could be generated, assuming a carbon price of USD 20/tonne of CO_2.

However, market, regulatory and legal barriers will need to be overcome, as described below. In particular, without reform of the natural gas market, bringing regulated Russian domestic gas prices to cost-covering levels and aligned with domestic coal prices (which were deregulated in the 1990s), the economics of projects for CMM use will not attract much investment.

The government could take policy measures to encourage CMM recovery and use including:

...financial and legislative measures...

There are policy measures that could be taken to enhance CMM recovery and use in Russia and there is considerable international experience on which to draw. Indeed, in Russia since mid-2008, several legislative initiatives have been started at the federal level to promote and encourage CMM recovery and utilisation, focussed on mandatory requirements on degasification of coal seams prior to mining. Any amendments to licence requirements should be based on a performance-based approach and avoid being too prescriptive in nature to ensure the most economic and cost-effective investment for each unique mine condition.

The Russian government enacted a decree for renewable energy in January 2009 that sets targets for the increase in the share of electricity generated by renewable energy sources; CMM qualifies for this incentive. To stimulate the utilisation of recovered methane, the government would need to elaborate a range of supporting regulations, amplifying important framework legislation passed in early January 2009. These regulations should provide more clarity on the specific requirements for power utilities who choose to obtain a certain share of power production from CMM to meet their renewable energy obligations.

In addition, the existing Russian legislative framework does not provide sufficient clarity on the ownership and licensing of recovered methane gas. Currently, uncertainty surrounds the legal status of recovered CMM and its usage, which hampers the activity of third party investors who are interested in the utilisation of the recovered gas (e.g. when mines are unable or unwilling to engage in CMM utilisation). A system needs to be established to allow the transfer of rights for the use of recovered CMM. Moreover, licensing of CMM activities is not a clear or easy-to-follow process either. When gas is used within the mine, there is no need to obtain any additional licences and the procedure is straightforward. However, once CMM (or heat and power generated from it) is to be sold to another party, then new mineral extraction licences are needed.

...measures related to the environment…

It may also be useful for the Russian government to assess the feasibility of raising environmental payments on industry for pollutant emissions (including methane). They should be set at a level which would provide the incentive for companies to undertake investments to enhance the recovery and use of CMM. Another option for consideration by the Russian government to stimulate the use of CMM is the possibility of providing tax credits or benefits.

More active Russian participation in international co-operative efforts may stimulate more focus within Russia on CMM recovery and use. In this regard, flexibility mechanisms under the United Nation's Kyoto Protocol – such as Joint Implementation – may also help to enhance the economics of CMM recovery and use projects. However, the Russian government has not yet approved any of about 30 submitted projects. These flexibility mechanisms could help make project economics somewhat more attractive – but cannot in themselves overcome the market failure caused by regulated gas pricing.

...flaring as an interim measure...

There is an interim measure that the Russian government could adopt while the appropriate utilisation technologies become more broadly available and effectively used: they could encourage the flaring of suitably recovered coal mine methane as opposed to venting the methane to atmosphere. Although the energy content of the flared methane would not be exploited, its global warming potential would be substantially reduced by combusting it and converting it to carbon dioxide and water. Further, international experience has shown that this type of staged approach (flaring followed later by utilisation) allows for much-improved project economics (IEA, 2009b).[6]

....and better national and international co-ordination

There is clearly a need in Russia for better co-ordinated efforts at the national level to address the issue of CMM recovery and use. A joint effort from R&D institutes, management of coal companies and engineers responsible for mining safety in methane-rich mines could focus attention on CMM and establish better dialogue and communication across government and industry. An effective and proactive national co-ordinating body should have the stature and ability to bring together representatives of relevant organisations: federal authorities, research institutes and companies. Such a body could focus attention on the key barriers and challenges to enhancing CMM recovery and use in Russia and promote better international dialogue with key international organisations and companies. It could be an effective channel for two-way information flows involving all major and small coal companies in Russia to raise awareness of the challenges faced by all stakeholders and to enhance information exchange on policies and international best practices. This could help promote a radical increase in the recovery and use of CMM in Russia to enhance mine safety, raise mine competitiveness and productivity, and lead to a more sustainable economic development of Russia's coal sector and its energy sector as a whole.

The IEA would also encourage Russia to take advantage of already existing international efforts focused on CMM use such as the Methane to Markets Partnership which can provide much support to improve information exchange and technology transfer and the promotion of international best practices to enhance the use of CMM in Russia.

This Information Paper therefore:

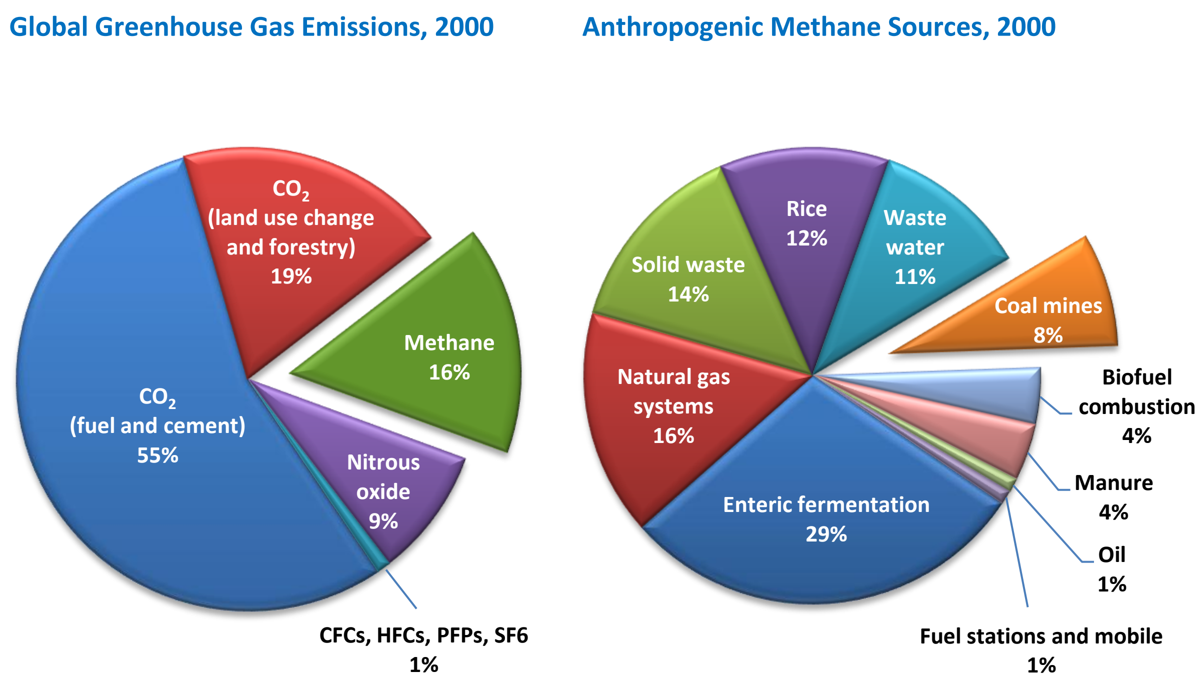
- assesses Russia's current coal production and its plans for the future (section 2);
- reviews the impact of these on current and future emissions of coal mine methane (sections 3, 4 and 5);
- explains the Russian policy framework for CMM, including responsible authorities and regulation (sections 6 and 7);
- explores the key drivers for increased recovery and use of CMM and the barriers to achieving this (sections 8 and 9);
- summarises the experience of other countries (section 10); and
- draws some conclusions on policy measures that Russia could consider to encourage increased recovery and use of CMM (section 11).

[6] For more information see www.iea.org/textbase/Papers/2009/methane_brochure.pdf.

1 Introduction

Globally, coal mines release important volumes of methane which could either on the one hand become an important energy resource if recovered and utilised or, on the other hand become a problem as a safety hazard or through its contribution to global warming (if released into the atmosphere). Methane is a powerful greenhouse gas, 21 times more potent than carbon dioxide (CO_2).[7] Figure 1 shows that in 2000 methane accounted for 16% of all anthropogenic (human-induced) greenhouse gas emissions globally; coal mining contributed 8% of the total methane emissions that year.

Figure 1: Global greenhouse gas emissions in 2000 and anthropogenic methane sources



Source: US EPA, 2006.

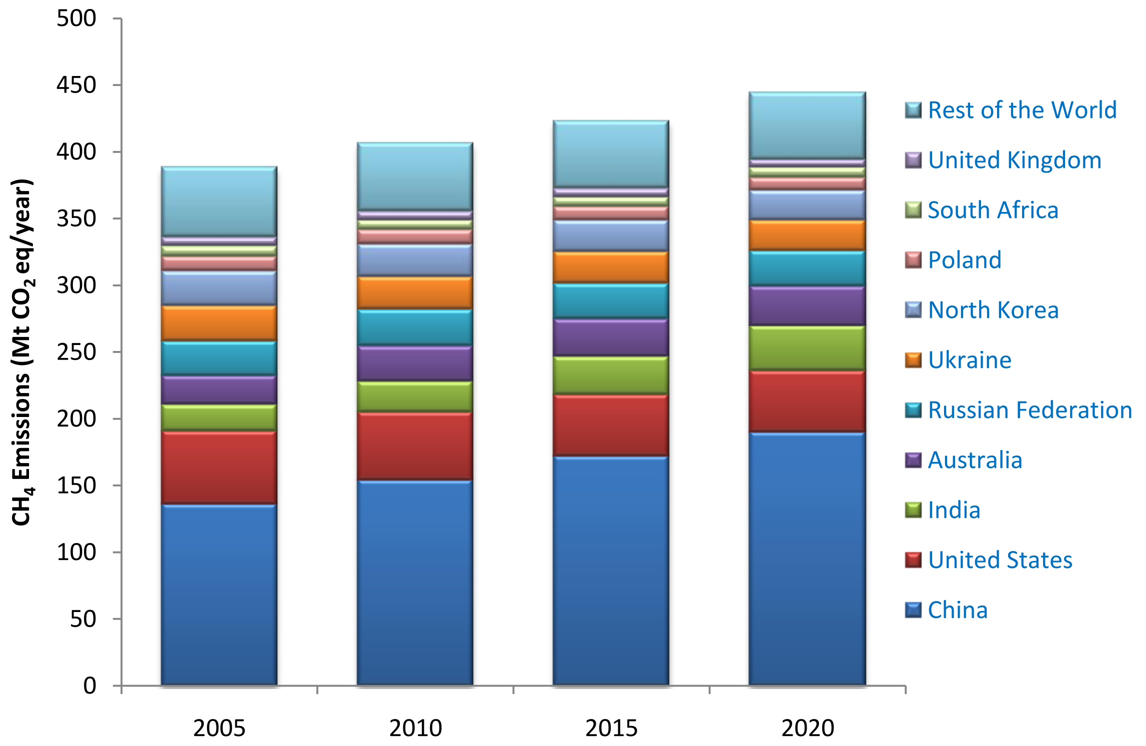
This paper discusses coal mine methane emissions – the gas that is released immediately prior to, during, or subsequent to underground coal mining activities and thus has safety and climate change impacts. It should be distinguished from coal bed methane (CBM) which is exploited as a natural gas resource.[8]

[7] See Intergovernmental Panel on Climate Change website, www.ipcc.ch. Other bodies have, at different times, used different GHG warming potentials for methane since its value depends on assumptions such as the time period considered (typically 100 years).

[8] For a glossary of international terms related to CMM, see www.unece.org/energy/se/cmm.html.

According to estimates by the Environmental Protection Agency of the United States of America (US EPA), global CMM emissions in 2005 were 21.8 bcm (329 Mt CO_2 equivalent (CO_2 eq)) of which 3.1 bcm (47 Mt CO_2 eq) was used as fuel. Almost 33% of this estimate of global CMM emissions came from China. The United States is the next largest emitter accounting for about 13% of global coal mine methane emissions. Russia and Ukraine are next in line, each accounting for 6% of global emissions (Figure 2).

Figure 2: Russia and other coal producers could continue to see rising CMM emissions

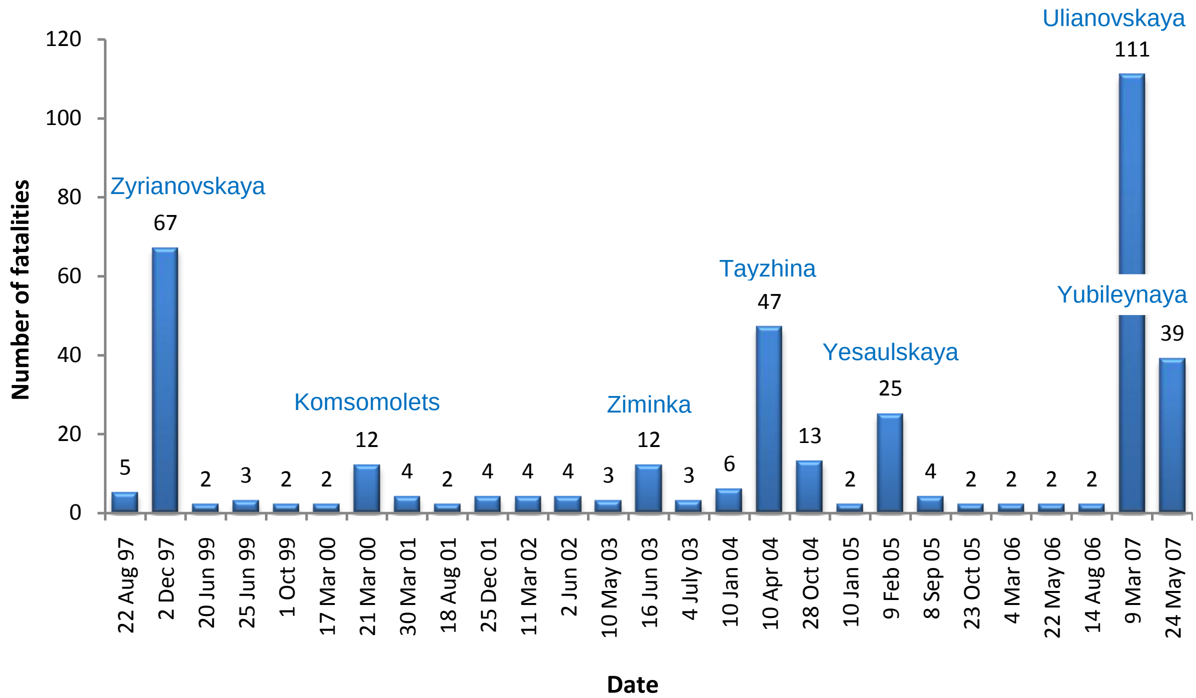


Source: US EPA, 2006.

According to the United Nations Framework Convention on Climate Change (UNFCCC) GHG inventory data,[9] methane emissions from Russian underground coal mines amounted to around 1.9 bcm (28.5 $MtCO_2$ eq) in 2006. In Russia nearly all of methane from coal mines is released into the atmosphere. Not only will this released CMM, as a greenhouse gas, contribute to global warming, but also high levels of methane are a critical issue for safety at coal mines. Most fatalities at Russian coal mines are related to methane. In 2007 alone, two catastrophic coal mine explosions in Russia killed 150 miners. Figure 3 illustrates the history of major mine explosions in Russia and the number of fatalities linked with each. In this regard, the issue of miner safety is the key driver to enhance the recovery of CMM in Russia.

[9] The UNFCCC estimate of methane emissions from Russian underground coal mines in CO_2 equivalent terms was used for this analysis and converted into billion cubic meters of methane using the UNFCCC conversion factor of 21. The UNFCCC inventory of GHG is available at http://unfccc.int/di/DetailedByParty.do.

Figure 3: Major mine explosions in Russia in 1997-2007



Source: Ruban, 2009.

Worldwide, in the process of underground coal mining, methane is often drained prior to mining (degasification) or captured during mining to reduce its release into the mine workings. Recovered gas can be used as a fuel, flared or simply vented. Methane concentration can vary widely across countries, depending on geological conditions and mining practices. CMM with over 40% methane can be used for power generation or in combined heat and power (CHP) plants, for industrial applications or in boilers for district heating. When the recovered CMM is of a higher quality (e.g. with 80% methane or higher, and after any necessary cleaning and upgrading), it can be piped into natural gas pipelines or used as vehicle fuel (M2M, 2008). However, there is less such high-quality CMM at Russian mines.

Any methane released into mine workings is generally mixed with ventilation air of sufficient quantity to dilute the methane to low concentrations for safety reasons. This ventilation air methane (VAM) is the lowest-quality (typically no more than 0.8% methane content). VAM is too dilute to sustain combustion and is the most difficult to capture and use due to challenges in designing suitable utilisation technologies. However, in some countries technologies are being honed to capture and even use ventilation air methane (see section 5.3).

2 Overview of Russia's Coal Sector

In 2008, Russia was the world's fifth largest producer of hard coal (over 247 Mt in 2008), producing about 1/11th of the level of China and about one quarter of the level in the United States and half that of India. It was the world's third largest exporter of hard coal (101 Mt) behind Australia (252 Mt) and Indonesia (202 Mt) (IEA, 2009a). Coal reserves in Russia are located in 22 coal basins and

118 separate deposits across Russia, with the major deposits concentrated in Siberia (80%) and the Far East (10%)(IEA CCC, 2008) (see Map 1 and 2).

Russia holds one of the largest coal resources in the world with an estimated 3 900 Giga tonnes (Gt) (IEA CCC, 2008). Russian coal mines are also some of the most gas-rich, with an average of 11.6 m^3 of methane per tonne of coal (see Table 1) (Ruban *et al.*, 2006). The Kuznetskiy and Pechorskiy coal basins encompass almost 80% of all gassy mines in Russia. This is partly due to the relatively high methane adsorption capacity of coal in these basins.

Table 1: Average methane content of coal by country (m^3/t)[10]

Country	Average Methane Content
Russia	11.6
UK	10.3
China	9.3
USA	7.0
Germany	5.0

Source: Ruban *et al.*, 2006.

In Russia, 40% of all coal produced and about 50% of all black coal produced comes from underground mining. The major deposits are concentrated mainly in Siberia (with an 80% share of coal resources) and to a lesser extent the Far East (accounting for 10%). The main coal basins are the Kuznetskiy (Siberia) and Kansko-Achinskiy (Siberia). In 2007, the Kuznetskiy basin produced 56% of all coal produced in Russia. Another 12% was produced in the Kansko-Achinskiy basin, 12% in East Siberian basins and 10% in coal basins of the Far East. Coal basins in these regions accounted for 90% of total Russian production. The outlook is for the main producing regions to be the Kuznetskiy and Kansko-Achinskiy basins while the east Siberian, Pechorskiy, Donetsk and South Yakutsk basins will have only regional importance.

2.1 Russia's Coal Industry

The growth in the production of coal started in the late 1990s after the completion of the first phase of restructuring of Russia's coal industry. The period 1999-2008 witnessed the most rapid sustained economic growth that Russia has ever experienced. Gross Domestic Product (GDP) increased by an average of 7% a year in real terms (inflation adjusted) and, given the gradual decline in the population, per capita growth was faster still. In its turn, this economic boom has required increased investment and production of energy to fuel the economy. The restructuring of

[10] It is important to note that methodology of desorption tests produced in Russia and Ukraine is slightly different from the one applied in western countries. Because coal samples are heated to 60-80°C in Russia, this might be a reason for the comparatively higher level of reported gas content of coal in Russian and Ukrainian mines.

the coal sector saw large-scale closure of uneconomic mines, resulting in an increase in the sector's competitiveness and labour productivity (IEA, 2002).

This was a difficult period, however, as closures brought much social dislocation and the need to address issues of resettlement and retraining of redundant coal miners. Most coal mines were privatised. Private owners made relatively large capital investments into new technologies, mining equipment, and development of mine facilities. This improved production efficiency and worker safety. The productivity of coal face machinery increased on average 3-4 times over the period 1997-2007. Russia's coal production has risen from a 1998 output of 221 Mt (including 141 Mt of hard coal) to 323 Mt (247 Mt of hard coal) in 2008 (IEA, 2009a). The increase in export volumes has led over the decade to a considerable rise in the share of coal that is treated to improve its quality – about 65% in 2005. According to the Ministry of Energy (2009), Russia's coal production in January-March 2009 amounted to 69.5 Mt – a decrease of 18.7% compared to the same period in 2008 due to the global financial crisis.

The restructuring of Russia's coal mining industry over the 1990s resulted in the closure of 188 loss-making, uneconomic mines. Many of these mines were among the gassiest, and this thereby led to a considerable drop in Russia's methane emissions at operating mines. In 2009, 57 out of Russia's 98 mines were rich in methane (over 10 m^3/t), including some superhazardous mines (over 15 m^3/t) and those with high risk of coal, gas and rock outbursts. However, less than 50% of those use degasification systems. There is discussion in more detail in section 5.2.

More generally, Russia's coal industry is still experiencing major problems, including:

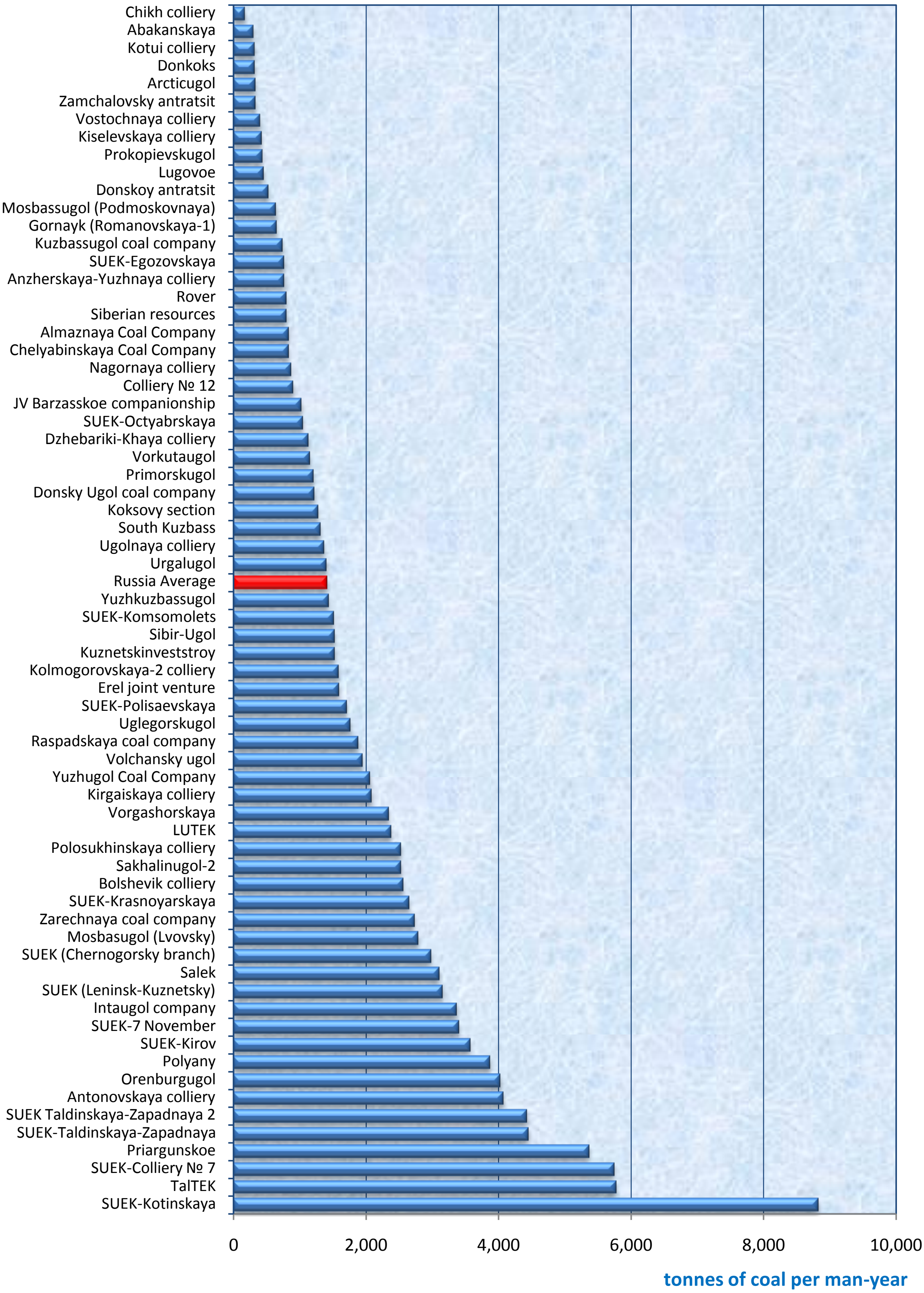
- low productivity (3-5 times lower than levels in the US, Canada, and Australia);
- old and outdated equipment;
- the remote location of most of Russia's coal deposits leading to large transport distances and costs;
- government regulation of energy markets and prices resulting in the low competitiveness of coal-fired power generation (because natural gas prices are held artificially low).

Despite these difficulties, since 2000 the overall trend in the development of Russia's coal industry has been positive. The volume of coal production is increasing and production efficiency of many coal companies and many mines has improved significantly. The structure of Russia's mining sector is changing with widespread use of more efficient technologies. However, productivity of Russia's coal mining industry is still relatively low compared to international levels. Russian underground coal mine productivity averages only 1 350 tonnes/man-year with some mines achieving less than 100 tonnes/man-year (see Figure 4). However, there are some notable exceptions such as OAO Siberian Coal Energy Company's (OAO SUEK[11]) Kotinskaya mine, achieving productivity of over 8,800 tonnes/man-year and approaching the best levels of productivity seen in other countries (RosInformUgol, 2009).

The high methane content of Russian coal and the associated risks during mining, referred to by some experts as the "gas factor", remain key constraints to improving the efficiency of coal mines in Russia. Thus addressing CMM issues is increasingly becoming an important prerequisite for Russia's coal sector to compete for energy market share domestically and on world coal markets.

[11] OAO in the name of a Russian company translates as "open joint stock company".

Figure 4: Productivity of Russian underground coal mines in 2008



Source: RosInformUgol, 2009.

2.2 The Outlook for the Russian Coal Sector

There are considerable uncertainties in relation to formulating an outlook for the Russian coal sector, given the economic crisis and associated unknowns. The Russian Energy Strategy to 2030 released in November 2009 (Government of the Russian Federation, 2009b) focuses attention on the goal of Russia's President to have the Russian economy become one based more on innovation as opposed to the export of energy resources. Russia's coal sector is as exposed as the oil and gas sector to the volatility of commodity export prices. That being said, the energy strategy 2009 projects a 160% increase in coal exports from 2008 to 2020. It also projects an almost three-fold increase in domestic capacity of hard coal processing plants by 2020, reflecting an increase in the domestic use of coal for electricity production.

This outlook assumes the continued exhaustion of capacity of existing coal basins in the European part of Russia and the Urals, the slowing of the development of new coal deposits and the higher cost of coal extraction and transportation. The outlook points to a few key challenges facing the Russian coal sector including the lack of investment funds for the implementation of large-scale infrastructure development projects and the lack of focus on innovation reflected in the weak development of Russia's coal-mining machinery and the consequent growing dependence on imported technologies and equipment and the growing lack of qualified coal sector engineers and miners. To achieve the strategic objectives set out in the Energy Strategy, the Russian coal industry will have to address the following challenges:

- complete the closure of uneconomic coal mines;
- continue to develop the transport and port infrastructure for transportation of coal at economically reasonable tariffs, ensuring diversification of their supplies;
- enhance government regulation of the coal industry, including transparency and corporate governance as well as the regulation of the transportation network;
- promote qualified professionals focused on long-term working relationships;
- improve the efficiency of extraction, enrichment and processing of coal on the basis of improved technologies, equipment and advanced organizational systems;
- promote the introduction of high-end products (synthetic liquid fuel, ethanol and other products of coal with high added value);
- promote the integrated use of coal and associated resources, including the extraction of coal mine methane;
- intensify environmental activities across the coal industry.

Another government document which reflects recent policy thinking is the General Scheme of Location of Power Industry Facilities to 2020 (Government of the Russian Federation, 2008). However, given that it was adopted by the Russian government in February 2008, it does not incorporate any assessment of the impact of the economic downturn from mid-2008 to the present. In this respect, the General Scheme can be considered as an upper estimate of projections. It projects the share of coal in the fuel mix for electricity generation and combined-heat and power plants to grow from 25% in 2006 to 39% in 2020. The Strategy projects an increase in the share of coal from 25% to between 30-35% in 2030. However, if domestic natural gas prices do not increase significantly, then the electricity generation sector will maintain its preference for natural gas over coal.[12]

The expected increase in Russian coal production is likely to translate into an increase in the rate of coal mine methane release, if no action is taken to enhance recovery and use of CMM. This could lead to a heightened challenge to ensuring mine safety standards are met, while still ensuring the competitiveness of mines and their productivity. For this reason it will be critical to install improved degasification technologies to ensure the competitiveness and safety of Russia's coal mines.

3 Coal Mine Methane Resources in Russia

Russia's CMM experience appears not to have been too different from that of its neighbours, Ukraine and Kazakhstan, at least during the 1990-1998 period for which comparable data are available. During that period, Russian CMM emissions were lower than those of Ukraine, even though Russia produced more coal (see Table 2). This table presents the latest available data on coal production and related methane emissions in Russia, Ukraine and Kazakhstan from 1990 to 1998. Ukraine CMM emissions were the highest at 2.44 Mt/y (3.4 bcm/y) in 1990 (including opencast). Despite the various mine closures over the 1990s, it remained the number one emitter among these important coal-producing countries in 1998, even though it produced less coal than Russia. Russian CMM emissions dropped from 1.58 Mt/y to 0.90 Mt/y (2.2 and 1.26 bcm/y) between the period 1990 and 1998, in line with the 41% drop in coal production. Utilisation of this CMM was negligible in all these countries.

Table 2: Methane emissions from CIS mines and open cast[13], Mt/year

Country	Coal production				Methane emissions				Methane capture at mines		Methane utilisation	
	mines		open cast		mines		open cast					
	1990	1998	1990	1998	1990	1998	1990	1998	1990	1998	1990	1998
Russia	175.9	81.0	219.5	144.4	1.58	0.90	0.08	0.06	0.34	0.21	0.03	0.02
Ukraine	155.6	70.3	9.2	n/a	2.43	0.96	0.01	n/a	0.35	0.19	0.12	0.06
Kazakhstan	39.7	12.9	78.9	63.7	0.80	0.29	0.06	0.05	0.13	0.03	0.01	0.01
Total	**371.2**	**164.2**	**307.6**	**208.1**	**4.81**	**2.15**	**0.15**	**0.11**	**0.82**	**0.43**	**0.16**	**0.09**

Source: Ruban *et al*., 2006.

[12] Further analysis of the Russian coal sector can be found in a recent IEA Implementing Agreement – Clean Coal Centre report *Prospects for Coal and Clean Coal Technologies in Russia* (IEA CCC, 2008).

[13] Open cast mining, also known as open-pit mining, open-cut mining, surface mining and strip mining, refers to a method of extracting rock or minerals from the earth by their removal from an open pit.

Many years of research have been carried out in the various Russian coal basins assessing the origins of gas in coal deposits, its chemical composition, the migration of methane in coal-bearing deposits as well as the main physiochemical factors affecting the adsorption capacity of coal and various strata. The key parameters used to assess the recoverable CMM potential at Russian mines are:

1) Reserves and deposits of coal in workable coal seams, taking due account of the efficiency of the degasification method used or planned;
2) Reserves of coal in seams and layers under workable thickness (less than 0.5 m) in areas where they will be de-stressed by nearby mining activity and hence release gas;
3) Volume of other gas-bearing strata within the area affected by mining;
4) Natural methane content (m^3 per tonne) of dry ash-free coal of workable coal seams. The calculation of methane potential is carried out for seams with natural methane content over 10 m^3/t (Ministry of Geology of USSR, 1977).

The methane content of coal in Russia's main coal basins, such as the Kuznetskiy basin, is linked to the coal rank[14] and depth of occurrence. This provides a useful basis to project the level of methane release into active mines. In general, the concentration of methane in coal seams increases with depth. This is illustrated in Table 3 for the Kuznetskiy basin. With future mining in Russia expected to be carried out at greater depths, methane emissions are expected to increase.

Table 3: Methane content of Kuznetskiy basin by rank and depth of occurrence

Coal rank	Depth at which methane first occurs, m	Inherent methane content of coal (m^3/t) at various depths (m) up to 1 800 m				
		< 300	300-600	600-900	900-1200	1200-1800
D: Long Flame (free burning high volatile bituminous)	65-225	2-10	11-15	14-18	16-20	17-21
G: Gas (light, fiery, high volatile bituminous)	65-270	2-15	12-20	16-24	19-27	21-30
Zh: Fat coal (meta bituminous, 89-91% carbon, still relatively high % of volatiles)	65-180	3-16	13-21	17-25	20-30	22-35
K: Coking (bituminous with 80-90% carbon)	100-370	3-17	15-25	20-30	23-34	25-38
OS: Hard caking (low in volatiles (15-17%), high calorific value)	70-300	3-13	12-20	18-28	21-34	22-36
T: Lean (hard coal, low volatiles, dry burning)	70-300	4-15	12-24	17-28	22-35	25-40
A: Anthracite (hard coal, 92-98% carbon, smokeless, short flame on ignition then disappears)	80-250	5-12	11-20	18-29	25-36	–

Source: Ruban *et al*., 2005.

[14] The Russian coal industry ranks coal into 17 different categories depending on the mean value of its vitrinite reflectance index, its volatile content measured on a dry ash-free basis, its calorific value, its caking properties, the thickness of the plastic layer, its free swelling index and the Roga index. See *Prospects for Coal and Clean Coal Technologies in Russia* (IEA CCC, 2008) for more information.

Data in Table 3 reflects the wide range of methane content in coal from the Kuznetskiy basin. Russian experts estimate the methane content of mined coal seams in the Kuznetskiy basin averages about 20 m^3/t. Current CMM potential in the Kuznetskiy basin (based on data from sixteen mines) is estimated at 30 bcm.

4 Coal Mine Methane Emissions at Russian Coal Mines

The government estimates CMM emissions using the Intergovernmental Panel on Climate Change (IPCC) methodology, which includes estimates of methane emissions during coal extraction by underground mining and open cast mining.[15] Emissions from underground mining are the most significant and it is this methane that can be captured and used. The volume of methane that is extracted and used is subtracted from the total volume of estimated coal mine methane emissions. Although special monitoring stations at underground mines survey methane concentration on a permanent basis to ensure worker safety, they do not necessarily measure methane volume flow rates, so the quality of data on methane emissions is variable. Data collected are available to the regulatory authorities in mining regions and are reported to the regional offices of the RosTechNadzor, and to regional environmental agencies.

According to UNFCCC GHG inventory data (UNFCCC, 2009), methane emissions from Russian underground coal mines amounted to around 1.8 bcm in 2005 (26.9 $MtCO_2$ eq) and 1.9 bcm (28.5 $MtCO_2$ eq) in 2006. At the same time, available statistics from RosTechNadzor and the Research Institute of Comprehensive Exploitation of Mineral Resources at the Russian Academy of Sciences (IPKON RAN) estimate annual emissions from underground mines in Russia in 2005-2006 at between 1.25-1.3 bcm (Ruban et *al.*, 2005-07). The 2008 data available from IPKON RAN suggests that CMM emissions from the two main Russian coal basins (Kuznetskiy and Pechorskiy) alone amounted to 1.5 bcm.

The share of methane emissions from the Kuznetskiy basin accounts for about 70% of total methane emissions from the entire coal mining sector of Russia. Due to the increase in underground coal mining in this basin and the depths at which mining is carried out in this region, methane emissions are increasing. Table 4 shows the coal mine methane gas release at potentially productive mines in the Kuznetskiy and Pechorskiy basins (Ruban *et al.*, 2006).

[15] Russia has 148 open cast mines.

Table 4: Coal production and estimated average methane releases during 2003 at potentially productive mines in the Kuznetskiy and Pechorskiy basins

Mine	Average daily production of coal, t/day	Volumes of gas released per minute, including captured CH_4, m^3/min		Volumes of gas released per tonne of coal produced, m^3/t		Average output of methane drainage vacuum pumps, m^3/min	Mine rating by methane hazard[16]
		CH_4	CO_2	CH_4	CO_2		
Siberian Coal Energy Company (SUEK) *(Kuznetskiy basin)*							
Kirova	9 225	99.0	20.8	18.6	3.3	64.8	Super hazardous
7 November	6 755	31.9	25.5	15.7	15.9	6.6	Super hazardous
Oktiabrskaya	5 200	54.7	21.5	15.2	6.0	40.9	Super hazardous
Polysayevskaya	4 717	79.3	13.0	31.4	6.5	40.9	Super hazardous
Komsomolets	4 363	88.1	17.4	29.1	5.9	61.9	Super hazardous
Yuzhkuzbassugol *(Kuznetskiy basin)*							
Yesaulskaya	12 531	165.4	30.5	20.6	3.9	1.1	Super hazardous
Yubileynaya	5 569	59.5	–	28.1	–	0.2	Hazardous with risk of sudden outbursts
Ulianovskaya	5 964	16.7	–	4.1	–	–	Category 3
Abashevskaya	6 148	133.4	–	31.2	–	61.7	Category 3
Alardinskaya	3 192	72.1	18.9	32.6	8.5	4.9	Super hazardous
Gramoteinskaya	4 947	10.9	8.1	3.1	2.1	2.2	Category 3
Osinnikovskaya	3 110	84.3	34.2	39.0	15.7	0.2	Hazardous with risk of sudden outbursts
Tayzhina	2 702	51.3	8.9	28.7	5.0	11.3	Hazardous with risk of sudden outbursts
Tomskaya	1 030	30.3	14.8	41.6	20.3	0.7	Hazardous with risk of sudden outbursts
Kusheyakovskaya	3 075	10.2	–	3.4	–	–	Super hazardous
Tomusinskaya 5-6	3 236	35.9	11.7	16.0	5.2	–	Super hazardous

[16] Coal mines in Russia are classified according to their relative methane content and nature of risks. There are five mine categories: Category 1 with methane content up to 5 m^3 per tonne (m^3/t) of daily coal production; Category 2: 5-10 m^3/t; Category 3: 10-15 m^3/t; Super-hazardous: over 15 m^3/t; and a fifth category for mines where coal seams with possible outbursts of coal, gas and rock are mined, “Hazardous with risk of sudden outbursts”.

Mine	Average daily production of coal, t/day	Volumes of gas released per minute, including captured CH_4, m^3/min		Volumes of gas released per tonne of coal produced, m^3/t		Average output of methane drainage vacuum pumps, m^3/min	Mine rating by methane hazard[16]
		CH_4	CO_2	CH_4	CO_2		
Sibir-Ugol *(Kuznetskiy basin)*							
Chertinskaya	1 716	69.9	–	58.6	–	27.1	Hazardous with risk of sudden outbursts
OAO “KuzbassUgol” Berezovskaya	3 111	12.0	9.1	19.1	15.0	–	Hazardous with risk of sudden outbursts
Pervomayskaya	2 547	19.3	6.9	21.8	10.5	–	Hazardous with risk of sudden outbursts
Uzhnii Kuzbass *(Kuznetskiy basin)*							
V.I. Lenin	2 748	45.0	–	26.5	–	13.0	Hazardous with risk of sudden outbursts
Usinskaya	1 427	28.8	8.5	28.6	8.5	3.2	Hazardous with risk of sudden outbursts
OAO “Raspadskaya mine”	15 100	120.8	–	31.0	–	0.4	Super hazardous
Vorkutaugol *(Pechorskiy basin)*							
Severnaya	6 096	153.9	–	36.4	–	103.0	Hazardous with risk of sudden outbursts
Vorkutinskaya	2 114	142,8	–	97,3	–	86,3	Hazardous with risk of sudden outbursts
Komsomolskaya	3 176	126.2	–	57.2	–	54.6	Hazardous with risk of sudden outbursts
Zapoliarnaya	2 812	931	–	47.7	–	23.3	Hazardous with risk of sudden outbursts
Ayach-Yata	2 360	115.0	–	70.2	–	38.6	Super hazardous
Vorgashorskaya	12 200	70.5	–	13.0	–	10.9	Super hazardous

Source: mine rating data collected annually by regional RosTechNadzor offices (Ruban and Zabourdyaev, 2008).

5 Coal Mine Methane Recovery in Russia

5.1 Technologies for Coal Mine Methane Recovery [17]

A large number of Russian coal mines, mostly located in the Pechorskiy and Kuznetskiy basin, are classified as hazardous or at high risk of coal mine methane explosions. This is reflected in Tables 4 and 5 where it is shown that many of these mine coal with a high methane content (10-15 m^3/t and above). A few of these hazardous mines can also be found in the Eastern (Russian) part of the Donbass. Therefore, removing methane from working areas of mines and goafs[18] is one of the main concerns of Russian mine operators which, as shown in this and the following sections, poses a number of difficulties in the Russian mining industry.

There are two ways to control methane in mines: i) ventilation systems and ii) degasification systems. Ventilation systems move large quantities of air through the mine to dilute and remove methane from the worked coal face. Ventilation air methane produced via this technique is generally released into the atmosphere; however, it can be captured and oxidised (sometimes the energy produced from its oxidation can also be utilised). In Russia, all VAM is currently released into the atmosphere but an experimental unit to utilise VAM is envisaged in an OAO SUEK JI project (see section 8.5).

Degasification systems are used to drain methane from coal seams and surrounding rock strata. To reduce the rate of coal seam methane emission into active mine workings, two types of drainage are used in Russia:

- **Pre-mining drainage** of un-worked seams prior to mining through drainage boreholes drilled from within the mine or during development from the surface. Degasification of coal seams in Russia is required when the coal's methane content is over 13 m^3/t. Suggested amendments to several Russian laws might result in degasification becoming obligatory at all mines (see discussion in section 7.3). Presently, degasification is not widely used in Russia.
- **Post-mining drainage** of de-stressed coal-bearing strata during mining which is obligatory when methane content of mined coal is over 13 m^3/t or at gassy mines when ventilation cannot keep methane levels in the mine safe. Currently in Russia drainage during mining is used more widely than pre-drainage.

Guidelines on Coal Mine Degasification approved by the Federal Environmental, Industrial and Nuclear Supervision Service of the Russian Federation (RosTechNadzor, 2006), the Russian state safety and environment regulator, recommend degasification of one or more methane sources to keep methane concentrations in mine ventilation air at safe levels. These include:

- seams being worked;
- adjacent coal seam(s), either above or below worked seam;
- gas-bearing strata; and
- goafs.

[17] For general information on the major methods of CMM recovery from gassy mines, visit the US EPA Coalbed Methane Outreach Program website at www.epa.gov/cmop/docs/cmm_primer.pdf.

[18] A goaf is that part of a mine from which the mineral has been partially or wholly removed. It can also be called a gob.

In Russia, degasification can be carried out by stationary central suction systems or mobile gas pumps and pipes or ducts, both common practice around the world. Mines with no properly installed degasification systems often use fans to move air from working areas of long-walls into goaf areas. These are much cheaper and less complex to use than proper degasification systems but are considered to be very dangerous by Russian experts as they allow accumulation of explosive concentrations of methane and dust (Ruban *et al.*, 2005-2006). However, the situation is changing; greater use of proper degasification is being used to ensure workers' safety and higher mining productivity.

More information on the criteria and required efficiency of degasification in Russia as well as specific degasification and drilling technologies, regimes and parameters of drainage for various mining conditions is set out in the *Guidelines on Coal Mine Degasification* (RosTechNadzor, 2006) and also in publications by IPKON RAN (Ruban *et al.*, 2005-06) and others listed in the bibliography to this paper (e.g. Sergeyev *et al.,* 2002, Ruban *et al.,* 2007). Degasification of coal seams to be worked is usually considered feasible when the gas content of the coal seams is over 10 m^3/t. It is carried out by means of surface boreholes, sometimes stimulated through hydraulic fracturing (hydrofracing)[19] of coal seams to improve permeability and gas recovery, and degasification of thick seams by means of boreholes drilled ahead of the working face; and degasification of adjacent coal seams and goats through underground or surface boreholes (Ruban *et al.*, 2005-07).

Although, these degasification technologies are recommended in the guidelines, their application is limited mainly due to the high cost and the fact that Russian coal companies do not have the expertise to operate drilling rigs for directional drilling of long boreholes (up to 300-320 metres). While Russian drilling rigs generally drill straight boreholes up to 200-300 metres, the actual depth of boreholes in seams with complex geology does not, as a rule, exceed 130-150 metres. The lack of leading-edge drilling equipment is one of the key limitations in Russia for the effective degasification of mined coal seams. Russian coal companies have, however, started to adopt foreign technologies. OAO SUEK, the largest Russian coal company, is using a Ramtrack drill at its Kirova mine to drill 450-500-metre directional boreholes into the seam.

Other causes for the limited and inefficient application of degasification in Russian mines are poor management practices and lack of investment in up-to-date equipment (drilling units, pipes, seals, water traps, dampers, etc.). Moreover, degasification procedures and parameters are often ill-defined and do not match the geological and specific conditions of the mine. Another issue is the lack of underground control systems and measuring equipment.[20]

5.2 The Rate of Methane Capture in Russia

In the 1980s, 212 coal mines across the Union of Soviet Socialist Republics (USSR) used degasification technology. These mines were located in Russia (Kuznetskiy basin, Pechorskiy basin and other regions), Ukraine and Kazakhstan (Karaganda). Part of the recovered methane was used to produce

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[19] Hydraulic fracturing is used to improve gas flows in coal seams with low gas permeability and gas yield. High pressure water is injected into the seam to create a network of fractures through which gas can flow. Sand may be injected to keep flow paths open.

[20] IPKON RAN together with OAO Giprougleavtomatizatsiya have developed a system to control CMM drainage at mines. This is being tested at Kirova mine (Kuznetskiy basin).

heat in boiler houses, dedicated gas and air heaters, and in thermal coal dryers[21]. Degasification was first used in Kuznetskiy basin mines in 1951. A peak of degasification was reached in 1990 when this method was used in 48 mines in the Kuznetskiy basin with methane recovery in the order of 220 Mm^3 of methane per year. According to 2006 data (Ruban *et al.*, 2006-07), 252 Mm^3 per year of methane were drained in Russian mines in the Kuznetskiy and Pechorskiy basins. Nearly all of this methane was vented into the atmosphere except 40 Mm^3 used locally in boilers at Vorkuta mines (Pechorskiy basin). In 2008, the rate of drained methane increased to 320 Mm^3, but the rate of utilisation remained almost the same (several mines in Kuznetskiy basin started the trial use of drained methane, but the volumes of gas used are insignificant).

With the restructuring of Russia's coal mine industry in the late 1990s, many loss-making mines were closed, including those that applied degasification. This led to a drop in the share of methane recovered by degasification while the overall level of coal mine methane emissions from underground mining increased due to a boost in coal production as mining equipment utilisation rates increased (Rosinformugol, 2003-07). In recent years the rate of methane recovery by means of degasification in Russia has not exceeded 27% to 30% on average.

Today, Russia has a set of regulations adopted by RosTechNadzor (2003, 2006) defining the minimum concentration of methane in drained gas recovered by means of degasification. Methane recovery technology currently used in the Kuznetskiy basin, including coal seam degasification and drainage of goaf areas, means that the methane concentration of CMM is below 25%. Safety regulations in force do not allow utilisation of such gas and it has to be vented to the atmosphere. All countries limit the use of such low-concentration CMM due to the danger of explosion. In this respect, Russian practices are fully in line with global practices.

The majority of the 98 Russian coal mines active in 2009 (Tables 4 and 5) are considered gassy with methane content of mined coal seams in the order of 10 m^3/t or higher. Despite the fact that degasification allows an increase in the output from coal faces and thus enhances the economics of coal production, only 25% of active mines in Russia in 2009 have installed degasification systems (see Table 5). The lack of degasification systems is one of the key factors leading to explosions at Russian coal mines. Another key factor is the sometimes poor installation and inefficient operation of degasification and drainage equipment which means that less methane is captured than should be possible. RosTechNadzor points also to the human role as another key factor leading to explosions (see Section 8.1). These factors, and the lack of resources at the state monitoring agency, RosTechNadzor, are of particular concern in Russia, given the relatively high methane content of Russian coal. Furthermore, the situation will worsen as deeper mines are exploited with higher methane content per tonne of coal extracted.

If all gassy mines were equipped with the appropriate degasification technology, the outlook would be for the rate of methane recovery to increase to 35-40% in the Kuznetskiy basin and to 45-50% in Vorkuta. Currently, degasification removes around 30% of methane from the mines. However, as Table 5 reflects, the number of mines with degasification fell sharply between 1992 and 2002, following the closure of a significant number of uneconomic gassy mines during the 1990s. According to Russian experts, the number of mines installing degasification systems is growing; in 2009, 25 mines are now using degasification – a modest improvement over the last few years.

[21] Thermal dryers for coal are used at coal preparation plants to produce a heated air stream that drives off moisture from the coal.

Table 5: Number of Russian mines with degasification systems compared with number of category 3 and super-hazardous mines

Coal basin, region	Mines with degasification / Category 3 and super-hazardous mines (>10 m^3 CH_4/t)			
	1992	1998	2002	2009
Kuznetskiy	33/72	17/47	13/46	16/48
Pechorskiy	10/12	6/7	6/6	6/6
Donbass	4/4	1/4	1/1	1/1
Chelyabinskiy	4/6	2/2	2/2	2/2
Other	6/26	4/9	n/a	n/a
Total	**57/120**	**30/69**	**22/55**	**25/57**

Source: Ruban, 2009.

At the same time, as illustrated in Table 6, the concentration of methane in gas captured by degasification systems in Russia is quite low, often below 25%. With the exception of mines in the Pechorskiy basin (Vorkuta) and a few mines in the Kuznetskiy basin where the concentration of methane in recovered gas is above 50%, mines in other Russian regions need to renovate and possibly replace degasification systems. This is because, in the past, Russian systems were built to meet mine safety requirements and did not envisage the utilisation of recovered CMM. The Vorkuta mines located in Pechorskiy basin are the only ones where CMM is utilised on an industrial scale. Most other degasification systems in Russian mines produce CMM with concentrations much lower than 25%, the minimum level allowed by regulations for the subsequent utilisation of CMM (RosTechNadzor, 2006).

Table 6: Efficiency of degasification systems in Russian mines

Coal basins, regions	Number of vacuum-pumping stations by % concentration of methane in recovered gas				
	0-20%	20-40%	40-50%	> 50%	< 25%
Pechorskiy	–	–	1	10	–
South Kuzbass	11	5	1	–	11
Prokopievsko-Kiselevskiy	2	–	–	–	2
North and Central Kuzbass	3	1	2	7	3
Ural	1	1	–	–	1
Eastern Donbass	1	–	–	–	1
Total	**18**	**7**	**4**	**17**	**18**

Source: Ruban *et al*. 2005.

5.3 CMM Utilisation Technologies and Practices

A number of technologies are in use today around the world to utilise CMM with a whole range of methane concentrations. These technologies are discussed below.[22]

After any necessary cleaning and upgrading, CMM with high concentrations of methane can be injected into natural gas pipelines or converted to liquefied natural gas (LNG). Typically, this CMM would come from degasification of coal seams prior to mining or be drawn from isolated goafs. However, such high-quality CMM is not often produced by drainage systems at Russian coal mines. There are several options for cost-effective use of medium-quality CMM (i.e. with a methane content of 40-80%), including in industrial boilers and power generation. In Russia, drained CMM from mines that have degasification systems in the Pechorskiy and Kuznetskiy basins has methane concentrations of 25-60%. CMM at the higher end of this range can be supplied to fuel industrial boilers to generate steam or hot water, if suitable sites are located close to the coal mines. This is the most common application in Russia. The main use of medium-quality CMM globally is for power generation. CMM power generation projects have been developing rapidly worldwide over the past decade, in countries such as Germany, Australia, China and the United Kingdom. For example, in September 2006, a CMM power plant began operating at one of Australia's largest coal mines, the Oaky Creek Colliery in central Queensland. Oaky Creek generates a total of 13 MW of power.

Where gas drainage yields a low concentration gas, in the range, say 2% to 25-30% range (giving a safety margin away from the 5% to 15% explosive range of methane in air by volume, with the actual limits depending on the judgement of the responsible safety authorities), it is not safe to be considered as a fuel for any process because of the risk of explosion. Drainage systems can be arranged to raise the methane concentration of the recovered gas into a safe range for use or flaring. This can be done through curtains around goafs, avoiding air leaks into suction pumps and pipes, and mixing with gas direct from boreholes. However this requires considerable skill by the mine operator.

Finally, very low-concentration CMM, the large volumes of ventilation air with diluted concentrations of methane (typically less than 1%) emitted from mine ventilation shafts, constitute a large source of CMM emissions globally. Historically, ventilation air methane (VAM) has simply been released into the atmosphere. However, thermal and catalytic oxidation technologies can mitigate VAM (i.e. convert methane to carbon dioxide and water), or even produce useful heat or electricity (US EPA, 2003). These technologies have been under development in the United States, Australia, and Canada.[23] For example, since 2007, a commercial-scale power plant using VAM has been generating 6 MW of electricity at a coal mine in Australia using a thermal oxidation system.[24] More work remains to demonstrate the cost-effectiveness and commercial viability of these options, but they may have a future role to play in Russia.

[22] For additional detailed information on specific CMM utilisation technologies, visit the US EPA Coalbed Methane Outreach Program website at www.epa.gov/cmop/resources/index.html.

[23] For a summary of technologies, see www.methanetomarkets.org/m2m2009/documents/partners_australia_cmm_tech_database.pdf.

[24] The West Cliff Ventilation Air Methane Project (WestVAMP). More information on the WestVAMP project can be found at www.environment.gov.au/settlements/industry/ggap/bhp.html.

6 Organisational Roles and Responsibilities for CMM in Russia

The institutional oversight of CMM recovery and use in Russia is managed at the federal and regional levels. However, no one institution at either the federal or regional level is directly charged with addressing the issue of coal mine methane utilisation. This lack of co-ordination or management within government is a key challenge to the enhanced recovery and use of CMM in Russia. Regional authorities (part of regional administrations) monitor activities of coal companies and issue licences for subsoil use. These are most often joint stock companies and coal companies whose main activity is producing and selling coal.

Coal mine methane is addressed to a certain degree by the following Federal agencies:

- **The Ministry of Energy** is responsible for the development and implementation of national energy policy and regulations in the country's fuel and energy sector, including power, oil production and refining, gas, coal, gas and oil pipelines and renewables. The Ministry delivers public services and manages state assets related to the production and use of energy resources.
- **The Ministry of Economic Development** is in charge of state policy and regulations in the areas of economic development, foreign economic activity, trade, state statistics, management of federal property, bankruptcy of companies, management of state reserves, registry of state fixed assets, enterprises and small businesses. It was also responsible for setting Russia's CO_2 reduction target for 2008-2012 and is currently in charge of Joint Implementation projects in Russia.
- **The Ministry of Natural Resources and Ecology** develops policy and regulations in natural resource management and protection, including: subsoil, water and mineral resources; monitoring environmental pollution; and developing environmental protection measures. It is also responsible for issuing licences and permits for development of subsoil containing mineral resources and for licensing properties with mineral resources.
- **RosTechNadzor (**the Federal Environmental, Industrial and Nuclear Supervision Service of the Russian Federation) is a federal regulatory authority, which controls and supervises activities in different areas including mining safety, industrial safety, nuclear safety and environmental protection, among others. It has the power:
    - to adopt regulatory and legal documents in those areas as well as to grant and revoke licences and permits;
    - to keep a register of industrial enterprises based on their environmental impact and establish emission limits for them;
    - to monitor how companies and individuals comply with environmental legislation and safety regulations and impose fines; and
    - to carry out reviews of safety regulations.

  RosTechNadzor is responsible for developing coal mine safety regulations, including methane recovery and use standards. RosTechNadzor carries out coal mine inspections, and collects data on methane concentrations in mines and methane emissions from underground mining.

- **The Federal Agency for Science and Innovation** (FASI) under the Ministry of Education is the official Russian state government co-ordinator of research and development in all technologies. As such it co-ordinates all R&D efforts and provides funding for various pilot and model projects. The FASI promotes targeted assistance to R&D projects, including CMM projects. It supports public-private partnerships in order to promote research and development of key technologies and broaden the use and commercialisation of these technologies. It commissioned a project on the development of technology for CMM recovery and use in 2007 in co-operation with the Siberian Coal Energy Company (OAO SUEK). This project, described in section 7.5, has been a great success and is to be used as a model for future CMM recovery and use projects.
- **Regional administrations** are state executive bodies responsible for social and economic development of regions. They develop and ensure implementation of regional budgets and programmes of regional socio-economic development, regional financial and investment policies, and environmental protection and management policies and programmes. Regional administrations can play an important role in promoting certain activities through legislative and regulatory incentives as well as financial support.

7 Government Policies, Legislation and Regulations Related to CMM in Russia

The policies and measures addressing recovery and use of coal resources in Russia are set out in the *Long-Term State Programme on the Exploration and Prospecting of Subsoil Reserves and Production of the Mineral Resource Base to 2020* (Ministry of Natural Resources of the Russian Federation, 2005). The focus of this document is aimed at increasing the role of coal in Russia's energy balance. Coal mine methane recovery and use in Russia has to comply with requirements set out in various laws and regulations focused on mine safety and on the legal aspects of ownership of the resource.

7.1 Russian Federal Laws and Regulations Related to CMM

There are various Russian federal laws which affect coal mine methane recovery and use. The key ones focus on safety of mine operation while the other laws and regulations deal with ownership issues. These include:

- *The Federal Law of the Russian Federation on Subsoil* (Gosudarstvennaya Duma, 1995): It regulates the exploration, use and protection of subsoil in Russia, including waste management in the mining sector. It sets the framework for comprehensive and sustainable subsoil management and protection, and guarantees the rights of the state and Russian citizens as well as licence holders. The uncertainty currently surrounding the legal status of recovered CMM and its usage in this law hampers the activity of third party investors who are interested in the utilisation of the recovered gas (for discussion see section 9.3).
- *The Federal Law on State Regulation in the Field of Extraction and Use of Coal, and on Social Protection of Workers in Coal Industry Enterprises* (Gosudarstvennaya Duma, 1996): This law sets the framework for state policy in extraction and use of coal and regulates relationships

in this area. It refers to coal and the products of its treatment as to the most reliable and socially significant energy sources, the extraction of which is especially dangerous and difficult. It also recognises the high capital intensity of coal mining and its negative impact on the environment. This Law includes provisions on control of safety during mining.

- *The Federal Law of the Russian Federation on Industrial Safety of Hazardous Industrial Facilities* (Gosudarstvennaya Duma, 1997): This Federal Law sets out the legal, economic and social framework whereby hazardous facilities can be operated in a safe manner. It aims to prevent accidents at hazardous facilities and to provide for emergency preparedness and efficient management in the event of accidents.
- *Mine Safety Regulations (ПБ 05-618-03)* (RosTechNadzor, 2003): These detailed regulations, obligatory for all organisations working in mines, set out requirements to ensure the safety of all aspects of mining. They specify the documentation that must be in place for the proper functioning of a mine, its transportation system and equipment. They set out accident prevention and management procedures, including those to avoid methane explosions. They define methane limits in mine ventilation air and set out monitoring procedures. They regulate degasification and ventilation and set out the procedure for closing mines and subsequent after care. Given the recent catastrophic mine explosions in 2007, there is a clear need for more effective enforcement of mine safety standards related to coal mine methane.

Box 1: Effective enforcement of mine safety regulations

RosTechNadzor (under the Ministry of Natural Resources) is responsible for the monitoring of safety and environmental standards and has methane specialists in the main office and in the regions. As such, RosTechNadzor does not focus on methane use, only monitoring the enforcement of mine safety standards.

According to current mine safety regulations (ПБ 05-618-03 and РД 15-09-2006), degasification is obligatory at mines where the methane content of the coal is above $13m^3/t$ of dry ash-free coal. Where the mine ventilation air methane concentration cannot be kept within established limits (i.e. less than 0.75% methane concentration in mine ventilation air), degasification should be used as a supplementary measure to ventilation. Thus gassy mines usually apply both ventilation and degasification.[25] Currently, an amendment to the federal law has been proposed making degasification obligatory, regardless of the methane content of the coal to be mined. The proposed amendments to the *Law on Subsoil* and the *Law on State Regulation in the Field of Extraction and Use of Coal, and on Social Protection of Workers in Coal Industry Enterprises* (see section 7.3) would directly require such degasification of coal seams and would also introduce requirements to use CMM recovered during the mining of seams with high gas content.[26] The Russian Government is supportive of these measures in general but further work and redrafting of the proposed amendments are underway. These amendments would facilitate the development of coal mine degasification and

[25] Refer to Section 5.1 for details.

[26] The legal changes being proposed are amendments to the two framework laws. If these amendments are adopted, more detailed regulations will need to be approved.

utilisation of the recovered methane. They should lead to a lower number of explosions at coal mines and to reduced methane emissions. These draft amendments to the laws proposed by the Federation Council are an important step that will raise the profile of CMM management, but could be a long process.

- *The Decree On Payments for Emissions of Pollutants into the Atmosphere from Stationary and Mobile Sources, Pollutant Discharge into Surface and Underground Water, and Disposal of Production and Consumption Waste* (Government of the Russian Federation, 2003): Under this decree methane is defined as a pollutant. This decree sets out formulas and regional emission limits and defines the amounts of payments that companies are to be charged annually for emissions of pollutants into the atmosphere and water.

Box 2: Environmental payments

Environmental payments are a means of compensating for damages caused by companies through pollution, including methane emissions. The system of billing for these annual environmental payments is set out in the Federal Law on Environmental Protection (Gosudarstvennaya Duma, 2002) which came into force in 2002. A comprehensive system of environmental quality standards forms the basis for setting fees or environmental payments. Air quality standards set limits for peak and average concentrations of environmental pollutants. The government sets maximum permissible emission limits for enterprises, based on these standards. All polluting sources are subject to a base fee proportional to their emissions. Multipliers or ecological coefficients raise the per-unit charges. When emissions are within the maximum permissible emission limits, the base charge is applied and when emissions exceed this limit a higher per-unit charge is applied. Charges for pollutants and waste disposal within permissible emission limits are allowable as a production cost when calculating an enterprise's taxable income, while any charges for excess emissions are not allowable and must be funded from after-tax profits.

In accordance with the Government of the Russian Federation Decree № 410 (2005), payments for methane emissions – as well as payments for the flaring of associated gas – within the maximum permissible emission limits increased 1000-fold in one year from RUB 0.05 to 50 per tonne of emissions of methane (USD 0.02 to almost USD 2 per tonne of emissions). They rose from RUB 0.25 to 250 per tonne for emissions of methane (USD 0.10 to almost USD 10 per tonne of emissions) over and above maximum permissible emission limits set for each mine.[27]

During 2005-2006, coal companies in Russia accounted for 44% of total environmental payments.[28] This increased from a level of less than 20% in the earlier part of this decade, due to the more comprehensive accounting of methane emissions and the increase in the rates of payment. In 2006, the Russian coal industry paid an estimated

[27] The average USD/RUB exchange rate in 2005 (RUB 28.27 to the USD) was used for this calculation.

[28] Private discussions with Yury Valentinovich Kaplunov, Deputy Head of the Organisation on Re-organisation and Liquidation of Non-Profitable Mines (GURSH) of the Ministry of Energy.

RUB 1 billion or USD 37 million in environmental payments.[29] Payments for emissions into the atmosphere by coalfield and basin in 2006 were:

- Kuznetsky Coal Basin – around RUB 350 million (approximately USD 12.8 million);
- West Siberian fields – RUB 25 million (approximately USD 920,000);
- Far East fields – RUB 10 million (approximately USD 370,000);
- Pechorsky Coal Basin – RUB 35 million (approximately USD 1.3 million);
- Yakutsky Coal Basin – around RUB 1 million (approximately USD 37,000);
- Donetsk Coal Basin – around RUB 0.5 million (approximately USD 18,500).

Compared to the sales income of coal companies, the environmental fines each company has to pay are relatively small. As a result, environmental charges provide little incentive to install emission-abating equipment that would reduce the venting of methane to the atmosphere. It may be useful for the Russian government to assess the feasibility of raising these environmental charges to levels which would provide an incentive for companies to invest in the enhanced recovery and use of CMM. Revenues raised by the government could help offset the costs of effective enforcement by RosTechNadzor of mine safety standards.

- *Guidelines on Coal Mine Degasification (РД-15-09-2006)* (RosTechNadzor, 2006): These guidelines are obligatory for all organisations dealing with design, construction and exploitation of coal mine degasification systems. Degasification is obligatory for all mines where the methane content is above 13 m^3/t of dry ash-free coal and for gassy mines when ventilation alone is insufficient to keep methane concentrations at safe levels. The guidelines cover planning and performance of degasification systems, monitoring of the captured methane-air mixtures, defining achievable CMM recovery in mines and ensuring its efficient use. They also set the minimum methane concentrations of mine gas that can be used as a fuel or substitute for natural gas: 25% for industrial purposes and 50% for non-industrial purposes.

7.2 Regional Laws

Regional administrations have the authority to offer tax incentives to attract investment and stimulate the recovery and use of CMM. The corporate income tax rate in Russia is currently 20%, 18% of which is directed to regional budgets. Therefore, regional administrations may offer tax incentives with respect to the part of the income tax they receive. A similar policy in the US proved to be effective in promoting CMM recovery and use (DTI, 2004).

[29] The average USD/RUB exchange rate in 2006 (RUB 27.19 to the USD) was used for this calculation.

7.3 Ongoing Development of Policies and Measures to Stimulate CMM Recovery and Use

Since mid-2008, several legislative initiatives have been started at the federal level to promote and encourage CMM recovery and utilisation. A group of Duma deputies have proposed a number of amendments to the *Federal Law on State Regulation in the Field of Extraction and Use of Coal, and on Social Protection of Workers in Coal Industry* Enterprises to require the pre-drainage of coal mine methane gas from coal seams to ensure mine safety. In July 2008, the Ministry of Energy, the Ministry of Natural Resources, the Ministry of Economic Development and RosTechNadzor were commissioned by the Russian government to develop mandatory requirements on degasification of coal seams prior to mining as well as proposals to encourage coal companies to carry out pre-drainage of coal seams. These requirements were to be incorporated into licence requirements and a system of indicators of gas content in coal seams was to be established, dependent on geological and mining conditions. In addition, during the related Duma hearings on 18 December 2008, it was suggested that regulations be developed to encourage methane recovery from coal deposits. More specifically, the proposals were:

- to develop national standards that would regulate the system of coal mine methane recovery, set up a registry system for recovered methane;
- to include a new type of product (recovered coal mine methane) and a new type of economic activity (coal mine methane recovery) into the national classification system of types of economic activity, products and services (a system used by business and government to classify and measure economic activity, products and services);
- to establish a 0% taxation rate for coal mine methane recovery;
- to reduce or abolish customs duty for imported equipment used for CMM recovery and utilisation.

These are all positive proposals that would encourage the further development of CMM projects. It is important to note that investors – both Russian and foreign – are concerned that any amendments to licence requirements be based on a performance based approach. Care should be taken to avoid licence requirements from being too prescriptive in nature to ensure the most economic and cost-effective investment depending on each unique mine condition.

A related amendment proposed by Russian State Duma deputies concerns *the Federal Law on Subsoil* and aims at creating a new image of CMM among licence holders. Its goal is to change the perception of methane as just an explosive and lethal gas to seeing its potential as a valuable and clean energy source that can be cost-effectively exploited. This should not detract however from the rigorous enforcement of safety standards, given the history in Russia of lax monitoring of mine safety. The aim of these legislative amendments is to orient producers towards ensuring greater safety by means of pre-mining degasification and CMM recovery, together with utilisation. In this way the legislative changes could contribute to solving a number of important issues: improving safety of mining personnel; introducing technologies for CMM recovery and utilisation in mines; and providing the Russian energy sector with a clean and high-quality fuel and Russian industry with a raw material for producing methanol, petrol, ammonia, diesel fuel and other valuable products. The adoption of such regulations would encourage coal companies to recover and use CMM. As of the publication of this report, there was no information available on the first hearing on this issue. Since the onset of the economic crisis in Russia, there has been little further focus on CMM by the Russian State Duma.

7.4 Policies and Measures which Indirectly Support CMM Recovery and Use

In January 2009, the *Russian Government Decree on Main State Policy Areas to Increase Electricity Supply from Renewable Power Generation by 2020* (Government of the Russian Federation, 2009a) was passed. It sets targets to increase the share of renewable electricity production within a clearly defined time schedule. To date recovered methane has been used locally for own use at coal mines (Vorkuta and OAO SUEK-Kuzbass mines). However, CMM is included in the list of energy sources eligible under this new Decree, thus improving its attractiveness to investors. Although the framework law is in place, the secondary legislation has not yet been proposed or enacted, and hence these arrangements are not yet in operation

According to the decree, a premium is to be paid for renewable electricity (calculated based on renewable certificates issued to the qualified generator). However, to become a qualified renewable power generator, a company has to be connected to the grid. This is quite difficult for smaller companies as there is no incentive or obligation for grid operators to connect renewable power plants to their network or to buy electricity from them. Issues such as grid access rules, renewable obligations and incentives could all be clarified in subsequent resolutions, but at the moment all of them are stalled.

To stimulate utilisation of extracted methane, the government will need to provide more clarity on the specific requirements for power utilities to obtain a certain share of power production from renewable sources. This measure could encourage the purchase by electricity companies of coal mine methane since this is an eligible energy source. Through such a renewable energy obligation, the Russian government could also stimulate investments into pipelines that would connect coal mine methane with power stations that could use it.

7.5 State Financial Assistance to Research & Development (R&D) Projects Related to CMM

In Russia, an example of a targeted assistance programme related to CMM recovery and use is its inclusion in the category of support for R&D projects. The public-private partnership contract on the Development of an Integrated Technology for CMM Recovery and Utilisation during Underground Mining of Coal Seams High in Methane Content (contract № 02.532.11.9001) was initiated by OAO SUEK, commissioned by the Federal Agency on Science and Innovation and is being implemented by the IPKON RAN research institute. The project is developing a range of operating procedures for CMM recovery and use that could be applied at many gassy mines across Russia. These operating procedures will conform to the Kyoto Protocol requirements, allow an increase in productivity of coal seams with high gas content, and aim to use CMM to generate electricity, heat and emission reduction units (ERUs) for carbon trading.[30]

Thirty percent of the project finance comes from FASI to cover research activities and the development of engineering specifications. OAO SUEK contributes the remaining 70% to undertake design, construction and installation, purchasing of equipment, etc. The project, based at the SUEK-

[30] This project should not be confused with the OAO SUEK JI project described in section 8.5 as the two serve different purposes, but both are implemented at Kirova mine.

owned Kirova mine, started in 2007 and is at the final stage of its implementation with preliminary and commercial trials of operating procedures and technology underway in 2009. Its results are intended to be used as a model for future CMM use projects at other mines across Russia. Information on the lessons learned from this project should be made available more widely in an effort to raise awareness and provide information to energy policy makers and coal mine owners in order to enhance the impact of this project on stimulating wider use of CMM.

8 Key Drivers for Methane Recovery and Use in Russia

In Russia, the key drivers to enhance the extraction of coal mine methane are safety of underground mining and improved labour and mine productivity. Secondary drivers are the interest in bringing additional clean fuel into the local fuel mix and reducing greenhouse gas emissions.

8.1 Safety of Underground Mining

The problem of mine safety in Russia is one of the most acute in the coal mining industry. Years of neglect after the collapse of the Soviet Union in 1991 have put Russia's mines among the most dangerous in the world. In the period 1985-1990, methane explosions and outbursts caused 6-11 accidents per year, while in the early 1990s, following the collapse of the Soviet Union, the number of methane explosions and outbursts rose to 17-18 per year. The rate of accidents doubled and the number of fatal accidents increased by 3.5 times despite a 40% drop in underground coal production (Ruban et al., 2006).

The main cause of mine gas explosions at Russian mines is the failure to observe safety standards and regulations that impose a statutory limit on the maximum allowable methane concentration in mine ventilation air. According to RosTechNadzor (2007), 21 reportable accidents were registered in Russian coal mines in 2007 with the number of fatalities increasing by 98% that year due to two accidents at Ulianovskaya and Yubileynaya mine killing 150 people. The lack of degasification systems is one of the key factors leading to high methane concentrations and resultant explosions at Russian coal mines. Another key factor is the misapplication of degasification and drainage equipment and its low efficiency in degasifying mines (reducing methane release into the ventilation air by 30% as opposed to the 60-70% that is achievable). RosTechNadzor also points to the violation of safety regulations as another cause of these mine catastrophes (RosTechNadzor 2007d, 2007e). Specialists of RosTechNadzor state that most often accidents are caused by violation of mine development plans, the poor state of equipment and poor organisational management. Almost all mines have a low level of production supervision. Often mine safety warning systems are not heeded or are switched off while mining continues. Such malpractices would appear to be correlated to higher export prices for coal and the greater opportunity cost of suspending coal production when methane concentration in a mine rises above statutory limits. From the miners' perspective, where wages are linked to coal production, miners face the dilemma of taking risks or losing income.

8.2 Labour and Mine Productivity

The need to close down mining operations at underground mines if the level of methane content in the mine ventilation air rises over a certain level (> 0.75%) has a direct impact on mine and labour productivity. High levels of methane in ventilation air can decrease mining productivity by up to 1.5-

3 times and can significantly complicate the process of coal extraction. Mines where the methane content of mined coal is 7-10 m^3 per tonne are two to three times more productive than gassy mines where the methane content is 20-60 m^3 per tonne. Gassy mines where the methane content is closer to the maximum allowable are more likely to experience work interruptions and thus have a lower coal-face output and lower productivity. (Ruban *et al.*, 2007).

8.3 Use of Methane as an Energy Source

Due to various economic, technical and regulatory barriers, coal mine methane utilisation in Russia is still very low – less than 3% of methane released during mining is utilised. Recovered CMM potentially has value as a fuel. Globally, it is most commonly used for heat and power generation. According to the US EPA, nearly all CMM in the US is injected into the natural gas pipeline system, principally because a high-quality gas is drained via vertical wells drilled from the surface prior to and during mining[31]. Overall, the CMM utilisation rate in the US was 24% in 2006.[32] However only a relatively small volume of CMM is recovered in Russia and an even smaller percentage is actually used, mainly at the mine site.

Table 7 lists the potential uses of CMM, based on its methane concentration (and hence calorific value). In Russia, the most prevalent use of CMM is at the mining facility to generate heat and electricity

Table 7: Recovery and use of CMM

Mine gas	Methane concentration, %	Recovery technologies	Calorific value of gas, MJ/m^3 (LHV)	Utilisation options and facilities
Ventilation air methane (VAM)	0.5	Mine ventilation systems	0.14	combustion air flow reversal reactors
Drained CMM	30-50	Drainage systems	11-17	flaring heat and power generation heating greenhouses
Drained CMM	50-95	Drainage systems (including CMM enrichment)	17-32	heat and power generation utility gas transport engines
Drained CMM	95-100	Degasification of seams and gas accumulations Drainage systems	32-36	chemical raw materials motor fuel utility gas heat and power generation feeding into gas pipelines

Source: Ruban *et al.*, 2005

[31] For more information see the US EPA Coalbed Methane Outreach Program website at www.epa.gov/cmop.

[32] US EPA reports that 46 bcf (1.3 bcm) of CMM was used in 2006 (US EPA, 2008), equivalent to around 1% of US natural gas production, while 58.4 MtCO2e (2.78 MtCH4 or 4.1 bcm) were released to atmosphere (www.epa.gov/methane/sources.html).

or to power thermal coal dryers. At the beginning of 2009, CMM was utilised at five mines in Vorkuta (Pechorskiy basin) and four mines in the Kuznetskiy basin. It was used to fuel: boilers (at seven mines), a thermal coal dryer (one mine), coal-enrichment plants (three mines) and a district heating system (one mine). At one mine, the gas was simply flared.

8.4 Reducing Russian Emissions of Greenhouse Gas

In 2006, Russia emitted 1.9 bcm of CMM out of its total methane emissions of 32.1 bcm from all sources (UNFCCC, 2009). Given the higher global warming potential of methane, these CMM emissions are equivalent to 28.5 Mt of carbon dioxide in their global warming effect. Although this is a small percentage of Russia's total GHG emissions (just over 1%) they are taking place in the context of ever-growing concern about the impact of human activity on global warming and the urgency to reduce related GHG emissions. It is therefore important to explore the potential reduction of even relatively small contributions. This is a problem for which every little step helps the solution: collective cost-effective efforts over a range of activities and countries to reduce even small amounts of emissions can lead to a worthwhile total. Therefore there is a rationale from the angle of global warming to try to improve the recovery and use of Russian CMM.

8.5 Economics of CMM Utilisation

There has been relatively little study of the cost-effectiveness of CMM recovery and use in Russia. This is partly due to the fact that there is no easy way to do so. For example, the use of CMM at coal mines in boilers would displace low-grade coal and hence would place a low value on the CMM. Even in applications where CMM displaces natural gas, its value might appear low because of the low prices paid by users of natural gas in Russia. A rough calculation, shows that if Russia were to recover and use the 1.9 bcm of CMM, it would have a potential value of around USD 130 million based on a natural gas price of about USD 2/mmBtu – reflecting the regulated wholesale natural gas price in Russia in 2008[33]. This IEA calculation is much in line with the results of the Russian Academy of Science discussed below. Neither calculation reflects the value of improved mine productivity which is by far a much stronger economic driver.

However, while the economics of CMM recovery for use as a fuel alone may be questionable, particularly while regulated Russian natural gas prices are so low (see section 9), the economics can be improved by taking advantage of credit schemes under the Kyoto Protocol flexibility mechanisms. Were carbon credits to be tied to the 1.9 bcm (28.5 Mt CO_2 eq) of methane released annually in Russia, then another USD 570 million could be generated assuming a carbon price of USD 20/tonne of CO_2. A pilot scheme to do this is under development in Russia.

When making decisions about specific investments for methane utilisation, several economic parameters should be taken into consideration. These include:

- The volume of methane in coal mine seams and average methane content.
- The physical parameters of drained CMM (dust and humidity) which determines the treatment (e.g. drying and cleaning) required before the gas can be used.

[33] The average USD/RUB exchange rate for 2008 (RUB 24.87 to the USD) was used for this calculation.

- The scale of drilling required and the cost of installing and operating gas drainage equipment.
- The improved mine productivity achievable through degasification.
- The level of local demand for heat and power, including on-site needs of the mine facility, which can be fuelled by recovered CMM.

The economics of methane recovery and utilisation and the extent to which these are cost-effective have received little attention in Russia. There have been a few attempts at undertaking detailed feasibility studies of the potential for CMM recovery and use, including studies at the Kirova and Pervomayskaya mines in Russia by the US EPA and Uglemetan.[34] The Research Institute of Comprehensive Exploitation of Mineral Resources at the Russian Academy of Sciences (IPKON RAN) attempted to estimate the economic benefits of degasification and further utilisation of recovered gas. This study (Ruban *et al.*, 2006) is based on the experience of mines that already use degasification systems.

The study estimates benefits from the recovery and use of methane in Russian mines in the Kuznetskiy and Pechorskiy basins. The study concludes that there could be economic benefit in terms of increased mine productivity and savings in electricity bills through the utilisation of recovered methane. However this study assumes benefits from selling emission reduction units (which is not currently done in Russia). Moreover, the capital costs of investment in equipment are not included in this estimate, so the results may not be widely applicable.

Nevertheless, flexibility mechanisms under the Kyoto Protocol may help to enhance the economics of CMM use projects. Russia's target under the Kyoto Protocol (which sets curbs on emissions of GHGs for all Annex I countries that have ratified it) is to reduce aggregate emissions by 5% below 1990 levels during 2008-12. The 2007 level of Russia’s emissions of GHG was the highest since 1994 but still 33.94% below emissions in 1990, the benchmark in the UN Kyoto Protocol. Russia can sell its surplus emission allowances while remaining under 1990 levels. However, procedures and a working system of approving JI projects[35] must exist in Russia before this will help.

Indeed a pilot project has been launched, intending to utilise this mechanism (see Box 3). The profitability of the project depends largely on the presence of Kyoto financing and the ability to sell generated emission reduction units (ERUs). However, it should be noted that the Russian government has not yet approved the Joint Implementation mechanism in Russia, nor the Green Investment Scheme[36].

[34] For more information see www.epa.gov/cmop/docs/inf001.pdf.

[35] Joint Implementation, one of the three Kyoto Protocol flexibility mechanisms, is set forth in Article 6 of the Protocol and allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex B Party) to earn emission reduction units (ERUs) from an emission-reduction or emission removal project in another Annex B Party, which can be counted towards meeting its Kyoto target. For more information see unfccc.int/kyoto_protocol/items/2830.php.

[36] The purpose of Green Investment Schemes (GIS) is to promote the environmental efficacy of transfers of excess emission allowances by earmarking revenues from these transfers for environment-related purposes in the seller countries.

Box 3: Pilot joint implementation project focussed on CMM use in Russia

OAO SUEK-Kuzbass, a subsidiary of the major Russian coal producer and exporter OAO SUEK, together with Emissions-Trader ET GmbH (with head office in Germany), have launched a pilot project on trading ERUs generated from coal mine methane utilisation under the framework of the Kyoto Protocol's Joint Implementation flexible mechanism. The project "Utilisation of CMM at Coal Mines of OAO SUEK" aims to use or flare drained CMM and VAM at five SUEK mines in the Kemerovo region (Kuznetskiy coal basin).[37] In 2008, the project was submitted to the Russian Ministry of Economic Development, which is responsible for Joint Implementation projects. It is awaiting approval.

Currently, the volume of CMM produced at all five coal mines is vented into the atmosphere emitting an estimated 50 $MtCO_2$ eq in 2008-2017. These coal mines use heat generated by coal-fired boilers and electricity purchased from the grid. The project envisages upgrading the five mines' existing boilers to enable the use of CMM to generate heat, thereby offsetting the need to use coal. Cogeneration units for combined heat and power production are envisaged as well. An experimental plant to utilise VAM will be constructed leading to further progress in honing this technology for use with coal mine methane. These measures should bring the share of utilised (including flared) CMM to nearly 100% with priority given to cogeneration units and then boilers.

Upgraded boilers will replace old coal-firing boilers to generate hot water for the central heating systems of the mines. Any surplus heat can be fed into the local district heating systems in the future. Electricity will be used for the mines' own needs and the surplus can be fed into the grid generating ERUs. Any CMM not used in boilers and cogeneration units will be flared, thereby reducing methane emissions from the mines. This will be the case mainly in the summer months when the demand for heat is low.

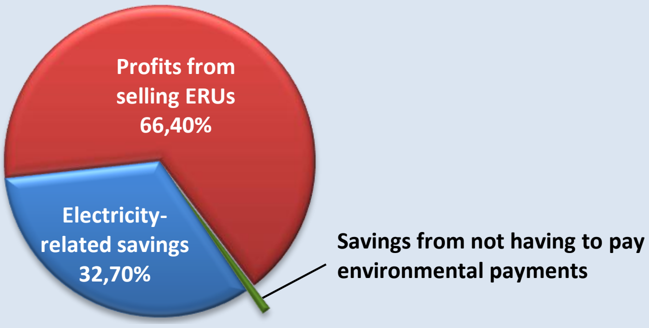
Table 8: Economic benefits from the SUEK JI project (including profits from selling ERUs)

Income Source	Calculation	Tariff, RUB/kWh	Total, RUB million
Electricity consumption	10 generators × 1.55MW × 8 760 hr/yr × 85%	0.49778	67
Power transmission	10 generators × 1.55MW × 8 760 hr/yr × 85%	0.10019	13
Payments for power capacity		–	1
Avoided environmental payments	10 generators × 386.7 m^3/h × 8 760 hr/yr × 85%	64.8	2
Selling ERUs	0.43 $MtCO_2$/yr × EUR 7.5/tCO_2 × 36.6 RUB/EUR	–	118
Total		**–**	**201**

Source: Adapted from Ruban, 2009 and assuming a generation efficiency of 37% Higher Heating Value (HHV) and an annual generation load factor of 85%.

[37] This information has been taken from the project design document available at http://ji.unfccc.int/UserManagement/FileStorage/O75QTRGH77YEL8V52PQY4ONHHEBQ0Z.

Figure 5: Economic benefits from the SUEK JI project (profits from selling ERUs included)



Source: Ruban, 2009.

Despite the absence of a procedural system to approve JI projects in Russia, the project started in January 2008. It is planned to run for at least 10 years with two five-year crediting periods. At this stage, a vacuum pump station has been constructed at Kirova mine and connected to a newly-built degasification pipeline; a boiler has been upgraded to use CMM; a CHP plant is being commissioned and the construction of another two is underway; and a flare unit has been assembled. The expected emission reductions will total 45 Mt CO_2 eq during the project's lifetime with 19 Mt CO_2 eq avoided in the first period (2008-2012) and 26 Mt CO_2 eq in the second period (2013-2017). As Table 8 and Figure 5 show, the profitability of the project depends largely on the presence of Kyoto financing and ability to sell generated ERUs.

9 Barriers to Methane Use in Russia

Although the Russian government and key coal companies such as OAO SUEK have become more active in the use of coal mine methane over the past five years, a number of barriers need to be addressed if the level of use is to be enhanced in the future. It is possible to distinguish several types of impediments to broad methane utilisation in Russia.

9.1 Economic and Financial Constraints Posed by Regulated Natural Gas Prices

Among the many legal, regulatory and enforcement issues which exist, the overarching barrier to enhancing CMM use in Russia is the low price of natural gas – which in itself poses a major constraint on the Russian coal sector as a whole, not only the coal mine methane related to it. A key for market reform in Russia's energy sector in general is the increase in natural gas prices to cost-covering levels that are appropriately higher in relation to coal. This has been a key goal set out in the past two national energy strategies and remains central to removing the significant dislocations across the entire Russian energy sector.

In 2009, under the current macroeconomic conditions of low domestic wholesale prices for natural gas (less than USD 70 per 1000 m^3 or USD 1.9/mmBtu) , low electricity and heat prices and no GHG emissions trading schemes, CMM recovery and use is only marginally profitable (with a payback period for CMM projects of more than eight years) or loss-making. In Russia, financing CMM projects is not an easy matter. Even when a pre-feasibility assessment has demonstrated that the economics of a CMM project are attractive, coal companies often do not have surplus capital available to invest and to date have been reluctant to allow equity investment by outside investors. This problem of a lack of finance has worsened since the onset of the global financial and economic crisis and may affect project financing in Russia harder still given the weakness of its banking sector. However, it may make companies more open to outside investors.

9.2 Geographic and Technical Barriers

In Russia, the remoteness of CMM sources from potential customers poses yet another economic barrier in terms of getting the CMM to market. The lack of infrastructure to transport methane by pipelines and the cost of construction can dramatically affect the economics of any project focused on CMM use. Many coal mining areas lack pipelines or gathering systems to collect and transport gas. In such cases, it is most economical to use CMM locally and thus avoid the need for gas compression and long-distance transportation.

In many countries, including Russia, a common barrier to implementing or expanding projects focused on CMM use is demand fluctuation. Many mines that currently use methane for heating purposes face a shortage of gas during the winter months when demand is high, yet vent large quantities to the atmosphere during summer months when demand is low. Seasonal demand fluctuation is a common problem in other countries and using CMM for power generation can be a solution. Fluctuations in methane production from mines raise similar issues. Developing or expanding gas storage capacity can allow better matching of supply and demand, but at a cost. In many natural gas-producing areas of the world, underground storage is the most common means of storing gas to meet peak seasonal market requirements. The most commonly used storage sites are porous reservoirs, including depleted oil and gas fields, as well as aqueous reservoirs (Bibler *et al.*, 1998).

9.3 The Need for Clarity over Ownership and Licensing of Methane Resources

Existing Russian legislation does not provide sufficient clarity on the ownership of recovered coal mine methane gas. A system needs to be established to clearly identify gas ownership and allow the transfer of rights to use recovered CMM. At present, in Russia, methane is recovered at coal mines to satisfy safety requirements and is considered a by-product of the coal mining process, which is ranked as the main activity. Given that coal mine methane is not a stand-alone resource, mines are not obliged to, and do not have, licences for its use. It can be regarded as a production waste with no clear ownership. This legal uncertainty, arising from a lack of explicit regulation, hampers the utilisation of the recovered gas by third parties (e.g. when mine owners are unable or unwilling to engage in CMM utilisation). At present, investors and companies who are not mine owners but are interested in exploiting CMM are obliged to form joint ventures with coal mining companies to avoid this ownership issue (Uglemetan, 2004).

Russia's natural resource licensing regime is complex. Licensing of CMM projects may be necessary in many cases, but the process is not simple, straightforward or rapid. It is possible that the licence for extracting and using CMM already rests with the coal operator, and if this is the case developers could pursue strategies to partner with coal companies so that the need for a new licence is avoided. However, if the mine sells its gas (or presumably also its CMM-fuelled heat or power) to a third party, then the project would need a new mineral extraction licence. It is then unclear whether a coal company owning several mines, would need such a licence if CMM were transferred from one of its mines to another. Similarly, third party companies or joint venture companies purchasing methane from an active mine may need a licence if the energy produced were resold back to the mine. To avoid any of these ownership risks, project developers may opt to limit gas use to applications within the coal company (or even the coal mine site). The lack of clarity over ownership may hinder many otherwise viable projects for gas sales.

Another question that remains unanswered is whether the sale of ERUs from a project that reduces methane emissions would result in the mine owner needing a licence. Presumably, if the coal mine methane is used directly by the mine, then the project would not require a licence since the language of the licensing requirement is in terms of energy. However, as this has not been considered by the authorities, it remains another potential risk (Schultz, 2005).

9.4 The Lack of a Common Framework or Focus on CMM in Russia

Currently leading edge technologies for CMM recovery and use are limited to only a few mines and coal companies in Russia. The lack of suitable technologies, reliable equipment and training of personnel are key barriers. The majority of mines in the Kuznetskiy basin use old and antiquated ventilation systems designed to dilute methane concentration in mine ventilation air to 0.75% or lower and drainage systems, where they are installed, are operated simply to remove and vent methane. To use recovered gas in boilers or electricity generators, methane concentrations need to be at least 30-40%. To satisfy this requirement, drainage systems need to be redesigned and refurbished, as they were not initially intended to provide gas of a quality for utilisation. Mines and coal companies do not usually have experience in CMM recovery for utilisation, and there are few institutions providing services at different stages of the process such as drilling gas drainage wells, building drainage pipelines or preparing documentation for GHG-reduction projects. None provides for a full spectrum of services in Russia where the market of CMM utilisation services is sparse. With few outsourcing possibilities available, coal companies often have to undertake CMM utilisation themselves and they often set up specialised divisions to do this (e.g. OAO SUEK-Kuzbass has such a division).

In Russia, to date, as in most countries, there is a lack of strategic focus and political will from the highest levels of government to engender the environment necessary to address the problem of coal mine methane use. A sustained push from the top would help co-ordinate efforts. There is also no common framework for the development of CMM utilisation projects and developers often lack experience in designing systems for methane utilisation. In the past, CMM research, development, and demonstration (RD&D) projects were carried out in close co-operation with research and development institutes. Today this work is scattered. Development and application of new CMM drainage and utilisation technology are carried out within individual projects without consolidated academic advice and management.

A competent and recognised institution could be established to bring a new focus to CMM in Russia. It would monitor and oversee CMM projects to facilitate and quicken the project approval process under the authority of RosTechNadzor.

9.5 Informational Barriers

In Russia, CMM utilisation is still seen as a relatively new concept to many coal operators. A related constraint is that some coal operators simply do not have the time or resources to investigate the potential to develop a profitable project at their own coal mine. In addition, they may not be aware of existing financial incentives put in place by authorities.

A key strategy for overcoming such informational barriers is to continue to distribute relevant information and link together interested parties, provide technical training and, in some cases, perform pre-feasibility assessments for specific projects. The Methane to Markets Partnership is a useful resource in this respect, enabling easy links to international networks and experience in CMM recovery and use. In Russia, international collaboration has been in place since the 1990s. An example of this is Uglemetan, established to provide information resources and a platform for networking.[38]

10 Experience in Other Countries

A range of policies to promote CMM utilisation have proved successful in different countries. Much can be learned from the variety of support mechanisms which have been developed around the world (Australia, UK, US and Germany) to encourage the use of CMM and coal bed methane (CBM)(fuller descriptions are given in Annex 1). These mechanisms vary in the form of support they provide but they have all proved successful in stimulating the development of CMM/CBM industry and bringing GHG emissions reductions, as well as promoting the exploitation of CMM and CBM resources. They can be categorised as follows:

- **feed-in tariffs,** which provide an incentive for electricity generation;
- **obligations,** which aim to provide legal incentives to specific market players to use specific resources by means of quotas/obligations, with fines for non-compliance;
- **tax incentives,** which provide investment and/or production incentives;
- **grants,** which provide capital expenditure incentives;
- **GHG emissions trading,** eligibility of CMM can provide a significant revenue stream;
- **information programmes,** which aim to promote the use of specific resources by providing technical assistance and disseminating information.

Table 9 gives a summary of support mechanisms used internationally to encourage the use of CMM, along with the benefits they present to developers. It is important to take into account the differences in each country, particularly due to varying political traditions, institutions and level of government centralisation. As reflected in the table below, different policies to promote CMM

[38] Uglemetan, or the International Coal and Methane Research Center, provides information and assistance to companies and government agencies interested in CMM. For more information see www.uglemetan.ru.

Table 9: Policies stimulating the control of CMM emissions through CMM recovery and use

Examples of Policy Instruments	Description	Country	Scheme status	Benefit to developers / sustainability of finance
Feed-in tariff	20-year guaranteed power offtake contracts given to electricity generator	Germany	Appears very successful with c.70MW of capacity commissioned since its inception. Applied to active and abandoned mines	Very attractive due to high tariff, guaranteed for a long period of time, greatly facilitating project finance
Obligation	Obligation on energy suppliers or generators to limit CO_2 emissions (GGAP; Queensland 13% Gas Scheme; NSW GHG Reduction Scheme)	Australia	Reported to have attracted interest from the CMM industry (only active mines) which aims to accredit CMM schemes. Queensland scheme reported successful and is to be raised to 18%	Market-driven incentive which, if properly designed, can provide the economic impetus to developers and if structured adequately facilitates access to project finance
Tax incentives	Section 29 Production Tax Credit; a 10-year guaranteed tax-driven incentives designed to encourage electricity generation	USA	Scheme not applicable anymore to CMM and CBM; however it contributed to the exploitation of more than 10,000 wells at active mines by the end of 2000	Effectively a feed-in tariff increasing level of income stream, thus facilitating project finance
	Exemption from Climate Change Levy for electricity produced using gas from coal mines, including abandoned mines	UK	Scheme introduced in 2003: limited impact today	An incentive improving project economics, but unlikely to be sufficient on its own in the context of low wholesale prices in the UK electricity market
Grants	The Greenhouse Gas Abatement Programme (GGAP) (50% grant towards project costs)	Australia	Five projects at active mines have already received funding, with the scheme anticipated to be fully subscribed	Grants can provide a significant boost and be suitable to project finance if adequately designed
GHG trading	UK Emissions Trading Scheme was a forerunner to the EU ETS	UK	Projects successfully developed at operating mines. UK ETS ended in December 2006	Generous cash flows following the reverse auctioning of emission reduction incentives in March 2002

Source: DTI, 2004.

utilisation have proved successful in different settings. It should be noted, however, that incentives concerning renewable energy projects and GHG mitigation measures have been developed as a package, rather than separately for each type of alternative energy source. Moreover, with the exception of Australia, different categories of incentives are not used simultaneously. In Germany, feed-in tariffs are employed, whereas in the UK tax incentives are the focus.

Various studies point to the legal framework in Germany as the one which provides a particularly noteworthy solution to the CMM ownership issue. Publicly available sources indicate that there are no endemic disputes over ownership of CMM recovered from coal seams in Germany. This country developed an effective and non-controversial way to resolve the managerial and administrative problems that may arise in the course of CMM extraction and utilisation. This, along with a generous feed-in tariff, is likely to be a key reason why Germany takes a leading place in the world in utilised CMM as a percent of its total mine-related methane emissions (Evans, 2009).

Education and information dissemination play an important role in the development of CMM utilisation projects. There are CMM clearinghouses and information centres in China, India and Poland. With support from US EPA and US DOE (Pacific Northwest National Laboratory (PNNL)), Uglemetan's role as an international clearinghouse in Russia was established in 2002. However the rate of CMM recovery and use in Russia remains low. With the renewed focus on CMM utilisation in Russia, it is perhaps a propitious time to review the best approach to enhance the widespread dissemination of information and contact with international experts and organisations. A new or enhanced co-ordinating body might be required, especially one that promotes organisations and activities at the national and political level (e.g. in Moscow) as well as organisations and activities in the coal mining regions.

11 IEA Conclusions on Enhancing CMM Recovery and Use in Russia

Russia has made progress since the restructuring of its coal sector in the early 1990s in developing new capacity for CMM recovery and use. The public-private partnership project focussed on R&D for CMM use (see section 7.5) and the pilot JI CMM project (see section 8.5) represent important steps for Russia in promoting the more widespread use of CMM. It is encouraging that, currently, a number of other Kuznetskiy-based companies plan to start such projects. However, a number of barriers, discussed earlier in this report, need still to be addressed in a comprehensive way. This would bolster progress and help avoid future catastrophic accidents at mines in Russia due to violations of safety regulations related to coal mine methane levels (RosTechNadzor, 2007a-e).

The following conclusions focus on two separate issues:

1) *recovery* of CMM for mine safety through the stricter adherence to existing safety standards in Russia; and

2) enhanced *use* of CMM through appropriate instruments and incentives.

11.1 Coal Mine Methane Recovery

11.1.1 Stricter Enforcement of Safety Regulations

The introduction by RosTechNadzor of requirements to degasify mines that extract high methane content coal in 2007 (РД-15-09-2006) has already led to improved mine safety. More effective enforcement of safety regulations in Russia is critical, given the outlook for an increase in the volume of coal produced from gassier mines to meet increasing domestic energy demand and coal export demand. However, Russia's regulatory bodies often lack the financial and human resources needed to carry out the tasks set out in environmental legislation and regulations (MEDT, 2006b). This becomes acute in the case of large companies who must be monitored and regulated by government bodies with substantially smaller resources at their disposal. The IEA, in this regard, encourages the Russian government to provide RosTechNadzor with the financial resources needed to ensure an adequate number of qualified personnel.

11.1.2 Promotion of Flaring of CMM as Opposed to the Venting of CMM

An interim measure as technologies related to CMM are honed and introduced more widely across Russian coal mines – especially while domestic natural gas prices are being raised to establish a level playing field – is for the government to encourage the flaring of suitably recovered coal mine methane as opposed to the venting of this methane to the atmosphere. Although the energy content of the flared methane would not be exploited, its global warming potential would be substantially reduced by combusting it and thus converting it to carbon dioxide and water. This would reduce the negative impact of CMM emissions on the environment and could be considered an interim measure prior to more complex investment projects aimed at enhancing the use of CMM.

The concentration of methane in VAM is too low to sustain combustion, so the large volumes of methane found in mine ventilation air cannot easily be eliminated or exploited. VAM can nevertheless be oxidised in specially designed catalytic or thermal devices as discussed in section 5.3. In some countries, these technologies are being tested, not only to oxidise VAM but to use the heat produced during oxidation (e.g. in Australia). In Russia, an experimental plant is planned at one of the mines in the SUEK JI project. The Russian authorities should keep national and international developments under review and encourage the deployment of the best technologies.

11.2 Coal Mine Methane Use

An overarching barrier to the use of CMM is the low domestic natural gas price in Russia. Without reform of Russia's natural gas market, bringing regulated Russian domestic gas prices to cost-covering market-based levels consistent with domestic coal prices, the economics of CMM utilisation projects will not attract much investment.

11.2.1 Clarify Ownership and Licence Terms Related to the Use of CMM

Under the existing Russian legislative framework, the legal status of recovered CMM and its usage are not regulated sufficiently clearly. This hampers the activity of companies or investors who are interested in the utilisation of the recovered CMM at Russian mines. Apart from ownership issues, licensing procedures for CMM prove to be another major challenge for investors – obtaining the multiple licences that may be needed is a long and costly process. Given that mines often are not interested or do not have funds to utilise CMM, the involvement of third-party companies or investors could enhance the rate of CMM utilisation at Russian mines. It is therefore important to develop clear rules on CMM ownership and transfer of ownership rights. A clear and simple licensing procedure would facilitate the development of projects that use recovered methane.

11.2.2 Enhance the Share of Renewable Energy Sources in the Electricity Sector

The Russian Government Decree *On Main State Policy Areas to Increase the Energy Supply from Renewable Power Generation by 2020* sets targets to increase the share of renewable electricity production and may encourage investment in CMM recovery and use since electricity generation from CMM is eligible under the decree. Secondary legislation and regulations will need to be drafted and approved to implement this law. Own use or use near the mine site are likely to be the most feasible options. If volumes generated are greater than these local needs, then sale of surplus electricity to the grid for use further afield could be considered. However, this would require more transparent third party access to the electricity grid. Where high quality CMM (above 95% methane or upgraded from above 80%) could be sold directly as a fuel gas, access to the trunk pipeline network of the state monopoly, Gazprom, would be needed.

11.2.3 Provide Financial Assistance to Research & Development Projects Related to CMM

Targeted assistance to R&D projects on CMM is already a practice in Russia. A government contract brought together the efforts of FASI, OAO SUEK and IPKON RAN (described in section 7.5). As of the publishing of this report, the project was in its final stage of development. Its results are intended to be used as a model for future CMM use projects at other mines. The IEA is keen to learn more about the results of this project and to help raise awareness of the lessons learned to enhance the possibility of technology uptake and replication across Russia and elsewhere.

11.2.4 Provide Tax Incentives or Increase Environmental Fines

Various forms of tax incentives – including tax credits, tax exemptions and tax deductions – could stimulate new practices and the adoption of new technologies that enhance the use of CMM by improving its economic viability. However, over the past decade, due to problems with transfer pricing in Russian corporate accounting practices, company profits can be reported as being zero, thereby making tax credits and other such fiscal incentives ineffective. This practice is slowly changing. Local authorities, such as regional administrations of coal-producing regions, could play a major role in improving the economics of CMM utilisation. The authorities would need to guard against the abuse of such tax credits by companies engaged in activities related to the extraction of coal bed methane (rather than CMM). Coal bed methane is exploited as a natural gas resource, not in the process of mining for coal – and as such, should not be eligible for such credits.

Another option open to the Russian government is the possibility of raising environmental fines on industry for pollutant emissions, including methane. Were these fines raised to levels high enough to incite reaction, there may be more interest by industry to use or flare the CMM as opposed to venting it. This would significantly reduce methane emissions from Russian coal mines and result in a much less negative impact on the environment.

11.2.5 Enhance Russian Participation in International Co-operation Related to CMM

The Russian federal government and regional authorities are looking at international flexibility mechanisms, including Joint Implementation and international emissions trading, to encourage coal mine methane recovery and use projects. CMM projects are already listed as possible JI projects in Russia. Emissions-Trader ET GmbH, a company trading emissions, has developed technical packages for 55 coal mine gas projects.

In addition to JI projects, the Green Investment Scheme (GIS) could be used to direct revenues generated by ERUs into CMM projects at active mines. However, implementation of the GIS mechanism in Russia is awaiting Russian government approval.

11.2.6 Enhance Institutional Co-ordination and Clarify Roles and Responsibility

No common framework for the development of CMM utilisation projects exists in Russia and developers often lack experience in designing systems for methane utilisation. There is also a lack of co-ordination among the various institutions responsible for different aspects of CMM recovery and use. There would be benefit from the Russian government taking a stronger leadership role for the development and implementation of a cohesive strategy for CMM recovery and use in Russia.

Moreover, in view of the increased global interest in CMM recovery and use – and the relatively low level of interest in Russia – it would be timely to review the current approaches to co-ordination and information exchange. An effective and proactive national co-ordinating body should have the stature to bring together representatives of relevant organisations, including: federal authorities (e.g. FASI, Ministry of Energy, RosTechNadzor); Oblast or regional authorities (e.g. of Kemerova), research institutes (e.g. IPKON RAN, Moscow State Mining University, Uglemetan, Promgaz, Skochinsky Institute of Mining, the St. Petersburg State Mining Institute and the Institute of Coal and Coal Chemistry); and companies (e.g. Gazprom, OAO SUEK). Such a body could focus attention on the key barriers and challenges to enhancing CMM use in Russia and promote better international dialogue with key international organisations and companies. It could be an effective channel for information flows or seeking input to industrial surveys involving all major and small coal companies in Russia to raise awareness of the challenges faced. It could also enhance information exchange on policies and international best practices to promote a significant increase in the use of CMM in Russia and lead to a more sustainable development of Russia's coal sector and its energy sector as a whole.

The IEA encourages Russia to take advantage of already existing international bodies focused on CMM use, such as the Methane to Markets Partnership, who can provide support to create a "clearinghouse" that increases information exchange and technology transfer, and promotes international best practices to enhance the use of CMM in Russia.

ANNEX I

Experience in Other Countries

Annex I illustrates some of the approaches adopted by countries to encourage the recovery and use of CMM. It is not intended to reflect the most up to date information. Much of the information in this Annex was drawn from the Methane to Markets Partnership website (www.methanetomarkets.org) with supplementary information from the sources cited.

Australia

Australia is rich in energy resources and has large petroleum, natural gas and coal reserves. It is the world's biggest coal exporter and fourth largest producer of coal, behind China, the US and India. Australia currently produces about 300 Mt of coal each year. Two Australian States, New South Wales (NSW) and Queensland, account for around 97 percent of coal production and all of Australia's black coal exports. Out of 121 black coal mines located across the country, 76 are open-cut mines and the remaining 44 are underground operations (Australian Coal Association, 2007). Coal plays a central role in the country's economy representing 10% of total export income and providing fuel for coal-fired power stations that currently generate 85% of all electricity produced in Australia.

Australia ranks sixth in the world in terms of methane emissions from coal mining activities with CMM emissions from operating mines reaching 34.5 $MtCO_2$ eq in 2006 (6.3% of net national emissions) (US EPA, 2009). It also has a commercially advanced CMM industry: 15 CMM projects, ten of which at active underground mines, are registered in the Methane to Markets International CMM Projects Database (M2M International Coal Mine Methane Projects Database, 2008). The recovered gas is flared, injected into pipelines or used in power generation, saving on average around 6.4 Mt CO_2 eq annually. Their generation capacity is estimated at 169 MW. As major sources of CMM emissions in Australia come from active mine sites, abandoned mines and post-mining emissions, mine safety has been the key driver for the development of CMM, especially with regard to coal mine ventilation practices in underground mining.

Australian Government programmes

Currently there is no national legislative framework in place for CMM. Instead, each state has its own legislation and licensing agreements. However, the government of Australia provides support to CBM/CMM projects at federal level by means of grants awarded to individual projects through its Commonwealth Greenhouse Abatement Programme (GGAP) and the Australian Coal Mine Methane Reduction Programme.

The Australian Coal Mine Methane Reduction Programme has been established to reduce methane emissions from Australian underground coal mines in the Kyoto target period 2008-2012 by an estimated 4.5 Mt. The grant funding available under the programme is AUD 15.9 million over five years starting from 2007-08 (Australian Department of Resources, Energy and Tourism, 2008). The principal activities supported under the programme are the capture, use and flaring of CMM. The

Commonwealth Greenhouse Abatement Programme (GGAP) is a government initiative aimed at reducing the country's greenhouse gas emissions to 108% of 1990 levels over the period 2008 – 2012. The GGAP is providing up to AUD 43.47 million to support projects using coal mine methane for electricity generation. The Australian Government is currently funding four projects (for seven individual power stations) in Queensland and New South Wales under the GGAP.

The governments of Queensland and NSW have legislation in place regulating the use of CMM/CBM resources. They also use incentives to provide additional market support to CBM/CMM schemes by way of a market obligation placed on energy suppliers. In both states, CMM drainage and CBM resources are separately administered leaving potential for conflict between the production of coal and CMM and the production of CBM where the CBM resource is located within a potentially economically mineable coal deposit.

Queensland initiatives

In November 2002, the Queensland government released a new CBM regime and the policy framework to govern the extraction of CBM and to accommodate the possible complexities that that could arise from having CBM and coal exploration and production activities co-existing on the same area of land (Zillmann, 2003). To implement a new regime in Queensland, a new Petroleum and Gas (Production and Safety) Act was passed in 2004 to replace the Petroleum Act 1923. Under the new legislation the holder of the mining licence for coal does not have the right for contained coal seam gas. CMM production under the new Petroleum and Gas (Production and Safety) Act 2004 requires a production licence, which can co-exist with a mining licence covering the same area.

The underlying objective of the new legislation is to maximise the recovery of the state's coal and CBM resources. It does not give any resource preference over the other, but rather grants the Minister the power in any given situation to determine the best use of resources in a particular area. The new legislation is also designed to encourage parties to enter into commercial agreements to allow CBM and coal mining operations to co-exist by stipulating that granting of production leases will largely depend on negotiations in good faith between parties who are seeking to establish alternate operations over the same ground (Zillmann, 2003).

Another Queensland government initiative is the Queensland 13% Gas Scheme established on 1 January 2005 and in force until 2020. Under this scheme electricity retailers are required to source at least 13% of their electricity from gas-fired generation (including CBM and CMM) or purchase Gas Electricity Certificates equal to 13% of electricity sold or used in Queensland. The scheme increases revenue for coal mine methane power stations, among other gas-based sources of electricity, by creating Gas Electricity Certificates which have value and can be traded separately to electricity. Building on the success of the scheme, the Queensland Government's climate change strategy, ClimateSmart 2050 included in mid 2007 an increase to the scheme target from 13 percent to 18 percent by 2020 (Queensland Government, 2007).

New South Wales initiatives

Mineral exploration, including CMM extraction and utilisation, in NSW is governed by The Mining Act of 1992. It provides for the ability of the miner to extract CMM from the coal seam for purposes associated with mining coal when considered desirable for the safer operation of the mine. Waste methane flaring in NSW has been standard practice, but further legislative changes to the Mineral Resources Act 1989 now require that pre- and post-drainage methane is used or flared rather than simply being vented (US EPA, 2009).

The NSW Greenhouse Gas Reduction Scheme, which commenced on 1 January 2003 and remains in force until 2012, aims to reduce GHG emissions associated with the production and use of electricity by using project-based activities to offset the production of greenhouse gas emissions. The scheme establishes an annual state-wide GHG reduction target and requires electricity retailers to meet mandatory benchmarks based on the size of their share of the market. Eligible generators, including coal mine methane power stations in NSW and Queensland, are eligible to generate NSW Greenhouse Abatement Certificates and receive revenue from NSW electricity retailers (GGRS, 2008).

A key characteristic working against the development of renewable energies in Australia is the predominance of accessible, well-located, inexpensive fossil fuels and an approach to climate change that is based on securing least-cost abatement opportunities. While certificate systems are recognised for their ability to keep costs down and promote greater efficiencies in equipment and operation, there have been some questions as to whether they can actually deliver the desired new installed capacity as effectively as other instruments, such as feed-in tariffs (Germany) or whether they can support a range of technologies rather than just the least expensive technology (IEA, 2005).

Germany

Germany's reserves of hard coal (118 Mt) and lignite (41 Gt), making these the country's most important indigenous fuels (BGR, 2009). Coal production in Germany totalled 21.9 Mt of hard coal and 180.4 Mt of lignite in 2007. Coal's role in Germany's energy sector is significant: it provides a large share of Germany's energy supply, comprising a quarter of primary supply and fuelling half of its electricity generation. Nearly all coal is used in the electricity and industrial sectors. In 2007, 47.3% of gross power generation came from coal (EURACOAL, 2008).

Germany's methane emissions from coal mining amounted to 4.8 Mt CO_2 eq in 2006 with nearly all of it coming from underground mining (UNFCCC, 2008). The country has 47 CMM projects, 36 out of which are at abandoned mines, and nine at active mines (US EPA, 2009). The recovered methane is used for power generation in 33 projects and for combined heat and power (CHP) in the remaining 14. Such extensive use of CMM is not due to an exceptional natural resource base but to Germany's policy in this area. Since April 2000, when the "Renewable Energy Sources Act" became effective in Germany, methane has acquired special importance becoming an independent energy source rather than only a by-product of hard coal extraction.

The legal framework for the economic utilisation of mine gas in Germany is set by the Federal Law on Mining and the Renewable Energy Sources Act (EEG). Exploration, extraction, and processing of mine gas are administered by the Federal Mining Authority. In operating mines CMM is considered the property of the mining company. When the mining lease expires, the capture of mine gas requires a renewed licence in its own right for at least another 30 years. According to the guidelines defined in the Renewable Energy Sources Act (2004), CMM is a regenerative energy source from which electrical power production (not thermal energy production) is supported by federal legislation (US EPA, 2009; BMU, 2007).

The system of feed-in tariffs, first introduced with a feed-in law in 1991 and later updated in the Erneuerbare Energien Gesetz (EEG) or "Renewable Energy Sources Act", established in 2000 and amended twice in 2004 and 2006, was set up to ensure the development of sustainable energy supply. The system places an obligation on the local grid operator to connect renewable power plants to their networks, to purchase electricity from them and to pay a fixed remuneration for it. The amount of remuneration is cost oriented, often differentiated by technology, commissioning year and capacity. This remuneration is fixed for 20 years (the EEG amendment of 2004 limits this period to 15 years for CMM and other renewables), ensuring investors of the reliability of planning and associated costs (Kelm, 2007).

Thus, electricity from CMM projects benefits from a pre-determined power off-take price which is significantly higher than wholesale electricity prices and consequently provides a strong incentive for CMM developers to capture the full potential of this energy source. Under the initial feed-in law of 1991, compensation for renewable generators was linked to avoided cost, taking average utility revenues per kWh as a proxy. With electricity prices falling in 1999 due to market liberalisation, the EEG has changed to a system with prices that are fixed in the law. However, amendments to EEG introduced stronger price differentiation by technology, and a reduction of tariffs over time (Wustenhagen and Bilharz, 2006).

The EEG also obliges grid operators to connect CMM installations to their network and to bear the costs of the grid upgrade; it also grants priority of dispatch to electricity generated from CMM sources (DTI, 2004). In addition, CMM operators have the right to sell the carbon emissions mitigated by the methane capture project; pay no local tax and no royalties on CMM; and because of inclusion in the Renewable Sources category, receive favourable attention at all stages of project development.

The feed-in tariff provides high investor security and guarantees renewables priority access to the electricity network. These factors have made the feed-in tariff successful, resulting in rapid deployment of renewables, helping give the technologies a firm footing on the market. However, costs for most renewable energy sources for power generation are still higher than those for conventional power production, and with increasing share of renewables promoted by the feed-in tariff the total costs for customers will increase over the next few years (although an annual decline rate is applied to account for technological and market learning). Furthermore, the feed-in tariff limits market flexibility and relies on the government to determine electricity payment rates, rather than letting market forces reflect costs dynamically. It may lead to the creation of a class of energy that requires fixed subsidies to survive; such subsidies can easily become entrenched and very difficult to remove (IEA, 2007).

The United Kingdom

In 2007, UK produced 17 Mt of coal, around 46% of which came from underground mining. The large majority of coal is used in electricity and heat generation. In 2007, electricity and heat generation accounted for around 84% of all coal supply (IEA, 2009a). Domestic coal production in the UK has been declining for many years. Currently, there are 6 major underground mines, 35 open cast pits in production and over 900 abandoned mines.

Internationally, the UK was the sixth largest producer of coal mine methane in 1990, behind China, the former Soviet Union, the USA, Germany and South Africa. However, the decline of the UK coal industry and subsequent large scale pit closures has resulted in far fewer mines and emissions. In

1947, there were 958 mines producing 189.6 Mt of coal annually (Jardine *et al.*, 2004). In 2006, there were just six deep mines and 35 open cast mines in operation in the country, producing a total of 18 Mt coal (BERR, 2007) and 3.7 Mt CO_2 eq in methane emissions. The M2M International CMM Projects Database (2008) currently identifies 33 CMM projects in the UK. Out of these 33, 15 are at active underground mines and the rest in are in place at abandoned mines. Of the 33 projects, four projects use the methane for boiler fuel, four for flaring, one for heating or cooling, one for industrial use, one for local pipeline injection, and 22 for power generation. New CMM utilization projects tend to be power generation projects. Pipeline injection can occur if local pipeline infrastructure remains from previous mining enterprises. However, the quality of CMM is generally not sufficient to enter the national natural gas network without upgrading, so the economic viability of pipeline injection is not typically strong (US EPA, 2009) and is not practiced in the UK.

Ownership of the methane in the coal rests with the UK government, but it passes to the licensee when the methane is captured. The rights to the methane gas are regulated by the Department of Energy and Climate Change (formerly the Department of Business Enterprise & Regulatory Reform) under the Petroleum Act of 1998. Petroleum Exploration and Development Licences (PEDLs) tend to be awarded in a series of “rounds”. Methane Development Licences (MDLs) are used primarily for operating mines. An MDL grants permission to recover gas “in the course of operations for making and keeping safe mines whether or not disused.” It grants no exclusive rights, so it can overlap geographically with one or more PEDLs. MDLs generally cover one mine, although the Coal Authority holds a licence that covers the whole country (US EPA, 2009).

In terms of support for CMM use, the beneficial environmental effects of using CMM as an energy source are recognised and hence it is exempted from the UK Climate Change Levy (CCL) – a tax on energy used by businesses. In relation to electricity, the CLL requires suppliers charge commercial customers (i.e. business not domestic, governmental or charitable customers) an additional fee per MWh, which is then remitted to the government and used to fund a national insurance contribution break and energy saving programmes (US EPA, 2009).

Electricity produced from designated renewable and certain other sources is exempt from CCL and is issued with exemption certificates which can be bundled with the power when sold to a supplier. When used for power generation, CMM currently represents an incentive of GBP 4.30 per MWe. This may be shared under commercial arrangements with the distribution company that accepts the power onto its system. The net benefit to the generator is likely to be closer to GBP 3.0 per MWe, realised by the sale of CCL Certificates. With the exception of this benefit, power from CMM must compete equally with that from all other generators in the electricity market. This is difficult when the price of electricity on the wholesale market is low. However, when prices rise, there is increased CMM project interest and activity. At the same time, CMM is regarded as an environmental issue that must be regulated and solved, rather than an energy opportunity. It is classified as fossil energy and electricity generated from CMM does not qualify for the premium price schemes offered to renewable energy under the Renewable Obligation (US EPA, 2009).

Apart from this, some support was given to CMM through the UK Emissions Trading Scheme (ETS) (April 2002 – December 2006) set up to bring GHG emission reductions and to give UK companies early experience of emissions trading, with a particular view to being ready for the European Union Emissions Trading Scheme. Under the UK ETS, CMM emissions credits generated from active mines (through either flaring or electricity generation) were traded. Emissions from abandoned mines did not qualify for carbon credits since there was no baseline measure for these emissions and therefore no way for reductions to count. CMM emissions trading under this scheme proved successful and demonstrated the feasibility of this approach for this sector (US EPA, 2009). However, since methane is not included in the EU ETS, this incentive to reduce GHG emissions no longer exists.

Currently, economic incentives are not in place to encourage the implementation of best-practice technologies. Apart from the Climate Change Levy, there are no other policies or incentives for energy recovery and the Levy Exemption Certificates do not have a high enough market value to encourage energy generation. Fiscal policies such as trading will encourage flaring rather than electricity generation, as the most cost-effective option.

The United States

Coal in the United States is the most abundant fuel and current Energy Information Administration (EIA) projections assume its role will further increase. In 2007, the US produced 1,040 Mt of coal at 1,374 mines around the country. Of these, 563 underground mines produced 319 Mt of coal. The majority of coal is used in electricity and heat generation: in 2007 the electric power sector (CHP plants and power stations) accounted for around 91% of total coal and coal-based generation increased by 16.8 Mt compared to 2006 levels (EIA, 2009).

The total methane emissions in the US amounted to 687 Mt CO_2 eq in 2006 and are estimated at 700 Mt CO_2 eq in 2007, the energy sector being the largest source of methane emissions with 281 Mt and 287 Mt of CO_2 eq in 2006-07 respectively. Coal mining in 2006 was responsible for 71.5 Mt of CO_2 eq and estimated 71.1 Mt of CO_2 eq in 2007. Seventy-eight percent of methane emissions in the mining industry came from underground mines (EIA, 2008). Underground mines in the US use ventilation systems to keep methane levels at safe concentrations and another 23 employ degasification systems to supplement ventilation. According to the M2M International Coal Mine Methane Projects Database (2008), there are currently 39 CMM projects in the US, 13 of which are at active underground mines and 26 in abandoned mines. Out of these, 33 use methane for pipeline injection, one for coal drying, two for heating or cooling, two for power generation and two for other uses (US EPA, 2009).

The majority of CMM projects sell recovered gas directly to natural gas pipelines, principally because a high-quality gas is drained via vertical wells drilled from the surface prior to and during mining. This is generally possible with pre-mine drainage as it is suitable to meet the high-quality gas standards (≥ 95% of methane with minimum contaminants). Lower-quality CMM from goaf wells (typically 50-80% CH_4) can be blended and/or processed to remove contaminants and upgraded to pipeline quality. The existing gas pipeline infrastructure determines whether and where pipeline sales are feasible. In some cases mines may have to build additional pipelines to transport CMM from the well or upgrading/processing facility. However, most mines have no easily accessible methane markets available. The vast majority of direct funding for projects comes from the private sector, especially mining companies or private investment firms that provide the capital investment for gas processing, blending and transport for pipeline sales (US EPA, 2009).

One of the most significant barriers hampering the development of CMM industry in the US is disputes over ownership of recovered methane. Ownership of carbon-based mineral rights is divided between oil/natural gas and coal. The coal lessee has the right to capture and discharge the methane to the atmosphere without paying "estate" royalties to maintain safe work conditions. To install drainage systems at active mines, mine operators receive approval directly from the Mine

Safety and Health Administration (MSHA). However, for pre-mining drainage exploration and production for property outside the MSHA jurisdiction and for CMM from abandoned mines, licences are granted by the state. Different states have tried to clarify the ownership issue, but there is no nationwide legislation from the government. Hence, on privately-owned lands, disputes are usually settled on the case-by-case basis (US EPA, 2009).

There is also misunderstanding and conflict where owners of mineral rights are different from the surface owners. Mineral owners have a prior right to access and develop their minerals which are difficult to accept for many ranchers, farmers, and residents with surface ownership (Phelps *et. al.*, 2001).

Mineral leases can be either owned by the US government or be in private ownership. In case of private leases, individual state laws govern the resource ownership. Federal law governs US government leases and the Bureau of Land Management in the Department of Interior manages the mineral rights on those properties.

In the US tax credits were used to encourage the production of domestic energy from certain non-conventional sources. The Alternative Fuel Production Credit (Section 29 of the Internal Revenue Code) until 21 September 2002 provided a dollar-for-dollar offset to CBM generators for taxes payable under the general income tax regime. It was available to CBM projects drilled by 31 December 1992 and was available for a period of 10 years from the date of project commissioning. The tax credit was originally worth around USD 1 per mmBtu and around USD 0.50 per mmBtu towards the end of the scheme. While the Section 29 tax credit may not be the only factor behind the rate of growth that the CBM industry witnessed over the last decade, it certainly has been a contributor, which led to more than 10,000 wells being in exploitation by the end of 2000 (DTI, 2004). Tax credits available for a certain period from project commissioning proved to be an attractive source of funds for organisations with suitable taxable profits. They are suitable for project finance in that they effectively act as a revenue stream and as such, contribute to ongoing project cash flows and ability to repay project debt.

The US has no national restrictions or regulations limiting GHG emissions. However, there exist a number of voluntary schemes aimed at achieving carbon emissions reductions. The US EPA's Coalbed Methane Outreach Program (CMOP) is a voluntary program whose goal is to reduce methane emissions from coal mining activities. CMOP aims to promote the profitable recovery and use of CMM by providing technical assistance and disseminating information to the industry by:

- evaluating CMM recovery technologies and use options and the project economics for those options;
- identifying financial mechanisms for project development;
- providing analyses to assist CMM-project developers;
- overcoming regulatory, institutional, and technological barriers to implementation;
- facilitating discussion among industry participants; and
- providing project-specific technical assistance.

By working cooperatively with coal companies and related industries, CMOP helps to address barriers to using CMM by encouraging and facilitating the development of environmentally friendly and economically sound CMM recovery and utilisation projects. The programme assisted the coal mining industry in successfully reducing its methane emissions by about 16 percent between 1994, (when the programme was launched), and 2006, due to recovery and utilisation of drained gas at active mines. Since the programme's launch in 1994, CMOP has developed detailed profiles of 50 active US underground coal mines that represent opportunities for recovering and using CMM and prepared assessments for project opportunities at abandoned underground coal mines and surface coal mines (CMOP, 2009).

Glossary of Terms and Abbreviations

For a glossary of international terms related to coal mine methane see www.unece.org/energy/se/cmm.html.

Annex 1	Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, European Community, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, United States of America.
AUD	Australian dollars
bcm	billion cubic meters
BERR	Department of Business, Enterprise and Regulatory Reform of the UK, known as the Department of Energy and Climate Change (DECC) since October 2008.
CBM	coal bed methane is exploited as a natural gas resource
CCL	Climate Change Levy (UK)
CH_4	methane
CHP	combined heat and power
CIS	Commonwealth of Independent States: Republic of Armenia, Azerbaijan Republic, Republic of Belarus, Georgia, Kazakhstan, Kyrgyz Republic, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Republic of Uzbekistan.
CMM	coal mine methane is the gas that is released immediately prior to, during, or subsequent to coal mining activities.
CMOP	Coalbed Methane Outreach Program (US)
CO_2	carbon dioxide
CO_2 eq	CO_2 equivalent
Coal face	the exposed seam of coal in a mine
DECC	Department of Energy and Climate Change of the UK
DTI	Department of Trade and Industry of the UK (now DECC)
Duma	The Russian State Duma is the lower house of parliament
EEG	Erneuerbare Energien Gesetz (Renewable Energy Sources Act) (of Germany)

ERU	Emission Reduction Units
ETS	Emissions Trading Scheme
EU	European Union
FASI	Federal Agency for Science and Innovation of the Russian Federation
GDP	gross domestic product
GGAP	Greenhouse Gas Abatement Programme (of Australian Government)
GGRS	Greenhouse Gas Reduction Scheme (of New South Wales Government)
GHG	greenhouse gas
GIS	Green Investment Scheme
goaf	That part of a mine from which the mineral has been partially or wholly removed; the waste left in old workings (called also gob)
gob	see definition for goaf, above
Gt	gigatonnes
GWP	global warming potential
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPKON RAN	Research Institute of Comprehensive Exploitation of Mineral Resources of the Russian Academy of Science
JI	Joint Implementation, under the Kyoto Protocol
kWh	kilowatt hour
Kyoto Protocol	The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change. The major feature of the Kyoto Protocol is that it sets binding targets for 37 industrialised countries and the European community for reducing greenhouse gas (GHG) emissions. These amount to an average of five per cent against 1990 levels over the five-year period 2008-2012.
LNG	liquefied natural gas
m	metres
m^3/t	cubic metres per tonne
M2M	Methane to Markets Partnership
mmBtu	million British thermal units
Mm^3	million cubic metres

MSHA	Mine Safety and Health Administration (USA)
Mt	million tonnes
Mt/y	million tonnes per year
MtCO_2	million tonnes of carbon dioxide
MtCO_2 eq	million tonnes of carbon dioxide equivalent; this unit represents the equivalent CO_2 mass of greenhouse gases, reflecting their various global warming potentials, usually computed over 100 years
MW	megawatt
NSW	New South Wales
OAO SUEK	OAO Siberian Coal Energy Company
OECD	Organisation for Economic Co-operation and Development
PNNL	Pacific Northwest National Laboratory
R&D	research and development
RD&D	research, development and demonstration
RF	Russian Federation
RosTechNadzor	(the Federal Environmental, Industrial and Nuclear Supervision Service of the Russian Federation) is a federal regulatory authority, which controls and supervises activities in different areas including mining safety, industrial safety, nuclear safety and environmental protection (mitigation of negative technology impact on the environment), among others.
RUB	Russian roubles
tCO_2	tonnes of carbon dioxide
TPES	total primary energy supply
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
US	United States of America
US EPA	United States Environmental Protection Agency
USD	US dollar ($)
VAM	ventilation air methane
WSSD	World Summit on Sustainable Development

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