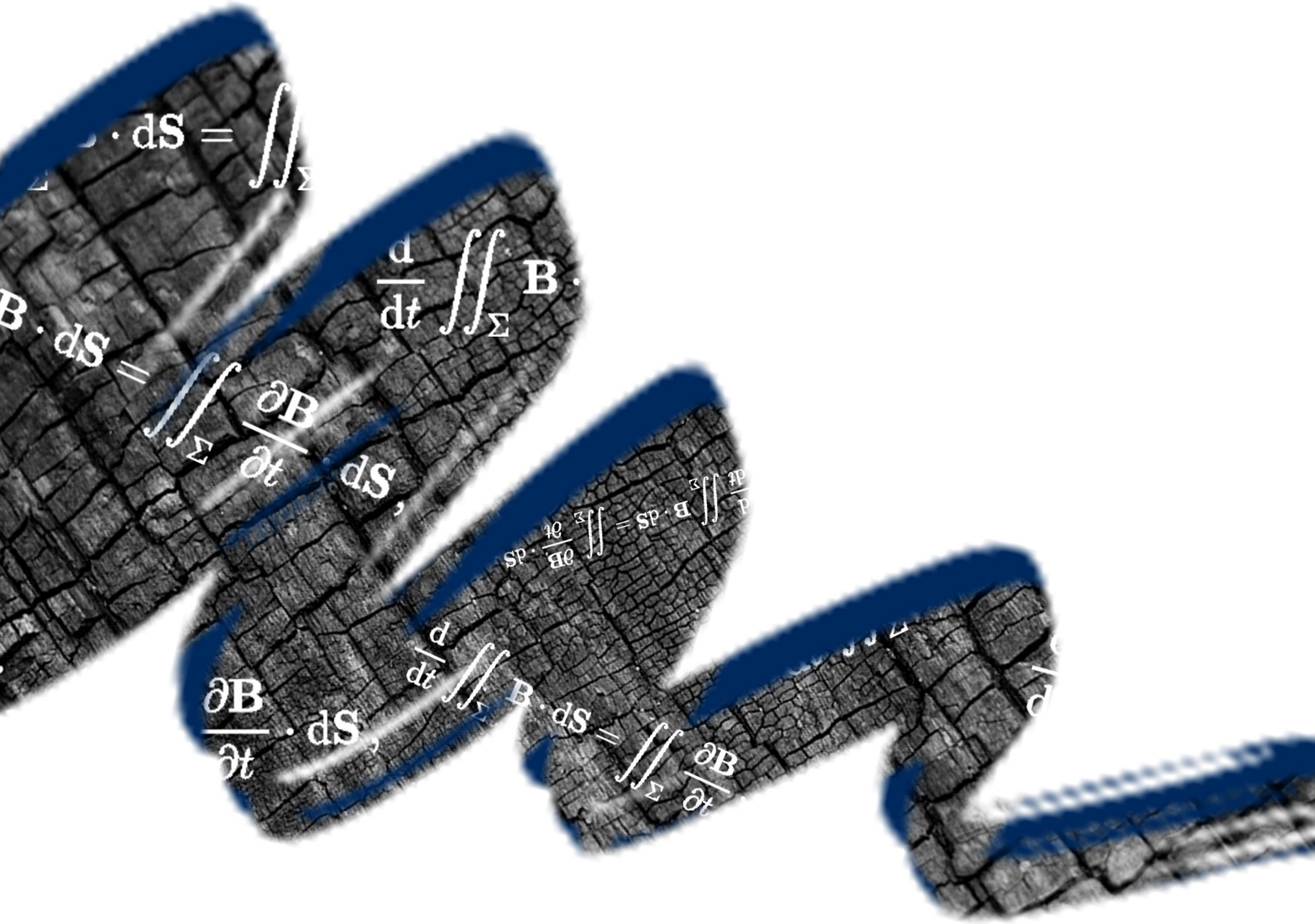
Appendix M

CoalBed pre-drainage feasibility report

EMM
creating opportunities

Feasibility of Pre-drainage Capture

For Hunter Valley Operations



FEASIBILITY OF PRE-DRAINAGE CAPTURE

For Hunter Valley Operations

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FINAL REPORT

FEASIBILITY OF PRE-DRAINAGE CAPTURE

For Hunter Valley Operations

CoalBed Energy Group (Australia) Pty Limited

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EXECUTIVE SUMMARY

Hunter Valley Operations (HVO) has undertaken coal seam gas emission studies at its open-cut operation in the Sydney Basin, New South Wales (NSW). This extensive database has informed a high-level review of pre-drainage capture potential. The results from this study are designed to address HVO submission requirements relevant to Department of Planning and Environment (DPE) advice as part of the application process for the extension of mining.

The following fundamental characteristics of the reservoir are relevant to pre-drainage capture:

- Gas content (m^3/t).
- Gas composition (%).
- Gas saturation (%).
- Permeability (mD).
- Net coal (m).

For successful and commercially viable gas extraction from coal, all these factors must be favourable. From a Coal Seam Gas (CSG) producer's perspective, if any of these factors are unfavourable, the outcome will likely be a non-commercial project with unreasonable drilling and handling costs. Considering that HVO is a Safeguard facility under the National Greenhouse Energy Reporting Scheme (NGERS), however, it may also be economic to conduct pre-drainage at a net cost if the facility is reducing the exceedance of its Safeguard Baseline. Given the declining Safeguard Baseline mechanism that HVO will face over the proposed Project's life, this is a relevant consideration.

This review of geological and gas properties at HVO reveals the following:

- Coal gas is contained in a multiple-seam environment.
- Coals generally have low gas content (<$6m^3/t$) but vary across the project.
- Coals are variably undersaturated.
- CO_2 is commonly found in parts of the proposed mine, and there are currently no commercially available methods to abate CO_2.
- Permeability is anticipated to be low at pre-drainage depths, based on regional observations. Site-specific data will need to be collected as part of further studies.

Given these gas reservoir properties, it may be challenging to produce meaningful gas at HVO through pre-drainage, and further detailed study is recommended to examine areas with higher potential. Low gas content, a high proportion of CO_2, low permeability, and variable gas undersaturation may limit successful pre-drainage. An added complication is the presence of spoil covering much of the site, the complexity of an advancing highwall operation, potentially adding to drilling costs and increasing risk.

Technical limitations similar to those observed at HVO have prevented successful long-term pre-drainage to date for existing open-cut operations in NSW and QLD. However, due to recent Safeguard Mechanism reforms and ongoing efforts to mitigate GHG emissions to meet reduction targets, there is increasing study into the development of cost-effective mitigation measures, including consideration of pre-drainage of open cut coal mining.

This high-level review has established that across the planned HVO mine area there is varying potential for pre-drainage, driven by varying gas content and composition. In summary:

- Domain 1 shows some potential for pre-drainage within Zone 3 and Zone 4, which represents <10% of the ROM coal modelled in Domain 1.
- Domain 2 shows the least potential for pre-drainage, due to its low gas content.
- Domain 3 may show some potential for gas drainage within Zone 3 and Zone 4 over the deepest (~50%) of the deposit, with the proviso that the CO_2 gas composition modelled is high compared to Domain 1.

For HVO a vertical completion strategy would likely be most appropriate as it provides connection to multiple coal seams from a single location. As the gas contents are already low and undersaturated, some well-stimulation may also be necessary to improve rates of production.

The amount of gas that may be captured and the likely cost of drilling needs to be investigated through a targeted study, including a trial program, in an area with higher potential, to determine the practicality and effectiveness of pre-drainage at HVO.

1. BACKGROUND

Hunter Valley Operations (HVO) is an established multi-pit open-cut coal mining complex near Singleton, NSW. The mine has a long potential life and is currently the subject of applications to continue mining operations at HVO North and HVO South to 2050 and 2045, respectively. The emissions profile of the project has been the subject of advice from the Department of Planning and Environment's (DPE) Climate and Atmospheric Science Division as part of the application process for the extension of mining. The company wishes to undertake a high-level review of the feasibility of pre-drainage of the coal seams proposed to be mined. The Climate and Atmospheric Science Division (CAS Advice) have raised some matters, and HVO is preparing a response. This report is designed to address the issue of feasibility of pre-drainage at HVO.

The aspect of the CAS Advice relevant to this report is quoted below:

> *'The Proponent has ruled out pre-drainage of coal seams as economically unviable for a multiseam open cut operation. However, the Proponent has provided no evidence or explanation for this in the EIS.*
>
> *Given the very large growth expected in fugitive emissions from the HVO Complex over the next 20-25 years, the Proponent must provide a comparison of the costs and benefits of pre-drainage to support the claim that it is not an economically viable option. The Proponent should also carry out in the first instance a feasibility study to assess the gas resource in the seams and the potential to extract that gas for beneficial use.'*

This report addresses the commentary above and provides supporting material to facilitate the HVO response to the DPE and CAS. This report's objective is to provide a high-level study and does not preclude future more detailed feasibility work being undertaken.

CoalBed and its Associates are experienced in coal mine geology, coal seam gas, coal geophysics and drilling. The company has been engaged in coal mine-related consulting since 1998 and has undertaken open-cut emissions studies for NGER purposes for over 15 years.

2. REPORT STRUCTURE

The report addresses the feasibility of pre-drainage at HVO via familiarisation with the HVO Greenhouse Gas (GHG) assignment model, mine plan and gas reservoir database. The report identifies the technical fundamentals that underpin pre-drainage capture in the context of the actual data provided by HVO, then addresses methods of capture from the commercial CSG industry and attempts to provide meaningful insight into what may be achievable in the application of pre-drainage methods at HVO. The report concludes with recommendations relevant to the feasibility of pre-drainage.

Specific information that has informed this study supplied by HVO, includes:

- Commentary from company professionals knowledgeable of the geological and gas assignment model.
- Company supplied gas assignment model, and relevant gas content and gas composition data.
- Company supplied gas data directly applicable to pre-drainage capture (including limited gas saturation and permeability data).
- The mining plan and relevant aspects of the geological model.
- Location of surface constraints that potentially impact upon drilling gas capture sites.

Independent investigations include:

- A review of available drilling options for capture that could be suitable for the HVO gas reservoir.
- Analogue data – where available – from similar sites in Australia and internationally.
- Indicative costs and likely benefits of any identified preferred approach to pre-drainage.

3. GEOLOGICAL FACTORS RELEVANT TO PRE-DRAINAGE FEASIBILITY

3.1 Fundamental reservoir factors

The following fundamental characteristics of the reservoir are relevant to pre-drainage capture:

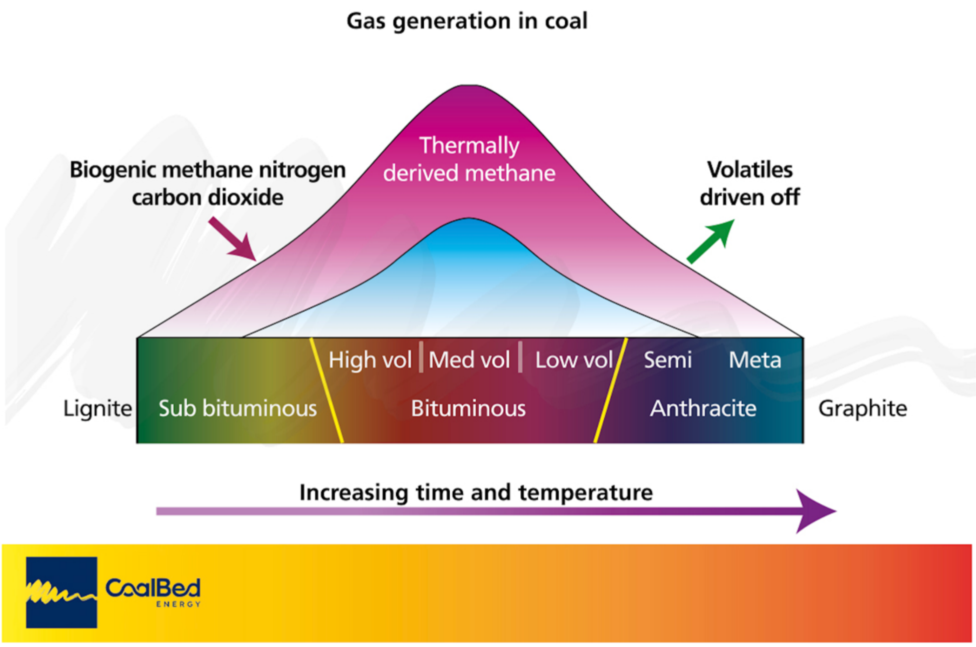
- Gas content (m^3/t).
- Gas composition (%).
- Gas saturation (%).
- Permeability (mD).
- Net coal (m).

For successful and commercially viable gas extraction from coal, all these factors must be favourable. From a Coal Seam Gas (CSG) producer's perspective, if any of these factors are unfavourable, the outcome will likely be a non-commercial project with excessive drilling and handling costs. Considering that HVO is a Safeguard facility under NGERS, however, it may also be economic to conduct pre-drainage at a net cost if the facility is reducing the exceedance of its Safeguard Baseline. Given the declining Safeguard Baseline mechanism that HVO will face over the proposed Project's life, this is a relevant consideration.

3.2 Gas Content

Coal seam gas content is measured in cubic metres per tonne (m^3/t). This describes the volume of gas a given tonne of coal may hold. Gas content is usually measured via a gas desorption test undertaken from bore core. The testing of the core for gas content is the fundamental building block for understanding coal seam gas properties and an essential ingredient in developing a reservoir model.

The ability of coal to generate gas increases with increasing rank (Figure 1). Peak generation occurs around Medium Volatile Bituminous rank coal, which declines thereafter. HVO coal is Bituminous, Medium Volatile, and is therefore of an appropriate rank to contain significant volumes of gas. However, due to its relatively shallow depth (and high levels of undersaturation - see Section 3.4), the coals contain significantly less gas than theoretically possible based on rank alone.



<u>Figure 1:</u> The peak for gas generation is around medium volatile bituminous rank. Most of this thermally generated gas from the HVO area has escaped over geological time.

HVO has an extensive exploration database and significant knowledge of sub-surface gas contents, reflected in the gas assignment model for the site (Table 1). Significant variation occurs over the lease area, reflected in separate and distinct gas domains (Figure 2).

<u>Table 1:</u> HVO Fugitive Gas assignment model showing three distinct domains, model as at 0723 (data supplied by HVO).

	Domain 1			Domain 2			Domain 3		
	Gas content (m3/t)	CH4%	CO2%	Gas content (m3/t)	CH4%	CO2%	Gas content (m3/t)	CH4%	CO2%
LGZ/Zone 0	0.3	0	50	0.3	0	50	0.7	31	39
Zone 1	1.4	62	18	2.3	86	7	1.2	56	22
Zone 2	3.1	91	5				2.5	82	17
Zone 3	5.3	95	3				6.1	59	40
Zone 4	6.8	94	4				4.4	55	45
20m below floor*	2.8	90	4	0.2	4	22	2.2	55	45

*includes B_Z=0.5 release factor

Figure 2: Location of three (3) distinct gas domains at HVO. Green dots represent relevant HVO boreholes used in establishing the model (figure supplied by HVO).

Coal seam gas content generally tends to increase with depth, with a gas-depleted surface zone commonly extending to a considerable depth (100-150m is standard in the Sydney Basin). This is usually followed by rapidly increasing gas content with depth. The gas content of this zone may vary from 4-12m^3/t throughout the broader Sydney Basin, highly dependent upon local levels of undersaturation. The measured relationship at HVO appears to fall in a typical range for many Sydney Basin coals of similar rank.

From the provided HVO gas model, some understanding can be reached of this relationship (Table 2 and Appendix I).

Table 2: HVO Fugitive Gas assignment model showing approximate depths (m) corresponding to the three distinct domains (data supplied by HVO).

High-level average depth range from pre-mining surface by Domain (0723 model)						
	Domain 1 - South West of Dyke		Domain 2 - North West of Dyke		Domain 3 - HVO South	
Zones	From	To	From	To	From	To
Low gas / Zone 0	0	70	0	180	0	90
Zone 1	70	120	below LGZ to pit floor where LGZ does not extend to pit floor		90	120
Zone 2	120	150-300			120	130-200
Zone 3	150-300	330			130-200	250
Zone 4	Below Z3 to pit floor where above zones do not extend to pit floor				Below Z3 to pit floor where above zones do not extend to pit floor	
20m Below pit	20 Below Pit Floor		20 Below Pit Floor		20 Below Pit Floor	

HVO note high variability between domains and zones, which is not unusual and consistent with the methodology adopted to satisfy NGER requirements and the inherent variability in undersaturated Sydney Basin coals.

Gas contents potentially suitable for pre-drainage occur in the following:

- Domain 1 shows some potential in Zone 3 and 4.
- Domain 2 shows the least potential for pre-drainage, due to its low gas content.
- Domain 3 may show some potential in Zone 3 and 4, noting the high CO_2 gas ratio in this area.

The gas content and composition data from HVO in the gas emission model suggest that the deeper parts of the proposed mine potentially contain enough gas for pre-drainage. Volumetrically, as a proportion of the total extracted ROM coal this is: <10% for Domain 1, 0% for Domain 2 and ~50% of Domain 3. The implications of this observation will be expanded in Section 5.

3.3 Gas Composition

The dominant coal seam gas is generally methane. Methane is a greenhouse gas, with a warming factor 28 times that of CO_2 for the same volume. It is, therefore, highly desirable to capture methane (where possible) and preferably utilise or mitigate (flare) that gas. However, all coal seam gas is not methane. Large proportions of CO_2 are present in the coals at HVO. Aside from mitigation of greenhouse gas there are currently no known benefits of capturing CO_2 emissions. Additionally, CO_2 can be challenging to extract from coal (due to its propensity to be retained in coals even at low pressures, a function of the shape of its isotherm – see Section 3.4). This also affects coal gas extraction strategies and drainage and utilisation practices.

In summary:

- Domain 1 shows high levels of CH_4 in Zone 3 and 4.
- Domain 2 has little gas, and much lower CH_4.
- Domain 3 shows both CH_4 and CO_2 in Zone 3 and 4.

The relatively high levels of CO_2 in Domain 3 and the shallow subsurface impact unfavourably on pre-drainage feasibility. The implications of the gas composition at HVO in terms of pre-drainage potential will be further discussed in Section 5.

3.4 Gas Saturation

The concept of saturation relates to the relationship between a) the amount of gas a given coal holds and b) the amount it can theoretically hold. If coals are saturated, they tend to be relatively easy to produce gas from and likely contain significant quantities of gas. Undersaturated coals imply that significant depressurisation will need to take place to produce gas – and this may produce large volumes of undesired water – and that the production life of the well may be limited.

To determine saturation, the following is needed: a measurement of the coal seam gas content, adsorption test results (the Langmuir Isotherm), and an understanding of the reservoir pressure of the coal. The isotherm will establish the theoretical gas-holding capacity of the coal (Figure 3).

Limited isotherm data has been supplied from HVO; which, alongside analogue data from the public record, suggests high undersaturation levels likely apply[1].

[1] *Thomson, S., Thomson, D., and Flood, P., 2014. Observations on the distribution of coal seam gas in the Sydney Basin and the development of a predictive model, Australian Journal of Earth Sciences, http://dx.doi.org/10.1080/08120099.2014.903860, see Figures 7 and 8.*

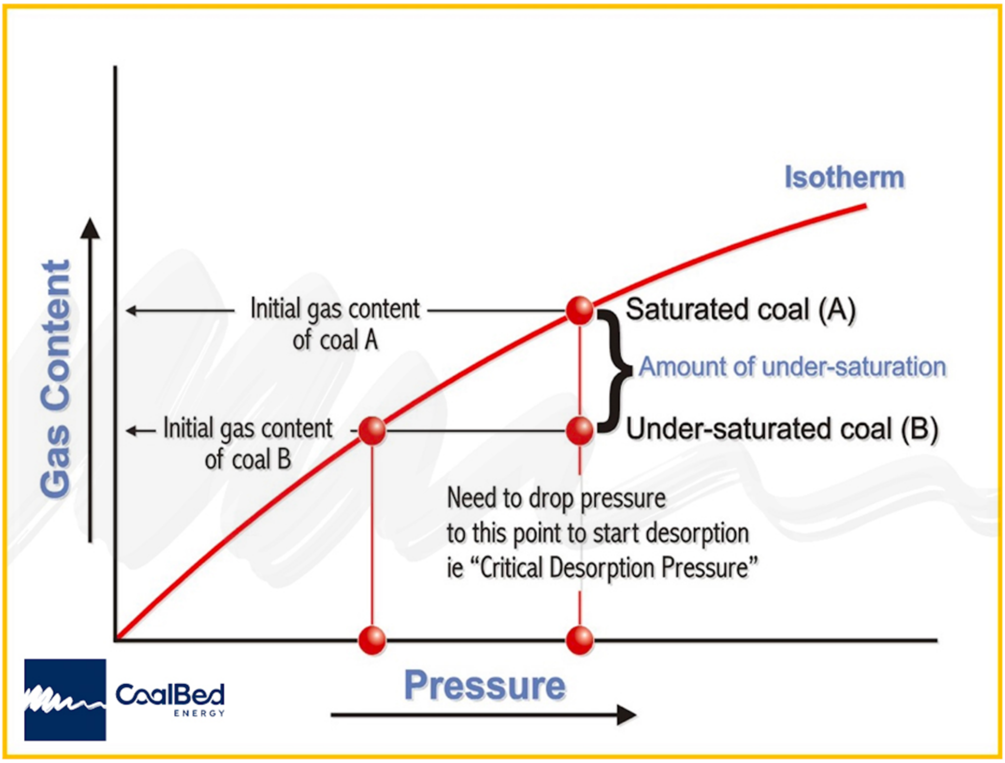


Figure 3: The concept of saturation expressed through the Langmuir isotherm. Coal A is saturated, and Coal B is undersaturated. The position of a given coal saturation condition - relative to the isotherm - determines the level of saturation of the coal.

The coals within the pit shell at HVO are anticipated to be variably undersaturated. This implies that potentially significant quantities of water may need to be extracted to reach critical desorption pressure, which is essential for the commencement of gas production. This would be achieved by lowering a pump into the borehole and physically removing water to create a zone of low pressure. Gas saturation data indicates that gas flow would likely occur after the removal of significant water at HVO.

The overall gas saturation condition at HVO is challenging for pre-drainage.

3.5 Permeability

Permeability in a coal seam is a product of the "openness" of the fracture system and the ability of the gas (and water) to flow from the micropore network (Figure 4). Permeability is measured in "Darcy's", or more commonly in coal, "milliDarcy's - mD). Most coals in the Sydney Basin would have a permeability somewhere between 5 and 30mD, with the number generally decreasing with depth[2]. Permeability is governed by a number of factors including:

- Mineralisation present within the fractures.
- The magnitude of the horizontal stress.
- The alignment of the fractures relative to the principal stress direction, i.e., if the fracture direction is perpendicular to the principal stress, the fractures tend to be closed.

If permeability is too low, producing gas will be extremely difficult. Permeability determines to a large extent the method of gas production that is likely to be deployed (for instance, low permeability often favours Surface to Inseam Directional Drilling techniques; however, this is not a favoured approach for multiple seam environments - like HVO).

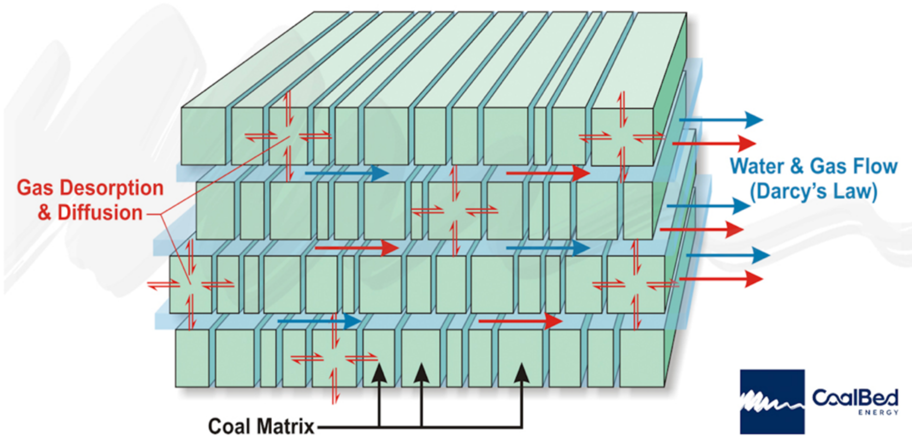


Figure 4: When gas is produced from coal the process involves diffusion and desorption. The ease at which gas and water will flow along cleat pathways in coal is the property known as 'permeability'.

Limited permeability data has been supplied from HVO; which, alongside analogue data from the public record, suggests that permeability will be low at the depths most suitable for pre-drainage[3]. This is challenging for pre-drainage at HVO.

[2] *Thomson, S., Thomson, D., and Flood, P., 2014. Observations on the distribution of coal seam gas in the Sydney Basin and the development of a predictive model, Australian Journal of Earth Sciences, http://dx.doi.org/10.1080/08120099.2014.903860, see Introduction, 3rd paragraph.*
[3] *As above.*

4. DATA SUFFICIENCY FOR PRE-DRAINAGE EVALUATION

HVO has utilised ~ forty (40) borehole sites for fugitive emission testing.

This gas sampling program extensively appraised all the major gas-bearing strata for the planned open-cut pit shell (a total of >500 samples).

This is sufficient data to undertake a meaningful high-level analysis of the viability of pre-drainage at HVO.

5. PRE-DRAINAGE CAPTURE METHODS

5.1 Summary of gas reservoir fundamentals relevant to gas capture methodology

The review of geological and gas properties at HVO reveals the following:

- Coal gas is contained in a multiple-seam environment.
- Coals generally have low gas content (<6m^3/t).
- Coals are variably undersaturated.
- CO_2 is commonly found in parts of the proposed mine.
- Permeability is likely to be low at pre-drainage depths, based on regional observations. Site-specific data will need to be collected as part of further studies.

Given these gas reservoir properties, producing meaningful gas at HVO through pre-drainage will be challenging, and further detailed study is recommended to examine areas with higher potential. Low gas content, a high proportion of CO_2, low permeability, and variable gas saturation may limit successful pre-drainage. An added complication is the presence of spoil covering much of the site, potentially adding to drilling costs and increasing risk.

Multiple seam environments tend to favour a vertical drilling approach. Low permeability (as anticipated at depth at HVO) implies some form of gas well stimulation may be required (for example, hydraulic fracturing), and low gas saturation means that a lot of water may need to be produced and disposed of to produce gas. None of these conditions are favourable for gas production in a commercial operation.

The various merits of the different primary gas extraction techniques are discussed below.

5.2 Vertical hole approaches

Vertical holes are the simplest and most cost-effective way to extract gas from coal seams. Coal seams can be under-reamed from vertical boreholes to increase the hole size (Figure 5). This method has been used very successfully in the Jurassic Surat Basin CSG fields of Queensland although there are no known open cut coal mining operations currently utilising this method. The Surat coals are low rank, the seams are heavily banded with bentonitic clay beds, and the coal plies are highly permeable.

Vertical wells with under-reaming would be the cheapest extraction method but rely on the coal being close to saturation and having permeabilities greater than about 50 millidarcy (mD) – unlikely to be the case at HVO.

For coals of lower permeability, some form of stimulation will likely be necessary, and hydraulic fracturing ("fracking") is commonly used in CSG applications.

If pre-drainage does occur at HVO, some form of multi-seam completion using vertical boreholes would be the most likely approach.

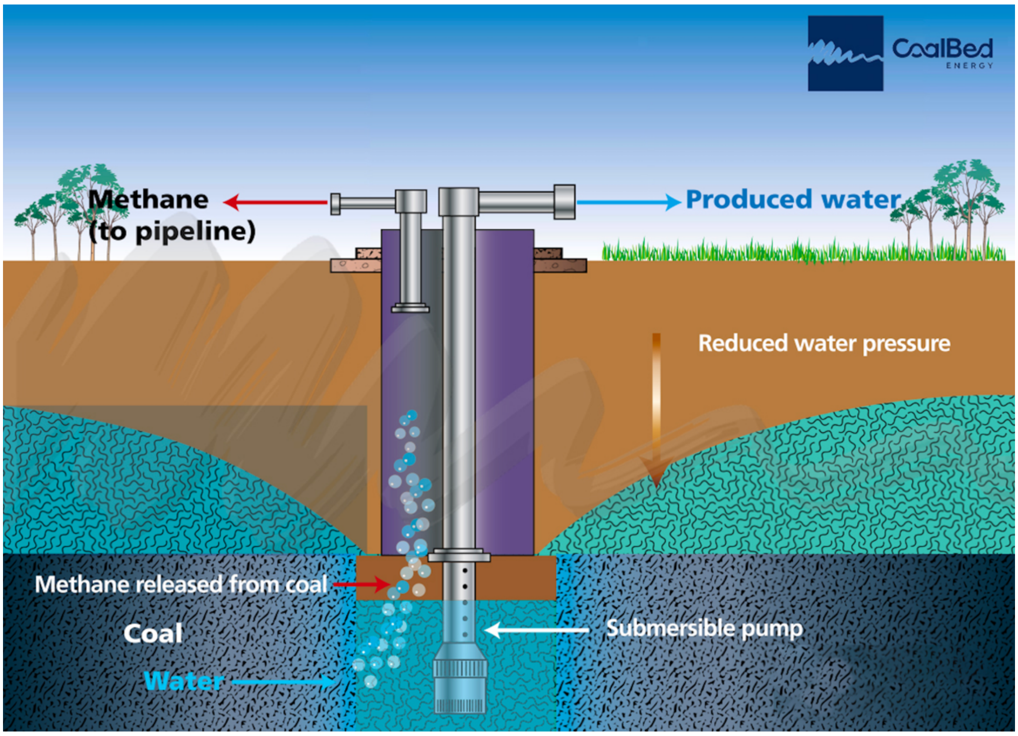


Figure 5: Example of a gas-producing vertical well in a coal seam.

5.3 Surface to Inseam Drilling

This method consists essentially of starting a borehole at the surface, bending the borehole through a medium radius arc, intersecting the target seam at a tangent, then continuing the hole laterally within the seam for (say) 500 to 1000m, and intersecting a pre-drilled vertical hole (Figure 6). Water is pumped through tubing in the vertical hole, and gas is produced from the annulus between the tubing and the bore casing. The water and gas are gathered throughout the length of the inseam section of the hole, and that section is analogous to a very well-directed fracture. There are other variations of this method, and all rely on having a long hole or holes inside the seam or seams.

This method can be very effective where conditions are suitable and cost-effective. For easy drilling, the seam needs to be structurally simple (without much faulting or folding), less than ~ 500m deep, thicker than ~ 2m, and the inseam section of the hole no longer than about 1000m. Excessive hole length makes navigation and control of the hole very difficult. Original coal permeabilities would need to be in the range 5 to 20mD.

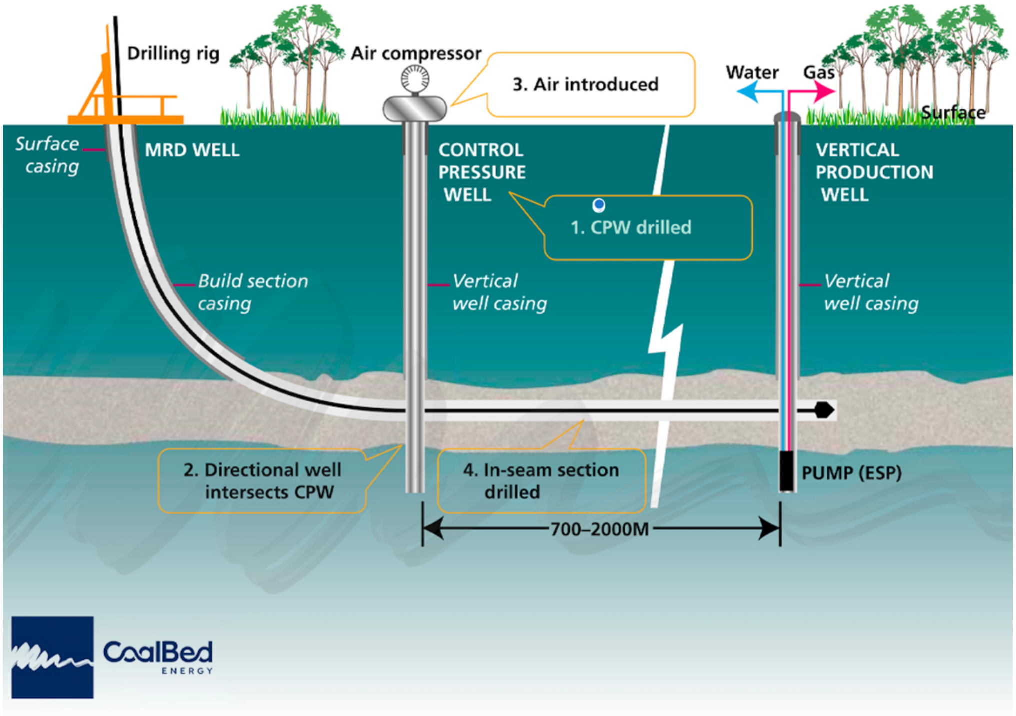


Figure 6: Example of a gas-producing horizontal well in a coal seam.

This method works best with one or two thick and gassy target horizons – not a multi-seam environment such as HVO.

It is possible that some kind of hybrid completion methodology is adopted that involves both vertical and horizontal wells.

6. ENVIRONMENTAL CONSTRAINTS

The extraction of gas from coal seams inevitably also involves the production of water, the volumes of which are largely determined by the unique gas saturation condition of the coals. The lower the gas saturation, the more water is produced prior to gas flow being initiated. HVO coals are anticipated to be undersaturated relative to gas and will likely produce significant volumes of water. This water must be transported, temporarily stored, and potentially disposed of, or otherwise utilised. A production trial will assist in determining the volumes of water likely to be generated from a pre-drainage program.

An additional potential environmental constraint associated with pre-drainage includes issues surrounding the use of chemicals associated with hydraulic fracturing – if this method is used to stimulate low-permeability coals.

A practical constraint will be drill-pad access for pre-drainage wells due to the dynamic nature of an active open-cut mining operation, and significant historic mining activity. The presence of previously emplaced spoil, tailings dams, rehabilitation areas, and the complex effect of the advancing highwall must be considered in evaluating the effectiveness of pre-drainage at HVO.

7. OVERALL FEASIBILITY

This high-level review has established that there is varying potential for pre-drainage across the planned HVO mine area, driven by varying gas content and composition, and requires further detailed study. In summary:

- Domain 1 shows some potential for pre-drainage within Zone 3 and Zone 4 which represents <10% of the ROM coal modelled in Domain 1.
- Domain 2 shows the least potential for pre-drainage, due to its low gas content.
- Domain 3 may show some potential for gas drainage within Zone 3 and Zone 4 over the deepest (~50%) of the deposit, with the proviso that the CO_2 gas composition modelled is high compared to Domain 1.

For HVO a vertical completion strategy would be most appropriate as it provides connection to multiple coal seams from a single location. As the gas contents are already low and undersaturated, some well-stimulation may also be necessary to improve rates of production.

Spacing between wells is yet to be determined (a reservoir model is required), but by analogue with a commercial coal seam gas project, it can be assumed that vertical / fracked production wells at HVO would need to be generally spaced on a grid pattern of roughly 200m–600m. Given the time constraints associated with the mine plan, and the rapid anticipated change in the groundwater regime, spacing may need to be significantly less than indicated.

Water will need to be removed from the coal seam to stimulate the movement of gas. This water will need to be stored in evaporation ponds on site, or otherwise utilised, as it is likely to be unsuitable for any potential offsite application.

A key driver of the feasibility of a pre-drainage strategy at HVO is overall recovery. Not all the gas will ever be obtainable. A percentage of the gas remains bonded to the coal (residual gas). A production finishing point occurs in every pre-drainage well, at an 'abandonment pressure'. This could possibly represent over 20% of the original potentially recoverable resource. The level of gas undersaturation can also impact unfavourably on overall recovery. Further work is needed, but as an indicative estimate, it is likely that a recovery of 65% of the potential gas available per well would be considered a good result in even the most optimum locations at HVO, given the gas reservoir fundamentals.

Vacuums on the surface can help extract a few more percent, but it is a slow and costly process with uncertain outcomes. A detailed reservoir study, followed by a trial program is needed to determine what may be achieved for HVO.

Complexities associated with interacting with existing open-cut operations at HVO also need to be addressed, e.g., the presence of the existing proximal highwalls. These areas have already caused significant changes to the depth of the groundwater table and the liberation of gas from shallow seams. Any pre-drainage strategy by HVO may require wells to be located significant distances from existing operations.

A final consideration is that current underground industry mitigation practices are associated with surface flaring of CH_4. CO_2, once extracted cannot be abated with flares and would need to be vented, thereby negating any emission reduction potential. CO_2 storage options would need further consideration.

In summary, there may be some pre-drainage potential in Domain 1 and Domain 3, Zone 3 and Zone 4. The cost of extraction is likely to be high due to the multiple gas reservoir issues raised in Section 3, and drilling will be affected by historical and active site disturbance. The amount of gas that may be captured and the likely cost of drilling needs to be investigated through a targeted study, including a trial program, in an area with higher potential, to determine the practicality and effectiveness of pre-drainage at HVO. This is the recommended next step for HVO.

8. CONCLUSIONS

Any likely pre-drainage recovery of gas at HVO will be challenging, and the areas of higher potential are <10% of Domain 1 and ~50% of Domain 3. Domain 2 gas is too undersaturated and has the least potential for pre-drainage recovery.

The amount of gas that may be captured and the likely cost of drilling needs to be investigated through a detailed gas reservoir and feasibility study, likely followed by a trial program. It is recommended that this level of study is considered.

The HVO low gas contents and undersaturated coals (a function mainly of depth and post-depositional history respectively) imply that significant volumes of water may need to be extracted before the coal seams reach critical desorption pressure and produce gas. This water will need to be disposed of or otherwise utilised.

Complexities associated with interacting with an operating site also need to be addressed e.g., the presence of nearby highwalls and other forms of site disturbance.

Potentially low gas recovery (due to practical abandonment pressure and level of undersaturation of the coals) may also provide significant operational challenges for gas capture and make the overall feasibility of on-site mitigation challenging.

Technical limitations similar to the ones discussed above have prevented successful long-term pre-drainage to date for existing open-cut operations in NSW and QLD. However due to recent Safeguard Mechanism reforms, and in ongoing efforts to mitigate GHG emissions to meet reduction targets, there is increasing study into the development of cost-effective mitigation measures including consideration of pre-drainage across the open cut coal mining sector.

9. RECOMMENDED FUTURE WORK PROGRAM

HVO has adequate gas content and gas composition data for a meaningful desktop gas reservoir study. However, there is limited isotherm or site-specific permeability data, and a future work program should address this deficiency, aimed at the deeper, gassier parts of the deposit.

Development of a gas reservoir production model and pre-drainage feasibility study using existing data is recommended, followed by a small-scale trial program. This will test how much gas may be captured, at what rate, and at what cost. This work is essential for establishing the true costs and benefits of pre-drainage at HVO.

APPENDIX I

ROM coal tonnes by Domain and Zone 2025-2050 (data supplied by HVO).

Gas contents potentially suitable for pre-drainage occur in the following:

- Domain 1 shows some potential for pre-drainage within Zone 3 and Zone 4 which represents <10% of the ROM coal modelled in Domain 1.
- Domain 2 shows the least potential for pre-drainage, due to its low gas content.
- Domain 3 may show some potential for gas drainage within Zone 3 and Zone 4 over the deepest (~50%) of the deposit, with the proviso that the CO_2 gas composition modelled is high compared to Domain 1.

Domain 1	ROM Mt	Domain 2	ROM Mt	Domain 3	ROM Mt
Low Gas Zone	45.5	Low Gas Zone	324.1	No Low Gas Zone	22.1
Zone 1	33.3	Zone 1	23.3	Zone 1	22.9
Zone 2	67.2	Zone 2		Zone 2	32.1
Zone 3	10.8	Zone 3		Zone 3	66.6
Zone 4	1.7	Zone 4		Zone 4	46.1
20m Below Pit	1.5	20m Below Pit	1.3	20m Below Pit	3.8

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