Surface Coal Mine Methane Offset Protocol

Background Information on Performance Standard and Additionality

March 11, 2013

Prepared by:

Ruby Canyon Engineering, Inc.

Surface Mine Methane (SMM) Background

In 2011, approximately 800 surface coal mines, located across 23 states, accounted for 69% of U.S. coal production. These mines emitted an estimated 32 billion cubic feet of methane, representing 19% of total coal mine methane greenhouse gas (GHG) emissions (13 million metric tons CO_2e) in the U.S. for 2011. The primary reason for this lower emission percentage as compared to coal production is due to the relatively low gas content of coals that are mined from surface mines. The low gas content of these coal seams is likely related to the shallow depth of burial, as well as the fact that some consist of lower rank coal with commensurately lower gas adsorption capacity. Gas contents used in estimating emissions from surface mines are based on a variety of studies, with emission rates ranging from 5 cf/ton to 75 cf/ton, depending on the coal basin and depth of burial.

Mine-specific emissions measurements are generally not measured for surface mines, because no measurements are required for health and safety reasons due to the low risk of accidents resulting from excessive methane concentrations. The current approach used by the U.S. Environmental Protection Agency (EPA) for estimating surface mine methane emissions is to apply a Tier 2 coal basin-specific emission factor to the amount of coal produced. As a result, emissions from surface mines (and post-mining activities) are calculated by multiplying basin-specific coal production by a basin-specific gas content and then by the country-specific emission factor to determine methane emissions.

There are three potential sources of fugitive methane emissions associated with surface coal mining:

1. Methane emitted by the coal excavated and processed during mining activities
2. Methane emitted by the coal and other gas bearing strata in the overburden and/or underburden exposed by mining activities
3. Methane emitted by the overburden coal excavated and stored on site in waste piles

<u>Methane Emitted by Excavated and Processed Coal</u>

Methane emitted by the excavated and processed coal is the estimated total gas content of the material excavated. Excavated coal will release methane as it is broken and removed from the mine face (also known as highwall), transported on-site, and crushed and sized for transportation off-site.

<u>Methane Emitted by Strata in the Overburden/Underburden</u>

Methane emitted in overburden/underburden is more uncertain as it depends on a variety of factors such as gas content and thickness of the adjacent coal seams, permeability of the coals and other strata found in the overburden/underburden, overburden thickness, and the amount of disturbance to the mine floor and highwall as a result of mining. The gas in coal and associated strata may be released during different stages in mining. In addition, methane emissions will also migrate out of the floor and highwall of the surface mine. The magnitude of the floor emissions will depend on several factors such as:

- Gas content of the unmined coal beneath the mine floor
- Proximity of the coal seams to the mine floor
- extent of disturbance of the coal and the effect this has on its permeability
- Amount of coal left in the floor
- Presence of water

The magnitude of emissions from the highwall will similarly depend on:

- Extent of disturbance of the coal near the highwall and the impact this has on the permeability
- Presence of water

Methane Emitted by Overburden Coal Excavated and Stored On-Site

Available methane to be emitted is also uncertain for storage piles as it depends on a variety of factors such as those listed above. Overburden, inter-burden and uneconomic coal is normally dumped together with non-coal material in waste piles. The methane contained in these coals will be released as the material is excavated, broken, dumped, and later used as backfill.

Methane Recovery

The only technically feasible type of methane recovery to be deployed at surface coal mines is pre-mine drainage wells drilled in advance of mining activities (as opposed to post-mining drainage wells deployed at underground mines). The drilling of methane recovery wells would take place in areas designated to be cleared and elevated prior to removal of the coal. As a result, the methane wells do not introduce any additional environment impacts to the land.

Many surface coal mine operations require the installation of dewatering wells in advance of mining in an effort to keep water in the coal from flooding the base of the highwall. It has been observed that some of these wells were also venting methane to the atmosphere. It is possible that dewatering wells could be converted to methane wells once the dewatering activities have been completed.

Studies have shown that vertical coal bed methane (CBM)-type wells are the most practical method to degasify coals ahead of mining as opposed to horizontal wells drilled into the mine face, since nearly all of the gas within 2,000 feet of the highwall has already been released. The recovered methane can be used for on-site combustion devices, or could be connected to existing gas pipeline infrastructure.

Performance Additionality for Surface Mine Methane Projects

The additionality assessment for surface mine methane was done based on data available from the Powder River Basin (PRB). The PRB has very active coal bed methane development with over 24,000 CBM wells drilled, as well as some of the largest surface coal mines in the world that produce approximately 78% of the surface mined coal in the U.S. The PRB also has the largest estimated GHG emissions from surface mines at 6.3 Million tCO2e based on the 2011 EPA GHG emissions inventory. The coal mining occurs along the eastern edge of the coal basin where the coal is near the surface while the CBM development primarily occurs to the west, deeper in the basin, where the coal contains more methane.

There are several characteristics unique to the PRB coals that make it the most active area for surface mining operations, as well as CBM and pre-mine drainage of methane.

- Very thick and continuous coal seams (~80 feet)

    - This allows surface mining at a very large scale and also allows the removal of fairly thick overburden before mining becomes uneconomic due to the cost of the removal of the overburden
    - Although the gas content of the PRB coals is relatively low, the very thick seams contain sufficient gas to make CBM wells economic on a total gas recovery basis
- Highly permeable coal seams
    - Allows the recovery of methane at rates sufficient to make CBM wells economic on a capital recovery basis
    - While the high permeability of the coal allows significant emissions from the exposed face of the surface mines, it also allows the efficient removal of gas through pre-mine drainage prior to the mine face reaching the drainage wells

While pre-mining drainage can be done at other coal basins, the above factors make the PRB the most likely location for such drainage to be economically attractive. Other reasons for this area to be considered the most prospective of the surface mining sites in the U.S. for pre-mining drainage:

- Ready access to pipeline infrastructure for sale of the gas
- Access to active oil and gas support services such as drilling, well completion and gas processing

It is important to acknowledge that the PRB area is most likely to see project activity penetration, so that when the current level of penetration is analyzed, it is based off of project circumstances that are most favorable to activity implementation.

This is also the case when assessing the additionality of the project based on financial viability in the absence of a value for emission reductions. The above stated conditions lead to the conclusion that this area provides the setting for the most cost-effective outcome for the project activity.

Project Activity Penetration

The project activity, pre-mining drainage of methane in order to reduce GHG emissions related to surface mining, might be considered to be occurring in the absence of a market price for emission reductions if it is found that this activity is economically viable within the boundaries established for the project activity. That is, among other requirements, within an established coal mining license area. This can occur where the coal mineral estate is separate from oil and gas mineral estate and each have been leased by different entities.

To date, there have only been two SMM projects ever deployed in the U.S., and both were located at the same mine in the Powder River Basin. The two project scenarios were 1) drilling and operating new pre-drainage wells, and 2) acquiring and operating existing pre-drainage wells scheduled to be abandoned. The first project drilled wells 2-7 years in advance of mining activities achieving emission reductions from 2006-2009. The second project acquired existing pre-drainage wells that were scheduled to be abandoned upon purchase. The project kept these wells operating for two additional years, generating emission reductions from 2009-2010 before all wells were shut-in.

While the PRB offers the largest opportunity, project opportunities exist in other U.S. coal basins as well. Outside of Wyoming and Montana (where most the largest surface mines in the U.S. are located), emission reduction opportunities exist at large surface mines in North Dakota, Texas, Indiana, Colorado, and New Mexico. It is estimated that up to 30 methane recovery projects could be viable at U.S. surface mines. Due to a lack of incentive and no infrastructure, no SMM projects have ever been developed outside of the PBR. The total emission reduction potential of all projects is approximately 2.5 million tCO_2e annually.

Relation of CBM and SMM Wells

The U.S. Bureau of Land Management (BLM) is the primary owner of both mineral estates in the PRB and recognized the potential conflict between separate lease holders of the oil and gas leases and a coal leases. To deal with this issue, the BLM established Conflict Administration Zones (CAZ), which delineate areas within a coal lease that are expected to be mined within ten years' time and which have an established oil and gas lease. In order to maximize revenue from the two resources the BLM allowed a 50% royalty reduction on the gas produced from the oil and gas lease. This was allowed as long as the lease holder was diligent in producing the gas on the lease as quickly as possible and was willing to plug and abandon the wells upon request by the BLM based on the encroachment of the mine towards the wells. The CAZ is the area where most of the SMM projects will be located; both the installation of new wells and the continuation of existing wells that would have otherwise been abandoned and shut-in. Areas outside of the defined CAZ may also qualify based on the offset protocol eligibility criteria.

Mine operators do not typically drill methane collection wells and the drilling of new methane collection wells into a CAZ zone is not part of current practice. In addition, as the mine face encroaches towards existing wells, mine operators are typically required to buy these wells, resulting in them being abandoned and shut-in. As of 2007, 2,489 CBM wells had been drilled within CAZs, with only 369 wells still active (15%). The rest of the wells have been plugged and abandoned or are dormant. In contrast, 6,908 of the 11,666 completed wells outside of the CAZ remain active (59%) based on 2013 data.

Financial Viability

Producing wells (new or existing) in close proximity to a mine face without the benefit of emission reduction credits is not financially viable for several reasons:

- Low adsorbed methane content
  - This is related both to the shallow nature of the coal (gas content is strongly correlated with depth) and loss of gas to the atmosphere at the mine face
- Low production rates
  - At shallow depths the pressure differential between wellbore and the coal is very low. It is this pressure differential that provides the energy for gas to flow from the coal to the wellbore. In order to maximize this energy gas compressors are required to provide suction at the wellbore. Gas compressors are capital intensive and also burn methane to operate which reduces the volume of gas available for sale.
- Contamination from atmospheric gases

- As the mine face approaches the wellbore and because the well is on vacuum, atmospheric gases are drawn in from the mine face diluting the methane content and hence the heating value of the produced gas. Eventually the gas falls below the acceptable sales quality and must be shut-in. Depending on the gas purchaser this will happen anywhere from 5% to 30% nitrogen content or whenever oxygen is found in the gas. If a flare is established, the gas can be safely burned down to 30% methane for additional methane mitigation.

Figure 1 shows the effect of production from wells drilled at various locations relative to a mine face. The plot shows the methane production rate over time for wells drilled at different distances from the mine face at the time of first production. The wells drilled within 4,500 feet of the face (CAZ 4500 and CAZ 3000) produced very little gas. The wells at greater distance produced more gas, but still had a steep decline as the mine face approached (see CAZ 7500 at February 2005).

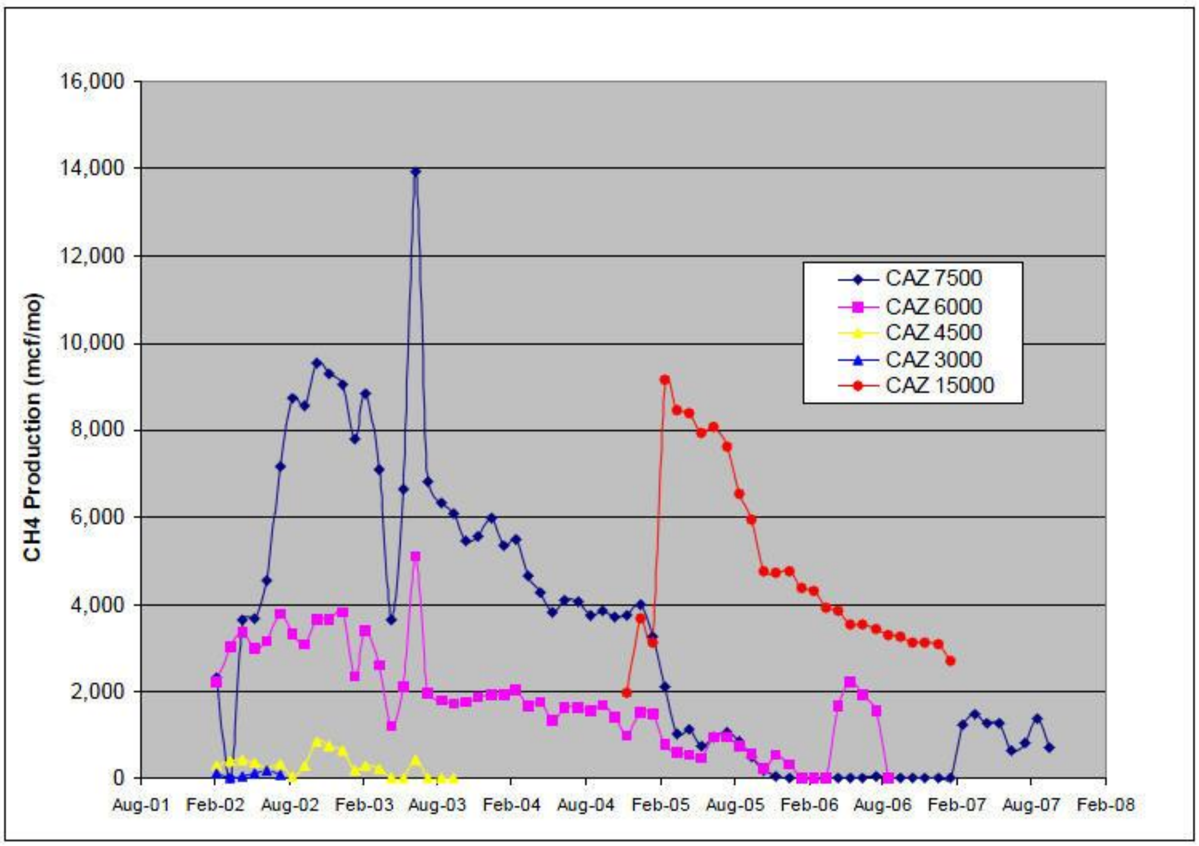

Figure 1: Production performance of wells related to distance from the mine face

An excellent example of pre-mining drainage occurred at the North Antelope Rochelle Mine (NARM) in Campbell County, Wyoming, operated by Peabody Energy. A 640 acre (one mile square area) section was drilled using sixteen, 40 acre locations. Figure 2 shows section 36 in relationship to the entire surface mine plan and the CBM field to the west (red well are producing, black wells are shut-in). The wells in section 36 were drilled in 2002.

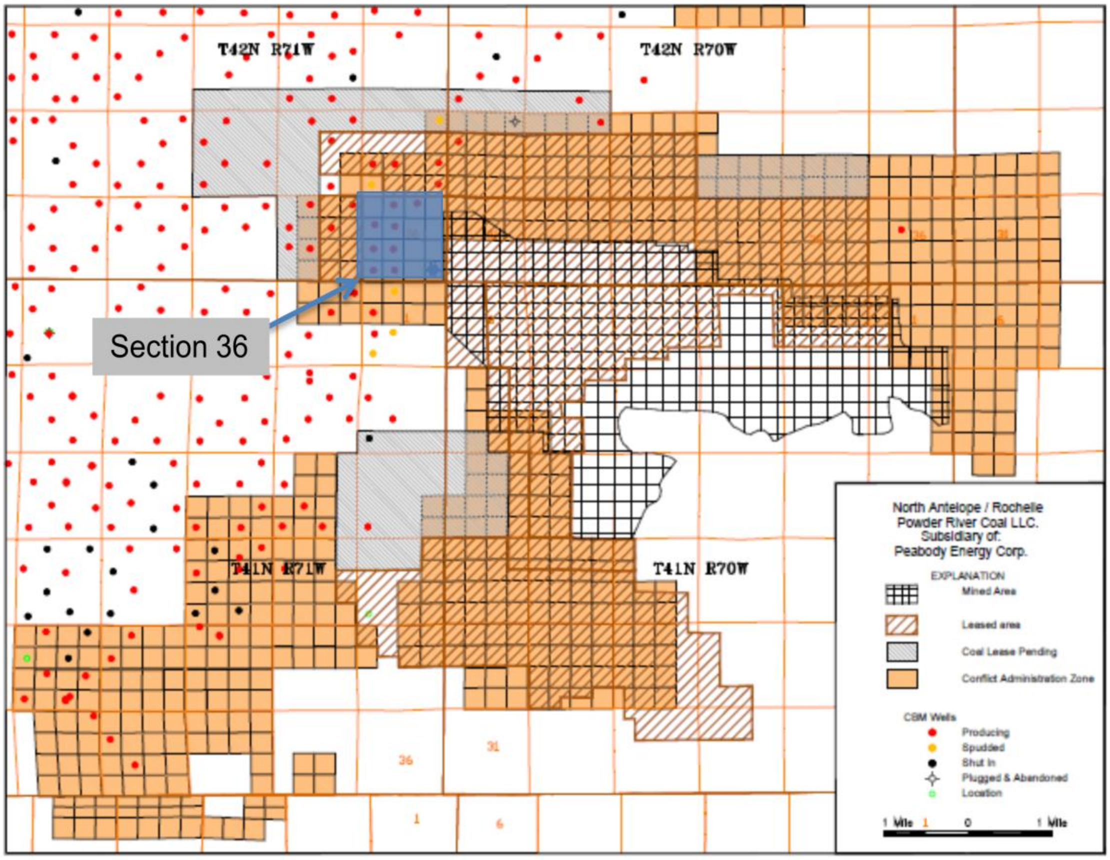

Figure 2: NARM coal lease area showing mined out area and pre-mine drainage wells

In Figure 3, the mine plan can be seen in more detail as each black block section labeled by the year in which that area will be mined. The first column of wells had been mined through by 2006 (location of the mine face) and the rest of the coal in section 36 was removed by 2010. By the end of 2003 the eight eastern most wells had been shut-in as uneconomic. By the end of 2006 four more wells had been shut-in and by 2007 all wells in the section had been shut-in. Yearly production from this section is shown in Figure 4.

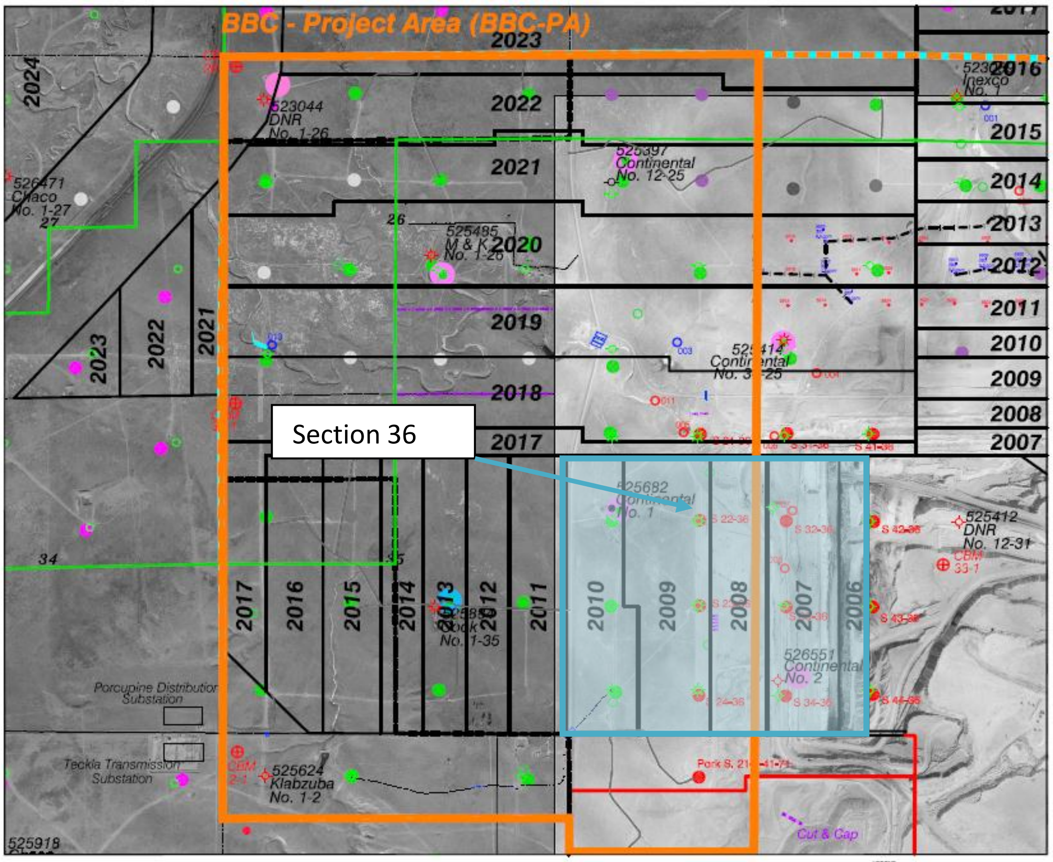

Figure 3: NARM aerial photo with mine plane overlay showing pre-mine drainage wells

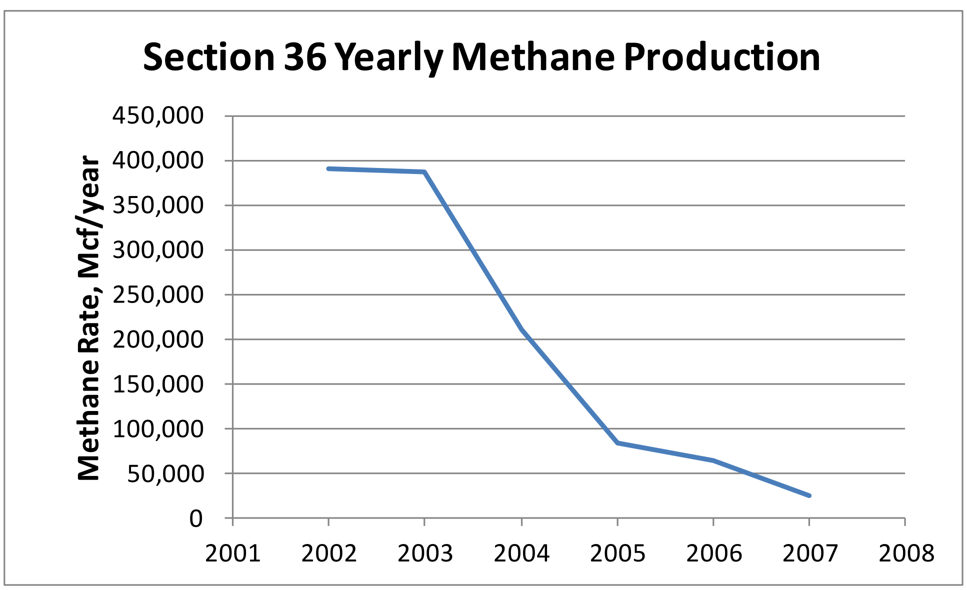

Figure 4: Yearly methane production from section 36 pre-mine drainage wells

The rapid decline in production from 2003 to 2005 is related to both shut-in of wells nearer the face and the production rate decline from the wells farthest from the mine face.

An economic analysis of the wells in this section illustrates the poor return on investment for the gas produced for sale from these wells. Table 1 shows the capital cost of installing the 16 wells in section 36.

Table 1: Capital cost of section 36 installation	
CAPITAL EQUIPMENT	COST, $
Blowers (well head compressors)	600,146
Wells (drilled and completed)	896,000
Pipe (purchased and buried)	844,800
Total	2,340,946

Operating cost is based on $1,000 per well month and $5,000 abandonment cost and were calculated yearly based on the number of active wells and number of wells that were abandoned in that year. Other parameters of economic interest are a net revenue interest of 76%, Wyoming state severance tax of 13% and an investment discount rate of 10%. The result of the analysis at a gas sales price of $3.76/MMbtu ***without*** emission reductions income is shown in Table 2.

TABLE 2: RESULTS OF ECONOMIC ANALYSIS	
Economic Parameter	Before Income tax
NPV10	($705,704)
IRR	NA
MIRR	NA

Please see Figure 5 below for the complete economic analysis.

DATE	WELL COUNT	GROSS MCF PRODUCTION	SHUT IN GAS MCF	TONNE CO2 metric ton	GROSS NRI SALES	STATE PROD TAXES	NET SALES	OPER EXP	OPERATING NET INCOME	EQUIITY INVESTMENT	ANNUAL CASH FLOW	AFTER TAX CASH FLOW
2002	16	391,166	3,898.41	1,366.78	945,371.00	122,898.00	822,473.00	192,000.00	630,473.00	2,340,945.86	(1,710,472.86)	(1,710,472.86)
2003	12	385,994	146,657.13	51,417.99	932,870.00	121,273.00	811,597.00	164,000.00	647,597.00		647,597.00	$680,517.00
2004	8	209,773	0.00	0.00	506,979.00	65,907.00	441,072.00	116,000.00	325,072.00		325,072.00	$349,681.00
2005	8	84,301	0.00	0.00	203,739.00	26,486.00	177,253.00	96,000.00	81,253.00		81,253.00	$103,488.00
2006	8	63,534	425,717.10	149,256.41	153,550.00	19,962.00	133,588.00	96,000.00	37,588.00		37,588.00	$60,258.00
2007	4	24,758	583,254.22	204,488.93	59,835.00	7,779.00	52,056.00	68,000.00	(15,944.00)		(15,944.00)	$538.00
		1,159,527	1,159,527	406,530	2,802,344.00	364,305.00	2,438,039.00	732,000.00	1,706,039.00	2,340,945.86	(634,906.86)	(515,990.86)
				Gas Sales Price	3.76	$/MMBTU			LIFE at 6YRS	NPV10	($705,703.68)	($621,441.21)
				CO2e Price	0.00	$/tCO2e				IRR	-25.67%	-19.03%
										MIRR	-2.47%	-0.67%

Figure 5: Economic analysis of NARM project

It should be noted that the above economic example was based on produced gas from the project being directed into a pipeline. In the case of other beneficial use projects (electric power production on-site), the economic analysis would not be altered based on an expected sale price of electricity and the capital expense of the power generation equipment. In addition, in the case of flare projects, there would be no additional revenue from the sale of gas or electricity, thus making the project economics even more difficult.

Project Application to SMM Offset Protocol

Based on the proposed baseline in the SMM offset protocol, when a well is shut-in because of encroachment from mining operations such as overburden removal prior to mining the coal or because of contamination by atmospheric gases, the gas produced from that well is then eligible to generate emission reductions. Table 3 illustrates how this process works. Prior to 2002, 16 wells were in place on the project area. During 2002, four wells were shut-in. These four wells produced a total of 3,898 Mcf of methane. Four more wells were shut-in in 2003 which produced a total of 146,657 Mcf. No wells were shut-in over the next two years so no emission reductions could be credited until 2006 when four additional wells were shut-in. In 2007, the last four wells in the project area were shut-in. Shutting in the wells also added $5,000 to the operating expenses for each well shut-in.

Table 3: Well Count And Qualifying Emission Reductions By Vintage

Year	Well Count	Shut-in Gas Mcf	tCO2e Metric Ton
2002	16	3,898	1,367
2003	12	146,657	51,418
2004	8	0.00	0.00
2005	8	0.00	0.00
2006	8	425,717	149,256
2007	4	583,254	204,489
Total		1,159,526	406,530

Economic Sensitivity Analysis

The economic performance of the project is most sensitive to the gas sales price. Figure 6 shows the statistical distribution of the Henry Hub natural gas price from January 2009 through January 2013 (from the Energy Information Agency of the U.S. DOE). The gas price used in the economic analysis subtracts $0.58/Mcf from the Henry Hub price for pipeline compression and transportation costs. The analysis indicates that there is a 90% chance of the price being between $2.43/mmbtu and $5.32/mmbtu with the mean being $3.76/mmbtu.

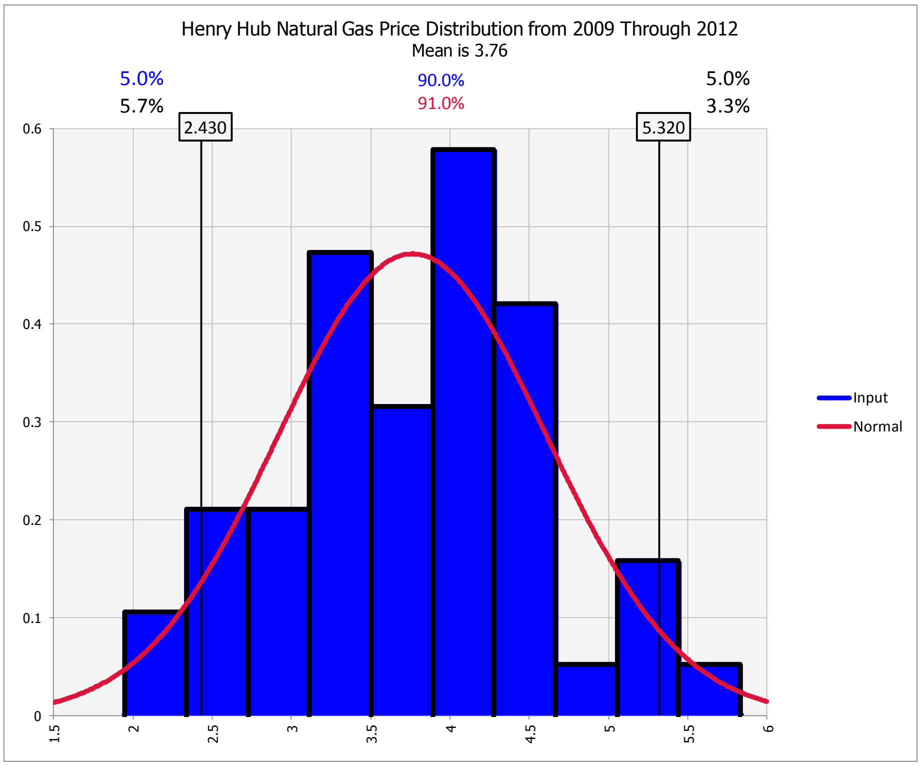

Figure 6: Histogram of Henry Hub natural gas prices from January 2009 through January 2013 in $/mmbtu on horizontal axis along with a normal distribution curve fitted to the data.

A Monte Carlo simulation was run using this distribution which produced the following cumulative probability function of Figure 7.

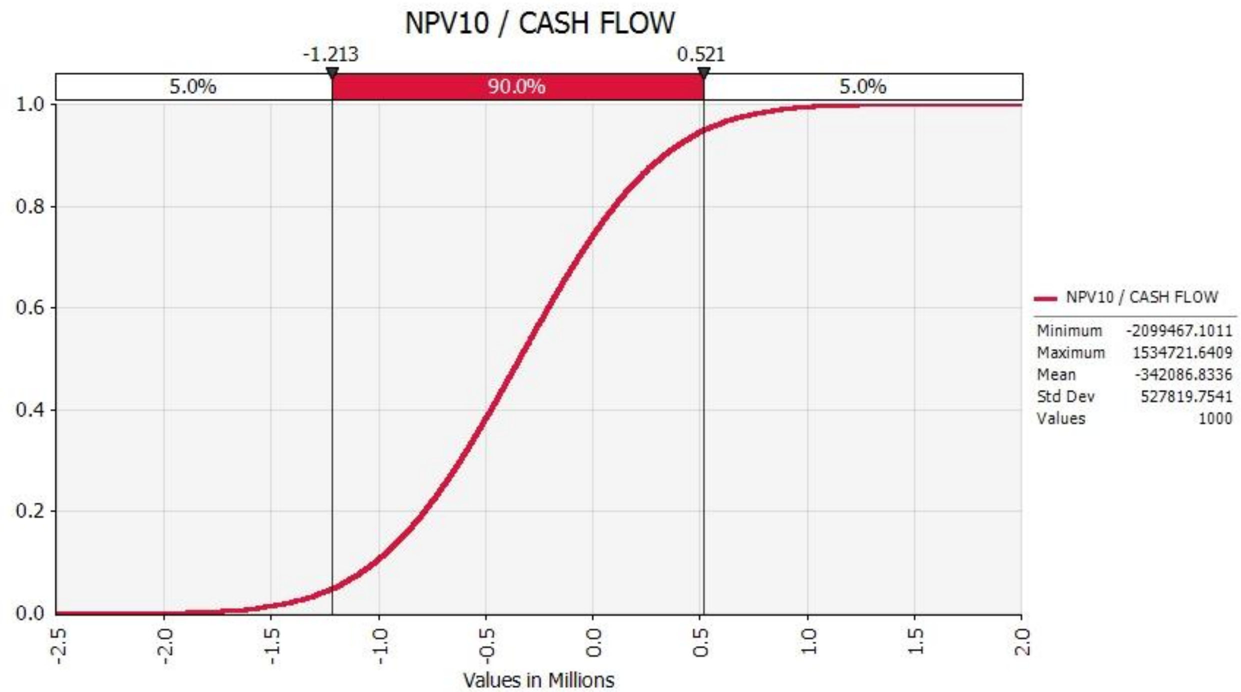

Figure 7: Cumulative probability distribution on 10% NPV based on gas price uncertainty

This figure shows that under this price uncertainty there is approximately a 78% chance that the project will have a negative discounted cash flow with the 90% chance that the NPV will be between $-1,213,000 and $521,000.

Given this analysis, the odds are too great that this project will lose money for the project to move forward without the support of GHG emission reduction income.