NERA
ECONOMIC CONSULTING

Determining a Reserve Price for a Short Term Gas Transmission Auction

A report for the Australian Energy Market Commission

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Introduction

The Australian Energy Market Commission (AEMC) has retained NERA Economic Consulting (NERA) to provide advice on reserve prices for short-term gas transmission pipeline capacity auctions. The AEMC proposed these auctions as part of a suite of reforms that collectively address pipeline capacity market issues that impede the Energy Council's Vision for Australia's future gas market.[1]

As the Australian contract carriage capacity market currently stands, contract shippers — shippers that purchase firm capacity directly from pipeline operators under a gas transportation agreement— typically must nominate their transportation requirements by a deadline (typically a day ahead). After the deadline, the contract shipper generally loses its entitlement to firm capacity that is contracted, but not nominated, allowing the pipeline operator to re-sell that capacity to another shipper—as a product called "as available" capacity— typically at a higher price and at the discretion of the operator.

As one possible method for improving economic efficiency and incentives for shippers to trade capacity, boost non-discriminatory access to capacity, allocate capacity to shippers that value capacity most and improve transparency, the AEMC is investigating regulator-administered auctions for contracted, but un-nominated, capacity on a day-ahead basis. Proceeds of such auctions would continue to go to pipeline operators, and the auction would have a regulated reserve price determined by the Australian Energy Regulator (AER). The purpose of this interim report is to propose and assess various methods to calculate that reserve price under such an auction. We do not address in this report the broader context of any such administered auction or the other alternatives to contract shippers for making the most of their un-nominated contract capacity. We also do not deal in this report with the question of how, if pipeline operators recoup some portion of their costs through auction proceeds now, those costs would otherwise be collected in a changed regulatory regime that includes such an auction of un-nominated capacity.

This report has three sections:

- Section 1 describes a method for calculating the short run marginal cost (SRMC) of gas transmission;
- Section 2 explores alternatives to SRMC for setting an auction reserve price and assesses the efficiency effects of including volumetric loading of fixed costs in that administered auction floor; and
- Section 3 concludes.

[1] AEMC, 'East Coast Wholesale Gas Market and Pipeline Frameworks Review, Stage 2 Draft Report', 2015 <http://aemc.gov.au/Markets-Reviews-Advice/East-Coast-Wholesale-Gas-Market-and-Pipeline-Frame#tab-subheading1007> [accessed 10 February 2016].

1. Calculating SRMC

Economists categorize costs to better understand them over time and at different levels of output. The “short run” describes periods where at least one factor of production is fixed. The “long run” describes a period where no factors of production are fixed. In the supply of pipeline capacity, the physical pipeline infrastructure is the least variable input, and so the short run describes any period in which the pipeline infrastructure is fixed and the long run describe a period in which a pipeline operators can propose to sell new capacity to respond to market signals. The short run costs of supplying pipeline capacity relate to the operating of essentially fixed assets and are therefore small to the long run costs.

In longstanding terminology used by the US Federal Energy Regulatory Commission (the FERC), costs are “classified” as either fixed or variable.[2] The FERC adopts a simple yet highly effective and relatively uncontentious method for classifying costs to set rates across all interstate pipelines. [3] Costs that make up the cost-of-service are identified as either fixed or variable. Fixed costs remain constant regardless of throughput and are predominantly associated with capital investment in the pipeline system. Variable costs increase with the volume of throughput. Since Order No. 636,[4] which is the major rulemaking defining the new regime competitive regime for US pipeline by which shippers control FERC-licensed capacity rights, the FERC recognised that the variable costs primarily consist of compressor fuel costs.[5]

SRMC describes the incremental cost incurred by pipeline operators to supply additional pipeline capacity—or unit variable cost— in the short run. In cases of adequate gas capacity—when un-nominated capacity is available for sale on the AEMC’s proposed auction—SRMC of gas transmission equals the cost of incremental fuel used to run compressors.

SRMC could be expressed in at least two ways: (1) in dollars per gigajoule ($/GJ); or (2) as a percent of throughput. In practice, an SRMC expressed in $/GJ would form the regulated reserve price of the auction. A winning bid at the reserve price ensures the “subletting” shipper compensates the pipeline operator for the incremental cost of shipping gas. Alternatively, a SRMC expressed as a percentage—gas consumed as fuel divided by throughput—sets the regulated reserve price of the auction at zero, but obliges the subletting shipper supply its incremental compressor fuel requirement to the pipeline operator.[6] Many US pipeline operators

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[2] The three operable terms for normal FERC gas pipeline tariff making are “functionalization” relating to which function (transport, storage, etc.) facilities serve, “classification” relating to the fixed/variable character of costs, and “allocation” relating to how costs should be apportioned along pipeline based on the characteristics of shippers (i.e., distance and maximum capacity).

[3] FERC, *Cost-of-Service Rates Manual*, June 1999, p. 28.

[4] FERC, ‘Order No. 636 - Restructuring of Pipeline Services’ <http://www.ferc.gov/legal/maj-ord-reg/land-docs/restruct.asp> [accessed 12 February 2016].

[5] Variable costs also include gas lost as fugitive emissions, but both US and Australian evidence suggests that total fugitive emissions are inconsequential, and how fugitive emissions change with throughput is undeterminable (see Appendix B).

[6] The latter is the approach currently adopted by most pipeline operators. It is called “System Use Gas” (SUG). SUG is determined by the pipeline operator, at its discretion, and allocated to shippers on a user pays basis.

retain fuel as a percentage of total receipts of gas. Those operators thus take fuel in kind and do not explicitly include fuel costs in their rates.[7] As in all cases before the FERC, the element of retained fuel percentages or fuel costs (as the case may be) are decided in either contested or settled cases between pipeline operators and shippers (mostly state-regulated gas distribution companies) on a case-by-case basis. There is no generic or FERC-imposed fuel retention or fuel cost.[8]

The advantage of expressing SRMC as a percentage of throughput is that by taking fuel in kind, a gas price is not needed. The eastern Australian gas market is generally opaque to a generally-acceptable spot price, in contrast to the United States where such spot prices are universally and objectively available (indeed this is one of the prompts for reform). Establishing an objective measure of price would entail extra investigations and assumptions—a complicated task under any circumstances in Australia. An SRMC expressed in $/GJ would need to be recalculated for a change in gas prices over time or location. For this reason, we recommend a method that expressed SRMC as a percent of throughput to simplify setting the reserve price if such an auction is implemented.

SMRC, expressed in as a percentage of gas used as fuel, is tied to physical pipeline characteristics. It is reasonable to expect a different SRMC for each pipeline, reflecting the difference in the length, diameter and age that influence fuel consumption in compressors.

In this section, we describe three methods for calculating SRMC. Each are informed by comprehensive data reported by US pipeline operators to the FERC under its "Form 2" according to the Natural Gas Act of 1938 (a uniquely longstanding, transparent and comprehensive data source). All pipelines around the world perform the same physical functions, so a pipeline regression analysis of this type for the United States—involving physical pipeline characteristics to pipeline gas losses—should apply well-enough to Australia for the purpose of setting a reserve price for a regulator-administered auction of un-nominated capacity.[9]

APA Group, *Standard Gas Transportation Agreement*, September 2015, p. 56.

[7] FERC, *Cost-of-Service Rates Manual*, p. 28.

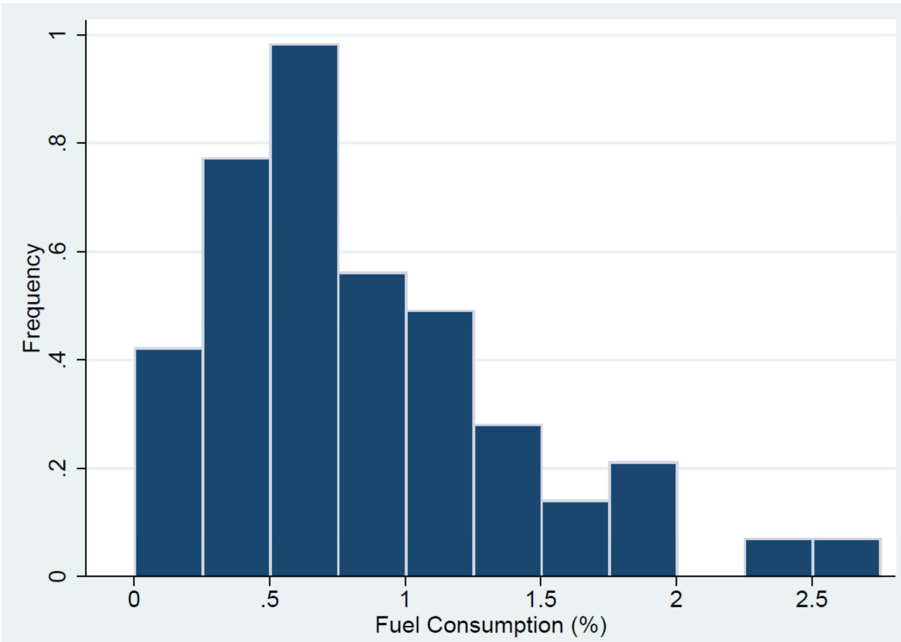
[8] For example the Public Service Commission of New York, the Pennsylvania Public Utility Commission, and the Pennsylvania Office of Consumer Advocate (State Agencies) filed a complaint against National Fuel, alleging that National Fuel's rates are unjust and unreasonable. They settled on a gas retainage allowance of 1.15 percent, down from 2 percent. Public Service Commission of, New York, the Pennsylvania Public Utility Commission, and the Pennsylvania Office of and Consumer Advocate (State Agencies), *Letter Order Approving Uncontested Settlement*, February 2007.

[9] We note that there are no such regulator-administered auctions in the United States, as capacity rights, as intangible property (comprising a bundle of definitive rights) are controlled by shippers. Pipeline shippers thus effectively "own" their rights to FERC-licensed transport capacity as part of their long-term capacity contracts. There is a competitive price for "released" capacity that presumably has a practical floor of SRMC, but as those transactions are deregulated, the FERC does not get involved in how the markets sets such a floor for capacity trading.

1.1. Method 1—A Fixed Percent of Throughput

The most straightforward approach to calculating SRMC is to adopt a fixed quantity that represents the available data. We identified 57 US pipeline operators that reported transmission compression fuel and throughput to the FERC.[10] Figure 1.1 shows the distribution of SRMC, expressed as fuel consumption per unit of throughput, for the 2014 financial year.

Figure 1.1
Distribution of SRMC, Reported by US Pipeline Operators



Source: FERC, 'Documents & Filing - Forms - Form 2/2A'.

The SRMCs range from less than 0.01 to 2.60 percent. The mean SRMC is 0.85 percent.

Method 1 adopts this mean. While it is a simple calculation, it does not reasonably reflect the changes in SRMC resulting from differences in pipeline characteristics. For this reason, we present alternative methods that account for physical factors affecting fuel consumption.

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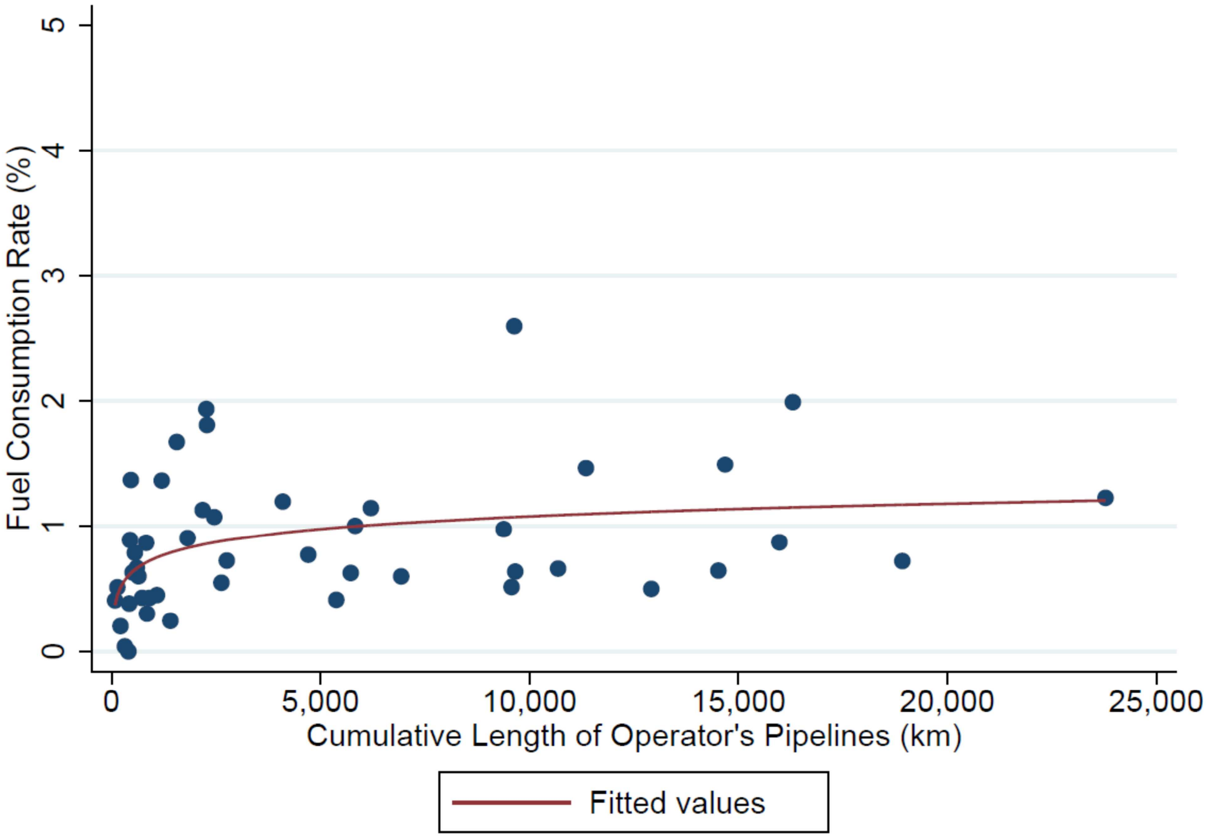
[10] Firms reported both gas used as compressor fuel and electricity used to power electric compressors. We assumed efficiency factors to convert the electricity into an equivalent amount of natural gas. We assumed that electric generators operate at 50 % efficiency, and natural gas compressors operate at 20% efficiency. Thus, a unit of electricity would require 2.5 units of gas to achieve the same level of compression. [Insert source]

1.2. Method 2—A Function of Pipeline Length

As pipeline length increases, a greater amount of fuel is required to transport a fixed amount of throughput from the injection and withdrawals points. Empirical evidence supports this relationship. Of the 57 firms that reported fuel use and throughput, 47 reported reliable pipeline length data.[11] Figure 1.2 illustrates that the SRMC is a log function of pipeline length.

Figure 1.2
SRMC and Pipeline Length



Source: Source: FERC, ‘Documents & Filing - Forms - Form 2/2A’; PHMSA, ‘Data & Statistics: Distribution, Transmission & Gathering, LNG, and Liquid Annual Data’.

[11] Pipeline operators report pipeline length to the FERC and to the US Pipeline and Hazardous Materials Safely Administration (PHMSA) along with other very detailed pipeline data. Eight pipeline operators that reported to fuel and throughput data to FERC, did not report pipeline data to PHSMA. Another two pipeline operators’ pipeline length data reported to PHMSA was more than 20 percent different to that reported to FERC. We excluded the data of those ten operators from Methods 2 and 3 because those methods rely on reliable pipeline characteristic information.

Box 1.1
SRMC as a Log Function of Pipeline Length

The following regression describes the observations in Figure 1.2.

$$SRMC = \frac{Fuel\ Consumed}{Total\ Gas\ Transported} = \beta_0 + \beta_1 \left(ln(Length)\right) + \varepsilon_i$$

Where:

β_0 = -0.276
β_1 = 0.147
ε_i = error term

Length = the pipeline length is measured in kilometres.

A p-value of less than 5 percent is strong evidence of a correlation. The p-value on the β_1 is 0.5 percent, which indicates there is strong evidence of correlation between SRMC and the natural log of pipeline length.

The log, rather than linear, relationship can be explained by looping. Looping describes the installation of a parallel pipeline adjacent to the existing line to lower the flow resistance and hence the pressure drop, and to increase the throughput and increase the available linepack. Some very large pipeline systems have 5 or 6 large diameter pipes laid along the same right-of-way.[12] Looped pipes may extend the distance between compressor stations, to reduce fuel consumption per unit of throughput. The relationship between SRMC and pipeline length can be captured in Equation shown in Box 1.1.

We note that Australian pipeline lengths are often reported as the distances between the major injection and withdrawal hubs, rather than the number of pipeline kilometres, inclusive of looped pipeline.[13] An estimate of the latter is needed to implement the method presented in Box 1.1.

The function described in Box 1.1 can be used to estimate SRMC for a given pipeline length, but also informs a confidence interval for SRMC. A 70 percent confidence interval for SRMC, as a

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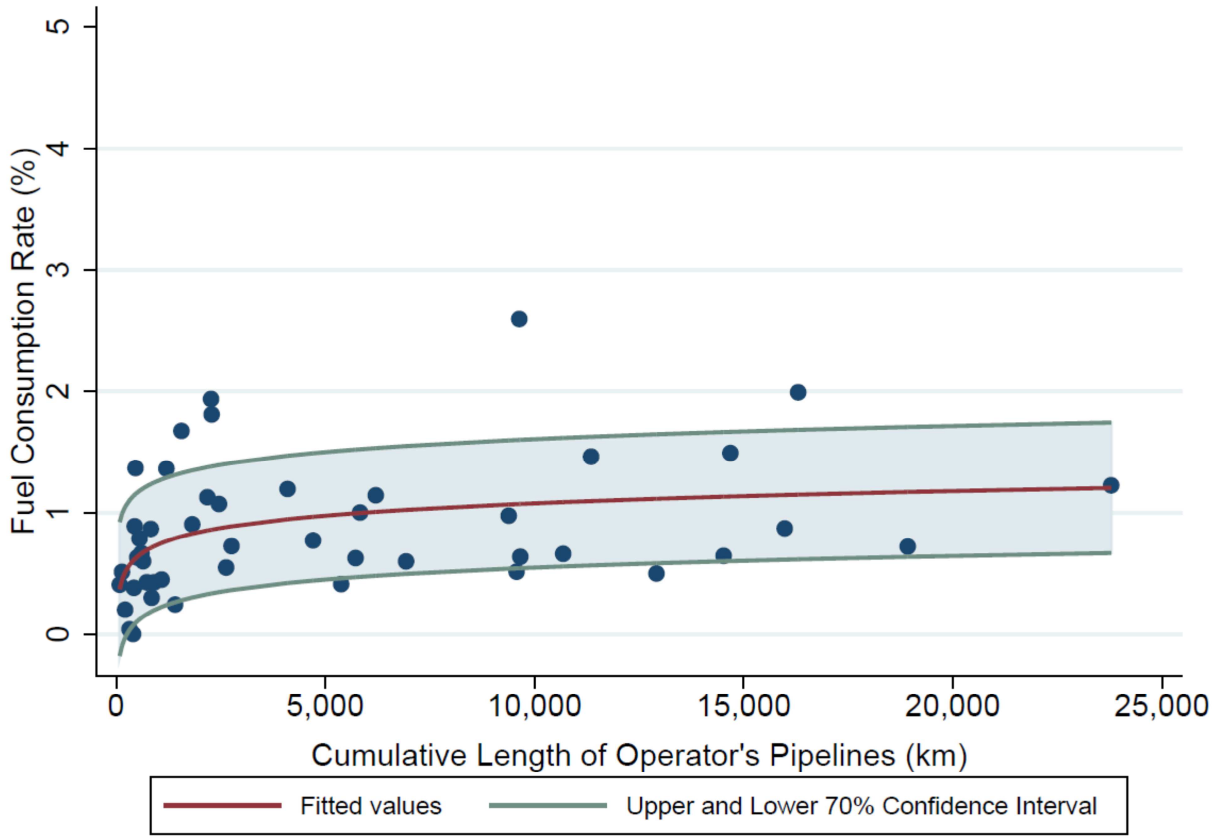
[12] EIA, 'Natural Gas Pipeline Network - Transportation Process & Flow', 2016 <http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/process.html> [accessed 11 February 2016].

[13] AER, 'State of the Energy Market 2015', 2016 <https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2015> [accessed 11 February 2016].

function of pipeline length is presented in Figure 1.3. The AER may find this interval helpful for evaluating pipeline operators' assertions regarding their estimates of SRMC.

Figure 1.3
70 Percent Confidence Interval for SRMC



Source: Source: FERC, 'Documents & Filing - Forms - Form 2/2A'; PHMSA, 'Data & Statistics: Distribution, Transmission & Gathering, LNG, and Liquid Annual Data'.

1.3. Method 3—A Function of Pipeline Length, Age and Diameter

In theory, SRMC is also affected by the age and diameter of the pipeline. Newer pipelines are finished with an internal ceramic seal, which minimised friction and reduces the compression requirements. Wider pipelines require a less pressure to ship the same quantity of gas, in accordance with *Weymouth's formula*.[14]

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[14] See Leeston, A.M, *et al* (1963), pages 69, 78. The formula is attributed to Mr. R. Weymouth (from a paper read in 1912 before the Society of Mechanical Engineers). Other, more empirical but generally equivalent approximations to Weymouth's formula appeared later, known as the *Panhandle* and *Modified Panhandle* equations.

$$Q = 670.8 d^{8/3} \sqrt{\frac{P_1^2 - P_2^2}{GL}}$$

Here, Q is the cubic feet per hour, d is the internal diameter of the pipe, P_1 and P_2 are the inlet and out pressures, respectively, G is the specific gravity of the gas and L is the length of the pipe.

Empirical analysis, however, revealed that such additions to a simple log-linear regression do not really improve the predictability of fuel use percentages. We find that fuel use:

- decreases with age—consistent with theory—but the correlation is statistically insignificant; and
- increases with diameter—contrary to theory—but the correlation is statistically insignificant.

Thus, given the data available on US pipelines, we would not recommend going beyond a measure of distance to measure SRMC in an objective fashion. For completeness, however, we present a regression including all three physical pipeline characteristics in Box 1.2.

Box 1.2
SRMC as a Function of Length, Age and Diameter

The following regression describes how SRMC relates to pipeline length, age and diameter.

$$SRMC = \frac{Fuel\ Consumed}{Total\ Gas\ Transported}$$

$$= \beta_0 + \beta_1 \left(ln(Length)\right) + \beta_2(Diameter) + \beta_3\,(Age) + \varepsilon_i$$

Where:

β_0 = -1.598
β_1 = 0.562
β_2 = 0.239
β_3 = 0.011
ε_i = error term

Length = the pipeline length is measured in kilometres.
Diameter = the distance weighted pipeline diameter in inches.
Age = an age factor between 0 and 1 calculated based on the proportion of pipeline constructed in each decade, as follows.

Time	Weight
Pre 1940	0.000
1940s	0.125
1950s	0.250
1960s	0.375
1970s	0.500
1980s	0.625
1990s	0.750
2000s	0.875
Post 2010	1.000

A p-value of less than 5 percent is strong evidence of a correlation. The p-value on β_1 is 0.3 percent, which indicates there is strong evidence of correlation between SRMC and the natural log of pipeline length. However, the p-value of β_2 and β_3 is greater than 30 percent, which indicated insufficient evidence of correlation between SRMC and *Age* and *Diameter*.

Furthermore, we suspect that the inclusion of *Age* causes multicollinearity, since the longest US pipelines also tend to be the oldest.

1.4. Evaluation of SRMC Methods

Of the three methods for calculating SRMC of gas transmission, Method 1 is the simplest. However, as a fixed number, calculated from US pipeline data, it does not account for differences in SRMC across pipelines, reflecting the physical pipeline characteristics that might affect fuel consumption.

Our initial analysis suggests that, of all pipeline characteristics, pipeline length is the single largest determinant of fuel consumption. Method 2 predicts SRMC based on a pipeline length, inclusive of looped pipelines.

While theory suggests that SRMC should also depend on pipeline age and diameter, the relationship is not empirically evident. Method 3 estimates SRMC based on pipeline length, age and diameter, but coefficients of dimeter is counterintuitive while the coefficients on both age and diameter are both statistically insignificant.

For these reasons, we recommend Method 2 to the AEMC as a reasonable objective method for calculating an estimate of SRMC. We note, however, that the regression in Method 2 contains an error term. Pipeline operators' SRMC will likely deviate from the best estimate. Method 2 and may well be used as the starting point for determining each pipeline operator's SRMC, noting that US fuel use percentages are subject to transparent analysis and verification by shippers—with any disputes left to either reasonable settlement or adjudication by the FERC.

2. Alternatives to SRMC as an Administered Auction Floor

Upfront capital costs comprise the bulk of pipeline costs, and much of the rest of the cost of pipeline undertakings (such as administrative and general costs) are unrelated to pipeline throughput.[15] As we would expect, given the up-front and fixed nature of pipeline costs, Australian pipeline operators recover the majority of their costs through reservation charges on firm capacity—although we do not have information on the size of that majority for particular Australian pipeline operators.

If SRMC (as we computed the measure in the last section) covers variable fuel costs related to throughput, then is there any other reason to raise the floor of an administered auction above that level? There may be a reason if an SRMC-based reserve price deprives operators of revenues upon which they currently rely in order to cover their total costs (including a compensatory return on investment). The questions thus are:

- Is there a straightforward way to reflect average historical costs in the reserve price?
- Does raising the floor affect economic efficiency?
- Does any of this relate to problems in incentivising new investment?

2.1. Reflecting Average Historical Costs in Volumetric Prices

For existing pipeline operations, long run average cost (LRAC) equates, as a practical matter, to average historical costs. As such, to the extent that those costs are objective and known, it is a straightforward exercise to apportion them to the volumes expected to flow through a pipeline for the purposes of adding some fixed cost component to SRMC. LRAC is calculated frequently in the US, but not for the purposes of setting an auction reserve price. In the US, such reserve prices are unnecessary, because capacity rights are clearly defined and contract shippers compete in the supply of sublet capacity in a deregulated secondary capacity market.[16] Rather, LRAC is calculated to set pipeline reservation and commodity tariffs in the primary capacity market according to the cost-of-service. The normal FERC methods for making prices involve five steps:[17]

1. Establishing permissible revenues over a “test period” and include operating and maintenance expenses, depreciation expense, taxes and a reasonable return on investment.

[15] On most Australian pipelines, the reservation charge collects the greatest portion of revenues. APA Group, ‘Indicative Transmission Tariffs’ <http://www.apa.com.au/our-business/gas-transmission-services/indicative-transmission-tariffs.aspx> [accessed 12 February 2016].

[16] In Order No. 637, the FERC waived price ceiling for short-term released capacity in response to the growing development of more competitive markets for natural gas and transmission capacity.

[17] FERC, *Cost-of-Service Rates Manual*.

2. “Functionalizing” the cost-of-service— computed by assigning costs incurred by the company to the various functions, e.g. storage and/or transmission.
3. Cost “classification” relating to fixed or variable. Fixed costs go to the reservation charge, variable costs to the charge for volumetric throughput.
4. Cost “allocation” on the basis of distance or other important attributes of customers along the pipeline (e.g., zone-based prices).
5. Rate design—adding up the various functionalized, classified and allocated costs to form monthly or volumetric charges for customers.

There is a considerable US history to draw from regarding the loading of fixed costs into volumetric pipeline tariffs as part of the “classification” step, although much of the recent US history in this respect was a reaction to gas shortages that resulted from failed attempts of the FERC to regulate the price of gas in the field.[18]

When the US FERC first adjudicated ratemaking questions in 1942, it employed a “peak responsibility” pricing method assigning all fixed costs to the “demand” (or reservation) portion of the charge unrelated to throughput. From 1952 and 1973, the FERC adopted the “Seaboard” method, which apportioned half of fixed costs to the reservation charge and the other half to the commodity charge. From 1973 to 1983, reflecting the gas shortages of the era (before regulatory restructuring of the industry) FERC adopted the “United” method, further loading another 25 percent of the fixed costs into the volumetric charge to attempt to choke-off incremental gas demand. From 1983 to 1992, as the gas shortages eased, FERC adopted the “Modified Fixed-Variable” approach, which apportioned all fixed costs to the reservation charge, except return on equity and related income taxes, which were apportioned to the commodity charge. Starting in 1992, the FERC returned to “Straight-Fixed Variable” method of 1942.[19]

To be sure, these questions simply involved how to collect costs through regulated tariffs of one form or another. The insertion of fixed costs into the volumetric part of the tariff simply made the collection of pipeline company fixed costs more uncertain (as there are no true-ups at the FERC if forecast volumes do not match actual volumes). Nevertheless, the mechanics of these various “fixed-cost-loading” formulae were straightforward—adding average fixed costs on projected throughput quantities to variable costs to compute the volumetric pipeline charges in the “classification” step in deriving pipeline prices. The same could readily be done in Australia, given reasonable projections of throughput on which to perform the volumetric loading for any chosen portion of the fixed costs. However, the simplicity of an LRAC calculation for pipeline services does not itself justify its use in setting the reserve price of a short term capacity auction. The inclusion of fixed costs into the reserve price has detrimental efficiency effects.

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[18] The reasons for those US gas shortages and pricing responses to it is described in Makholm, J.D., *The Political Economy of Pipelines*, The University of Chicago Press, Chicago and London (2012), pp. 138-140.

[19] See: FERC Cost of Service Rates Manual, 1999, pp. 31-33.

2.2. Efficiency Effects of Volumetric Loading of Fixed Costs in the Reserve Price

Economic efficiency perhaps has a number of vernacular definitions, but to an economist it is a well-defined industry term. The regulatory economics literature gives various distinct definitions for “economic efficiency.” Given an existing pipeline system, operators exhibit *productive efficiency* when they produce their services at least cost over time. The provision of services reflects *allocative efficiency* when the societal resources consumed in the provision of those services go to their highest valued use.

Raising the auction reserve price would affect allocative efficiency. It would mean that a potential shipper willing to pay more than SRMC but less than the fixed-cost-loaded auction floor would be priced out of the pipeline. In other words, this potential shipper, that would be willing to pay more than society’s incremental costs for providing the service would not get it—an economically inefficient result. The magnitude of the potential inefficiency would depend on the extent of fixed cost loadings into the reserve price.

A reserve price of SRMC facilitates maximum welfare gains as it ensure efficient capacity utilisation by subletting shippers; where they value that capacity more than the incremental cost of utilisation. A reserve price greater than SRMC takes away some of these welfare gains, because it prevents trade and utilisation of the capacity that shippers’ value marginally more than the incremental cost. As the reserve price increases, more welfare gains are lost.

Indeed, administered auctions for un-nominated capacity raise important questions that generally lie outside of the particular focus of SRMC and its alternatives in this study. For example, such auctions *implicitly* exist in the United States, but they take place in a highly transparent, albeit *deregulated*, market for FERC-licensed capacity rights. In that market, the “floor” on the sale re-sale of capacity rights tends toward the SRMC variable fuel costs level—but migrates upward whenever there is an expectation that short-term capacity is tight. Potential pipeline investors use those upward-migrating price signals to investigate where to propose to shippers long-term contracts for incremental FERC-licensed capacity. Contract shippers are in complete control of those transactions, with no regulatory involvement other than a requirement for complete transparency in the resulting transactions. To be sure, there is a strong institutional foundation for such an efficient regime that eschews administered actions that depends both on regulatory action to set pipeline prices (in the primary market) and regulatory restraint in permitting competition in the market for capacity resale by shippers (in the secondary market).

The creation of such markets requires specific regulatory action to define and defend the shipper property rights that trade in competitive markets. However, such a regime is consistent with both short-term allocative efficiency and long-term productive efficiency in terms of a genuinely competitive market for capacity additions. The institutional considerations that would permit such a regime to be pursued in Australia, upon which we have commented elsewhere, are outside the scope of this assignment.[20]

2.3. The Auction Reserve Price and Potential Investment

The extensive economic literature on the methods for achieving productive and allocative efficiency takes the existing regulated facilities as given. *Dynamic efficiency*, as a separate concept, addresses what motivates such facilities as pipelines to be built in the first place. Because pipeline enterprises are highly capital intensive, last for decades and, once installed, cannot be easily converted to other uses or locations, they require particular forms of long-term assurance of stable relations with shippers. These stable assurances (whether contractual or regulatory) change the context of the periodic charges levied by pipeline enterprises—signalling a long-term relationship unlike the prices for other regulated businesses like natural-monopoly local distributors of gas and electricity.

The rapid growth of the pipeline industries in places like Canada, the United States and Australia depended heavily, as one would expect, on those predictable prices and service terms, as that was what the capital markets demanded to underwrite major gas pipeline investments. Neither pipeline nor shipper investments would flow in the way they did in these markets unless parties could rely on such continuity and predictability.

Pipeline operators made capital investments to construct and expand pipeline capacity with the understanding that they would be entitled to re-sell "as available" capacity on their own terms. A deprivation of those entitlements under an administrated auction regime is the manifestation of a regulatory risk.

Such is the perspective from which to assess the possible harm to new investment from the imposition of a new administered auction with a floor that is effectively below that upon which pipeline operators have planned. It is feasible that some operators recover a portion of those costs from the re-sale of contracted but un-nominated capacity that they re-sell to other shippers.

We do not know the extent that operators rely on these revenues to recover their existing costs or how the imposition of a floor of SRMC on such auctions would deprive pipeline of expected revenues. As much as it may cause problems with the expectations of existing pipeline operators, however, by itself it is unlikely to materially alter future investment in pipeline capacity if a new, forward-looking regulatory regime is held by pipeline companies to be credible.

3. Conclusion

To the extent that regulators impose an administered auction among the choices available to them as elements of a broader reform package, it is efficient to set the short-term gas

[20] Jeff D. Makholm and Nina Hitchins, *Pipeline Capacity Rights to Support a Competitive Gas Market: Theory and Applications*, A Report for Victoria's Department of State Development, Business and Innovation, 24 September 2015.

transmission auction reserve price at SRMC, calculated as a function of pipeline length. Apart from any question of whether it affects pipeline revenue expectations, such a floor maximises welfare in the pipeline capacity market given the existing pipeline facilities. We wish to emphasize, however, that our recommendation pertains to *how* a short-term administered capacity auction floor could be computed, not *whether* the auction should be imposed in the wider context of the AEMC's suite of regulatory reforms—to be released to deal with the Energy Council's vision that we referenced in our introduction.

Appendix A. US Pipeline Data

Company Name	Fuel consumption (% of throughput)	Total length (km)	Age Factor (1 = all built in 2010s, 0 = all built pre-1940s)	Distance Weighted Average Diameter (inches)
Algonquin Gas Transmission, LLC	0.91%	1,817	0.43	20
Alliance Pipeline L.P.	1.68%	1,559	0.89	34
ANR Pipeline Company	0.87%	15,979	0.37	22
Cheyenne Plains Gas Pipeline Company, LLC	0.58%			
Cimarron River Pipeline, LLC	2.41%			
Colorado Interstate Gas Company, L.L.C.	0.36%			
Columbia Gulf Transmission, LLC	0.41%	5,376	0.36	29
Dominion Transmission, Inc.	0.63%	5,721	0.50	21
East Tennessee Natural Gas, LLC	1.07%	2,456	0.52	14
El Paso Natural Gas Company, L.L.C.	1.99%	16,300	0.36	23
Elba Express Company, L.L.C.	0.80%			
Empire Pipeline, Inc.	0.00%	402	0.80	24
Enable Gas Transmission, LLC	0.52%	9,570	0.46	15
Equitrans, L.P.	0.18%			
ETC Tiger Pipeline, LLC	0.04%	317	1.00	42
Gas Transmission Northwest LLC	1.13%	2,178	0.57	37
Guardian Pipeline, L.L.C.	0.38%	422	0.88	32
Gulf Crossing Pipeline Company LLC	0.67%	602	0.88	41
Gulf South Pipeline Company, LP	0.66%	10,683	0.31	19
Gulfstream Natural Gas System, L.L.C.	1.36%	1,200	0.88	33
Kern River Gas Transmission Company	1.81%	2,281	0.82	35
Maritimes & Northeast Pipeline, L.L.C.	0.79%	556	0.76	26
MarkWest Pioneer, LLC	0.41%	83	1.00	24
Midcontinent Express Pipeline LLC	0.87%	826	0.88	38
Midwestern Gas Transmission Company	0.60%	643	0.33	28
MIGC, LLC	1.59%			
Millennium Pipeline Company, LLC	0.46%			
Mojave Pipeline Company, L.L.C.	0.43%	904	0.79	33
National Fuel Gas Supply Corporation	0.55%	2,627	0.45	14
Natural Gas Pipeline Company of America LLC	1.49%	14,680	0.37	28
North Baja Pipeline, LLC	0.51%	138	0.88	30
Northern Border Pipeline Company	1.94%	2,266	0.68	39
Northern Natural Gas Company	1.23%	23,782	0.34	15
Northwest Pipeline LLC	1.15%	6,204	0.45	20
Ozark Gas Transmission, L.L.C.	0.30%	847	0.69	17
Panhandle Eastern Pipe Line Company, LP	2.60%	9,634	0.25	22
Questar Overthrust Pipeline Company	0.28%			
Questar Pipeline Company	1.05%			
Rockies Express Pipeline LLC	0.73%	2,756	0.88	41
Sabine Pipe Line LLC	0.20%	213	0.38	21
Sea Robin Pipeline Company, LLC	0.25%	1,407	0.51	24
Southeast Supply Header, LLC.	1.37%	461	0.88	37
Southern Natural Gas Company, L.L.C.	1.46%	11,350	0.47	18
Southern Star Central Gas Pipeline, Inc.	0.98%	9,381	0.38	16
Tallgrass Interstate Gas Transmission LLC	0.60%	6,929	0.39	10
Tennessee Gas Pipeline Company, L.L.C.	0.72%	18,919	0.32	26
Texas Eastern Transmission, LP	0.65%	14,519	0.38	27
Texas Gas Transmission, LLC	0.64%	9,658	0.35	22
Trailblazer Pipeline Company LLC	0.43%	731	0.64	35
TransColorado Gas Transmission Company LLC	0.63%	502	0.75	22
Transcontinental Gas Pipe Line Company, LLC	0.50%	12,913	0.40	32
Transwestern Pipeline Company, LLC	1.20%	4,096	0.51	27
Trunkline Gas Company, LLC	0.77%	4,705	0.40	28
Vector Pipeline L.P.	0.89%	441	0.88	42
Viking Gas Transmission Company	0.45%	1,085	0.46	22
WBI Energy Transmission, Inc.	1.00%	5,828	0.45	10
Wyoming Interstate Company, L.L.C.	0.24%			

Source: FERC, ‘Documents & Filing - Forms - Form 2/2A’, PHMSA, ‘Data & Statistics: Distribution, Transmission & Gathering, LNG, and Liquid Annual Data’.

Appendix B. Fugitive Emissions in Gas Transmission

Fugitive emissions occur at normally sealed components on the pressurized piping and equipment systems. The most significant fugitive emissions are associated with three sources: 1) centrifugal compressor seal oil gas, 2) reciprocating compressor piston rod packing systems, and 3) compressor blowdown line open-ended lines.[21]

Many pipeline operators, including those in the US, report "unaccounted-for gas." At first glance, this may seem to measure fugitive emissions, and a necessary input to calculate SRMC. However, it measures the difference between the amount of gas purchased and the quantity of gas sold, whether it is more or less. According to US Pipeline and Hazardous Materials Safety Administration (PHMSA), the term "unaccounted-for gas," does not always indicate a leak. Seventeen or more factors contribute to unaccounted-for gas, including meter errors.[22]

We do not perceive that there is a reasonable and empirically-verifiable tie between fugitive emissions and SRMC. Indeed, we would reasonably question whether such emissions have anything to do with throughput as opposed to static pressure. Put another way, it is difficult to estimate fugitive gas emissions in transmission, and even more difficult to calculate how those emissions increase with pipeline utilisation. However, Australian high pressure gas transmission system is of relatively recent vintage (the oldest line dates from 1969), has been built to high quality standards and is well maintained. Work undertaken by the Pipeline Authority—the organisation formerly responsible for operation of the Moomba to Sydney pipeline—concluded that losses from a typical gas transmission pipeline in Australia are 0.005% of throughput.[23] It follows that an incremental increase in pipeline utilization will result in an insignificant increase the fugitive emissions. For this reason, it is unlikely that the inclusion of a fugitive emissions estimate will significantly affect the calculation of SRMC. For this reason, we exclude it from our methods, and conclude that compression fuel is the single key determinant of SRMC.

[21] Matthew R. Harrison and others, *Natural Gas Industry Methane Emission Factor Improvement Study* (Austin, TX, 2011).

[22] US Pipeline and Hazardous Materials Safety Administration, 'Chapter V: Unaccounted For Gas', in *Guidance Manual for Operators of Small Natural Gas Systems*, 2002.

[23] Australian Government, Department of the Environment, 'National Inventory Report 2013, Volume 1', 2015, p. 124 <https://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/national-inventory-report-2013> [accessed 12 February 2016].

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