METHANE TO MARKETS PARTNERSHIP

METHANE RECOVERY AND UTILIZATION OPPORTUNITIES

ULAANBAATAR 2009

Methane to Markets

METHANE RECOVERY AND UTILIZATION OPPORTUNITIES

Edited by the **Prof. Dr. M. Badarch and B. Namkhainyam**
Ulaanbaatar 2009

FORWARD

Since entering the 21st century the issues of climate change has caused increasing extensive concern of the international society. Climate change brings about severe challenges to sustainable development and to the future of world. It has already become an urgent topic facing the entire mankind.

Mongolia is a developing country and is well recognized internationally for her efforts to reduce green gas emissions and Mongolia has consistently demonstrated its strong support of international initiatives in protection of the global climate. In order to comply with her international obligations and commitments Mongolia developed and implemented several environmental protection policy documents such as Mongolian Sustainable development strategy and national Agenda 21, National climate change action Plan, energy policy strategy, the renewable energy aimed at reducing green house gases emissions in Mongolia.

In recent years, Mongolian Government and Coal industry are attaching great importance on the Coal methane mine(CMM) and coalbed methane(CBM) development and utilization Therefore, the Government of Mongolia becomes 24th member of the Methane to Markets Partnership program operated by US Environmental Protection Agency's Climate Change Division on 27th March 2008.

The Government of Mongolia supports Methane to markets partnership. It will provide more financing channels and technical support , and accelerate development of methane recovery and utilization. In the framework of the Methane to Market Partnership program, Mongolian Nature and Environment Consortium has being implemented small pre- feasibility study on methane recovery and utilization possibilities in Nalaikh mine area with financial support of Environment Protection Agency of the USA.

We have organized workshop on methane recovery and utilization possibility in Nalaikh mine area. The objectives of the Workshop were to a better understanding of the methane recovery and utilization development issues.

During the workshop more than 20 coal experts and scientists of Mongolia , international coal mine methane experts, Government officials, and representatives of provide sector discussed the opportunities of use of methane for sustainable development.

The workshop was inaugurated by Mr. Tumurbaatar, senior officer of energy coordination policy department of the Ministry fuel and Energy of Mongolia. Mr. Tumurbaatar noted that Mongolia will actively taken part in all activities of the methane to market partnership program.

The workshop particularly benefitted from the presence and contribu¬tions of Dr. Pamela, Coalbed Methane Outreach Program, US Environmental Protection Agency and Dr. Ray President, Raven Ridge Resources, Incorporated.

The workshop also decided to publish and distribute the proceedings of the workshop. Also, we have included in this workshop proceedings some articles which were published in another proceedings.

We have the hope is that this proceedings contributes to promote public awareness for methane recovery and utilization development.

We welcome any comments and inquires related to the proceedings. Please feel free to send to the Mongolian Nature and Environment Consortium, Mongolia.

Mongolian Nature and Environment Consortium

CONTENTS

COAL RESOURCES OF MONGOLIA : SOME ASSUMPTIONS AND SUGGESTIONS FOR COAL METHANE GAS RECOVERY

Dr. G.Tulga, *MCS International Co., ltd*

Brief about Mongolia

Mongolia is a Central Asian country neighboring with the Russian Federation and the People's Republic of China. The country has a total territory of 1 565 600 km^2. Mongolia has a sharply continental climate, with long, cold and dry winters and brief, mild, and relatively wet summers. Mongolia is divided into 21 aimags (provinces), and further into 331 soums (counties). Ulaanbaatar is the national capital, approximately 1 million people live in Ulaanbaatar. The Darkhan and Erdenet is the second and third largest cities with population of 70 000- 85 000 people.

According to statistics of 2007, the population of Mongolia is 2 635 100. This is an increase by 1,6 percent or 40,3 thousand person since 2006.

Since the collapse of the Soviet Union and COMECON in 1990 (withdraw of Soviet assistance was equivalent to the loss of 30 percent o GDP) , Mongolia has faced with restructuring and transforming its previously centrally planned economy into one that is market-based and private sector driven. Mongolia has implemented a series of economic reforms since 1990, aiming at stabilization of the economic performance and restructuring the economy into a market based system. Since October 1995, the budget revenue and expenditure have been compiled according to the International Monetary Fund standard classifications. For the 2007, total revenue and grants of General Government Budget amounted to 1851,2 billion tugrugs and total expenditure and net lending -1749,2 billion tugrugs. For the 2007, GDP was 4557,5 billion tugrugs at current prices. Compared to 2006, that was more by 842,6 billion tugrugs or 22,7 percent.

In 2007, total industrial output was 1712,0 billion tugrugs at the constant prices 2005, that was more by 155,4 billion tugrugs or 10,0 percent compared with the 2006.

Energy resources and consumption in Mongolia

Coal

Coal is most important primary energy source in Mongolia, due to insufficient oil reserves , absence of natural gas and presence of large coal reserves.

Coal supplies about 93 percent of Mongolia's total energy requirements. Diesel power stations and renewable energy sources (hydro, wind, solar stations etc.) respectively supply 5,4 percent and 0,47 percent, as of 2007.

Mongolia has vast coal resources, contained within 15 large-scale coal bearing basins. (See please figure 1.) There are around 320 coal deposits and occurrences (80 deposits and 240 occurrences), according to Geological Information Center of Mongolia. Total geological coal resources are estimated at approx. 150 billion tons, including about 20 billion tons explored.

All the coal deposits and occurrences are located relatively in all areas of the country, but most of them in east, central and south areas. (See please figure 2.)

The Carboniferous and Permian coals belong to the bituminous to sub bituminous or transitional (to lignites) coals.

The Jurassic and Cretaceous ones belong to mostly lignites of high grade and partially to transitional (to sub-bituminous) coals. About 2/3 of all coal resources belong to lignites of high grade.

Main coal mines and perspective coal deposits by regions are:

Central Mongolia

- Tavantolgoi coal mine and deposit (6,4 billion tons of bituminous , subituminous and coking coals, Pre-FS is done)
- Baruun Naran coal deposit (155 million tons of thermal and metallurgical coals, FS is done
- Nariin Sukhait coal mine and deposit (250 million tons of bituminous and metallurgical coals, export to Gansu met. Plant of China)
- Ovoot tolgoi coal mine and deposit (Extension of Nariin Sukhait, 150 million tons of bituminous and sub bituminous coal)
- Baga nuur coal mine and deposit (600 million tons of brown coals)
- Shivee-Ovoo coal mine and deposits (2,7 billion tons of brown coal)
- Tugrug nuur and Tsaidam nuur coal deposits (2 billion tons of brown coals)
- Ulaan-Ovoo coal deposit

Eastern Mongolia

- Aduunchuluun coal mine and deposit (100 million tons of brown coals)
- Tugalgatai coal deposit (3 billion tons of brown coals)

Western Mongolia

- Hushuut coal deposit (300 million tons of bituminous and metallurgical coals,)

More than 30 deposits are now under operation. (Locations are shown in figure 2.)

In, 2007 annual coal production was 8,5 million tons including 3,25 mi/n tons of coal export.

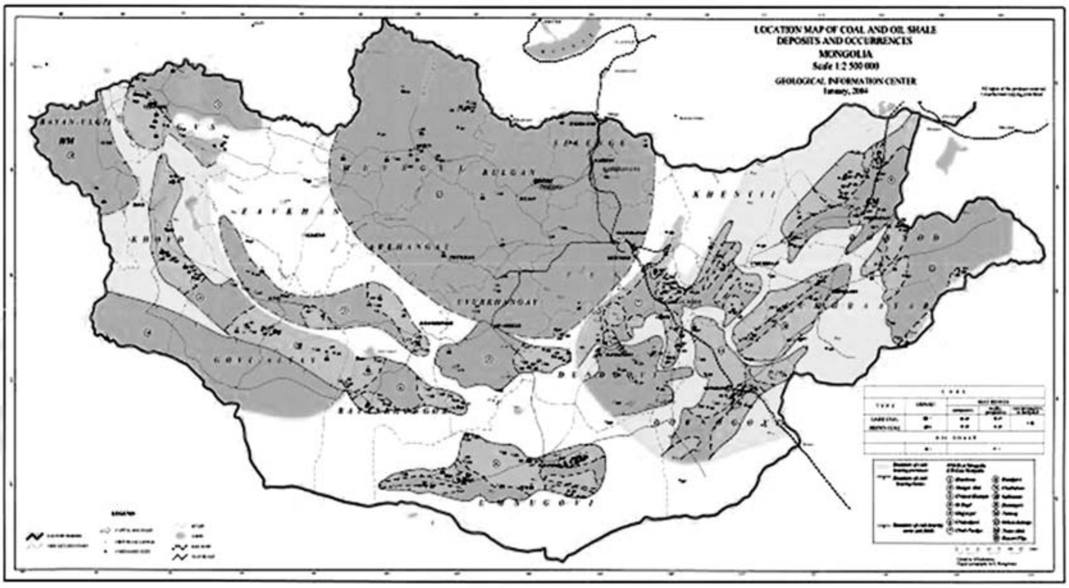


Figure 1

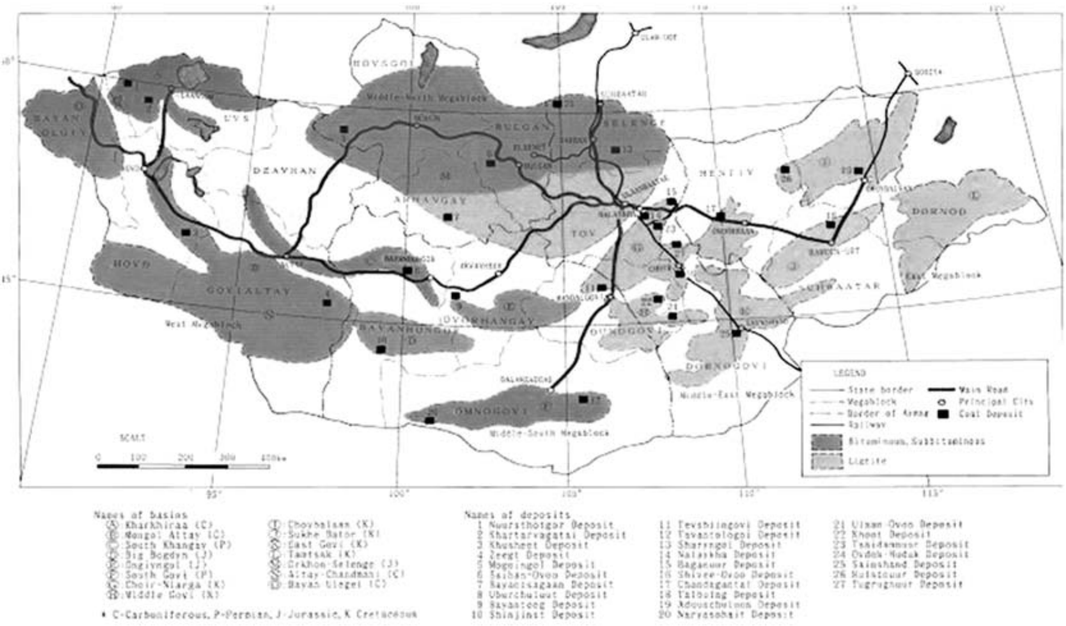


Figure 2

Oil

Present consumption of oil products in Mongolia are relatively small (See please Table 1), however overseas dependency of the country for oil products are about 100%. Mongolia's oil products have been imported mainly from the Russia, small portion - from China.

Annual import of oil products in Mongolia was 776.6 thousand tons in 2007. Based on this, recent demand for oil products roughly can be estimated to 1million tons per year.

Recent prospecting and exploration for oil in Mongolia has brought some positive results in southern and eastern regions of the country. Around 150 exploration wells were drilled, they would pump up 140.000 tons of oil in 2008. Oil production is planning to reach 300.000 tons in 2010, also investment for oil exploration, (mostly foreign investment) is increasing, reaching 433,1 million US$ in 2008. However, confirmed oil reserves in Mongolia is not enough to built own refinery.

Oil imports of Mongolia for last 5 years are given in the Table 1

Table 1. Oil imports of Mongolia by product types

Petrol, thous. Tons	259,1	270,1	254,8	280,4	340,2
Diesel oil, thous. Tons	214,8	258,2	270,9	310,0	387,0
Jet fuel thous. Tons	23,9	22,8	18,9	41,9	39,2
Mazut, thous. Tons	12,4	11,1	4,9	4,4	7,6
Lubricant, thous. Tons	2,7	1,7	1,8	1,5	2,6
E	512,9	563,9	551,3	638,2	776,6

Gas

Natural Gas: Mongolia possesses no natural gas deposits.

Liquefied petroleum gas (LPG): Imported LPG is in use. Over 10 private companies in Mongolia have licenses for LPG import and sale. LPG is used for households, transport, tourism and industry sectors.

In 2007 LGP was supplied to 20 thousand customers in province centers and other local areas and over 12 thousand customers in Ulaanbaatar.

Coal Bed Methane Gas (CBMG): CBMG is one of possible source of gas, that can be used for clean and efficient energy development and other purposes in Mongolia. It will be described more in detail later.

Gas, obtained from coal gasification

Worldwide, considerable progress and advances have been made in the field of coal gasification and other coal processing technologies in connection with deficiency of other natural resources, also in response to sharp increase of oil price at world market and increased environmental requirements. Recent period, some investigations, research and development are initiated in Mongolia, that mainly focused on small-scale power generation, smokeless semi-coke fuel production, using coal gasification technology.

These include followings:

A small 2x100 kw Coal Gasifying Plant was tested in UB and installed in Bukhmurun sum of Uvs province (Western Mongolia).

Bidding to select the Contractor to built the lignite semi-coke briquette plant at the TTP# 2 was announced.

Coal processing plant to produce medium temperature semi-coke and singas is being built by the Tugrug nuur Energy Company at Tugrug nuur coal mine. The company uses the technology of "Sibtermo" company of Russia.

- In 2006-2007, New Energy Development Organization (NEDO) of Japan carried out the study to produce smokeless coal briquette, using Japanese technology.

Also, some foreign companies, such as ThyssenKrupp Uhde, Umwelttechnik Ingenieure GmBH (Germany), Headwater Inc (USA) in cooperation with Mongolian organizations and companies are carrying out some research and investigations on possibility of indirect coal liquefaction, using coal gasification technologies.

<u>Renewable Energy</u>

Renewable energy resources, including hydro, wind, solar ($,13 MW) are in use in Mongolia and account for 0.47% of total energy supply.

<u>Others</u>

It is noted in the Uranium Redbook of 1995, that Mongolia has a some uranium resources, which totals about 83000 tons or 1.8% of the world uranium reserves. Some foreign companies including French, Canadian and Russian companies are doing uranium exploration in Mongolia.

Some Assumptions for Coal Bed Methane Gas Recovery in Mongolia

Geneal

CBM occurs in association with coal during the coalification process. Methane is locked in coal by the water in cheats. So, water must be pumped out, also water quality in coal seams needs to be investigated. Generally, the gas content of coal increases with depth and rank of the coal seam. CBM is produced in association with coal mining. There exist mine-gas problems. At the same time, many ways exist to develop CBM. Main way is drilling: (Conventional drilling, Horizontal Drilling, Drilling before mining, Post-mining gas extraction etc.)

Gas composition (60-90% CH4+Nox, Cox) is important. Sometimes gas cleaning is required. Unlike natural gas from conventional reservoirs, CBM contains very little heavier hydrocarbons (propane, butane) and no natural gas condensate.

<u>Advantages of CBMG recovery</u>

- Relatively large reserves and high calorific value (1000m^3 CBMG equals to 1 ton of oil products)
- Significant environmental benefits, because of reducing green-house gas emissions and comprehensive utilization of natural resources

- Economic benefits, encouraged by relatively low cost of exploration and extraction, comparing with oil and natural gas (But exploration and production technologies are quite similar to oil and natural gas technologies.)
- Possibility of use CBMG as raw materials for chemicals production, including liquid fuel, singas, fertilizers, methanol, ammonia, polymers, solvents etc.
- Support to safe underground mine operation

Disadvantages or Issues

- Requirements for infrastructure development, including gas transportation pipelines, compressor stations , distribution facilities, road network, railways etc.
- Limited possibility of direct filling of CBMG into gas containers or cylinders under pressure. It will require CBMG cooling or liquefaction plant.
- Some environmental problems, associated with water, pumped out from coal seam due to high salinity.

International experience

USA

- Intensive efforts and achievements since mid of 1980's. New policy and legislation, relating unconventional energy sources. Tax reduction by 0,9 US$ for every 28m^3 of extracted CBMG.
- Geological reserves-11300 billion cubic meters, mineable reserves-2832 billion cubic meters.

Main basins:

- Powder River (Wyoming and Montana), Sa Juan (Colorado and New Mexico), Raton (Colorado and New Mexico) Black Warrior (Alabama), Canaba (Alabama), Cherokee (Kansas)
  - Extraction in 2004 was 45 billion cubic meters. Average gas content is 14- 16,7m^3/ton

Australia

- Australia has rich basins and deposits along the east coast of the country Bowen basin (Fairview, Scotia, Spring Gully) in Queensland
- Surat basin (Berwyndale, Windibri, Kogan, Daandile, Tipton West) in Queensland
- Basins in New South Wales Geological resources of 3 deposits in NSW are estimated to 2500 billion cubic meters, mineable reserves- 500 billion cubic meters.
- Now in Sydney power plant on CBMG with 100 MW capacity is operating.

Canada

Canada also has big experience on CBM development and rich deposits, such as:

Telkba basin (British Columbia)

Western Canadian Sedimentary basin (Alberta)

China

- Intensive efforts in this field, including expanding CBMG exploration, establishment of many joint ventures and projects, purchasing know-how, technology etc.

- Power plant on CBMG with 10-15 MW capacity is operating in China by Yangquan Coal Mine Group.

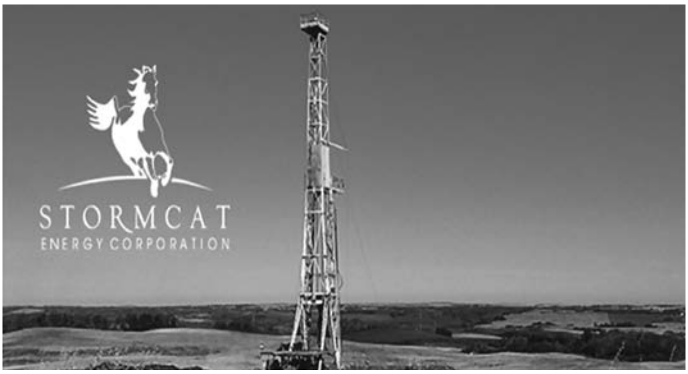
Russia

- Special Project "Uglemetan"
- Mini power plant on CBMG put into operation in 2008 at Kirov under-ground mine in Kuzbass
- Electric capacity -0,96 MW, steam capacity-10tons/hour. Plant uses 13,3m^3 CH_4 per minute. Cost is 250 thousand roubles.

Japan

Power plants on CBMG were operated at Taihaiyo, Akabira and other coal mines in 1990's.

Mongolian experience or projects



Stormcat energy is a Canadian oil and gas company, who firstly carried out CBMG Projects in Mongolia (see please figure 3).

Figure 3.

Noyon Project in South Gobi Desert

Storm Cat Energy Corp. Acquired its Noyon coal bed methane (CBNG) exploration License on 49,000km^2 of land in the form of a Production Sharing Contract (PSC) with the Petroleum Authority of Mongolia in 2004. Under the terms of the PSC, Storm Cat gained exclusive rights to explore and develop coal bed methane (CBNG) resources located in parts of the Nemegt-VI and Borzon-VII petroleum exploration areas in the Noyon Uul region in Umnugovi Aimag (South Gobi Province) of Mongolia.

Storm Cat Noyon field exploration program commenced in the summer of 2004 and ended in nearly March of 2005. The investigation area consisted of a 144km long and a 10 to 20 km wide band of relatively steeply dipping, folded and faulted Upper Permian, Triassic and Jurassic strata to the surface. Six preliminary geological maps, covering a 900km^2 area, were compiled.

In addition to the geological mapping, Storm Cat drilled a series of 11 core holes to evaluate the location and quality of coals in the six mapped areas. In 2004 and 2005, the Company followed up by drilling 5 additional deep core holes to better determine the thickness and gas content of the coal. Four (4) of the core holes, the Noyon #1, #2, #3 and #4, were drilled and cored in the Central Nariin Sukhait area. The fifth core hole was drilled and cored in the Erdene Bulag (Khuree Del) area over 200 kilometers to the east. The result of the coring and desorption are as follows:

- The Coal rank is high volatile C bituminous
- Vitrinite reflectance Ro=0.62%/
- Twenty-one (21) coal seams were penetrated
- Total coal thickness of 76.6 meters.
- Gas content of these coals ranged from 75.7 scf/ton to 379,9 scf/ton

Storm Cat has estimated the potential CBNG resource of the Nariin Sukhait area to range from 0.6 to 1.2 trillion cubic feet (TCF0, with a best estimate of 0.9 TCF. This resource estimate is based on the volume of coal estimated to exist at depths shallower than 1,500 meter drill depth, combined with average gas contents obtained from desorption analyses.

The coals in the Noyon project are of Permian age and are believed to be of similar rank as those fount in the prolific San Juan Basin of Colorado and New Mexico.

Tsaidam project in Central Mongolia

On December 14,2004, Storm Cat announced entering into an Exploration Contract with the Petroleum Authority of Mongolia, comprising 5,536,893 acres of land of which over 500,000 acres include geologically mapped coal deposits. Subsequently on this Tsaidam Project, located in the vicinity of Ulaanbaatar (the capital city of Mongolia), a large coal sample was taken and analyzed for coal rank and adsorption capacity. Storm Cat geologists are pleased to observe that the Tsaidam coal is similar to the Powder River Basin Coals in rank, absorption capacity and depth and with potentially thicker coals. An initial drill program is planned for early June 2005. Storm Cat, also negotiated an extension of the Tsaidam block area to include an additional 5,632km^2 increasing the total contract area to 28,039km^2 (6,928,436)

Suggestions for further activities

Based on coal age, type, reserves and structures of the deposits, Mongolia should posses large CBMG potential. First activities of some foreign investment companies show the relatively large potential for CBMG in the country. However, no economic reserves have been identified presently, that requires more intensive geological exploration and investigations on CBMG resource.

We suggest followings for the future activities:

- improving and creating basic legal frameworks, that insures flexible economic incentives to develop unconventional energy resources and attract foreign direct investment in the related field (Petroleum law, Minerals law, law on Gas Supply etc.)
- Capacity building and international cooperation, focusing on personnel training, resource evaluation and investigation facilities
- Expanding exploration program and geological surveys, financed by state budget with target on CBMG potential of largest, perspective deposits (Tsaidam area, including Nalaikh deposit, Tavantolgoi area etc)

GLOBAL OPPORTUNITIES FOR COAL MINE METHANE PROJECT DEVELOPMENT

Dr. Pamela M. Franklin: *US Environmental Protection Agency*

Executive Summary

This paper provides a brief introduction on the Methane to Markets Partnership and the US Environmental Protection Agency's (US EPA) role in supporting coal mine methane (CMM) project development. It provides background on the important role of methane as a greenhouse gas. A summary of global opportunities and challenges to CMM project development is presented, as well as profiles of four coal-producing countries: the United States, China, Russia, and Mongolia. Finally, this paper concludes with a summary of important legal and regulatory considerations for establishing a strong framework for CMM development in Mongolia.

Background: United States climate policy

In 2002, the United States committed to reduce the greenhouse gas intensity of the US economy by 18% by the year 2012. The greenhouse gas intensity is a metric of greenhouse gas emissions normalized for economic growth.

The US government has set out to achieve this goal in four primary ways: through public-private partnerships, through acceleration of the development and deployment of key technologies, by focusing on the key remaining gaps in climate science, and through international cooperation. Examples of successful public-private partnerships include many US EPA programs to promote renewable energy use, recovery and use of methane and non-carbon dioxide (CO2) gases, and effective agricultural practices. They include US EPA's successful Energy Star and methane emissions reductions voluntary programs. Examples of the US government's engagement in international efforts include support for the United Nations Framework Convention on Climate Change, including the Intergovernmental Panel on Climate Change; the Methane to Markets Partnership; the Asia-Pacific Partnership on Clean Development and Climate; and the Carbon Sequestration Leadership Forum, among others.

The US EPA's Climate Change Division works to assess and address global climate change and the associated risks to human health and the environment. US EPA's Coalbed Methane Outreach Program is a voluntary program created in 1994. The program's mission is to promote the profitable recover and use of coal mine methane (CMM) by working cooperatively with coal companies and related industries. Since its inception, the program has worked both domestically and internationally. Its focus is on greenhouse gas emission reduction opportunities.

Methane to Markets Partnership

The Methane to Markets Partnership (or M2M) encourages the development of cost-effective methane recovery and use opportunities in four key sectors with the potential for near-term emissions reductions: coal mines, oil and gas systems, landfills, and agricultural waste. It is a public-private partnership with the participation of (as of September 2008) 27 Partner governments, including Mongolia, one of the most recent Partners. The combined total of the Partners are responsible for over 60% of all anthropogenic methane emissions (over 85% of methane emissions in the coal sector). Private companies, multilateral development banks, and other relevant organizations participate in the Partnership by joining the “Project Network.” There are currently over 790 organizations participating.

One example of a successful M2M Partnership event was the 2007 Partnership Expo: A Forum for Projects, Technology, Financing, and Policy, held in October 2007, in Beijing, China. The Expo featured high-level government participation from the host country and many partner countries. It featured 91 project opportunities in the four sectors that, if fully implemented, would yield annual methane emission reductions of about 11.5 million metric tonnes CO2 equivalent (MMTCO2E) by 2015. The Expo also featured 39 private sector booths and 13 country booths. The Partnership is planning for a second Expo to be held in the winter or spring of 2010.

The role of methane

Methane is an important greenhouse gas that contributes to global climate change. Its global warming potential is 23 times greater than carbon dioxide on a mass basis over a 100 year time span (*IPCC Third Assessment Report, 2001*). Methane also has a shorter atmospheric lifespan (about 12 years) than carbon dioxide (up to 200 years), so methane emissions reductions have a more near-term effect on atmospheric concentrations of greenhouse gases. Methane is also the primary constituent of natural gas, a relatively clean-burning energy source. Methane that is released from coal mining activities and vented to the atmosphere wastes a locally-available energy resource.

Total global anthropogenic methane emissions were about 422 billion cubic meters in 2000. Methane emitted from coal mines accounted for about 8% of this total. See Figure 1.

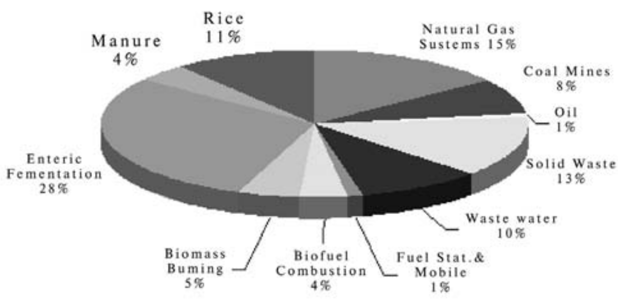


Figure 1. Global Methane emissions

Coal mine methane (CMM) refers to methane released as a result of coal mining activities. Methane is formed during the process of coal formation, and the methane remains in the coal seams, adsorbed onto the coal or filling the void spaces. All coal mines are not equally “gassy,” however. The amount of methane contained in a given coal deposit, and the amount released as a result of mining activities, varies greatly from site to site, depending on a number of geologic and production characteristics. The most important geologic factors are the coal depth (deeper coal seams generally have more methane), permeability, coal rank, in situ gas content, desorption characteristics. Also important is the mining method; longwall mining, which produces coal the most quickly, produces more methane generally than other types of mining.

Methane is an explosive gas in the range of 5 to 15% methane in air. For this reason, regulators require that underground mines keep their in-mine methane concentrations well below this level, typically below 2% methane.

There are a number of distinct sources of methane from coal mines:

Ventilation air shafts from underground mines produce large volumes of dilute methane (known as ventilation air methane or VAM), typically less than 1% methane by volume. Because ventilation air is circulated in such large quantities through underground mines to keep in-mine concentrations at safe levels, VAM is the single-largest source of all coal mine methane emissions globally (accounting for over 50%).

Degasification (or “drainage”) from active underground mines. This may be pre-mine drainage (ahead of mining, sometimes several years in advance), or during mining through in-mine boreholes or gob (also known as “goaf”) wells. Pre-mine drainage can yield very high quality gas (over 90% methane). Gob wells may produce gas concentrations from about 50% methane to about 80% (highly site-s-specific).

Abandoned (or closed) underground coal mines. These mines still continue to emit methane to the atmosphere through naturally occurring or manmade fissures, cracks, and shafts. This methane can be recovered for years after mine closure.

Surface (also known as open-cut or open-cast) coal mines. These mines are typically not as gassy as underground coal mines but in certain coal seams with high gas content and/or high permeability, it may be possible to recover high-quality gas in advance of mining.

End uses for CMM that is recovered varies greatly depending on the gas quality. For high-quality gas (as a general rule of thumb, gas over 90% methane), injection into natural gas pipelines or direct use is a highly desirable and often lucrative option. This high-quality gas can also be converted into liquefied natural gas (LNG) or compressed natural gas (CNG), which is advantageous when pipeline infrastructures are not extensive or convenient.

Medium-quality gas (generally, between 50% and 80% methane) has many options. One of the most popular globally is power generation, often using internal combustion (IC) engines, and sometimes using turbines. Combined heat and power end uses are also possible. Other end uses include coal drying, boiler fuel, industrial applications, heating or cooling, or for fuel cells.

Low quality gas (generally below 40%) has limited applications. Many engine manufacturers will not certify their equipment to operate on gas below this range as it is considered to be too close to the explosive range of methane. Some lean-burn turbines may be able to operate in this range, and some Chinese engines operate in this range. It is still possible to combust or oxidize (i.e., flare) this gas. By destroying the methane and converting it to carbon dioxide, the global warming potential of the gas is greatly decreased.

Finally, it is also possible to mitigate and even recover energy from the dilute ventilation air methane (also known as VAM). Several thermal oxidation technologies have been or are in the process of being demonstrated, and several other technologies (including catalytic) are in development. One commercial scale project at the West Cliff Colliery operated by BHP Billiton in Australia uses ventilation air methane to generate 6 MW of power.

Figure 2 shows the 12 leading emitters of CMM (blue bars). China is by far the leading emitter of CMM, followed by the US, Ukraine, Australia, Russia, and India. This figure also shows the amount of emissions avoided through CMM utilization projects for each country. The US is the world leader in amount of CMM emissions avoided, followed by Germany, China, Australia, and Poland.

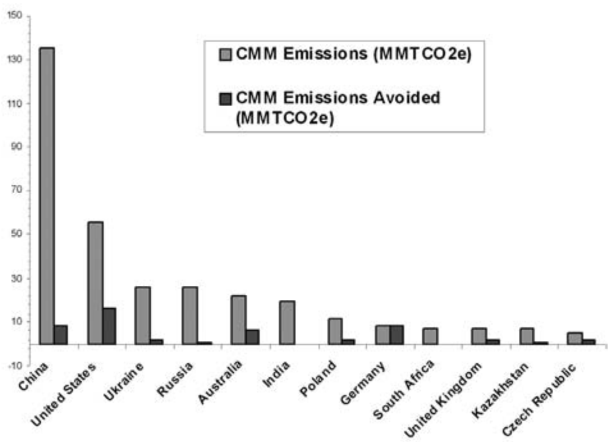


FIGURE 2. Global emissions of coal mine methane (2005 estimates).

Currently, 14 countries have degasification systems in place for drainage of CMM at some of their active underground coal mines. Of these countries, 12 countries have projects for recovery and utilization of CMM at active and /or abandoned coal mines. There are more than 220 CMM recovery and utilization projects worldwide that are documented, with a total of 3.8 billion cubic meters of avoided emissions annually (equivalent to more than 54 MMTCO2E). For more information, see the Methane to Markets Partnership International CMM projects database. **http://www.methanetomarkets.org/coalmines/index.htm#profiles**

Global opportunities for CMM project development

The four main sources of coal mine methane emissions represent the four primary opportunities for CMM project development. In descending order of importance, they are as follows:

Drained gas from active underground coal mines. This is the “low-hanging fruit” because it represents relatively high-quality gas for which the infrastructure for extraction and collection has already been developed and invested (i.e., it is a sunk cost). It is still possible to increase the recovery and utilization of this type of drained gas. For instance, in the United States alone there is nearly 5 billion cubic feet (over 130 million cubic meters) of such high-quality drained gas that is simply vented to the atmosphere. There are several primary ways that recovery and use of drained gas can be increased:

Increase gas drainage efficiency and recovery by installing effective pre-mining and gob wells, as appropriate on a site-specific basis

Improve gas quality by employing gas upgrade or refining technologies to increase the gas heat content and/or reduce contaminants. See: **http://www.epa.gov/cmop/docs/red24.pdf**

Tailor end-use technologies to utilize medium quality gas

Improve infrastructure (e.g., access to pipelines for gas

Ventilation air methane from underground coal mines. Ventilation systems are the most significant source of CMM emissions, although the VAM is typically at 1% or less methane concentrations. 16 billion cubic meters (230 MMTCO2E) were emitted in 2000. Technologies have been demonstrated and are operating or under construction in Australia, US, and China. See **http://www.epa.gov/cmop/docs/ventilation_air_methane.pdf** and **http://www.epa.gov/cmop/docs/2008_mine_vent_symp.pdf**

Abandoned (closed) underground coal mines. In many countries, these are a relatively untapped resource. In other countries that have had declining coal production as many mines are shut down, such as Germany, Poland, and the United Kingdom, there are a number of projects underway, many of them power generation. These projects have the advantage of being independent of mining operations. Also, there is significant potential for emissions reductions and energy recovery for these projects for a number of years after a mine has been closed. There are a number of challenges with these sites as well, of course. It is complex to accurately predict the gas flow and design an appropriately-sized project. One of the biggest unknowns is the extent of flooding at any given abandoned mine, which greatly curtails the gas availability. The remoteness of sites may make it difficult to access markets or end-users. Finally, depending on the country (or state or province), ownership claims to this gas may not be very clear.

Surface coal mines. Many countries have extensive surface coal mining but this is a relatively untapped source of CMM. There are only a few documented projects of this type in Australia and the US, but there is growing interest globally, especially in countries with extensive surface mining such as India. These projects involve pre-mine drainage in advance of the highwall.

Global Challenges to CMM Project Development

While each country faces its own unique circumstances and challenges to CMM project development, there are certain common challenges that many countries face in trying to promote this sector.

First, lack of clarity about legal and regulatory issues, especially rights to the coal mine methane, are the biggest stumbling block to project development.

Second, lack of technology and technical knowledge can be a hurdle, although it is being rapidly overcome. This includes the ability to conduct accurate resource assessments, to properly select appropriate technologies, and the ability to conduct technical and economic feasibility studies.

Third, there is a lack of pilot projects to demonstrate site-specific economic recovery and utilization. This is most important in countries that have no or very little track record in this area (e.g., India) or for which a particular technology has not been demonstrated (e.g., effective in-mine directional drilling).

Fourth, lack of financing or capacity to obtain financing. Again, this hurdle is becoming less of a barrier although in-country capacity to prepare "bankable" documents still needs to be developed in some cases.

The M2M Coal Subcommittee has been engaged over the past four years in a number of activities designed specifically to address these barriers. These activities are summarized briefly below.

Pre-feasibility and feasibility studies to assess technical and economic viability of CMM recovery and utilization projects on a site-specific basis. Examples include a pre-feasibility study of VAM oxidation in Huainan, China, conducted by US EPA, and the new initiative being launched in Mongolia to evaluate project possibilities at the Nalaikh coal mine. Examples of full-scale feasibility studies include analyses in Ukraine (conducted by USTDA) and three studies in China (Songzao mining area in Chongqing, Hebi mining area in Henan, and Liuzhang mine in Anhui), funded by US EPA.

Demonstration projects of specific technologies at coal mines. Examples include in-mine drilling technology using a directionally-drilled horizontal drill at a mine in Ukraine (funded by US AID and US Department of Labor). Another example is a demonstration of ventilation air methane mitigation technology in Tiefa, China, conducted by Australia CSIRO and funded by US EPA.

Capacity building for project financing. US EPA funded a four-year program implemented by the UNECE to develop financing capacity for CMM projects in the former Soviet Union, including missions, trainings, and workshops in Russia, Kazakhstan, Poland, and Ukraine, and culminating in a road show for a Russian coal mine with potential project investors in London.

Workshops and training to increase technical knowledge. There have been a number, including in Beijing, China (2005), Geneva, Switzerland (2006), Brisbane, Australia (2006), Beijing, China (2007), New Delhi, India (2007), and Szyrzk, Poland (2008).

Supporting in-country information centers. US EPA has supported the establishment and ongoing support of several in-country information centers or clearinghouses that provide capacity-building and collect information to promote CMM projects. These include the China Coalbed Methane Clearinghouse, operated by the China Coal Information Center, and the India Coalbed Methane / Coal Mine Methane Clearinghouse, operated by the Central Mine Design Institute and the Directorate General of Hydrocarbons. US EPA is also working with an organization in Ukraine to help develop an appropriate in-country network there.

Development of information resources. The Methane to Markets website (**www.methanetomarkets.org**) serves as a repository for a number of resources about coal mine methane. This includes an overview document with profiles of 33 coal-producing countries; a global database of CMM projects that are operating or under development; and a database of technologies to recover and utilize CMM. It also includes white papers on standard terminologies for CMM and CBM and on flaring.

Country-specific examples

United States

The US has the 2nd-largest CMM emissions globally, with about 4 billion cubic meters methane emitted in 2006 (equivalent to 58.5 MMTCO2e). The US is the 2nd largest coal producer, with about one-third of its coal production coming from underground coal mines. About 50 underground coal mines are considered to be "gassy" (although there is no formal definition of this term used in the US). Currently, 23 underground coal mines conduct mine degasification. US EPA has identified 400 gassy abandoned (closed) underground mines as potential project sites.

Figure 3 shows the distribution of CMM emissions in the United States in 2007. Ventilation air methane emissions represented 52% of all US CMM emissions, while surface mines contributed 22%, post-mining 14%, abandoned mines 9%, and drained gas from active underground mines, 3%.

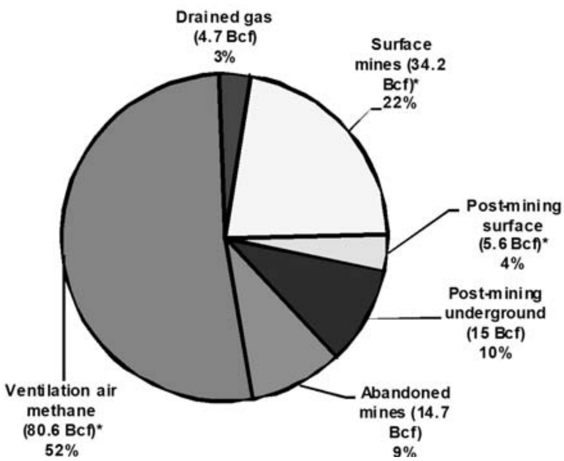


Figure 3. US Coal mine methane emissions (2007) in billion cubic feet (Bcf)

In the US, about 1.4 billion cubic meters (20 MMTCO2e) of coal mine methane was recovered and used in 2006, the largest amount of any country. Most of this came from active underground mines (1.3 billion cubic meters), where there are currently recovery and use projects at 14 active mines. There were recovery projects at over 30 abandoned mines.

At this point, no reductions associated with ventilation air methane projects at underground mines have been achieved, although two projects are under development. One project is a demonstration of a thermal oxidation technology (MEGTEC's Vocsidizer) at a closed CONSOL Energy mine in West Virginia. This mitigation-only project has been operating unmanned successfully from April 2007 through October 2008. The other project is planned at an active mine operated by Jim Walter Resources in Alabama using the Biothermica VAMOX technology (also thermal oxidation). This demonstration is planned to be installed by the end of 2008.

The US has relatively few challenges to CMM project development. The Western US, where many coal mines are located on federal lands, remains largely untapped for CMM project development. The western US has relatively little infrastructure (i.e., natural gas pipelines); the mines are often in remote spots, making market access difficult; and the terrain is often quite rugged, making access to gas collection difficult. Furthermore, many coal mines are located on federal lands, where the gas is also subject to federal leasing laws. So far, the issue of ownership or rights to the coal mine methane has also proved to be a barrier to project development on federal lands because of the lack of a clear policy or process for access to those rights.

There are several important reasons for the success of the CMM industry in the United States. First, there is an important body of knowledge and understanding about how to assess gas resources over time, and there are sufficiently gassy mines to support projects. Secondly, CMM projects have been successfully integrated with mining operations. Thirdly, particularly in the Eastern US (privately held lands and mineral rights), there has been sufficient clarification about mineral rights and the process of obtaining them. Fourthly, there have been effective price signals particularly for natural gas prices in the last several years. Fifthly, particularly in the Eastern US, there is reasonable access to gas and electricity markets. Finally, several of the leading coal companies that have hosted successful CMM projects have been very progressive and innovative and have made a transition from thinking about themselves as simply “coal companies” to conceiving of themselves as “energy companies.”

China

China is the world’s leading emitter of CMM (about 14 billion cubic meters in 2004, nearly 200 MMTCO2e). China is also the world’s leader in coal production. About 90% of China’s coal production is from underground coal mines.

There are estimated to be about 24,000 coal mines in China, some of them very small in scale. About half of the large, state-owned coal mines are considered gassy. Over 200 coal mines have drainage systems installed (as of 2004).

There are currently at least 60 CMM recovery and use projects operating at active coal mines, avoiding a total of about 240 million cubic meters annually. These projects consist of power generation of over 100 MW total installed capacity; town gas for heating and fuel supplied to over 500,000 households; boiler fuel; industrial applications; and vehicle fuel. There are many other projects planned or under development, including power generation projects of over 220 MW additional capacity, and town gas to be provided to tens of thousands more households.

One of the most high-profile CMM projects in China, or indeed, the world, is located at the Sihe Mine, operated by the Jincheng Mining Group in Shanxi Province. This 120 MW power generation project uses Caterpillar internal combustion engines to generate electricity, and is the world's largest CMM power generation project. The capital costs were at least $237 million, including funding from Asian Development Bank, the World Bank, Japan JBIC, and local entities. The US Trade & Development Agency also provided funding to develop specifications for the IC engines.

There are still a number of challenges to CMM project development in China. Most mines are not accessible to gas pipelines, making gas pipeline injection infeasible. Regulations for foreign investors and project developers limit their ownership and investment in projects to less than 50%. Finally, perhaps the biggest challenge is the poor quality of drained gas from Chinese mines – in many cases, less than 30% methane – that results from impermeable coal and inappropriate drainage technologies and techniques. This gas is very close to, or in some cases within, the explosive range of methane, making it very dangerous to access and use safely.

Russia

Russia is the 4th leading emitter of CMM, with about 1.4 billion cubic meters of CMM emitted in 2003 (about 21 MMTCO2E). It is the world's 5th largest coal producer. Approximately 44% of its coal mines are underground and 85% of those are considered gassy. The coal industry was restructured and privatized between 1996 and 2001, and now about 77% of Russia's coal is produced from independent producers.

There are CMM recovery and utilization projects operating or under development in the Pechora and Kuzbass coal regions. There are boiler fuel, power generation, and mine heating projects that collectively account for about 43 million cubic meters emissions avoided, primarily in the Pechora basin. In the Kuzbass, there is currently a UNDP – Global Environmental Facility (GEF) project underway to remove barriers to financing and implementing CMM recovery and utilization projects.

There are several important challenges to CMM project development in Russia. CMM projects must compete with plentiful natural gas resources and a low-state regulated gas price. Foreign investors face complex rules on foreign investments in projects. Finally, there is lack of appropriate technologies, particularly for effective gas drainage.

Mongolia

Mongolia's CMM emissions in 2006 were an estimated 3.5 million cubic meters (about 50,000 TCO2e), accounting for about 3.5% of the country's total anthropogenic methane emissions. These emissions are expected to increase as planned coal mine developments are implemented.

Mongolia's coal production (7.5 million tonnes in 2005) is ranked 23rd globally, with virtually all of its coal production from surface mines. More surface coal mines are planned for development. The Tavan Tolgoi deposit alone is expected to produce as much as 20 million tonnes annually.

Underground coal mining could increase with a planned project at the Nailakh mine and at other possible developments, such as the Ovoot Tolgoi project adjacent to the existing MAK / Qinhua coal mine, where surface mining will be supplemented by underground mining.

Mongolia's coal production has increased in recent years following the privatization of several state-owned mines, and in response to the increasing demand for coal from China.

There are several important challenges to CMM project development in Mongolia. Currently there is no natural gas production or consumption in Mongolia, so there is no existing market or infrastructure for this gas. Mining often occurs in remote areas distant from prospective markets. The legal and regulatory framework for CMM projects is currently undeveloped.

Legal and Regulatory Considerations for Development of CMM Projects

Strong, clear, and transparent legal and regulatory frameworks are critical in promoting CMM project development. The three most important areas are as follows:

- Ownership of mineral rights
- Mine safety
- Environmental impacts

Ownership of mineral rights.

Clear definitions of and determination of ownership of coal seam gas, and any associated rights to carbon credits, is the most critical factor for determining project viability. The ownership of or rights to the coal seam gas may be legally defined as either (a) part of the coal estate, or (b) separate from the coal estate.

- Legal approaches for which parties own the rights to coal mine methane vary widely from country to country. The level at which these determinations are made can be at the national (or federal) level or at the state or provincial level.
- For example, in Australia, the state governments own all the gas resources. Petroleum and gas lease holders have the rights or ownership of the CMM. One key exception is for coal mine operators who extract CMM as part of their mining operations.
- In China, the national government owns the rights to CMM, which is regarded as an "associated mineral of coal" rather than a separate mineral.
- In Italy, the national government grants rights to mine coal or lease gas. Separate concessions are granted for coal and gas leases. The party with the coal mining concession has priority to obtain the coalbed methane concession.
- In Ukraine, the national government grants rights to mine coal or extract CMM; extracting either resource requires government permission.
- In the United States, the legal status of CMM – who owns it or has the rights to extract or use it – depends upon the jurisdiction. On private lands (most coal mining areas in the eastern US), the rights to CMM varies according to state law, based on precedents set by court decisions in states where the ownership is not clearly

defined by law. In some states, the coal owner has the rights or ownership to the CBM and CMM. In other states, the gas owner has the ownership of the CBM and CMM. On federally-owned lands, on which many western US coal mines are located, the federal government owns the subsurface minerals: the coal, oil, gas, and other minerals. The US government leases these minerals, usually through competitive processes, in accordance with federal land management plans, in return for royalty payments. Coal and gas are leased separately (known as a "split estate").

Split estates require resolution of conflicting rights to operate, between the coal mining and the gas development. In cases where there is private ownership of these two resources, these conflicts are resolved through negotiation or legal disputes. Some of the issues that must be resolved between the parties include operational issues (timing or the sequence of mining versus gas extraction); the terms of sharing access roads; the extent of information sharing (e.g., geologic or environmental studies); and reclamation efforts and costs.

Where there is public (government) ownership, there are regulatory approaches to determine the conflicting development rights. For example, in the case of surface mines in the Powder River Basin, the US Bureau of Land Management which has authority over federal resource development on these lands, has established so-called "Conflict administration zones" to encourage gas developers to drill gas wells and drain as much gas as possible before mining starts. In return, the government offers royalty rate reductions and allows more gas production than it would otherwise.

Mine safety

Mine safety must be paramount in encouraging coal mine methane recovery and use projects. The legal or regulatory framework must not encourage or prioritize CMM project development at the expense of mine safety. All mine safety regulations must be appropriately incorporated or coordinated with plans to encourage or require CMM project development.

Mine safety regulatory agencies typically have jurisdiction over many aspects of project development. These include the following: allowable in-mine ventilation concentrations; the right to (or requirement to) drain gas from underground mines; the allowable ranges of mine drainage methane concentrations; the use of flares at the mine site; the use of technologies to mitigate or recover energy from ventilation air methane; and the allowable end-use technologies onsite.

For example, in the United States, the coal operator has the right to capture and discharge methane to the atmosphere to maintain safe working conditions, as measured by in-mine methane concentrations that are below regulatory thresholds. Mines must develop and implement mine ventilation plans that are approved by the US Mine Safety and Health Administration (MSHA). This agency has jurisdiction over all equipment at the mine (including gas recovery and utilization, flares, onsite power generation, oxidation, etc.).

Environmental impacts

Projects to recover and use CMM may have environmental impacts that must be considered during project development. For instance, there may be impacts to sensitive ecosystems caused by drilling or accessing degasification wells or installing equipment. There may also be environmental impacts associated with various end uses for the gas, such as combustion byproducts associated with power generation or oxidation systems, or the construction of equipment, facilities, or pipelines. CMM projects should be evaluated by the appropriate environmental regulatory authorities and assessed for their overall impacts. Any necessary permitting (for example for air emissions or water discharges) should be properly secured.

Special issues for CMM project development in Mongolia

Overall, it appears that Mongolia has a generally favorable climate for foreign investment in CMM projects. For instance, under the 1993 Law on Foreign Investment, an investor may request a stability agreement providing the investor a legal guarantee for a stable fiscal environment and protection from changes in taxation policy for 10 to 15 years. In addition, Parliament Resolution #140 (June 2001) includes oil and gas production and pipeline construction as "favored industries" for foreign investment. In addition, the Department of Fuel's Regulation policy outlines development goals, including the extraction of petroleum products from coal.

Mongolia's tax policy also appears to be favorable towards CMM project development. Materials and equipment necessary to conduct petroleum operations that are imported by contractors are exempt from customs taxes, value added taxes, and excise taxes. Contractors' earnings from petroleum shares are exempt from income taxes.

Several issues must still be addressed for Mongolia.

- How will coal licenses be coordinated with gas production sharing contracts (PSCs) made through the Mineral Resources and Petroleum Authority of Mongolia (MRPAM)? Will coal licensees be given priority to obtain a PSC?
- What safety regulations are applicable to coal and gas developers?
- What environmental permits are necessary for a CMM development project?
- What parties will be eligible to own carbon credits associated with CMM projects?

Conclusions

CMM projects have multiple benefits. First, they achieve greenhouse gas emissions reductions of methane, a potent greenhouse gas. Second, they provide a local source of clean energy. Finally, they also provide important economic revenues for the mine and/or project developer.

Mongolia has great potential for developing CMM projects. The extensive global experience in CMM project development, especially from fellow Methane to Markets Partner countries, can be shared to encourage these projects.

DEVELOPING COAL MINE METHANE PROJECTS: FROM RESOURCE TO END-USE

Raymond C. Pilcher: President, Raven Ridge Resources, Incorporated

I. background

Key Definitions

- Coalbed Methane (CBM)
  - CBM refers to methane adsorbed into the solid matrix of coal. It is sometimes referred to as coal seam gas, because it may contain other gases such as CO_2.
- Coal Mine Methane (CMM)
  - CMM refers to methane and other gases released from the coal and surrounding rock strata due to mining activities. In highly gassy mines it is necessary to augment the ventilation system with a degasification system The gas from the degasification system is often emitted to the atmosphere.
- Ventilation air methane (VAM)
  - CMM is removed via ventilation systems which use fans to dilute the methane to safe levels by circulating fresh air through the mine workings. VAM is the largest source of methane emissions from underground coal mines.
- Surface Mine Methane (SMM)
  - SMM is methane released by surface or open-pit/open-cast mining activities as the mined coal is broken, mined and transported. and is commonly emitted to the atmosphere.
- Abandoned Mine Methane (AMM)
  - Coal mines that are temporarily or permanently closed (or “abandoned”) mines can still produce significant methane emissions from diffuse vents, fissures, or boreholes.

Issues for Mongolia CMM Development

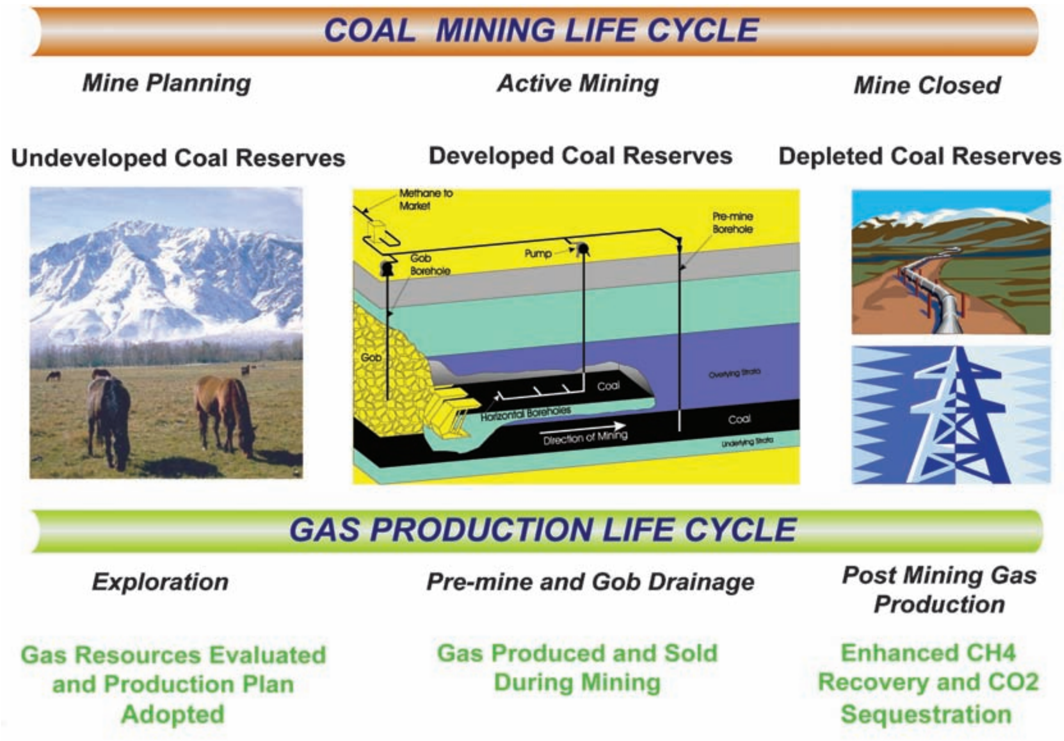
- Climate- Low Winter Temperature
  - Increases wear on equipment, maintenance and replacement.
  - Pose challenges for gas processing.
  - Limits “field” season fro exploration and development of resources
- Gas Transportation Infrastructure
  - Requires long range planning and investment
  - Local use of CMM (power generation and space heating) is logical beginning, followed by transportation as CNG and LNG
- Status of coal mine development CBM and CMM.
  - Underground coal mine development is beginning and can be executed in concert with CMM use and CBM development.

What makes a good CMM/CBM project?

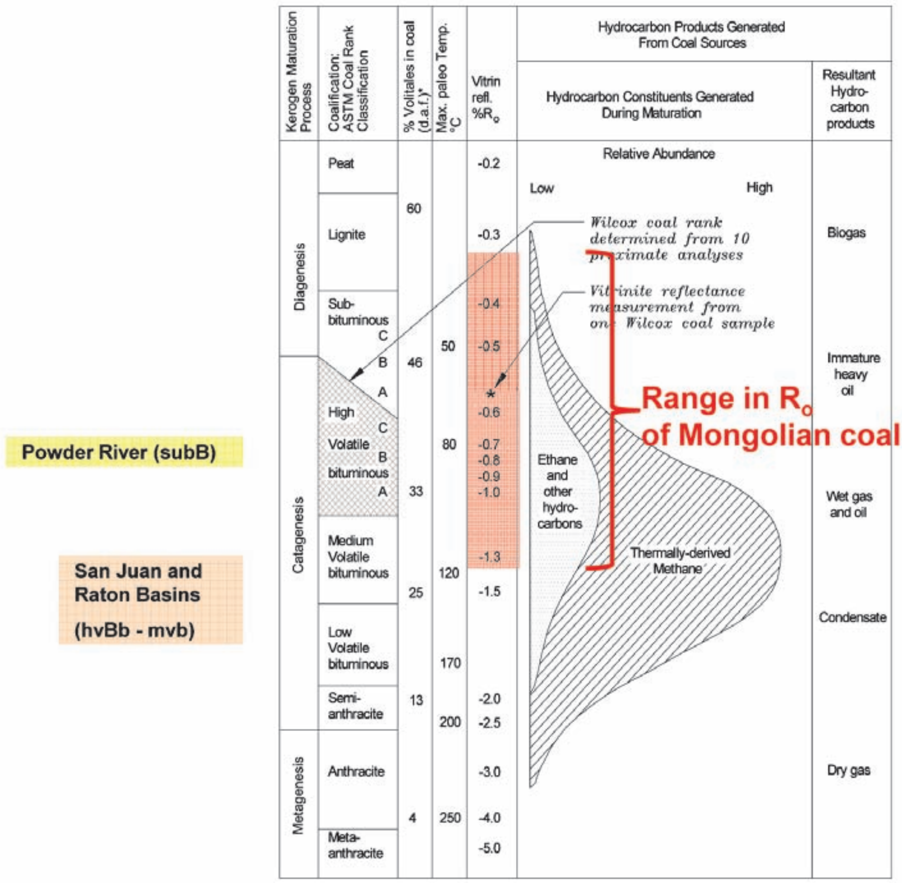
1. Natural Conditions: Large coal resources with favorable geologic conditions for maturation of coal, storage of gas, and high permeability

2. Human Resources: Trained professionals and workforce that can assess, plan and execute complex programs to explore and develop resources
3. Favorable legislative and regulatory environment: Enables and facilitates resource development while guaranteeing environmental preservation
4. Favorable economic and market conditions: investment encouraged, market conditions allow reasonable expectations for return on investment

II. CBM Resource Potential and CMM Emissions



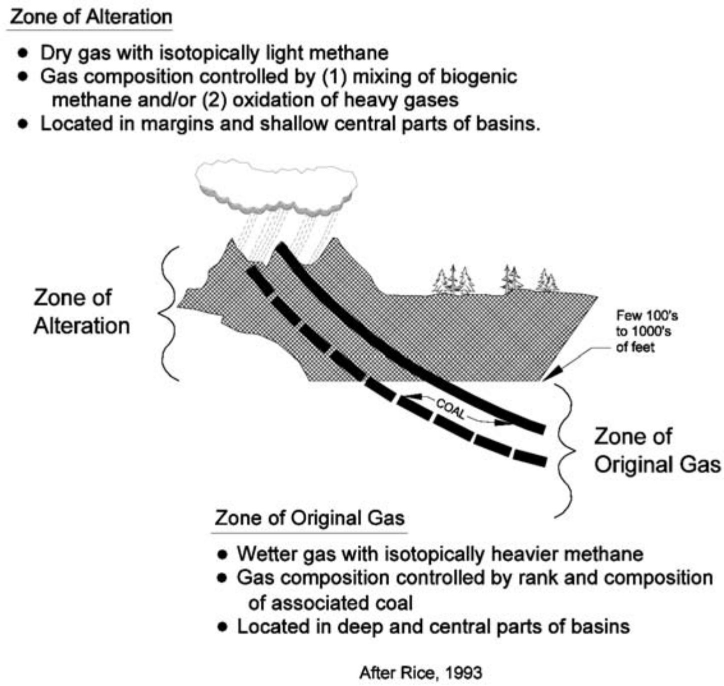
Coal Rank and Hydrocarbon Generation



Comparison of CBM Producing Basins in USA to Coal Basins in Mongolia

	San Juan	Raton	Powder River	Tavan-tolgoi	Nariin-sukhait	Nuurstk-hotgor
Coal Rank	hvBb-mvb	hvBb-mvb	subB	hvBb-mvB	hvBb	hvBb-c
Gas Content m^3/tonne	3-14	6-14	<3	?	?	?
Max. Coal Thk.	8-14m	<3.5m	30-50m	1-73m	1-54m	1-38m
Cum. Coal Thk.	13-20m	13-22m	75-105m	?	?	?
Sorption Time	>52 days	>8 days	>7 days	?	?	?
Depth of Completion	~800m	~650m	~150m	?	?	?

Model for Gas Generation and Accumulation in Western USA Coal Basins



Resource Assessment Considerations

Resource assessment requirements;

- Coal: extensive drilling, coring, and borehole logging, seismic (3D for underground mine design).
- CBM: utilizes coal resource information and additional testing to determine gas content, permeability, water saturation, and gas composition.
- CMM: integrates knowledge gained from coal resource exploration and coal mine development; requires experience in region to reliably forecast resource and producibility.
- AMM: utilizes historical coal mine information regarding size and extent of mining, methane emission during active mining, and time since closure to estimate potential resource. Forecasting is unreliable without AMM gas production testing.
- VAM: resources determined by volume of ventilation air, methane concentration, and exposure of coal in mine workings and gas drainage efficiency. Safety considerations establish ceiling on methane and ventilation air.

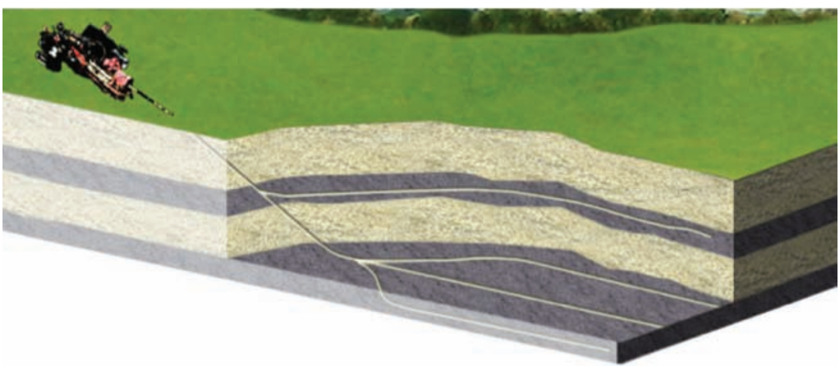
Vertical Drilling

Conventional drilling technology can be used with water-based drilling fluids and/ or air to bore holes in virgin coal in advance of mining or into gob areas. A variety of completion techniques can be used to ensure optimum production.

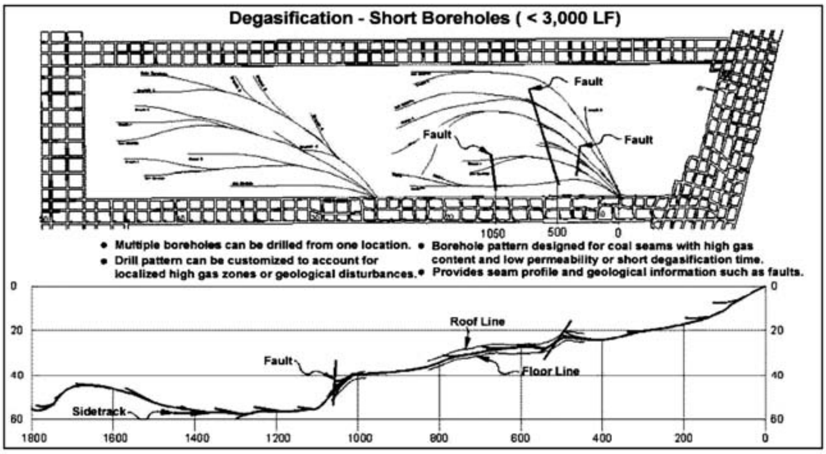
Large Hybrid Rig in San Juan Basin of Colorado, USA. Rig can effectively use conventional drill pipe or coiled tubing

Small hybrid rig capable of drilling micro-holes or conventional boreholes, may be similar to the configuration needed to serve remote coal mining activities.

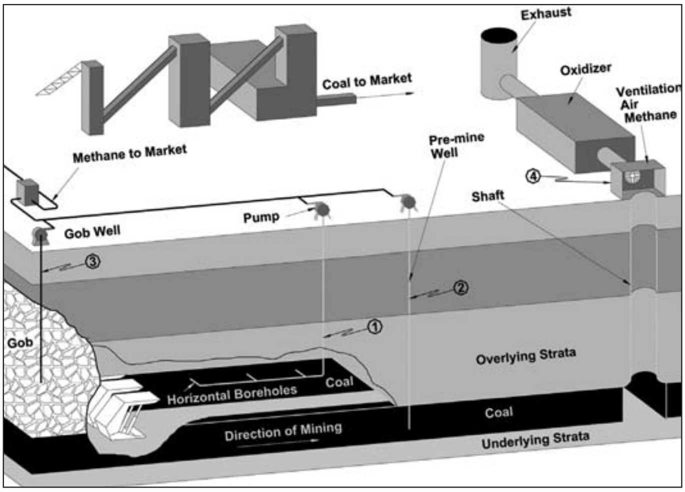
Example Directional Borehole Drilled from Surface



Example of Underground Directionally Drilled Degasification Boreholes



CMM Emission Sources



Categorization of Coal Mine Gassiness

Country	Category	Specific Emission, m^3/t
China	Slightly Gassy	≤10
	Highly Gassy	>10
Poland	Non-Gassy	<5
	Slightly Gassy	5-10
	Gassy	10-15
	Very Gassy	>15
Former Soviet Union	I	<5
	II	5-10
	III	10-15
	Super Category	>15*
Germany	Insignificantly Gassy	0.3-3.0
	Slightly Gassy	2-6
	Gassy	4-12
	Moderately Strong	8-25
	Strongly Gassy	20-60
	Very Strongly Gassy	50-120

* seams prone to outburst of gas and coal. Gas flows 1.5 m^3 per minute per tonne of coal.
Source: IEA Coal Research, London, April 1997. Gas Control in Underground Coal Mining. IEACR/91

III. CMM project development

Positive Impacts of CBM & CMM Growth

- Job creation.
- Use of natural gas over coal for residential and district heating
- Preservation of local and global environment.
- Conservation of natural resources-monetizing resources while encouraging con servation.

What makes a good CMM/CBM project?

1. Natural Conditions: Large coal resources with favorable geologic conditions for maturation of coal, storage of gas, and high permeability
2. Human Resources: Trained professionals and workforce that can assess, plan and execute complex programs to explore and develop resources
3. Favorable legislative and regulatory environment: Enables and facilitates resource development while guaranteeing environmental preservation
4. Favorable economic and market conditions: Investment encouraged, market conditions allow reasonable expectations for return on investment

Project Design Drivers

- Characteristics of the market and extent of transport systems to get product to market , including size, proximity, and diversity. i.e. the need for natural gas, CNG, LNG, waste heat, and electricity, vehicle fuels.
- Availability of engineering expertise and experience.
- Magnitude and characteristics of the resource:
  - Large volume medium to low concentration of methane
  - Moderate volume of high concentration; or,
  - Variable volumes, rates of production , concentration

Principles of coal and CMM development

- Sustainable development of coal related gas resources requires concurrent establishment of infrastructure and services:
  - Coal and gas extraction and processing activities can share space and resources
  - Transport systems to allow extracted mineral resources to get to market.
  - Coal mining and CMM can be designed to be complimentary. Examples: gas fired coal drying, CMM fueled mine power, gas fueled truck transport, rail transport facilities for coal and LNG
  - CBM requires advanced drilling and production technology gas transport or conversion to marketable products. Requirements overlap conventional natural gas and with only some CMM activities

Potential Markets For Gas

- Sales to a national gas pipeline grid or end users via the grid
- Direct use by coal mine or nearby allied industry
- Energy conversion to heat or electricity
- Chemical feedstock. i.e. methanol, DME, carbon black
- Vehicle fuel

Potential Markets for Electricity

- Mine and allied industry
- Sales to national grid or end-user
- Consumption at mine and nearby worker communities and villages
- Nearby industrial or commercial user
- Industrial park supplied by CMM fueled power facilities

CMM Utilization and Gas Quality

Option	Gas Quality Necessary	Applicability
Direct use on-site	Medium	Suitable for most mines, can be used to fuel coal preparation plants, heat space and water, and treat water.
On-site electricity generation	Medium	Most suitable for mines with large electricity needs, especially those which already produce their own electricity.
Sale into an Existing Gas Distribution Transmission System	High	Most suitable for mines using pre-mining degasification and located near existing high quality gas pipelines.
	Medium	Most suitable for mines located near medium quality pipelines.
Sale directly to an industrial, residential, or commercial user	Medium	Suitable for mines located near industrial or commercial facilities, or near residential areas.
Chemical Feedstock	High	Most suitable for very gassy mines using degasification techniques that recover nearly pure methane and are located near chemical plants.

Utilization Technology

- Power Generation
    - Internal combustion (IC) engines
    - Gas Turbines
    - Boiler/Steam Turbines
    - VAM Oxidation
- Pipeline injection
- Coal Preparation Plants: Coal mine methane can fuel the thermal dryers that heat the air used to remove surface moisture from the coal.
- Flaring,not considered utilization in its present form, used solely for the purpose of GHG emissions reduction

Utilization Options for Mongolia

- Convert CMM to heat
  - Mine Boilers -- bath houses or dormitories
  - Heat intake ventilation air in the winter
  - Heat may also be generated with VAM Oxidation
- Compressed natural gas (CNG) for vehicle fueling
- Liquefied natural gas (LNG) for vehicles and other uses
- Chemical Feedstock: CMM may be recovered and used in methanol or carbon black production
- Electricity Generation– internal combustion engines are very successful

IV. CMM & AMM utilization EXAMPLES

Gas Pumping and Storage Facilities

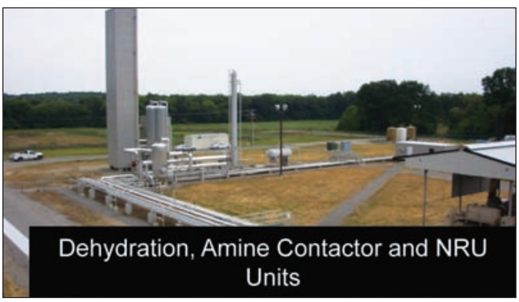
Medium to High Concentration Methane Used for Intake Ventilation Air Heating

CMM Vehicle Fueling in Shanxi, PRC

DTE Abandoned Mine Project

CO_2 Removal

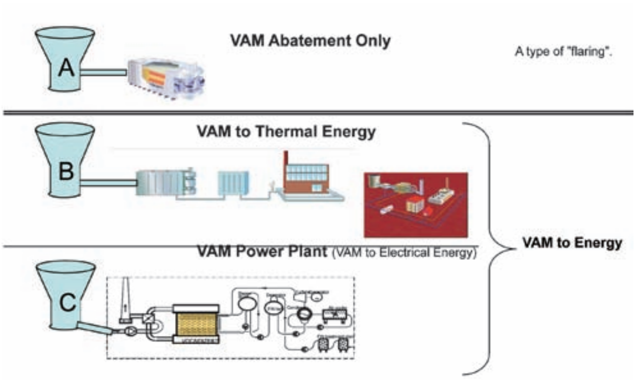
Oxygen



Dehydration, Amine Contactor and NRU Units

Processing Plant Compression Units

CMM Power Generation

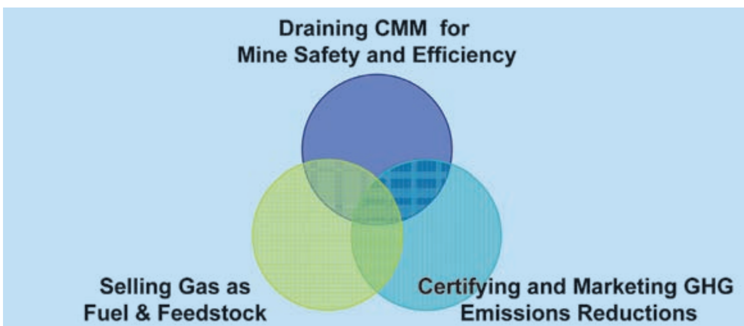


THREE OPTIONAL VAM VOCSIDIZER CONCEPTS

VAM System Photo

V. CMM project economics

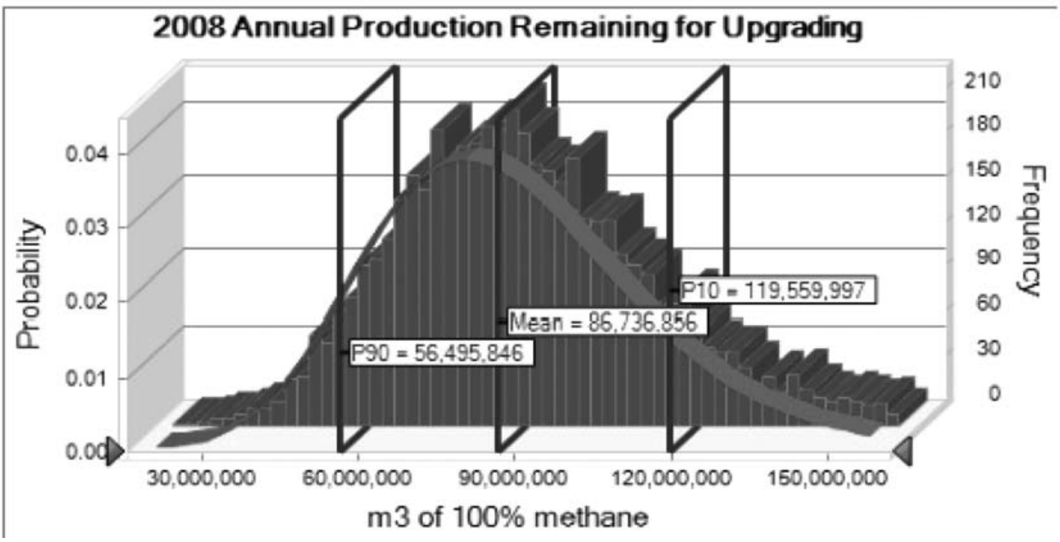
Understanding the Issues that Drive the Operation and Economics of a CMM Project

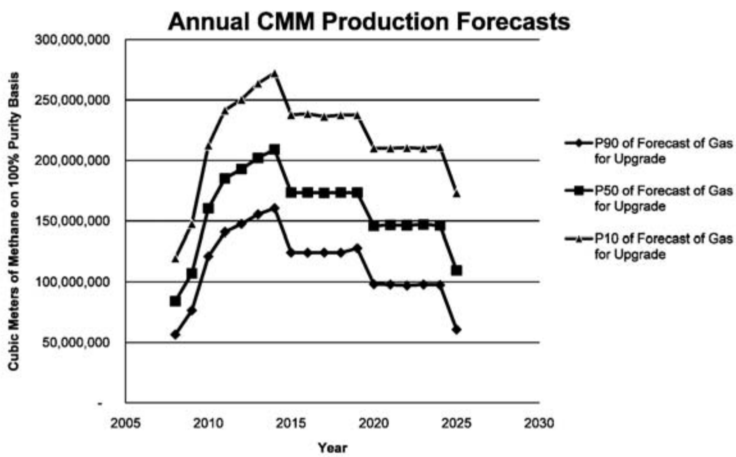


Economics of CMM Projects

- Developing an Economic Model to aid in determination of options for production and utilization of gas
- Considerations for construction of model:
  - Project life
  - Expectations for performance
  - Production forecasts
  - Capital equipment and construction costs
  - Operation and Maintenance

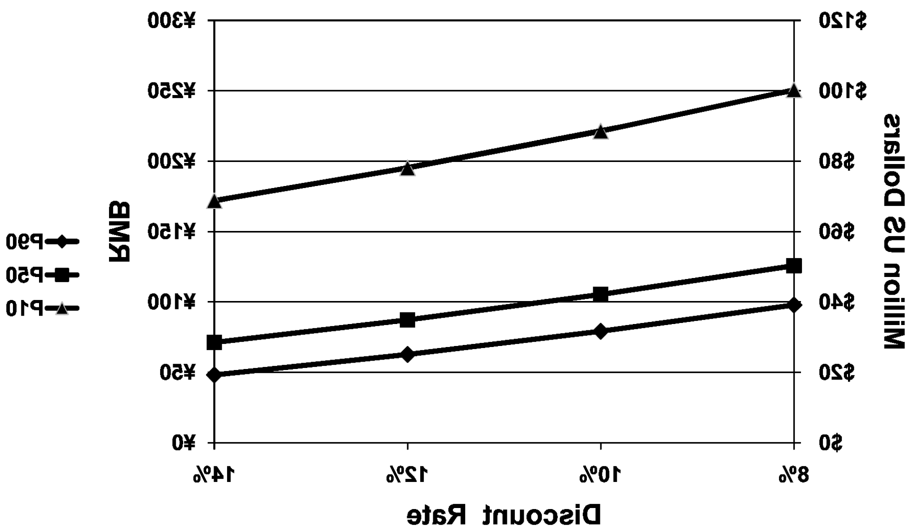
Annual Production CMM Forecast for Mining Complex



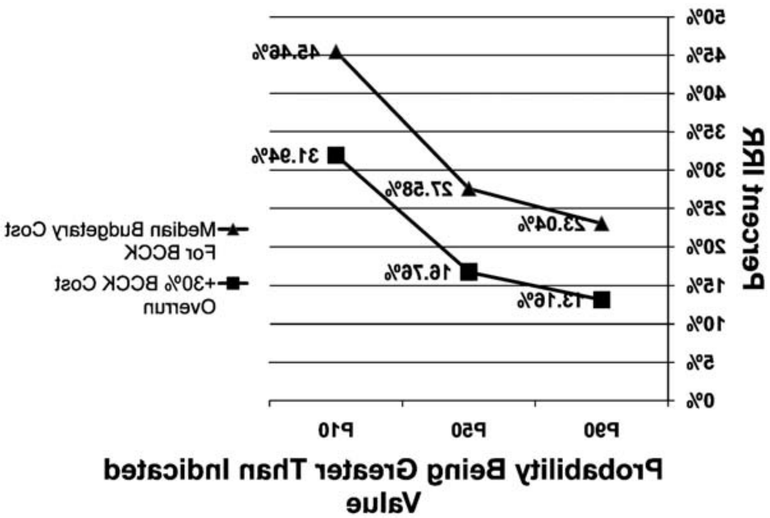


Probabilistic Production Forecasts

NPV at Each Indicated Discount Rate and Probabilistic Production Forecast



IRR for Each Indicated Probabilistic Production Forecast



VI. CONCLUSIONS

Closing Comments

- Mongolian coal basins have huge potential for development of coal and associated gas resources– but requires additional exploration to ensure viable commercial development
- Learning from other country's coal and CBM/CMM development experience provides a valuable opportunity for Mongolia to develop its coal and associated gas resources in a comprehensive and environmentally friendly manner

GEOLOGICAL CONDITION OF NALAIKH DEPOSIT

Dr. Mablet: *Mine engeener*

The mining deposit at Nalaikh is located at 107^0 17'' east, 45^0 51'' south. The total area under mining exploitation is about 6.2 sq. km.

Nalaikh mining deposit benefits from being located in an area of well-developed infrastructure, connected UB city by railway, paved road, high voltage wire and telephone.

Nailakh was initially developed in 1912 by Chinese companies and merchants from the Russian Empire.

Mongolia, on becoming autonomous, also used coal. Da Khuree which used to be the capital city of the country, had a few European-styled small houses made of timber and bricks. Altogether those houses had about 150 stoves, which used approximately 2700 pood of coal per year.

In 1922, the government began, for the first time, to mine coal layer by layer from concealed, low depth mining. In the 25 years from 1922 to 1947, 2.5 million tons of coal were extracted, and during the 5 years from 1948- 1952, a further 1.8 million tons of Nailakh coal were extracted.

In 1958, a new, abyssal coalmine with extractive capacity of 600,000 tons per year was established. Around that time, extraction from small-scale, sloping mines were discontinued, but extraction from small-scale open cut mines continued.

From 1970-74, the Cussbasenproshakht Institute of Russia and the Mongolian Research Institute of Mining undertook a new project. The main aim of this project was to increase coal mining capacity to 600,000-800,000 tons per year. By this time, new technical equipment had been installed at Nalaikh.

A total of 21 million tons of coal were extracted from Nailakh until its closure in 1994. At that time, Baganuur, and Shariin gol were opened to fulfill coal demands in the central region of Mongolia.

Coal deposits consist of 5 main layers, each of different thickness and complexity of structure. The layers are described as coal stratum II, III, IV, V, each consisting of middle (1.21- 3.2 m) to extra thick stratum. Each layer is comparatively stabilized.

Nailakh coal layers are described below:

V stratum - the thickness is 1.39- 10.04 m and it lies below IV layer for 5-36 m. V stratum of the Eastern side of the deposit, is deep in the ground to 1330 m, and has been completely utilized. Most of the thick V stratum (5-10 m) is located in the central and western side of the Nailakh deposit, between prospect line V-XI. Among sloping layers, the thickness of the stratum decreases to 4 meters. Also, the consistency changes, with 8 layers of stones separating coal into 9 stratums. In 1998, exploration at Nailakh established that the V stratum of coal spread about 3-3.6 m in thickness, located between prospect lines XX and XII, and it also may spread to eastern side of the deposit.

IV stratum- has comparatively the most simple structure, with 5 layers of stone, each stone layer being 0.2- 0.3 meter in thickness. The IV stratum is about 2.5-3.3 meter thick, in some areas increasing to 4-5 m.

III stratum lays below II stratum for 3.65 meter, and separates into 2 sections. The first section is between the I- XVIII prospect lines, spreading a total of 6.16 sq km, and the second section is between the XIX-XX prospect lines, spreading 1.84 sq km. All III stratum is about 1.2-3.5 m thick. A total of 1.6 km2 of III stratum coal has been utilized in the south-east side of deposit.

The average laboratory analysis data shows:

- Humidity of work place 21.2%
- Humidity of laboratory W 9-10.2%
- Covering of ashes 17.9%
- Productivity of steaming gas 45.7%
- Concentration of sulfur 0.9%
- Heating 6620kkal/kg

The chemical analysis shows:

- carbon 71.6%
- hydrogen 4.8%
- nitrogen 1.1%
- Oxygen 22.6%

Average index of quality that estimated by prospects complete

- average of coal ashes 18.06%
- coal ashes of product 23%
- laboratorial humid of coal 9.8%
- natural humid of coal 24.6%
- Productivity of steaming gas 45.7%
- concentration of sulfur 0.75%
- heating -6536 kkal/kg

Nalaikh mining is included in occasionally methane producing group. And the ability of coal to endogenic fire, it might produce SiO_2 and can cause dangerous silicosis.

Final reports of the Nalaikh mining deposit in 1992, established that the total supply of coal is 50 million tones, and 80 million tones outside the exploitation area.

The supply of coal estimated only on west side of prospect line IV-VI, and between prospect line IV-VI, and between prospect line XVIII-XVIII is estimated by each stratum. It is estimated that the western side of the deposit had a supply of 20.6 million tons of coal.

After the savings in 1994, during the mining determined great volume of methane in west side of deposit. To use gas properly for fuel, and technical purpose we process project “Carbon gas”.

The project contents are:

The main object of project is to use well method. Well method will use to oxygenate carbon deeply in ground to extract mix of CO_2, CO, H_2, CH_4, N_2 gases. From the gas will produce product that will used in fuel, technical purpose.

In the project we had version to produce gas mixes from V stratum of coal oxygenating them deeply in ground by well method. The cause of chosen Nalaikh mining by research deposit are: at first: to extract gas mixes by well method. The gas mixes produced from endogenic fire, deeply in ground. At second: oxygen, the main raw material of carbon oxygenation, had been produced by plants in Nalaikh.

The laboratory analyze index of gas mix, in Nalaikh mining in 1990-1992, shown below:

CO_2 1.2-6.0%
CO 0.005-3%
O_2 3.2-10.2%
CH_4 2.3-4.7% sometimes methane had reached 74%.

The coal from Nalaikh, had been researched in Freiberg Geological Academy of Germany, and research response had had excellent.

After the heating, laboratorial coal oxygenating reactor into 520^{0}C, place into the reactor 4-5 kg kg of coal. Then increase internal pressure of reactor into 1.8 MPA, by pressing the heated gas into reactor. When internal pressure of reactor reaches 1.8 MPA instead of heated gas, start to use heated steam by (5:1)-(8:1) kg/m^3. Among experiment, the gas concentration must measured. When oxygen gas occurs in analyze, experiment stops. The laboratory analyze index from experiment shown in below table.

Gas concentration extracted from Nalaikh coal

Deposit name	Ratio of heated steam and oxygen	Concentration of gas, %							Gas acid MJ/kg
		CO_2	CO	CH_4	$C_n H_n$	H_2	H_2S	N_2	
Nalaikh	6:1	28.8	19.6	10.5	0.5	39.4	0.2	1.0	10.79
	7:1	30.9	15.8	9.5	0.4	42.2	0.2	1.0	10.25

From experiment data, as we can see that from Nalaikh coal produces flammable gas with heating capacity 10-11 MJ/kg calories, of which methane concentrate is 10%.

By the speculation, if the concentration of methane gas is above 10%, it can be used instead natural gas. Today the world agree with appropriate depth of carbon oxygenation is about 1000 meter, and trying to increase depth.

But, our ''Coal- gas'' project conception is little different. For example: after 70-ies in west and east side of Nalaikh closed mining had been left supply of gases, which produced by endogenic fire. To use natural ''lava-generators'' for a power purpose, we dug couple of well with 100 meter depth. By one of the well squeezed oxygen, by another well extracted synthetic gas.

The experiment had made in Russian brown coal, which spread around Moscow, and in Cusbass coal stone. By experiment, concentration of hydrogen, CO, CO_2, methane and oxygen in flammable gas extracted from 100 meter depth had changed in 50 meter depth and stabilized in end of slopping well. The flammable gas which consists of hydrogen, carbon oxide, and other steaming gases is equal to ‘’comparatively methane’’. Also, it had gases such as sulfur, hydrogen, carbon, argon in small concentration. Non flammable gas consists of oxygen (0.2%), carbon dioxide (20-22%), and nitrogen. By the method of oxygenation deeply in ground, when pressing steam and oxygen (6:1) in high pressure, could extract heating gas with 9-13.5 MJ/cubic meter calories.

Technical request of synthetic gas, used by electric (power) purpose:
Coal oxygenation

Coal	Concentration of gas, %							Heating kkal/kg MJ/kg
	CO_2	CO	CH_4	$C_n H_n$	H_2	H_2S	N_2	
Stone coal	5.0	0.1	26.5	13.5	2.5	51.9	0.2	1400
Brown coal	4.6	0.2	28.5	13.0	2.0	47.8	0.2	1500

‘’Bechtel” (USA) corporation made economic assessment of synthetic- gas using for electric purpose. By the assessment it is estimated that, if the oxygenation depth is 100 meter, output of one well equal to 200 thousand cubic meters and to produce 1000 cubic meter of synthetic gas the investment of manufacturing depends on capacity and equal to 300-400 doll per cubic meter.

Oxygenating coal deeply in ground, extracting it from depth the utilization coefficient of coal supply is 0.5-0.6.

Prospects for the future

1. for the beginning the project will implement only in west side of deposit. And than will use by well method VIII stratum of coal, which is in 350-500 meter depth.
2. For the installation of first wells in west side of mining, we will use planning atlas of III, IV, V stratum which had in savings State rescue office.

The project “Well method mining technology of coal deposit” had been processed by “The principle of process project in Science of Technology”, Government of Mongolia, 1998.

We had experienced to extract methane from depth, and to use it in fuel, as chemicals in chemic factory purpose.

OPPORTUNTIES TO IMPROVE HEAT SUPPLY OF NALAIKH DISTRICT OF ULAANBAATAR CITY THROUGH UTILIZATION OF METHANE GAS

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Coalbed methane utilization at Nalaikh Heat Plant

Current efficiency of heat supply network of Nalaikh district is low and this feature has been considered to result in intensifying air pollution and reduction of real income of the residents. As of today, the air pollution rate in Nalaikh district has reached a disaster level same as in Ulaanbaatar city. During winter season, the pollution level is estimated as three to five times higher than permitted level. An outbreak of respiratory diseases also rapidly increases at same period, respectively.

Nalaikh power plant, a sixty MWt capacity plant, has 3 Russian-originated boilers of KBTS-20-150 those started to operate in 1992. These coal-burning boilers have and efficiency of 65% (not so well) and weak technology. As it operates with coal, the structure of equipment and machinery is huge and has high frequency of breaks and damages. Its higher costs of coal, electricity and maintenance result in higher value of heat production and further give pressure to consumers.

Mongolia is unique of having a harsh climate with cold and long winter and it is vitally important for living to heat accommodations no matter of how high the heat price is. Most of budget expenses in urban areas are spent for heating, and this applies to Nalaikh district too.

Technical-Economic indicators of Heat plant in Nalaikh district (by 2006)

- Design heat load - 24 Gcal/h
- Annual Heat production -66000 Gcal
- Annual coal comsumption - 29000 ton
- Price of coal- 30000,0 tugrig
- Price cost heat prodution-40000 tug/Gcal

Currently, a coal is the only main source of fuel for Mongolian energy sector due to below reasons.

1. There are no gasoline processing plants in the country and liquid petrol is imported in higher prices;
2. Reserves for natural gas are not found, importing price of LPG is high- at average 1 kg of LPG is MNT 900, as of 2008;
3. Advanced technology of raw coal pre-processing is not yet introduced in domestic sector. Prices for pressed and gas fuel, products of experimental industry, is again unreasonably high.

Experts made a preliminary conclusion that there might be an opportunity to overcome the above-mentioned obstacles for Nalaikh coal mining site, operated from 1912 till 1990s. The studies determined the certain amount of coalbed methane reserved in depth of Nalaikh coal mining. Now it is important to estimate and certify the reserve amount.

Among many possible measures to reduce the air pollution, utilizing methane instead of the coal can be the most efficient option for Nalaikh district.

Coal mining methane Parameters:

Methane rate of Nalaikh coal mine 5-15 m^3/tonne
Net Heating Value- 10000 kcal/kg (37 MJ/ m^3)
Density- 0,72 kg/m^3
Price is three times low than coal's
4 times less Hazardous Gas Emission than Coal

T*echnical innovation of the Heat Plant*

Though technology of utilizing the methane as a fuel for power plants is same to coal technology, utilization and operation safety requirements are stricter. Operation of gas stoves can allow engineers and technical staff to wear "white" uniforms which explains that hygiene of working environment will certainly improve.

In order to utilize methane instead of coal, the below changes and innovation preparation have to mad:

1. Take away unloading, processing, transporting and storing equipment of the coal;
2. Keep the stoves and change its coal loading, distributing parts into gas types. If financial resources are enough, replace old stoves with new ones. That is estimated to increase efficiency up to 94 per cent;
3. With a new gas-operating regime, renew automatic regulation system of the gas;
4. Take away dash blowing and transporting parts;
5. Build and install new equipments of methane gas storage and distribution;
6. Install pipe transmitting gas from the coal site to heat plant

Heat principle scheme of heat plants operating with gas is shown in figure.

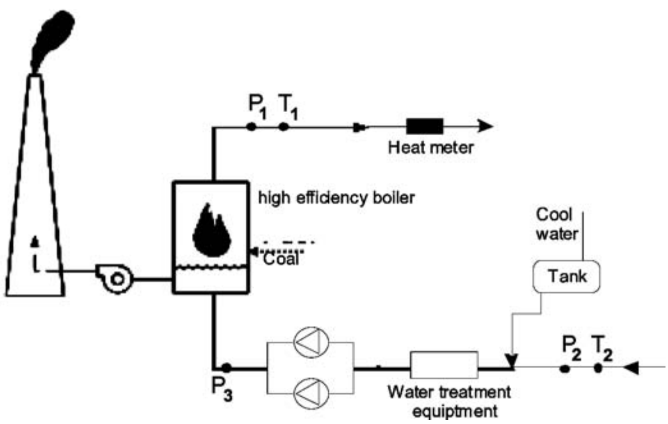

Figure 1. Diagram of Heat Plant with gas-fired boilers

Main impacts of rehabilitation heat plant

Replacing old backward coal-fired by advanced gas-fired boilers will achieve the following objectives:

- Replacement of old hot-water boilers with high efficiency, new technological boilers will save energy.
- Regarding environmental issues of the project, the project will improve environment by reducing emission of harmful gases and dust.
- For people, the project will improve working environment for operators, creating a better environment for people.

Technical-Economic impact

- Introduction of effective modern heating only boilers will result in increasing efficiency from 0.65 to 0.94. This feature is a main force of reducing GHG emission and saving fuel related expenses.
- Fuel is changed from coal to gas will save area for fuel storage, ash
- field and reduce green house gas emission, eliminating dusts and harmful gases emission.
- operation will be 100 % automatic, improving working condition
- Less fuel consumption will result in less cost of heating i.e. the estimate is that the unit cost for heating can be reduced.

The substitute gas-fired boilers with equivalent capacity will consume 4020 tons of gas. Heating value of gas is Q=11290 kcal/kg., 3.5 times more than brown coal

Annual heat consumption by Heat plant in Nalaikh :

$$Q = Q_a \cdot n_{HS} = 0.5 \cdot Q_d \cdot n_{hs} = 0{,}5 \cdot 12 \cdot 5500 = 66000{,}0\,\text{Gcal}$$

where: Q_d - design heat load, Gcal/hour; Q_a - Average heat load for of heating term, n-duration of heating term,hours

Average heat load for of heating term, Gcal/hour;

$$Q_a = \frac{(t_{in} - t_{out})}{(t_{in} - t_{out.d})} \cdot Q_d = \frac{18 - (-11)}{18 - (-39)} \cdot Q_d = 0.5 \cdot Q_d$$

t_{in} – inside temperature; t_{out} – outside …..temperature; $t_{out.d}$ – outside design temperature for Ulaanbaatar, -39^{o}C $\cdot n_{hs}$ - duration of heating term, hours

Coal consumption:

$$B = \frac{Q}{\eta \cdot Q_c};$$

Where: η · - boiler efficiency; Q_c -heating value, Kcal/kg; Q_d - design heat load, Gcal/h;

Fuel consumption of Heat Plant (Hot water Boiler-HOB)

For coal -fired boilers of efficiency, η · =0,65

$$B = \frac{Q}{\eta \cdot Q_c} = \frac{66000{,}0 \cdot 10^3}{0.65 \cdot 3500} = 29000{,}0 \text{ ton}$$

For gas-fired boilers of efficiency, η · =0,94

$$B = \frac{Q}{\eta \cdot Q_c} = \frac{66000 \cdot 10^3}{0.94 \cdot 10000} = 7020 \text{ tn}$$

Annual saving cost of fuel consumption

$$\Delta 3 = B_n \cdot y_n - B_m \cdot y_m = 29000 \cdot 30000 - 7020 \cdot 40000 = 590{,}0 \text{ mln.tugr}$$

Reduced cost price of one Gcal by 8900 tugr

Social impact

- When new gas boilers have been installed, they will work more reliably, contributing to a more comfortable social environment, thus reducing the amount of illness and work absence. This will reduce the amount of money people spend on medical supplies and increase their ability to attend work.
- Expenses on annual fuel consumption of businesses and households located in the city's remote or *ger* districts is to be saved; and

Environmental benefits

☐. *Reduction of GHG emissions*

Utilizing methane as a fuel has a strong potential to reduce air pollution within areas, improve financial capacity of consumers and reducing emission of GHG.

- CO_2 emission from combustion in the boilers is to be reduced;
- Methane emission from coal mining into the atmosphere is to be reduced

Annual Reduction of GHG emission per unit heat production

Per GCal heat: CO_2 – 0,33 tn/Gcal
CH_4 – 0.1 tn/Gcal

Annually reduction GHG of Heat Plant in Nalaikh: By CO_2- 21780 tn, by ☐H_4 -6600 tn

B. Reduction Air pollution in Nalaikh:

It will be following environmental impacts other than GHG emissions,

Air and environmental pollution of the city is to reduced;

Coal and biomass fuel emit ash. Dry ash from boilers will pollute water and atmosphere.

Combusting process in the boilers will emit CO and SO_2 .

Chambers of boilers are not high, therefore air pollution in the city is very big.

In the winter season 1998-1999 content of CO and SO_2 was 6-12 mg / m^3 and 10 mg/ m^3, but standards of CO and SO_2 contains should be 4.0 and 2,5 mg / m^3.

Conclusion

The current outdated technology burning raw coal pollutes the environment and air of urban areas in Mongolia with no reserves of natural gas. Utilization of coalbed methane gas in energy sector can be an optimum solution for replacing these old technologies and technique and those activities certainly needed in urgent support from the Government. These support activities include:

1. Supporting and examining ideas and proposals developed by professional and non-governmental organizations and individual researchers;
2. Providing financial aid for exploring and evaluation of coalbed methane reserves in Mongolia;
3. Improving legal environment for exploring and utilization of the methane gas;
4. Developing legal standards for regulation of exploring, mining and utilization of coalbed methane from land owned by certain organizations and invidividuals;
5. Developing programme to consider and utilize the methane gas as a potential source of energy.

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ASSESSMENT OF SOCIO-ENVIRONMENTAL BENEFITS OF METHANE IN ULAANBAATAR

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Methane is an ancient fuel. Its proven reserve on the Earth reaches 240 trillion cubic meters and it usually extracted from depths of 800 meters or more. United States, Russia and China are the countries that contain the biggest reserves of methane. In 2006, China emitted 6-19 thousand million cubic meters of methane from coal mining annually. This resource was not captured for use.

Methane in the Earth's atmosphere is one important greenhouse gas (GHG) with warming potential 25 times higher than that of carbon dioxide. Its emission has been intensified through industrialization and total emissions have doubled during the last 100 years. About 18 per cent of the Earth's atmosphere consists of methane. Scientists report that the annual average emission of methane is expected to increase by 0.6 per cent. Methane persists in the atmosphere for approximately 11 years.

The world's estimated liquid fuel reserve is only 30-50 years. Conversion of vehicles to utilize methane fuel is one solution which can contribute to a reduction in fuel availability.

Mongolia also emits a significant amount of methane during mining of black coal, including the *Nalaikh* deposit, every year. Like China, this resource is no currently captured and used. Further, utilizing methane instead of liquid fuel can result in a reduction of greenhouse gas emissions by 13 per cent.

Air pollution in Ulaanbaatar city and aimag centers and its causes

Bigger cities and *aimag* centers use substantial amounts of raw coal for heating buildings and households in various types of combustion stoves. Typically, these stoves pollute the air significantly. The air pollution in Ulaanbaatar city has reached a crisis level. Recent studies estimate that the city pollution during the winter season exceeds average allowable air quality levels by 5-6 times. One of its critical impacts is fast-growing rate of respiratory diseases in urban areas.

UB's main sources of air pollution are:

- Over 135 000 stoves and wall-stoves in gers and private households;
- Over sixty water heating boilers of schools, hospitals, and public apartments not connected to district heating system;
- Over 1000 low-pressure boilers in small scale buildings of businesses and services.

Figure1. Visible air pollution on a typical winter day in Ulaanbaatar city

There are many potential measures that can be applied to reduce air pollution. However, given that many consumers are not connected to the district heating system, one solution is to replace the raw fuel material with methane.

Replacing fuel needs of Ulaanbaatar city and its remote (*ger*) districts with methane can significantly reduce coal consumption and its associated toxic emissions.

Methane replacement can achieve the following beneficial outcomes:

- Air and environmental pollution of the city is reduced;
- Fuel cost savings for businesses and households located in the city's remote or *ger* districts; and
- Atmospheric methane emissions from coal mining reduced.

The following benefits are expected from methane utilization:

1. Methane burns more efficiently than coal. Efficiency rates for stoves and boilers using gas fuel is more than 90 per cent. This means less GHG emissions and financial savings through lower fuel-related expenses.
2. Total consumption amount of methane will be lower, considering that its heating value is higher than coal by 2.5 times and higher than gasoline by 1.2 times. It allows savings through mining and distribution costs.
3. Methane is cheaper than other fuels; its heating economic unit value is lower due to its relatively cheaper price.

Possibility of improving an economic capacity of heat-consuming businesses and households through utilization of methane

Mongolia has extreme weather, with temperatures falling as low as - 45□□ during winter. This results in a heating season that continues eight months of the year and consequently, substantial amounts of money spent by government, businesses and households on heating and fuel consumption.

Coal price by volume in 2007

Price of Nalaikh's coal- 35-45 U$/tn
Price of Baganuur's coal- 32-40 U$/tn
Heating cost - In heat-only boilers… 24 u$/GCal.

Coal price contributes 60% of heating costs.

Here is a sample calculation of coal consumption and heating expenses for some consumers:

1. On average, one household in an urban areas (in 2007) spends MNT 250,000-.300,000 (USD 260) for purchases of fuel

   ~ 4.5 tons of coal * MNT 45, 000 = MNT 250,000-300, (USD 260.00)
2. One Gcal of heating unit of building heating for public service organizations (such as schools, hospitals and business entities that are not connected to district heating systems) costs MNT 40,000. Heating expenses comprise more than 30 per cent of the overall budget of the organizations.

Annual coal consumption of Ulaanbaatar city and Nalaikh district

□. Nalaikh disrict*:*

- The district is a home for 9000 gers and households that combust 37,800 tons of coal per year.
- The estimated load of thermal plants of the district is 24 Gcal/h and annual coal consumption is 71,600 tons.

B. Annual coal and gasoline consumption of Ulaanbaatar city

Table 1.

N	Consumer	Fuel type	unit	Fuel consumption
1	Combined heat and power- CHPs	Coal	Million tonnes	3.5
2	Heat-only boiler-HOBs	Coal	Thousand tonnes	156.7
3	Private houses	Coal	Thousand tonnes	540
4	vehicles	gasoline	Thousand tonnes	220
5	Apartments, cooking	electricity	Million kilowatt hours	200
6	Total coal consumption, thous.tn			**890.5**

Methane Parameters

- Methane is the major component of natural gas, 90 percent by volume
- Methane rate- Nalaikh coal mine 5 m^3/tonne
- Net Heating Value- 10000 kcal/kg (37 MJ/ m^3)
- Density- 0.72 kg/m^3
- Price is three times lower than coal
- 4 times less Hazardous Gas Emission than Coal

Areas where methane can be utilized as a fuel

Household cooking: As of today, all households living in public apartments use electric stoves for cooking in Mongolia.

Figure.2. Methane gas stoves for cooking

Water heating boilers of business entities and private houses: Coal-burning stoves of lower efficiencies are widely used in urban areas of Mongolia.

Figure 3. Water heating boilers

Power plants: Methane power plants are utilised internationally, including: (1) South Wales, USA - capacity of 94MWt, (2) a boiler in Vorkutoli mining (capacity of 975 kWt) and Belovougoli mining of Kemerovo district, Russia and (3) power plants in China- capacity of 120 MWt.

Road transport:

Figure 4. Gas distribution station

Estimation of methane consumption

Preliminary studies determined that *Nalaikh* mining area is estimated to be rich in methane reserves for Mongolia. Furthermore, the introduction of methane fuel in the *Nalaikh* district and Ulaanbaatar city was recommended, being 40 km from the district at the first stage.

Methane can be used as a fuel in a number of applications. This essay assumes that methane can be utilized for *gers* or private houses, boilers, public apartments and vehicles (i.e. areas except Thermal Power Plants). The following table shows estimated consumption of methane for the period 2015-2030 in Mongolia:

Total number of Methane consumers

Table 2.

N	Consumer type	2015	2020	2025	2030
1	Annual heat production of HOBs, Gcal	100000	275000	325000	350000
2	Ger or Private houses, households	27000	40000	50000	50000
3	Apartments, cooking, households	10000	40000	60000	80000
4	Vehicles, cars	1000	10000	20000	40000

Annual Methane consumption (million cubic metres)

Table 3.

N	Consumer type	2015	2020	2025	2030
1	HOBs, mln. m^3	14.6	40.5	47.45	51
2	Ger or private houses, mln. m^3	37.8	56	70	70
3	Apartments,cooking mln. m^3	2.5	8.6	12.9	17.2
4	Vehicles, mln. m^3	2.2	22	44	88
5	Total, mln. m^3	57.1	127.2	174.4	226.2
6	Flow of methane per hour, m^3/h	11.4	25.5	34.9	45.25

Environmental benefits

Reduction of GHG emission

Utilizing methane as a fuel has a strong potential to reduce air pollution within urban areas, improve financial capacity of consumers and reduce GHG emissions.

Annual Reduction of GHG emissions per unit

Per household: CO_2 - 2.2 tn/year
CH_4 – 1.1 tn/year
Per GCal heat: CO_2 – 0.33 tn/Gcal
CH_4 – 0.1 tn/Gcal
Per kW.h electricity: CO_2 – 1.1 kg/kW.h
CH_4 – 0.086 kg/kW.h

Based on the above estimates, Tables 4 and 5 show the total volume of GHG emissions reduced as a result of switching to methane fuel:

Annual reduction of CO_2 (GHG)

Table 4.

N	Consumer type	2015	2020	2025	2030
1	HOBs, million tonnes	44	121	143	154
2	Ger or Private houses, million tonnes	59.4	88	110	110
3	Apartments,cooking, million tonnes	14.8	59.2	88.8	118.4
4	Vehicles, million tonnes	0	0	0	0
5	TOTAL, million tonnes	118.2	268.2	341.8	382.4

Annual reduction of CH4 (GHG)

***Table 5*.**

N	Consumer type	2015	2020	2025	2030
1	HOBs, million tonnes	10.6	29	34.3	37.1
2	Ger or Private houses, million tonnes	29.7	44	55	55
3	Apartments,cooking, million tonnes	1.55	6.2	9.3	12.4
4	Vehicles, million tonnes	1.8	18	36	72
5	TOTAL, million tonnes	43.65	97.2	134.6	176,5

Economical benefits of Methane Consumption

Specific financial benefits (at 2007? 2008? Prices):

a) Heat-only boilers will reduce their heating cost by 16,000₮ or USD$14/Gcal per annum?

b) Householder will save(?) 100,000₮ or USD$86 in fuel expensesper annum

c) Vehicle fuel expenses saved:500,000₮ or USD$460/year

Annual cost saving for fuel in Ulaanbaatar city and Nalaikh district (estimated for year 2020)

<u>in Nalaikh district</u>
heat-only boilers-66000*14=$924,000
Households -9000*86=$774,000
total-$1.9 million

<u>In Ulaanbaatar</u>
heat-only boilers-275000*14=$3.8 million
Household's -40000*86=$3.44 million
Vehicles-10000*460=$4.6 million
total- $11.84 million

COALBED METHANE AND ITS EXPECTED RESOURCES OF NALAIKH MINE AREA

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When producing the coal, coal bed internal pressure reduces and escapes gas. That gas contains mainly methane (60-95%), nitrogen, hydrocarbons and other gases. This gas has different origin, accumulation, but it contains mainly methane. Therefore coal bed gas has same characteristics with nature gas and its available product[1].

Coal bed methane(CBM) may produce the drilling and production well.

Coal bed gas production has few stages. Including:

1. Exploration, researching, testing and drilling the production wells
2. Form the condition to stand out gas(methane) as maximum from coal bed (to initiate the cavern, to reduce the well pressure)
3. pump the underground water
4. Producing the methane
5. Accumulation, transportation, distribution and using the methane

Principle scheme of production the coal bed methane by well in a fig-1.

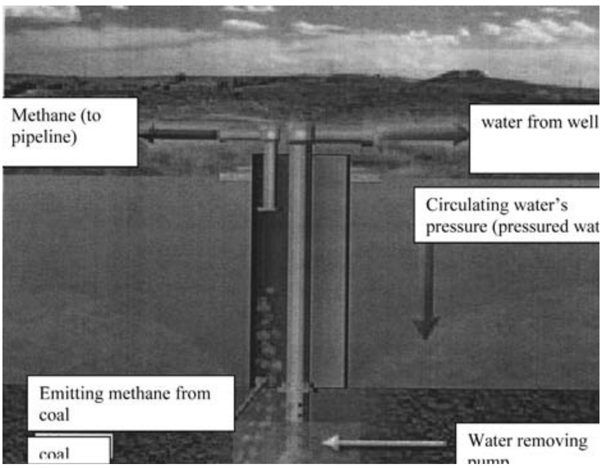


Figure 1. Principle scheme of production the coal bed gas by well.

First drilling and penetrating the coal bed with methane and cementation the well. Then form the condition to stand out gas to the well and surface freely. After that must install the pump and impenetrate the wellhead. Pump out the bottom water of well and coal bed pressure will reduce by water flow. Then the coal bed gas will penetrate to well and to surge the production string's inner surface. In the wellhead will install separator and the separator will separate pure gas and water by pump out.

In the researching stage measures absorbent methane of drilling core sample, which saves in a impenetrable container. Gas segregation measures for 7-30 days continuously.

Remove the underground water from well is very important. Because underground water reduces gas escaping. Centrifugal and spiral pumps use for remove underground water. If underground water's amount less, gas escaping will improve. Gas production rate shown in a fig 2.

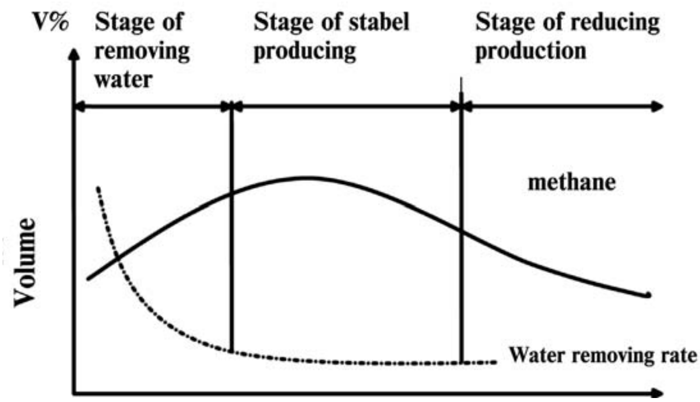


Figure 2. Curve of production rate for coal bed gas

Impenetrable of gas producing well from bottom to head of well, furthermore, must be closely for all pipelines to tank. Coal bed methane's producing well only not vertical, if horizontal well has economical profit, it shall be use for production coal bed methane (fig-3).

Method, technique and technology of drilling well maybe difference, but reducing pressure, completion of well, assemble and install the tank and principle of operating well are the same.

Recommending an opinion for exploration, researching and producing methane of some coal fields footing this common method and foreign countries experiment. In first stage recommending opinion for exploration-prospect and research-testing of Nalaikh's coal field, if will receive good aftereffect, production operating will begin. Nalaikh's secondary structure high improved and locate near the users.

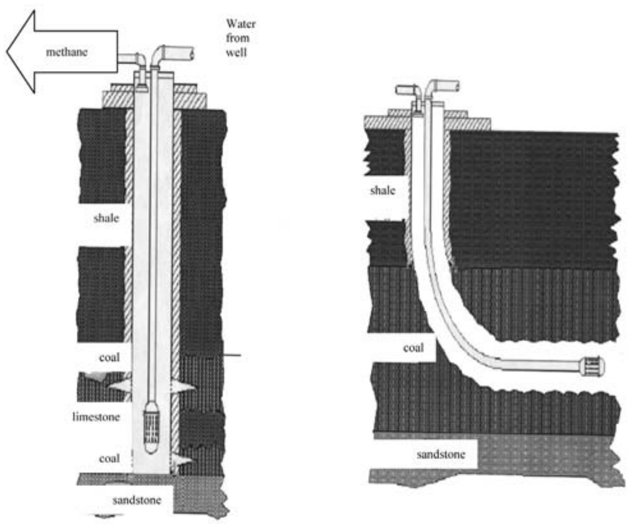


Figure 3. Gas emitting well completion of coal field
vertical well, b- horizontal well

Nalaikh's coal field allotted between mountain through the latitude and occurrences 6.2 km^2 areas. Nalaikh coal field have been utilizing since 1912 and exploration had been effectuated in 1992, reported the 1st of January in 1993, the balance resource 58845.8 thousand tons, in the mining zone's resource is 32259.8 thousand tons.

This field consists of five layers (V, IV, III, II, I). The II, III, IV and V layers contain mainly middle(1.21-3.5m) and maximum(3.51-15.0m) thickness bed and layer's structure changing from elementary to complex, highest complex, layer changing category is comparative stable. A brief description of each coal bed:

The fifth bed's thickness is from 1.39 to 10.01m and locate below 5-36m from the fourth bed. Fully utilized the east side level to +1330m. The maximum thickness (5-10m) locate in the center and west of field, between exploration lines V-XI. The thickness reducing until 4m through layer azimuth. Near the XX and XXI exploration line the fifth layer's coal dispersion were 3.0-3.6 m in 1991, and might be disperse to the east side.

The fourth bed has comparative elementary structure, consists of five rock layers, every layers thickness 0.20-0.30m, amount thickness of bed 2.5-3.3m. The thickness of bed improve through the azimuth and reaches 4-5m.

The third bed locates below 3-6.5m from second bed. The highest dispersion bed is third bed. The third bed has two parts, where locates in 6.16 km^2 areas between I-XVIII lines and 1.84 km^2 areas between XIX-XX lines. The thickness of bed's main section 1.2-3.5 m. In the north east side of field, the third bed had been utilized about 1.6 km^2 area. When compared basic and monitoring analyze, the basic detection such as coal ash A^d and yield of bounce substance V^{dat} were in permissible level. But the coal laboratory wet (moisture) W^{ab} and heat excretion Q^{dat} had much differences. Maybe it depends from storage time, weather of analyzing place.

The average detections of previous analyze:

- operation wet (W_z^r) – 21.2%
- laboratory wet Wd-10.2%
- ash Ad-17.9%
- yield of bounce substance (Vdat) – 45.7%
- content of sulfur S_t^d -0.9%
- heat excretion (Qdat) – 6620ccal/kg

The detections of chemical analyze:

- carbons (Cr) -71.6%
- hydrogen (Hr) – 4.89%
- nitrogen (Nr) – 1.19
- oxygen (Or) – 22.6%

The quality average detections of effectuated exploration:

- coal average ash Ad-18.06%
- ash of ready coal – 23%
- coal's laboratory wet W9-9.8 %
- coal's nature wet – 24.6%
- yield of bounce substance (Vdat) – 45.7%
- content of sulfur S_t^d -0.9%
- heat excretion (Q^{dat}) – 6620ccal/kg

Nalaikh mining has unexpected secretion of methane, depends upper class and coal has ability of absolutely burning, coal's dust with SiO_2 might derive "antricoze" damage.

In table ¹ 1 shown methane analyze of this field (measured by gas detector LI-4). Measured different places of field in various time from 1982 to 1994.

Content of methane in air were 2.8-54% by measure. Much content of methane (44-54%) transpired in junction of excavation. This content was depending from methane accumulation for period. But places of methane content less than 10%ь may secrete from excavation well's wall.

Since utilizing the Nalaikh mining to the level +1330", in the preparing rectification excavation weren't methane. Methane transpired only in мухар excavations. Particularly, 257 samples taken from mining (1972-1973), but only in 16 samples transpired methane less than 1.3% (Myagmar and others, 1973).

In July, 1973, Mongolian and Sovet Union (by the old name) specialists studied together with VostNII's workers the Nalaikh Mine Hazardous Research. Used methods directly measure the emission gas from wax (from coal bed) and measure contents of methane. Gas emission determined by observation.

When producing 1 tonnage coal, the gas emission depends to first grade ("Rule of safety for coal and shale", gas comparative emission to 5 m^3/ton). Mining absolute gas emission by estimation were 1238 m^3/day, for carbon 6422 m^3/day.

But gas comparative emission were 1.0 m^3/ton for methane. By frequency measurement for mining hazardous and measured every month in 1975, determined 0.1-5.8% methane in second layer's 25^{th} gradient and in 252^{th} wax ventilation drift May and July in 1975.

By account indefinites the Nalaikh Mine methane absolute emission $0.12m^2$/min ($172.8m^3$ per day), comparable emission $0.24m^3$/ton and the measurement in +1330m level (in 1975) describes the Nalaikh Mine depended the first grade's methane emission. This measurement guaranteed previous result.

While deepen the preparing and cleaning excavation, observed improvement of the methane content in lifted air, particularly, when excavated the central gradient methane content were 2.0%, April, in 1976.

When geology-exploration did not study the methane emission. In the mining depth of "+1200m" level, the methane emission may count method of MaKNII.

$$\Gamma = \left\{ \frac{3}{\lg V_\Gamma} + \frac{H - H_o}{\left[0.02(H - H_0) + 0.0015 V_\Gamma^{\ 2.7}\right]} \cdot \frac{K}{\left[1 + \dfrac{11000\alpha}{(H - H_0)\alpha + 5 \cdot 10^4}\right]} \right\} \cdot \frac{100 - A^P - W^P}{100};$$

including,

Г –probable content of coal methane in the studying depth, m^3/ton

H – distance from surface to coal bed of necessary defining content of methane, m

H_0- Surface depth of methane zone, m

V_r – yield of bounce matter for per coal fire section , %

α – the coal bed’s azimuth angle from methane zone mete to studying depth, degree
K – temperature coefficient

$$\kappa = \frac{1.15 + 0.0007H}{1.2}$$

t-temperature of in the “n” depth, degrees
A^p- average content of coal ash, %
W^p- average content of coal operation wet, %

In count choosing those value: H=303, H_0=50m, t=10^0C, A^p=13%, W^p=26%, V_t=45%, α=10^0

$$\Gamma = \left\{\frac{3}{45} + \frac{303-50}{0.02\cdot 253 + 0.0015\cdot 45^{2.7}}\cdot\frac{1.1351}{1+\frac{11000\cdot 10}{(303-50)10+5\cdot 10^4}}\right\}\cdot\frac{100-13-26}{100} = 22\text{м}^3/\text{тн}$$
$$75$$

In previous project, if Nalaikh Mine’s year coal production will be 800.000 tonnages, then the count of methane emission 2.2m/ton*800.000ton=1.760.000m^2. These are indirect measurement and orientation count, therefore, if we will count improvement of methane emission to deep, the amount will be so high.

Basing all these things, we are offering to study coal bed methane emission in the area of Nalaikh Mine, drill research and testing well for purpose producing coal bed methane in possible condition. We are reflecting in project, the drilling well’s minimum depth 300m, maximum depth 500m, diameter of well maximum, but today’s technology and technique condition diameter 150-250mm (fig-4).

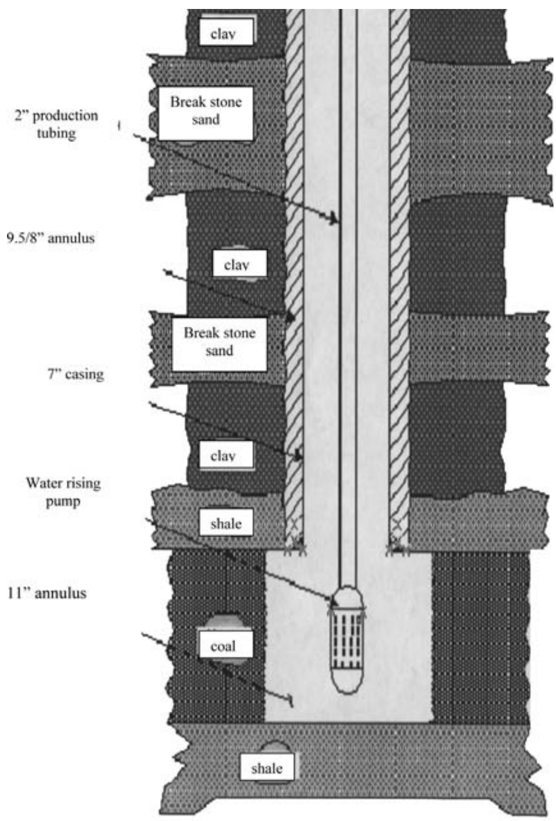
We are planning quickly drill the well and use few equipments of production. Flow rate of underground water indeterminate, therefore, we are planning to install electric centrifugal pump EVTS-6 in the experimental well. We will use 50mm diameter water rising pipe. First will drill in the friable surface formation (15-20m) by 295mm diameters roller cone bit and 3 blade bit, after that will place 273mm casing tube and will cement the well. Then will reach project depth (300-500m) drilling by 244.5 mm diameters 3 blade bit. While drilling the well, will take core samples from any coal bed and will study content of methane using special cylinder. After drill the well we will install pump and impenetrate the well.

The depletion water can use for industry and agriculture. If emission methane we will collect the methane in tank, then will transport to users or bottle in a balloon. If the methane emission high the experimental well can use for production well. This project might finance from Scientific and Technology Fund or companies have interest of this problem.

The methane measurement consequent in several places of Nalaikh coal field (by device LI-4)

Table-1.

Date	Sample taken place	Content of methane, CH_4, %
1982.11.10	In the 263rd air drift	3.1
	Near the bracket	2.8
	Water pump near the bracket	2.7
1982.11.14	550th conveyer drift	6.1
	From 574th junction	7.2
1990.06.20	From 263rd wax	3.8
1990.06.25	263rd conveyer drift	3.9
1991.07.03	Before place 515th bracket	3.1
1991.07.11	From 437th air drift sample pipe	6.4
1992.06.22	Near water in the 45th azimuth	44
	The 45th and 43rd azimuth's cross-road	54
	The 541st conveyer drift	52
1992.06.24	The 541st conveyer drift	8.8
1992.07.16	43rd azimuth	10.2
1992.12.30	From 537th wax and 15th azimuth	2.95
1993.01.16	537th air drift	3.0
1994.04.20	4th mining	5.9
1994.04.21	4th mining bottom	6.8
1994.06.01	35th azimuth	2.9



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COAL CATALYST FOR IMPROVED COMBUSTION AND ENVIRONMENT

Peter Smith, *Asia Coal Catalyst Company*

Abstract: ASIA COAL CATALYST CO. (ACCC) provides combustion catalysts and additives for

use with coal, heavy oils and diesel fuels. These products offer an inexpensive and easy - to - use way to effect more rapid and complete combustion of fossil fuels. Improved combustion efficiencies result is less pollution, improved efficiency (more heat per unit of fuel) and lower equipment maintenance costs.

Our product is a dry powder that can either be injected into the boiler to provide a catalyst “bed” in the combustion chamber, or it can be fed continuously along with the fuel. In the United States it has been widely used in industrial boilers for central heating systems.

China has a large system of coal fired boilers under 100 MWe in size that are currently operating at fairly low combustion efficiencies and with slagging and fouling problems. Both of these problems cause excess amounts of pollution to be emitted into the atmosphere and consume greater quantities of coal than is necessary. With the use of our catalyst, more efficient boilers can be obtained and lower levels of pol-lution can be achieved. Recent laboratory tests on a Chinese coal reveal a 17% improvement in the com-bustion of the carbon contained in the coal.

Our catalyst accelerates the oxidation -reaction of carbon to produce more heat per unit time. It is also an Oxidizing Agent, oxidizing carbon at temperatures lower than normal ignition temperatures to speed combustion and thereby reduces carbon and slag deposits in the colder regions of the boiler. As a Slag Modifier, our catalyst alters slag deposits to a more friable, softer easy to remove deposit that pro¬vides greater heat - transfer and reduces cleaning costs. The catalyst will also acts as a Emission Control Agent that separates sulfur substantially reducing the quantity of sulfur dioxide, a “acid rain” contribu¬tor, in the flue gases. Fly Ass reductions also occur when greater amounts of carbon are combusted re¬ducing the loading to the particulate collection devices.

Our liquid fuel additives include catalysts for fuel oils, especially heavy fuels, and diesel fuels from high sulfur contents to an additive for ultra low sulfur.

Improving coal combustion efficiencies through a simple and cost effective means such as our catalyst will conserve fuel resources, allow longer operation of the small and medium sized boilers and reduce pol¬lution.

1. What is a Catalyst

As we know, combustion is a complex sequence of exothermic chemical reactions between combustible components of fuel and oxygen resulting in the produc¬tion of heat energy.

A catalyst is a compound or element that can in¬crease the rate of a chemical reaction. Catalysts can lower activation energy of a reaction to help a reaction proceed faster and with less energy. CC - 88 is a com-bustion catalyst.

During the coal combustion process, the oxidizing properties in CC -88 promote the increased movement of free radicals. CC -88 helps to promote1 .the physical and chemical reactions that occur during combustion. This releases more oxygen to the carbon contained in the coal, and at lower combustion temperatures than normal. The net effect is to add nothing to the carbon oxygen chemistry, just to speed it up.

2. What does CC —88 accomplish

The use of CC - 88 accomplishes many things within the combustion chamber besides the improved combustion efficiency of the carbon contained within the coal. These include; reducing slagging, lowering fuel feed rates, and reducing the amount of excess air.

By reducing slagging/boiler deposits, boiler downtime is reduced thus reducing the costs of mainte-nance. In addition to the combustion benefits, CC -88 reduces the emissions of many pollutants that contribute to the formation of acid gases, and Global Warming. It also promotes longer life expectancy of equipment, im¬proves the performances of the heat exchanger and particulate collection devices.

Using CC - 88 is also risk - free. We have used CC - 88 in hundreds of boilers without any negative effects to the system.

3. Combustion Chamber

The use of CC - 88 as an improved combustion catalyst by retrofitting existing low combustion efficien¬cy boilers will result in improving the combustion effi¬ciency from 2% to 7% and up to 15% or more depen-ding on the type of coal and boiler furnace firing meth¬od. When improved combustion efficiency occurs, the boiler operator will have the option of either.

1) reducing the coal feed rate by the percentage of improved combustion efficiency while maintaining the same steam production or 2) producing additional steam at the original coal feed rate.

Another combustion zone improvement is the abili¬ty of CC - 88 to remove slagging and maintain a clean¬er operating furnace for improved heat transfer. A light -weight deposit will result that is friable and easily re- moved by steam or blowing air.

Because the catalyst improves the combustion, the use of excess air can be reduced. The amount will de¬pend upon the level of reactivity of the catalyst and the coal being burned. Lower excess air will reduce the formation of NOx emissions as well as reduce the a-mount of flue gases passing through the system, impro¬ving the efficiencies of the heat exchanger and electro¬static precipita

4. Emissions

With the reduction of coal needed to maintain the same steam production, a corresponding reduction in the emission of carbon particles will occur. This reduc¬tion will happen in two areas.

First, the amount of carbon leaving the boiler will be reduced by the improvement in the combustion effi-ciency. Secondly, the resistivity of the ash will be al¬tered favorably resulting in an improvement in the elec¬trostatic precipitator performance.

Hence, less carbon will be leaving the stack by the amount of reduced carbon being produced and by the added efficiency of the collection device. This means a lowering of the black plume and emission of the carbon into the atmosphere.

In addition, a portion of the gaseous emissions will be affected. It is known that using CC - 88 will re¬duce S03, which, often mixes with the moisture in flue gases and produces sulfuric acid. This condition will attack metals in the cold regions of the system such as the air preheater, electrostatic precipitator, breeching, ID fan and stack with a metal corrosion and shorten life expectancy.

With the use of CC - 88 some S02 gases will be converted to a sulfate and precipitate out in the particulate device. This will reduce the emissions of S02 thus reducing the formation of acid gases. The amount of the S02 reduction will depend upon the amount of CC - 88 injected into the boiler. With higher injection rates of CC - 88 , higher levels of S02 can be removed, up to 50% . Also, C02 emissions will be reduced by the amount of the reduction of the coal feed rate. If the feed rate is reduced 15% , the emission of C02 into the atmosphere will be reduced 15% less the C02 pro¬duced from the combustion of the added carbon that is consumed.   All emissions will be affected in this man¬ner.

Asia Coal Catalyst Company will be maintaining its leadership in coal catalyst technology with the de-velopment of new catalysts to address other combustion and environmental issues.

5. How is CC —88 used

I would like to discuss the methods of injection of CC - 88 , the rate of feed, type of appropriate fuels and types of furnaces. (Let slide complete before going on to #7.)

6. Injection Methods — Line Diagram

Coal Catalyst 88 is a dry powdered combustion catalyst (see grey portion of logo) that is mechanically injected into the boiler furnace to create a catalyst “ bed” in the bottom of the combustion chamber.

The catalyst injection system is low - cost and easy to install. For consistent results, CC - 88 is added continuously into the coal feed pipe or into the combus¬tion air pipe or directly into the combustion zone. CC - 88 application methods vary with the method used to fuel the furnace, the size and configuration of the boil¬er, the type of coal and the goals of its use.

7. photos of feed system

The method of transportation can be either dilute phase or via the use of dense phase (low air) trans¬porters as seen here. Feed rates will depend upon; coal type, furnace dynamics, and goals for using the catalyst. Some coals have a propensity to slag boiler tube areas, others have too high a sulfur content, oth¬ers burn inefficiently. Furnace designs vary and (lie use of CC - 88 can be customized to handle most all designs.

Goals may vary from fuel economy, to de -slag¬ging, or reducing certain emissions. Whatever the goal, CC -88 can be utilized. The nominal feed rate for improved combustion efficiency is 1. 1 kg/tonne of coal burned.

8. Types of boiler photos

All types of solid carbon fuels can benefit from the use of CC -88; all types of coal, coal briquettes, wood products, and refuse . Coal briquettes can be impregnated with CC - 88 so they provide the same benefits as coal. This provides safer operation addressing formation of carbon monoxide and provides more or home heating and cooking. It will also reduce the chimney buildup of unburned carbon particles and

All boiler furnaces can benefit although the place-of the catalyst will vary. Stoker fired units will the catalyst spread over the grate or chain grate ;e, usually by dropping the catalyst onto the coal is fed into the furnace while the PC or Fluid Bed is will require the catalyst to be blown in with the combustion air or separately directly into the furnace. Asia Coal Catalist Company.

9. Testing recent laboratory tests have been conducted on a Shaanxi sub - bituminous coal using a Cone Calorimeter Crucible Loss on Ignition (L. 0.1.) Analysis. These test results are summarized on the next slide.

10. Most recent laboratory results

ONE CALORIMETER SUMMARY

The CC -88 treated coal ignites faster, burns efficiently at a lower temperature and with less than the untreated Coal"

CRUCIBLE L. 0.1. Analysis

CC -88 treated coal shows a 75% GREATER HT LOSS, as supported by the Cone Calorimeter which represents a higher efficiency in the oxidation " burning") of the Coal".

The CC - 88 treated coal shows a 50% DE-iSE in the amount of Residual Carbon left in the 38 treated Coal, which represents a lower amount - Oxidized Coal remaining in the Ash due to the r efficiency in the burning process. "

Summary:

'This data shows that when CC - 88 was applied Shaanxi coal it created a faster flame at a lower requirement with less smoke generation and a :r loss of carbon, which appears to improve the content of this coal. "

Full scale demonstrations will be performed on ex-units to help in gaining knowledge of the actions that take place on various Chinese coals and for differ¬ent boiler designs.

Presently, Asia Coal Catalyst Company is desig¬ning a CC - 88 catalyst system for a major US chemical company. The coal fired boiler burns West Virginia strip mined coal containing 12,000 BTU/Hr, < 2% S, 115,000 Ib/hr steam in a PC boiler. The unit is experiencing severe slagging problems and has a very high L. 0.1. which indicates an incomplete combustion problem.

11. Benefits

The following slides; Environmental Benefits, Fu¬el Savings, Monetary Savings will take us through the different aspects of using CC - 88 and how they con¬tribute to a positive Return On Investment.

12. Environmental

Our cc - 88 Coal Catalyst Minimizes Pollution

Coal is expected to be the main source of electrici¬ty until the year 2025. China, India, and the other A-sian countries recognize an immediate need to clean up their coal - fired power plants and the millions of facto-ries that burn coal, to prevent pollution levels soaring to unacceptable levels both at home and around the globe.

Coal burning plants will need to reduce emissions more efficiently, especially for those plants established in the 1970's, 80's and 90's and even some of those presently being con-structed based on 25 year old tech-nologies. Unfortunately, these older plants still release gases and solids that cause smog, acid rain, lung dis¬ease and mercury poisoning. They also produce be¬tween 30 and 40 percent of the world s carbon dioxide and sulfur dioxide emissions, a leading cause of global climate change.

Industries using coal - fired furnaces, coal and oil - fired boilers, diesel engines, coal pellets and bri¬quettes have used CC - 88 to minimize harmful emis¬sions. With only a minimal installation cost, CC -88 Coal Catalyst best reduces pollution emitted by facto¬ries , especially in the utility and industrial boilers used at steel mills, chemical manufacturing and concrete / cement industries.

By optimizing combustion efficiency and reducing the amount of coal or oil needed to produce steam, CC-88 minimizes the output of C02 , S02, S03, NOx,

and harmful particulate emissions such as carbon. The catalyst is completely con-sumed by the combustion process.

As an emission - control medium, CC - 88 se¬questers sulfur, minimizing the quan-tity of sulfur diox-ide in the flue gas. It also minimizes the carbon carry over that normally provides " seeding" of fly ash particles, thereby decreasing particulate emissions (carbon). Without exception, Asia Coal Catalyst helps us¬ers to best improve environmental stan-dards and achieve the most efficient utilization of coal resources.

This compound is the optimal solution for environmen¬tal problems related to pollutant emissions and green house gas emissions from coal usage in existing boilers.

Reducing emissions will save money for expensive emission control equipment capital investments, and operating expenses as well as any potential emission penalties.

13. Fuel Savings

CC -88 provides the lowest cost and money - sav¬ing method to burn raw coal in the cleanest and most cost effective method. Our product improves boiler effi¬ciency through optimal combustion and maximal heat transfer. Significant return on investment is achieved by utilizing all available carbon in the fuel. This will allow older boilers that were, perhaps shut down be¬cause of low combustion efficiency and high emissions, to be operated more efficiently and reduce the capital cost of adding expensive new systems. In addition, by permitting the use of higher sulfur bearing fuels, up to the capability of the catalyst removal, you can reduce the need for costly gas - scrubbing equipment, the lead time for installation of the gas scrubbers and realize the lower cost of higher sulfur coals.

14. Monetary savings

For a typical 50,000 kg/hr steam producing boiler burning 40,000 tonnes of coal per year, and obtaining a modest 3% improvement in combustion efficiency u-sing CC - 88, you can expect a net fuel savings alone of approximately $ 50 ,000 USD per year.

In the case of a potential 15% improvement in combustion efficiency, this same boiler will yield a net fuel savings of approximately $ 250, 000 USD per year.

In most cases, a combustion efficiency improve¬ment of 2% will pay for the combustion catalyst. Once the catalyst is paid for, additional savings can be real¬ized as profits.

15. ROI - Return on Investment

In computing your Return on Investment, the fuel savings would be added to the cost savings of; fewer shut - downs for maintenance, reduced losses due to metal corrosion, lower need to purchase power during the downtime, reduced ash disposal and emissions, may eliminate the need for purchase of S02 scrubbers, etc.

In summary, applying CC - 88 will increase effi¬ciencies thereby increasing your profits.

If you would like to discuss our technology, or if you are interested in any cooperating opportunities, business partnerships, or purchasing CC - 88, please visit us at our booth #3A at the Expo Center.

Thank you again for this opportunity and we look forward to working with Government Officials, coal suppliers, boiler owners and operators, and the Chi¬nese people, in Helping to Green the World.

16. Questions and Answers

We would be pleased to answer any of your ques¬tions at the end of this session.

COAL MINE METHANE OPPORTUNITIES: PARTNERING FOR SUCCESS

Robert.S Kripowicz: *Milestone Consulting, LLC*

Abstract

Coal mine methane (CMM) recovery and utilization activities are widespread and increasing rapidly. There are a wide range of technologies applicable to CMM from power generation or upgrading of the CMM to pipeline quality gas, as well as uses such as heating or simply flaring. Milestone Consulting, LLC (Milestone) , CMM Energy, LLC (CMME) , and the Energy and Environmental Technology Center of Tulane University (EETC) have established a comprehensive partnership (consortium) to develop CMM resources. This concept is unique in providing an instrument bringing all the essential elements of a successful project under *a* single umbrella organization.

The Consortium concept brings the technology expert (CMME) and an expert in Chinese government and industry relations (EETC) with an integrating company (Milestone) respected in industry and governmental venues in both the US and China. The consortium forms a partnership with a Chinese coal mine company to examine the feasibility of, and commercially implement, viable CMM projects, utilizing the optimal equipment for the project, with consultation with extraction specialists and resources assessment specialists. The applicability to the Clean Development Mechanism (COM) of the Kyoto Protocol is closely examined in this process, as well as other carbon credit markets, including the sale of *Voluntary* Emissions Reductions (VER) . The Consortium is in the forefront of using these VER markets for Chinese projects. These can provide supplementary sources of income for CMM projects and will not affect the potential revenues from the COM approach. Project financing is also identified by the members of the consortium from both Chinese and external sources.

Pre - project activities include; site visits; data gathering; prefeasibility/feasibility studies; and equipment specification.

Project activities include; CDM applicability; VER applicability; project financing; and commercial development.

Data required from the coal mine for analyses includes the following categories; coal characteristics; mining activity and plans; air shaft locations; methane drainage systems and quantities; and methane utilization.

Upon completion of technical and financial analyses, if the project was shown to be feasible, financing is obtained and project activity begins.

I. Introduction

I Milestone Consulting, LLC (Milestone), CMM Energy, LLC (CMME) , and the Energy and Environmental Technology Center of Tulane University (EETC) we established a comprehensive partnership (Consortium) to develop Coal Mine Methane (CMM) resources in China. The Consortium is unique in bringing all the essential elements of a successful project into a single organization. Such a “one -stop” organization allows for a smoother, more responsive, and faster reaction to all the elements necessary to complete a CMM project. The Consortium offers services from concept, feasibility work, and technology identification through financing and actual project construction and operation. The Consortium also coordinates the preparation of documentation for, and sale of, Certified E-missions Reductions (CER) for the Clean Development Mechanism (CDM) of the Kyoto Protocol, and of Voluntary Emissions Reductions (VER) for sale on voluntary carbon exchanges.

The Consortium brings together the foremost technology expert in the USA (CMME) ; an expert in Chinese government and industry relations, and cooperation between the US and China (EETC) ; and an integrating company respected for long experience at an executive level in both industry and government venues in both the US and China (Milestone). The Consortium will partner with Chinese coal mine companies to examine the feasibility of, and commercially implement , viable CMM projects, utilizing optimal equipment for the project developed in conjunction with extraction specialists and resource assessment experts. As an integral part of each project the Consortium examines the applicability of the Clean Development Mechanism of the Kyoto Protocol as well as other carbon credit markets. Project financing is also identified by the Consortium from both Chinese and external sources, and business arrangements include Joint Ventures to carry out such projects.

One of the unique capabilities of this Consortium is its development of the VER markets for Chinese projects. Even if a coal company has started the CDM process, these VER markets may provide quicker revenue for the credits until the CDM registration process is completed. The VER markets may also provide revenue for some credits that are rejected by the CDM Executive Board (CDM EB).

2. Identification of Potential Projects

CMM can be captured and utilized for a variety of applications depending on the quality and volume of CMM emissions and the available opportunities to utilize the captured gas in an economic manner. Most commonly CMM can be used in power generation equipment either to offset existing power requirements or for sale to local utilities; such generation is commonly produced by either internal combustion engines or gas turbines, although fuel cell use has been determined to be technically feasible (but not economically viable). Higher quality CMM can be upgraded to pipeline quality gas or compressed or converted and transported a= Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG) . Finally such gas may be used for its heating value locally in mining operations or nearby towns,

The Consortium has developed detailed questionnaires to assess, on a preliminary basis, the reasonableness of proceeding with detailed studies of CMM utilization at specific mines. For a small effort mining companies may have the Consortium determine whether it is worthwhile to proceed with detailed feasibility work to determine whether CMM can be developed on an economic basis. The basic information necessary includes coal characteristics and the methane content of the coal, the extent of mining activity and the amount of coal production, mine plans, methane drainage systems and amounts and concentrations of methane vented , and current or planned methane utilization. Often the amount of data available, even on a preliminary In-sis, is sufficient to make an assessment that commercial development is likely to he feasible.

Once the Consortium has received basic data and determines that further study is warranted, site visits are then undertaken to confirm and expand on the data available, to ascertain local market and government regulatory conditions, and to establish the degree of interest that the coal company has in participating in a CMM project. Depending on the amount and quality of the data originally received from the coal company it is sometimes possible to bring potential investors in n project or its emission reduction credits to the site simultaneously with the data gathering phase.

Soon after the initial site visit pre - feasibility and feasibility studies need to he undertaken. This phase involves a significant expenditure of funds and at this point preliminary financing needs to be obtained. The coal company and the Consortium determine the of funds at this stage. Outside financing is a viable option at this point provided that the investor has assurances of the ability to participate in the management, financing, revenues and carbon credits of any ensuing project.

The feasibility study will be undertaken by the Consortium with the aid of selected experts as in ry. A feasibility study will normally include site selection, detailed project design, specification of equipment and cost estimates for construction and operation. The study will also identify and quantify both the size and financial potential of immediate markets. This information is utilized for a detailed economic analysis for the specific site delineating the needed investments and the time, size and profits expected to be derived by a successful project. Integral to this analysis is inclusion of an analysis of the sale of certified emission reduction (CER) credits as part of the Clean Development Mechanism (CDM) of the Kyoto Protocol or on other markets as voluntary emission reduction (VER) credits. The value of these emission reduction credits significantly enhances the financial return of CMM projects compared to prior to the existence of such mechanism.

Depending on the amount and quality of the data and the activity that the coal company has already undertaken, this phase of a project will take from six months to a year to complete. At the end of this part of the process the organization of the project and the necessary investment need to be completed. Various organizational structures are viable, including joint ventures with outside partners, and investors are available both within China as well as externally, depending on the wishes of the coal company. The sooner such decisions are made in the process the more quickly the project can proceed. Often it is possible to determine this structure while the feasibility studies are underway. Upon completion of the organizational and investment phase construction of the project can proceed and typically can take from nine months to a year.

3. Emession Reduction Credits

The most important new aspect of CMM activity is the availability of emission credits for greenhouse gases. Although most are aware of their existence, the procedures and work necessary to successfully obtain such credits are considerable and time consuming. Consideration of Certified Emission Reduction (CER) credits needs to be made at the outset of activity involved in studying the feasibility of moving forward with I a CMM project. Often approval for projects that are submitted to the United Nations process for obtaining a certification of such credits lags long after investments are made. The process for applying for and receiving approval of, CER credits is very structured and time consuming. Detailed documentation, called a Project Design Document (PDD), must be prepared, then reviewed by a Designated Operational Entity (DOE) and approved by the CDM Executive Board (CDM EB). Central to this process is the concept of “Additionally” which defined simply is the conclusion that the project being submitted for CER credits would not have gone forward unless the CDM existed - that it is “ ADDITIONAL” to what would normally be done. Because of this requirement many projects often are ready for implementation well before formal approval can be obtained for the credits from the UN.

The Consortium has found that although there are also “ additionality “ requirements in voluntary markets, the approval process is expedited relative to the UN process. In cases where UN approval has not been obtained, voluntary credits, or VER, can be sold until UN approval is obtained. These credits can also be sold retroactively, which is not a feature of the UN process. Because these credits are not formally part of the Kyoto process the monetary value of VER is considerably less than CER. Nevertheless VER provide a potential source of revenue to projects until the CER are registered with the CDM EB. There may even be some VER available for sale in parallel with CER. If the coal mine uses gas that contains less than 30% methane, it is technically violating Chinese coal mine safety regulations. The UNEB will not approve credits associated with this type of gas. The VER markets are not as stringent and will generally accept the VER from use of such gas streams. So the VER markets provide the potential for earlier revenue than CER markets, retroactive credits from activities before validation, and (3) additional credit revenue from sources that the CDM EB would not accept.

The Consortium is involved in both the UN and voluntary markets, and CMME is a registered member of the Chicago Climate Exchange (CCX) in America. CCX is the largest formal market for VER in the world.

4. Project Experience

The Consortium currently is part of a Joint Venture with Hebi Coal Industry Group Company, Ltd. The Joint Venture, Hebi Zhongyuan Sakel Science and Technology Company, Ltd (Sakelcn) , was formed in early 2008 to exploit the methane resources of the Hebi Coal Group. Currently the Joint Venture is continuing the UN CDM process while examining the possibility of selling VER on the Chicago Climate Exchange. In addition, a US Environmental Protection Agency (USE-PA) contractor is preparing a feasibility study on the further utilization of methane resources above those already being used by Hebi.

5. Summary

CMM projects in China are of interest to both the coal mining industry and potential outside investors because the economics of such projects has been enhanced by the ability to sell emission reduction credits as part of the Kyoto protocol, as well as on voluntary carbon markets such as the Chicago Climate Exchange and others. The Consortium has been formed to integrate all the necessary activities in a single entity with extensive experience in CMM technology and markets, significant business acumen, and vast international experience , with a particular emphasis on China. The business model established by the Consortium can react quickly to many circumstances and provide all the services necessary to achieve a successful CMM project.

COAL MINE METHANE UTILIZATION OPTIONS AND A NEW REVENUE SOURCE FOR PROJECT DEVELOPMENT

Peet Soot: *CMM Energy LLCLake Oswego, OR 97035 USA*

Abstract Coal mine methane (CMM) utilization activities have been accelerating over the last 20 years. The applicable technologies range from power generation and pipeline delivery of the CMM to uses such as combustion for thermal heating or simply flaring to mitigate man - made emissions of methane into the atmosphere.

CMM Energy LLC (CMME) staff has design and operating experience with the following technologies over the last three decades, which are described in this presentation;

- Electricity generation fueled with CMM, including projects with internal combustion engines micro **-** turbines fuel cells
- Processing and delivery of methane to a natural gas pipeline
- Direct combustion of methane for mine air heating
- Replacement of propane use at a mine with CMM
- Flaring of CMM to generate carbon offset (greenhouse gas) credits

The Company is involved with the following additional technologies that are currently being considered for application at mines;

- Compression of methane to produce compressed natural gas (GNG)
- Conversion of CMM to liquefied natural gas (LNG)

Financing these projects is made easier with the availability of carbon emission credits. These credits can generate positive cash flows or create an incentive for carbon funds to provide capital for implementing the projects. The credits can take the form of certified emission reduction (CER) or voluntary emission reduction (VER) credits. The CER result from the Kyoto Protocol as administered by the UNFCCC. The VER markets are primarily in the USA, where the Kyoto Protocol is not applicable. VER have not previously been defined at Chinese CMM projects. CMM Energy is currently developing the first such project at the Hebi Coal Group Mines in Henan Province, This creates a new opportunity for additional revenue that will not affect the potential sales of CER from a CMM project.

CMM Energy can evaluate a Chinese coal company's CMM project and provide technical recommendations as well as an assessment of the VER sales potential from the project.

1. Introduction

CMM Energy LLC (CMME) staff has been studying and developing coalbed methane (CBM) and coal mine methane (CMM) for nearly three decades. This work has included both commercial projects as well as technology R&D. It has also included development of markets for the carbon emission credits associated with CMM projects.

Demonstrated utilization technologies have ranged from demonstration of three different power generation prime movers, gas processing and delivery to pipeline, direct combustion for mine air heating and flaring of the gas to mitigate greenhouse gas emissions. CMME lias also performed researched on the use of abandoned underground coal mines for concentrating C02 emissions from power plants.

2. Power Generation

In *the USA, the* geographic areas where coal resources exist are generally also areas with coal - fired power plants. That is an economic benefit for the local region, but creates a challenge for new power plants fueled by CMM. One must have a very low capital cost. Even though the CMM may be virtually free, the capital cost of new power generation makes it difficult lo justify in such areas. In considering these cost elements of power generation, one needs to be innovative in order to develop economically viable power genera-ling projects.

In its early power generation projects, CMME staff performed a market survey and found the survey to be helpful in establishing the size for prospective CMM generating units. It became evident that there would be a limited market for large (> 10 MW) power plants u-sing CMM as fuel in the US. There were two examples of large CMM power plants in the world. In Australia, 94 MW of generating capacity were installed at the Ap-pin and Tower Collieries. In Buchanan County, Virginia, Consolidation Coal Company was operating an 88 MW peaking plant. Now in China there is a project with more than 100 MW of capacity being installed. Unlike these projects, most coal mines in the US do not have the capacity of producing enough methane for such large installations. Even at the Australian opera-lion, natural gas is used to supplement the available coal mine methane. This approach would not be economic in most cases.

The same situation applies at abandoned under-j pound mines. Such mines do not emit as much methane as they did while coal mining was active, hence the power generating potential is even less. The power . generating potential will be 1 to 3 MW at even the gassiest abandoned mines. That meant that CMME should develop a generating plant module that would be capable of producing about 1 MW.

2.1. Internal Combustion (1C) Engines

As a result of the market evaluation, CMME decided to work with Northwest Fuel Development, Inc. (NW Fuel) to develop a small internal combustion (1C) engine as the prime mover. The generating equipment was developed based on more than a decade of R&D. The basic module is an engine/generator skid package that can produce 75 kW of electricity as shown in Exhibit I. The first units built operated 8,000 to 10,000 hours before requiring significant maintenance, i. e. valve replacement. The complete engines were replaced after about 20,000 hours of operation. The latest gensets have significantly improved on these benchmarks as the valve replacement is now at over 12,000 hours and some engines are lasting over 30,000 hours before needing new cam shafts.

Tile small size of the units flies in the face of the conventional wisdom of “ economies

Exhibit 1. Engine Drive for Single Generator

of scale" . The advantage that small equipment has is the economies of mass production. The production levels of the engines are orders of magnitude greater than the industrial engines that are typically considered for power generation options at coal mines. The modular skids have a lower total price than comparable generating units based on *indusiria) rngines.*

Multiple units have been installed at two locations at the Nelms Mines in Ohio and at one location at the Federal No. 2 Mine in West Virginia. The West Virginia location is host for 18 engines with a total capacity of 1.2 MW. One of the Ohio sites has had as many as 14 units operating, see Exhibit 2.

Exhibit 2. Gensets at Nelms Mine

Even though these options were developed for USA applications, CMME evaluates each opportunity individually. In most Chinese coal mines it is apparent that u-sing domestically manufactured Shendong generators is likely the best way to produce electricity.

2.2 Gas Turbines

Gas turbines are another way of using CMM for power generations. The 1 to 3 MW turbines may not be cost competitive with internal combustion engines since they cost nearly $ 800/kW for just the bare equipment. But, if there is enough CMM to fuel a 5 to 8 MW gas turbine, the capital cost of the equipment drops to about $ 600/kW. Even adding the cost of compressors to raise the fuel gas pressure to deliver it to a gas turbine, the total plant investment for a gas turbine system is competitive with commercial 1C engines. That is the situation in the USA. It may not he the case in China.

The one aspect of gas turbines that are superior to 1C engines is the potential for such prime movers to use the methane emitted from mine air shafts as the combustion air in (he turbine. That would combust the extremely dilute methane in the mine ventilation air. The reason that the gas turbine has an advantage is the stoichiometric ratio of fuel to air in the respective prime movers. Gas turbines typically burn 4% methane in air within the combustion canister. 1C engines require much higher concentrations of methane in air mixtures, nominally 8 - 10% methane. Given the 1% , or less, methane in mine ventilation air, it is obvious that gas turbines can offset a larger fraction of the fuel requirement by using the mine ventilation air as **combustion air.**

GMME has physically demonstrated the concept «f I using mine ventilation air as the comhustion air in a turbine. The test showed the displacement of conventional fuel by the methane in the combustion air as the fuel controller automatically reduced the amount of conventional fuel delivered to the combustion canister while maintaining a constant output from the generator,

CMME also has direct experience with tin used micro - turbines for power generation using CMM as the fuel. This approach was applied in Japan. Sumitomo Coal Company invited CMME staff to help them d up such units at their sealed Akabira Mine on Hokkaido Island in Japan, as seen in Exhibit 3. CMME evaluated the CMM resource at that Mine and fabricated the fuel supply compressor that provided CMM to tilt pictured micro turbines.

Exhibit 3. Micro Turbines - Japan

2.3 Fuel Cells

Fuel Cell Energy (FCE) of Stamford, CT installed and operated a demonstration fuel cell at the Rose Valley (sealed) Shaft of the Nelms No. 2 Mine in Ohio. This $ 6 MM project was co - funded by FCE and the US Department of Energy. The fuel cell *used* CMM from the Nelms 2 Mine and delivered electric power to the utility grid. The unit was installed in May, 2003 and operated successfully until early 20W.

3. Cmm Delivery to Natural gas Pipelines

With recent high natural gas prices, it is often more profitable to deliver CMM to pipeline than to burn the gas for power generation in the US. This is the case even if the gas must be processed to bring it to pipeline quality standards. Most pipeline companies in the US require that delivered gas have less than 4% inert components and that water be less than 0. 1 g per cubic meter (m). CMM normally contains $C0_2$, N_a, and water that would not meet these specifications. The $C0_2$ plus N_2 must be reduced to less than 4% of the total gas stream. Ninety - nine percent (99%) of the water must be removed since the gas coming from an underground mine typically contains 10 g / m .

Neither the $C0_2$ removal, nor dehydration, is particularly difficult. One can install an amine scrubbing system to remove virtually all the $C0_2$ in any gas stream. And, glycol scrubbing equipment is commercially available to remove the water from the CMM.

Another significant consideration is oxygen (0_2). If there is 0_2 present in the CMM, which is often the case, then one may have to add an oxygen removal system.

Nitrogen rejection is not as easy as $C0_2$ or water removal. Cryogenic processing can separate the N2 from methane, but such plants need to be very large in order to be economically attractive. Smaller scale CMM production (20 m /min of CH_4 or less) requires the use of a different process - pressure swing adsorption (PSA). Commercial PSA systems have finally become available through Engelhard, NW Fuel and Nitro-tech.

4. Direct Combustion Applications

Recent interest in global climate change has provided the motivation to add another technology to the list of CMM utilization options - flaring. CH_4 is about 7.6 times as potent as $C0_2$ on a volumetric basis. That means that every cubic meter of CH_4 that one can burn would reduce $C0_2$ -equivalent ($C0_2e$) greenhouse gas emissions by a net value of 6. 6 cubic meters. (Note: Many people publicize that methane is over 20 times as potent as $C0_2$ but that is on a weight basis. Since few people in industry measure gases by weight, that is a useless number.)

In reflection of that desire to limit methane emissions , CMME has developed flares to burn the methane in CMM so it is not emitted into the atmosphere. After R&D was performed several units were then fabricated for "commercial" application (i. e. to produce carbon offset credits) and have been operated at the Nelms No. 2 Mine - see Exhibit 4.

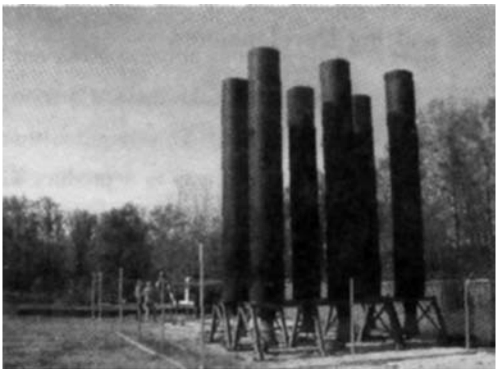

Exhibit 4. Main North Shaft Flares

The flare burner design was subsequently modified for application as an air heater at an active coal mine in the US. Coal mines in cold climates have problems in the winter with the mine inlet air arriving in the underground workings at extremely low temperatures. CMME s heaters are now in operation at a mine in Colorado, USA. They are producing the desired amount of heat for the mine inlet air heating while meeting safety guidelines for carbon monoxide (CO) concentrations inside the mine. Four heaters were installed. Each one can produce 35 BJ/hr (35 x 109 Joules/hour). One of the heaters is shown in Exhibit 5.

Exhibit 5. Coal Mine Air Heater

Many coal mines use propane as a fuel for space heating or water heating. CMME is currently working at an active coal mine to install a CMM pipeline and modify combustion equipment to accommodate CMM. Once the conversion is complete, the mine will be able to save about $400,000 per year in propane costs.

5. Cng and Ing Developments

Options are available to make the CMM transportable or usable for vehicle fuel. This requires that the CMM be modified from a light gas to a product with a much higher energy density. This can be accomplished by compressing the gas to very high pressures to produce a compressed natural gas (CNG) or by cryogenically producing a liquid natural gas (LNG).

We are developing the CNG application at a project in India, where the CNG will be used as a fuel in coal mining trucks. The diesel truck engines will be converted to bi - fuel capability. Some diesel will be needed to provide the basis for igniting the CMM in the engine , but most of the fuel requirement will be met by the CMM.

CMME has also been involved in a project that produces LNG from CMM. Appalachian Pacific (AP) was working under an US DOE contract to demonstrate this application for CMM and CMME staff provided critical consulting services.

6. Carbon Emission Credits

A very important part of CMM project development is the carbon emission credits that are generated by the capture of methane. These can take the form of certified emission reduction (CER) or voluntary emission reduction (VER) credits. The CER require approval by the UNFCCC under their administration of the Kyoto Protocol. There is no single organization that approves VER. The potential purchasers establish the specifications under which they will buy the VER.

The VER provide an easier and faster method for creating revenue than CER. Some CMM projects in China have been trying to get CER registered with the UNECCC Executive Board (EB) for several years -without success. The typical VER project can move from project identification, through verification, to sales and actual revenue within a few months.

Aside from the speed of sales, VER have other characteristics that make them better than CER. They can be retroactive. That means that VER are available for methane capture that occurred before the approval by CCX. One can go back as far as operations during 2003 to define VER. That means that credits that have been generated (luring the CER approval process can] be sold as VER. The VER can also be defined f« I credits that the UNFCCC may reject. Coal companies in China have found out that any CMM that they us which has a methane concentration below 30% will not be validated by the UNFCCC DOE. That is not the case for VER. VER credits can be attributed to any methane capture.

There are two major markets for VER; exchange] and over - the - counter (OTC). The largest VER exchange in the US, and the world, is the Chicago Climate Exchange (CCX). CCX trades on a daily basis and has been setting records in the volumes of their trades. CCX trades the VER as Carbon Financial Instrument (R) (CFI(R)) contracts.

The OTC market is also significant, but one must find individual buyers. The possibilities are numerous, There are many, many carbon broker companies who will try to arrange for sale of VER from projects to potential buyers. Most often, the buyers are companies who desire to show their commitment to environmental issues. The difficulty with the OTC market is that a VER buyer seldom knows for sure if they can have their VER sold until after they make a commitment with the carbon broker. There have been instances where a VER buyer signs a contract and is tied up for a year before they find out that the carbon broker is unable to find a buyer for their VER. That has lost the VER seller considerable flexibility in the sale of their VER and required them to find another broker WIN j might he more successful.

One should think of VER AND CER as complementary markets, not competitive or exclusionary. The CER are currently selling at prices that are about 10 times the VER prices so it is in the best interest of the! coal company to try to sell the credits as CER. The VER should be considered as a help in creating revenue from credits that can not be sold as CER.

A coal company in China should look at VER as A quick and responsive market An easy source of new revenue A potential for credits that are not accepted by UNFCCC / CDM

CMM Energy and our US/China VER Consortium is working closely with CCX to expand the VER market for coal companies in China. It will only take a simple inquiry CMM energy by the coal company to get a review of the potential for VER in their projects. This will not affect the CER potential from their projects but will provide a new source of revenue that had not previously been defined. During the review process, CMM Energy will also provide its considerable experience in the CMM technologies described above to possibly expand the CMM projects and provide even more methane capture and utilization, along with the associated increase in CER and VER sales.

My associate, Mr. Kripowicz, has provided more information on this option earlier today.

PRE-FEASIBILITY STUDY ON REPLACEMENT OF OLD COAL-FIRED BOILER IN ULAANBAATAR WITH NEW GAS-FIRED BOILERS OF EQUIVALENT CAPACITY

Prof. B. Namkhainyam: *Mongolian University of Science and Technology*
Dr. M. Badarch: *Mongolian Nature and Environmental Consortuium*

The main goal of the pre-feasibility study is to conduct an economic analysis of the cost of replacing old coal fired hot-water boilers in Ulaanbaatar with new gas fired boilers.

The overall objective of the study is to develop a project proposal for the Ministry of Fuel and Energy of Mongolia on increasing efficiency and reducing coal consumption of boiler houses for the reduction of air pollution in the capital city of Mongolia, to reduce green house gas emissions, improve working conditions for laborers, and create an environment for people. The project's main goals will be achieved through the following steps:

1. Proposing major technical solutions aimed at meeting the future heating demands of consumers of Ulaanbaatar.
2. Determining investment costs of the project;
3. Determining the economic and financial effectiveness of the project.

Savings generated by using the new heating systems will enable Mongolia to build-up the financial capability for further replacement of old hot-water boilers with new boilers that contain water treatment units that allow it to be operable for the long term.

Number of replaced boilers:	50
Total heat capacity:	24.0 MW
Project lifespan:	10 years
Total investment cost:	US$1.03 million

The results of analytical calculations of the project are as follows:

"PRE-FEASIBILITY STUDY OF OLD COAL-FIRIED BOILER REPLACEMENT IN ULAANBAATAR BY NEW GAS-FIRED BOILERS WITH EQUIVALENT CAPACITY"

Table: 1. Alternative A

N	Indicators	50 old coal- fired hot-water boilers	50 new gas- fired hot-water boilers	Reduction, saving
1	Heat consumption, Gcal/year	40850.0	40850.0	-
2	Fuel consumption, ton/year	30345.0	4020.0	-
3	GHG emission, ton/ year	42484.0	11853.6	- 30630.4
4	Reduced GHG emission cost, U$/ year	-	-	30630.4*10=306304.0
5	Fuel cost, U$/ year	30345*20=606900.0	4020*220=884400.0	+277500.0
6	Heat price, U$/ Gcal	21.8	22.6	+0.8

Table: 2. Alternative B

N	Indicators	50 old coal- fired hot-water boilers	50 new gas- fired hot-water boilers	Reduction, saving
1	Heat consumption, Gcal/year	40850.0	40850.0	-
2	Fuel consumption, ton/year	30345.0	4020.0	-
3	GHG emission, ton/ year	42484.0	11853.6	- 30630.4
4	Reduced GHG emission cost, U$/ year	-	-	30630.4*10=306304.0
5	Fuel cost, U$/ year	40850.0*20=606900.0	4020*170=683400.0	=+76200.0
6	Heat price, U$/ Gcal	21.8	22.2	+0.4

The project will be put into operation in 2006 and will end in 2015. Total investment cost is US$ 1.03 million, equivalent to 1.256.6 million MNT.

Emission reduction prediction:

- CO_2: 306310. t/year in 10 years

Financial indicators of the project:

Table: 3. Alternative A

1	NPV	0.1
2	B/C	0.15
3	Payback time	8.5 year

Table: 4. Alternative B

1	NPV	2.58
2	B/C	0.37
3	Payback time	2.2

2. Introduction

The objectives of the project are to increase efficiency and reduce coal consumption of boiler houses for the reduction of air pollution in the capital city of Mongolia, reduce green house gas emission, improve the working conditions for laborers, and create a cleaner environment for people.

The project consists of the following stages:

- Preparation of FS report, submission for approval
- Preparation of technical design, bidding documents
- Implementation of the project

The project was started in November 2004 and completed February 2005. This work was done by the NTE for the PREGA Project with support of researchers from Technical University of Mongolia.

3. Background Information:

The production and use of energy generates pollution, which has negative impacts to both the environment and public health. Reducing the use of coal fuel will help preserve the environment and improve air quality which ultimately will reduce the impact to human health.

The Mongolian Government has developed and endorsed the LPG utilization action programme and it is now being implemented. Part of the programme includes tax exemptions for any gas products that are purchased. The government is also actively encouraging and providing support for gas exploration within the Mongolian territory. There are currently two exploration projects that have commenced, one of which is located close to Ulaanbaatar and has shown some early positive results.

At present, two organizations within the private sector are working on changing the fuel of vehicles to gas. This exercise will assist in reducing the harmful health effects of vehicle emissions. Currently, 1 in 3 people in Ulaanbaatar are infected with Tuberculosis and a large portion of people have respiratory diseases of some kind. The aim of the conversion of vehicle fuel to gas is to reduce the health problems and the levels of air pollution in the city, particularly in the winter time. Another goal of the government is to increase the use of LPG in different sectors also. This may not seem economically important, but it is definitely very socially important.

On the other hand, impacts of the industrial centers on the environment have been increasing because many types of industry are congregated in limited areas.

The Mongolian Government has taken several measures to study the impacts of industrialization on the environment and for the development of remediation methods to mitigate the negative impacts.

Coal is the main source of energy production in Mongolia. The General Energy System generates 93-95 % of the public electricity by burning coal, with the remainder of the energy supply being produced using diesel.

During the winter time, larger thermal power plants provide 76-77 % of the total heating load of all consumed in Ulaanbaatar and the small capacity hot water boilers serve the remianing 23-24 % of heat provided by the city.

One of the peculiarities of the Mongolian climate is that, in winter it gets very cold, and the persistent temperature inversion dramatically increases air pollution. In particular, concentrations of PM, SOx, and NOx in the air of Ulaanbaatar exceed permissible levels. The main sources of pollution include emissions from thermal power plants, motor vehicle emissions, dust from bare surfaces, and smoke from small boiler houses and individual wood and coal burning Ger stoves.

Coal combustion causes the emission of PM, SOx, NOx, and over 3 million tons of CO_2 a year in Ulaanbaatar. It constitutes about 53 % of the total national emissions. As of 2001 there are over 400 boiler houses with more than 1600 small capacity hot-water boilers (0.38-0.8 MW) operating in Mongolia. 300 of these hot-water boilers operate for heating and hot water supply for consumers in Ulaanbaatar. These boilers are a very outdated low efficiency design, and usually provide heating for schools, hospitals, kindergartens and other public and private institutions in different areas of Ulaanbaatar.

About 40% of these hot water boilers are located in Bayanzurkh district and 32% are in Khan-Uul district. 41% or most of these boilers are of type HP-18, and about 27% are of type BZUI-100. The heat capacity of boiler BZUI-100 is 0.81 MW, and of HP-18-54 it is 0.4 MW.

Uncomplete combustion occurs regularly in the operation of most of the small capacity hot-water boilers, due to faulty design rather than due to the composition and quality of the coal. The coal consumption of these small capacity hot-water boilers is high because of their low efficiency, between 40-55 %. Annually, average coal consumption of one hot water boiler of type BZUI-100 is over 1000 tons, and for HP-18-54 it is 630 tons.

These small capacity boilers are one of the main sources of GHG emissions and urban environmental pollution. At present, the Boiler houses Exploitation centre of Ulaanbaatar has 50 small capacity hot-water boilers.

Installed capacity and heat load of existing Boiler houses of the Boiler houses Exploitation centre in Ulaanbaatar

Table 3.1.

¹	Boiler houses	Location	Boiler		Year	Installed capacity, MW	Heat load, MW
			Type	Number			
1	Boiler house ¹ 1	Songinokhairhan district Khoroo ¹ 11	BZUI-100 NR-18-54	2 2	1995	2.65	0.9
2	Boiler house ¹ 2	Sukhbaatar district Khoroo ¹ 14	NR-18-54 NR-18-54	1 1	1986 2001	0.9	0.63
3	Boiler house ¹ 9	Songinokhairhan district Khoroo ¹ 6	DTH-1.4 DTH-0.7	2 2	2001	4.9	5.9
4	Boiler house ¹ 10	Bayanzyrkh district Khoroo ¹ 12	Í Ð-18-54	2	2002	0.9	0.34
5	Boiler house ¹ 11	Bayanzyrkh district Khoroo ¹ 10	China	2	2002	0.9	0.43
6	Boiler house ¹ 14	Khan–Uul district Khoroo ¹ 13	NR-18-60	2	2000	0.9	2.1
7	Boiler house ¹ 15	Bayanzyrkh district Khoroo ¹ 8	NR-18-54	2	2002	0.9	0.42
8	Boiler house ¹ 16	Bayanzyrkh district Khoroo ¹ 21	BZUI-100	4	1987	3.35	1.1
9	Boiler house ¹ 18	Khan–Uul district Khoroo ¹ 7	NR-18-54	2	1975	0.9	0.89
10	Boiler house ¹ 19	Khan–Uul district Khoroo ¹ 7	BZUI-100	2	2001	1.77	0.98
11	Boiler house ¹ 20	Khan–Uul district Khoroo ¹ 5	BZUI-100 NR-18-54	1 1	1994 1997	1.325	0.55
12	Boiler house ¹ 22	Khan–Uul district Khoroo ¹ 6	NR-18-54	2	1984,1991	0.9	0.27
13	Boiler house ¹ 23	Bayanzyrkh district Khoroo ¹ 20	BZUI-100 NR-18-54	1 1	1994 1963	1.77	0.55
14	Boiler house ¹ 24	Khan–Uul district Khoroo ¹ 12	BZUI-100 DTH-1.4	1 1	1994 2001	2.44	4.0

15	Boiler house [1] 25	Chingeltei district Khoroo [1] 11	NR-18-54	2	1975	0.9	0.38
16	Boiler house [1] 26	Chingeltei district Khoroo [1] 13	NR-18-54	2		1.1	0.48
17	Boiler house [1] 30	Bayanzyrkh district Khoroo [1] 11	BZUI-100	2	2002	1.63	1.04
18	Boiler house [1] 31	Songinokhairhan district Khoroo [1] 1	BZUI-100 NR-18-54	1 1	1994 1963	1.77	0.655
19	Boiler house [1] 65	Songinokhairhan district Khoroo [1] 3	BZUI-100	2	1985	1.63	1.3
20	Boiler house [1] 67	Songinokhairhan district Khoroo [1] 6	BZUI-100	2	1985	1.63	1.06
21	Boiler house [1] 87	Bayanzyrkh district Khoroo [1] 10	NR-18-54	2	1972	0.9	0.24
22	Boiler house [1] 107	Khan–Uul district Khoroo [1] 9	NR-18-54 NR-18-27	1 1	2002 1983	0.66	0.241
	Total			**50**		**34.725**	**24.456**

Technical indexes of some old hot water boilers

Table: 3.2.

[1]	Name of indexes	Measuring Unit	Type of boilers			
			HP-54	BZUI-100	DTH-0.7	DTH-1.4
1.	Heat capacity	Gkal/h (MW)	0.38 (0.4)	0.7 (0.81)	0.7 (0.81)	1.4 (1.6)
2	Working pressure	MPa	0.6… 0.8	0.6… 0.8	0.6… 0.8	0.6… 0.8
3	Temperature of water	Degree Celsius	95/70	95/70	95/70	95/70
4	Flow rate of water	m^3/h	17.5	35	35	70
5	Heating surface	m^2	54	100	90	205
6	Boiler efficiency	%	50	45..55	75	78
7	Fuel consumption (LHV 3200 kkal/kg)	Kg/h		383	255	550
8	Weight of steel construction	ton	3	4.5	4.0	7.2
9	Workers per shift	No. of people	1	1.5	1.5	3

Improving small capacity hot water boilers and increasing their efficiency is one of the most important social-economic and ecological challenges for our country. Replacing the boilers will allow for the reduction of coal consumption by one half and lessen the pollution and contribute to implementation in our country goals set by Agenda 21.

The Boiler houses with small capacity hot-water boilers located around the city continuously emit smog that flows down the valley and pollutes the central districts of the city.

The air in the center of Ulaanbaatar is polluted by smoke from the Boiler houses, which are located in the Bayanzyrkh and Songino khairkhan districts. The wind currents come from the northeasterly direction during January and February and from the north-west direction during the other winter months, thus blowing smog into the center of the city.

Presently, hot water boilers and other heating equipment use untreated water that contains dissolved salts, gasses and traces of many minerals and metals. When the water temperatures change, minerals precipitate in the form of hard, brittle scale that collect in piping and on heat transfer surfaces. This insulating scale build-up reduces the efficiency of the equipment, increases fuel requirements, and increases costs, downtime and may eventually result in dangerous explosive potential.

Most scale prevention techniques are either chemical or electrical and all require the constant use of water treatment chemicals or expenditures for power and bulky equipment. Higher operating and maintenance costs, expensive labor and pollution are also a part of these ordinary water treatment processes.

3.1. Sustainable development objectives of the project

Replacing old inefficient and expensive coal-fired boilers with advanced gas-fired boilers will achieve the following objectives:

- Higher efficiency boiler, (up to 90 % compared to 50- 60 % at current) therefore saving fuel.
- Fuel is changed from coal to gas, saving area for fuel storage, ash field and reducing green house gas emissions, eliminating dust and harmful gas emissions while delivering a higher efficiency.
- Operation will be 100 % automatic, improving working conditions by negating the need for heavy manual transport of coal to the many coal stove boiler locations.

3.2. Governmental policies and strategies related to the areas of the project

- Use of New and Renewable Energy Resources
- To increase the efficiency of energy production, distribution, and consumption through modification of energy sector management systems and adopting new laws and regulations to deal with the issues of energy supply for local consumers;
- To introduce environmentally friendly and effective new techniques and technologies in the energy sector and increase production efficiency through modification of the structure of energy sources;
- Bring the levels of emissions down to international standards through introduction of environmentally friendly, efficient and progressive techniques and technologies in electricity and heat production;

3.3. Overlap of the governments and ADB's policies and strategies

At the request of the Government of Mongolia, ADB's intervention was focused in energy sector in following sector:

- Improving the Governance in energy sector
- Supporting inclusive social development through improvement of energy supply at local levels
- Introducing new energy sources and energy technologies
- Strengthening the capacity building and institutional development in energy sector

Therefore, the energy development policies of the Government of Mongolia are similar to the policies and strategies of ADB.

3.4. Benefits of the project

- Replacement of old hot-water boilers with high efficiency, new technological boilers will save energy.
- Regarding environmental issues of the project, the project will improve environment by reducing emission of harmful gases and dust.
- For people, the project will improve working environment for operators, creating a better environment for people.

4. General description of the project

4.1. Name of the project

Replacement of old coal fired hot-water boilers of The Boiler houses Exploitation centre in Ulaanbaatar with new gas fired boilers of equivalent capacity.

Project country: *Mongolia*

Contact address and related responsibilities: The Ministry of Fuel and energy of Mongolia. This ministry will be responsible for overall management of the project.

4.2. Necessity of project implementation

One of the peculiarities of the Mongolian climate is that, in winter it gets very cold, and sits in a mountain range, which creates a persistent temperature inversion that dramatically increases air pollution. In particular, concentrations of sulfuric gas, nitrogen dioxide and hydrogen sulfide in the air of Ulaanbaatar during the winter time exceed permissible levels. The main sources of pollution include emissions from thermal power plants, motor vehicle emissions, dust from bare surfaces, and smoke from small boiler houses. Also, coal based boiler equipment and its spare parts are very expensive in Mongolia and the local coal quality is very low. Therefore, we have selected new gas fired boilers because retrofitting the old equipment would create little improvement at a high cost due to its age and inefficient design.

4.3. Objective, outputs, activities, scope, specifications and options of the project

Objective:

To create a working environment with high security, reliability, and efficiency and to contribute in the development of industries without dust, and with little pollution.

Targets:

The new boilers will be highly automated (100%) with efficiency ≥ 90%. The emission indicators must meet sustainable development standards.

Outputs:

The system will increase reliability, stability, and improve working conditions for workers. The environment will be less polluted.

Activities:

- Preparation of feasibility study report, submission for approval.
- Preparation of technical design, bidding documents
- Implementation of the project

Features of the project:

Due to the continuity of production, dismantling the old boiler and construction of a new one will be carried out for each boiler in sequence.

4.4. Poverty alleviation.

When new gas boilers have been installed, they will work more reliably, contributing to a more comfortable social environment, thus reducing the amount of illness and work absence. This will reduce the amount of money people spend on medical supplies and increase their ability to attend work.

4.5. Technology transfer

The advanced, highly automated boiler technology will be transferred. Highly efficient gas-fired boilers with low gas emissions will be the replacement.

Technologies of high efficiency gas-fired boilers with low gas emissions will be applied in many boiler houses in Ulaanbaatar. Implementation of this project will contribute to the expansion of clean, environmentally friendly industries.

4.6. Product information

The anticipated new boilers will have the following technical specifications.

Type:	VIESSMANN VITOROND 200
Capacity:	0.4 - 1.0 MW
Temperature of heating water:	95/70 ^{0}C
Flow rate of heating water:	17.0 - 35.0 t/h
Fuel consumption:	40.0 - 81.0 kg LPG/h
Efficiency:	up to 90 %

5. Project implementation schedule

- Preparation of feasibility study report, approval: June, 2005- Dec, 2005 (tentative schedule)
- Preparation of technical design, bidding documents: Oct, 2005-April, 2006
- Implementation of the project: 2007 – 2009
- Project completion: 2015

6. Contribution on sustainable development

6.1. Long-term reduction of green house gas emissions and local pollution reduction

The calculation of existing gas emissions is carried out based on existing production situation, data of replaced boilers, IPCC emission factor and data of new gas-fired boilers.

6.1.1. Emission due to use of coal fuel:

At present there are 50 coal fired hot-water boilers, which consume **30345.0** tons of coal per year. Coal is as follows:

Type:	Brown coal
Particle size:	0 - 50 mm of which 0 - 6 mm constitutes about 40 %.
Heat value:	Q_i^r= 3200 - kcal/kg
Volatile constant:	V^{daf}=42.5 - 43.9%
Ash content:	A^r=12.0 - 24.0 %
Moisture content:	W^r=22.0 - 33.0 %
Sulphur content:	S^r= 0.3 - 0.4 %

- The above coal is burnt in the old boilers, its fuel gas is not precipitated and desulphurized in accordance to IPCC, the emission coefficients are as follows:

CO_2: 95.5 kg/GJ or 1.4 kg CO_2/kg coal
CO: 2.3 kg/GJ or 0.0333 kg CO/kg coal
SO_2:0.63 kg/GJ or 0.009 kg SO_2/kg coal
NO_x: 0.325 kg/GJ or 0.0048 kg NO_x/kg coal

- Apart from that, according to IPCC, exploitation of 1 ton of coal produces 20 m3 of CH4 or 14.28 kg of CH4 equivalent to 300 kg CO2 to the environment. Therefore gas emission of coal exploitation is 0.3 kg CO_2/kg coal.

6.1.2. Emissions due to using gas fuel

The substitute gas-fired boilers with equivalent capacity will consume 4020 tons of gas. Heat value of gas is Q=11290 kcal/kg., 3.5 times more than brown coal
CO_2: 2.95 kg CO_2/kg LPG, without impact of transport factored
The emissions due to using gas-fired boilers are presented in the following table.

Gas emissions from using gas-fired boilers

Table: 6.1

1	Emission	Emission coefficients of 50 coal fired boilers	Emission amount in 1 year (tons/year)	Emission amount in 10 year (tons/year)
1	CO_2 due to combustion	2.95 kg CO_2/kg LPG	11 853.6	118 536.0

6.1.3. Emission reduction:

CO_2: 30631.o t/year in 10 year

SO_2: 387.0 t/year in 10 years
$NO_{x:}$ 206.4 t/year in 10 years
$CO_{:}$ 1431.9 t/year in 10 years

7. Base line of the project and calculation of GHG reduction

7.1. Existing production situation and emission distribution

At present, the energy enterprise operates 3 coal-fired boilers, which produce the following emissions:

- Emission due to coal exploitation:
  0.17 kg CO_2/kg coal
- Emission due to coal transportation:
  17.6 $\cdot 10^{-3}$ kg CO_2/kg coal
- Emission due to using coal
  $CO_{2:}$ 1.4 kg CO_2/kg coal
  CO: 0.0333 kg CO/kg coal
  SO_2: 0.009 kg SO_2/kg coal
  NO_x: 0.0048 kg NO_x/kg coal

8. Monitoring and checking GHG emission

8.1. Necessary data, quality, accuracy

The data necessary for monitoring and checking emissions are:

+ Working contents of fuel (C, O, S, N, H)
+ Boiler specifications, techno-economic characteristics in operation of boilers (Efficiency, precipitation, desulphurization …)
+ Environmental data (dust concentration, $SO_{2,}$ NO_x concentration etc.)

8.2. Methodology for collection and monitoring of data base.

The following methods are used for collecting and monitoring data;

- Collect manufacture and operation data of equipment for carrying out calculation
- Use measuring instruments and gauges at point of emission sampling (maybe at emission source and in the area).
- The quality of collected data and measuring instruments must be ensured and calibrated for preparation of reports and monitoring database effectively

8.3. Estimate of costs for monitoring and inspection

During the process of monitoring and inspection, a framework on the requirements of people and equipment needs to be prepared. Monitoring will be extended for period of about 10 years. In the scope of the project, monitoring work is expected to last for 10 years with annual inspections.

Cost of environmental monitoring end inspection: US $ 15 000/ year

9. Financial analysis of the project

9.1 Calculation of Investment cost

Legal Documents used for financial analysis:

- Unit cost of equipment and materials of foreign and domestic manufacturers
- Economic- financial analysis guideline Documents of WB, ADB for projects that improve energy conservation efficiency.
- Related papers in force
- Exchange rate- US $ 1= Mongolian tugrik 1220.0

Total investment cost for 50 replaced gas- fired boilers – US $1. 0296 million

- Components of investment cost are:
- Equipment costs- US $ 780 000.0 for 50 gas-fired boilers
- Installation cost- 20% of Equipment cost= US $156 000.0
- Other initial investment costs- 5% of (Equipment cost+ Installation cost) =
- US $46,800.0
- Spare cost - 5% of (Equipment cost+ Installation cost)= US $46,800.0

9.2 Other costs and input data conditions

Maintenance and repair costs:

- Cost of environmental monitoring end inspection: US $ 15 000 /year
- Electricity price: 4.4 US cent/kW·h
- Fuel price:
- Gas price: US $ **220.0** /ton for Alternative ***A*** and US $ 170**.0** /ton for Alternative ***B***
- Coal price: US $ **20.0** /ton

Data of product and product price:

- Average product quantity of 50 coal-fired boilers: 40850.0 Gcal/year
- Selling price of heat: **21.5** US $/ Gcal
- Year of starting investment: 2006
- Year of ending analyses: 2015
- Company benefit tax rate: 12 %
- Deprecation period: 10 years
- Exchange rate: 1220 tug/ US $ 1
- Reduced GHG emission price for project: US $10.0/ton CO_2

9.3 Financial Analyses

Objective:

Financial analysis is used to evaluate the financial feasibility of a project, and define financial indicators achieved during the lifetime of the project.

Financial analysis includes the following reports:

1. Report of Revenue: represents annual revenue, costs and net income of project during its lifetime.
2. Table Cash Flow: represents revenue flow, cost flow and net present value for the project during its lifetime with discount rate taken into account.

Revenue Flow of the project is defined from heat output of gas-fired boilers.

Cost Flow of the project includes:

- Total investment cost for 50 gas-fired boilers
- Costs depending on norm and heat output of gas fired boilers include maintenance and repair cost, fuel cost and electricity.
- Environment monitoring and inspection cost is calculated for ten years of the project from the beginning of the operation of the project.
- Revenue tax of company

Table of cash evaluates financial effect, defines financial indicators of the project including:

- Financial internal rate of return: FIRR
- Financial net present value: FNPV
- Ratio of Benefit and cost: B/C

According to commercial loan conditions, the project investor must contribute reserved capital (or equity capital) at least 30 % of total investment (include interest during construction) 70 % remaining is credit loan.

Components of borrowing capital sources

Table: 9.1

Sources of Fund	Weighted	Nominal cost	Income tax rate	Tax-adjusted Nominal cost
Loan	70%			
Among which				
ADB Loan	10 %	6.7 %	10 %	6.03 %
Domestic loan	60 %	12 %	10 %	10.8 %
Equity participation	30 %	12%		

From the above sources of fund and interest rates and company income tax rate of 10 %:

WACC=0.1*6.03%+0.6*10.8%+0.3*12% = 10.7%

It is anticipated to borrow a loan with the terms and conditions as follows:

- payback time: 3 years
- grace period: 1 year
- lifetime of project: 10 years

Financial analysis is to evaluate financial effects of gas – fired boilers contributing to total benefit of the company.

Results of financial analysis of the project

Table: 9.2.

Indicators	With CO_2 Emission Reduction taken into account	
NPV (mil. USS)	Alternative **A**	0.1
	Alternative **B**	2.58
(i) B/C	Alternative **A**	0.15
	Alternative **B**	0.37

9.4. Sensitivity Analysis

This study carries out sensitivity analysis based on the most likely changes.

Base case:

+ WACC of 10.7%
+ CO2 emission reduction taken into account
+ Investment capital from loans

Changes:

- an increase in investment cost by 20%
- decreases in benefit due to decrease in product selling price by 20%
- an increase in costs of operation and maintenance by 20%
- an increase in costs of fuel, material and power by 20%
- combination of variables : the effects on FNPV and FIRR of a simultaneous decline in benefits and an increase in investment cost, O&M costs, fuel costs can be computed.

10. Economic Analysis

10.1. Contents

Economic analysis is used to assess the feasibility of the project, calculate and compare economic indicators to select the ideal solution to implement.

Economic analysis includes a table of economic cash flow and economic indicators achieved by each technological and constructional scenario to define economic effects of the project. For this boiler replacement project, the economic analysis compares the economic effects of replacing 50 coal-fired boilers by gas-fired boilers.

10.2. Poverty reduction impacts

Technologies of high efficiency gas-fired boilers with high heat capacity make product…

10.3. Social and environmental impacts

The project of 50 backward coal-fired boilers by gas-fired boilers makes profit for the company as well as contributing to increase economic benefits for society and environment.

For the project, replacing old backward coal-fired boilers by high efficiency gas-fired boilers takes full advantages and saves coal. Regarding environmental issues of the project, the project will improve the environment by reducing emissions of GHG and dust.

The proposed fuel efficiency measures for coal-fired boilers in city Ulaanbaatar will save 43000.0 ton coal, making possible to decrease CO_2 emissions by 30631.0 ton for each year.

10.4. Economic and social analysis

Following the positive social impacts will be created:

Air pollution in Ulaanbaatar will be reduced by 20 %

Reduced the respiratory and other infectious diseases among the public

Cost for buying the fuel will be reduced if the cost of LPG is US 170/ton or less

Financial analysis for gas-fired boilers project, mil. US $
ALTERNATIVE.A Gas price 220 US$/ton

Table: 10.1

No	Fiscal year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	Total Income	0.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	15.0
2	Total Investment Cost	1.03											
3	Total direct costs	0	1.298	1.298	1.298	1.298	1.298	1.298	1.298	1.298	1.298	1.298	12.98
4	Operation and Maintenance cost	0	0.189	0.189	0.189	0.189	0.189	0.189	0.189	0.189	0.189	0.189	1.89
5	Depreciation	0	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	1.06
6	Fuel cost	0	0.884	0.884	0.884	0.884	0.884	0.884	0.884	0.884	0.884	0.884	8.84
7	Electricity cost	0	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.61
8	Environmental monitoring and inspection costs	0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.15
9	Material cost	0	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.43
10	Total benefit	0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	2.0
11	benefit tax	0	0.03	0.03	0.03	0.0.3	0.03	0.03	0.03	0.03	0.03	0.03	0.3
12	Net benefit	-1.03	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	1.7
13	Circle of Cash		0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	1.7
14	Discount Coefficient (8%)		0.925	0.856	0.793	0.735	0.680	0.632	0.585	0.540	0.50	0.463	
15	Present value		0.157	0.145	0.135	0.125	0.116	0.1	0.1	0.09	0.085	0.08	1.133

1	NPV	0.1
2	B/C	0.15
3	Payback time	8.5 year

ALTERNATIVE.B Gas price 170 US$/ton

Table: 10.2

1	Fiscal year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
1	Total Income	0.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	15.0
2	Total Investment Cost	1.03											
3	Total direct costs	0	1.097	1.097	1.097	1.097	1.097	1.097	1.097	1.097	1.097	1.097	10.97
4	Operation and Maintenance cost	0	0.189	0.189	0.189	0.189	0.189	0.189	0.189	0.189	0.189	0.189	1.89
5	Depreciation	0	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	1.06
6	Fuel cost	0	0.683	0.683	0.683	0.683	0.683	0.683	0.683	0.683	0.683	0.683	6.83
7	Electricity cost	0	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.61
8	Environmental monitoring and inspection costs	0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.15
9	Material cost	0	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.43
10	Total benefit	0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	4.0
11	benefit tax	0	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.6
12	Net benefit	-1.03	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	5.4
13	Circle of Cash		0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	5.4
14	Discount Coefficient (8%)		0.925	0.856	0.793	0.735	0.680	0.632	0.585	0.540	0.50	0.463	
15	Present value		0.5	0.46	0.43	0.39	0.37	0.34	0.31	0.29	0.27	0.25	3.61

1	NPV	2.58
2	B/C	0.37
3	Payback time	2.2

11. The main factors affecting the project

11.1. Regarding policies, laws

There are some laws and policies of Mongolia as basic factors impacting feasibility of the project as follows:

1. On June 12, 1992 The Government of Mongolia signed the United Nations Framework Convention on Climate Change (UNFCCC).
2. The law for Energy, was confirmed by Mongolia state Great Hural on December 1995.
3. Mongolia has developed a National Action Programme on Climate Change. On 19 July 2000, the Government approved this programme, which includes the Government's policies and strategies to deal with climate change related concerns and problems.

11.2. Regarding the project risk

Gas prices are very expensive at the current time, so to this project may not be possible to implement until gas prices are reduced in the future. This project has a very high level of social importance for Mongolia, in contrast to the level of economic costs it may employ.

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LAW AND REGULATION FOR COAL MINE METHANE UTILIZATION AND EXPECT

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Coalbed methane (CBM) is a natural gas located underground together with a coal, so it's accumulated under a mine layer and have a danger to explode when exploring a coal. Organizations acting against earth temperature warming stated that during the Coal mining explorations, the methane gas appears and accumulated in the air, thus affects the earth temperature warming. Instead of loosing this gas in the air, it can be used as a source of energy and furthermore can be used for electricity, heating and transportation fuel. Considering all these specialties of CBM gas, the followings are some articles and regulations currently applied in Mongolia:

1. A consititution of Mongolia, Article 6 "A mineral resourse in Mongolia, is owned by the state" accordingly CBM is owned by the state.
2. CBM is considered between several laws of the mineral resources. The Exploration and Mining Lisence of coal is being regulated by the /Law of Mineral resources/, and an exploration of the CBM gas is regulated by the /Petroleum Law/ according to the production sharing agreement.
3. Gas distribution and import is being regulated by the "Petroleum Law".

The "Gas supply law" is developed and submitted to the Mongolian Parliament as it's stated in the "Strategic directions to improve Mongolian laws until 2008" of the 26th resolution of the Mongolian Parliament in 2005. According to this law the gas is not only used for transportation but it could be used for energy, heating, apartments, developing gas channels, supporting gas industries, entities, developing a projects for gas supplies, providing services for utilization and providing safety environment.

Current condition, requirements

The 140th resolution of the Mongolian Government made in June 21st, 2006 has approved an extension of the "Liquid combustible gas" program from 2006-2010. This program has an aim to expand a gas channels, using a gas for the production, apartments and improving services.

There are some improvements made for citizen's fuel consumption and people understand it more for reducing air pollution. Considering these conditions, the Mongolian Government has included article "Support and expand environmental friendly activities, promoting less smoke, solid and liquid gas fuel consumption" in the Action Plan from 2004-2008.

Mongolian Government is improving a policy for developing a regulation of increasing energy supply, providing safety environment, developing coal through heating, manufacturing coal by producing energy and heating, expanding services and supply of gas fuel, investigating and applying advanced technologies, decreasing negative impacts in nature and environment caused by energy consumption.

Since the approval of the "Gas supply law", a proposal to make an amendment is being developed to the Law of Government, Energy, Entity License, Land use, Petroleum and Petroleum production law.

According to the Petroleum law, the exploration of the natural gas and petroleum gas import is being regulated by the Petroleum production law.

Gas supply is considered as a type of energy supply according to international level, the Ministry of Fuel and Energy is responsible for gas supply policy and regulation issues and making a change to the Law of Energy and Law of Government.

"Main directions and activities of the Mongolian Government" stated the main sources for increasing the energy consumption, decreasing air pollution, promoting sustainable economic growth is to eliminate fuel-energy imports and to have an independent for fuel and energy consumption by producing cheap gas fuel using local resources.

There are a lot of opportunities In Mongolia for using different kinds of gas, natural gas, CBM gas, solid and liquid natural oil, gas from manufacturing coal, waste gas, biogas, synthetic gas etc.

Therefore, it's considered that Mongolia have a lot of methane gas resources and calculated total emissions from coal basin. This shows a natural gas can be used for energy supply in the future.

There are some obstacles for electricity and heating issues faced for the projects for providing apartments in UB through the 40 thousand apartment program. Government realizes that energy supply for the new construction district will be utilization of the CBM locally.

As a conclusion would like to state that a new law will be focused to dispose Mongolians from energy shortage to live in a healthy environment, remove dependency on the fuel import by supporting CBM gas production and exploration, providing safety environment, preparing human resources and employees capacity, promote manufactures and industries to utilize economical fuel in the market, provide business opportunities and increase government's, decision maker's and citizen's participation and improve their coordination in this field.

Coal program is initiated by the Fuel Policy Coordination Department of Ministry of Fuel and Energy and it's been submitted to Parliament for approval. This program would be main government policy document that has set several objectives that will be completed by 2020 and these are development of coal processing industrial complexes including coal and chemical factories for recovering and utilizing CBM.

AIR POLLUTION AND NATURAL GAS

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Air pollution has both acute and chronic effects on human health. Impact of air pollution on health shown on table 1. Air pollution has been shown to cause acute respiratory infections in children and chronic bronchitis in adults [1]. Over the last decade, several dozen scientific studies have been published indicating an association between air pollutants to which people are routinely exposed and a wide range of adverse health outcomes. Early studies of 14 winters in London, England showed statistical associations between daily change in PM, measured as black smoke, and daily changes in mortality. These efforts indicated that mortality was associated with air pollution over the entire range of ambient concentrations, not only during the high episodes associated with the earlier London winters.[2]

The elderly, unborn babies, infants, children are most sensitive to air pollution [3].

Table 1. Summary of health impacts [4]

Particulates	Nitrogen Dioxide	Carbon Monoxide	Air Toxics	Air Toxics (PAHs
• Increase in cardiac and respiratory mortality • Admissions to respiratory and cardiovascular casualty room and hospital • Increased incidence of acute bronchitis in adults and children. • Increased prevalence and exacerbations of chronic obstructive pulmonary disease in adults and children	Increased mortality • Impaired lung function • Impaired respiratory defence mechanisms leading to increased susceptibility to infections • Increased respiratory disease in children	Mortality, especially those with cardiovascular disease • Aggravation of cardiovascular disease and chest pain • Nausea • Headache • Fatigue	Benzene: • Leukaemia • Long-term harm to immune system • Skin and eye irritations • Drowsiness • Dizziness • Headaches Toluene: • CNS dysfunction (often reversible) • Narcosis • Lightheadedness Xylene: • Irritation of respiratory	• Cancer • Kidney and liver damage • Respiratory irritation • Exacerbation of asthma • Chronic bronchitis • Coughing and throat rritation

Table 2. Estimated annual cost of air pollution on the health system in Australia [3]

Health outcome	Cost estimate per episode ($)	Estimated increased annual cost due to air pollution ($ '000)
Cardiovascular admissions	7,099	3,982-8,561
Respiratory admissions	5,336	1,917-4,185
ED attendances – cardiac 65+	359	94
ED attendances – respiratory 65+	359	150
ED attendances – asthma 1-14 years	359	541
	Total	**6,685-13,533**

Since the 1980s, a number of studies examining the relationship between ambient air pollution and health effects in China have been conducted. One of most definitive of these studies examined the relationship between air pollution and mortality in two residential areas of Beijing. According to this study, the risk of mortality was estimated to increase by 11 percent with each doubling of SO2 concentration, and by 4 percent with each doubling of TSP. When the specific causes of mortality were examined, mortality from COPD increased 38 percent with a doubling of particulate levels and 29 percent with doubling of SO2. Pulmonary heart disease mortality also increased significantly with higher pollution levels [5].

In the Apheis-3 study involved 22 hospitals of Europian Union. The incidence rate for cardiac admissions for all ages was the highest in Budapest (2 686 per 100 000) followed by Stockholm (1 093 per 100 000), and the lowest was for Valencia (485 per 100 000). The incidence rate for respiratory admissions was slightly higher for London (719 per 100 000) [6].

Jakarta is one of the most polluted cities in the world. Air pollution in Jakarta is above the safe limits specified by the World Health Organization. It is estimated that the health cost of Jakarta's air pollution in 1999 reached $US220 million [7].

According to the California Air Resources Board the annual health impacts of exceeding state health-based standards for air pollution include:

- 6,500 premature deaths
- 4,000 hospital admissions for respiratory disease
- 3,000 hospital admissions for cardiovascular disease
- 350,000 asthma attacks
- 2,000 asthma-related emergency room visits

Table 3. Annual Damage to Children's Health from Air Pollution in New Jersey, USA [9]

Health Effect	Number of Cases
Infant Mortality	40 to 80
Asthma Hospitalizations	290 to 440
Asthma ER Visits	190 to 3,400
Acute Bronchitis	21,000 to 77,000
Asthma Attacks	150,000 to 170,000
Missed School Days Roughly	610,000

Table 4. Annual Premature Deaths Caused by Air Pollution in New Jersey [9]

Health Effect	Number of Cases
Premature Mortality (age 30 +)	2,300 to 5,400

Researchers with the World Health Organization in Europe found that air pollution caused 6% of all deaths in Switzerland, France, and Austria (40,000 per year). Motor vehicle pollution caused about half of these deaths. We estimate that soot pollution causes 2,300 to 5,400 deaths each near in New Jersey, or 5.4% to 7.7% of all non-injury- or accident-related deaths.[9]

Table 5. Respiratory disease incidence among children 0-14 year, in UB city (per 10000) [13]

1	**Disease**	**Cases**
1	Respiratory disease	1384,7
2	Glositis	112,4
3	Bronchitis	183,12
4	Pneumonia	304,7

Respiratory diseases are not the only health impacts of concern associated with air pollution. Lead exposure, for instance, leads to neurological damage, impaired intelligence, neurobehavioral development, and physical growth. (The U.S. standard is 10 micrograms per deciliter.) Between 65 and 100 percent of children in Shanghai have blood-lead levels greater than 10 micrograms per deciliter. In Shanghai, prenatal exposures to lead from urban air were associated with adverse development in the children during their first year of life [10].

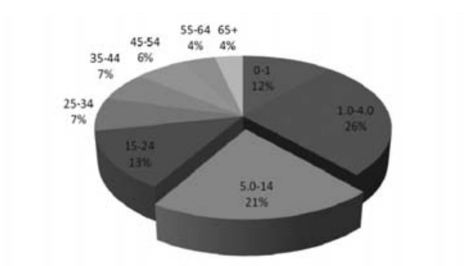
Health impact on air pollution in Ulaanbaatar city

From 9700 hectare area of ger district disperses 178 thousand tonns of air pollutants, in Ub city annually. Whereat carbon monoxide 130 thousan tonn, sulfur dioxide 36 thousand tonn, nitrogen dioxide 12 thousand tonn. The Ulaanhuaran district consumes much more fuel, and air pollutants in this area estimated as 40 tonn per hectare a year [11]. In Ulaankhuaran, Denjiin myanga, and in Gandan area the distribution of air pollutants per hectare square is 26-31 tonn carbon monoxide, 7-8 tonn sulfur dioxide, 2-3 tonn nitrogen dioxide. Air pollution level: The Ulaankhuaran, Technical market, 32iin Toirog, Denjiin myanga are high and very high air polluted areas [11].

Air pollution level

Very high	16.4
Moderate high	15.2
High	11.9
High	11.4
Moderate	7.7
Low moderate	7.1

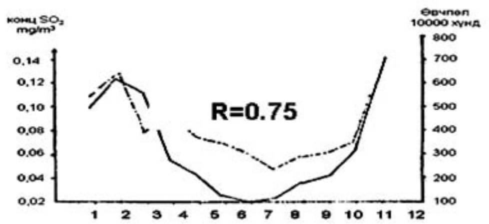
The 40% of all population of Mongolia inhabits in UB city. Children and aged populations are more sensitive to air pollution. Because of increasing air pollution the respiratory system disease case increase rapidly.



RESPIRATORY SYSTEM DISEASE CASE IN 2006, BY AGE

In 2006, in the UB city estimated 32259 cases of respiratory system disease, of which 3759 cases or 12% was infants, 26% or 8522 cases was children of 1-4 years [12].

Study showed high and middle correlation between children respiratory system disease and air pollutants such as carbon monoxide, and nitrogen dioxide. Nitrogen dioxide causes pulmonary cancer in 11.9% cases. By statistical report from 1994 to 2000, sulfur dioxide content increased by 2.25 times, nitrogen dioxide content increased by 1.78 times. Sulfur dioxide causes COPD, and nitrogen dioxide causes asthma, COPD, pulmonary cancer [13].



Relationship between SO2 concentration and

Content of lead in air of UB city is about 0,0014mg/m^3 +/-0,0001 mg/m^3. This means t5hat lead content had overcome tolerable concentration for more than 4.6 times. By the blood analyse of 120 children about 7-14 years, shown that lead concentration of blood is 15,7+/-1,13mg/dl in boys, 17,4+/-1,82 mg/dl in girls, whereas the tolerable concentration of lead in blood is 10 mg/dl. Lead exposure, for instance, leads to neurobiological damage, and neurobehavorial change. Respiratory disease incidence among children 0-14 year, shown on the table 5. [13]

Bronhitis incidence among children of Ub city, is higher for 5.1- 14.9 times than in children, who lives in rural areas.

Every year in Mongolia occurs 90.7 thousand respiratory disease, for treatment of respiratory disease disbursed approximately 4.8 billion tugrugs. Whereas in Ulaanbaatar city incidence of respiratory disease is about 40.2% or for treatment of 36.4 thousand patients disbursed 2.4 billion tugrugs. [13]

In 2005, in UB city the incidence of respiratory disease is estimated approximately 37 thousand and for treatment disbursed 3 billion tugrugs, and in 2015 expected to increase until 42 thousand incidence of respiratory system disease will occur, and for treatment will disburse 5 billion tugrugs.

Table 6. Estimated cost of air pollution on the health system in UB city (2002-2006)

	2002	2003	2004	2005	2006	5 year
Incidence of disease	51012	53891	58430	60799	45326	269458
Estimated cost due to air pollution million tugrug	508,0	462,0	421,0	453,8	467,2	2312,0

From the table, the incidence of disease is increased during 2003, 2004, 2005. The compare study of respiratory disease due to air pollution by district, show that in Bayanzurkh district the incidence of respiratory disease is higher than in other districts, and the disease incidence is highly correlated with usage of raw coal.

Health impact of reducing air pollution

The NSW Government advised that air pollution caused between 643 – 1,446 deaths annually in the Sydney region, and that a ‘conservative estimate’ of the health related financial costs due to air pollution was between $706 million and $5,994 million per annum [3].

The numbers of lives saved and illnesses avoided are impressive. Using the central or medium estimate of the dose-response relationships, Ostro estimated that each year in Jakarta the benefits from reducing particulates to Indonesian standards include 1,200 premature deaths avoided, 2,000 fewer hospital admissions, 40,600 saved emergency room visits, and over 6 million fewer restricted activity days, among other benefits for the population of 8.2 million [7].

Table 7. Health Benefits of Reducing Particulates in Jakarta to Indonesian Standards [7]

Health effect	Medium estimate
Premature mortality	1,200
Hospital admissions	2,000
Emergency room visits (ERV)	40,600
Restricted activity days (RAD)	6,330,000
Lower respiratory illness (LRI)	104,000
Asthma attacks	464,000
Respiratory symptoms	31,000,000

Just about everyone in the US uses natural gas. Natural gas ranks number three in energy consumption, after petroleum which provides almost 39% of total energy demend, and coal which provides 22.6%. About 21.6% of the energy comes from natural gas.

Natural gas is used in over 60 million homes. In addition, natural gas is used in 78 percent of restaurants, 73 percent of lodging facilities, 51 percent of hospitals, 59 percent of offices, and 58 percent of retail buildings.

In addition to long-term benefits of greenhouse gas (GHG) reductions in the form of avoided health and ecosystem damage, there are important near-term benefits resulting from the reduction in health-damaging pollutants (HDP) that can accompany GHG reductions [14]. The use of fossil fuels for energy contributes to a number of environmental problems. As the cleanest of the fossil fuels, natural gas can be used in many ways to help reduce the emissions of pollutants into the atmosphere. Burning natural gas in the place of other fossil fuels emits fewer harmful pollutants into the atmosphere, and an increased reliance on natural gas can potentially reduce the emission of many of these most harmful pollutants [15].

According to the Department of Energy (DOE), about half of all air pollution and more than 80 percent of air pollution in cities are produced by cars and trucks in the United States.

Table 8. Fossil fuel Emission levels (Pounds per Billion BTU of Energy Input) [15]

Pollutant	Natural gas	Oil	Coal
Carbon Dioxide	117,000	164.00	208.00
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1.122	2.591
Particulates	7	84	2.744
Mercury	0.00	0.07	0.016

Source: Natural Gas Issues and trends

Mongolian Government assigned programme ”Respiratory disease risk factors in metropolitan city”, the programme will implement during 2007-2011. To reduce the air pollution many conutries using natural gas. Mongolian Government should implement programme of Natural gas using to reduce air pollution.

Conclusion

During 1998- 2005, ger district area in UB city increased by 202% (by the end of 2006, it is estimated 9700 hectare), the population of ger district rised by 50%. Last 5 years the population of ger area increased by 10%, and this progressive increase of population is considerable growth for cities of the world. Due to considerable growth of UB city has leading to air pollution. To save the population health we should use natural gas, instead of raw coal, and petroleum. By using natural gas instead of petroleum for trucks, cars, and buses we could avoid distribution of health damaging pollutants. The cost of natural gas exported from other countries is high. So, we need to establish new natural gas resorting source such as coalbed methane. In the form of avoided health and ecosystem damage, there are important benefits resulting from the reduction air pollution.

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