PB ASSOCIATES

DAMPIER BUNBURY NATURAL GAS PIPELINE

Evaluation of the Impact of a Broader Gas Specification

PUBLIC VERSION

Prepared for

ECONOMIC REGULATION AUTHORITY

Western Australia
Economic Regulation Authority

PB Associates *Quality System:*

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EXECUTIVE SUMMARY

This report presents the findings of an assessment of the impact of the proposed gas quality specification changes to the capacity of the Dampier to Bunbury Pipeline. The study has been undertaken to provide advice to the Economic Regulation Authority (the Authority) on the potential impacts of a change proposed in the Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline.

The Authority's proposed gas specification change is based on a number of parameters including closer alignment of the gas specification for the Dampier to Bunbury Natural Gas Pipeline with the National Gas Specification, and providing an environment where gas reserves other than those which currently supply the pipeline may be encouraged to be brought into production.

The Authority has received a number of submissions from DBNGP(WA) Transmission Pty Limited (DBP) and others that are not supportive of the proposed change for a number of reasons, including the potential for it to impact on pipeline capacity.

Having independently assessed the impacts of the proposed broadening of the allowable gas composition, the following conclusions are drawn:

- A capacity reduction occurs if the existing specification in the Standard Shippers Contract is changed to the broadest specification (proposed under Amendment 15 of the Draft Decision)

  The change would cause a capacity reduction for gas delivered to Kwinana of less than 1%.

  This not considered a material capacity reduction.

- While current producers have the capacity to deliver gas with inert levels at the maximum permitted concentration, they do not currently do this. Projections by the main existing producers suggest that the expected higher heating value (HHV) of the shipped gas will remain higher than the permitted minimum, and the associated Wobbe Index will remain higher than the permitted minimum. Accordingly PB Associates considers that the broader limits are a theoretical rather than a practical limit.

In light of the above conclusions, PB Associates is of the opinion that the broadening of the gas specification is unlikely to cause existing producers to change significantly from their current "normal" quality to the minimum permitted quality.

Further, given that the capacity loss in moving to the broadest gas quality specification proposed by the Authority is not significant, PB Associates is of the opinion that the overall technical (capacity) impact on the DBP is negligible. The change may have commercial implications however these are not considered in this technical assessment.

1. INTRODUCTION

DBP is in the process of establishing a revised access arrangement.

The Economic Regulation Authority (the Authority) has reviewed submissions in respect of gas quality, and in its Draft decision on the proposed revised Access Arrangement (Amendment 15) has proposed an alternative gas specification that further extends the concentration of inert components, and lowers the permitted Wobbe Index.

DBP and others have made submissions to the Authority on the potential commercial and technical (capacity) impacts that a further broadening of the gas specification would make to the pipeline and its users. To assist in forming an appreciation of these submissions and provide an independent view of the impacts, the Authority has engaged PB Associates to:

- Review and comment on submissions made by DBP and others in relation to the capacity impact of a broadening of the gas specification to the pipeline performance and;
- To undertake independent calculations of the pipeline capacity for a number of gas composition scenarios and a number of scenarios involving injection of quantities of “broadest” specification gas into the pipeline transporting gas currently shipped from the primary producers (North West Shelf Gas [NWSG] and Apache).

This report presents the results of those investigations.

2. IMPACTS OF A BROADER GAS SPECIFICATION

2.1 GENERAL

On May 11, 2005, the Authority released a Draft Decision on Proposed Revisions to the Access Arrangement for the Dampier to Bunbury Natural Gas Pipeline submitted by DBNGP (WA) Transmission Pty Ltd.

This document incorporates a requirement (Amendment 15) to broaden the composition of gas currently permitted to access the pipeline for transportation. In its Draft Decision, the Authority gave particular consideration to:

- the fact that widening the gas quality specification would potentially be of substantial benefit to many Users and Prospective Users through increasing the number of sources for gas that could enter the pipeline, increasing competition in the upstream market.
- the fact that widening of the gas specification would potentially reduce the cost of gas treatment prior to supply to the DBP (particularly for a gas whose composition is just outside the specification, where major capital cost is required to deliver a small composition change)

The parameters in the proposed gas quality specification that could impact negatively on the capacity of the pipeline are presented in Table 2-1.

Table 2-1 Minimum Gas Quality (Amendment 15)

Item	Unit	Value	
		Proposed (Amendment 15)	Existing (Standard Shipper Contract)
Maximum carbon dioxide	Mole %	4.0	3.6
Maximum inert gases	Mole %	7.0	5.5
Minimum higher (gross) heating value	MJ/scm	37.0	37.3
Minimum Wobbe Index	MJ/scm	46.5	47.3

The Authority has received submissions from a number of organisations commenting on the Draft Decision in general and on the impact of the proposed change to the gas composition in particular.

The Authority requested that as part of the work included in the assignment to develop this report the consultant:

> *Evaluate and comment on the veracity of the case put by DBP in its submissions in relation to the gas specification issue (i.e. that introduction of the Authority's broad gas specification in the next Access Arrangement will result in a major reduction in pipeline capacity)*

The Authority provided for consideration submissions by DBP from March, May and June 2005. The Authority also provided copies of submissions from:

- Wesfarmers LPG Pty Ltd (May 2005)
- Western Power (June 2005 and May 2005)

- BHP Billiton (May 2005)
- CSBP Limited (May 2005)
- NWSG (May 2005)

The evaluation and comments made in this section relate to the technical matters referenced in the various documents, principally those authored by (or for) DBP and DBNGP. Matters relating to commercial, contractual or economic performance of the pipeline asset, or economic benefit to the State or nation are beyond the scope of this assessment and thereby not included.

2.2 PURPOSE OF A GAS SPECIFICATION

A gas specification defines the envelope of gas composition for which:

- The gas transmission pipeline and associated distribution systems is designed;
- A gas composition which satisfies the requirements of the gas user, whether it be limited by combustion characteristics, or as a feedstock for a chemical process, or for other purposes; and
- Certain parameters which are necessary for the safety of personnel employed to operate and maintain the pipeline.

Under certain circumstances the gas specification may be developed with restrictive provisions, designed to protect a gas consumer from fluctuating properties that could for instance impact on the performance of a chemical process plant, or it might be restrictive simply for the pipeline owner's commercial purpose.

All (or practically all) natural gas transmission pipelines in Australia supply gas to a mix of industrial, commercial and domestic gas users. Consequently the transmission pipeline gas specification must at least satisfy the requirements for gas consumed in each of these market groups, resulting in a general purpose natural gas specification.

In 2003 an Australian Standard was published for general purpose natural gas (AS 4564). The scope and application of the standard is stated as:

1 General
This specification sets out requirements that ensure that general purpose natural gas that is transported and supplied is safe for use in natural gas appliances and equipment and for use as fuel in natural gas vehicles. Gas complying with this specification is safe for general purpose use but is not necessarily fit for purpose in all applications. General purpose natural gas is subject to contractual requirements between buyer and seller and in some cases to National or State requirements as to quality, including allowable excursions from the specification.

2 Inclusions and exclusions

The specification covers gas for general purpose use but is not intended to apply to gas supplies where no "general purpose" users are connected to the supply system, eg. a dedicated supply to an industrial user. General purpose natural gas can be formed by blending gas from different supplies. The hydrocarbon dewpoint limit in the specification may be more restrictive than need be for some general purpose natural gas supply systems that are confined to only one State. For these systems, where gas suppliers could face unnecessary additional expenditure in order to meet the limit, the relevant State regulatory body may provide for a higher limit if local conditions are favourable and it is possible to avoid excessive condensation with the higher limit. Compliance with such higher limit will constitute compliance with the Standard within that State only. In the absence of such provision the limit in the specification shall apply. Certain limits defined in the specification may be temporarily departed from under some circumstances. The issue of such departures is not within the scope of this

Standard and is subject to and provided for under relevant gas sales contracts, legislation and/or government guidelines.

3 Application

The specification applies to natural gas –

(a) from petroleum, landfill, biogas, coal seam and other sources where these sources provide gas for direct or blended supply on a commercial basis through supply systems serving general purpose customers;

(b) *transported and supplied to users for use in natural gas appliances and equipment complying with the relevant Standards. This includes natural gas powered vehicles, natural gas compressors and refuelling facilities. This specification is not intended to apply to natural gas for supply as a process feedstock, but may provide a basis for such a specification*.

Within Australia, this specification is considered suitable for *General Purposes* (broadly speaking gas consumers, rather than industrial plant). *General Purpose* users typically burn the gas in gas appliances. Gas appliances are not usually subjected to routine maintenance, but for safety reasons are required to have a very high reliability and safe combustion characteristics.

AS 4564 has established the following limits to the gas specification:

- Wobbe Index = 46 – 52 MJ/scm
- Inerts = 7.0% max
- Hydrocarbon Dewpoint = 2°C at 3,500 kPa

In determining the acceptable range of Wobbe Index, the Standard notes that the values are determined for a gas with a higher heating value in the range 37 to 42 MJ/scm and relative density in the range of 0.55 to 0.7.

The Standard also nominates levels of contaminants including oxygen, sulphur, hydrogen sulphide and water, which are not significant to this assessment.

Industrial combustion plant can be designed to accommodate gas compositions that fall outside the nominated range, but the design may require a relatively stable composition for the combustion efficiency (including the effective conversion of the hydrocarbon components to exhaust gases with characteristics that fall within permitted discharge limits).

When a pipeline is designed it is usual to establish a gas specification for the pipeline, which may be developed around specific source gas or consumer requirements. Notwithstanding this, it is usual for a pipeline developer to define a specification that is sufficiently broad to provide access to the broadest range of possible gases. This is because the developer is interested in attracting load to the pipeline to encourage revenue growth.

2.3 CHARACTERISTICS OF NATURAL GAS

Natural gas is a fluid composed predominantly of methane, but comprising proportions of higher chain paraffinic compounds, together with gases associated with the environment from which the natural gas was formed, typically carbon dioxide and nitrogen, but also containing a range of other components in small concentrations including oxygen, helium, argon and other rare gases.

Each gas reservoir has a characteristic composition, and this may change through the production life of the reservoir.

Each component of the gas has a commercial value. The characteristic reservoir composition, the reservoir size and the proximity to a market typically determine the extent of processing that the producer will undertake.

It is generally accepted that readily liquefiable components (propane [C_3] and higher) have greater value when sold separately as a liquid rather than remaining within natural gas. Consequently, gas transporters must assume that where a gas resource is of sufficient size and the composition of the gas carries sufficient condensable components, the gas will typically be processed to remove them. It is also reasonable to assume that little or no processing will be undertaken to remove components with no significant commercial value, except as necessary to satisfy a transportation specification.

Because the composition of a gas resource is fixed by nature (i.e. predominantly determined by the reservoir characteristics) it is most unusual for the composition of the natural gas components in each resource to change significantly throughout its production life, unless the world market for some of its components changes.

2.4 THE DBP GAS SPECIFICATION

The DBP specification was until recently dictated by the requirement to incorporate a specific minimum quantity of liquefiable components for extraction in a plant at Kwinana.

It is reasonable to expect that once the requirement to incorporate minimum quantity of liquefiable components is removed, the producers will adjust their processing plant to recover the liquid at source and market the valuable product separately. That this has not happened is presumably a combination of limits on the processing plant and commercial negotiations between customers and shippers (and presumably DBP) to maintain reasonable concentrations of these components in the gas to limit the impact of such a change on the pipeline capacity.

DBP has advised that its negotiations with Shippers and Users have determined that a potential exists to move from the existing Operating Specification in the Standard Shipper Contracts to a broader gas specification. However the proposed specification revision is not as broad as that proposed by the Authority in Amendment 15 to the Draft Decision.

2.5 THE EFFECT OF GAS COMPOSITION ON PIPELINE PERFORMANCE

Transportation of a compressible gas (such as natural gas) in pipelines behaves differently to that of a non-compressible fluid. When fluid flows in a pipe the pressure drops as a result of the frictional losses. However, a compressible gas expands as the pressure drops, with a resulting increase in the flowing velocity which accounts for the exponential curve of increasing pressure drop relative to distance. Accordingly the most efficient gas pipelines are those that operate at higher overall pressures.

The friction loss can be reduced by operating the pipeline at increased pressure, by internally lining the pipeline to create as smooth a surface as practicable, and by installing compressors at sufficient frequency so that the average pressure in each pipe segment is as high as possible (i.e. the average flowing velocity in a section is as low as possible). Once a pipeline is constructed there is little a pipeline operator can do to change its inherent hydraulic characteristics.

For hydrocarbon gases there is another effect called super-compressibility. When hydrocarbon gases are compressed they do not behave as an ideal gas. Super-compressibility means that more gas is contained in a unit volume at a given pressure than it would if it were an ideal gas.

The super-compressibility is dependent on the gas composition and is increased by the concentration of liquefiable components. Consequently the volumetric capacity of a pipeline carrying a gas composition with high levels of liquefiable components is higher than one carrying essentially methane. When the increased volumetric capacity is multiplied by the specific energy of the delivered gas (typically higher for a gas that contains liquefiable components than one that is essentially methane) there is a further boost to the energy delivered. Therefore it is in the interest of all users of the pipeline to maintain the concentration of liquefiable components as high as is practicable, to maximise pipeline efficiency.

On the other hand, inert gases that do not contribute to the gas specific energy (carbon dioxide and nitrogen) displace volume in the pipeline that could be occupied by combustible components and hence reduce the pipeline's energy transportation efficiency.

2.6 GAS MEASUREMENT

Gas received into and delivered from the pipeline is measured by volume (and in some cases, by mass).

Because commercial transactions are measured in energy units, each gas meter is equipped with a flow computer that performs the necessary calculations to convert the volumetric flow to energy flow, generally using the energy properties of the gas measured at the delivery point.

The DBP pipeline control system will monitor both the volumetric and energy flow, and should be capable of continuously calculating the blended gas composition at each blending point.

Most modern pipeline control systems allow set points for gas control equipment to be set for either an energy flow rate or a volumetric flow rate and hence the control systems are capable of managing the receipt or the delivery to accommodate variability in gas composition that may result from receiving gas with variable composition, such as may occur when blending is required.

2.7 DBP SUBMISSIONS TO THE ACCESS ARRANGEMENTS REVIEW

In this report PB Associates mainly focuses on DBP Submission #28 relating to technical issues which are raised relevant to this assessment.

2.7.1 Specification Alignment

With the development of a national specification for natural gas (AS 4564), it is reasonable that wherever possible the specification for transmission pipelines should be brought into alignment.

Retail customers use gas appliances that are sold in retail outlets, are required to operate with high reliability, and are seldom maintained (if at all). Many of these appliances are used in the home and are typically un-flued.

Consequently the combustion characteristics of these devices must be suitable to accommodate the permitted gas specification. Hence it simplifies manufacture and distribution of these devices if manufacturers can rely on the natural gas at any location satisfying a common specification.

Technically, the Authority's proposal to broaden the gas specification within the limits of the AS 4564 specification, is reasonable.

2.7.2 Capacity Impact

DBP presents an extensive argument against any move to the broadest gas specification on the basis of capacity impact.

It is true that any change in the composition from the composition for which the pipeline capacity is based, will impact on the capacity or the operating cost of the pipeline. These two parameters are considered below.

System Use Gas Impact

When the pipeline utilisation is less than its "capacity", then a change from a rich gas specification (high HHV and often low inerts) to one with a lean gas specification (low HHV and often high inerts) will still allow the energy delivery obligations to be satisfied, but at the expense of increased compression (with associated fuel and indirect maintenance costs).

When the pipeline is operating at its maximum capacity, then a change from its capacity rated gas composition to a lean gas composition will mean that the pipeline is unable to deliver the shipper's nominated energy, even though it might deliver the same and possibly higher volume than the volume for which it is rated.

Many gas pipelines require shippers to provide fuel for the equipment installed on the pipeline (generally called system use gas). This insulates the pipeline operator from the cost associated with transporting variable composition gas (e.g. if the shipper delivers low energy gas, then the shipper must provide more system use gas). It is understood that the DBP is itself required to supply system fuel, and hence this safety net does not apply. Consequently it is to be expected that DBP would resist any change to the gas specification that could require it to supply increased compression, and consequently to consume and pay for increased fuel. However, DBP has subsequently advised that its fuel costs are recoverable.

It is reasonable to expect that a pipeline operator will ensure that the pipeline capacity exceeds its contracted capacity by an amount that allows it to accommodate permitted variations in gas quality.

Gas Pipeline Capacity

DBP has made submissions stating that:

- There is a real and significant impact on the capacity of the pipeline for reasons other than the removal of liquefiable gas components from the gas specification; and
- The capacity impact is driven by heating value and Wobbe Index, both of which vary with gas composition and the quantity of inerts.

PB Associates considers that the first DBP statement is inaccurate, while the second part is correct.

The reason that the first part of the DBP statement is inaccurate is because the liquefiable components (predominantly C3 and C4) contribute significantly to the higher heating value and to the Wobbe Index.

The higher heating value of a gas is the sum of the proportion of each component multiplied by the heating value of the component. The Wobbe Index is equal to the gas higher heating value divided by the square root of its relative density. Table 2-2 illustrates the properties of each of the more significant components in natural gas.

Table 2-2 Comparative Gas Properties

Component	Higher Heating Value (MJ/scm)	Relative Density	Wobbe Index ($\frac{HHV}{\sqrt{Density}}$)
Methane	33.95	0.55	45.61
Ethane	60.4	1.04	59.31
Propane	86.4	1.52	70.03
Butane	112	2.00	79.07
Carbon Dioxide	-	1.52	-
Nitrogen	-	0.967	-

Revision 3: HHV values corrected and Wobbe Index recalculated

Table 2-2 shows that an increase in the C2, C3 or C4 components in the gas will increase the gas HHV and the Wobbe Index. Because carbon dioxide and nitrogen do not contribute to the heating value and increase the effective relative density, they will lower the Wobbe Index.

DBP has chosen to present their argument using Dutton Diagrams. The Dutton Diagram was developed by Brian Dutton for British Gas in 1984 as a method of assessing "gas interchangeability". It is understood that Britain is the only country to have adopted the Dutton Diagram for assessing gas interchangeability.

The Dutton Diagram represents the gas composition as an equivalent mix of propane and nitrogen in methane, plotted against the Wobbe Index. In the form that it was originally intended, the diagram represents limits for:

- Incomplete combustion;
- Sooting Index; and
- Flame lift.

The purpose of the Dutton Diagram is to provide a standardised method of assessing the performance of different gases in "gas appliances" (those that are typically used by retail and commercial gas users, not industrial users). It is used primarily for understanding the issues relating to the blending of imported gas into the UK gas system (some of these gases comply with different specifications from those in UK).

A Report "Importing Gas into the UK – Gas Quality Issues"[1] describes the issues faced with importing European sourced natural gas, and the importation of LNG from the Middle East with Wobbe Index in the range of 48.3-53.9, and blending it with other gases to match the UK Gas Safety Management Regulation gas specification, which requires the Wobbe Index to fall in the range of 47.2 to 51.4 MJ/scm (and between 46.5 and 52.9 under "emergency" conditions).

DBP has used the Dutton Diagram to compare gases that would comply with the proposed gas specification. The calculations presented with Submission # 34 are summarised in Table 2-3.

The information sought to be conveyed by DBP can, since each gas complies with the limits of the national specification for natural gas (AS 4564), be simply (and probably more clearly) conveyed by plotting the pipeline capacity against the Wobbe Index.

[1] Ilex Energy, November 2003.

Table 2-3 DBP Capacity Impact Calculation

Gas	HHV (MJ/scm)	Wobbe (MJ/scm)	Dutton	Max Capacity (TJ/d)	% Change
Stage 3A Post 07/05 "Average" Gas	Confidential				
Pure Methane	Confidential				
Min HHV, Inert <Max	Confidential				
Min HHV, Min Wobbe	Confidential				
Min Wobbe, Max Inert	Confidential				
Max HHV, Wobbe > Min, Max Inert	Confidential				
Max HHV, Wobbe > Min, Max Inert, No CO_2	Confidential				
Max HHV, Max Wobbe, Inert <Max	Confidential				
Max Wobbe – no Inert	Confidential				

Note 1: Confidential

Note 2: Value calculated in model used for calculations in this report.

Since DBP has an accurate model of their pipeline, including accurate performance modelling of each compressor on the pipeline, there is no reason to doubt that the compositions used in the calculations provided by DBP would deliver the flows reported by them.

Change in Capacity Compared with Existing Limits

It is noted that the "base" capacity in Table 2-3 is the "average" gas post stage 3A expansion, July 2005. Table 2-4 illustrates the key gas properties for the "average" gas delivered post July 2005 and the minimum gas properties permitted in the existing Standard Shipper Contract.

Table 2-4 Comparison between Stage 3A (7/2005) Average Gas and Standard Shipper Contract Minimum Gas Composition

		Average Stage 3A (post July 2005)	Standard Shipper Contract (Page 93 – Draft Decision
Higher Heating Value	MJ/scm	Confidential	37.3
Wobbe Index	MJ/scm	Confidential	47.3
CO_2	Mole %	Confidential	3.6
Inerts	Mole %	Confidential	5.5

While it is recognised that the pipeline currently enjoys the benefit of relatively "rich" gas (gas containing more than 1% C3+) it is obligated to accept and transport gas with considerably lower HHV and Wobbe Index.

DBP has (Table 2-3) illustrated the impact on pipeline capacity of changes to the gas quality against a base of the properties of the gas currently being shipped. While this is true as an actual comparison based on gas currently being shipped, it is not representative of the impact of broadening the gas quality specification. The correct comparison is either:

- Based on the existing gas composition with "new" gas supplied to the broadest gas specification as incremental capacity, or as gas displacing part of gas currently supplied by existing producers or;
- A theoretical comparison against a base of the existing minimum gas specification compared with the capacity for the "broadest" gas specification.

PB Associates has independently calculated the capacity reduction for the theoretical comparison between the current minimum gas specification and the proposed gas specification under Amendment 15. The reduction in capacity that results from a move from gas complying with existing Standard Shipper Contracts to gas complying with the broadest specification is summarised below:

Table 2-5 Capacity reduction between broad gas specifications

		Existing Gas Operating Specification[2]	Proposed Specification (Amendment 15)[3]
Higher Heating Value (min)	MJ/scm	37.3	37
Wobbe Index (min)	MJ/scm	47.3	46.53
CO_2 (max)	Mole %	4.0	4.0
Inerts (max)	Mole %	6.0	7.0
Max Capacity	TJ/d	564.84	561.87

Thus the incremental capacity loss due to the broader gas specification is 3TJ/d or 0.53%.

2.8 CONCLUSIONS

DBP has correctly identified that changes to the gas composition affect the specific volume, specific energy and calculated parameters including higher heating value and Wobbe Index. Because a pipeline transports volume, not energy, any change to the specific volume of the gas (by a change to its composition) will impact on the volume or mass of gas delivered, if the pipeline is operating at maximum capacity, and will impact on the operating cost of the pipeline if it is not operating at capacity (via increased fuel costs).

Because a change to the gas composition will result in a change to the specific energy, the change to the pipeline capacity expressed in energy terms may be greater than the change in its volumetric capacity.

DBP has taken a position that any change to the pipeline capacity as a result of a change in gas specification should be measured against the capacity when it is transporting gas with a composition typical of that delivered for shipment following expansion Stage 3A, post July 2005. This appears to ignore the fact that the existing gas specification permits gas that has a significantly lower HHV and Wobbe Index. (i.e. the capacity is referenced against a gas composition that is in the mid range of the existing specification limit).

This report considers that the correct comparison should be based either:

- On the existing gas composition with "new" gas supplied to the broadest gas specification as incremental capacity, or as gas displacing gas currently supplied by existing producers; or

[2] Draft Decision, Page 93.
[3] Draft Decision, Page 105.

- The capacity for the “broadest” gas specification compared against the existing minimum gas specification.

When assessed against either of the above recommended bases, the capacity change (reduction) is expected to be not more than 1%.