CMM Development at the Amasra Mine, Turkey

Global Methane Forum

March 28-30, 2016

Washington, D.C.

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Global Methane Initiative

Presentation Outline

- Project Overview and Background
- Gas Drainage System Design
- Reservoir Simulation and Gas Production Forecasting
- Market and Economic Assessment
- Project Finance

Project Overview and Background

Project Overview and Background

- The Amasra mine is located in northern Turkey, along the Black Sea Coast and is owned and operated by a division of Hattat Holdings A.Ş., a large Turkish industrial and energy company;
- The mine is scheduled to go into production later this year to fuel a mine-mouth power plant;
- The coal seams are known to be gassy and methane emissions into the mine workings are expected to be high;
- With funding assistance from USEPA and GMI, a pre-feasibility study was performed to examine the application of directional drilling for methane control and CMM capture;
- Following from the results of the study, TD Bank and the U.S. Export-Import Bank (EXIM) are structuring a credit facility to provide $40 Million in senior debt through an export trade mechanism to fund the first stage of project development.

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Observations – Amasra Mine

- Multiple coal seams (up to 15 seams), with mineable seams generally 1-3 m thick;
- Multi-seam longwall mining is planned;
- *Interburden*: Varies, 1-40 m between seams.
- *Overburden Depth*: 700-800 meters
- *Coal rank:* High Vol. Bituminous A-B
- *Gas Content*: 6-13 m^3/ton
- *Permeability:* ~1 MD
  - Will require longer drainage times and in-seam boreholes to achieve reduction of methane levels in advance of mining
- Overlying coal seams >250 m above EC100 seam
- Long hole directional drilling will have great application at this mine property due to multi-seam longwall mining.

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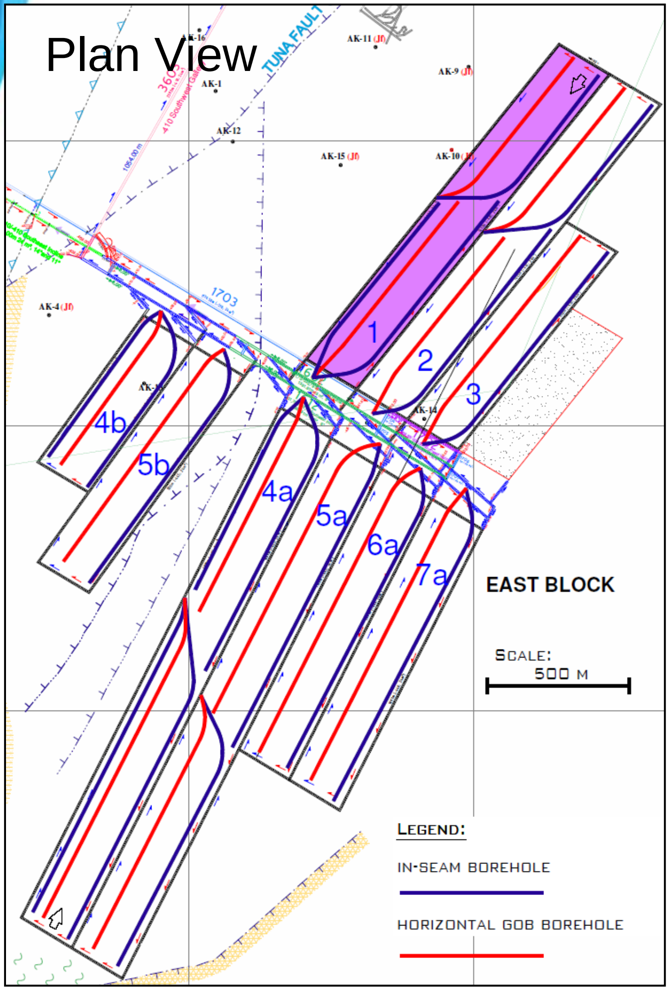
Gas Drainage System Design

Proposed Gas Drainage Approach



- Drilling approach utilizing a combination of in-seam drilling in advance of developments and gob gas drainage via horizontal gob boreholes.
- Flanking in-seam boreholes to shield and drain gas ahead of development galleries.
- Horizontal gob boreholes above the formation of gob as longwall mining progresses.
- Coordination of drilling operations with mining sequence.

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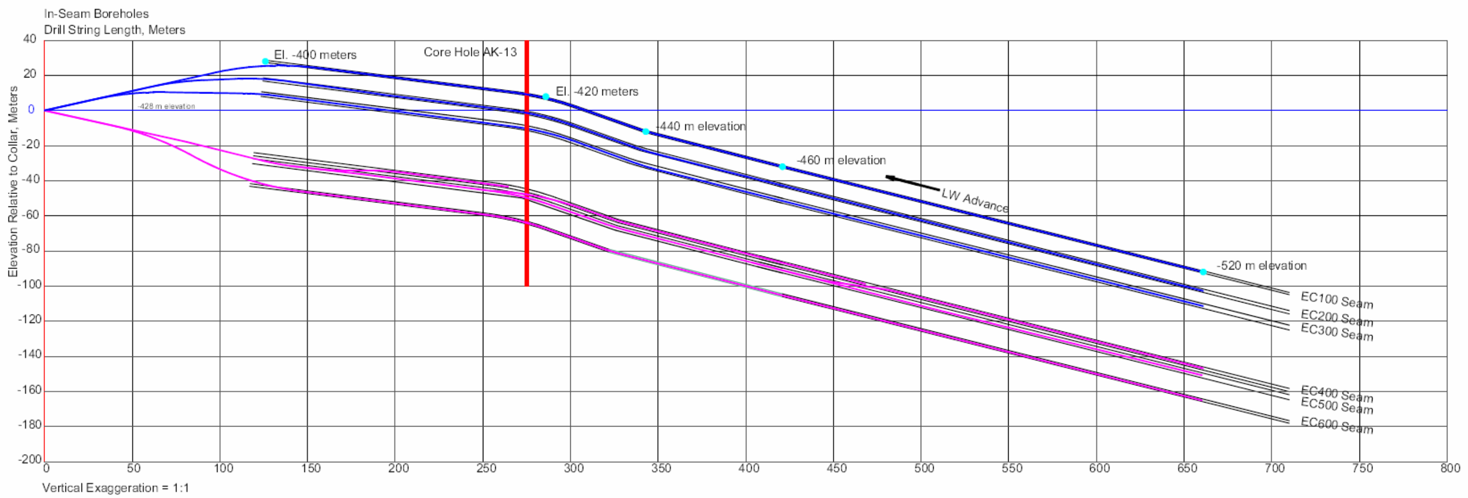
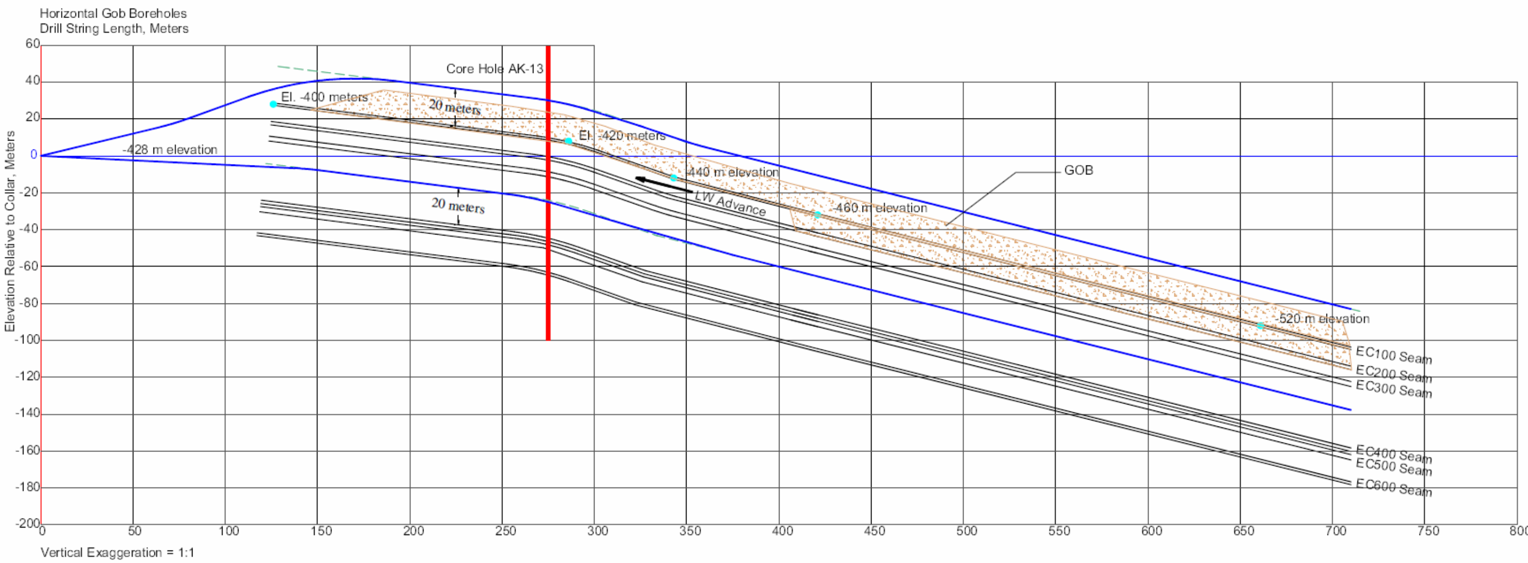
In-Seam Gas Drainage Boreholes

- Drilled in advance of gate road gallery advancement.
- Boreholes are drilled in parallel to advance and flank the gate road developments.
- Coordination of drilling operations with mine plans is key to the success of an in-seam drainage program.
- Depending on drilling conditions and hole deviations, boreholes can be drilled up to 1500+ meters.



Horizontal Gob Boreholes

- Boreholes placed > 5 times mining height above the rubble zone to remain intact after undermining. Typical placement is 20 to 30 m above the mining level.
- Drilled parallel to the mining direction on the up-dip and tailgate (ventilation return) side of the longwall panel.
- Due to separation between EC300 and EC400 (up to 44 meters), it is recommended that an HGB be placed between these seams. It would not be expected for the gob to extend through EC300 and EC400 interburden after LW mining.
- Upon completion, boreholes are typically placed on vacuum (-10 to -20 kPa) once mining progresses.



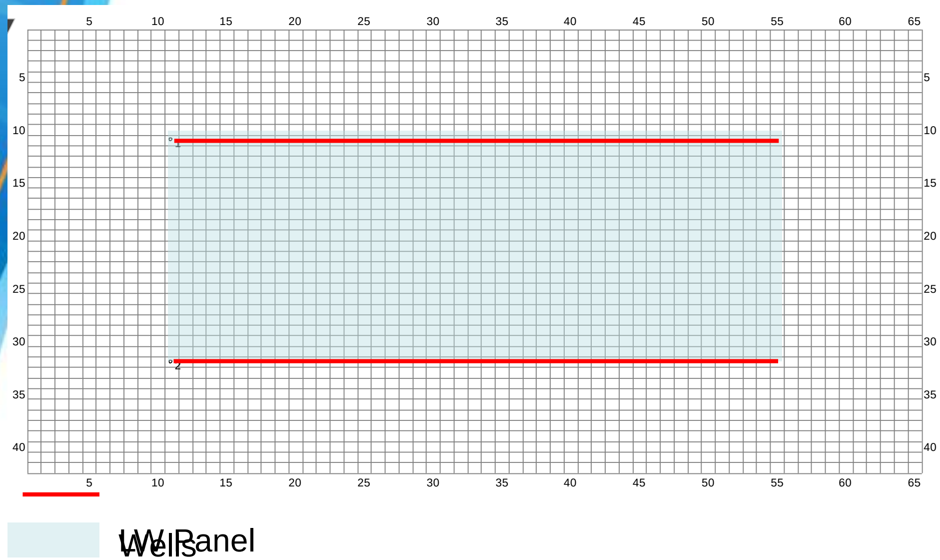
Reservoir Simulation and Gas Forecasting

Reservoir Parameters for In-Seam Borehole Simulation

Reservoir Parameter	Value(s)
Avg. Coal Depth, m	500
Avg. Coal Thickness, m	2
Coal density, g/cc	1.68
Pressure Gradient, kPa/m^3	9.80
Initial Reservoir Pressure, kPa	4896
Initial Water Saturation, %	100
Langmuir Volume, m^3/tonne	13.81
Langmuir Pressure, kPa	1966
In Situ Gas Content, m^3/tonne	9.85
Desorption Pressure, kPa	4896
Sorption Times, days	17
Fracture Spacing, cm	2.54

Reservoir Parameter	Value(s)
Absolute Cleat Permeability, md	0.5
Cleat Porosity, %	2
Relative Permeability	Curve
Pore Volume Compressibility, kPa^{-1}	27.6 x 10-4
Matrix Shrinkage Compressibility, kPa^{-1}	6.9 x 10-6
Gas Gravity	0.6
Water Viscosity, (mPa·s)	0.44
Water Formation Volume Factor, reservoir barrel per stock tank barrel (RB/STB)	1.00
Completion and Stimulation	-2 Skin
Pressure Control	-13.5 kPa

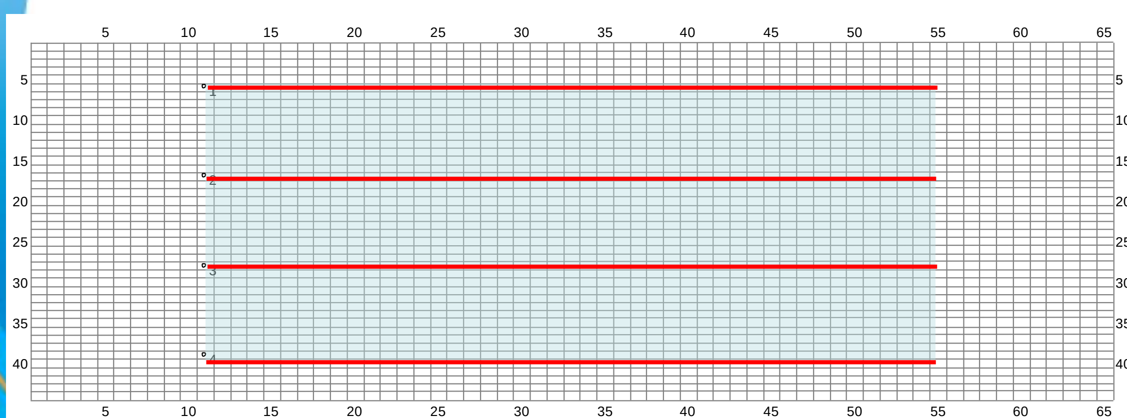
Estimating Production from In-Seam Gas Drainage Boreholes: COMET® Model Layout



2 Wells Per Panel Case

Model length = 3,317 ft (1,011 m)
Model width = 1,641 ft (500 m)
Total model area = 125 ac (51 ha)

Number of wells: 2
Lateral length: 2,297 ft (700 m)
Spacing between wells: 820 ft (250 m)



4 Wells Per Panel Case

Model length = 3,317 ft (1,011 m)
Model width = 1,094 ft (333 m)
Total model area = 83 ac (34 ha)

Number of wells: 4
Lateral length: 2,297 ft (700 m)
Spacing between wells: 273 ft (83 m)

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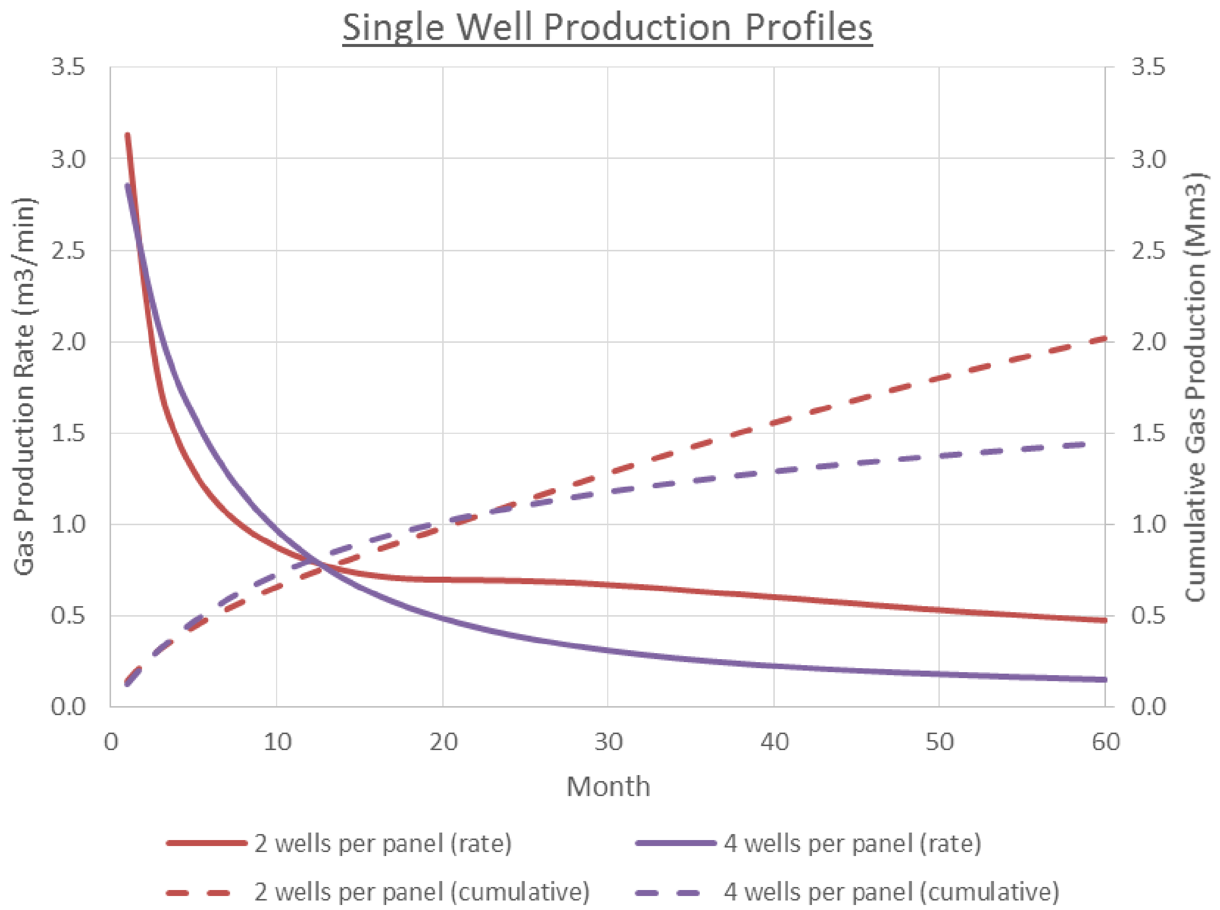
Simulated Gas Production Profiles



Simulated Reduction of Coal Seam Gas Content Over Time

2 Wells Per Panel

Production Duration	Cumulative Gas Production (Mm3)	Reduction in Gas Content* (% Reduction)
After 6 Months	0.97	10%
After 1 Year	1.45	15%
After 2 Years	2.20	21%
After 3 Years	2.26	27%
After 5 Years	2.32	35%

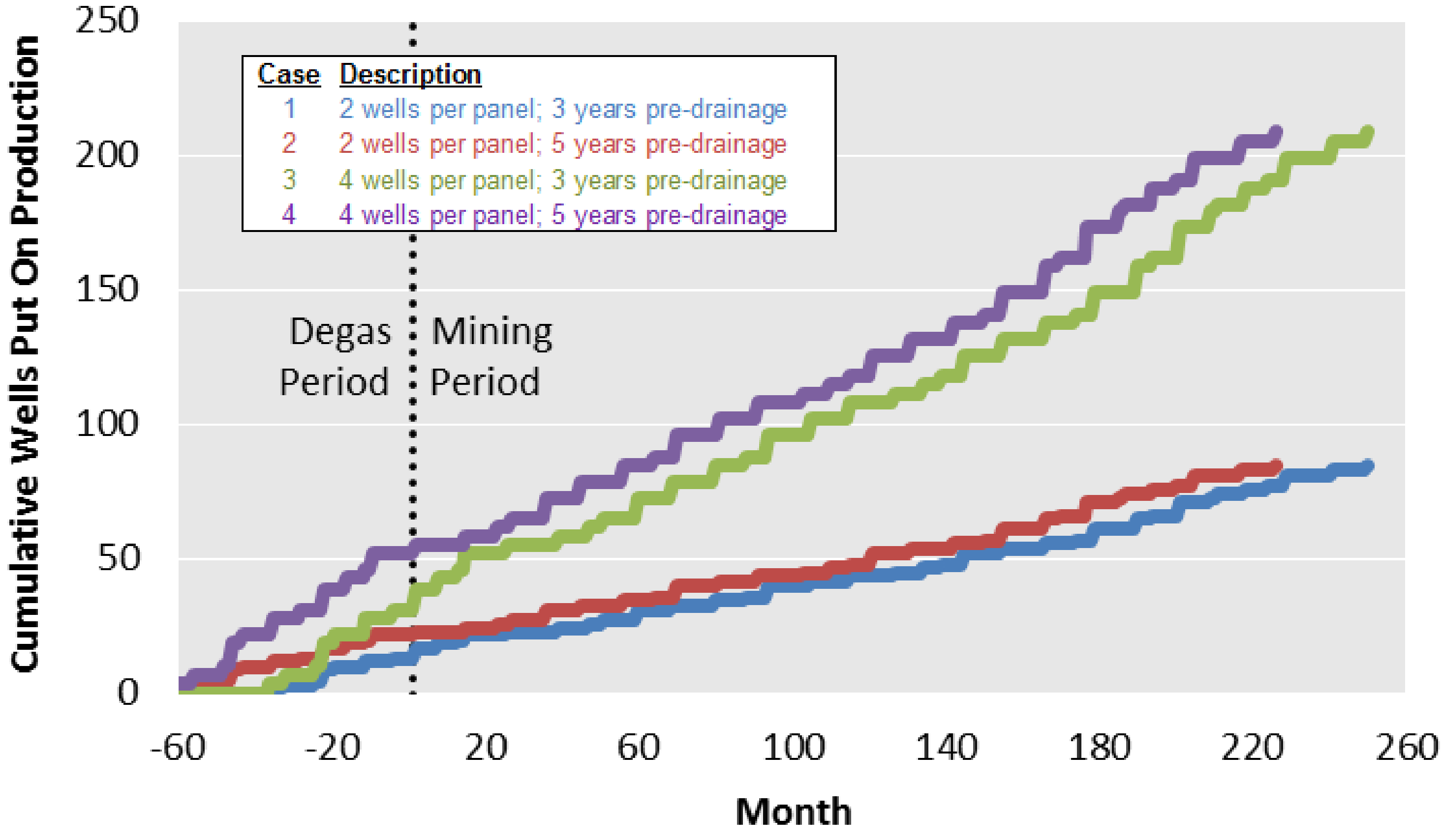
* Calculated from within longwall panel area only

4 Wells Per Panel

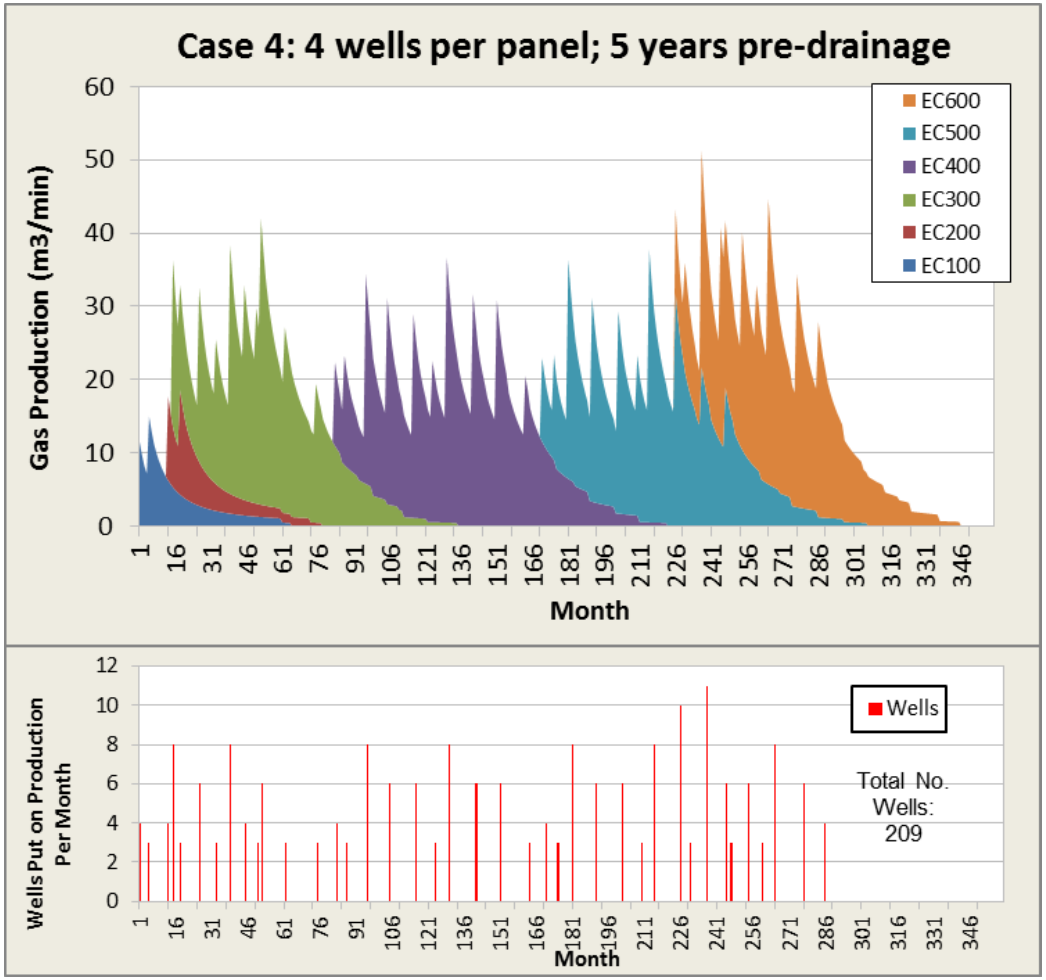
Production Duration	Cumulative Gas Production (Mm3)	Reduction in Gas Content* (% Reduction)
After 6 Months	2.12	29%
After 1 Year	3.21	42%
After 2 Years	4.36	56%
After 3 Years	4.42	63%
After 5 Years	4.49	70%

* Calculated from within longwall panel area only

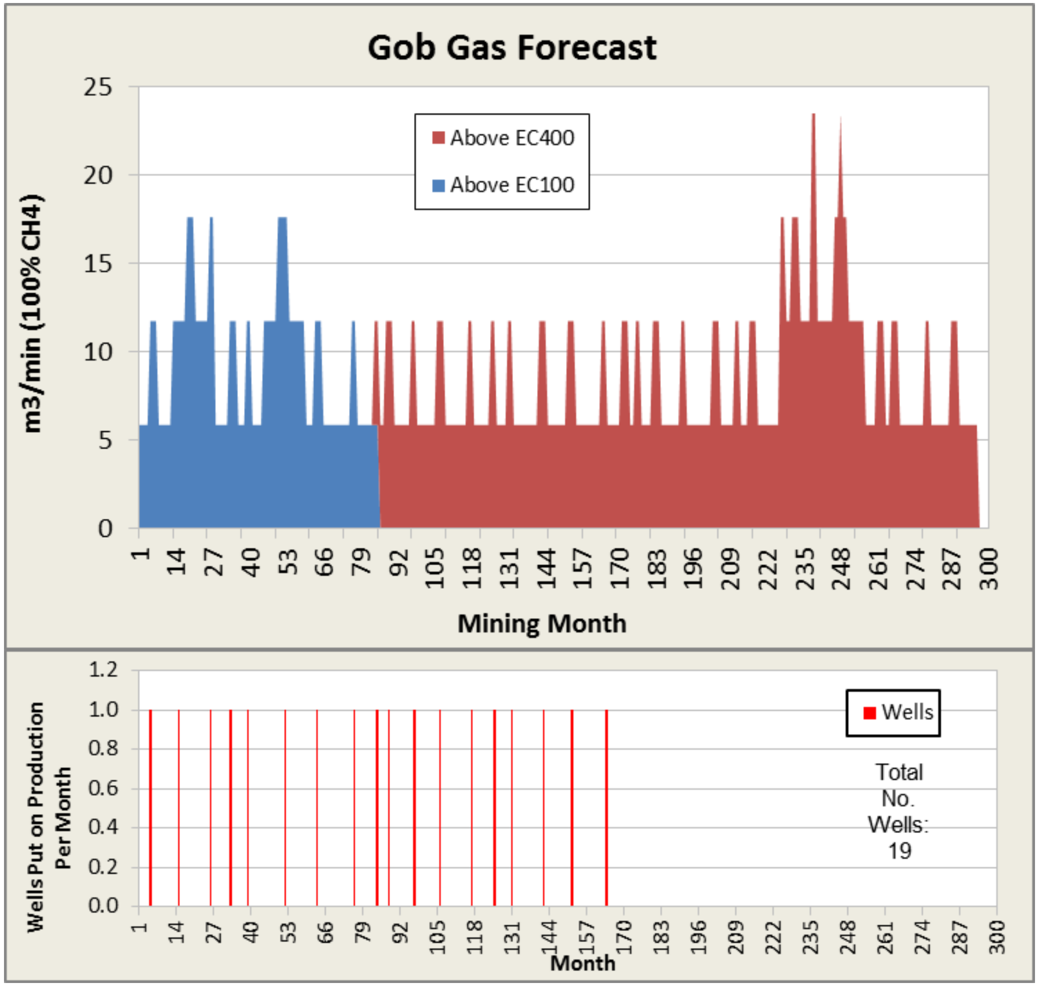
Well Schedule for Pre-Drainage Project Development



Pre-Drainage Gas Production Forecast



Gob Gas Production Forecast



Market and Economic Assessment

Market Information

- The primary markets available for a CMM utilization project for the Amasra Hard Coal Mine are power generation using internal combustion engines and vehicle fuel in the form of compressed natural gas (CNG).
- Given the relatively small CMM production volume during the first stage, as well as the requirement for gas upgrading, constructing a pipeline to transport the gas to demand centers would be impractical.
- Generating electricity on site is attractive, because the input CMM gas stream can be utilized as is, with minimal processing and transportation. Additional generating sets can be installed relatively cheaply and infrastructure for the power plant and distribution system is already planned.
- The mine’s power demand is estimated to be at least 32 MW, providing ample opportunity to offset power purchases with on-site generated electricity from CMM.
- Although the CMM-based power could be used on-site, the Amasra coal mine would likely remain connected to the grid to ensure an uninterrupted supply of electricity.
- As of the end of 2013 the average rate of electricity for industrial customers was EUR 0.0763/kWh (inclusive of all taxes and levies), equivalent to USD 0.1038/kWh at current exchange rates.

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Market Information (Continued)

- With respect to the market for transportation fuels, Turkey is known to have some of the highest gasoline prices of any country in the world.
- Current price for gasoline and diesel in Turkey is $2.38/l and $2.07/l (equivalent to $9.00/gal and $7.82/gal), respectively.
- While the CNG utilization option requires significant processing of the CMM gas stream to increase its methane concentration and remove contaminants, the current high price of transportation fuel in Turkey improves the economics of this utilization option.
- Based on ARI's gas supply forecasts, the mine could be capable of operating as much as 8.8 MW of electricity capacity or produce over 1.5 million Diesel Liter Equivalent (DLE) per month.

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Economic Assessment Methodology

- For each of the proposed project development cases, discounted cash flow analyses were performed for the upstream portion (i.e., CMM production) and the downstream portion (i.e., electricity generation or CNG production).
- A breakeven gas price was calculated in the upstream segment where the present value of cash outflows is equivalent to the present value of cash inflows. The breakeven gas price was then used in the downstream segments to calculate the fuel cost for the power plant and the feedstock cost for the CNG station.
- Likewise, breakeven electricity and CNG sales prices were calculated for the downstream segments, which can be compared to the current price of electricity or diesel fuel observed at the mine in order to determine the economic feasibility of each potential CMM utilization option.
- Results are presented on a pre-tax basis and the selection of a downstream utilization option is assumed to be mutually exclusive.

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Economic Assumptions for Upstream Project (CMM Supply)

CMM Supply Model Inputs

Case		**1**	**2**	**3**	**4**
Wells per Panel		2	2	4	4
Years of Pre-Drainage		3	5	3	5
PHYSICAL & FINANCIAL FACTORS					
Royalty	%	12.5%	12.5%	12.5%	12.5%
Price Escalation	%	3.0%	3.0%	3.0%	3.0%
Cost Escalation	%	3.0%	3.0%	3.0%	3.0%
Calorific Value of Drained Gas	MJ/m3	34.58	34.58	34.58	34.58
Calorific Value of Gob Gas	MJ/m3	26.60	26.60	26.60	26.60
CAPEX					
Drainage System					
Well Cost	$/well	90,300	90,300	90,300	90,300
Surface Vacuum Station	$/W	1.34	1.34	1.34	1.34
Vacuum Pump Efficiency	W/1000m3/d	922	922	922	922
Gathering & Delivery System					
Gathering Pipe Cost	$/m	131	131	131	131
Gathering Pipe Length	m/well	354	354	144	144
Satellite Compressor Cost	$/W	1.34	1.34	1.34	1.34
Compressor Efficiency	W/1000m3/d	922	922	922	922
Pipeline Cost	$/m	180	180	180	180
Pipeline Length	m	1,999	1,999	1,999	1,999
OPEX					
Field Fuel Use (gas)	%	10%	10%	10%	10%
O&M	$/1000m3	17.66	17.66	17.66	17.66

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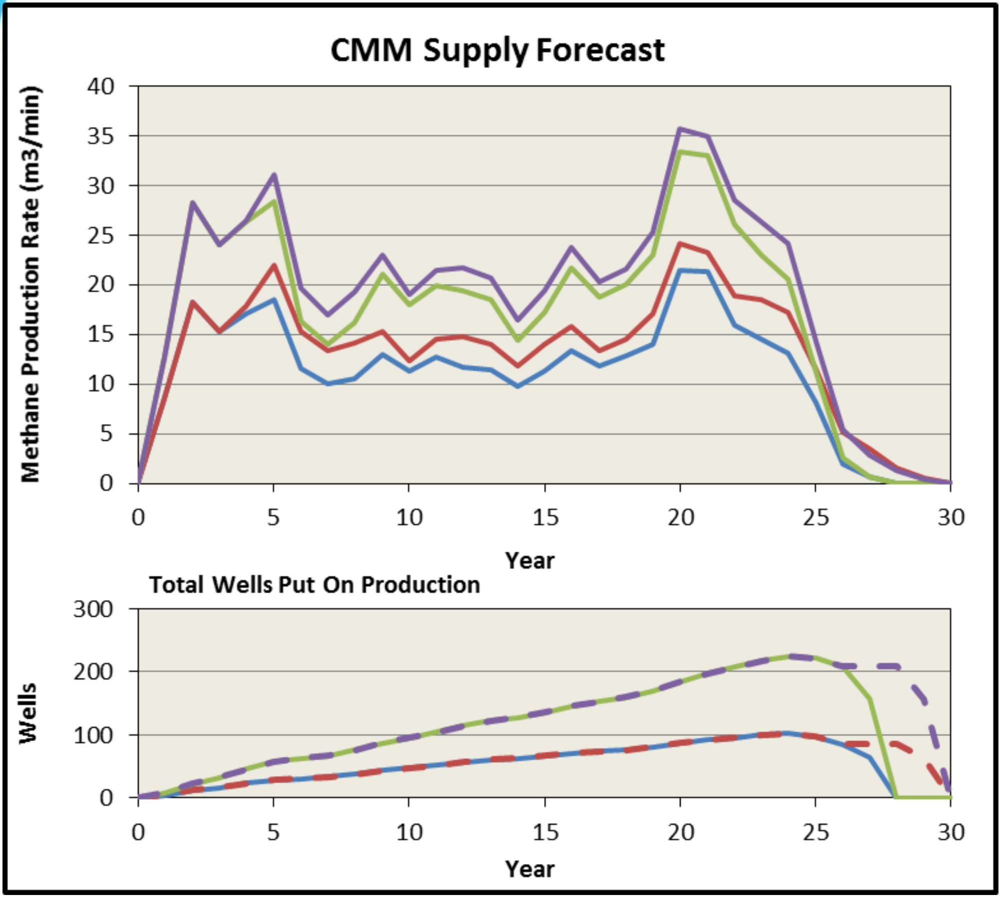
Summary of Economic Results CMM Supply



Case	Wells per Panel	Years of Pre-Drainage	Breakeven Gas Price $/1000m3
1	2	3	71.93
2	2	5	63.57
3	4	3	90.85
4	4	5	84.00

Case	Description
1	2 wells per panel; 3 years pre-drainage
2	2 wells per panel; 5 years pre-drainage
3	4 wells per panel; 3 years pre-drainage
4	4 wells per panel; 5 years pre-drainage

Economic Assumptions for Downstream Project (Power Supply)

Power Supply Model Inputs					
Case		**1**	**2**	**3**	**4**
Wells per Panel		2	2	4	4
Years of Pre-Drainage		3	5	3	5
PHYSICAL & FINANCIAL FACTORS					
Generator Efficienty	%	0.35	0.35	0.35	0.35
Run Time	%	0.90	0.90	0.90	0.90
CAPEX					
Power Plant	$/kW	1,300	1,300	1,300	1,300
OPEX					
Power Plant O&M	$/kWh	0.02	0.02	0.02	0.02

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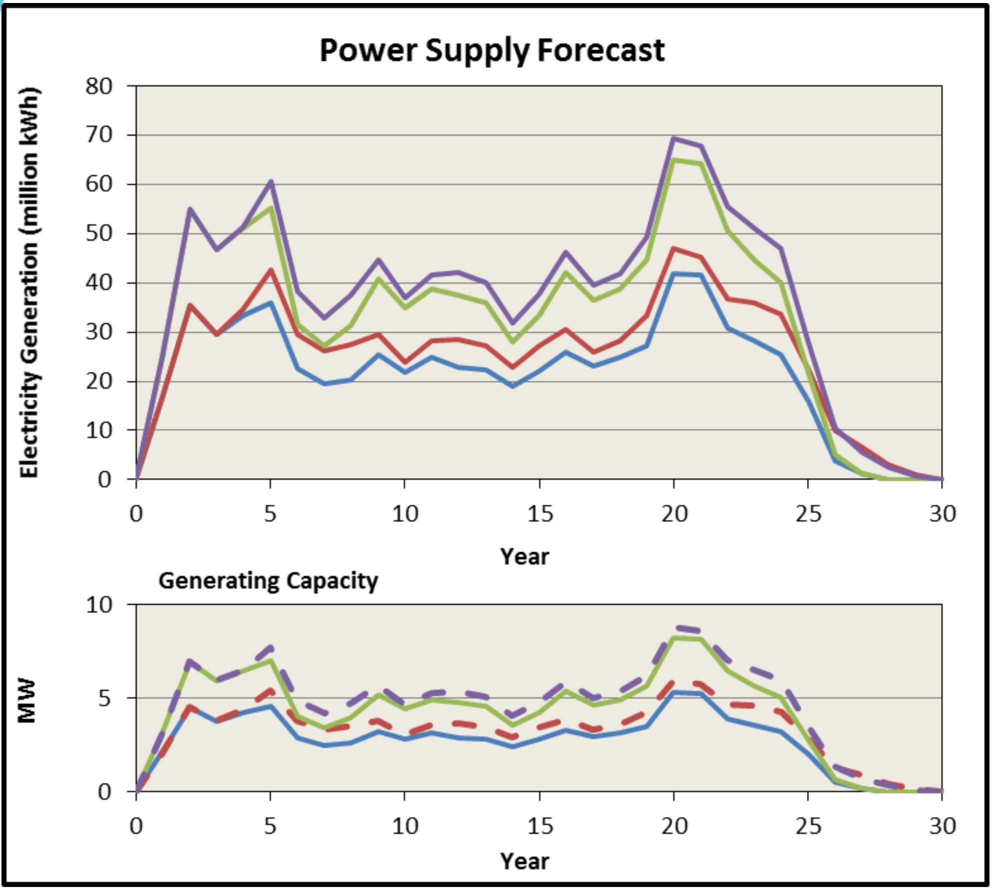
Summary of Economic Results
Power Supply



Case	Wells per Panel	Years of Pre-Drainage	Breakeven Power Price $/kWh
1	2	3	0.0526
2	2	5	0.0485
3	4	3	0.0561
4	4	5	0.0533

Case	Description
1	2 wells per panel; 3 years pre-drainage
2	2 wells per panel; 5 years pre-drainage
3	4 wells per panel; 3 years pre-drainage
4	4 wells per panel; 5 years pre-drainage

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Project Finance

Project Finance

- The project company, HEMA Natural Energy Resources, will place $40 million in senior debt through a structured financing mechanism involving the Export-Import Bank of the U.S. (Eximbank) and TD Bank NA; with a local bank participating as the loan servicing bank.
- In addition to the debt financing, the project company will have an equity investment of approximately $11.4 million.
- The grace period for the loan will be up to 24 months over which the payments to principal are deferred for the period; the balance of the loan will be fully amortized over the remaining 10 years

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