Duplication of proposed QGC pipeline

A REPORT PREPARED FOR QUEENSLAND GAS COMPANY

January 2010

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1 Introduction

1.1 Background

Queensland Gas Company (QGC) has asked Frontier Economics (Frontier) for its opinion as to whether QGC's proposed Surat Basin-Curtis Island pipeline would (or would not) likely satisfy pipeline coverage criterion (b) for a Greenfield Pipeline Exemption as outlined in s15 of the National Gas Law (NGL).

Queensland's discovered Coal Seam Gas (CSG) reserves have grown rapidly over the last few years – reserves have now reached levels sufficient to motivate strong interest in the large-scale production and liquefaction of this gas for eventual export to global markets.

While numerous proposals for LNG projects have been announced, Frontier understands that there are four *key* players looking to construct LNG processing facilities in southeast Queensland (utilising gas sourced from CSG reserves predominately in the Surat Basin) and to begin exporting processed LNG in the next few years:

- Arrow Energy-Shell consortium – planning to initially construct a 1.5 mtpa LNG processing train and begin exporting processed LNG at full capacity sometime over the period 2012-13.[1]
- Queensland Gas Company – planning to initially construct two LNG trains on Curtis Island capable of producing 7.4 mtpa of LNG, and begin exporting at full capacity sometime during 2014.[2]
- Santos-PETRONAS consortium – planning to initially construct a 3-4 mtpa LNG train on Curtis Island, with first deliveries expected sometime during 2014. Initial capacity is expected to be 3 mtpa.[3]
- Origin-ConocoPhillips consortium – planning to initially construct two 3.5 mtpa LNG processing trains on Curtis Island, with an additional two 3.5 mtpa trains to be developed at a later date. Initial capacity is expected to be 7 mtpa, with first deliveries of processed LNG expected sometime during 2014.[4]

In order to transport gas from its CSG reserves in the Surat Basin to its planned LNG processing facility on Curtis Island, QGC is proposing to build a 341 km

[1] See here and here for project details.

[2] See here for project details.

[3] See here for project details.

[4] See here and here for project details.

pipeline commencing at a point near the town of Wondoan and ending at a point on Curtis Island, just offshore of Gladstone.

This 'mainline' will be fed by several pipeline headers that will collect gas from multiple coal seam gas wells scattered across QGC's tenement areas in the Surat Basin. At this time it is proposed that all components of QGC's pipeline (mainline and headers) will have a diameter of 42 inches.

1.2 Structure of the report

The remainder of this report is structured as follows:

- Section 2 outlines Frontier's understanding of pipeline coverage criterion (b) and discusses our conceptual approach in determining whether criterion (b) is or is not likely to be satisfied.
- Section 3 outlines the data relied upon in this report and presents Frontier's resultant analysis and findings.
- Section 4 concludes.

2 Frontier's understanding of criterion (b)

2.1 Introduction

Section 151(1) of the NGL states that the service provider of a *Greenfield pipeline project* may, once a pipeline project has been proposed or commenced but before the pipeline has been commissioned, apply for a 15 year no-coverage determination.

An application for a 15 year no-coverage determination must be made in writing to the NCC. In recommending whether the pipeline be either exempt or not exempt from being a covered pipeline for a period of 15 years, the NCC, in accordance with s154(1):

(a) must give effect to the pipeline coverage criteria; and

(b) in deciding whether or not the pipeline coverage criteria are satisfied must have regard to the national gas objective.

Pipeline coverage criterion (b) states:

(b) that it would be uneconomic for anyone to develop another pipeline to provide the pipeline services provided by means of the pipeline.

While criterion (b) appears at first glance to be a standard natural monopoly test, its wording indicates that it is not. Specifically, the phrase "by means of the pipeline" references criterion (b) to the pipeline as proposed in the Greenfields exemption application.

A standard natural monopoly test with respect to a natural gas pipeline would seek to determine, given all feasible pipeline technologies, whether it is socially efficient to build only one pipeline to meet expected demand. A standard natural monopoly test is 'unconstrained' in this sense – the least-cost option over all possible alternatives is considered and tested.

In contrast, criterion (b)'s reference to **the pipeline** the subject of a Greenfield exemption application implies that the appropriate test is whether, given the existence of this pipeline, it is socially efficient to build only this pipeline (along with any augmentations to that pipeline) to meet expected demand. This test is thus constrained by the existence of the pipeline proposed in the exemption application.

2.2 Natural monopoly test

Notwithstanding the differences between a standard natural monopoly test and the test required by criterion (b), we now briefly consider the elements of a natural monopoly test and how such a test can be applied in practice.

Since in effect the test required under criterion (b) is a constrained form of a standard natural monopoly test, this discussion is relevant for the analysis subsequently presented in section 3.

2.2.1 Definition of a natural monopoly

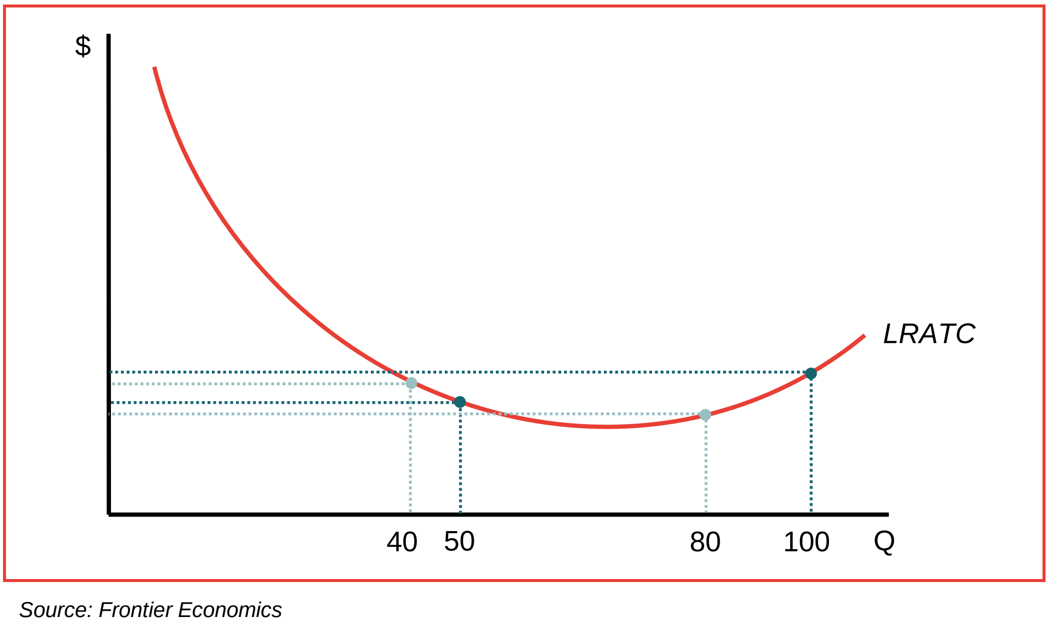
A natural monopoly is said to exist if it is efficient (i.e. least cost) for one firm to meet entire market demand rather than two or more firms. Kahn (1971, p.2)[5] describes the concept of a natural monopoly as:

> ... the technology of certain industries or the character of the service is such that the customer can be served at least cost or greatest net benefit only by a single firm...

Natural monopolies tend to arise in industries exhibiting a high proportion of fixed to variable costs, such that economies of scale are present over a large range of output.

Since total output is the same regardless of whether one or more firms produce (total output will be set by market demand) it is socially efficient (i.e. welfare maximising) for the number of firms in an industry to be such that the long-run average total cost (LRATC) of meeting total market demand is minimised. This level of output is referred to as efficient scale.

Figure 1: Natural monopoly example



Source: Frontier Economics

[5] Kahn, A.E. (1971). *The Economics of Regulation: Principles and Institutions: Volume II (Institutional Issues)*, New York, US: John Wiley & Sons.

This concept is illustrated diagrammatically in Figure 1 above. Consider a firm who possess a quadratic total cost function of the form $C = c \cdot Q^2 + F$, with Q representing output, c some constant and F fixed costs. The LRATC curve for a firm with the above cost function will be 'u-shaped'. Quantities to the left of the minimum of this curve imply that economies of scale in production exist – increasing output lowers the average cost of total output. Conversely, quantities to the right of the minimum imply diseconomies of scale –increasing output results in greater average total cost.

In this simple example, whether the industry or service implies a natural monopoly or not depends on market demand. For a total level of demand of 100 units, it is cheaper for two identical firms (or services) to produce 50 units each than it is for 1 firm to produce 100 units. Thus at a level of demand of 100 units, this service does not exhibit natural monopoly characteristics.

Conversely, at a market demand of 80 units, it is cheaper for 1 firm (or service) to meet the entire market demand than it is for two identical firms to produce 40 units each. Thus at a market demand of 80 units, this service does exhibit natural monopoly characteristics. In this case, it is socially efficient for only one firm to exist.

The characteristics of a natural monopoly, and of the test used to determine whether an industry or service within an industry exhibits natural monopoly characteristics, can be summarised as follows:

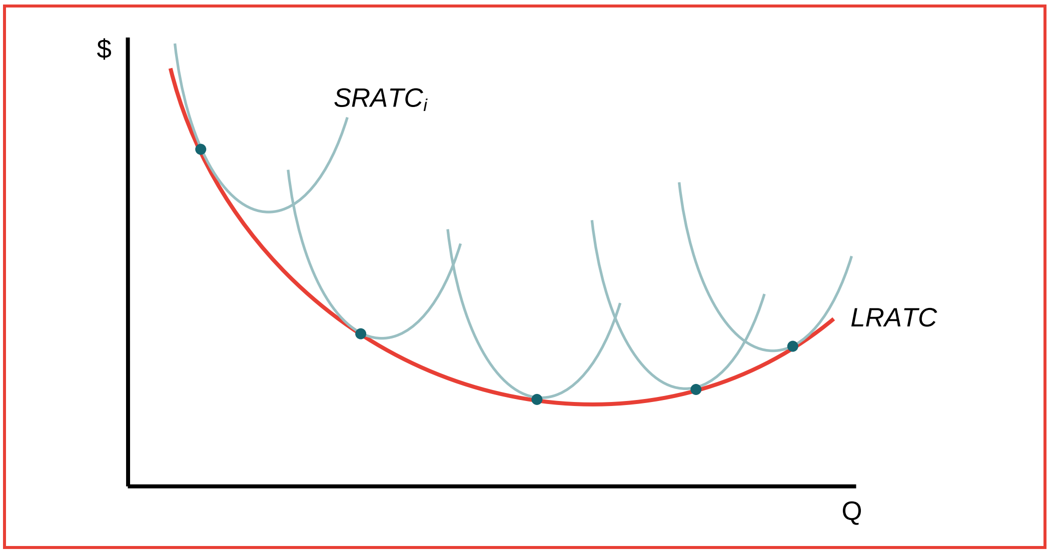
- Natural monopolies tend to exist when the relevant range of total output for the market or service exhibits economies of scale. This is often the case when fixed costs are large relative to variable costs.
- The test of a natural monopoly is to determine whether market demand is met at least cost by a single firm or service.
- Whether a service exhibits natural monopoly characteristics or not will depend on (i) production technology (shape of the LRATC curve) and (ii) the level of market demand.

2.2.2 Applying a natural monopoly test in practice

While in theory a firm's or service's cost function can be represented algebraically, the actual cost function that applies in any factual situation must either be estimated or approximated in a piecewise fashion.

The LRATC curve is defined as the lower envelope of a set of short-run average total cost (SRATC) curves. Each SRATC curve illustrates the relationship between average total cost and output for a given production technology or capital mix. Production technology, and thus the average total cost of producing a given level of output, varies across the SRATC curves.

Figure 2: Short-run average total cost and long-run average total cost



Source: Frontier Economics

Since in the long-run all inputs to production are variable, a firm can choose an efficient level of output by selecting its 'optimal' SRATC – that is, by choosing an optimal level of output produced by the optimal production technology. This concept is illustrated in Figure 2 above.

To approximate the LRATC curve of a firm or service, it is necessary to know the total cost of producing a given level of output over a range of production technologies. In practice, differing production technologies generally implies different levels of capital investment – in the case of gas pipelines, this might reflect different pipeline routes, diameters, levels of compression and/or looping.

Once the total cost of producing a given level of output for each available production technology is known, the SRATC curves of the firm or service can be approximated – one SRATC curve exists for each production technology. A LRATC curve can finally be approximated by taking the lower envelope of these various SRATC curves.

In the case of natural gas pipelines, in order to test whether a pipeline exhibits natural monopoly characteristics it is necessary to estimate the LRATC curve of providing the transportation services of the pipeline. This is achieved by following the process described above.

Once a pipeline service's LRATC curve has been approximated, the natural monopoly test described in section 2.2 can be applied using (i) the derived LRATC of the pipeline's service and (ii) expected demand for the pipeline's service. A pipeline is considered a natural monopoly if it is socially efficient (welfare maximising) for only one such pipeline to exist.

Frontier's understanding of criterion (b)

2.3 The test relevant to criterion (b)

As noted above, the test outlined in criterion (b) differs from that of a natural monopoly test, in that it supposes that there is an extra constraint: the pipeline for which exemption has been applied must exist.

The question in this case then becomes: what is the cost-minimising way for society to meet total market demand given the existence of this pipeline? In particular, given that the pipeline in question is going to be built, would the cost-minimising method of producing total market demand involve the development of another pipeline?

Since the test required by criterion (b) is a constrained form of a standard natural monopoly test, the appropriate cost to consider when deciding whether pipeline duplication is socially efficient or not is a 'constrained' long-run average total cost – that is, the long-run average total cost of providing pipeline services assuming the pipeline contained in the Greenfields no-coverage application is built.

3 Frontier's analysis and findings

3.1 Introduction

In order to determine whether QGC's proposed pipeline is likely to satisfy criterion (b), Frontier has applied a modified version of the standard natural monopoly test explained in section 2.3. This test in effect seeks to answer the following question:

> Given the existence of QGC's proposed gas pipeline, would it be socially optimal (i.e. economically efficient or welfare-improving) to build another pipeline to duplicate the pipeline services provided by QGC's proposed pipeline?

In answering this question, a view must be taken as to the meaning of the term *pipeline services*. For the purposes of our analysis, Frontier has interpreted pipeline services as meaning the transmission of gas from the Surat Basin to Curtis Island.

Testing criterion (b) also requires formulation of a theoretical additional pipeline, capable of duplicating the services provided by QGC's proposed pipeline. Based on Frontier's interpretation of criterion (b) this additional pipeline could take any form, so long as it is capable of duplicating the services (i.e. the transmission of gas from the Surat Basin to Curtis Island) provided by QGC's proposed pipeline.

Due to a lack of readily available and detailed cost and throughput information, Frontier's analysis considers only the appropriateness of duplicating the mainline of QGC's proposed pipeline – our analysis does not consider the header pipeline(s) required to feed this mainline with gas gathered from CSG wells.

Further, also due to the lack of information regarding cost and throughput for potential duplicate pipelines, Frontier's analysis is limited to considering the welfare impacts of developing additional pipeline(s) with costs and capacities that are founded on the costs and capacities of QGC's proposed pipeline, including potential augmentations to that pipeline such as compression or looping.

For this reason, pipeline options capable of providing gas transportation services from the Surat Basin to Cutis Island that are entirely different to the pipeline proposed by QGC (i.e. different routes and/or diameters) are not considered in this report.

In summary, the analysis subsequently presented in section 3 examines the various ways that transportation can be achieved via:

- augmentations to QGC's proposed pipeline (such as compression and looping)
- duplication of QGC's proposed pipeline.

Having taken a view as to the meaning of pipeline services and having defined an alternative pipeline capable of duplicating the services provided by QGC's proposed pipeline, Frontier's analysis proceeds by testing whether it is socially efficient to duplicate QGC's proposed pipeline in order to meet expected demand for the transmission of gas from the Surat Basin to Curtis Island, given that QGC's proposed pipeline is constructed.

3.2 Pipeline costs, throughput and demand data

In order to determine whether it is efficient to duplicate the pipeline services provided by QGC's proposed pipeline, it is necessary to determine and compare:

- the expected cost and throughput of augmenting QGC's proposed pipeline to meet expected demand
- the expected cost and throughput of duplicating QGC's proposed pipeline to meet expected demand.

To compare these alternatives, information regarding the cost, throughput and total demand for the services provided by QGC's proposed pipeline is required. Outlined below is a discussion of the key data inputs used in Frontier's analysis.

3.2.1 Pipeline costs

Frontier has relied on pipeline capex, opex and expected life estimates for various pipeline configurations provided by QGC – these estimates are based on the data available to QGC regarding its proposed pipeline.

In order to compute and compare the constrained average total cost of these various pipeline configurations, Frontier has calculated an annual pipeline cost by amortising relevant capital costs over an assumed life at an assumed discount rate, and then adding to this annual capex figure an estimate of annual opex costs.

Frontier's analysis considered nine potential configurations of QGC's pipeline:

- **Free flow** – the mainline configuration that QGC initially intends to construct. This configuration involves construction of a 42 inch, uncompressed mainline.
- **Single compression** – this configuration involves augmenting the free flow mainline with a single 28 MW compressor.
- **Maximum compression** – this configuration involves augmenting the free flow mainline with four, 40 MW compressors. Due to technical constraints this is the maximum feasible compression of QGC's proposed mainline.
- **Looped: free flow / free flow** – this configuration involves fully looping the free flow mainline. Full looping effectively doubles the pipeline's free flow capacity. Both pipelines are assumed to operate at free flow pressure.
- **Looped: free flow / single comp** – this option involves full looping of the mainline. One pipeline operates at single compression while the other pipeline continues to operate at free flow pressure.

- **Looped: single comp / single comp** – this configuration involves full looping of the mainline and single compression of both pipelines via two, 28MW compressors.
- **Looped: free flow / max comp** – this option involves full looping of the mainline. One pipeline operates at maximum compression while the other pipeline continues to operate at free flow pressure.
- **Looped: single comp / max comp** – this option involves full looping of the mainline. One pipeline operates at maximum compression while the other pipeline operates at single compression.
- **Looped: max comp / max comp** – this configuration involves full looping of the mainline and maximum compression of both pipelines via eight, 40 MW compressors.

Based on advice from QGC, Frontier's analysis assumes that QGC's mainline has an expected life of 40 years, while compressors have an expected life of 20 years. To consistently compare annual costs across pipeline configurations, we have assumed that QGC's LNG project has an expected life equal to the expected life of its proposed pipeline, or 40 years.

To match the expected life of QGC's pipeline with the expected life of its compressors, we have assumed it is necessary to replace pipeline compressors 20 years into the project. To account for this, the present value of future compressor re-investment costs have been added to upfront capex costs for configurations involving compression.

For the amortisation calculations, capital costs have been amortised over 40 years at an annual discount rate of 12% – this figure is consistent with the 12% real, pre-tax WACC used by MMA in their report to the Queensland Government regarding the financial viability and economic impact of Queensland's LNG industry.[6]

QGC provided estimates of up-front capex, annual opex and daily maximum achievable throughput (MAT) for the above nine pipeline configurations. The estimated upfront capex, annual opex and total annual cost of each configuration are outlined in Table 1 below.

Frontier understands that the upfront capex cost estimate associated with pipeline looping provided by QGC is based on an assumed construction cost multiple of 1.2 times the construction cost of building the original pipeline. This construction cost premium stems from the engineering complexities that arise when construction must occur in close proximity to an existing high-pressure gas mainline.

[6] See: MMA (2009). *Queensland LNG Industry Viability and Economic Impact Study*, prepared for: Queensland Department of Infrastructure and Planning, May 2009, p.57 and p.10 respectively, available here.

Assuming that the construction costs associated with pipeline looping are 20% greater than the construction costs associated with the original pipeline, and given that construction costs represent only a proportion of total upfront pipeline capex, this assumption implies that doubling pipeline capacity via complete looping as compared to doubling capacity via pipeline duplication is roughly 12% more expensive in terms of incremental upfront capex.[7]

Table 1: Pipeline configuration cost estimates[8]

Pipeline configuration	Upfront capex	Annual opex	Total annual cost
Free flow	[c-in-c]	[c-in-c]	[c-in-c]
Single compression	[c-in-c]	[c-in-c]	[c-in-c]
Max compression	[c-in-c]	[c-in-c]	[c-in-c]
Looped: free flow / free flow	[c-in-c]	[c-in-c]	[c-in-c]
Looped: free flow / single comp	[c-in-c]	[c-in-c]	[c-in-c]
Looped: single comp / single comp	[c-in-c]	[c-in-c]	[c-in-c]
Looped: free flow / max comp	[c-in-c]	[c-in-c]	[c-in-c]
Looped: single comp / max comp	[c-in-c]	[c-in-c]	[c-in-c]
Looped: max comp / max comp	[c-in-c]	[c-in-c]	[c-in-c]

Source: QGC capex and opex estimates; Frontier Economics calculations

3.2.2 Pipeline throughput

In addition to upfront capex and annual opex estimates, QGC also provided estimates of daily maximum achievable throughput for each pipeline configuration. These estimates are outlined in Table 2 below.

Table 2: Daily maximum achievable throughput estimates (TJ/day)

Pipeline configuration	Daily maximum throughput (TJ/day)
Free flow	1,510
Single compression	2,213
Max compression	2,916

[7] Looping capex / Duplication capex = ([c-in-c]/[c-in-c])-1 = 12.49%

[8] Compressor capex costs were provided in $USD/MW. This was converted to $AUD/MW using an assumed USD:AUD exchange rate of 1.111.

Pipeline configuration	Daily maximum throughput (TJ/day)
Looped: free flow / free flow	3,020
Looped: free flow / single comp	3,723
Looped: single comp / single comp	4,426
Looped: free flow / max comp	4,426
Looped: single comp / max comp	5,129
Looped: max comp / max comp	5,832

Source: QGC estimates; Frontier Economics calculations

3.2.3 Demand for gas transmission services

In its report to the Queensland Government, MMA predicted that south-east Queensland's CSG industry could readily achieve a reserve capacity of 35,200 PJ, sufficient to support eight 3.5 mtpa LNG trains located on Curtis Island.[9]

Assuming that eight LNG trains were to be simultaneously constructed, and that each train required 220 PJ/year[10], total CSG requirements for Queensland's LNG industry would be 1,760 PJ/year. This equates to 4,819 TJ of gas per day.

In a report prepared for QGC, ACIL Tasman has estimated that domestic and industrial demand for CSG in the Gladstone region will rise to roughly 67 PJ/year by 2015 and remain at these levels through to 2030. This equates to domestic and industrial demand of 181 TJ/day.[11]

The combined maximum daily demand for coal seam gas from the Surat Basin (both from domestic/industrial users and for LNG processing) is thus assumed to be 5,000 TJ/day.

3.3 Analysis and findings

This section presents Frontier's analysis and findings with respect to determining whether it is socially efficient to develop an additional pipeline to QGC's proposed pipeline.

This question is addressed by first considering the appropriate scale of pipeline infrastructure necessary to meet maximum expected CSG demand, and then

[9] MMA (2009), p.58-59.

[10] MMA (2009), p.10.

[11] ACIL Tasman (2009). *Gas Demand Study*, prepared for QGC, p.34.

subsequently determining whether this pipeline capacity is more efficiently provided by:

- augmentation of QGC's proposed pipeline (via compression and/or looping)
- duplication of QGC's proposed pipeline (via construction of additional pipeline(s)).

3.3.1 Determining efficient pipeline scale

The socially efficient pipeline scale is the level of throughput for which the constrained LRATC of pipeline services is minimised. In the following analysis, it is assumed that a given pipeline's daily maximum throughput can be multiplied by integer values for an equivalent multiplication in cost. In other words, we have assumed that it is possible to duplicate any given pipeline option for the same cost as the initial pipeline option.

As noted in section 3.2.1, the construction costs of completely looping a pipeline are assumed to be 1.2 times the construction cost of the initial pipeline, due to the engineering complexities associated with constructing in close proximity to an existing high-pressure mainline.

By contrast, pipeline duplication at a sufficient distance from the initial pipeline does not, as Frontier understands it, pose these additional engineering complexities. As such, our analysis assumes that duplicating a pipeline in its entirety has a capex cost equivalent to that of the duplicated pipeline, provided this duplication occurs at a reasonable distance from the original mainline.

For example, it is assumed that duplicating the free flow configuration of QGC's proposed pipeline at a sufficient distance from the original mainline would result in a daily maximum achievable throughput of 3,020 TJ/day (2 x 1,510 TJ/day) for a total annual cost of [c-in-c] (2 x [c-in-c]).

Assuming a maximum daily demand for the services provided by QGC's proposed pipeline of 5,000 TJ/day, the socially efficient pipeline scale involves construction of two pipelines – the first operating under single compression and the second operating under maximum compression.

In combination, two such pipelines have a combined daily maximum throughput of 5,129 TJ and a combined total annual cost of [c-in-c]. To meet an expected daily demand of 5,000 TJ/day, this mix of pipeline configurations results in a unit cost of transported gas of [c-in-c]/TJ.

This mix of pipeline configurations is lower cost than the cheapest mix involving the construction of only one pipeline – a fully-looped mainline with one pipeline operating at single compression and the other pipeline operating at maximum compression – which would result in a unit cost of [c-in-c]/TJ.

Table 3: Long-run average total cost: Pipeline configuration mixes capable of delivering at least 5,000 TJ/day

Pipeline configuration mixes	Expected daily throughput (TJ/day)	Max. achievable throughput (TJ/day)	Total annual cost	LRATC at EDT ($/TJ)	LRATC at MAT ($/TJ)
1 x Single compression 1 x Maximum compression	**5,000**	**5,129**	**[c-in-c]**	**[c-in-c]**	**[c-in-c]**
2 x Free flow 1 x Single compression	5,000	5,233	[c-in-c]	[c-in-c]	[c-in-c]
1 x Looped: Single comp / Max comp	5,000	5,129	[c-in-c]	[c-in-c]	[c-in-c]
1 x Looped: Free flow / Single comp 1 x Free flow	5,000	5,233	[c-in-c]	[c-in-c]	[c-in-c]
1 x Looped: Free flow / Free flow 1 x Single compression	5,000	5,233	[c-in-c]	[c-in-c]	[c-in-c]
2 x Maximum compression	5,000	5,832	[c-in-c]	[c-in-c]	[c-in-c]
1 x Looped: Max comp / Max comp	5,000	5,832	[c-in-c]	[c-in-c]	[c-in-c]
4 x Free flow	5,000	6,040	[c-in-c]	[c-in-c]	[c-in-c]
2 x Looped: Free flow / Free flow	5,000	6,040	[c-in-c]	[c-in-c]	[c-in-c]

Source: Frontier Economics

For completeness, the average total cost of a range of feasible pipeline configurations capable of meeting a daily demand of 5,000 TJ/day are presented in Table 3 above. An average total cost is provided for both expected daily throughput (EDT) of 5,000 TJ/day and for the maximum achievable throughput (MAT) of that configuration mix. Those configuration mixes involving augmentation of QGC's proposed mainline (as opposed to duplication) have been highlighted blue.

The findings of this analysis are broadly consistent with those presented by MMA in their report to the Queensland Government. In that report, MMA state:

> Several factors suggest that the capacity requirement will be met most efficiently by a series of replica pipelines using the same route, rather than by one very large capacity pipeline.[12]

In addition to the quantifiable capex and opex costs associated with meeting expected demand of 5,000 TJ/day via a single pipeline (i.e. fully looped, single / maximum compression) there are likely to be additional unquantifiable costs associated with a single pipeline that make pipeline duplication additionally attractive. These include:

- **Coordination costs** – including the cost of negotiating, contracting and enforcing an agreement for the shared use of a single pipeline. While the magnitude of these costs is hard to estimate, Frontier understands that high-level discussions regarding coordinated pipeline investment have occurred in the past between representatives of the various parties interested in extracting, liquefying and exporting LNG gas from south-eastern Queensland. Given that evidence of a pipeline coalition or joint venture has to date not materialised, these costs may have proved significant.
- **Risk allocation** – multiple pipelines provide a diversification benefit with respect to the risk of pipeline failure. If a common pipeline were shared, it would likely be difficult and costly to allocate the risk of pipeline failure between concerned parties (pipeline operator and multiple users) in the event that a shared pipeline failed.

Both the costs associated with coordination and risk allocation between multiple parties strengthens the case that pipeline duplication is likely to be socially efficient. The lack of an emerging pipeline coalition or joint venture between interested parties enforces this view.

3.3.2 Sensitivity analysis

The results presented in section 3.3.1 are essentially invariant to **common changes** in discount rate, expected life, capex or opex assumptions. That is,

[12] MMA (2009), p.112

scaling these assumptions equivalently across all pipeline configurations changes the level of average total cost, but does not materially change the cost relativities between the options.

In order for a change in input assumptions to alter the result indicating that pipeline duplication is likely to be socially efficient, it is necessary for either:

- the cost of looping to be relatively cheaper than the cost of pipeline duplication. This is equivalent to a case where economies of scale (rather than diseconomies of scale) exist in pipeline looping, such that it is cheaper to double capacity via looping rather than duplication.
- the demand for pipeline services to be lower than expected.

Pipeline looping relatively cheaper than duplication

If the cost of pipeline looping relative to the cost of pipeline duplication falls considerably, it is possible for a single, fully-looped mainline (with one pipeline operating at single compression and the other at maximum compression) to be more efficient than a combination of two unlooped pipelines, again with one pipeline operating at single compression and the other at maximum compression.

In order for this to be the case, it is necessary for economies of scale to exist in pipeline looping, such that it is cheaper to double pipeline capacity via pipeline looping rather than pipeline duplication.

Based on the assumed upfront capex costs associated with pipeline looping outlined in Table 1, for a single, fully-looped pipeline of optimal configuration to be socially efficient would require a reduction in the upfront capex cost associated with pipeline looping of [c-in-c] (a fall from [c-in-c] to [c-in-c]). This represents a roughly 11% reduction in the assumed upfront capex costs associated with pipeline looping.[13]

Demand for services lower than expected

In addition to the cost of pipeline looping relative to the cost of pipeline duplication, a second key parameter in determining socially efficient pipeline scale is expected daily maximum demand for pipeline services.

Frontier's analysis assumes a daily maximum demand of 5,000 TJ, which is consistent with:

- eight, 3.5 mtpa LNG trains operating at full capacity – each 3.5 mtpa LNG train is assumed to require 220 PJ per annum, or roughly 600 TJ/day[14]
- domestic demand for CSG gas from the Surat Basin of 181 TJ/day.[15]

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13 ([c-in-c]/[c-in-c]) - 1 = -11.1%.

14 Based on MMA (2009).

For daily demand in excess of 2,916 TJ/day, either pipeline looping or pipeline duplication is required, due to technical constraints associated with the maximum achievable compression of QGC's proposed mainline.

Since any looped pipeline configuration can be replicated at lower cost by building two separate pipelines of the same configuration, it will always be socially efficient to duplicate (rather than loop) QGC's proposed mainline for daily demand in excess of 2,916 TJ/day. As discussed above, this result is driven by the assumed diseconomies of scale in pipeline looping.

Based on this analysis, an important question to ask is: how reasonable is the assumption of daily maximum demand of 5,000 TJ, and more importantly how likely is it that demand for the services provided by QGC's proposed pipeline will exceed 2,916 TJ/day?

As was outlined in section 1.1, Frontier understands that there are four *key* players looking to construct LNG processing facilities in southeast Queensland and to begin exporting processed LNG in the next few years. The initial expected capacity of these four projects is as follows:

- Arrow Energy-Shell consortium – planning to initially construct a 1.5 mtpa LNG processing train
- Queensland Gas Company – planning to initially construct two LNG trains with a total capacity of 7.4 mtpa
- Santos-PETRONAS consortium – planning to initially construct a 3-4 mtpa LNG train
- Origin-ConocoPhillips consortium – planning to initially construct two 3.5 mtpa LNG processing trains with an initial capacity of 7 mtpa.

These four projects amount to a combined LNG industry of roughly 18.9 mtpa. Assuming that a 1 mtpa LNG facility requires roughly 63 PJ/annum of gas supply[16], a conservative estimate of likely demand for pipeline services from the Surat Basin to Curtis Island would be 1,320 PJ/annum, or 3,614 TJ/day.[17]

Thus even at a conservative estimate of daily pipeline demand, QGC's proposed mainline would require either complete looping or duplication, given that conservative daily demand of 3,614 TJ/day exceeds the daily maximum achievable throughput of a single, unlooped pipeline of 2,916 TJ/day. As noted above, due to the diseconomies of scale associated with pipeline looping, pipeline duplication would be the socially efficient option in this case.

15 ACIL Tasman (2009).

16 Based on MMA (2009), who estimate that a 3.5 mtpa LNG facility requires roughly 220 PJ of gas per annum.

17 Assuming an annual pipeline load factor of 90%, consistent with MMA (2009).

4 Conclusion

Frontier interprets pipeline coverage criterion (b) as being a 'constrained' form of natural monopoly test. Rather than considering whether, given all feasible technologies, it is socially efficient for only one pipeline to exist, criterion (b) requires consideration of whether, given the existence of the pipeline contained in a Greenfields no-coverage application, it is socially efficient to build only that pipeline (allowing for augmentations to that pipeline).

Based on capex, opex and daily maximum achievable throughput estimates for various configurations of QGC's proposed mainline, Frontier estimated the constrained long-run average total cost of providing gas transmission services from the Surat Basin to Curtis Island given QGC's chosen pipeline technology. This analysis only considered duplicate pipelines equivalent to that proposed by QGC due to a lack of detailed cost and throughput information for alternative pipelines.

Based on this estimated constrained long-run cost function, our analysis indicates that the socially efficient pipeline scale to meet an expected daily maximum demand of 5,000 TJ consists of two pipelines – the first operating at single compression and the second operating at maximum compression.

Since it is more efficient to duplicate QGC's proposed mainline than it is to meet expected daily maximum demand via one such pipeline that has been augmented, it is unlikely that pipeline coverage criterion (b) would be met with respect to QGC's proposed pipeline.

This result is essentially invariant to common changes in assumed asset lives, discount rates or levels of capex and opex. In order for pipeline duplication to become socially inefficient, it is necessary for either:

- the assumed cost of pipeline looping to fall considerably relative to the assumed cost of pipeline duplication
- the demand for pipeline services to be considerably lower than forecast. Specifically, it would require the demand for pipeline services to be lower than 2,916 TJ/day based on Frontier's calculations.

These findings are broadly consistent with the views expressed by MMA with respect to likely efficient pipeline scale in its report to the Queensland Government regarding the financial viability and economic impact of Queensland's LNG industry.

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