Ashton Coal Mine Greenhouse Gas Abatement Investigation Report

APPENDIX 9

Wells Environmental Services

ASHTON COAL MINE

GREENHOUSE GAS ABATEMENT

INVESTIGATION REPORT

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GREENHOUSE GAS ABATEMENT INVESTIGATION REPORT

ASHTON UNDERGROUND MINE

December, 2011

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Contents

Prepared by: **Dennis Black, *PacificMGM***

1.0 INTRODUCTION

Ashton Coal Operations Pty Ltd (ACOL) operates the Ashton Coal Project (ACP) located approximately 14km west of Singleton in the Hunter Valley, NSW. The ACP comprises an open cut and underground mine, coal handling, processing, rail transport and associated support facilities. The ACP is approved to extract and process up to 5.45 million tonnes of run of mine coal per annum. The underground mine is approved to extract coal using longwall mining methods from four coal seams, namely the Pikes Gully, Upper Liddell, Upper Lower Liddell and Lower Barrett seams (in descending order). Open cut reserves were exhausted in September 2011 and the open cut pit is no longer operational.

Increasing gas emissions into the ACOL underground mine workings led to the introduction of goaf drainage in 2010. Goaf drainage involves extracting gas from the caved zone formed behind the retreating longwall face, via a series of vertical boreholes to the surface, to maintain the level of flammable, and potentially explosive, gases in the working areas of the mine at a safe level. An initial three (3) vertical goaf wells were installed on the surface overlying longwall panel 6A, to support longwall operations in the Pikes Gully seam. This goaf drainage arrangement uses a relocatable venturi drainage plant and associated safety and control devices fitted to the drainage well standpipe. In 2011, ACOL gained approval to install a further fifteen (15) vertical goaf wells into the remaining Pikes Gully seam longwall panels.

Based on the demonstrated success of the goaf drainage program to date, ACOL intends to continue goaf drainage and are planning to implement a more effective gas drainage solution involving the construction of a centralised gas drainage plant and gas flaring facility. ACOL is presently seeking proposals from suitably qualified suppliers for the supply and installation of the central gas drainage plant and flaring facility and is now awaiting responses from potential suppliers. ACOL's plan is for goaf gas to be reticulated from each goaf well to the central gas drainage plant via a surface pipe network and the discharge from the central drainage plant will be directed to a flaring facility where the methane component in the drainage gas will be combusted to significantly reduce the global warming potential (GWP) of the gas mix. ACOL is currently preparing an application to modify its development consent for the mine to enable the development of a centralised gas drainage plant, gas flaring facility and surface gas reticulation pipe network in preparation for goaf drainage of Upper Liddell longwall panels.

In the period until the new gas drainage plant has been approved, installed and commissioned, ACOL propose to continue to use the existing relocatable goaf drainage arrangements, as a contingency where required, to support safe and efficient longwall mine operations.

2.0 SCOPE

PacificMGM has been engaged by Ashton Coal Operations Pty Limited (ACOL) to identify and conduct a preliminary assessment of potential options for the abatement and reuse of methane drawn from the Ashton underground mine to reduce the release of greenhouse gas emissions from the site. This report has been prepared to address the requirements of condition 6.10B to Schedule 2 of DA 309-11-2001 for the Ashton Coal Project. The abatement and potential reuse of methane present in drainage gas and mine ventilation air is considered within the scope of this report.

A variety of standard and developing industry greenhouse gas abatement options have been considered and briefly described, with comment relating to general advantages and disadvantage of each option relative to potential application at the Ashton underground mine.

ACOL's current and planned approach to gas drainage, as understood by PacificMGM following review of various ACOL reports and documents, is described.

It is not within the scope of this report to evaluate the gas reservoir, methods used at Ashton to drain gas, or to undertake detailed analysis of the greenhouse gas abatement and reuse options identified in this report.

3.0 Current Practice – Drainage and Treatment of Coal Seam Gas

ACOL currently employ a simple, yet effective, relocatable surface gas drainage plant that relies on a venturi effect to create suction that draws free gas from the goaf, through a cased 300 mm diameter borehole to the surface. Drained gas is presently exhausted from the top of a vent stack at a height of approximately 4.5 metres where it dilutes and dissipates.

Each relocatable surface goaf drainage installation is contained within a 15 m x 20 m perimeter fence, as shown in Figure 1, and contains the following components:

(1). A 300 mm internal diameter cased gas drainage borehole, drilled to a target horizon approximately 17 metres above the working seam;

(2). An extraction plant to apply negative pressure to the goaf gas drainage borehole;

(3). A vent stack, flame arrestor, non-return valves and fire suppression system;

(4). A 1,000 cfm diesel compressor with self-bunded fuel tank;

(5). Safety, monitoring and telemetry equipment;

(6). A buried earth mat;

(7). Solar panel, storage batteries and control panel; and

(8). Gravel pad.

Figure 1: Typical goaf drainage surface equipment layout compound

Gas extraction from the goaf drainage wells has been consistent with similar programs in other mining areas, such as the Illawarra, that employ relocatable goaf drainage plant with a peak gas extraction rate reaching 800 L/s and the average flow in the range of 400 to 500 L/s. It is characteristic for gas flow from vertical goaf wells to increase rapidly soon after initial connection to the goaf, reaching peak production for several weeks, followed by a progressive decline until the well is closed in and the plant relocated to the next well in the sequence.

4.0 Planned Gas Drainage and Emissions Reduction Strategy

The goaf drainage wells installed in the Pikes Gully seam longwall panels have proven successful in reducing gas emissions into the underground mine workings, thereby having a positive impact on improving mine safety by preventing methane concentrations from exceeding statutory safe limits, as well as improving productivity.

ACOL plan to replace the existing relocatable goaf drainage plant with a permanent centralised gas drainage plant that draws gas from individual goaf wells to the plant via a network of gas reticulation pipes, for longwall extraction of underlying coal seams. A flaring facility is planned to be located in close proximity to the gas drainage plant.

Detailed technical specifications and scope of work for supply and installation of the gas drainage plant and central gas flaring facility, utilising current enclosed flare technology, has been provided to potential equipment suppliers. ACOL is also preparing an application to modify its development consent to allow for this development.

PacificMGM recommend that ACOL also consider installing a free venting stack to safely discharge peak gas flows in excess of the capacity of the flaring facility. Although unlikely to be used under normal circumstances, the free vent stack represents prudent risk mitigation enabling gas extraction from the underground mine to continue in the event of excessive gas flows or a failure within the flaring facility.

Although the response from each equipment supplier will indicate lead time for the supply of major components and timeline to complete the installation of the gas drainage plant and flaring facility, it is reasonable to expect that, subject to receiving planning approval, the installation of the drainage plant and flaring facility will take a minimum of six to twelve months to complete. During this period it is recommended that ACOL continue extracting goaf gas, where required, using the existing relocatable drainage plant, as shown in Figure 1.

Several options to reduce greenhouse gas emissions from the existing relocatable goaf drainage plant are being investigated, as discussed in Section 5 of this report.

5.0 Potential Interim Actions to Reduce Fugitive Emissions

ACOL may consider investigating the availability and suitability of relocatable enclosed flare units to use in conjunction with the existing relocatable venturi gas drainage plant to treat drained gas and reduce fugitive emissions. Several companies offer such units for hire; however, the current availability must be determined.

Adding relocatable flares to the existing goaf drainage well installation will increase the footprint of the plant, therefore the impact on local environment and stakeholders would need to be assessed and managed appropriately. Increasing the footprint and potential disturbance in the voluntary conservation area (VCA), for example, may not be acceptable and may require gas drained from any wells located in such sensitive areas to be free vented.

An example of relocatable enclosed flares, the GF1000 carbon credit enclosed flares supplied by Landfill Management Services Pty Ltd (LMS), is shown in Figure 2. The GF100 units are modular and rated to flare landfill gas at a rate of 1,000 m^3/hr per unit. In coal mine goaf drainage applications, where the energy content of the drained gas is greater than landfill gas, the flaring capacity of each 20 ft containerised unit is approximately 120 L/s. Using flares of this type to burn 120 L/s of goaf gas comprising 90% methane equates to an annualised GHG emissions reduction in the order of 40,755 $tCO_{2\text{-}e}$ per enclosed flare unit.

The potential impact of the venturi, which adds air to the drained gas, hence reducing the methane concentration, must be assessed to determine if the concentration is within the acceptable operating range of any relocatable flare(s) considered for use in conjunction with the existing gas drainage plant.

Figure 2: Example of relocatable enclosed flares treating drained goaf gas

6.0 OPTIONS TO REDUCE DRAINAGE GAS EMISSIONS

This section provides a general summary of potential options that have been considered by ACOL to reduce and potentially reuse drainage gas to reduce fugitive emissions. The various options available for the utilisation of gas drained from the mine are classified into three separate groups; flaring, power generation and pipeline gas sales. The suitability of each option for use at a particular mine site will be impacted by individual mine conditions, including services, access, environmental and stakeholder considerations. A summary of the following assessment of drainage gas treatment and processing options is provided in Appendix 1.

6.1. Flaring

There are two types of flares, open and enclosed, discussed below.

6.1.1. Open Flares

Open flares have a high gas flow capacity relative to the enclosed flares. However, they are reported to be less efficient at combusting the methane component of drainage gas (UNFCCC, 2006). Figure 3 shows an example of an open flare which emits a large open flame that is highly visible, particularly at night. This type of flare is generally not considered appropriate for use in developed areas and is therefore not a practical option for use at Ashton.

Figure 3: Open "candlestick" flare in operation

6.1.2. Enclosed Flares

In comparison to open flares, enclosed flares are capable of more efficient methane gas combustion as the gas is contained within the high temperature environment internal to the flare enclosure for a longer duration. Figure 4 shows an example of a permanent enclosed flare installation.

Enclosed flaring is a relatively low cost and effective solution to reduce greenhouse gas emissions, and is presently the favoured gas treatment and fugitive emissions reduction option being considered for implementation at Ashton.

Figure 4: Enclosed flare installation

6.2. Power Generation

Utilising methane rich drainage gas to generate electricity is an alternative to flaring. In Australia, there are currently eight mines that have installed power generation facilities that utilise coal mine methane as the primary fuel supply. The combined power generation capacity of the eight existing Australian installations, listed below, is 212 MW.

- Appin (54 MW)
- Tower (40 MW)
- Moranbah North (45 MW)
- Grasstree (32 MW)
- Oaky Creek (20 MW)
- Glennies Creek (10 MW)
- Tahmoor (7 MW)
- Teralba (4 MW)

Gas-fuelled reciprocating engines are the most common device used to drive electrical generators installed at coal mine methane (CMM) power generation plants. The power generator units, similar to the unit shown in Figure 5, are available in a range of sizes, ranging from approximately 0.1 to 10 MW, and can be sourced from several manufacturers.

The minimum methane concentration required to maintain efficient combustion is in the order of 35 to 40% CH_4; however, higher concentrations are preferred. It is also common for CMM power stations to be connected to a natural gas supply that is used to increase and stabilise the purity of the fuel supplied to the engines. Figure 6 provides an example of a typical coal mine methane power generation plant.

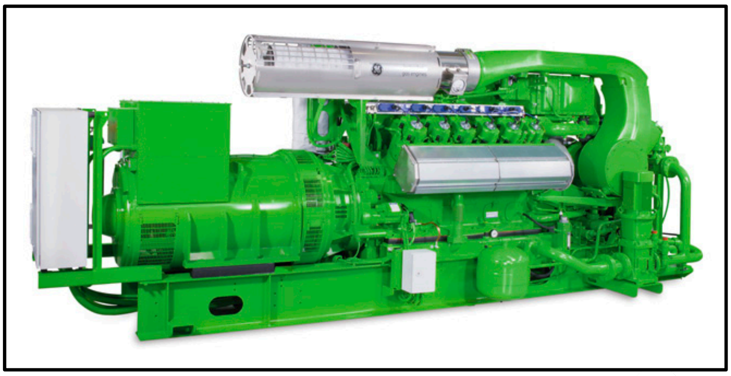

Figure 5: V12 GE Jenbacher Gas Engine

Figure 6: Coal Mine Methane Power Generation Plant

Several options have been investigated by ACOL to utilise drained goaf gas to produce electricity, which are described below.

6.2.1. Gas supply to Glennies Creek power station

Once installed and commissioned, constructing a pipeline between the ACOL gas drainage plant and the Glennies Creek Power Station (GCPS), owned and operated by Envirogen, would enable drainage gas to be utilised for power generation.

Although a seemingly good option for reuse of the drained gas there are several issues that prevent this option being pursued at this time, the most significant being that the 10 MW GCPS is operating at maximum capacity and is unable to accept additional gas. Other issues relate to the pipeline which includes: design, approvals, capacity, ownership and cost to install and maintain. It is also expected that a booster station would be required, in close proximity to the gas drainage plant, to compress the drainage gas and increase the gas pressure in the pipeline sufficient to overcome internal resistance and pressure losses.

This option is presently not available. However, it should be reconsidered in the event of Envirogen increasing the capacity of the GCPS.

6.2.2. Gas supply to Macquarie Generation

Macquarie Generation (MacGen) has proposed a project involving the installation of a gas collection pipeline to gather coal mine drainage gas for use as a supplementary fuel at MacGen's Liddell power generation plant.

Although the proposed pipeline has received development approval it is understood that MacGen have not entered into gas supply agreements with existing coal mines in the local area. ACOL is not aware that MacGen has any plan to construct the pipeline in the short term, therefore the option of transferring drained gas offsite for use in power generation through the MacGen power station is not a practical option for ACOL in the short term.

Should a pipeline become available in the future, which has capacity to accept CMM from the Ashton gas drainage plant, and subject to acceptable commercial terms, ACOL may consider this option as an alternative to onsite flaring.

6.2.3. ACOL to construct a power station on the Ashton Coal mine site

As an alternative to onsite flaring of drainage gas, ACOL may consider the construction and operation of a power station, adjacent to the proposed centralised gas drainage plant. A number of potential issues must be considered when assessing the viability and practicality of this option, such as:

(a) Power generation is not ACOL's core business and the company has no experience or expertise in power generation. Therefore it is more appropriate to consider entering into an agreement with a suitably qualified third party to build, own and operate (BOO), or to operate and maintain (O & M) such a plant;

(b) Variable gas flow rate may impact the performance and utilisation of such a plant. Therefore it would be prudent to design such a plant based on the demonstrated achievable average gas extraction rate. Any peaks in gas extraction rate would be directed to the centralised flaring facility; and

(c) Variable gas quality, i.e. changes in the methane concentration of the drainage gas, may impact operating efficiency of such a plant. In cases where gas quality is variable, CMM power stations typically include a natural gas, or equivalent high quality gas supply, to supplement lower quality drainage gas in order to maintain the operating efficiency of the power station.

Given ACOL's limited gas drainage experience, more information should be gathered through the continued operation of the company's gas drainage program, to support the design of an appropriately sized power station and to evaluate the commercial merits of pursuing such an option, in addition to maintaining the centralised flaring facility.

It would also be necessary to determine whether power generated by such a plant was purely for internal consumption to offset power purchase, or exported from the site, which would necessitate a power purchase agreement with an energy retailer.

6.2.4. ACOL and Ravensworth Underground Mine shared power station

A concept has been proposed to construct a shared power station that would source coal mine methane from both ACOL and the adjacent Ravensworth underground mine (RUM).

Sourcing gas from two mines may support a higher capacity power station; however, the potential issues listed in Section 6.2.3 continue to apply. A number of other potential issues may arise in a situation where such a facility is shared and would require appropriate contract terms to be negotiated to ensure the rights and obligations of all Parties associated with the operation of such a power station are clearly defined.

6.3. Natural Gas Pipeline

Where high quality gas is extracted from the coal seam / mine there is an opportunity to sell the gas directly into the high pressure natural gas pipeline. Eastern Star Gas has proposed the construction of a natural gas pipeline from Coolah to Newcastle.

Coal mine drainage gas is typically not suitable for supply into this market due to the presence of impurities such as oxygen, carbon dioxide, nitrogen and moisture. To improve the quality of drainage gas an expensive and complex gas conditioning plant would be required.

The historical average methane concentration of goaf drainage gas has been approximately 90% which is too low to be acceptable for sale into this market.

7.0 Options to Reduce Ventilation Air Methane Emissions

Coal mine methane is also present in mine ventilation air. However, the concentration is typically very low, with methane concentration ranging between 0.1% and 1.2%, but more commonly within a range of 0.3% to 0.5%. In the twelve months to June 2011 the methane concentration recorded in the main ventilation return at the Ashton underground mine averaged 0.28% CH_4. This dilute methane, known as ventilation air methane (VAM), is difficult to capture and use because it has such a low methane concentration.

A number of potential VAM utilisation technologies exist in various stages of development. These potential utilisation technologies include (1) Thermal Flow Reversal Reactors, (2) Regenerative Afterburners, (3) Hybrid Coal Gas Turbines, and (4) Lean Burn Turbines. These technologies are briefly described below.

Several significant issues must be addressed in the design of a full scale VAM utilisation plant, which include (a) connection to the mine and the ability to effectively capture the VAM without adversely impacting the mine ventilation system, and (b) implementing accurate environmental monitoring and process controls capable of instantaneously detecting changes in VAM concentration and plant condition, and responding accordingly to maintain the safety of the plant and mine.

Further trial and development of VAM utilisation technologies is required prior to being considered for implementation at the Ashton underground mine.

7.1. Thermal Flow Reversal Reactor

Thermal flow reversal reactors direct ventilation air through a heat-transfer bed filled with a ceramic or rock medium. To initiate the reaction the bed centre must be heated above methane ignition point, this is typically achieved through the use of integrated electrically operated heating elements. As the VAM passes through the reactor the methane oxidizes and releases heat to the far end of the bed. The direction of airflow through the bed is periodically reversed to maintain a relatively constant heat distribution throughout the heat transfer bed. Once operating, the process is self-sustaining with no additional energy input required however a stable gas supply concentration and flow rate should be maintained.

Thermal flow reversal reactors are presently the most advanced VAM treatment and utilisation option available with demonstration units having been successfully installed and operated at coal mines in Australia and overseas.

In addition to destruction of methane and overall reduction of fugitive emissions the heat generated from the oxidation reaction may be utilised for other purposes, such as power generation. Although requiring a far more complex plant and increased capital investment TFRR units can be designed with internal plumbing to heat a working fluid to drive a turbine unit(s) to generate electricity. The working fluid may be either water, to drive a steam turbine, or gas to drive a gas turbine.

There are two TFRR technologies presently operating in pilot VAM treatment trials, these are (i) the Vocsidizer, supplied by Megtec Systems, and (ii) the VAMOX, supplied by Biothermica.

7.1.1. Megtec – Vocsidizer

A Megtec Vocsidizer is operating at the BHP Billiton West Cliff Colliery Ventilation Air Methane Project (WestVAMP) and a second unit is in field demonstration at an abandoned mine in the United States owned by CONSOL Energy. The WestVAMP unit, shown in Figure 7, draws 20% of the available West Cliff mine ventilation air (70 m^3/s). The heat produced by the Vocsidizer units is used to power a 6 MW conventional steam turbine and the generated electricity is utilised at the adjacent West Cliff Colliery.

Figure 7: Vocsidizer Installation at West Cliff Colliery (WestVAMP), Australia

The Vocsidizer beds are relatively simplistic in their design with few moving parts thereby reducing the risk of breakdown and ongoing maintenance costs. Experience at WestVAMP has however identified issues with the dust present in the ventilation air causing problems within the Vocsidizer beds requiring premature replacement of the ceramic medium.

7.1.2. Biothermica – VAMOX

The Biothermica VAMOX unit is similar to the Vocsidizer in that both encompass thermal flow reversal reactor technology. Similar to the Vocsidizer, the VAMOX requires a VAM concentration in the range of 0.2% to 1.2% however process efficiency is adversely affected when VAM concentration is low.

Biothermica's first VAM demonstration project is located at Jim Walter Resources' (JWR) No.4 coal mine in Brookwood, Alabama. This plant, shown in Figure 8, reduces fugitive emissions from the No.4 mine by 40,000 tCO_{2-e} annually (Duplessis, 2009).

Figure 8: Biothermica – VAMOX Installation

7.2. Regenerative Afterburner

Regenerative afterburner (RAB) technology is being developed to treat low concentration VAM. Australian based company, Corky's, is presently engaged in the development of RAB for the treatment of VAM. Figure 9 shows a small-scale RAB trial pilot plant which represents the status of RAB technology development.

Figure 9: Development of Corky's VAM RAB Concept

A conceptual layout of a full-scale RAB VAM treatment plant, shown connected to the mine ventilation fans, is illustrated in Figure 10. The development of a full scale RAB plant capable of processing total mine VAM emissions has been reported to be some years away from being a viable option for use in coal mine VAM emissions reduction (Cork, 2011).

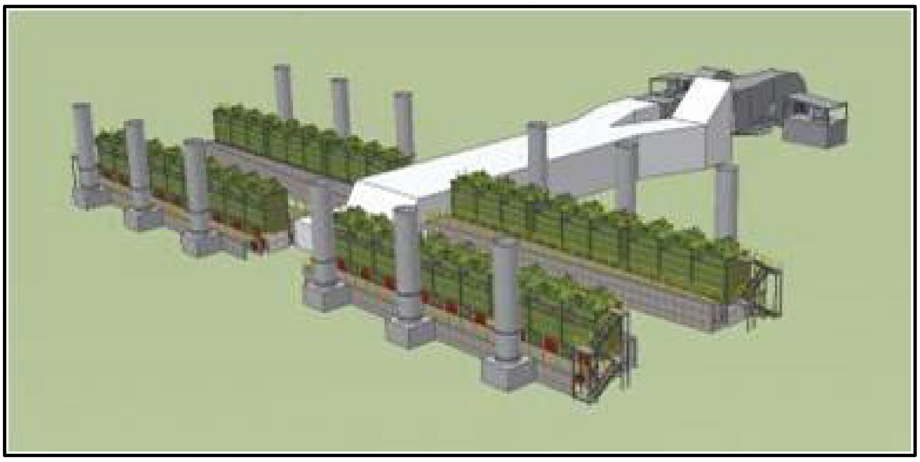

Figure 10: Conceptual Design of a Full Scale RAB VAM Treatment Plant

7.3. Hybrid Coal and Gas Turbine

Hybrid coal and gas turbine (HCGT) technology involves the combustion of both VAM and organic material (e.g. coal waste) within a rotating kiln to generate sufficient energy to drive a turbine to generate power. Compared to the TFRR power plant (WestVAMP) the design of an HCGT plant appears to be more complex with the addition of the rotating kiln(s) and the need for solid fuel supply and associated storage and handling facilities.

The HCGT plant can be configured to provide 5 to 30 MW electrical output (Lynch, 2009). Figure 11 shows a conceptual layout of a HCGT VAM utilisation plant.

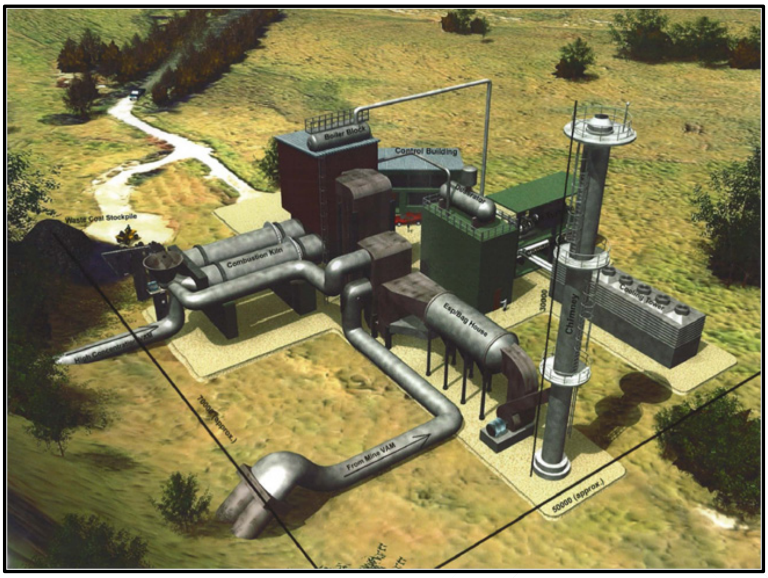

Figure 11: Conceptual layout of a Hybrid Coal and Gas Turbine (HCGT) VAM utilisation plant

The need for solid fuel, in addition to VAM, is expected to increase the overall complexity and cost of the HCGT GHG destruction and power generation plant by introducing the need for materials transport, storage and handling.

7.4. Lean Burn Gas Turbines

The utilisation of VAM in lean-fuel turbines represents a very efficient use of VAM however the development of the technology has been limited to turbine capacities of less than 1.0 MW, known as micro-turbines. CSIRO are involved in the trial and demonstration of a lean fuel turbine with catalytic combustor which has potential application to VAM utilisation (CSIRO, 2011). This technology, which may have an application for VAM utilisation, is known as VAMCAT (Ventilation Air Methane Catalytic Turbine).

Ingersoll Rand was actively involved in the development of lean-fuel microturbine technology prior to the technology being sold to Flex Energy. An example of an Ingersoll Rand microturbine unit is shown in Figure 12.

Figure 12: Ingersoll Rand Micro-turbine Unit

The capacity of existing microturbine units is quite low and insufficient to cater to the high ventilation air flow through Australian underground coal mines. Therefore microturbines are not a practical option for use in VAM treatment.

8.0 SUMMARY

ACOL introduced goaf drainage in 2010 to extract gas from the underground workings to improve mine safety and productivity.

During the initial trial and demonstration of goaf drainage, involving the operation of three (3) separate goaf wells into Pikes Gully longwall panel 6A, a relocatable venturi drainage plant and associated safety and control devices were used. Based on the success of the goaf drainage trial ACOL extended the use of the relocatable venturi drainage plant arrangement for the remaining Pikes Gully longwall panels.

ACOL is planning to construct a state of the art centralised gas drainage plant and gas flaring facility to support future longwall extraction from the remaining deeper coal seams, where required. It is intended that the drainage plant will draw gas from individual goaf wells via an overland pipe network. From the discharge side of the drainage plant the gas will be directed to a gas flaring facility comprising one or more enclosed flare units. The central gas drainage plant and flaring facility may include capability to vent peak gas flows that exceed the capacity of the enclosed flares.

ACOL is presently tendering for the supply and installation of the centralised gas drainage plant and flaring facility however due to industry demand for similar plants, long lead times for key components may delay the installation. In the meantime, ACOL plan to continue using the existing relocatable gas drainage plant until the centralised plant and flares become available. Use of either arrangement will be contingent on ACOL gaining the necessary development approvals.

ACOL intend to investigate the feasibility of utilising relocatable enclosed flares to assist in treating goaf gas to reduce fugitive emissions. Where possible, the use of a relocatable flare(s), in conjunction with the existing relocatable drainage plant, will assist in reducing fugitive emissions until such time as the central gas drainage plant is available.

Based on an assessment of available options to reduce greenhouse gas emissions from the Ashton underground mine the actions proposed by ACOL are considered appropriate and effective.

There may however be areas where the use of additional items of plant is not appropriate or acceptable, such as within the voluntary conservation area and other similar sensitive areas. In such areas, flaring of the drained goaf gas may not be achievable.

Ventilation air methane (VAM) is also a significant contributor to fugitive emissions from the Ashton underground mine. There are however limited technologies presently available to support full mine VAM capture and processing to reduce greenhouse gas emissions. Until such time as whole-of-mine VAM capture and treatment processes have been proven and are commercially available, ACOL may consider investigating more intensive gas extraction from the Ashton underground mine to reduce the volume of coal seam gas liberated into the mine ventilation system.

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APPENDIX 1 – OPTIONS TO REDUCE FUGITIVE EMISSIONS FROM DRAINAGE GAS

EVALUATION OF GREENHOUSE GAS EMISSIONS REDUCTION AND ABATEMENT OPTIONS - DRAINAGE GAS

CATEGORY	OPTION	DESCRIPTION	COMMENTS	RATING
FLARING - ENCLOSED FLARES	Permanent enclosed flare installation adjacent to centralised gas drainage plant.	Provide and maintain a permanent enclosed flare gas treatment and abatement facility in close proximity to a centralised gas drainage plant to flare all drainage gas.	A centralised plant eliminates requirement to relocate flare units to new goaf wells during longwall retreat thereby reducing operating cost. Enclosed flares are more complex than open flares and are therefore the process of relocation is more complex and time consuming. There is presently no centralised drainage plant at the Ashton underground mine. A high capacity, variable flow, enclosed flare installation would enable a high percentage of drained gas to be processed to reduce GHG emissions. Any additional gas from potential future pre-drainage programs, extracted through the centralised gas drainage plant, may aslo be directed to and processed by the centralised enclosed flares.	1
	Mobile enclosed flare units adjacent to existing mobile goaf drainage plant.	Provide and maintain one or more relocatable flare units, in close proximity to the existing mobile goaf drainage plant, to flare gas extracted from the mine.	Enclosed flares have significantly reduced visible impact due to the shrouding of the produces flame within a stack, similar to a silo, up to 8 metres in height. Enclosed flares typically have reduced throughput rate in comparison to open flares due to the requirement to maintain the flame within the confines of the stack. Potentially require multiple enclosed flare units which would increase the surface footprint of each drainage plant installation.	1a
POWER GENERATION	Reticulate goaf gas to Envirogen's Glennies Creek Powerstation.	Install an overland pipeline to reticulate drained goaf gas to Envirogen's Glennies Creek Powerstation.	Glennies Creek powerstation is presently under-rated for the potential gas supply from the Integra underground mine therefore, at present, has no capacity to accept additional gas. Potentially an option to consider in future should the capacity of the Envirogen powerstation be increased.	2
	Supply drained goaf gas to Macquarie Generation for use in offsite power generation.	Macquarie Generation have proposed and are believed to be considering the installation of an overland pipeline to source gas from coal mines to fuel an offsite powerstation.	Macquaries Generation have not yet committed to the installation of an overland gas collection and reticulation pipe network. Should such a pipeline be constructed and have the capacity to accept gas from ACOL, and subject to suitable commercial terms, this option may be worth considering for potential beneficial use of drained gas.	3
	Construct a standalone powerstation, adjacent to the proposed ACOL centralised gas drainage plant.	Ashton Coal Operations Pty Ltd (ACOL) to construct a standalone powerstation, adjacent to proposed centralised gas drainage plant to generate power using drainage gas as the principal fuel.	The relative commercial merits of such an option should be investigated in future. Presently not an option until such time as the centralised gas drainage plant is installaed and operational. Capacity of such a plant is unlikely to be rated to process total gas emission due to the likelihood of highly variable flow rate from goaf drainage wells. Gas extraction from multiple wells will provide some buffering to reduce the magnitude of flow variation however more likely to design a powerstation based on demonstrated consistent flow with provision to flare the periodic peak gas emissions.	4
	Construct a powerstation to be shared between ACOL and the adjacent Xstrata Ravensworth Underground Mine (RUM).	Ashton Coal Operations Pty Ltd (ACOL) to negotiate suitable terms and conditions with Xstrata RUM to build, own and operate a powerstation fuels by drainage gas suplied by both mines.	Presently this is a concept only and no discussions have been held between ACOL and Xstrata. Xstrata should be contacted to detemrine interest in such a concept and to assess the relative merits of considering such a concept. A powerstation that sources fuel from several mines would logically be a larger, higher capacity installation and may have the potential to reduce supply variability.	5
FLARING - OPEN FLARES	Mobile open "candlestick" flare adjacent to existing mobile goaf drainage plant.	Provide and maintain a relocatable open "candlestick" flare in close proximity to existing mobile goaf drainage plant to flare all drained gas.	Comparitively low cost and effective option to abate greenhouse gas discharged from existing mobile goaf drainage wells. Exposed flame - High visible impact. Potentially require multiple flare stacks to reduce flame height, however this would result in increased surface footprint and no effective reduction in visible impact.	6
	Permanent open "candlestick" flare installation adjacent to centralised gas drainage plant.	Provide and maintain a permanant "candlestick" flare installation in close proximity to a centralised gas drainage plant to flare all drained gas.	A centralised plant eliminates requirement to relocate flare units to new goaf wells during longwall retreat thereby reducing operating cost. There is presently no centralised drainage plant at the Ashton underground mine. The proposed centralised gas drainage plant is planned to be located within 500m of the New England Hwy therefore open flares in this location represent a high visible impact. Potentially require multiple flare stacks to reduce flame height, however this would result in increased surface footprint of the flaring installation and achieve no effective reduction in visible impact.	7
COMMERCIAL PIPELINE GAS SALES	Supply drained goaf gas into the high pressure natural gas pipeline	Install a gas processing (dewatering and conditioning plant), compression facility and overland pipeline to enable drainage gas to be sold into the natural gas pipeline.	The quality of coal mine drainage gas is typically too low to be consider for supply into the natural gas market. In addition to the high cost to extract the mine far greater expense would be required to process the drained gas to remove moisture and oxygen and in addition to installing a suitable pipeline to reticulate the gas from Ashton to the nearest connection point into the natural gas pipeline at least one gas compression station would be required to deliver the gas into the high pressure pipeline.	8

RATING: 1 = Most Preferred to 8 = Least Preferred.

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