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Relative risk of gas transport services

A report for Vector

March 2016

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1 Introduction

1. CEG has been engaged by Vector to prepare an expert report which provides an assessment of the merits of retaining a 0.10 uplift to the asset beta for gas distribution and transmission services relative to the asset beta for electricity transport services. The context for this analysis is a report by Dr Lally[1] proposing to remove the above uplift previously applied by the Commerce Commission (the Commission).

2. In 2010, the Commission adopted an asset beta for gas transport businesses based on an uplift of 0.10 to the estimate asset beta for comparable companies. In this report we consider the relative risks facing electricity and gas transport business from competitive stranding. We consider there to be strong theoretical support for a conclusion that, relative to electricity transport businesses, gas transport businesses face higher risk of competitive stranding due to technological developments including solar PV panels and battery storage. The higher relative risk comes from both:

   i. the potential for these advances to have a greater effect on gas transport networks than electricity transport businesses. This would occur if the adoption of solar technologies makes it more likely that households will choose electricity as the primary source of energy for heating and hot water systems. This choice will likely drive the choice of fuel for other uses such as cooking, making it less likely that households will connect to the gas transport network; and

   ii. the fact that gas distribution has lower penetration and can be expected to be on the steeper part of the average cost curve. This is, even if the observation in (i) is not correct and technological advances have an equal effect on connections to electricity and gas transport networks, the likelihood that a reduction in the number of connections to gas transport networks will result in competitive stranding is greater.

3. We would generally not expect the observed differentials in asset beta to reflect the true cost of competitive stranding. However, when investors' assessment of the likelihood or cost of standing occurring is correlated with the market, firms with greater risk of asset stranding will report a higher beta than firms with lower risk of stranding. In this case, a higher allowed asset beta is required to compensate for the non-diversifiable risk created by the existence of that stranding. In other words, we would expect the higher competitive stranding risk facing gas transport businesses (relative to electricity transport businesses) to have a systematic component that would be appropriately reflected in a higher allowed asset beta.

[1] Lally, Review of WACC Issues, 25 February 2016.

4. We examine empirical evidence to test the theoretical case described above. Whilst we do consider evidence of differences in reported asset beta, we also look at broader evidence of market perceptions of the competitive stranding risks facing gas transport businesses relative to electricity transport businesses. This includes evidence on firm credit ratings and risk premiums as indicators of future default risk. Whilst this is an imperfect indicator of competitive stranding risk on an absolute basis, it is nevertheless an indicator of the relative risk of gas and electricity transport businesses.

5. At a high-level, we find evidence to support the proposition that gas transport businesses face higher risk of competitive stranding than electricity transport businesses. Comparing the credit ratings for gas and electric business in Australia for businesses specifically involved in electricity and gas transport, we find the median credit rating of gas transport businesses over the last 5 years to be BBB-, and the median credit rating for electricity and mixed distribution businesses to be BBB+. We find a similar result in the United States, where businesses across the entire gas sector have lower credit ratings than businesses across the electric sector.

6. An analysis of reported asset betas allowed by regulators in Europe shows that regulators generally allow an asset beta for gas transport business which is at a premium to the asset beta allowed for electricity transport businesses. The reasons for this differential are not always clear. As noted above, the higher expected costs of stranding will not necessarily give rise to higher estimated asset betas for gas transport business but, nonetheless, these are real costs that require compensation in regulated revenues.

7. This report is structured as follows:

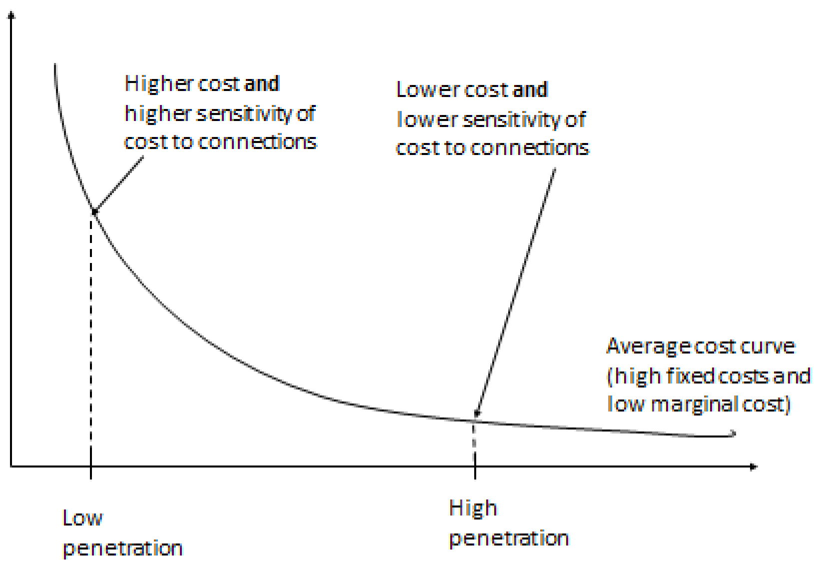
- **Section 2** provides a review of the theoretical basis for believing that gas businesses are riskier than electricity businesses. A key conclusion of this analysis is that gas transport businesses are subject to greater risks of competitive stranding than electricity businesses.
- **Section 3** provides an overview of empirical evidence on the theoretical issue surveyed in section 2. In particular, this section surveys evidence on:
  - Differential credit ratings applied to gas and electricity businesses;
  - Differential cost of debt for gas and electricity transport businesses with the same credit rating;
  - A survey of European regulatory decisions on asset beta for gas vs electricity transport businesses; and
  - An overview of the growth in use of new technologies that may *raise* the best estimate of asset stranding risk since the Commission last determined to apply a 0.1 uplift to asset beta.

2 Conceptual basis for distinguishing risk

8. Both gas and electricity transport services deliver energy to end users over infrastructure that has high levels of fixed (and sunk) costs such that there are material economies of scale in serving customers. In this context they are providing similar services. However, the key difference between the services relates to the level of penetration of these services (connections per premise) and the potential for a material number of customers to 'give up' their current connections such that it is not possible for the supplier to recover its costs by raising prices to remaining customers without also causing them to give up their connection to the network.

9. The risk of stranding via low customer demand for connections is affected by the level of penetration and the likelihood of customers giving up their connections. The higher the level of penetration, the more use that is made of economies of scale, and the less severe the impact of any given loss of customers.

Figure 2-1: Penetration and risk of standing

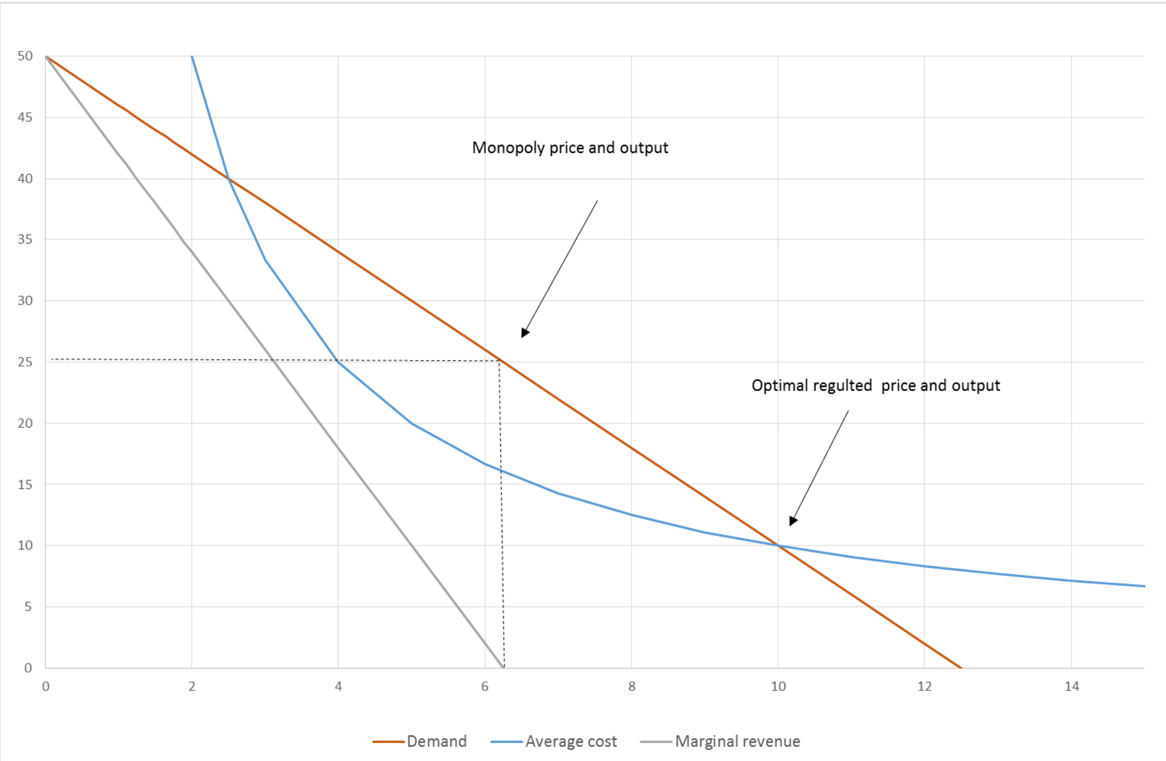


Source: CEG

10. Similarly, the greater the prospect that customers will cease to connect to the network, the greater the prospect of the rising average cost scenario described and the potential for the profit maximising price being below average costs.

11. The following figures illustrate how a reduction in demand can lead to asset stranding. These figures illustrate that asset stranding can be a material risk faced by a distribution business even if that business is currently profitable and has relatively high utilisation. In Figure 2-2 below the distribution business faces a demand curve that passes above at least some portion of its average cost curve (here the average cost curve is drawn on the assumption of $100 fixed cost and zero marginal cost. The fact that the demand curve passes above the average cost curve means that there are some prices at which demand will be sufficient to recover costs. The profit maximising price is found at the quantity where marginal revenue equals marginal cost (as drawn this is a little over 6 units and the monopoly price is $25 per unit). However, regulation can set the price lower while still allowing costs to be recovered – with the optimal price associated with full cost recovery being $10 and the associated quantity being 10 units.

Figure 2-2: Business with healthy utilisation but material risk of asset stranding

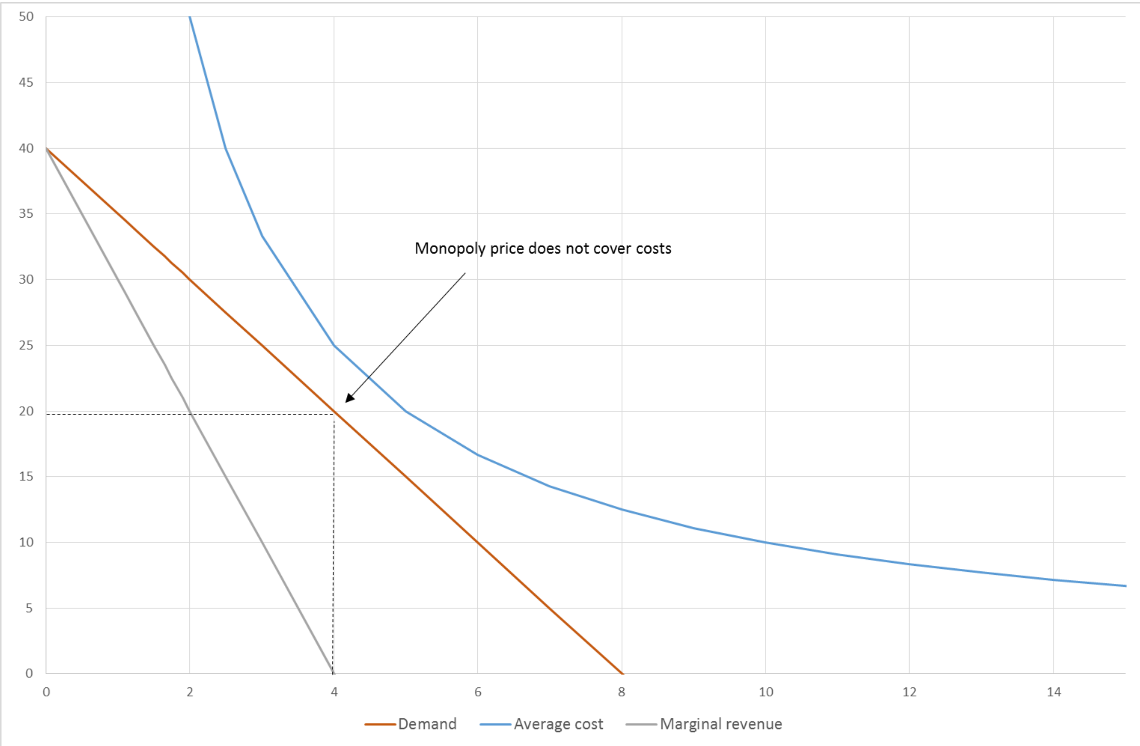


Source: CEG

12. However, in Figure 2-3 below the demand for the service has decreased 20% (i.e., the intercept of the demand curve has fallen from $50 to $40) and the sensitivity of prices to demand has increased 25% (i.e., the slope of the demand curve has changed from -4 to -5). It can be seen that with this change in circumstances, what

might otherwise have appeared to be a healthy business is now unable to recover its costs at any price. Assuming regulation is removed (which is a significant assumption) the business will optimally set prices at the new monopoly price of $20 – which is still below average cost per unit of $25. That is, there is a stranding cost of $5 per customer ($25 per year) being borne by the business.

Figure 2-3: Asset stranding resulting from a 20% demand reduction and price sensitivity increase



Source: CEG

13. The above figures illustrate the fact that stranding of assets does not imply zero use of assets – which would be an extreme and unlikely event. Rather, it simply requires that a business will be unable, even if given the freedom to set its prices as it sees fit, to recover its average costs. This is important to understand because there may be a perception that asset stranding requires the network to be at very low utilisation levels. This is not correct. The risk of asset stranding exists so long as there is a material prospect that a sufficient number of customers will cease to pay for connections in the face of higher prices for the service *relative to* the price of substitutes.

14. In this context it is clear that gas networks face higher risks of asset stranding than electricity. Relative to electricity distribution, gas distribution has lower penetration and can be expected to be on the steeper part of the average cost curve.

Moreover, the cause of this lower penetration is greater substitutability of gas connections for electricity connections but not *vice versa*. That is, in the current technological environment, electricity connections are a necessity for all residential, commercial and industrial premises. By contrast, the vast majority of residential, commercial and industrial premises gas could give up their gas connections and serve the entirety of their energy needs with electricity connections.

15. It is the case that technological change, in the form of falling costs for solar generation and battery storage, is increasing the asset stranding risks faced by electricity businesses. However, these trends quite plausibly raise the stranding risks of gas networks even faster because the effect of these trends is to lower the cost of running electric appliances – reducing the value of a gas connection.

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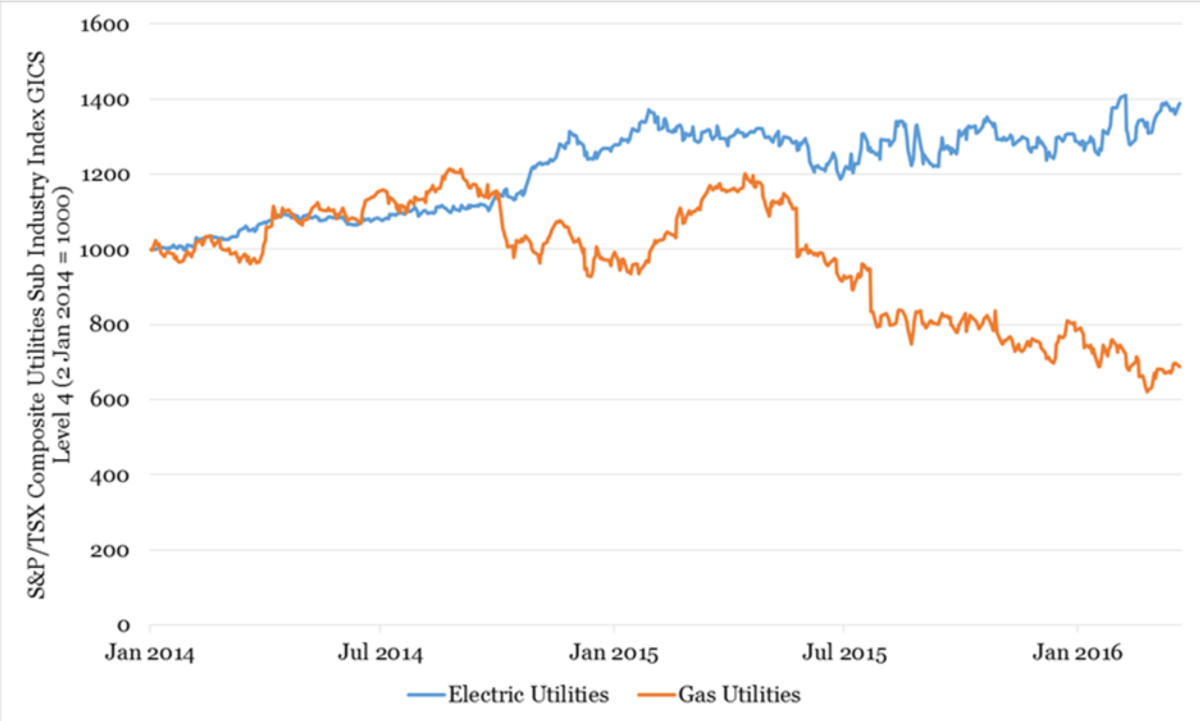
3 Empirical evidence

16. This section discusses a range of empirical evidence to test the proposition that gas transport businesses are subject to greater stranding risk than electricity transport businesses. In general, recent trends indicate that the value of gas utilities have fallen relative to electric utilities. This may be for a range of reasons, including perceptions of the relative risk of competitive stranding amongst utilities.

Figure 3-1: S&P composite utilities index for gas and electric utilities



Source: Bloomberg, re-indexed to January 2014

3.1 Asset beta differentials

17. In this section we compare the differential in the asset betas allowed for regulated gas and electric transport businesses in Europe.

18. It should be noted that we would generally not expect the observed differentials in asset beta to reflect the true cost of competitive stranding. However, it may be that firms with greater risk of asset stranding will report a higher beta than firms with lower risk of stranding.

19. To see this, consider a business that currently has an assessed risk of asset stranding of 10%. That is, there is a 10% probability that future states of the world will not allow the firm to recover its historic cost even if it were allowed pricing freedom to

do so. Now consider the case where that assessment of the risk of stranding changes with the movements in the market. For example, where the economy is doing well the assessed probability (or value impact) of asset stranding may fall, whilst when the economy was doing poorly it increases. In these circumstances, the measured beta of the business will be higher than for an otherwise identical firm with no or lower stranding risk.

20. As can be seen from the above description, the higher beta would not be adequate compensation for the firm for the underlying risk of competitive stranding which over time might have an expected probability of 10%. It would however be compensation for the non-diversifiable risk created by the existence of that stranding.

21. The Council for European Energy Regulators (CEER) Report on Investment Conditions in European Countries presents data on the asset betas used in the regulation of electricity and gas of European countries as reported by the respective National Regulatory Authorities.[2] A comparison of the average difference between the asset betas applied to electricity and gas transport operators across the sample reveals a higher beta applied to gas transport operators.

22. In order to compare electricity with gas, an average of the asset beta for electricity transmission and electricity distribution was compared with the average of asset beta for gas transmission and gas distribution. Gas distribution, on average, has a higher asset beta than electricity distribution. Asset betas are evaluated using both the Hamada and Brealey, Allen, Myers (BMA) methods (referred to here as asset beta 1 and asset beta 2 respectively).

Table 3-1: Mean electricity and gas asset betas

	Hamada	**BMA**
Electricity Transmission	0.37	0.33
Electricity Distribution	0.37	0.34
Gas Transmission	0.40	0.34
Gas Distribution	0.39	0.35
Electricity (transmission and distribution)	0.37	0.33
Gas (transmission and distribution)	**0.39**	**0.34**

Source: CEER

23. Table 3-2 reports the median electricity and gas asset betas, and demonstrates that the asset betas for gas distribution are greater than 0.34. The median of gas distribution is also greater than that of gas transmission. Similarly, the gas asset betas are greater than or equal to 0.34.

[2] CEER, *Report on Investment Conditions in European Countries*, CEER Report, Ref: C15-IRB-28-03, 14 March 2016

Table 3-2: Median electricity and gas asset betas

	Hamada	BMA
Electricity Transmission	0.36	0.33
Electricity Distribution	0.37	0.34
Gas Transmission	0.40	0.34
Gas Distribution	0.39	0.36
Electricity (transmission and distribution)	0.36	0.34
Gas (transmission and distribution)	**0.40**	**0.34**

Source: CEER

24. However, one limitation of this analysis in respect of calculating average asset betas for electricity and gas is that some countries may not necessarily be reporting a decision for both electricity and gas transmission and distribution. For example, Great Britain reports asset betas for electricity transmission, gas transmission and gas distribution, but does not report asset betas for electricity distribution. Therefore, the comparison is not necessarily like-for-like.

25. Table 3-3 sets out the difference between electricity and gas asset betas where asset betas are reported for both gas and electricity within the same country. These asset betas are reported for electricity transmission, electricity distribution, gas transmission and gas distribution respectively.

Table 3-3: Average difference in asset betas between electricity and gas

	Hamada	BMA
Electricity Transmission vs. Gas Transmission	-0.02	0.00
Electricity Transmission vs. Gas Distribution	-0.03	-0.02
Electricity Distribution vs. Gas Transmission	-0.02	0.00
Electricity Distribution vs. Gas Distribution	**-0.03**	-0.02
Electricity vs. Gas	**-0.02**	**-0.01**

Source: CEER

26. The CEER Report also presents data on the debt risk premium that reflects a higher debt premium being assigned to gas compared to electricity. This similarly shows that gas businesses are allowed higher returns relative to electricity business in Europe.

Table 3-4: Average difference in debt premium between electricity and gas

	Debt Premium
Electricity Transmission vs. Gas Transmission	-0.06
Electricity Transmission vs. Gas Distribution	-0.06
Electricity Distribution vs. Gas Transmission	-0.01
Electricity Distribution vs. Gas Distribution	**-0.01**
Electricity vs. Gas	**-0.04**

Source: CEER

3.2 Credit ratings for Australia gas and mixed transport businesses

27. Gas and electric utilities firms can also be compared based on their credit ratings. If companies with similar characteristics in the two industries face similar risks, then one would expect the companies to have similar credit ratings on average. On the other hand, if the companies from the two industries have different credit ratings, then this is evidence that the industry with higher average credit ratings is inherently riskier.

28. In a submission to the AER, Jemena Gas Networks (NSW) previously carried out a credit rating comparison of Australian gas businesses compared to electricity and mixed businesses.[3] Their sample includes 5 "gas only" businesses and 8 "electricity and mixed" businesses. We have updated their data to include the credit ratings of the same businesses as at the end of the 2015 calendar year. This is shown in Table 3-5.

29. The median credit rating of the five gas only businesses has historically been riskier than that of the electricity and mixed businesses. The median credit rating of the sample over the last five years (rightmost column) is BBB+ for electricity and mixed businesses. On the other hand, the median credit rating over the last five years for gas only businesses is BBB, which suggests that gas only businesses are perceived to be slightly riskier than electricity and mixed businesses.

3 Jemena Gas Networks (NSW) Ltd, 2015-20 Access Arrangement: Response to the AER's draft decision and revised proposal, Appendix 7.10 – Return on debt response, February 2015, pp. 9-10.

Table 3-5: Credit ratings for energy network businesses (Jemena sample)

	2011	2012	2013	2014	2015	Median
Gas only						
APT Pipelines	BBB	BBB	BBB	BBB	BBB	BBB
ATCO Gas	BBB	BBB	A-	A-	A-	A-
DBNGP Trust	BBB-	BBB-	BBB-	BBB-	BBB-	BBB-
Energy Partnership (Gas)	BBB-	BBB-	BBB-	BBB-	BBB-	BBB-
Envestra Ltd	BBB-	BBB-	BBB	BBB+	BBB+	BBB
Median for gas	**BBB-**	**BBB-**	**BBB**	**BBB**	**BBB**	**BBB**
Electricity and mixed businesses						
DUET Group	BBB-	BBB-	NR	NR	NR	BBB-
ElectraNet Pty Ltd	BBB	BBB	BBB	BBB+	BBB+	BBB
SAPN	A-	A-	A-	A-	A-	A-
Powercor Australia LLC	A-	A-	BBB+	BBB+	NR	BBB+/A-
SP AusNet	A-	A-	A-	A-	A-	A-
SGSP (Australia) Assets	A-	A-	BBB+	BBB+	BBB+	BBB+
CitiPower	A-	A-	BBB+	BBB+	NR	BBB+/A-
United Energy Distribution	BBB	BBB	BBB	BBB	BBB	BBB
Median for electricity and mixed	**A-**	**A-**	**BBB+**	**BBB+**	**BBB+**	**BBB+**

Source: Bloomberg, CEG analysis

30. We note that the Jemena sample has only a small overlap with the comparator sample used by the Commission. It also does not account for the firm level of gearing and other factors which we have previously shown to be correlated with credit ratings.[4] It is nevertheless useful for considering the relative riskiness of gas and electricity transport businesses.

3.3 Credit ratings of gas and electric companies on SNL

31. SNL's industry classification for electric companies includes categories for "Electric Generation", "Electric Transmission", and "Electric Distribution". Its classification for gas companies, however, only has categories for "Gas Utility" and "Midstream". Furthermore, it would not be appropriate to compare "Electric Distribution" firms

4 CEG, *Benchmark credit ratings*, September 2013

against "Gas Utility" firms since it leads to a very small sample size with non-robust results. As such, we carried out the comparison based on the broadest category that includes all three categories for electric companies, and both categories for gas companies.

32. We compare the credit ratings by assigning numbers to each credit rating as shown in Table 3-6, where riskier credit ratings are mapped to higher numbers and vice-versa. We note that this implicitly assumes that there are equal intervals between adjacent credit ratings, even though credit ratings actually constitute ordinal data with unequal intervals between each rating category.

Table 3-6: Mapping of S&P credit ratings to numerical ratings

Rating	**A+**	**A**	**A-**	**BBB+**	**BBB**	**BBB-**	**BB+**	**BB**	**BB-**	**B+**	**B**
Number	1	2	3	4	5	6	7	8	9	10	11
Rating	**B-**	**CCC+**	**CCC**	**CCC-**	**CC+**	**CC**	**CC-**	**C+**	**C**	**C-**	**D**
Number	12	13	14	15	16	17	18	19	20	21	22

Source: CEG

33. The simple average and median numerical credit ratings of the gas and electric companies are shown in Table 3-7. The 245 electric firms in the sample have a mean numerical rating of 4.94, which is equivalent to a BBB rating, and a median numerical rating of 4.0, which is equivalent to BBB+. The 151 gas firms in the sample have a mean numerical rating of 6.57, which is between BBB- and BB+, as well as a median numerical rating of 6.0, which is equivalent to BBB-. These findings suggest that firms in the gas industry are generally perceived to be more risky than their counterparts in the electric industry.

34. We note that these findings should not be interpreted to mean that a benchmark transport business in the gas industry has a BBB- credit rating, since the two samples both include vertically integrated firms with midstream gas, electric transmission, and electric generation operations. The findings from these samples therefore only serve as a comparison of the credit ratings of firms in the electric and gas industries. Regardless, the findings suggest that a benchmark transport business in the gas industry is likely to have a riskier credit rating than one in the electric industry.

Table 3-7: Average numerical ratings of gas and electric firms

	Gas	**Electric**
Number of firms	151	245
Simple average numerical rating	6.57	4.94
Median numerical rating	6.0	4.0

Source: SNL, CEG analysis

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3.4 Gas vs electric cost of debt for the same credit rating

35. Notwithstanding the finding in the above sections that gas companies have a higher average credit rating compared to electric companies, it is also possible to compare the costs of debt across the two industries for companies with the same credit rating. This section carries out such an analysis using two methods. First, we compare the 10-year cost of debt obtained from the yield curve of BBB US Gas Transmission firms as published by Bloomberg against that of the BBB US Utility curve. Second, we obtain a list of bonds issued by utilities firms in the US and compare the yields of those issued by gas utilities against those issued by electrical utilities.

3.4.1 Comparison of yield curves

36. Bloomberg publishes a "BFV USD US Gas Transmission (BBB)" curve, from which a 10-year estimate of the cost of debt for BBB rated US gas transmission firms can be obtained ("C52710Y Index"). There is no equivalent curve for US electric transmission firms, so we carry out the comparison against the 10-year cost of debt for BBB rated US utilities ("C03910Y Index"), which would include firms in the gas, electric, sewage, and water utilities. This comparison is shown in Figure 3-2. We note that the chart is only shown until April 2014 because the US Gas Transmission curve was replaced with a "USD US Energy BBB+ BBB BBB- BVAL Yield Curve" on 1 May 2014, with the new curve no longer reflecting the cost of debt for US electric transmission firms.

37. The 10-year cost of debt for BBB US Gas Transmission firms tracks very closely with the 10-year cost of debt of US utilities, but the former has historically been slightly higher than the latter, save for a brief period in 2001. This observation suggests that gas transmission firms are perceived to be slightly riskier than other utilities even when difference in credit rating is accounted for.

Figure 3-2: 10-year cost of debt of BBB US Gas Transmission firms and BBB US Utilities

Source: Bloomberg

3.4.2 Yields of bonds issued by utilities firms

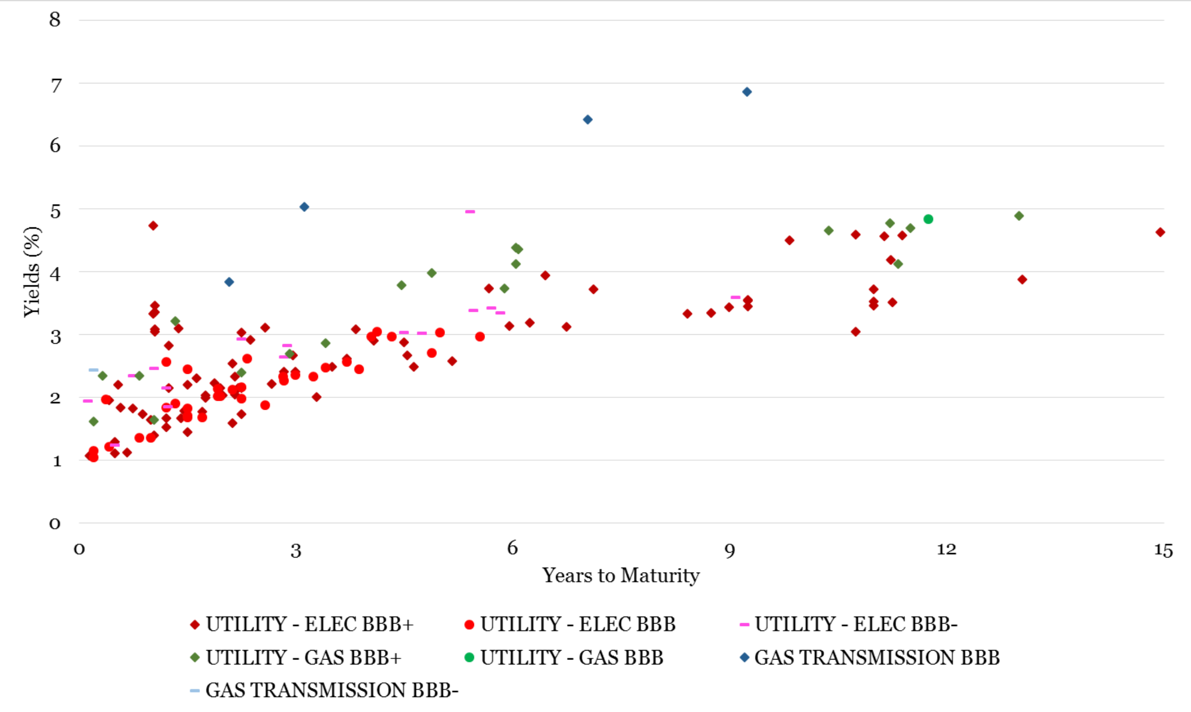
38. We ran a Bloomberg search for bonds on 18 March 2016 using the following criteria:

- Issued in USD;
- Issued by firms incorporated in the US;
- Issued by firms in the utilities sector;
- Bond credit rating between BBB- and BBB+;
- Maturity type listed as "at maturity";
- Fixed rate coupons; and
- Time to maturity up to 15 years.

39. This resulted in a sample of 168 bonds, of which 133 were issued by electric utilities, 20 by gas utilities, 5 by gas transmissions, 7 by industrial firms, and 3 by special purpose firms. For the purpose of this analysis, we focus only on electric utilities, gas utilities, and gas transmissions. The yields of the sample of 158 bonds are shown in Figure 3-3, while Figure 3-4 shows the yields of the BBB+ bonds issued by

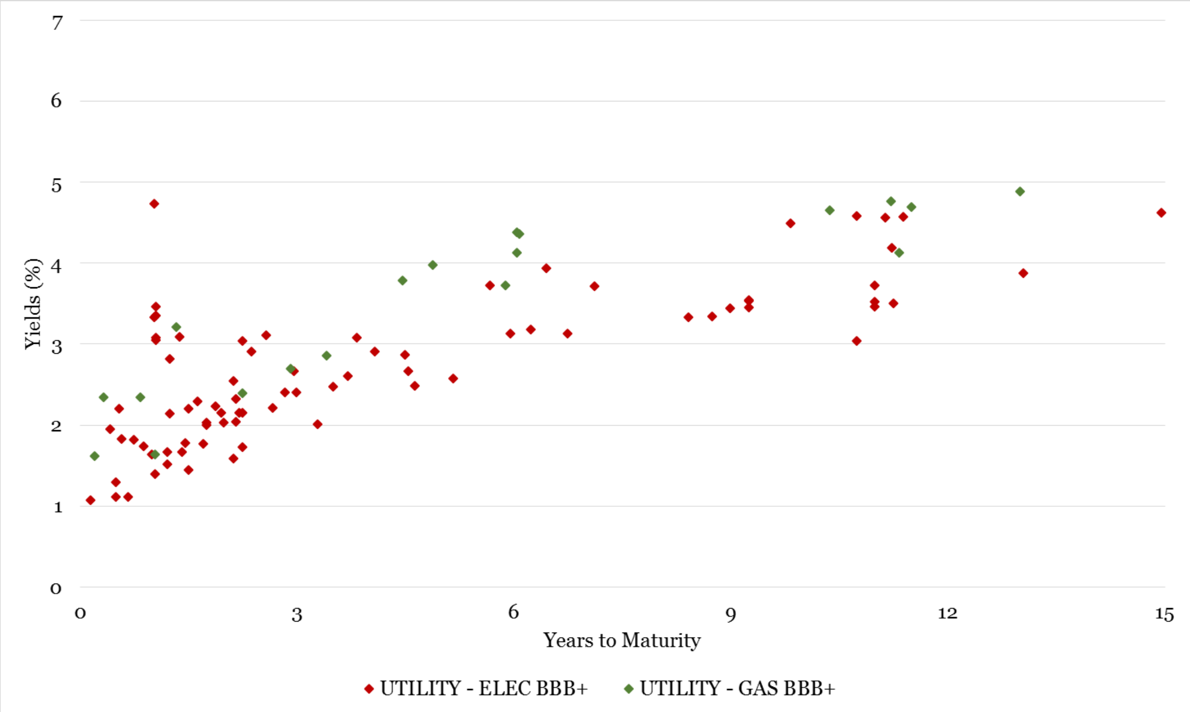
electric utilities and gas utilities (the sample only contains one BBB bond and no BBB- bond issued by gas utilities).

Figure 3-3: Yields of bonds issued by US utilities firms



Source: Bloomberg, CEG analysis

Figure 3-4: Yields of BBB+ bonds issued by US electric and gas utilities



Source: Bloomberg, CEG analysis

40. As seen in Figure 3-3 and Figure 3-4, the yields of bonds issued by gas utilities (green markers) tend to be closer to the upper end of the range of yields of bonds issued by electric utilities (red markers) at similar residual maturities, while the yields of bonds issued by gas transmission firms are higher than those of gas and electric utilities. This observation once again demonstrates that gas utilities are generally perceived to be slightly riskier than electric utilities even if the same credit rating is assumed.

3.5 Relative effect of alternative technologies

41. This section provides an overview of the growth in use of new technologies that may *raise* the best estimate of asset stranding risk since the Commission last determined to apply a 0.1 uplift to asset beta.[5] We note that others including Concept have also recently undertaken assessments of the long-term demand risks for electricity and gas transport businesses.

5 See Concept, *Relative long-term demand risk between electricity and gas networks*, Prepared for Powerco, 27 January 2016

42. We note that Professor Lally has criticised parties for associating higher demand elasticity with a need for higher returns. For example, Professor Lally states:[6]

> *Colonial first state argues that gas businesses warrant a higher asset beta than electricity businesses because the price elasticity of demand for gas is higher than that of electricity. However, Colonial appear to be confusing the price elasticity of demand with that of income elasticity of demand. Only the latter is relevant to beta: differences in beta are driven by differences in sensitivity to GDP shocks and GDP shocks affect the demand for a product in accordance with its income elasticity of demand, not its price elasticity*

43. However, in the context of our analysis of the need for returns to compensate for the risk of competitive stranding, the greater long-term price elasticity for gas connections (relative to electricity) is clearly relevant.

44. In relation to that, we note that the increasing ability of households to generate electricity through rooftop solar (and potentially other) technologies reduces their reliance on energy transported to their homes over the distribution grids of both gas and electricity businesses. The developments in battery storage capacity may over time mean that an increasing number of households can go 'off grid'. If such technologies continue to advance this could lead to stranding of investments in both electricity and gas distribution networks.[7]

45. These advances may be particularly relevant to gas distribution networks as the adoption of solar technologies makes it more likely that households will choose electricity as the primary source of energy for heating and hot water systems. This choice will likely drive choice of fuel for other uses such as cooking making it less likely that households will connect to the gas transport network.

3.5.1 Embedded solar generation and battery storage

46. In recent years, there have been vast improvements in the economics of solar power. McKinsey report that the prices of solar-PV modules have dropped from more than $4 per Wp[8] in 2008 to just under $1 per Wp in 2012. This is corroborated by the US

6 Lally, Review of WACC Issues, 25 February 2016, page 8

7 This might be expressed as the change in technology is increasing the price elasticity of connections such that the ability to raise prices for a declining customer base and achieve the same level of cost recovery is diminished to the point where past costs cannot be recovered.

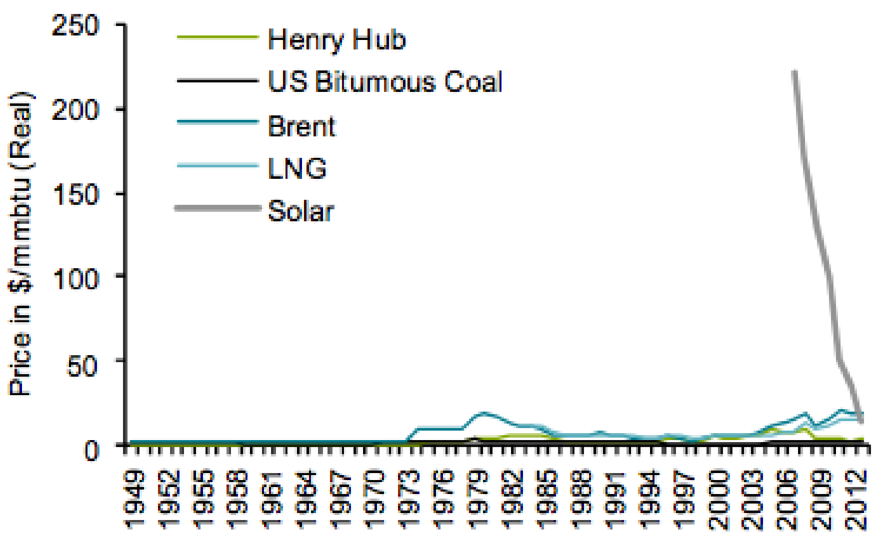
8 The output of a solar generator operating under standard conditions is defined as its peak output, which is measured in watts or kilowatts and expressed as either watt peak (Wp) or kWp, respectively.

Department of Energy in a report entitled "*Revolution Now*" in which it is estimated that there was a 75% reduction in solar PV costs in the four years since 2008.[9]

> *"…today we are in the midst of a generational shift to solar energy. Falling costs for solar power mean that the infinite power of the sun is increasingly within reach for the average American homeowner or business. This shift has come about because of a dramatic retreat in the price of solar PV modules – a trend that has accelerated over the past 5 years. Today, solar PV is rapidly approaching cost parity with traditional electrical generation from gas, coal and oil in many parts of the world, including parts of the U.S."*

47. McKinsey estimate that global installed capacity increased from 4.5 GW in 2005 to more than 65 GW by 2012.[10] Sanford Bernstein highlights the same trend in a recent report that received widespread media coverage (but that is not publicly available). Figure 3-5 below illustrates.[11]

Figure 3-5: Prices per Energy Type



Source: Energy Information Administration, World Bank, Sanford Bernstein analysis.

48. These rapid developments in what is now a hundred billion dollar industry worldwide have potentially enormous ramifications for electricity distribution

9 US Department of Energy, *Revolution Now, The Future Arrives for Four Clean Energy Technologies*, September 2013, pp.4-5.

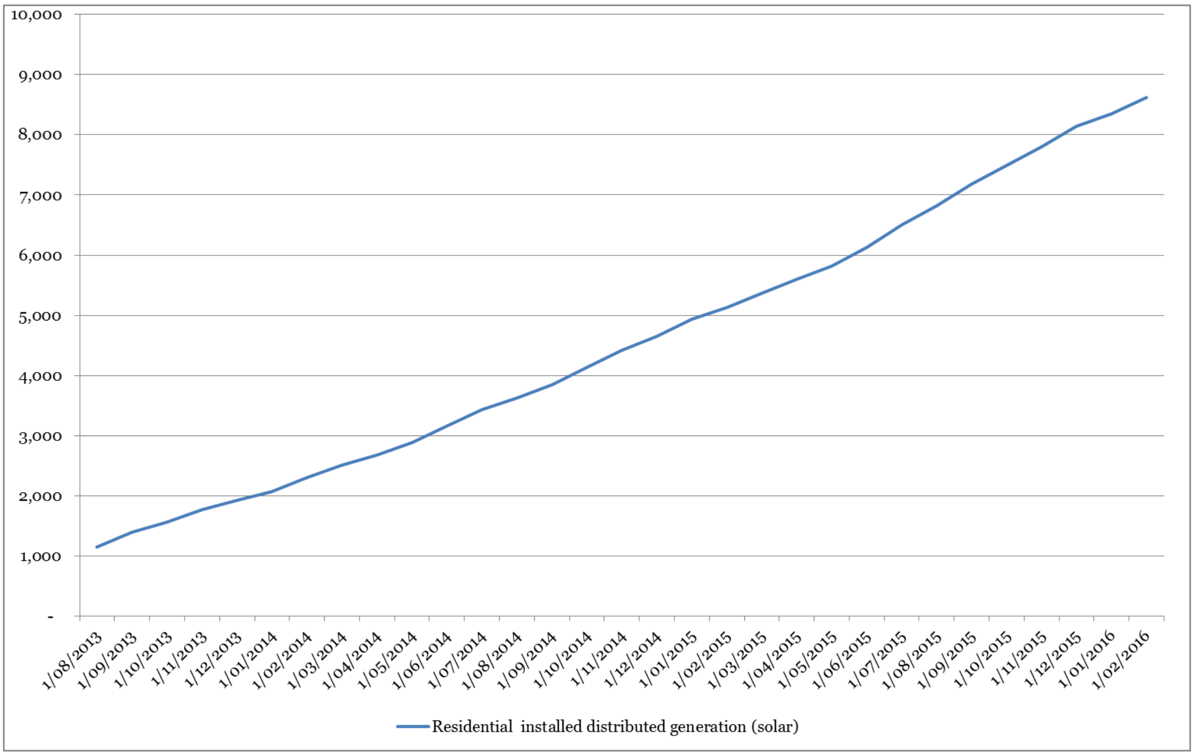
10 McKinsey and Company, *Solar power: Darkest before dawn,* May 2012, p.3.

11 The comparison is Figure 3-5 is on an MMBTU basis. MMBTU is the standard unit of measure for liquid fuels, often referred to as one million British thermal units.

businesses. Although solar has only a small share of the energy market now, over the next decade and beyond the rapidly improving economics of solar cells may lead to it having a much greater, and rapidly escalating share of delivered energy. McKinsey conclude that distributed rooftop generation is likely to be the dominant source of solar demand in OECD countries.[12]

49. At present, New Zealand is at a relatively low base of solar penetration but has increased rapidly over the last two years, as shown in Figure 3-6.

Figure 3-6: Installed distributed generation - residential solar units



Source: www.emi.ea.govt.nz provided by the Electricity Authority (New Zealand)

50. Presently, despite the growth in solar and wind energy, their intermittent nature means that it is difficult for customers to be completely self-sufficient on these forms of energy (i.e., it is difficult to go completely "off grid"). However, as solar prices continue to drop, the concept of installing PV cells and keeping a separate, back-up source of generation such as a diesel generator – or even a community-owned energy source of the type described above – becomes increasingly attractive.

51. Moreover, this intermittency problem may be overcome by improvements in battery storage technology. It was recently reported that Professor Michael Aziz, at Harvard University, is developing a flow-battery with funding from the US Advanced

12 *Ibid*, p.8.

Research Projects Agency over the next three years that promises to cut the cost of energy storage by two-thirds below the latest vanadium batteries used in Japan.[13] There is currently very significant investment in battery storage solutions focussed on electric vehicles (EVs). The US Department of Energy estimates that that cost of these batteries has halved in the last four years. It is likely that the development of knowledge in this area will lead to significant advances in electric energy storage solutions for households.

52. Cheap solar plus cheap storage would have large implications for network businesses. For example, Sanford Bernstein has predicted that it may not be long before home energy storage is cheap enough to lure households away from the grid *en masse* across the world.[14] It has foreshadowed that grid companies will lose customers to these alternative technologies in the relatively near term and then face the prospect of a "death spiral". This spiral occurs because:[15]

- as customers go off grid (or reduce their demand), distributors must attempt to recover broadly the same pool of fixed costs from a dwindling customer base;
- this then causes prices to rise, making it more likely that more of those remaining customers will also switch; and
- this leads to further price rises and more switching, and so on and so on.

53. Even if that "tipping point" where customers start disconnecting from (or substantially reducing their use of) the grid has not yet arrived it may be unavoidable. If solar and battery costs continue to fall relative to "poles and wires", then that tipping point will one day come and, because distribution assets have overlapping lives and must constantly be replaced in order for other assets to retain their value, when it does, this will cause assets to be stranded.

3.5.2 Heat pumps and hot water systems

54. As noted above, if households choose electricity over gas as their fuel choice for heating of space and water, the likelihood of them maintaining a gas connection for other minor uses (i.e., cooking) is lower.

55. Sales of reverse cycle air conditioners, referred to as "heat pumps" in New Zealand, have trebled in the five years from 2001 to 2006. Data from the Energy Efficiency and Conservation Authority (EECA) shows that around 230,000 single phase air conditioners (most of which have a reverse cycle function) were sold in New Zealand

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13 Evans-Pritchard A., "Global solar dominance in sight as science trumps fossil fuels" *in The Telegraph*, 9 April 2014.

14 Ibid.

15 Ibid.

between March 2000 and March 2006.[16] In 2014, the EECA reported on the "heat pump success story", recognising their efforts to improve the performance of heat pumps, with some heat pumps "being more than twice as efficient as they used to be".

56. Table 3-8 shows the sales of heat pumps in New Zealand from 2004, including the sales of single split heat pumps. From 2004 to 2015, 1.1 million heat pumps have been purchased in New Zealand.

Table 3-8: Heat pumps sales in New Zealand

Year	Sum of Sold	Annual Percentage change
2004	38,538	-
2005	55,128	43.05%
2006	73,648	33.59%
2007	87,664	19.03%
2008	114,336	30.43%
2009	121,420	6.20%
2010	120,180	-1.02%
2011	111,887	-6.90%
2012	103,971	-7.07%
2013	94,083	-9.51%
2014	100,964	7.31%
2015	106,437	5.42%
Total	1,128,256	

Source: EnergyConsult

57. In a report prepared for the Equipment Energy Efficiency Program, a joint initiative of Australian, State and Territory and New Zealand Governments, EnergyConsult states that gas heating is "being displaced by reverse cycle air conditions (heat pumps)" and that gas ducted heaters are "used in only around 1% of New Zealand homes"[17]. The report also states that "their energy use is projected to decline from 1.2 PJ in 2010 to 1 PJ by 2025 … due to declining sales"[18]. Furthermore, the New Zealand gas ducted heaters market is small, with only around 1000 sales per year. [19]

16 Branz, National Impacts of the Widespread Adoption of Heat Pumps in New Zealand, Study Report No.169, 2007. Available at: http://branz.co.nz/cms_show_download.php?id=fb1c48ebe34c6d9abed860867c38983461869395

17 EnergyConsult, Gas Ducted Heaters, Prepared for the Equipment Energy Efficiency Program, January 2011. Available at: http://www.paltech.com.au/wp-content/uploads/2015/04/E3_gas_ducted.pdf

18 Ibid.

19 Ibid.

The existing installed stock of gas ducted heaters in New Zealand is around 18,000 heaters.[20]

58. EnergyConsult also develops a projection of annual energy consumption from 2000 to 2025 from natural gas and LPG ducted heaters set out in Table 3-9. The decline to 1 PJ (1,022 TJ) is predicted to result from a declining stock of gas ducted heaters.

Table 3-9: Annual energy consumption from LPG and gas ducted heaters

Year	TJ	Annual Percentage Change
2000	1001	
2001	1038	3.70%
2002	1071	3.18%
2003	1102	2.89%
2004	1129	2.45%
2005	1152	2.04%
2006	1170	1.56%
2007	1,185	1.28%
2008	1,196	0.93%
2009	1,203	0.59%
2010	1,208	0.42%
2011	1,209	0.08%
2012	1,207	-0.17%
2013	1,203	-0.33%
2014	1,196	-0.58%
2015	1,187	-0.75%
2016	1,176	-0.93%
2017	1,163	-1.11%
2018	1,149	-1.20%
2019	1,133	-1.39%
2020	1,117	-1.41%
2021	1,099	-1.61%
2022	1,080	-1.73%
2023	1,061	-1.76%
2024	1,042	-1.79%
2025	1,022	-1.92%

Source: EnergyConsult

59. A report for Meridian Energy[21] notes the ongoing electrification of space heating in New Zealand, as well as high uptake of heat pumps. Extrapolating current New

20 Ibid.

Zealand residential heat pump penetration levels, Meridian projects heat pump penetration to 2050. In particular heat pump penetration is shown to transition from only living area heating to whole house heating. By 2030, the penetration level of heat pumps reaches approximately 50 percent.

60. The EECA also provides data on sales of electric storage water heaters and gas water heaters, set out in Table 3-10. This data shows that sales of electric storage water heaters continues to dominate gas water heater sales.

Table 3-10: Total sales (units sold) of electric and gas water heaters

Year	Electric storage water heaters	Gas water heaters
2000	60,605	-
2001	57,414	-
2002	56,065	-
2003	56,155	-
2004	56,166	-
2005	56,453	-
2006	61,075	-
2007	66,156	-
2008	64,094	-
2009	53,369	-
2010	53,831	-
2011	57,231	-
2012	51,603	19,126
2013	48,189	19,400
2014	46,232	25,568
2015	52,950	29,242

Source: EECA

21 Strbac et al., Smart New Zealand Energy Futures: A Feasibility Study, January 2012. Available at http://www.meridianenergy.co.nz/assets/Investors/Reports-and-presentations/Industry-reports/Smart-Enegy-Futures-Summary-Report-Jan2012-2759757-1.PDF