Comparison and Discussion of USEPA/GMI Feasibility and Prefeasibility Studies: Songzao, Naryn Sukhait, and Baganuur

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Mongolia Coal Mine Methane Recovery and Utilization

Ulaanbaatar, Mongolia
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Presentation Outline

- Introduction
- Nahryn Sukhait Prefeasibility Study
- Baganuur Prefeasibility Study
- Songzao Prefeasibility Study
- Project Comparison and Key Points

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INTRODUCTION

Introduction

- Feasibility and prefeasibility studies mentioned in this presentation were developed in support of the Global Methane Initiative (GMI) by Raven Ridge Resources (RRR) under contract to the United States Environmental Protection Agency's (USEPA) Coalbed Methane Outreach Program (CMOP)
- In each case, these studies have been used by the mine operators for discussion and project planning
- The feasibility and prefeasibility studies are also useful as case studies and can be used as templates for similar mines.

FEASIBILITY STUDY: CMM USE AT SONGZAO COAL AND ELECTRIC COMPANY CHONGQING, CHINA

Challenges and Considerations of Methane Resources at Songzao Mines

- Songzao Coal and Electric Company Ltd. (SCEC) identified and targeted for LNG using drained methane and/or VAM project by Methane to Markets (presently GMI)
- Songzao coal basin is remote and located in mountainous terrain, slopes are steep
- SCEC mining complex extends ~25 km along the length of the basin. Six separate mines are producing and new mine construction underway at time of study
- Population is concentrated near mining development and roads connect mines along drainages
- Prime agricultural development neighbors mining in south and is important to local economy. Conflicts may arise over land use

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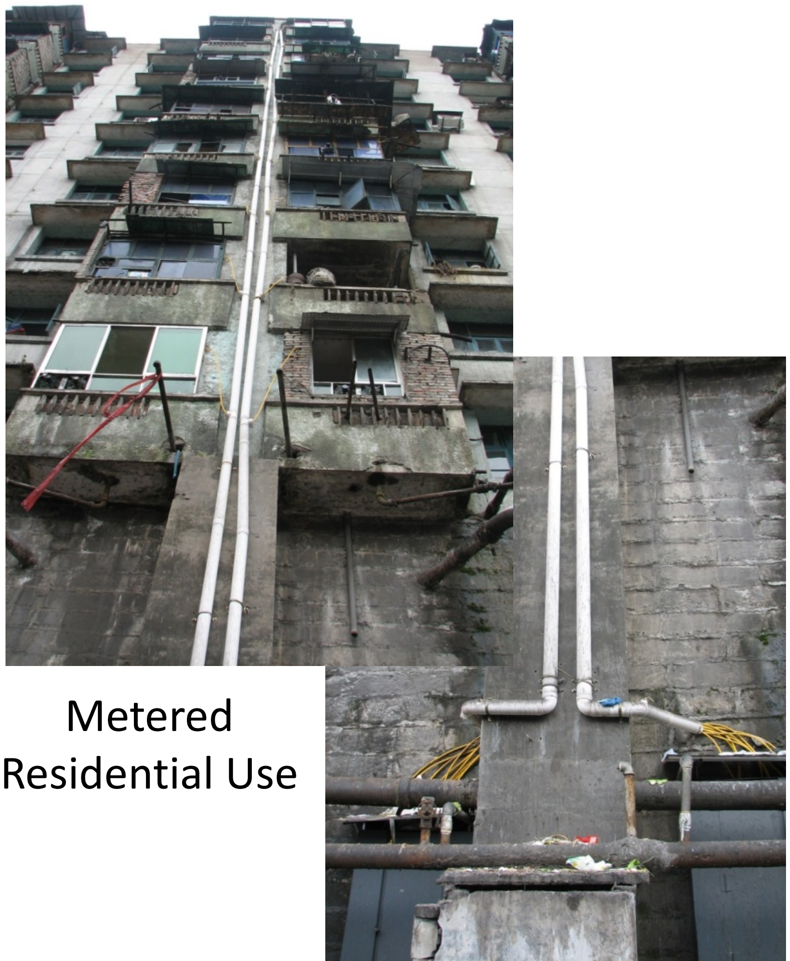
Challenges and Considerations of Methane Resources at Songzao Mines



Metered Residential Use

Unmetered Residential Use

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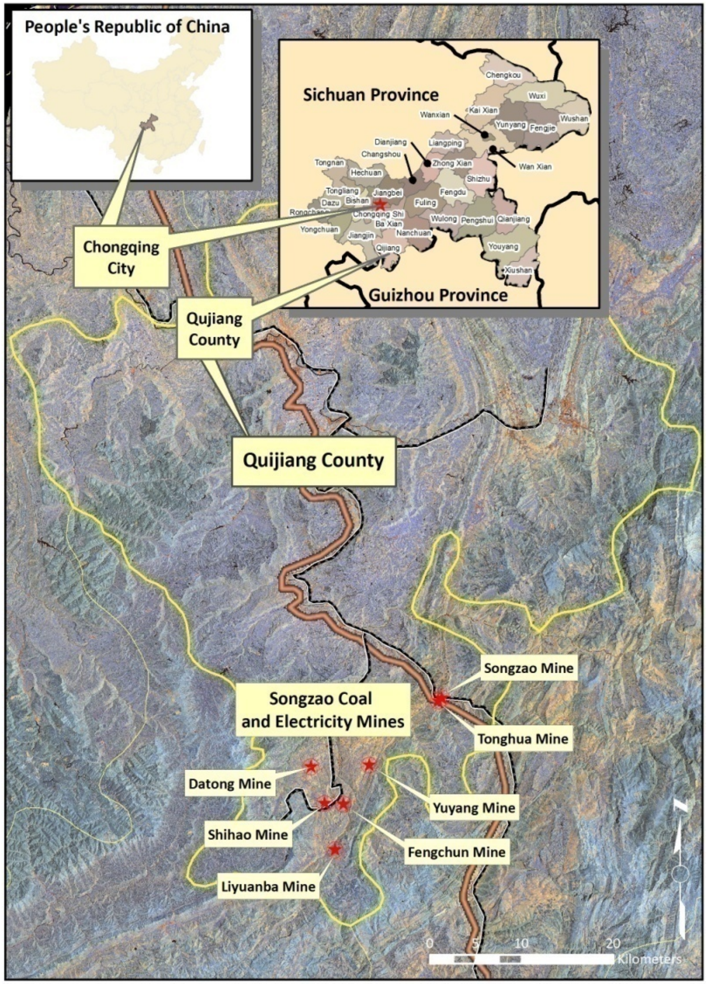
Feasibility Study Approach



- Submitted detailed questionnaire
- Met with mine players of CQEIG and SCEC. Visited each mine and potential construction sites.
- Detailed evaluation of previous studies.
- Conducted market analysis, gathered costs for equipment and construction.
- Drafted prefeasibility study
- Reported results to CQEIG and SCEC upper management
- Management chose best end use option(s) and RRR finalized conceptual design and costing
- Revised economic analysis, drafted, and submitted final report; the report is available in English and Chinese

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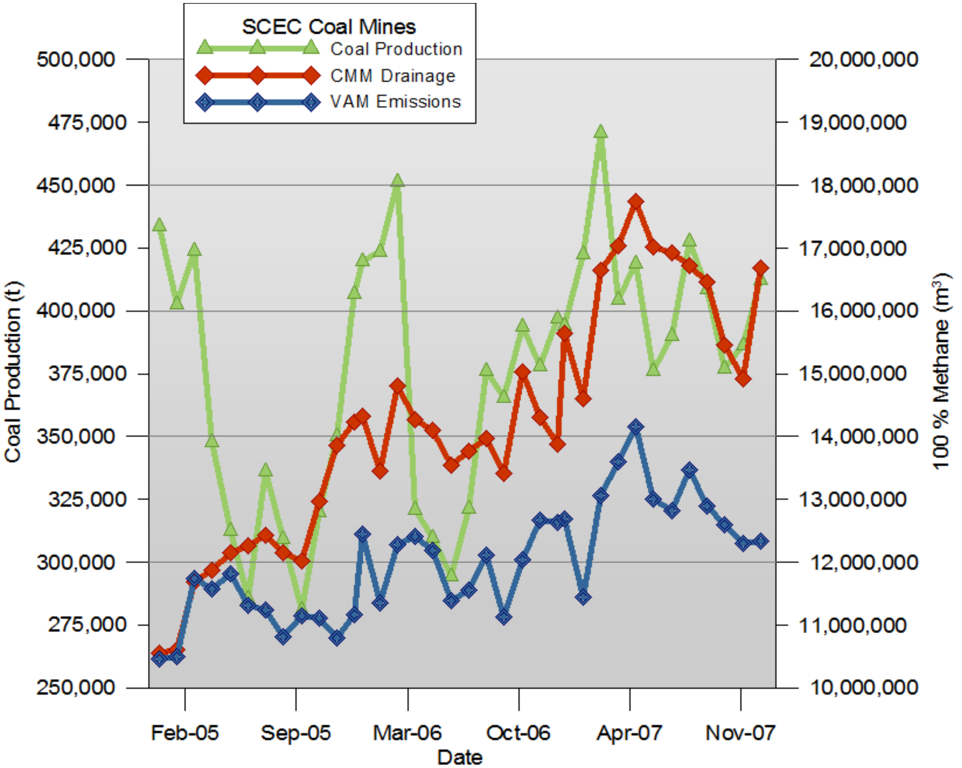
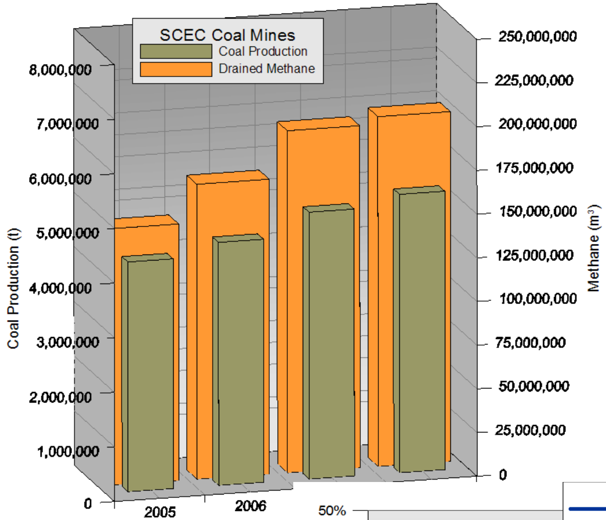
Trends in SCEC Coal and Gas Production

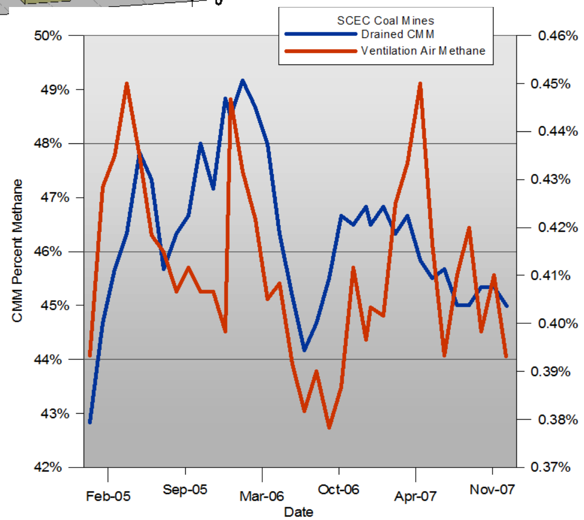
- Plans are underway to increase drained gas concentration and volume
- Coal production may increase to nearly 9 million tons per annum over the next 10 years
- Gas production may increase to over 300 million cubic meters per annum



Input Probability Distributions for Forecasting Gas Available for New Project End Use

- Coal production (based on plans for expansion)
- Gas drained per tonne of coal mined
- Gas concentration
- VAM emitted
- VAM concentration
- Ratio of gas drained to VAM emitted (drainage efficiency)
- Gas Used at CMM power facilities
- Residential and Commercial Use (metered and unmetered)





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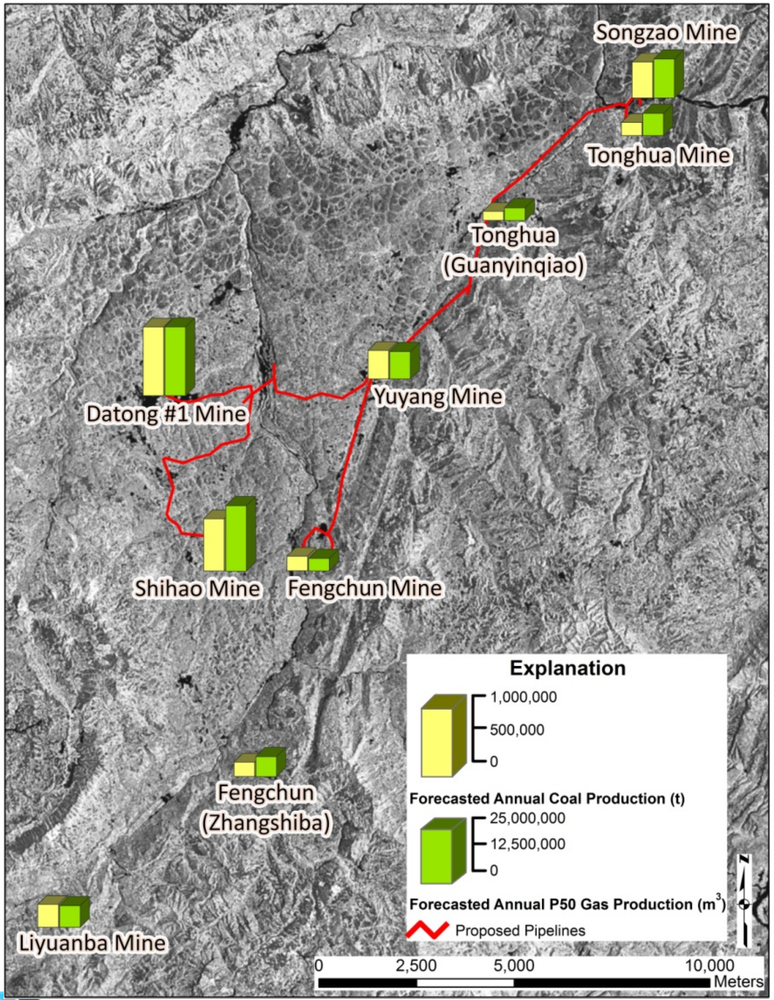
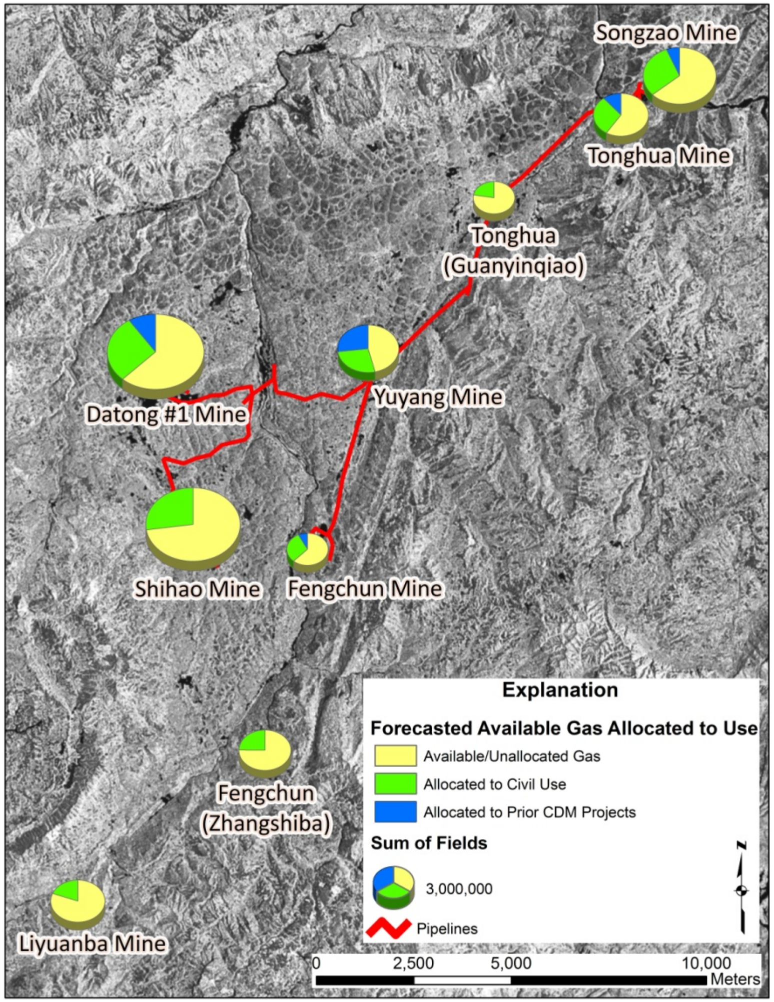
Forecast of Coal, Gas Production and Use





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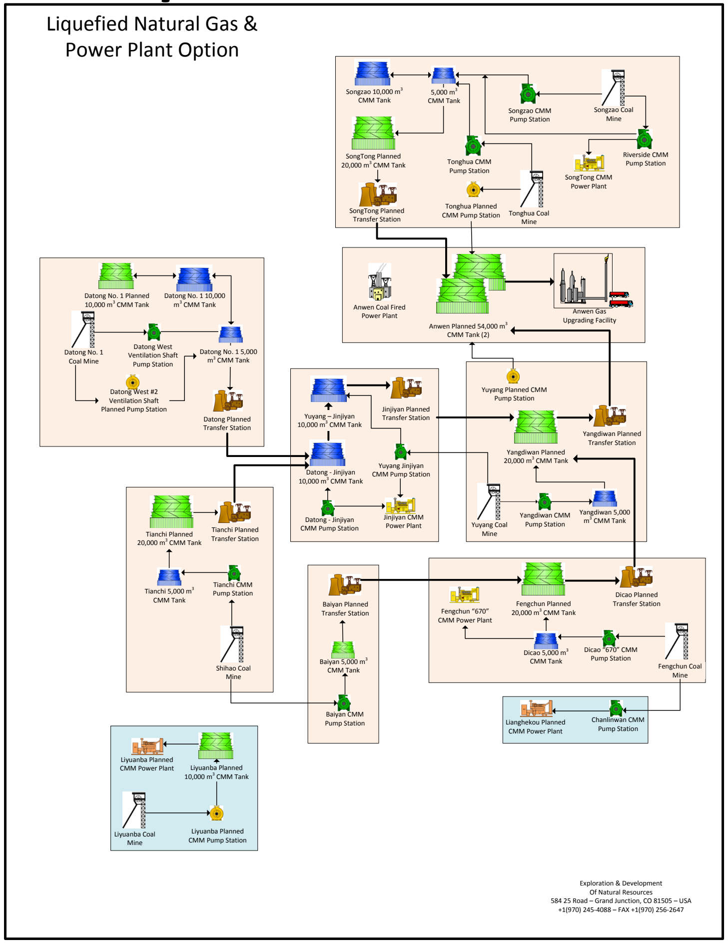
End-use Options and Optimized Scheme

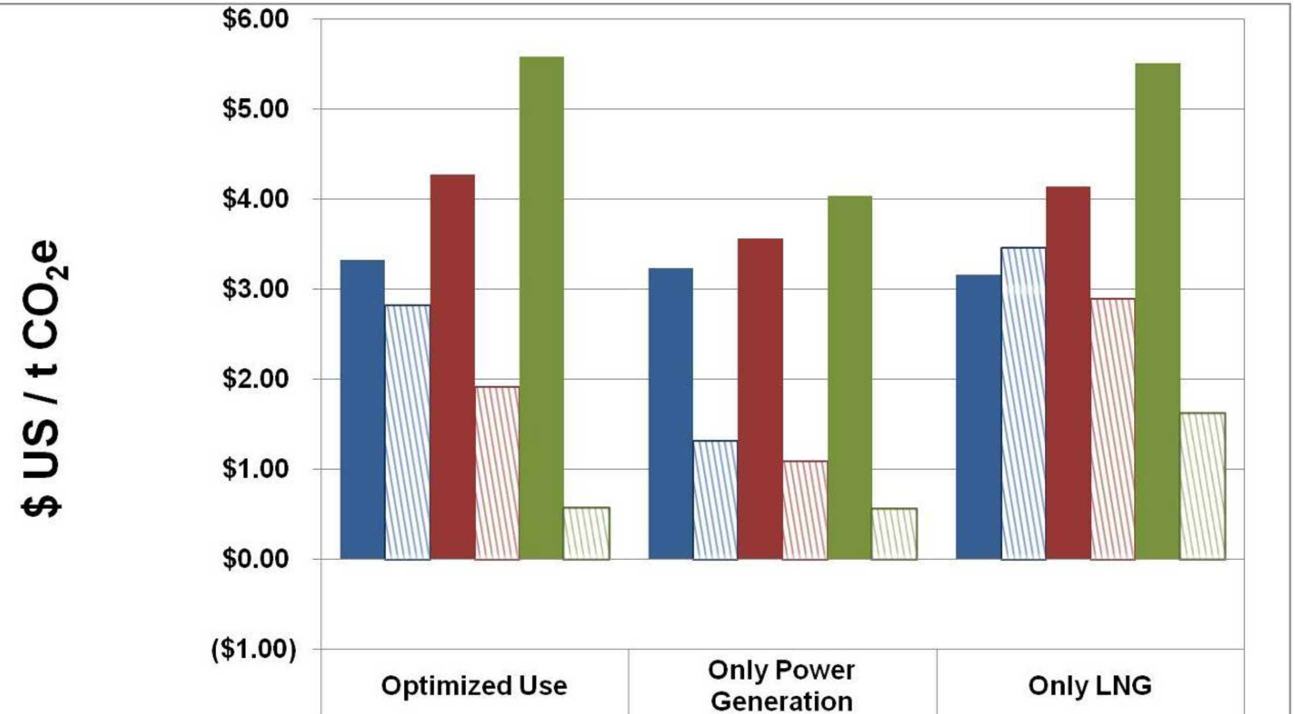
End-use Options

- Power Generation Only
- LNG Only
- Optimized mix of LNG and power production

Optimized Scheme



CAPEX and NPV per tCO_2e Reduced for Each End-use Option



	Optimized Use	Only Power Generation	Only LNG
p10 CAPEX $s / t CO2e	$3.33	$3.24	$3.16
p10 $s NPV / t CO2e	$2.82	$1.32	$3.46
p50 CAPEX $s / t CO2e	$4.28	$3.57	$4.14
p50 $s NPV / t CO2e	$1.91	$1.09	$2.89
p90 CAPEX $s / t CO2e	$5.59	$4.04	$5.52
p90 $s NPV / t CO2e	$0.56	$0.55	$1.62

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Conclusions and Lessons Learned

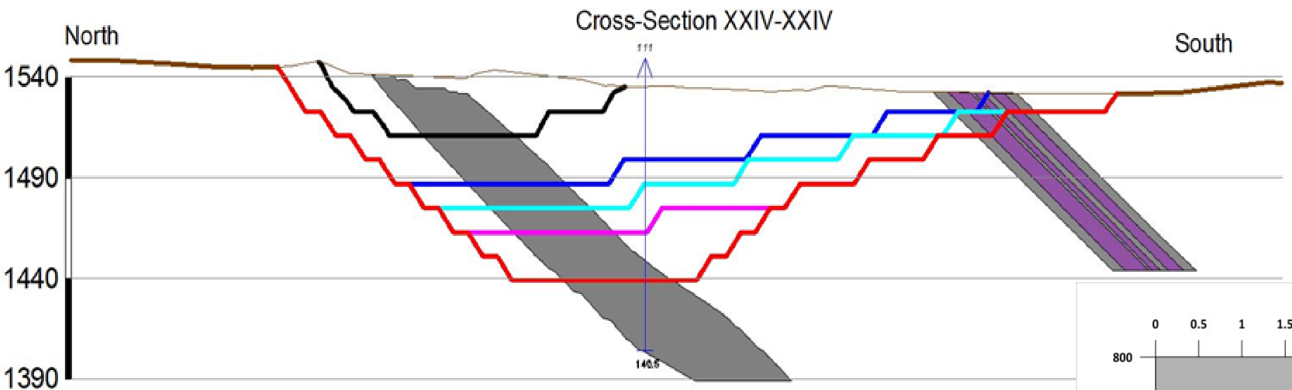
- For 15 year life of project and p50 gas production forecast :
  - 44.1 million tonnes of CO_2e emission reduction average 3 million tonnes per annum after 2015 (emissions reduction are less than 2 million tonnes CO_2e until full production is achieved and equipment is installed)
- Range in investment from $150 to 225 million USD
- Project economic performance is most sensitive to gas sales price.
- The project NPV is sensitive to post 2012 emissions reductions market. VERs or CERs are important to overall economic performance.
- Project easily demonstrates financial additionality under present economic conditions in China.
- Civil use of gas is often not metered, and prices are artificially low, often free. Therefore, cost recovery of drained gas and subsequent treatment is difficult. Difficult to determine costs and sales prices

PREFEASIBILITY STUDY:
CMM RESOURCES AND END USE OPTIONS AT NAHRYN SUKHAIT MINE

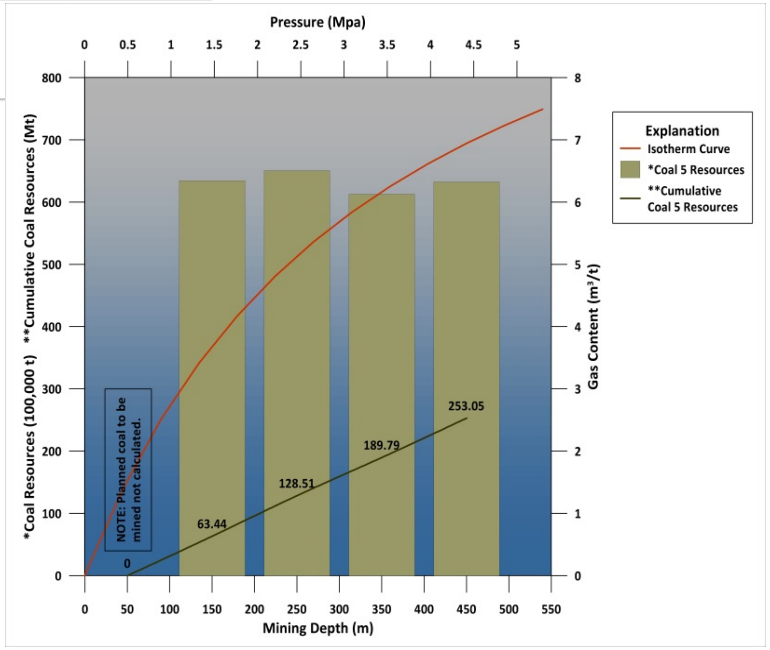
Methane Resources at Naryn Sukhait Mine

- Initial investigations of coal characteristics and gas content, indicate coal mine methane (CMM) may occur at Naryn Sukhait Mine
- Open pit production capacity is 3 million metric tons per year and is expected to increase to 5-8 million tons per year upon installation of a railway system to transport coal
- Minable coal resources estimated to be contained by Coal Seam 5 are 225 million metric tons from surface to -150m depth throughout the licensed area

Example Cross-Section Used in Coal and Gas Resource Estimations



- Coal resources were estimated between -150m to -450m
- These limits comprise the limits of the coal resources that are likely to contain gas that will migrate up dip and be lost to the atmosphere if not pre-drained and used prior to dewatering and strata relaxation that will occur during the mining process
- The cumulative Coal Seam 5 resources calculated between -150m and -450m is **253.05 million tonnes**



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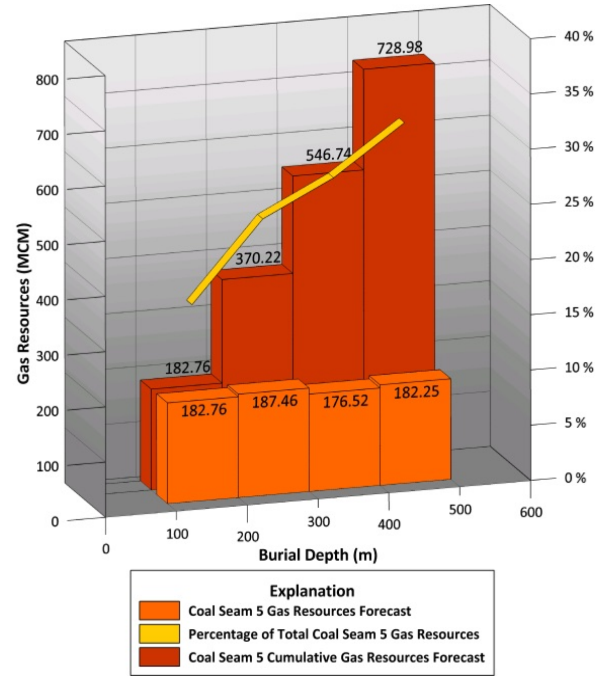
Gas Resources and Production Modeling

- Raton Basin coal in south-central Colorado are similar in rank and depth, have comparable gas contents, and have been exposed to similar tectonic activities during its depositional history
- Long history of CBM development in the Raton Basin with extensive production from the coals of the Raton Formation were used to forecast a distribution of production profile outcomes (p10, p50, p90)
- 12 vertical wells from which gas will be drained from the down dip extent of the planned mining area were proposed



Forecast GIP for Proposed Pre-mine Drainage Wells

Percentile Class	p90	p50	p10
GIP per 32.4 hectare well location	5,639,982	12,073,142	18,043,670
Potential Drainage Efficiency	37%	57%	85%

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End-use Option and Economic Performance

On-site Power Generation

- Install a CMM-fueled internal combustion power generation facility in close proximity to the mine's surface facilities
- Designed to supply power to the mine as well as sell any unused electricity to the grid
- With peak production, 68,400 MWh of electricity could be generated
- 8.55 MW of combined electrical and thermal generating capacity

Economic Performance

Power Generation Option	
Evaluation Scenario	Base Case
Annual Operating Hours	8,000
Gas Forecast-Project (million m^3)	144.9
Total CAPEX (million USD)	7.77
Tons of CO_2e (x thou.)	187.9
Carbon Sales Price (USD)	1.00
Plant Size (MW)	8.55
CAPEX/Tons CO_2e	0.04
Electricity Sales Price (₮/kWhr)	105
NPV/Tons CO_2e	0.02
NPV (Million USD)	3.31
IRR (%)	16.1%

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Conclusions and Recommendations

- Installation of a CMM drainage system could produce 144.9 million m^3 methane over 15 years

On-site Power Generation

- 68,400 MWh of electricity generated annually
- CAPEX of 7.77 million USD with an IRR of 16.1% and a payback period of 6.75 years
- Carbon emissions reductions of 187.9 thousand tons of CO_2e over the project's 15 year life

Recommendations

- A comprehensive data collection program should be carried out and incorporated into mine's geologic model
- Commission a technical and economic feasibility study that will determine the potential for developing a cost effective plan to construct and operate a CMM-fueled power generation facility

PREFEASIBILITY STUDY: CMM RESOURCES AND END USE OPTIONS AT BAGANUUR COAL MINE

Methane Resources at Baganuur Mine

- Initial investigations of coal characteristics and gas content, indicate coal mine methane (CMM) may occur at Baganuur in a manner similar to mines in the coalbed methane (CBM)- rich Powder River Basin (PRB) of the US
- Mine plans to increase the present rate of mining from 3 million metric tons annually to 6 million metric tons per year in the near future
- Baganuur is an established presence as an important and reliable coal mine, supplying most of Mongolia’s central region coal demand for use by in the country’s main electricity grid, the Central Electricity System (CES)
  - Geographically located to allow a CMM project to provide additional, gas-fueled electricity to the CES electricity grid

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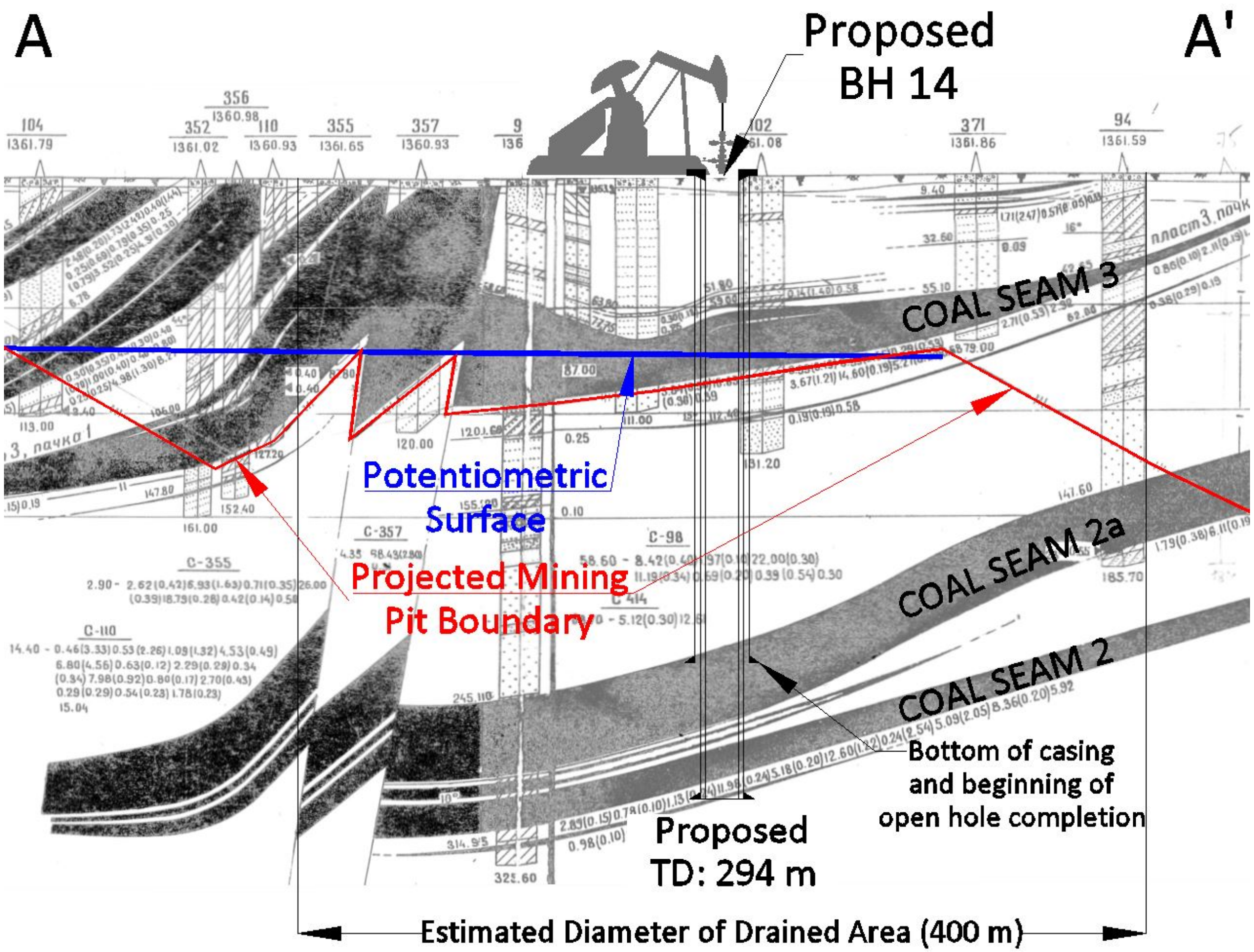
Mine Cross-Section showing Proposed Borehole



- MRAM estimates 599 million tonnes of coal resources within the entire Baganuur mine property
- Proposed 19 vertical pre-mine boreholes on the western side of the mine pit based on analysis of geologic maps and hydrologic data from mine
- Potentiometric surface was used to assure proposed boreholes were sited below this surface and within mineable coal seams

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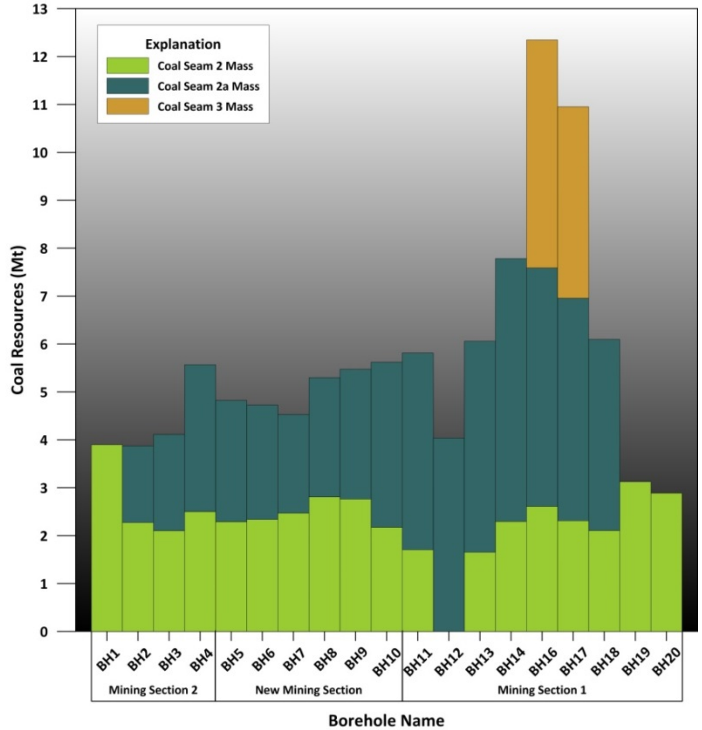
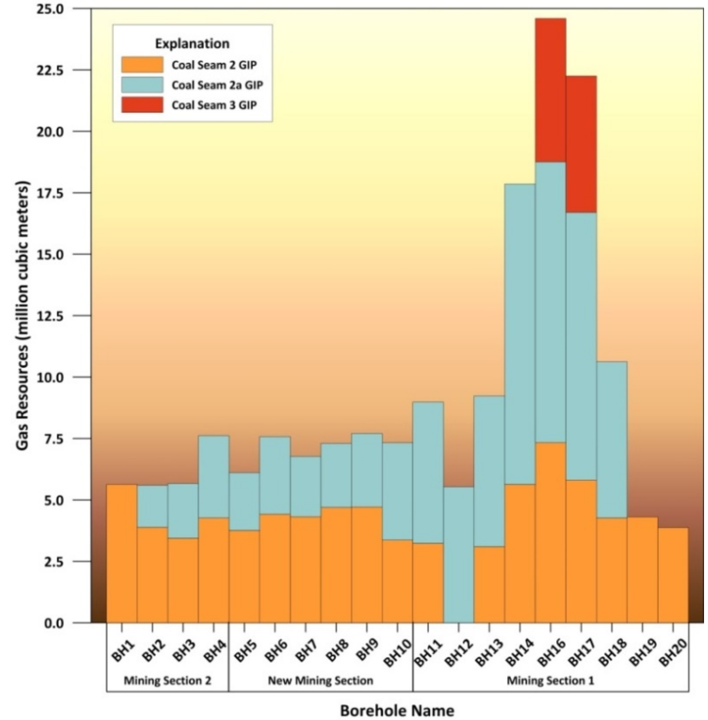
Coal and Gas Resources within Proposed Boreholes





Production Forecasts	YEAR									
	1	2	3	4	5	6	7	8	9	10
Annual Gas (million m^3)	2.05	4.93	7.35	9.27	8.38	6.48	5.29	4.44	3.69	3.13
Annual Water (thousand m^3)	31.3	70.3	104.0	132.2	117.8	98.5	83.7	71.3	62.0	52.5

- 19 well production forecasts over 10 year project life
- **55.01 million m^3 methane**
- **823.7 thousand m^3 water**
- 32% drainage efficiency

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End-use Option and Economic Performance

On-site Power Generation

- Install a CMM-fueled internal combustion power generation facility in close proximity to the mine's surface facilities
- Designed to supply power to the mine as well as sell any unused electricity to the grid
- With peak production, 40,000 MWh of electricity could be generated
- 5.0 MW of combined electrical and thermal generating capacity

Economic Performance

Evaluation Scenario	Base Case-p50
Annual Operating Hours	8,000
Gas Forecast-Project (million m^3)	54.3
Water Forecast-Project (million m^3)	0.8
Total CAPEX (million USD)	5.41
Tons of CO_2e (x thou.)	104.5
Carbon Sales Price (USD)	$1.00
Plant Size (MW)	5.00
CAPEX/Tons CO_2e	0.05
Electricity Sales Price (Tugrik/kWh)	130
Electricity Sales Price ($/kWh)	$0.09
NPV/Tons CO_2e	0.02
NPV (Million USD)	1.93
IRR (%)	22.7%
Return on Investment (%)	35.6%
Payback Period (years)	4.32

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Conclusions and Recommendations

- Installation of a CMM drainage system could produce 55.01 million m^3 methane over 10 years

On-site Power Generation

- 40,000 MWh of electricity generated annually
- CAPEX of 5.41 million USD with an IRR of 22.7% and a payback period of 4.32 years
- Carbon emissions reductions of 104.5 thousand tons of CO_2e over the project's 10 year life

Recommendations

- A comprehensive data collection program should be carried out and incorporated into mine's geologic model
- Commission a technical and economic feasibility study that will determine the potential for developing a cost effective plan to construct and operate a CMM-fueled power generation facility

PROJECT COMPARISON AND KEY POINTS

Project Comparison

MINE	STATUS OF MINE DEVELOPMENT (coal type)	STATUS OF CBM/CMM EXPLORATION	METHANE RESOURCES ESTIMATE	GAS PRODUCTION	POTENTIAL EMISSIONS	END-USE OPTIONS
Songzao	mature-underground (anthracite)	mature	7 Bm^3 entire mining property	100 Mm^3/year	350Mm^3/y all mines in 2007	electricity production direct use, LNG
Nahryn Sukhait	young-surface (bituminous)	early	729 Mm^3 one seam	none	729Mm^3 if no project	electricity production
Baganuur	mature-surface (subbituminous)	early	175 Mm^3 pilot area	none	175 Mm^3 pilot area	electricity production

Key Points

- Data needed for prefeasibility studies need not be expensive to acquire and training for collecting the data and testing samples is not costly
- Surface mine methane recovery employs technology that is proven and available in Mongolia
- Energy market conditions will support development of CMM/CBM in Mongolia; environmental concerns provide justification for government facilitation
- Designing underground coal mines to coproduce methane is less expensive and easier than waiting until the mine is in the mature stage of its life cycle

Thank you!

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