DESIGN AND IMPLEMENTATION OF A 120 MW COAL MINE METHANE FIRED POWER PLANT IN SHANXI PROVINCE, PEOPLE'S REPUBLIC OF CHINA

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Introduction

Methane is naturally found in coal seams throughout the world. The amount of methane trapped in a coal seam varies by country and by region. The presence of methane in coal represents the principal hazard associated with underground mining of coal. It is necessary to continuously extract methane to keep the methane concentration in the mine below its lower explosive limit. The lower explosive limit of methane is five percent by volume.

Methane can be extracted from a coal seam in three forms:

Coal Bed Methane (CBM) -- Extracted by drilling wells from the surface into the coal seam prior to mining, or from a coal seam which may never be mined. CBM generally has a methane content of over 90 percent;

Coal Mine Methane (CMM) -- Extracted from the mine itself, while mining is underway, or sometimes after mining is complete. CMM generally has a methane content of 35 percent to 60 percent. The non-methane fraction of the CMM is virtually all air (nitrogen and oxygen). CMM is extracted by drilling horizontal wells into the coal seam; and

Ventilation Air -- Ventilation air contains very low concentrations of methane. As the name implies, it is the exhaust from systems designed to flush the mine with fresh air to provide a safe environment for mine personnel. Ventilation air is generally unsuitable for energy recovery.

CBM and CMM can be converted into several forms of useful energy, including electricity, boiler fuel, pipeline quality gas, or vehicle fuel.

CBM and CMM has been converted into electricity using reciprocating engines and combustion turbines. The largest currently operating reciprocating engine project is located in New South

Wales, Australia. It employs 94 reciprocating engines having a total installed capacity of 97 MW. It has been operating since 1996. The largest currently operating combustion turbine project is located in Virginia, USA. It employs two simple cycle combustion turbines. It has a capacity of 88 MW.

The above two projects are exceptionally large. CMM/CBM power projects currently exist in Australia, China, Germany, Japan, Poland, Russia, United Kingdom, Ukraine and the United States. Approximately 50 projects, ranging in size from 150 kW to 94 MW are currently operating, with an aggregate output of about 300 MW.

It is also possible to convert CBM and CMM to pipeline quality gas (natural gas equivalent). The quality of gas that a natural gas distribution company will accept varies somewhat throughout the world. Often, the energy content of CBM is satisfactory with minimal processing. If the air fraction of CBM is too high, it can be beneficiated to pipeline standards by removing nitrogen using pressure swing adsorption.

CBM can be used to produce vehicle fuel, or to produce transportable fuel (if a pipeline is not present) by converting the CBM or CMM to compressed gas or liquefied gas. Compressed gas is transported to markets in high pressure tube trailers. Liquefied gas is transported in low pressure tank trucks.

The Shanxi Jincheng Anthracite Coal Mining Group Company (JMG) operates one of the largest and most successful coal mining companies in the People's Republic of China. The Sihe Mine is JMG's largest mine. The Sihe Mine is located in southeastern Shanxi Province. It is about 500 kilometers southwest of Beijing, and about 20 kilometers west of the city of Jincheng.

JMG currently collects CMM using horizontal wells. The CMM is pulled from the mine to an above-ground CMM drainage facility (a vacuum pump house). JMG uses some of this CMM as boiler fuel and to supply a 15 MW combustion turbine power plant and some of the CMM is discharged directly to the atmosphere.

JMG is now engaged in a project to increase the capture of CMM, which will improve the working conditions and JMG will simultaneously install the world's largest CMM power plant to utilize the CMM of the Sihe Mine. The gross capacity of this power plant will be 120 MW.

JMG engaged SCS Engineers to provide technical assistance in development of the project. SCS's responsibility includes: design review; assistance in procurement; assistance in monitoring contractors and equipment suppliers; operator training; and assistance in plant performance testing.

<u>CMM Supply</u>

At Sihe Mine, CMM is extracted from the in-situ coal using horizontal wells. Boreholes of up to 530 meters in length have been drilled ahead of the working face of the mine. The boreholes are converted into wells and the wells are connected together through a network of piping inside the mine. The piping extends through a shaft to the surface where it terminates in a CMM drainage station (a vacuum pump house). All of the CMM from the Sihe Mine is pulled to a single vacuum pump house. The CMM exits the pump house at a slight positive pressure (7.7 kPa). It is now stored in a 10,000 m^3 low pressure gas holder, and it is used to fuel a 15 MW combined cycle power plant and to fire boilers to supply building heat.

In support of the new 120 MW power plant, JMG is making the following improvements to the CMM supply system:

- Four new drilling machines, capable of drilling boreholes over 1,000 meters in length have been procured;
- The capacity of the vacuum pump house will be increased from 1,432 Nm^3/min to 2,796 Nm^3/min; and
- Two new 30,000 m^3 low pressure gas holders will be installed.

The combination of more aggressive drilling, and the above facilities, is expected to increase the capture of CMM and supply the 120 MW power plant with a reliable and adequate source of CMM.

Power Plant

The new 120 MW power plant will incorporate the following principal components:

- A pressurization station which will draw CMM from the gas holders and which will increase the CMM pressure to the 35 kPa required by the reciprocating engines;
- Sixty 1.8 MW Caterpillar 3520 reciprocating engine/generators. The engine/generators will be installed in four contiguous power houses;
- Twelve waste heat recovery boilers (three per power house). Each boiler will serve five engine/generators; and
- Four steam turbine/generators (one per power house).

The characteristics of the engine/generators will be as follows:

Gross Output	1.8 MW
Heat Rate	9.15 MJ/kWh
CMM Inlet Pressure	10-34.5 kPa (g)
Exhaust Temperature	458° C
Generator Voltage	10.5 kV
Usable Hot Water	744 kW
NO_x Emissions	<500 mg/Nm^3

The design methane content for the project is 41 percent; however, the engine/generators will operate on a methane content as low as 30 percent.

The characteristics of the waste heat boilers are as follows:

Steam Production	6 tonnes/hour
Steam Pressure	2.5 MPa (g)
Steam Temperature	400° C
Feedwater	105° C

The characteristics of the steam turbine/generators are as follows:

Gross Output	3.0 MW
Steam Flow	16.26 tonnes/hour
Steam Temperature	390° C
Exhaust Pressure	0.0108 MPa (a)
Generator Voltage	10.5 kV

Other important power plant subsystems include the following:

Cooling

Cooling for the engine/generators will be provided by roof-mounted, air-to-water heat exchangers. Cooling water for the steam turbine/generators' main steam condensers, generators and lube oil will be provided by a mechanical draft cooling tower.

Hot Water Recovery

Jacket water will be used to provide hot water for building heating. The productive use of this waste heat will free up more CMM for electric power production.

Water

Raw water, in an amount up to 141 m^3/hour, will be provided by six groundwater wells. The water will be softened and be used as makeup water for the cooling tower and for the hot water building heating loop. The softened water will be further processed by reverse osmosis to provide boiler makeup water.

Wastewater

Principal sources of wastewater will include: softener regeneration water; reject water from the reverse osmosis system; cooling tower blowdown; boiler blowdown; and building drains. After oil/water separation, as appropriate, the wastewater will be discharged to the coal mine's existing wastewater treatment plant.

Interconnection

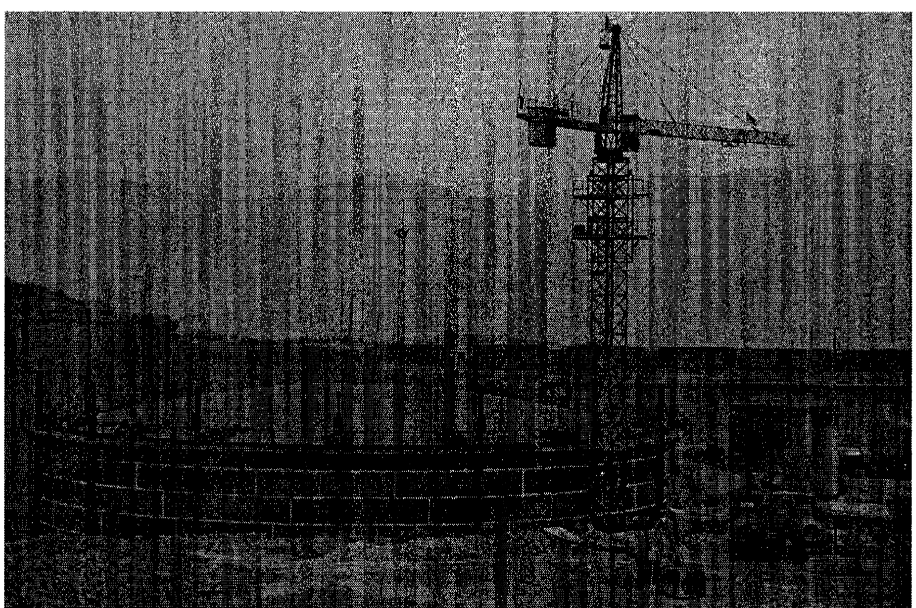
The generators will produce power at 10.5 kV. The power output will be aggregated and will be stepped up to 220 kV using two 75 MVA transformers. The 270 kV power will be interconnected into the Shanxi Province Power Company's (SPPC's) transmission grid using indoor GIS SFG switches. A 220 kV transmission line will be constructed to SPPC's existing Quinchi 220 kV transformer station.

Project Schedule

A contract for the supply and installation of the engine/generators, and all major power generation equipment, was awarded in May 2006. It is currently anticipated that two of the power houses (60 MW) will be operational in June 2007. The other two power houses (60 MW) will come online in December 2007.

Project Funding

The project is being funded through a loan from the Asian Development Bank (ADB) and by JMG. The project cost is about US $200 million. Revenue produced by the project will consist of avoided power purchases, sale of excess power to the local utility company and the sale of certified emission reductions (CERs) under the Clean Development Mechanism (CDM). A portion of the CERs have already been sold to the World Bank's Prototype Carbon Fund.



30,000 m^3 Gas Holder

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Morning 11:00 – 12:30

Strategic Session: Room 205

Investor issues & IPP development

Chairman: Tom Watters, Technical Director, PB Power Asia Pacific, Thailand

Where will investment come from for financing big baseload projects?
Hu Jing Yan, Chief Director General for Foreign Investment, Ministry of Commerce, P.R. China

Managing greenfield power projects in China- Fangchenggang model
Peter Littlewood, Group Director - Operations, CLP Group, Hong Kong SAR

Comparative benefits of EPC integration
Jianing (Robert) Feng, Regional Marketing Manager, P.R. China

E.P.C. contracting in China: an open or closed book?
Kim Yee Lau, Project Manager, Meiya Power Company Limited, Hong Kong SAR

Managing power assets in China: closing the cultural gap?
Dr. Alan Chan, President, Meiya Power Company Limited, Hong Kong SAR
Co-Author: Sally Sun, Director - Human Resources, Meiya Power Company Limited, Hong Kong SAR

Technical Session: Room 204

Power generating technologies I

Chairman: Lu Guangjie, Vice-Manager of Department of R & D, China Guodian, P.R. China

Integrated gasification combined cycle (ICC) versus supercritical pulverized coal (PC) for power generation from coal
Sheldon Wood, Senior Vice President - Director of Projects, Black & Veatch, USA

Authors: Rich Chapman, Black & Veatch, USA
George P. Gruber, Black & Veatch, USA
Robert A. Slettehaugh, Black & Veatch, USA

A new application from ABB company in CSCS for large pumped storage power station in China
Yang JiDe, Supervisor, Hydro Plant Automation, ABB Ltd, P.R. China

Coke oven gas firing CHP plant
Kenny Hu, Area Manager, Power Generation, Solar Turbines International Co., Singapore

Co-Author: Pen Yu Cheng, Shanghai Mariso Gas Turbine Service Co., P.R. China

Design and implementation of a 120 MW coal mine methane fired power plant in Shanxi province, People's Republic of China
Jeffrey L Pierce, P.E, SCS Energy, USA

Co-Author: Li Zhang Liang, Shanxi Jincheng Anthracite Mining Company, P.R. China

Afternoon 14:00 – 16:30

Strategic Session: Room 205

Market status & future developments

Chairman: Chris Raczkowski, Managing Director, Azure International, P.R. China

*Forming the right policy to meet future energy needs
Dr. Philip Andrews-Speed, Director, Centre of Energy, Petroleum and Mineral Law & Policy University of Dundee, UK

Crystal gazing at China's future of the electric power industry: major trends in 2006 and in 2020
Joseph Jacobelli, Senior Director, Head of AsiaPac Utilities Research, Merrill Lynch (Asia Pacific) Limited, Hong Kong SAR

Panel Discussion: Facing near term challenges
• Joseph Jacobelli, Merrill Lynch (Asia Pacific) Limited, Hong Kong SAR
•*Dr. Philip Andrews-Speed, Centre of Energy, Petroleum and Mineral Law & Policy University of Dundee, UK
•*Prof. Daojiong Zha, Centre for International Energy Security, Renmin University, P.R. China
•*Hu Jing Yan, Foreign Investment, Ministry of Commerce, P.R. China
•*Li Zhang Liang, Shanxi Jincheng Anthracite Mining Company, P.R. China

Technical Session: Room 204

Power generating technologies II

Chairman: Jason MacDowell, Principal Consultant, GE Energy, P.R. China

Technical features and operations 900 MW supercritical tower type boiler
Wei Zhong Feng, Deputy General Manager, Shanghai Waigaoqiao No. 3 Power Generating Co. Ltd., P.R. China

Co-Author: Gao Zi Yu, Shanghai Boiler Works, Ltd., P. R. of China

Supercritical boiler options for firing low volatile Chinese coals
Dr. Pengzhi Jiang, Technical Manager, Proposal, Foster Wheeler, P.R. China

The best dry main cooling system for steam condenser
Akbar Adibfar, Mechanic Senior Engineer, MAPNA Group, Iran

Plant operation & maintenance

Black Point power station: a journey to achieve world class reliability
Chum Ka Yeung, Station Manager, Black Point Power Station and Penny's Bay Power Station, CLP Power Hong Kong Limited, Hong Kong SAR

Co-Author: PANG Wai Kwong, Stephen, CLP Power Hong Kong Limited

Alstom steam turbine retrofit solutions for the Chinese generating fleet
Angus Grahamslaw, Retrofit Development Manager, Alstom Power Ltd, UK

Control systems technology for the Yuhuan ultra-supercritical power plant
Paul Tong, Senior Engineer, Emerson Process Management, USA

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Shanhong Wu, Emerson Process Management, P.R. China