

Jemena Gas Networks (NSW) Ltd

2015-20 Access Arrangement

Response to the AER's draft decision and revised proposal

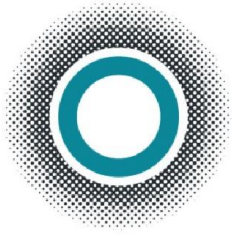
Appendix 3.5 - HoustonKemp review of AER demand forecasts

Public

27 February 2015



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Review of the Gas Consumption Forecasting Methodology for Jemena Gas Networks

A Report by Adrian Kemp for Gilbert + Tobin

26 February 2015

Contact Us

Level 40, 161 Castlereagh Street
Sydney NSW 2000

Phone: +61 2 8880 4800

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Executive Summary

Jemena Gas Networks (JGN) engaged Core Energy Group Pty Ltd (Core Energy) to develop forecasts of gas consumption for JGN's Access Arrangement proposal for the period 1 July 2015 to 30 June 2020. In light of concerns raised by Deloitte Access Economics (DAE), the Australian Energy Regulator substituted its own forecasts for gas consumption. The AER's principal concern JGN's gas consumption forecast was:¹

... in forecasting consumption Core Energy:

- Did not include a variable to capture future economic activity, for example, GSP or SFD in its forecasts. As discussed below, economic activity is expected to increase over the next access arrangement compared with the current access arrangement. As a result, the absence of such a variable in Core Energy's forecasts means they are likely to under estimate per customer consumption.

In light of the AER's draft decision I have been asked by Gilbert + Tobin to consider a number of matters relating to the reliability of DAE's analysis to support the AER's conclusions on JGN's gas consumption forecasts for Tariff V customers, the reasonableness of DAE's Tariff V gas consumption forecasts, and whether there are alternative forecasting methodologies that are likely to produce more reasonable and/or reliable estimates of forecast Tariff V gas consumption in the circumstances.

Is DAE's analysis sufficiently reliable to support the AER's conclusions?

In my opinion, DAE's analysis is not a sufficiently reliable basis to support the AER's conclusion that Core Energy's forecasts are likely to underestimate Tariff V gas consumption per customer.

I have reached this conclusion having reviewed the analysis undertaken by DAE, and having identified a number of fundamental flaws in the analysis. Specifically:

- DAE provides no theoretical basis for including state final demand as an explanatory variable of residential gas consumption per connection. State final demand, as measured by the Australian Bureau of Statistics is a measure of final consumption expenditure in the state, including household final consumption expenditure, government final consumption expenditure, and gross fixed capital formation. In my opinion, there is no basis in economics to suggest that residential consumption per connection is influenced by changes in any of these expenditure categories over time.
- DAE's econometric model is based on data for nine observations (for the period 2002 to 2010) and includes three explanatory variables. In my opinion the small number of observations used by DAE given the number of explanatory variables means that the regression results are sensitive to the choice of period for the data. I demonstrate that the parameter estimates vary considerably if alternative periods are chosen to estimate the regression models for both residential consumption per connection and industrial and commercial consumption per connection.
- I have applied standard statistical tests to the data used by DAE to ensure that the resultant regression models produce reliable estimates. I find that the variables used in both the residential gas consumption per connection and industrial and commercial gas consumption per connection models fail the tests, which mean that the resultant parameter estimates are biased and so unreliable.

I also considered whether an alternative measure of economic activity (specifically NSW gross state product and gross household disposable income) would be appropriate for inclusion in a model of residential gas consumption per connection. In my opinion for these variables to be relevant, there is a need to demonstrate a theoretical relationship between the specific variable and gas consumption per connection.

In economic theory the main drivers of demand for a good or service by consumers are price and consumer income. Given this, in my opinion gross state product is not appropriate for inclusion in a model of residential

¹ Australian Energy Regulator, (2014), *Jemena Gas Networks (NSW) Ltd, Access Arrangement 2015-2020*, Draft decision, Attachment 13 – Consumption, p13-10.

gas consumption per connection because it includes a number of components unrelated to household income.

Further, given that gross household disposable income is in theory relevant to residential gas consumption per connection, I have considered whether it should be included as an alternative to state final demand in DAE's regression model of residential gas consumption per connection. My analysis demonstrates that gross household disposable income is not a statistically significant factor to explain residential gas consumption per connection. In addition, the variable is found to be non-stationary, which means that the resultant regression is biased and so would provide an unreliable basis for forecasting residential gas consumption per connection.

Irrespective of my conclusions set out above, DAE's regression model results do not support a conclusion that Core's forecasts underestimate residential consumption per connection. This is because the resultant residential gas consumption per connection estimates that are derived directly from DAE's model² are below (not above) the Core forecasts – Figure 1 below. This means that in its own terms, DAE's regression model does not support a finding that the Core model overestimates residential gas consumption per connection.

Figure 1: Comparison of actual residential gas consumption per connection with DAE regression model predicted consumption, and Core forecasts, 2002 to 2020



Finally, we note that the AER's conclusions are predicated on the observation that "economic activity is expected to increase over the next access arrangement compared with the current access arrangement". This statement is inconsistent with the historic evidence of NSW State Final Demand, which is DAE's preferred metric of economic activity.

Specifically, NSW State Final Demand grew at an annual compound rate of 3.0 per cent over the period of Core's historic trend, (i.e., 2002 to 2013), and was 2.5 per cent for the five year period ending 2013. DAE's forecast of NSW State Final Demand increases at an annual compound rate of 2.4 per cent, which is lower than for the historic period.

² As compared with DAE's approach of applying the year-on-year percentage changes to estimated 2014 residential gas consumption per connection.

Are DAE's gas consumption forecasts reasonably based and reliable in the circumstances?

DAE does not actually use the estimated customer gas consumption outputs from its model, but instead uses these estimates to derive an annual percentage change in gas consumption per connection for residential and industrial and commercial customers. This is then combined with forecasts of the number of connections within Core Energy's model to estimate total gas consumption for each customer segment.

By applying the modelled rate of change, to actual gas consumption per connection in 2014, DAE is assuming there has been a structural change in the trend of gas consumption per connection in 2014. However, DAE provide no support for such an assumption. This adjustment has the effect of arbitrarily increasing DAE's forecast of residential consumption per connection.

As I identify earlier, if the DAE model is used to directly forecast residential gas consumption per connection, then the resultant forecasts of residential gas consumption per connection would be below Core's forecasts.

I note that DAE do not explain its reasons for the approach it has adopted. The lack of reasoning to support a structural shift in gas consumption per connection in 2014 combined with flaws in the regression models means that in my opinion, DAE's residential gas consumption forecasts are not reasonably based and reliable in the circumstances. In addition, the arbitrary increase in DAE's forecast of residential consumption per connection means that in my opinion DAE's forecasts are likely to overestimate residential gas consumption per connection, compared to the estimates that would be directly obtained from the regression model.

Is there an alternative forecasting methodology that is likely to produce a more reasonable and/or reliable gas consumption forecast?

DAE contend that there are two potential econometric approaches to forecasting energy consumption, namely:

- a structural (econometric approach) by which I understand DAE to mean the use of a regression model with multiple explanatory variables as it has applied in developing its alternative gas forecasts; and
- a time-series model, by which DAE mean the approach used by Core Energy which involves modifications to a historic trend.

In my opinion the distinction drawn by DAE between the two approaches is so fine as to be unhelpful because both can be considered to be time series models as they rely on data over a historic period of time.

While in principle both techniques can be employed in theory to produce gas forecasts, the best approach will be influenced by the availability of historic data. A regression approach, as adopted by DAE, typically requires a sufficiently long period of historic data so as to produce reliable estimates. As I demonstrate, DAE's model is unreliable in part because of the limited data available.

It follows, that in my opinion the lack of sufficient historic data means that DAE's regression model approach will not produce reasonable and reliable forecasts of gas consumption per connection.

Given this conclusion, in my opinion forecasting gas consumption by explicit consideration of modifications to a historic trend, as undertaken by Core Energy, is a reasonable basis for producing reliable forecasts of gas consumption per connection.

The remainder of this report sets out in detail the reasons underpinning these conclusions.

1. Introduction

I have been asked to prepare this report by Gilbert + Tobin on behalf of Jemena Gas Networks (JGN). The context for my report is the Australian Energy Regulator's (AER) draft decision in respect of JGN's Access Arrangement proposal for the period 1 July 2015 to 30 June 2020. In particular, the AER's draft decision as to the appropriate gas consumption forecasts to be applied based on analysis undertaken by Deloitte Access Economics (DAE).

1.1 Instructions

Gilbert + Tobin has asked that I provide my opinion as to:

- Whether DAE's regression models and analysis provide a reliable basis to conclude that Core Energy's forecasts of gas consumption per connection for Tariff V customers (in particular, for residential customers) are an underestimate due to the absence of a specific variable to capture future economic activity (i.e., State Final Demand or Gross State Product).

I address this question in section 3 of this report.

- Whether the regression models of gas consumption per connection developed by DAE and the method used to apply the results of those models to forecasting gas consumption per connection for Tariff V customers for the JGN network, produce forecasts of gas consumption that are reasonably based estimates and which are reliable in the circumstances.

I address this question in section 4 of this report.

- Whether there is an alternative approach to forecasting gas consumption per connection for Tariff V customers for the JGN network that is likely to produce more reasonable and / or reliable gas consumption forecasts in the circumstances.

I address this question in section 5 of this report.

Gilbert + Tobin's instructions to me are attached as Annexure A. I have also been provided with a guideline to preparing an expert report by Gilbert + Tobin, and confirm that in the course of preparing this report, I have read, understood and complied with these guidelines. My acknowledgement, made in accordance with the guidelines, is contained at the end of my report, as section 6.

1.2 Qualifications

I am a founding Partner of the economic consulting firm, HoustonKemp. I am an economist with over 16 years of experience in the application of economics to infrastructure regulation, public policy and energy markets. In that time, I have advised governments, regulators and businesses across a wide range of regulatory and market analysis assignments. My industry experience spans electricity, gas, ports, roads, rail, water, and wastewater.

Over the last twelve years I have analysed the consumption for utility services, principally in the electricity and water sectors, and considered the implications of forecast changes for those sectors. This has involved the application of statistical and analytical tools to understand the principal determinants of consumption. In 2012 I undertook a study for the Australian Energy Market Commission analysing electricity price trends, and in 2005 I analysed the determinants of water consumption, using household survey data collected in Sydney.

I hold a Masters in Economics from the Australian National University, which I was awarded in 2001. I also hold a Bachelor of Economics with honours and a Bachelor of Laws from the University of Western Australia, which I was awarded in 1997. I attach a copy of my curriculum vitae as Annexure B.

In preparing this report, I have been assisted principally by my colleague, Oliver Nunn. Notwithstanding this assistance, the opinions in this report are my own, and I take full responsibility for them.

1.3 Structure of the report

The remainder of my report is structured as follows:

- section 2 provides the context for my review of the methodology applied by DAE to forecast Tariff V gas consumption;
- section 3 sets out my analysis of the reliability of the regression modelling undertaken by DAE so as to support a conclusion that Core Energy's gas consumption per connection for Tariff V customers is an underestimate due to the absence of a specific variable to capture future economic activity;
- section 4 sets out my critique of the method used by DAE to apply the results of its regression modelling to forecast gas consumption per connection for Tariff V customers;
- section 5 sets out my opinion on the best approach to forecasting residential gas consumption per connection; and
- section 6 contains my declaration.

Annexure A reproduces the instructions provided to me by Gilbert + Tobin, and my detailed curriculum vitae is provided as Annexure B.

2. Context

In this section I set out the context for my report, which involves explaining the methodology used by Core Energy Group Pty Ltd (Core Energy) to forecast gas consumption for JGN, and the subsequent reviews and alternative forecasts developed by DAE for the AER.

2.1 JGN's gas consumption forecasts

JGN's forecast of residential gas consumption was developed by Core Energy for the Access Arrangement period commencing 1 July 2015 and ending 30 June 2020.

The forecasting methodology applied by Core Energy for forecasting gas consumption for Tariff V customers, which comprises residential, small business, and industrial and commercial customers, can be characterised as a 'bottom up', methodology. It involves projecting the historic trend of gas consumption per connection and the total number of connections, which is subsequently modified based on expected differences from the trend with respect to a number of factors expected to influence gas consumption per connection and the number of connections. The gas consumption forecasts for each customer segment (i.e., residential, small business, industrial and commercial) are summed to obtain JGN's total forecast gas consumption for the Access Arrangement period.

The general methodology applied by Core Energy for Tariff V customers involves a number of steps, which are applied to each customer segment independently, namely:³

- Step 1: Normalise historic consumption data to remove the influence of abnormal variations caused by weather effects. The normalised consumption is extrapolated to form the base starting point for the consumption forecast;
- Step 2: Identify material factors that influence changes in consumption per connection for each customer segment, and collect data to support forecasts of consumption per connection;
- Step 3: Identify material factors that influence changes in the net change in connections (i.e., new connections minus disconnections) for each customer segment, and collect data to support forecasts of net connections;
- Step 4: Select a preferred methodology for quantifying all material factors affecting consumption per connection and net connections;
- Step 5: Adjust extrapolated gas consumption based on quantified material factors affecting consumption per connection and net connections; and
- Step 6: Review and validate results based on literature and discussions with JGN.

In simple terms Core Energy's methodology forecasts gas consumption by extrapolating a historic trend of gas consumption, modified to take into account factors that might otherwise influence the historic trend over the Access Arrangement period.

2.1.1 Approach for Tariff V residential customers

Core Energy's approach for forecasting gas consumption per connection for Tariff V residential customers involved extrapolating the historic trend, and then applying modifications to the trend to reflect anticipated changes to a number of material factors over the forecast period (2015 to 2020) compared to the historic trend period (2002 to 2013).

The three material factors identified are:

- changes in the price of retail gas, leading to additional declines in gas consumption (own price elasticity);
- changes in the price of energy substitutes, specifically electricity, leading to additional declines in gas consumption (cross price elasticity); and
- reductions in gas consumption by new dwellings.

³ Core Energy Group (2014), *Gas Consumption and Customer Forecasts*, A report for Jemena Gas Networks, NSW Gas Access Arrangement 2015-2020, April, Sydney, p12.

The own price elasticity (i.e., the percentage change in consumption per connection for residential customers for a one per cent change in the price of gas) was assumed to be -0.30.

The cross price elasticity (i.e., the percentage change in consumption per connection for residential customers for a one per cent change in the price of electricity) was assumed to be -0.10.

Notably, Core Energy's methodology requires any adjustments to the trend to reflect an anticipated future change over and above that implied within the historic trend. For example, changes in forecast gas consumption per connection away from the trend need to be based on anticipated changes in prices relative to historic prices observed during the historic trend period.

Importantly, the approach used by Core Energy captures all other influences on forecast residential gas consumption per connection within the trend, which can include for example the influence of household income changes amongst other factors. This means that it is only anticipated material changes to factors outside of the trend that influence consumption per connection in the future that need to be accounted for via adjustments to the forecast trend.

2.1.2 Approach for Tariff V small business, industrial and commercial customers

For Tariff V small business, industrial and commercial customers Core Energy has applied the same general methodology as applied to residential customers. The historic trend of gas consumption per connection is modified for small business and industrial and commercial customers by two material factors, namely:

- changes in the price of retail gas, leading to additional declines in gas consumption (own price elasticity); and
- changes in the price of energy substitutes, specifically electricity, leading to additional declines in gas consumption (cross price elasticity).

The own price elasticity for small business, industrial and commercial customers was assumed to be -0.35. The cross price elasticity was assumed to be the same as for residential gas consumption per connection, namely -0.1.

2.2 Deloitte Access Economics' critique

In August 2014, DAE was engaged by the AER to undertake a high level review of JGN's gas consumption forecast, which involved critiquing the methodology applied by Core Energy. In light of concerns expressed by DAE, they were subsequently asked to prepare an alternative forecast of gas consumption.

DAE concluded that:⁴

... the approach adopted by Core was transparent, clear and generally sound in terms of methodology. However there were a number of areas where Deloitte Access Economics considered the forecasts to not necessarily represent the best forecast of consumption in the circumstances.

DAE's principal concern with Core Energy's forecasting methodology related to the absence of Gross State Product (GSP) or alternatively State Final Demand (SFD), as an explanatory variable. In particular DAE indicated that:⁵

By not explicitly accounting for the effect of improving economic conditions on gas consumption, Core's time series model has likely under-forecast consumption over the Review period.

The associated footnote says:⁶

By basing the forecasts on years where economic conditions were considerably weaker than usual, the forecasts will not account for the expected pick-up in economic activity over the Review period.

Further:

⁴ Deloitte Access Economics, (2014), *Gas consumption forecast for Jemena's NSW network*, Australian Energy Regulator, 24 November, p7.

⁵ Ibid, p11.

⁶ Ibid, footnote 3, p11.

The risk is that by not including GSP (or State Final Demand) is that forecasts of usage may be understated as forecasts of NSW GSP growth are generally healthier than recent outcomes. Deloitte Access Economics forecasts an average GSP growth of 2.5% annually across the 7 year outlook period, compared with an average 1.9% in the last 5 years.

I note that the compound annual growth rate of NSW State Final Demand (which was DAE's preferred metric for economic activity) for the period 2002 to 2013 was 3.0 per cent. I have also calculated the annual growth rate of NSW State Final Demand for the five year period 2009 to 2013 as 2.5 per cent. In contrast DAE's forecast for NSW SFD for the period 2014 to 2020 increases at an annual rate of 2.4 per cent, which is lower than the preceding historic period.⁷

These results highlight that DAE's statement that economic conditions in the period used by Core to project historic trends reflects a period of weaker than usual economic conditions compared to the expected future economic activity is inconsistent with the actual historic evidence of its preferred metric of economic conditions, i.e., NSW State Final Demand.

I further note that while Core Energy used GSP to forecast industrial and commercial gas consumption per connection for Envestra in Victoria,⁸ it did not use GSP to forecast residential gas consumption per connection. Instead, for residential customers Core Energy used gross household disposable income as an explanatory variable to forecast residential gas consumption per connection.

2.3 AER's alternate gas consumption forecasts

The AER has accepted the concerns that DAE expressed about Core Energy's methodology. The AER indicates that:⁹

... in forecasting consumption Core Energy:

- Did not include a variable to capture future economic activity, for example, GSP or SFD in its forecasts. As discussed below, economic activity is expected to increase over the next access arrangement compared with the current access arrangement. As a result, the absence of such a variable in Core Energy's forecasts means they are likely to under estimate per customer consumption.

As I have noted above, DAE's own forecasts of State Final Demand, which it uses as its preferred measure of economic conditions, reflects a weakening of economic activity - 2.4 per cent annual growth for the period 2014 to 2020 - compared with the period over which Core's historic trend has been extrapolated (i.e., 3.0 per cent for the period 2002 to 2013). It follows that the AER's statement is inconsistent with DAE's forecasting assumptions.

Given DAE's concerns about Core Energy's gas forecasts, they were asked by the AER to develop alternative forecasts for gas consumption.

The approach used by DAE to forecast residential gas consumption per connection involved:

- estimating econometrically applying ordinary least squared techniques¹⁰ the relationship between residential consumption per connection and gas prices and State Final Demand, using data for the period 2002 to 2010. The specific equation estimated is reproduced below:¹¹

$$\ln Y_t = \alpha + \beta_1 \ln(P_t) + \beta_2 \ln(P_{t-1}) + \beta_3 SFD_{t-1} + \varepsilon_t$$

⁷ The compound annual growth rate for NSW GSP is 2.0 per cent for the period 2002 to 2013 and 2.1 per cent for the five year period 2009 to 2013. DAE's estimate of 1.9 per cent is based on a simple average of the annual change in NSW GSP, rather than the compound growth rate. The compound growth rate is the standard approach to measuring annual changes in a series of data.

⁸ Core Energy, (2012), *Consumption, Energy and Customer Forecasts*, Envestra Limited – Gas Access Arrangement Victorian and Albury Networks (2013-2017), March, p33.

⁹ Australian Energy Regulator, (2014), *Jemena Gas Networks (NSW) Ltd, Access Arrangement 2015-2020*, Draft decision, Attachment 13 – Consumption, p13-10.

¹⁰ For a description of ordinary least squared estimation techniques see section 1.2, Hayashi, F., (2000), *Econometrics*, Princeton University Press, New Jersey.

¹¹ Deloitte Access Economics, (2014), *Gas consumption forecast for Jemena's NSW network*, Australian Energy Regulator, 24 November, p26.

Where:

- > $\ln Y_t$ is the natural logarithm of residential consumption per connection in year t ;
 - > $\ln(P_t)$ is the natural logarithm of a residential gas bill in year t ;
 - > $\ln(P_{t-1})$ is the natural logarithm of a residential gas bill lagged by one year (i.e., in year $t-1$);
 - > SFD_{t-1} is the annual change in state final demand lagged by one year (i.e., in year $t-1$); and
 - > α , β_1 , and β_2 are model parameters, and ε_t is the error term;
- estimating residential consumption per connection for the fitted period and for the period 2014 to 2020, using estimated parameters from the regression model;
 - estimating the percentage change in residential consumption per connection, and using this percentage as the modified change in actual consumption within the Core Energy spreadsheet;
 - summing the percentage change from the regression with the percentage change associated with Core Energy's cross price elasticity effect; and
 - forecasting consumption by applying the percentage change in consumption to historic consumption, and multiplying by the forecast number of connections.

The approach used by DAE to forecast industrial and commercial gas consumption per connection involved:

- estimating econometrically applying ordinary least squared techniques the relationship between industrial and commercial gas consumption per connection and gas prices and Gross State Product, using data for the period 2002 to 2010. The specific equation estimated is reproduced below:¹²

$$\ln Y_t = \alpha + \beta_1 \ln(P_t) + \beta_2 GSP_{t-1} + \varepsilon_t$$

Where:

- > $\ln Y_t$ is the natural logarithm of industrial and commercial consumption per connection in year t ;
 - > $\ln(P_t)$ is the natural logarithm of a residential gas bill in year t ;¹³
 - > GSP_{t-1} is the annual change in Gross State Product lagged by one year (i.e., in year $t-1$); and
 - > α , β_1 , and β_2 are model parameters, and ε_t is the error term;
- estimating industrial and commercial consumption per connection for the fitted period and for the period 2014 to 2020, using estimated parameters from the regression model;
 - estimating the percentage change in industrial and commercial consumption per connection, and using this percentage as the modified change in actual consumption within the Core Energy spreadsheet;
 - summing the percentage change from the regression with the percentage change associated with Core Energy's cross price elasticity effect; and
 - forecasting consumption by applying the percentage change in consumption to historic consumption, and multiplying by the forecast number of connections.

For small business gas consumption per connection, DAE applied the same methodology as for the other Tariff V customer segments. However, it found that the historic trend differed from that implied by the econometric modelling and so concluded that:¹⁴

... the structural econometric equation for this customer group did not produce reliable and robust results.

DAE chose to forecast small business gas consumption per connection applying the same methodology as used by Core Energy.

¹² Ibid, p27.

¹³ I note that DAE have used residential gas bill as a proxy for information on the commercial and industry gas bill, which may in practice differ from the residential gas bill due to differences in particular with network tariff structures.

¹⁴ Deloitte Access Economics, (2014), *Gas consumption forecast for Jemena's NSW network*, Australian Energy Regulator, 24 November, p27.

3. Is DAE's Regression Model a Reliable Basis to conclude that JGN Underestimates Forecast Gas Consumption?

In this section I set out my critique of DAE's regression model, which is used to estimate the percentage annual change in forecast Tariff V gas consumption per connection for each year of the Access Arrangement period. The DAE estimated percentage annual changes are substituted for the assumptions used by Core Energy to derive alternative forecasts for residential and industrial and commercial gas consumption per connection for the Access Arrangement period.

3.1 Concepts in the development of a regression model

A regression model uses statistical techniques to develop a mathematical relationship between a dependent variable, in this case gas consumption per connection, a number of explanatory variables, and an unobservable error term.

The starting point for specifying the variables and functional form of the regression model is to consider the purpose to which the model is to be used, which in this case is to derive forecasts of Tariff V gas consumption per connection. Having identified the purpose, the specific choice of variables to include in the model and the associated mathematical functional form is guided by three factors, namely:

- a unifying theory (in this case economic theory);
- the availability of data, and any data limitations; and
- the requirements for the statistical techniques to develop reliable parameter estimates.

Specifying the model with reference to economic theory is important to ensure that the estimated relationship between the parameters is meaningful. This ensures that unrelated variables are not considered, which if included in the model might lead to spurious conclusions.

For example, it is possible to statistically estimate a model that relates two otherwise unrelated variables, say residential gas consumption with the growth in the number of hours households spend on Facebook. While this might lead to a **positive and statistically significant** relationship between gas consumption and Facebook time (i.e., the variables are correlated), it would be **incorrect** to conclude that increases in Facebook time was a relevant factor in **predicting** residential gas consumption (ie, there is no causation), in the absence of an underlying theory suggesting that the two variables were somehow related.

Data limitations are a relevant factor for considering which variables might be considered in the specification of the model. In some circumstances, data for a relevant variable might not be collected (e.g., types of appliances by household, or changes in consumer preferences). By not including relevant variables, the relationships between those variables included might not be appropriately estimated by the model.

In addition, when a time-series model is being estimated the model is unlikely to be reliable if the sample size is small (i.e., the number of degrees of freedom is small). The degrees of freedom for a time-series model are the number of data points that are available to explain (or estimate statistically) the relationship between the explanatory variables and dependent variable, once the model has been specified.

For example, if there are ten data points and four explanatory variables then there will be six data points available (i.e., ten minus four equals six) to estimate the relationship between the explanatory variables and the dependent variable. While the minimum number of degrees of freedom to estimate an equation is the number of model parameters plus one, it is generally accepted that for the parameters to be reliable a time-series model with two to three explanatory variables will need a sample size of between 15 and 20 data points (i.e., about 14 to 18 degrees of freedom).

That said, more data is always preferred to less and the minimum sample size needed will be influenced by the extent of random variability in the underlying data. If the data is not variable then smaller sample sizes can produce reliable parameter estimates.

In general and assuming there are no other technical problems with the data, the more degrees of freedom available, the more reliable an estimated model will be.

The final consideration is the requirements for the statistical technique employed to estimate the parameters of the model. For a linear model estimated using ordinary least squares (OLS), the explanatory variables need to be stationary to ensure that the estimated model parameters are not biased or inefficient.

In statistics a time series is stationary if its mean and variance is constant through time. This is important when estimating a regression model using OLS, because the technique estimates the parameters so as to minimise the sum of the squared errors between the estimated value and the observed actual value. It follows that if the mean of the time series of a model variable changes over time, then the minimised sum of the squared errors will be affected by changes in the mean and variance, rather than changes based on the underlying relationship between the variables.

To put this more simply, a regression involving a variable that is stationary and one that is non-stationary will lead to parameter estimates that reflect changes in the mean and variance of the non-stationary variable rather than the underlying relationship between the two variables. This leads to the estimated parameters being biased compared to the “true” value. A regression equation with biased parameter estimates means that the estimated relationships between the variables are unreliable.

3.2 Is DAE's residential gas consumption per connection regression model specification consistent with economic theory?

DAE's regression model of residential gas consumption per connection includes the following explanatory variables:

- price of gas (as approximated by the customer's bill);
- lagged price of gas (as approximated by the customer's bill lagged by one period); and
- the change in State Final Demand, lagged by one period.

In economic theory, price is considered to be an important determinant of consumption. In this circumstance economic theory would support the inclusion, in theory, of a variable that captures changes in the retail price of gas paid by consumers as a potential factor explaining changes in residential gas consumption.

There are numerous studies that support a conclusion that in practice residential gas consumption will be influenced by changes in price, and potentially the price of substitutes.¹⁵ In practical terms, residential gas consumption is likely to be affected:

- in the short term by decisions to either make use of substitutes for gas (say, making greater use of reverse cycle air conditioning rather than gas, for space heating) or by choosing to use less gas by say using less space heating; and
- in the medium to long term, by decisions to replace electric or gas cooking, water heating, and space heating appliances with an alternative energy source, or more permanently modify behaviour to use less gas.

In addition to price, economic theory would also support considering whether changes in consumer income are a factor explaining changes in residential gas consumption per connection. The theory would say that as residential income increases, the household would have more income available to purchase gas. For such an affect to be important, household income would need to be considered as a constraint on the amount of gas consumed. In other words, within the household budget the price of gas is less than the value afforded to the consumer from the use of the gas, and so it is the consumption for limited household budget on other goods and services which is the limiting factor for a household's gas consumption.

In addition to price, DAE includes the change in State Final Demand lagged by one period as an explanatory variable for residential gas consumption per connection. State Final Demand is measured by the ABS as part of Australia's national accounts. Specifically:¹⁶

¹⁵ See for example, Blattenberger, G., Taylor, L., Rennhack, R., (1983), “Natural Gas Availability and the Residential Demand for Energy”, *The Energy Journal*, Vol 4, No. 1, pp23-45; Beierlein, J., Dunn, J. and McConnon, J., (1981) “The Demand for Electricity and Natural Gas in the Northeastern United States”, *The Review of Economics and Statistics*, Vol. 63, No. 3, pp403-408.

¹⁶ Australian Bureau of Statistics (2013), *Australian system of national accounts: concepts, sources and methods*, Cat No: 5216.0, p476, section 21.71.

State Final Demand is the aggregate level of final consumption expenditure and gross fixed capital formation within a state over a specified period of time. SFD is defined as the final use of goods and services within a given period by households, government and businesses; that is:

Household final consumption expenditure (HFCE)
+ Government final consumption expenditure (GFCE)
+ Gross fixed capital formation (GFCF)

In simple terms, State Final Demand is a measure of expenditure by households and governments, and also includes expenditure on fixed assets within the economy.

For State Final Demand to be a relevant explanatory variable for a regression model of residential consumption per connection either:

- there would need to be an economic theory that directly relates State Final Demand with residential gas consumption per connection; or
- State Final Demand would need to be related – in terms of economic theory - to household income, and so act as an effective proxy for household consumption.

I note that DAE does not provide any explanation as to its reasoning for including State Final Demand as a relevant explanatory variable for residential gas demand per connection. In my opinion, there is no underlying economic theory, or link between State Final Demand and household income that could justify its inclusion as a relevant explanatory variable for residential gas consumption per connection.

In economic theory, there is no expected direct relationship between residential gas consumption per connection and government expenditure or gross fixed capital formation (i.e., two of the components of State Final Demand).

Household final consumption expenditure may have some relationship with residential gas consumption, which is likely to be one, albeit small, component of total household final consumption expenditure. If DAE used State Final Demand because they wanted to capture household consumption expenditure as an explanatory variable, then by including State Final Demand they are assuming that residential gas consumption per connection is a function of household consumption expenditure in the previous year. Given that consumption expenditure is simply the average price multiplied by the quantity consumed, this is equivalent to assuming that residential gas consumption in this period is a function of total household consumption in the preceding period, holding prices constant.

However, if the intention was to use State Final Demand as a proxy for lagged consumption, given the other components of State Final Demand I would expect it to be a poor proxy. Rather, lagged actual gas consumption per connection could be directly included in the regression model.

Further, because the components of State Final Demand are based on expenditure, in my opinion it would not provide a useful proxy for household income. This is further reinforced by the observation that there are alternative variables (e.g., gross household disposable income) that could have been used as an explanatory variable if it was considered to be a relevant and material factor influencing residential gas consumption per connection.¹⁷

3.3 Is residential gas consumption a function of Gross State Product?

Separate from considering whether residential gas consumption per connection is a function of State Final Demand, I have also considered whether Gross State Product is relevant as an alternative explanatory variable in the regression model.

Gross State Product is measured by the ABS on a quarterly basis. Specifically:¹⁸

Gross State Product is the aggregate which details the total economic production of a state economy, and is the state equivalent to GDP.

It is measured using an income approach and an expenditure approach, which is then combined.

¹⁷ I consider the implications of using gross household disposable income in a regression model of residential gas consumption per connection in section 3.4.

¹⁸ Ibid, p464, section 21.18.

The income approach is:

... derived by summing the income flows accruing to factors of production, plus taxes less subsidies on production and imports:

$$\begin{aligned} \text{GSP(I)} &= \text{Compensation of employees} \\ &+ \text{Gross operating surplus} \\ &+ \text{Gross mixed income} \\ &+ \text{Taxes on production and imports} \\ &- \text{Subsidies on production and imports} \end{aligned}$$

The expenditure approach is:

... derived as the sum of all final expenditures on goods and services:

$$\begin{aligned} \text{GSP(E)} &= \text{Final consumption expenditure} \\ &+ \text{Gross fixed capital formation} \\ &+ \text{Changes in inventories} \\ &+ \text{Exports} \\ &- \text{Imports} \end{aligned}$$

GSP measures the total economic production of a state economy.

In economic theory, GSP is not expected to have a direct influence on residential consumption per connection. This is because, changes in GSP can reflect relative changes in consumption expenditure, inventories and gross operating surplus, as well as compensation to employees. These other factors mean that GSP is also likely to be a poor proxy for changes in household income.

In my opinion, there is no theoretical basis to support a conclusion that residential consumption per connection is a function of GSP. It follows that in my opinion it would not be appropriate to include GSP in the regression model.

3.4 Is residential gas consumption a function of Household Disposable Income?

For completeness I have also considered the implications of using a measure of gross household disposable income instead of state final demand, which in my opinion might be more closely related to residential consumption per connection.

Specifically I have estimated the following equation:

$$\ln Y_t = \alpha + \beta_1 \ln(P_t) + \beta_2 \ln(P_{t-1}) + \beta_3 \text{HHI}_{t-1} + \varepsilon_t$$

Where:

- > $\ln Y_t$ is the natural logarithm of residential consumption per connection in year t ;
- > $\ln(P_t)$ is the natural logarithm of a residential gas bill in year t ;
- > $\ln(P_{t-1})$ is the natural logarithm of a residential gas bill lagged by one year (i.e., in year $t-1$);
- > HHI_{t-1} is the annual change in household disposable income lagged by one year (i.e., in year $t-1$);¹⁹ and

¹⁹ I have chosen to use the change in HHI lagged by one year as the explanatory variable in this equation, which assumes that residential gas consumption per connection is a function of the change in HHI rather than the level of HHI. However, I have also tested the implications of using the level of HHI lagged by one year. The parameter for HHI is negative and significant at the 5 per cent level of significance.

> α, β_1, β_2 and β_3 are model parameters, and ε_t is the error term;

The results of this regression using data for the period 2002 to 2013 are set out in Table 1 below.

Table 1: Estimated parameters, residential gas consumption per connection substituting HHI for SFD

Parameter	Estimate	p-Value
Constant	4.99	0.00**
$\text{LN}(P_t)$	0.23	0.18
$\text{LN}(P_{t-1})$	-0.53	0.02**
Change in HHI_{t-1}	-0.003	0.27

** denotes statistical significance at the 5% level of confidence.

At face value, these results suggest that residential gas consumption per connection decreases as the change in gross disposable household income increases (i.e., the parameter estimate is negative), which is contrary to expectations from economic theory that consumption should increase with increasing household income. However, the parameter estimate is not significant, meaning that it is not statistically different to zero, indicating that gross household disposable income is not a significant explanatory variable for residential gas consumption per connection.²⁰

In my opinion these results provide clear support for a conclusion that gross household disposable income is not a relevant explanatory variable to explain changes in residential gas consumption per connection.

3.5 Data limitations in estimating DAE's regression model

Irrespective of my conclusion on DAE's specification of the regression model being inconsistent with economic theory, I have also considered whether the estimated parameters of the regression model for both residential customer and industrial and commercial customers can be considered as statistically reliable given the data available.

Relevantly, DAE estimate the regressions using data for the nine year period, 2002 to 2010. This means for the regression for residential gas consumption per connection there are only five degrees of freedom with which to estimate the model parameters. Similarly for the industrial and commercial gas consumption per connection there are only six degrees of freedom.

To demonstrate how data limitations affect the reliability of the parameter estimates, I have re-estimated DAE's regression model using different data time periods using the same data.²¹ The results of these regressions for residential customers are set out in Table 2, and for industrial and commercial customer in Table 3.

²⁰ That said, this regression also suffers from being unreliable because as we set out in section 3.6 below, $\text{LN}(P_t)$, $\text{LN}(P_{t-1})$ and residential gas consumption per connection are non-stationary. I have also applied the Augmented Dickey-Fuller test to the change in HHI lagged by one period, and find that it is also non-stationary.

²¹ I have also undertaken the analysis in this section using the same data employed by DAE in its original analysis. The conclusions drawn in this section are not affected by the updating of the data.

Table 2: Effect of the choice of time period, on regression parameters for residential gas consumption per connection

Variable	2002-2010	2002-2013	2003-2011	2004-2012	2005-2013	2002-2014 ²²
Constant						
• Coefficient	5.88	4.75	5.80	5.60	7.14	5.00
• P-value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**
Gas bills (price)						
• Coefficient	-0.32	-0.04	0.02	0.26	0.52	0.32
• P-value	0.27	0.62	0.95	0.14	0.00**	0.05**
Gas bills (price) (lagged one period)						
• Coefficient	-0.13	-0.23	-0.46	-0.66	-1.16	-0.63
• P-Value	0.26	0.01**	0.07*	0.03**	0.00**	0.00**
Annual change in SFD (lagged one period)						
• Coefficient	0.01	0.01	0.01	0.01	0.01	0.01
• P-Value	0.01**	0.00**	0.01**	0.03**	0.00**	0.07*
* denotes statistical significance at the 10% level of confidence. ** denotes statistical significance at the 5% level of confidence.						

Table 3: Effect of the choice of time period, on regression parameters for industrial and commercial gas consumption per connection

Variable	2002-2010	2002-2013	2003-2011	2004-2012	2005-2013	2002-2014 ²³
Constant						
• Coefficient	8.57	8.98	9.43	8.44	8.74	9.22
• P-value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**
Gas bills (price)						
• Coefficient	-0.36	-0.43	-0.50	-0.35	-0.39	-0.47
• P-value	0.05**	0.00**	0.07*	0.07*	0.01**	0.00**
Annual change in GSP (lagged one period)						

²² We have also considered the results using updated actual residential consumption per connection for 2014.

²³ We have also considered the results using updated actual commercial and industrial consumption per connection for 2014.

• Coefficient	0.03	0.03	0.03	0.03	0.03	0.04
• P-Value	0.17	0.07*	0.16	0.10*	0.11	0.03**

* denotes statistical significance at the 10% level of confidence. ** denotes statistical significance at the 5% level of confidence.

Importantly, the statistical significance of each parameter estimate is not in-and-of-itself evidence that the associated variable is a relevant factor to explain changes in the variable under investigation (in this case gas consumption per connection). As I outline earlier, there is also a need for a unifying theoretical relationship between the parameters, and the statistical techniques must have been properly applied.

For the residential gas consumption per connection regressions, there is significant variability in the parameter estimates. For example, the sign on the coefficient for gas bills varies between negative suggesting that as gas prices rise gas consumption falls, and positive, suggesting that as gas prices rise gas consumption rises. The positive sign does not reflect what economic theory would predict. This highlights that DAE's specific choice of time period for the regression modelling is driving the results. That said, this outcome more than likely reflects problems with the variables being non-stationary. We explicitly test whether each of the regression variables are stationary in section 3.6 below.

For the industrial and commercial gas consumption per connection regressions, there is less variability in that the signs of the parameter estimates are consistent across the regressions. However, the estimated parameter for gas bills ranges from -0.35 to -0.50, which is potentially a large difference.

It follows that in my opinion, DAE's estimated parameters for both the residential and industrial and commercial equations are unlikely to be a reliable estimate of the true underlying relationship between the explanatory variables and the dependent variable given the limited number of degrees of freedom available.

Finally, in reviewing the DAE regression estimates, I discovered that DAE have incorrectly used nominal residential gas bill for 2001 (i.e., \$351), whereas it has used constant 2013 dollars for the residential gas bill for the period 2001 to 2010. So as to remove the effect of general price changes, DAE should have used a residential gas bill of \$479 in real 2013 dollars.

3.6 Problems with the statistical methodology employed

DAE estimate the parameters of the regression model using ordinary least squared techniques. To ensure that OLS results in unbiased estimates of the parameters, the explanatory variable data must be stationary. If any variable is not stationary, then the variable should be replaced with a variable calculated as the difference in the variable between two periods. This has the effect of further reducing the degrees of freedom available.

I have tested whether each of the explanatory variables and the dependent variable are stationary applying standard tests.²⁴ Table 4 provides the results of this analysis for the variables in the residential gas consumption per connection regression model, and Table 5 provides the results for variables in the commercial and industrial consumption per connection regression model.

²⁴ We have applied a standard augmented dickey fuller test of non-stationary for each variable. See section 9.4, Hayashi, F., (2000), *Econometrics*, Princeton University Press, New Jersey, for an explanation of these tests. The null hypothesis for the ADF test is that the variable is non-stationary. P-values range between an upper bound of 1 and a lower bound of zero. A p-value of 0.5 means that it is equally likely that null-hypothesis cannot be rejected even though it is actually true. A p-value below a significance threshold (usually 0.05) indicates that null hypothesis, in this case that the variable is non-stationary can be rejected. A p value below 0.05 therefore means that the associated variable is stationary. It follows that p-values above 0.05 indicates that the null hypothesis cannot be rejected, and so the variable is non-stationary.

Table 4: Augmented Dickey Fuller test results – residential gas consumption per connection regression model

Variable	ADF Test Parameter	P-Value
Natural Log Residential Consumption per Connection	-3.26	0.097*
Natural Log Gas Bill	-0.30	0.98
Natural Log Gas Bill (lagged by one period)	-0.61	0.97
First difference in NSW State Final Demand (lagged by one period)	-3.82	0.03**

* denotes statistical significance at the 10% level of confidence. ** denotes statistical significance at the 5% level of confidence.

Table 5: Augmented Dickey Fuller test results – commercial and industrial gas consumption per connection regression model

Variable	ADF Test Parameter	P-Value
Natural Log Commercial and Industrial Consumption per Connection	-0.02	0.99
Natural Log Gas Bill	-0.30	0.98
First difference in NSW Gross State Product (lagged by one period)	-4.88	0.01**

* denotes statistical significance at the 10% level of confidence. ** denotes statistical significance at the 5% level of confidence.

The results for the residential consumption per connection model variables indicate that:

- the natural log of residential gas bill (current year) is non-stationary; and
- the natural log of residential gas bill (lagged by one period) is non-stationary.

The natural log of residential gas consumption per connection is stationary at the 10 per cent level of significance, and the first difference in state final demand lagged by one period is stationary at the 5 per cent level of significance.

If only one variable is non-stationary then the parameter estimates for every variable in the equation will be biased and so are unreliable. It follows that by finding that two of the four variables are non-stationary the DAE regression model parameters for residential consumption per connection are also unreliable and so are not a reasonable basis for forecasting residential gas consumption per connection.

The results for the commercial and industrial consumption per connection model variables indicate that:

- the natural log of commercial and industrial gas consumption per connection is non-stationary; and
- the natural logarithm of gas bill (current year) is non-stationary.

The first different in NSW Gross State Product lagged by one period is stationary at the 5 per cent level of significance.

As with the residential consumption per connection model, the presence of non-stationary variables means that the resultant parameter estimates for each variable in the estimated equation will be biased and so are unreliable. The DAE regression model parameters for commercial and industrial consumption per connection

are therefore also unreliable and so are not a reasonable basis for forecasting commercial and industrial gas consumption per connection.

To correct for these variables being non-stationary would require differences to be taken for each variable until a stationary parameter was identified. However, doing so would further reduce the degrees of freedom, thereby making the entire regression model even less reliable for estimating the model parameters given the limited number of years of available historic data.

It follows that in my opinion, the DAE model parameters are unreliable given flaws in the application of the statistical technique, by not accounting for the assumptions that need to be satisfied for OLS to produce reliable parameter estimates. Further, given data limitations in my opinion there is no merit in using regression techniques to estimate a gas consumption model as specified by DAE.

As I explain further in Section 5, in my opinion the DAE approach cannot produce reliable estimates of gas consumption per connection, and so the forecasts developed by DAE are unreliable.

3.7 Conclusions

In my opinion:

- DAE's regression model and analysis does not provide a reliable basis to conclude that Core Energy's forecasts of gas consumption per connection for Tariff V residential customers is an underestimate due to the absence of a specific variable to capture future economic activity. This is because:
 - > the choice of State Final Demand is inconsistent with the economic theory of factors that are likely to influence residential gas consumption per customer;
 - > the estimated parameters vary widely depending on the model specification, and data period chosen due to the limited data available;
 - > the data used mixes real and nominal gas prices, and so are inconsistent; and
 - > a number of the explanatory variables are non-stationary and so violate the requirement for OLS to produce unbiased estimates.
- DAE's regression model and analysis does not provide a reliable basis to conclude that Core Energy's forecasts of gas consumption per connection for Tariff V industrial and commercial customers is an underestimate due to the absence of a specific variable to capture future economic activity. This is because:
 - > the estimated parameters for gas price vary significantly depending on the data period chosen, due to the limited data available;
 - > the data used mixes real and nominal gas prices, and so are inconsistent; and
 - > a number of the explanatory variables are non-stationary and so violate the requirement for OLS to produce unbiased estimates.

The flaws with DAE's regression models means that, in my opinion, they provide no insight on the relationships between price and economic activity on Tariff V gas consumption per connection.

4. The Appropriateness of DAE's Method of Applying the Results of the Regression Model

Irrespective of my concerns with the reliability of the parameter estimates produced by DAE from its regression model as I have set out in section 3, I also have concerns about how the regression results have been subsequently used to produce alternative forecasts of gas consumption per customer for residential customers and industrial and commercial customers.

Specifically DAE has:

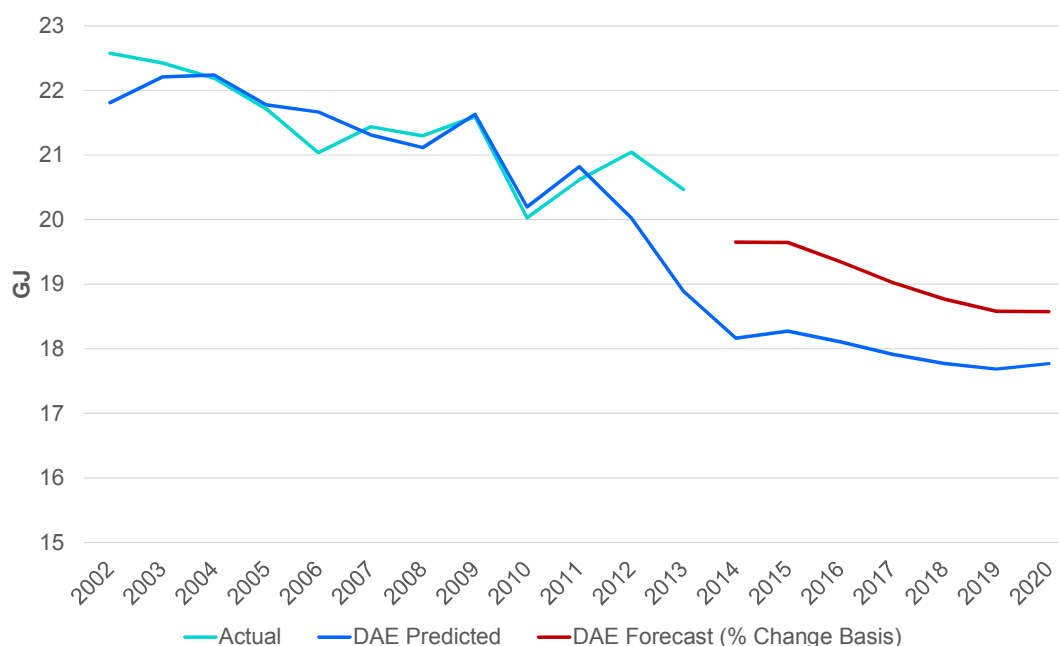
- estimated the annual percentage change in residential gas consumption per connection for the period 2014 to 2020, based on the estimated regression parameters and expectations about forecast gas prices and future state final demand for New South Wales; and
- applied the calculated percentage change from the regression analysis to expected gas consumption in 2014 within Core Energy's spreadsheet model, so as to derive the base case for forecast gas consumption per connection.

To be clear, DAE does not rely on the estimated residential gas consumption predicted directly from its regression model. Rather, it uses the predicted annual consumption to derive the year-on-year change in gas consumption per connection, which is then applied to expected gas consumption in 2014 to derive forecast gas consumption per connection.

Applying a percentage change in consumption from the regression model to the expected gas consumption in 2014 (which is higher than predicted in the regression model), has the effect of increasing the resultant gas consumption per connection compared to that predicted from within the regression model.

To illustrate this, Figure 2 plots actual versus predicted consumption per customer using the DAE regression results for the period 2002 to 2013. For the period 2014 to 2020 I have plotted the forecast of consumption per customer applying the regression model compared to the results estimated by DAE taking the percentage change and applying it to Core Energy's 2014 expected gas consumption.

Figure 2: Comparison of actual with DAE regression model predicted residential gas consumption per connection and DAE forecasts, 2002 to 2020



By not using the regression model directly, DAE are implicitly assuming that there has been a shift in the regression modelled trend (upwards), without affecting the year-on-year change in consumption. DAE provide no explanation as to the basis for such a shift. This has the effect of arbitrarily increasing DAE's forecast of residential consumption per connection.

Subject to my concerns about the reliability of the regression model, in my opinion the lack of any reasoning to support a structural shift in gas consumption in 2014, DAE should be forecasting residential gas consumption per connection directly from its regression model, rather than applying the resultant percentage change to expected consumption in 2014. This ensures that the forecast is consistent with the model that has been used to develop the relationships between the explanatory variables and historic gas consumption per connection.

Figure 3 compares the DAE predicted residential gas consumption per connection for the period 2015 to 2020 with Core's original forecasts.

Figure 3: Comparison of actual with DAE regression model predicted residential gas consumption per connection, and Core forecasts, 2002 to 2020

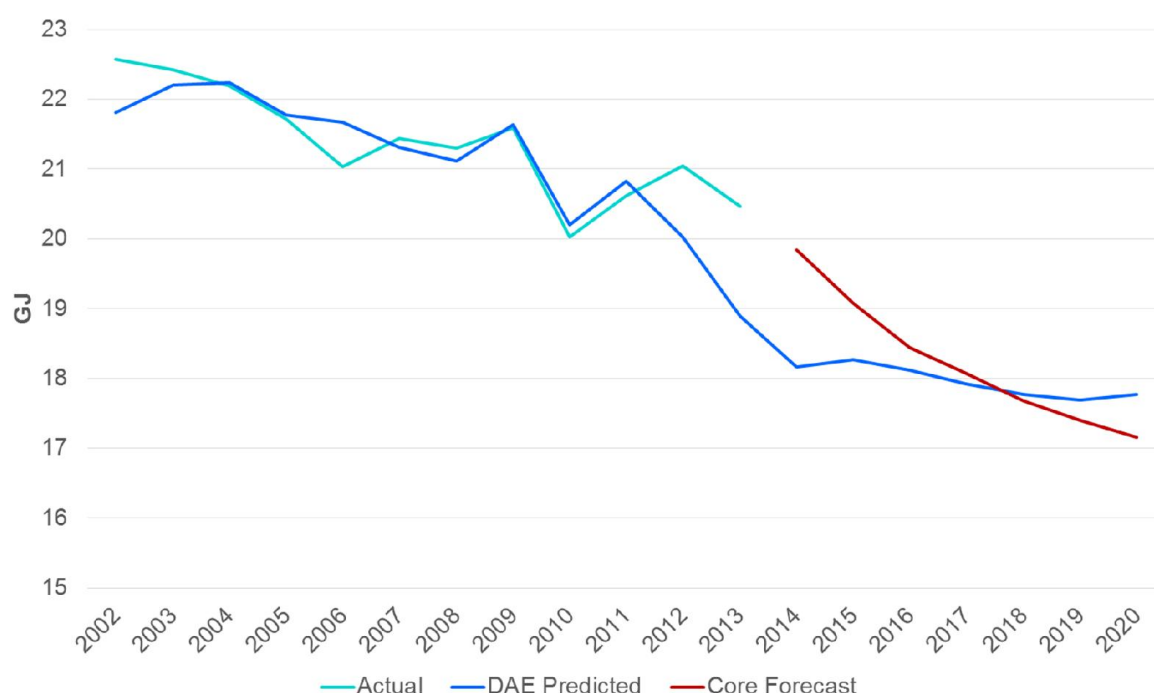


Figure 2 highlights that irrespective of my conclusions about the reliability of DAE's regression modelling, DAE's regression model when properly applied to forecast residential gas consumption per connection forecasts lower consumption than Core for the period 2015 to 2018, and higher for 2019 and 2020. It follows that in my opinion if DAE's regression modelling was reliable, it does not support a conclusion that Core's model underestimates demand. Rather it would support a conclusion that Core has overestimated consumption up until 2018 and underestimated consumption for 2019 and 2020.

5. Alternative Forecasting Methodologies

In this section I set out my opinion as to whether there is an alternative forecasting methodology that is likely to produce more reasonable and/or reliable estimates of forecast gas consumption in the circumstances.

5.1 Alternative forecasting methodology

DAE contend that there are two potential econometric approaches to forecasting energy consumption, namely:²⁵

the structural (economic) approach which incorporates a range of potential explanatory variables in an attempt to understand the drivers of consumption, and the time series approach which models consumption trends.

DAE characterises its approach as a ‘structural’ approach whereas the Core Energy approach is characterised as a ‘time series’ approach.

In my opinion the distinction drawn by DAE between the two approaches is so fine as to be unhelpful. Both the DAE regression model and the Core Energy approach employ econometric time series concepts and techniques to forecast gas consumption per connection.

The only distinction between the two approaches is that DAE attempts to econometrically estimate the specific influence of a limited number of identified drivers of gas consumption per connection to then forecast future consumption. In contrast, Core Energy’s approach takes account of the same drivers of gas consumption per connection within the historic trend to the extent that they are relevant plus any other factors that might influence consumption per connection, combined with explicit modifications to the trend to account for anticipated out of trend changes in those consumption drivers.

In my opinion both of these techniques could in principle be employed to forecast gas consumption per connection. The choice between employing a specific technique rests principally on the availability of data to reliably econometrically estimate the influence of each driver on gas consumption per connection. As I have set out in detail in this report, the lack of data over a sufficiently long period of time means that the DAE approach is unlikely to produce reliable forecasts of gas consumption per connection.

It follows that in my opinion, DAE’s contention that “Core’s time series model has likely under forecast consumption over the Review period”²⁶ is not supportable from the analysis it has undertaken.

As I set out in section 3, in my opinion it is best practice when forecasting consumption to:

- specify the model based on economic theory and evidence of a relationship between consumption and the identified theoretical factors influencing consumption;
- apply forecast techniques consistent with the availability of data, given the model specification; and
- where statistical techniques are used, ensure that the statistical technique assumptions are satisfied, so that estimated coefficients can be relied upon.

I conceptually apply this approach to considering alternative methodologies for forecasting gas consumption per connection in the following sections.

5.2 Consumption model specification

The factors influencing consumption for a good or service will vary according to the specific circumstances of the market.

²⁵ Deloitte Access Economics, (2014), *Gas consumption forecast for Jemena’s NSW network*, Australian Energy Regulator, 24 November, p11.

²⁶ Ibid, p11.

In economic theory, consumption for a good or service is typically considered to be a function of the price of the good, and the income of the consumer. In addition, there may be other factors that influence consumption, including demographic characteristics, or the price of close substitutes.

However, whether these factors are in practice relevant to forecasting consumption for a particular good or service, depends on the specific nature of consumption for the good or service.

There are many examples of goods where consumption is typically unresponsive to changes in prices. For example, consumption for water by residential customers is typically considered to be unresponsive to changes to prices because it is needed as a basis for life, and is typically a relatively small proportion of a household's budget.

Similarly, there are many examples of goods where consumption is typically unresponsive to changes in income of the consumer. These might include, say, the consumption for pencils, which is unlikely to be strongly influenced by changes in income.

It follows that while the starting point for specifying a regression model for consumption is economic theory, the specific model specification will be affected by:

- the nature of the specific good, and so expectations as to whether consumption will be affected by the theoretical factors; and
- data limitations, which restrict the extent to which every conceivable factor can be included within a regression model.

An appropriate regression of gas consumption per connection should include only those explanatory factors that influence consumption, given the specific circumstances.

In my opinion, it would be appropriate for residential gas consumption per connection to be a function of at least:²⁷

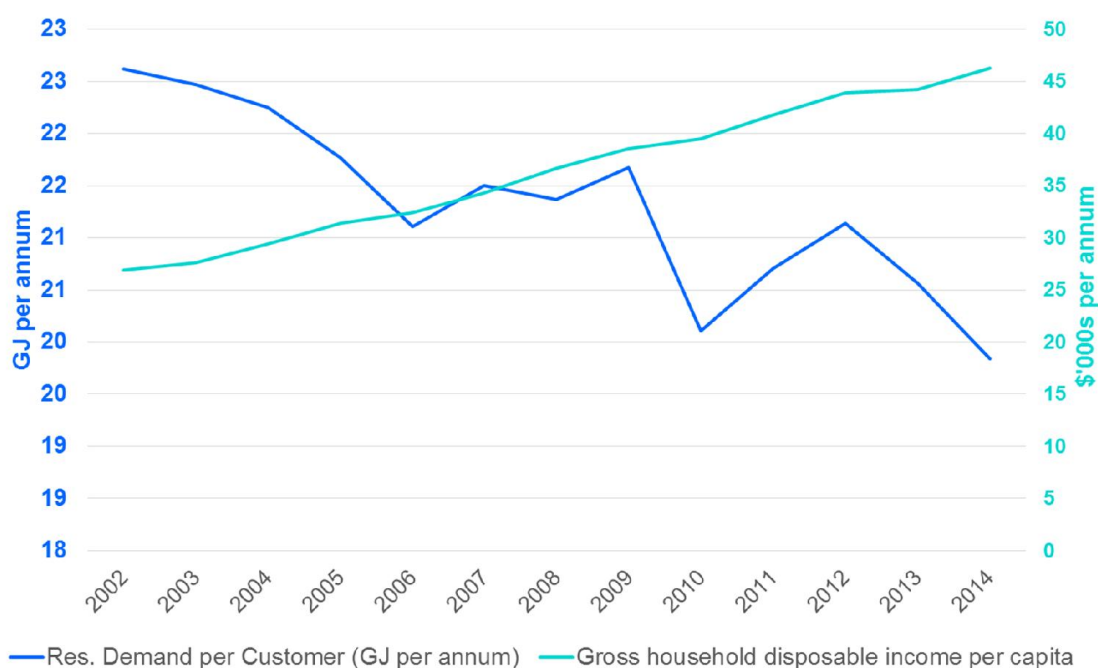
- gas price; and
- the price of substitutes (i.e., electricity).

However, while household income might be considered a factor relevant to residential gas consumption, in my opinion income is unlikely to be a constraint on residential gas consumption per connection. Figure 4 shows that in recent years as residential gas consumption per customer has been falling, while household disposable income has been rising.

In addition, the analysis I have undertaken on the inclusion of gross household disposable income in a regression of gas consumption per connection in section 3.6 is consistent with a conclusion that gross household disposable income is not a relevant variable to explain gas consumption per connection.

²⁷ I acknowledge that such a limited specification might omit other factors that could influence consumption per connection.

Figure 4: Comparison of residential gas consumption per customer and gross household disposable income



5.3 Choosing a residential gas consumption forecasting methodology

Forecasting residential gas consumption for JGN is particularly challenging in light of the limited data available.

In my opinion, there is insufficient data to allow for residential consumption to be estimated using statistical techniques and a specified econometric consumption model. My critique of the DAE approach highlights the problems that can arise, given the limited data available.

It follows that in my opinion the best methodology that can be used to estimate residential gas consumption per connection is to take a historic trend, and project the trend forward making adjustments for changes in factors that are expected to influence consumption. This approach assumes that the historic consumption trend is a reasonable basis for forecasting future consumption, and that expected factors influencing consumption can be separately measured and taken into account.

I note that Core Energy's approach is consistent with my opinion of the best approach to be used to forecast gas consumption per connection, given the limited data available. It follows that in my opinion forecasting gas consumption by explicit consideration of modifications to a historic trend, as undertaken by Core Energy, is a reasonable basis for producing reliable forecasts of gas consumption per connection.

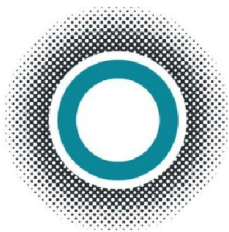
6. Declaration

In accordance with the requirements of the guideline for preparing an expert report, I declare that I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance that I regard as relevant have, to my knowledge, been withheld from the report.



Adrian Kemp

26 February 2015



HOUSTONKEMP
Economists

Level 40, 161 Castlereagh Street
Sydney NSW 2000 Phone: +61 2 8880 4800

Partner Luke Woodward
Contact Bridget Liedig
T +61 3 8656 3348
bliedig@gtlaw.com.au
Our ref LXW:BAL:1019305



L A W Y E R S

15 January 2015

By email

Adrian Kemp
HoustonKemp

Level 40, 161 Castlereagh Street
Sydney NSW 2000

adrian.kemp@houstonkemp.com

Confidential and privileged

Dear Adrian

Jemena Gas Networks (NSW) 2015-20 Access Arrangement Review: Demand Forecasts

We act for Jemena Gas Networks (NSW) Ltd (**JGN**), the owner of the principal gas distribution network in NSW.

We have been instructed to seek an expert report from HoustonKemp in relation to the adoption by the Australian Energy Regulator (**AER**) of estimates of forecast gas demand for JGN based on regression models of gas consumption data developed by Deloitte Access Economics (**DAE**).

Background

On 30 June 2014, JGN submitted its Access Arrangement (**AA**) proposal for the period 1 July 2015 to 30 June 2020 to the AER.

As part of JGN's AA proposal, JGN submitted gas demand forecasts for its network based on forecasts prepared by Core Energy. Relevantly, for volume market customers, Core Energy's consumption per connection forecasts were based on weather-normalised historical trends in gas consumption, adjusted for the expected impact on gas consumption of future increases in gas prices (based on an estimate of own price elasticity) and relative changes in gas and electricity prices (based on an estimate of cross price elasticity).

The AER's draft decision in respect of JGN's AA was published on 27 November 2014. The AER engaged DAE to advise on JGN's demand forecasts and to assist it in developing alternative demand forecasts. Relying upon DAE's advice, the AER did not approve demand forecasts for volume market customers in JGN's AA proposal on the basis that the forecasts do not comply with r 74(2) of the National Gas Rules (**NGR**). Rule 74(2) of the NGR provides that a forecast or estimate: (a) must be arrived at on a reasonable basis; and (b) must represent the best forecast or estimate possible in the circumstances.

While DAE determined that Core Energy's approach "was transparent, clear and generally sound in terms of methodology", a key component of the AER's rejection of the consumption forecasts for volume market customers was that Core Energy's approach did not include a variable for future economic activity (for example, State Final Demand (**SFD**) / Gross State Product (**GSP**)).

Melbourne

101 Collins Street Melbourne VIC 3000
Australia
GPO Box 90 Melbourne VIC 3001
T +61 3 8656 3300 F +61 3 8656 3400
www.gtlaw.com.au

The AER adopted demand forecasts derived from the application of annual estimated rates of change in gas consumption per customer based on a regression model of gas consumption data developed by DAE (**DAE regression model**). The DAE regression model includes both own price elasticity for gas and state macroeconomic parameters (SFD for residential volume market customers and GSP for I&C volume market customers). DAE provided estimates of forecast gas consumption derived from the annual changes in forecast gas consumption under its regression models and applied a reduced cross price elasticity for the impact of electricity prices than that proposed by Core Energy.

Request for Expert Report

HoustonKemp is requested to provide a report, for submission to the AER in response to its draft decision, setting out its expert opinion as to:

- (a) whether DAE's regression models and analysis provide a reliable basis to conclude that Core Energy's forecasts of gas consumption per connection for Tariff V customers (in particular, for residential customers) are an underestimate due to the absence of a specific variable to capture future economic activity (i.e. SFD or GSP);
- (b) whether the regression models of gas consumption per connection developed by DAE and the method used to apply the results of those models to forecasting gas consumption per connection for Tariff V customers for the JGN network, produce forecasts of gas consumption that are reasonably based estimates and which are reliable in the circumstances; and
- (c) whether there is an alternative approach to forecasting gas consumption per connection for Tariff V customers for the JGN network that is likely to produce more reasonable and/or reliable gas consumption forecasts in the circumstances.

HoustonKemp are required to set out its opinion in a written report which may be provided to the AER along with JGN's revised AA proposal.

In producing the report, HoustonKemp are to:

- review the material provided to you by Gilbert + Tobin as listed in **Appendix A**; and
- follow the guidelines in **Appendix B**.

The work is to be performed in accordance with the terms set out in your Consultancy Agreement with Jemena Limited dated 3 November 2014.

Yours sincerely

Gilbert + Tobin

Luke Woodward
Partner
T +61 2 9263 4014
lwoodward@gtlaw.com.au

Bridget Liedig
Lawyer
T +61 3 8656 3348
bliedig@gtlaw.com.au

Appendix A: Material provided in relation to request for expert report

JGN's proposal

1	JGN, Demand Forecast chapter (Chapter 5, AAI)	30 June 2014
2	JGN, Demand Forecast Report by Core Energy dated April 2014 (Appendix 5.1, AAI)	30 June 2014
3	JGN, Core modelling	30 June 2014

Draft Deloitte Report

4	Deloitte, Review of Core Energy Group gas demand forecast for JGN	11 August 2014
5	Core Energy, Response to Deloitte Report	August 2014

AER Draft Report

6	AER, Draft Decision, Attachment 13 – Demand	27 November 2014
7	Deloitte, Review of Core Energy Group gas demand forecast for JGN	24 November 2014
8	Deloitte's version of Core Demand forecasting model	22 October 2014
9	Deloitte's data for regression	21 October 2014

2014 data

10	Tariff V consumption, connections disconnections and tariff D customer lists, tariff V-D movements, customers numbers and GJ	Provided on 21 January 2015
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Appendix B: Guidelines for preparing your report

In producing any report, Houston Kemp is instructed at all times to provide its independent views as an expert, in accordance with the Federal Court of Australia's "Guidelines for Expert Witnesses" (Federal Court Practice Direction CM 7, hereafter **Expert Guidelines**). These are enclosed with this letter.

In accordance with the Expert Guidelines, the report:

- must be signed by the expert who prepared the report;
- contain an acknowledgement at the beginning of the report that the expert has read, understood and complied with the practice note;
- contain particulars of the training, study or experience by which the expert has acquired specialised knowledge (for example, this could be set out in a CV attached to the report);
- identify the questions that the expert has been asked to address;
- set out separately each of the factual findings or assumptions on which the expert's opinion is based;
- set out separately from the factual findings or assumptions each of the expert's opinions;
- set out the reasons for each of the expert's opinions; and
- contain an acknowledgement that the expert's opinions are based wholly or substantially on the specialised knowledge of the expert.

At the end of the report the expert should declare that: "[the expert] has made all the inquiries that [the expert] believes are desirable and appropriate and that no matters of significance that [the expert] regards as relevant have, to [the expert's] knowledge, been withheld from the report".

Adrian Kemp

Partner

Houston Kemp - Economists
Level 40, 161 Castlereagh Street
Sydney NSW 2000
Tel: +61 2 8880 4811
Mob: +61 406 753 352
E-mail: adrian.kemp@houstonkemp.com
Website: www.houstonkemp.com



Overview

Adrian Kemp is an economist with over 16 years of experience advising on regulatory and policy matters affecting the energy, water and transport industries. His particular interests and expertise include:

- market analysis across the electricity, gas and transport sectors;
- regulatory design for monopoly infrastructure;
- development and analysis of regulatory prices; and
- regulatory modeling and accounting.

Adrian has worked closely with regulated businesses, particularly in the electricity and water industries throughout Australia. He has also advised regulators including the Australian Energy Market Commission, the Civil Aviation Authority of Singapore, the Essential Services Commission, the Independent Pricing and Regulatory Tribunal, the Essential Services Commission of South Australia, the Economic Regulatory Authority, and the World Bank on a range of regulatory and pricing matters.

His industry experience spans electricity wholesale and retail markets, electricity transmission and distribution, urban water, bulk water, gas pipelines, road, rail, airport and port infrastructure, heavy vehicles, sugar, forestry, and grains.

Qualifications

2001	AUSTRALIAN NATIONAL UNIVERSITY Masters of Economics
1997	UNIVERSITY OF WESTERN AUSTRALIA Bachelor of Economics with Honours
1997	UNIVERSITY OF WESTERN AUSTRALIA Bachelor of Laws

Career Details

2013-2014	CONSUMER CHALLENGE PANEL, AUSTRALIAN ENERGY REGULATOR <u>Member</u>
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2005-2014	NERA ECONOMIC CONSULTING <u>Director</u> <u>Associate Director</u> <u>Senior Consultant</u>
2002-2005	INDEPENDENT PRICING AND REGULATORY TRIBUNAL <u>Acting Director</u> , Analysis & Policy Development <u>Program Manager</u> , Analysis & Policy Development <u>Senior Analyst</u> , Water Pricing, Sydney
1998-2002	AUSTRALIAN BUREAU OF AGRICULTURAL AND RESOURCE ECONOMICS <u>Program Manager</u> , Forestry Economics, Canberra <u>Senior Researcher</u> , Land and Water Economics, Canberra

Project Experience

Energy analysis

2014	Infrastructure Australia, National Energy Infrastructure Plan Adrian advised Infrastructure Australia on regulatory reforms initiatives for inclusion as part of its ten year national infrastructure plan.
2014	Territory Generation, Development of Wholesale Pricing Strategy Adrian worked closely with the newly formed Territory Generation, to develop its wholesale pricing strategy following separation of the electricity generation assets from the former Power and Water Corporation.
2014	Energy Networks Association, Supporting Vulnerable Energy Customers Adrian conducted a detailed review of options to support vulnerable energy customers affected by proposed changes to electricity network tariff structures. The project involved detailed consultation with consumer groups and network businesses, to identify gaps in the existing policy framework and to identify possible reform options.
2014	Department of State Development, Peer Review of Network Tariff Reform Issues Paper Adrian undertook a peer review role as part of the Department's development of a paper exploring options for reforming the regulatory arrangements underpinning current electricity network tariffs.
2014	Australian Energy Market Commission, Economic Concepts for Pricing Electricity Network Services Adrian was asked by the Commission to set out the economic rationale for and concepts underpinning the distribution network pricing principles set out in the National Electricity Rules, and outlining practical approaches to comply with the principles, including how to estimate long-run marginal cost.
2014	EnerNOC, Necessary Conditions for an Effective Energy-Only Market in Western Australia Adrian developed a report to set out the necessary conditions for an effective energy-only wholesale electricity market design in Western Australia, given the prevailing market context. The paper was provided as a submission to the WA energy review, which was investigated possible market design reform options.
2014	Australian Competition and Consumer Commission, AGL Purchase of Macquarie Generation

Adrian provided expert wholesale market advice to the ACCC in relation to the proposed purchase by AGL of the assets of Macquarie Generation.

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| 2014 | Australian Energy Market Commission, Efficiency of Network Tariffs for Current and Emerging Technologies
Adrian was part of a project team that investigated the implications for network tariffs of emerging technologies, including solar PV and battery technology. |
| 2014 | Department of Premier and Cabinet, Ownership and Electricity Network Performance
Within the context of the proposed partial lease of the NSW electricity network businesses, Adrian developed a paper that explained the relationship between network ownership and performance. The paper drew upon both theoretical considerations, and case study experience from the Victorian and South Australian network privatisations. |
| 2014 | Australian Energy Market Commission, Consumer Protection given Open Access Regime for Smart Metering Infrastructure
Adrian provided advice to the Commission on the implications for consumer protections of the proposed open access regime for smart metering infrastructure. The advice focused on existing consumer protections, and considered whether consumer protections in other contexts should be provided to energy consumers. |
| 2013 | Power and Water Corporation, Development of Electricity Regulatory Models and Systems of Accounting
Adrian worked with Power and Water Corporation to design and build internal regulatory models for each of the key business units including, electricity generation, transmission, retailing, water and sewerage. The project involved advising on methodologies for allocating costs within a revenue cap regulatory framework, drawing upon the best practice principles applied in both Australia and the United States. |
| 2013 | Ausgrid, Analysis to Support the Smart Grid Smart Cities Trial
Adrian was engaged to work with Ausgrid's Smart Grid Smart Cities project team to analyse the data, and draw out any implications, from the customer applications network and retail pricing trials. This involved investigating how consumers have responded to the information tools provided to trial participants, so as to determine the relative advantages of each information tool. |
| 2013 | Australian Energy Market Commission, Comparative Assessment of Retail Electricity Margins between Jurisdictions
Adrian led a project team that reviewed estimates of retail margins across a number of jurisdictions. This involved considering the likely explanations for observed differences in the resultant margins. |
| 2013 | Standing Council on Energy and Resources, Review of Energy Enforcement Regimes
Adrian was part of a project team led by Allens Linklaters that has undertaken a comprehensive review of the enforcement regimes applying to the national energy regimes. Adrian's focus as part of this review has been on benchmarking civil penalties, and making recommendations about possible changes to the current civil penalty arrangements. |
| 2013 | Essential Services Commission, Peer Review of a Report Estimating Retail Margins in Victoria |

Adrian conducted a peer review of a report that estimated electricity retail margins in Victoria.

- 2013** **Standing Council on Energy and Resources, Analysis of Policy Options to Facilitate Enhanced Gas Transmission Capacity Trading**
 Adrian investigated the benefits and costs of a number of policy options designed to address perceived market failures in the provision of gas transmission pipeline capacity to third parties.
- 2013** **Confidential Client, Implications of Proposed Carbon and Renewable Energy Target Policies on Wholesale Market Prices and Wind Investment**
 Adrian led a project team that investigated the implications of a number of alternative carbon pricing and renewable energy target policies. This included considering the likely implications for spot prices, wind investment and the achievement of the large-scale renewable energy target.
- 2013** **Australian Energy Market Commission, Projections of Wholesale Electricity Costs in the NEM – Review of Retail Electricity Price Trends**
 Adrian led a project team that projected the costs to supply electricity to residential customers in the National Electricity Market and the South-West Interconnected System in Western Australia for the period from 2012-13 to 2015-16. This principally involved projecting electricity purchase costs using NERA's wholesale electricity market model 'PowerMod'. In addition, forecasts of other costs were developed including for those costs arising from energy savings schemes and market participant fees.
- 2013** **Australian Energy Market Commission, Wholesale Electricity Costs in the NEM – Review of Best Practice Retail Price Regulation**
 Adrian led a project team that investigated the implications of using a number of alternative methodologies to estimate wholesale electricity purchase costs, which is a critically important component for regulated retail price setting purposes. The methodologies included both stand-alone and perturbation approaches to estimating long-run marginal cost, and a market modelling methodology based on projected spot prices and hedging arrangements.
- 2013** **Australian Energy Market Commission, International Approaches to setting Wholesale Electricity Market Price Caps**
 Adrian led a project team that investigated the arrangements used in eight international wholesale electricity markets for setting the market price cap. The particular focus was on approaches that sought to set the market price cap with reference to the value to consumers of reliable electricity.
- 2013** **Australian Energy Market Commission, Feed-in Tariff Arrangements Applying in Australia**
 Adrian led a project team that investigated the current arrangements for feed-in tariffs for solar PVs installed by residential customers, in each jurisdiction in Australia. The project also involved examining the implications for incentives of both feed-in tariff arrangements and the small scale renewable energy scheme.
- 2013** **Energy Networks Association, Analysis of the Australian Energy Regulator's Proposed Efficiency Incentive Schemes**
 Adrian was asked to examine the incentive properties of the AER's proposed capital and operating expenditure efficiency schemes. This involved quantifying distributor's

benefit shares and implied rate of recovery of actual incurred costs under a number of possible scenarios.

- 2013** **Australian Energy Market Commission, Analysis of Prices and Profit Margins for New South Wales Electricity Retailers**
 Adrian undertook a detailed analysis of electricity retail prices and associated retailer profit margins in New South Wales. The analysis was an input to the AEMC's review of the effectiveness of retail competition in New South Wales.
- 2012-13** **Power and Water Corporation, Assessment of Regulatory Pricing Models and Options for Structural Separation**
 Adrian led a project team that investigated the regulatory models used to determine regulated retail electricity and water tariffs for Power and Water Corporation in the Northern Territory.
- 2012** **Department of Climate Change and Energy Efficiency, Compliance Costs of Energy Savings Schemes**
 NERA examined the costs of complying with existing energy savings schemes in New South Wales, Victoria and South Australia. This information has been used to analyse the potential benefits and costs of a number of policy scenarios to harmonise or move to a single national energy savings scheme.
- 2012** **Ausgrid, Form of Price Control**
 Adrian advised Ausgrid of the advantages and disadvantages of shifting to a revenue cap form of price control, from the currently applied weighted average price cap. The analysis involved examining how much revenue volatility is caused by forecasting errors, and the likely welfare implications of shifting to a revenue cap.
- 2012** **Energy Savings Initiative Secretariat, Peak Energy Savings Scheme Design Options**
 Adrian undertook a project for the Energy Savings Initiative Secretariat to develop options for providing a direct incentive for peak energy savings as part of a national ESI scheme. The project involved working closely with energy market participants to consider the incentive implications of scheme design options, and to determine the relative merits of each design.
- 2012** **Australian Energy Market Commission, Market Power in the National Electricity Market**
 Adrian examined whether there is historic evidence of market power in the NEM. This involved considering the appropriate market definition and comparing estimates of the long run marginal cost with observed market prices.
- 2011** **Australian Energy Market Commission, Generation Market Power**
 Adrian undertook a project that developed the framework for the analysis wholesale generation market power in the National Electricity Market. The next stage of the project applied the framework to investigate whether wholesale market power has been exercised in South Australia.
- 2011** **Confidential Client, Analysis of implications of generation retirements in the wholesale energy market**
 Adrian led a project team that investigated the implications for wholesale market prices of proposals to accelerate the shutdown of a number of high-emitting generation plants in the National Electricity Market.

- 2011** **Confidential Client, Wholesale electricity market impacts of the large scale renewable energy target**
 Adrian undertook a detailed analysis of the wholesale energy market implications of the large scale renewable energy target, with a particular focus on identifying the implications for renewable energy certificate prices. The study also examined the financial viability of achieving the targets given the current penalty price within the scheme.
- 2011** **Western Power, Option value analysis for transmission works to supply the Binningup Desalination Plant**
 Adrian led a team that assessed the potential option values created by a proposed investment to upgrade the transmission capability of the network as a consequence of the construction of a desalination plant in Binningup, south of Perth in Western Australia.
- 2010** **Prime Minister's Task Group on Energy Efficiency, Improving Energy Efficiency in the National Electricity Market**
 Adrian was asked by the Prime Minister's Task Group on Energy Efficiency to identify and evaluate options for changing the National Electricity Market framework to drive or support a 'step change' improvement in energy efficiency. The report focused on the principal elements of the market framework, including the market objective, institutional arrangements, and incentives created to each business along the supply chain to promote energy efficiency.
- 2010** **Department of the Environment, Water, Heritage and the Arts, Smart Grid, Smart City – Advice on implications for electricity businesses**
 Adrian assisted the Department in its development of a business case for the Australian government's Smart Grid, Smart City project, which involves the development of a smart grid demonstration network. The winning bidder for this project was a consortium led by EnergyAustralia.
- 2010** **EnergyAustralia, Review of network pricing proposal**
 Adrian provided an expert report providing an opinion of the compliance of the network pricing proposal for EnergyAustralia, with the obligations set out in the National Electricity Rules.
- 2010** **Ministerial Council on Energy, Smart Meter Working Group, The costs and benefits of electricity smart metering infrastructure in rural and remote communities**
 This report extended an earlier analysis undertaken of the costs and benefits of a mandatory roll out of smart meters, by consider the implications of a roll out in rural and remote communities in the Northern Territory, Western Australia and Queensland. The project focused on eight case study communities and examined the implications of prepayment metering and remoteness on the overall costs and benefits of a roll out.
- 2009** **Choice Magazine, Energy Efficiency in the National Electricity Market**
 This project examined the role of electricity retailers in the promotion of energy efficiency, in light of policies designed to lower Australia's carbon emissions. The report focused on the economic principles underpinning energy efficiency policy, and the programmes being implemented by retailers both within Australia and abroad.
- 2009** **Australian Energy Market Commission, Key challenges facing the energy market's development**
 Adrian undertook a review for the Commission on the challenges facing the future development of the national electricity and gas markets. While much of the focus

was on the implications arising from climate change policy, the review examined broader emerging developments including in the fields of network regulation and management of network risks.

- 2009** **Australian Energy Market Commission, Strategic matters affecting the National Energy Market's development**
 Adrian assisted the AEMC to identify a number of strategic policy matters affecting the development of the National Energy Market. These included considering the implications of climate change policies on the market's development, and the development of new innovations such as smart grid and smart metering technologies.
- 2009** **EnergyAustralia, Review of network pricing proposal**
 Adrian reviewed the network pricing proposal for EnergyAustralia, which included assisting in the development of methodologies for estimating the avoidable cost, stand-alone cost and long run marginal cost, for each tariff class.
- 2009** **VENCorp, Development of indexation methodologies for estimates of the Value of Customer Reliability**
 Adrian led a project team that reviewed alternative methodologies for annually indexing estimates of the Value of Customer Reliability.
- 2008** **Confidential client, Review of proposals to adopt the National Electricity Law and the National Electricity Rules in the Northern Territory**
 Adrian provided an assessment of the practicality and feasibility of proposals for the Northern Territory to adopt the National Electricity Law and the National Electricity Rules. The review highlighted the emerging challenges for the power industry in the NT and how promoting competition where feasible was most likely to result in improved investment decisions.
- 2008** **Swiss Reinsurance, Australian energy market overview**
 Adrian undertook a report that outlined the main features of the Australian energy market, including market structure and developments, and influences on the formulation of wholesale energy prices. A particular focus of the report was to describe the statistical methods used in the market to forecast energy prices.
- 2008** **Australian Energy Market Commission, Compensation arrangements under an administrative price cap**
 Adrian completed the AEMC review of EnergyAustralia's rule change proposal relating to compensation arrangements under an administrative price cap, as set out in Chapter 3 of the National Electricity Rules.
- 2008** **Australian Energy Market Commission, Review of the implications of climate change policies on network businesses**
 This review involved setting out the implications of climate change policies, such as the development of a national emissions trading scheme, for network businesses and the National Electricity Rules.
- 2008** **Australian Energy Market Commission, Review of impediments for the connection of embedded generation**
 Adrian considered three questions relating to the connection of embedded generation, namely: what are the appropriate principles for connection charges; the treatment of avoided TUOS and DUOS payments; and whether there are impediments for embedded generation arising from the treatment of minimum technical standards.

- 2008** **COAG Working Group on Climate Change and Water, Review of international energy efficiency and conservation policies and programmes**
 Adrian completed an international review of energy efficiency and climate change policies in the United States, Canada, the United Kingdom, France, Italy, Japan and New Zealand. The report considered the potential justifications for energy efficiency policies in the context of the development of an emissions trading scheme for Australia.
- 2008** **Australian Energy Market Commission, Review of demand-side participation in the National Electricity Market**
 This review was the first stage of the Commission's review of the role of demand side participation in the NEM. The project objectives included developing a framework for considering the role of demand side participation, and then identifying the impediments to DSP in the context of the Commission's current work program.
- 2008** **Powercor, Advice on the proposed Victorian metering rule derogation**
 Adrian provided advice to Powercor on the proposed amendments to Chapter 7 of the National Electricity Rules to facilitate the Victorian Governments policy of a mandatory rollout of electricity smart meters by distributors.
- 2008** **Western Power, Optimal treatment and application of capital contributions**
 Adrian led a project team assessing Western Powers' approach to determining capital contributions to its transmission and distribution network. The assessment included outlining the principles underlying capital contributions policy to promote economic efficiency.
- 2007** **Smart Meter Working Group, Ministerial Council on Energy – Assessment of the costs and benefits of a national mandated rollout of smart metering and direct load control**
 Adrian led a project investigating the costs and benefits of a national mandated rollout of electricity smart meters. This included an overall assessment of smart metering functions and scenarios, and also considering the likely demand responses from consumers and impacts on vulnerable customers.
- 2007** **Independent Pricing and Regulatory Tribunal of New South Wales, Analysis of the results of the 2006 survey of households**
 Adrian led the second stage an assessment of the results of IPART's 2006 survey of residential households. This analysis included consideration of the demographic characteristics of households compared with their consumption of water, electricity and gas.
- 2007** **Smart Meter Working Group, Ministerial Council on Energy – Assessment of the demand responsiveness of time-of-use tariffs and critical peak pricing**
 Adrian led a project that estimated the likely demand responsiveness of residential customers to time-of-use tariffs and critical peak pricing. The project developed a pricing model that allowed the financial implications of new tariff products to be evaluated.
- 2007** **Independent Pricing and Regulatory Tribunal of New South Wales, Australia Analysis of the results of the 2006 residential energy customer survey**
 This project involved the analysis and reporting of IPART's residential customer survey including a consideration of the relationship between energy consumption, income and a number of household demographic characteristics. This project drew upon earlier work undertaken by Adrian to estimate the determinants of demand for energy and water using the 2004 IPART household survey results.

- 2007** **Ministerial Council on Energy, Australia**
Advice in relation to proposed changes to the new capital investment criteria in the draft proposed gas rules
 Adrian assisted Greg Houston by providing advice on proposals to amend the new capital investment criteria in the National Gas Rules to promote efficient investment in regulated gas pipelines.
- 2007** **Australian Energy Market Commission, Australia**
Review of the wholesale gas and electricity markets and implications for retail competition
 Adrian Kemp led a project team to provide an overview of the operation and structure of the wholesale gas and electricity markets within the National Electricity Market (NEM) jurisdictions and to identify the issues that the AEMC should consider when assessing the influence of the wholesale markets on competition within the retail gas market in each jurisdiction.
- 2007** **Ministerial Council on Energy, Review of the provisions in Chapter 5 of the National Electricity Rules relating to connection applications and capital contributions**
 Adrian completed a review of the framework for connection applications and capital contributions as provided in chapter 5 of the NER. The review focused on applications for connection to distribution networks and implications for demand side response and embedded generation.
- 2007** **Australian Energy Market Commission, Expert advice relating to a review of the congestion management regime**
 Adrian assisted with the finalisation of the Commission's review of the congestion management regime in the national electricity market. Consideration of issues relating to wholesale market financial risks, approaches to redefining region boundaries and improving overall dispatch efficiency.
- 2006** **Australian Energy Market Commission, Expert advice relating to a number of Rule Change Proposals**
 Adrian assisted with the development and finalisation of a number of Rule Change Proposals including relating to Transmission Revenue, the Regulatory Test, Last Resort Planning Power, reconfiguration and replacement investments, reallocations and network service provider connections.
- 2006** **Ministerial Council on Energy – Network Policy Working Group, Assistance with the development of the Initial Electricity Distribution Rules**
 Adrian provided assistance to the Network Policy Working Group by providing advice on various policy proposals for the initial electricity distribution rules. The areas of advice included the scope of regulation, cost pass through, service standards incentive frameworks and the regulatory framework for operating and capital cost evaluation.
- 2006** **Ministerial Council on Energy, Expert Panel on a national framework for energy distribution and transmission regulation**
 Adrian assisted Greg Houston in the development and drafting of two chapters of the Expert Panel report, which considered issues surrounding the harmonisation of energy distribution and transmission regulation in Australia.

Transport regulatory analysis

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| 2014 | Infrastructure Australia, National Transport Infrastructure Plan
Adrian advised Infrastructure Australia on possible regulatory reforms for transport infrastructure, including ports, roads, and rail, as part of the development of a ten year national infrastructure plan. |
| 2014 | Essential Services Commission, Review of Accident Towing and Storage Regulation in Victoria
Adrian undertook a comprehensive review of options to reform the regulatory arrangements applying to the accident towing industry in Victoria. This included assessing the extent of competition, and the form of regulation that might apply. |
| 2014 | National Heavy Vehicle Regulator, Cost Recovery Study Project
Adrian developed a proposed methodology and work plan for conducting the proposed study of the costs for providing heavy vehicle regulatory services. |
| 2014 | Freight and Logistics Council of Western Australia – Reforming heavy vehicle charging and road infrastructure investment
Adrian developed a short paper that set out the rationale underpinning proposed national reforms to heavy vehicle charging and road infrastructure investment, so as to explain the possible opportunities for the transport industry in Western Australia. |
| 2014 | Department of Treasury and Finance, Regulatory Advisor – Port of Melbourne Transaction
Adrian is currently acting as the principal regulatory advisor for the proposed lease of the Port of Melbourne. |
| 2013 | Transport for New South Wales, Development of a Submission to the National Transport Commission’s Review of the PAYGO Methodology
Adrian undertook a detailed review of the conclusions resulting from the NTC’s review of the PAYGO methodology, to support the development of NSW’s submission to the review. |
| 2013 | National Heavy Vehicle Regulator, National Registration System Cost Benefit Analysis
Adrian constructed a detailed model to support the development of a high-level business case as part of a consideration of options for investing in a national heavy vehicle registration system, to be operated by the National Heavy Vehicle Regulator. |
| 2013 | Transport for New South Wales, Heavy Vehicle Access and Investment Regime
Adrian led a project team that documented NSW’s arrangements for managing heavy vehicle access, in light of the transition in responsibilities to the National Heavy Vehicle Regulator. |
| 2013 | Essential Services Commission, Benchmarking Charges for Regulated Accident Towing Services
The study involved providing information on changes in fees and costs for comparable industries to accident towing, including trade towing and heavy vehicle piloting services, to provide a benchmark to assess changes in regulated accident towing services. In addition, Adrian developed options for the annual adjustment of regulated charges. |

- 2012/13 National Heavy Vehicle Regulator, Jurisdictional Service Agreements**
 Adrian worked closely with the NHVR and jurisdictions to agree to service agreements for the provision of regulatory services. This work included defining the regulatory activities and developing mechanisms to agree to funding and service level arrangements.
- 2012 COAG Road Reform Plan Deputy Heads of Treasury Steering Committee, Heavy Vehicle Charging and Funding Reform**
 Adrian developed a number of practical, outcome oriented reform packages for heavy vehicle charging and funding. The project focused on meaningful 'first steps' road reforms, drawing on the significant microeconomic reforms that have been undertaken in other sectors, including for electricity, water and gas infrastructure.
- 2011-12 New South Wales Treasury, Road governance reform options**
 Adrian led a team advising the New South Wales Treasury to assess various road governance reform options for Australia and NSW, including potential implementation pathways.
- 2011 New Zealand Transport Agency, Alternative Funding Mechanisms for Transport Infrastructure**
 Adrian undertook a research study that investigated the potential benefits from and impediments to, implementing alternative funding mechanisms for transport infrastructure, including charging land use beneficiaries for infrastructure investments. The study was an important input to a wider debate occurring in New Zealand on how best to provide the funds needed for additional transport infrastructure.
- 2011 National Heavy Vehicle Regulator Project Office, Development of the Funding Strategy**
 Adrian developed the funding strategy for the NHVR, which includes considering the approach to national fees and charges, heavy vehicle charging and funding of activities provided under service agreements.
- 2011 COAG Road Reform Plan Feasibility Study, Development of draft findings and recommendations**
 Adrian was engaged as the principal advisor to develop the initial draft findings and recommendations for the COAG Road Reform Plan Feasibility Study.
- 2011 National Heavy Vehicle Regulator Project Office, Development of National Performance Standards**
 Adrian developed a framework and the associated standards for managing the performance outcomes of the regulatory activities to be undertaken by the NHVR upon its establishment. This involved working closely with jurisdictions to better understand current performance systems and standards, as the basis for developing new national performance standard targets.
- 2011 New Zealand Transport Agency, Total Costs of Transport to Business**
 Adrian undertook a research study into the total costs of transport to New Zealand businesses. The project is investigating a number of case study industries, where there might be opportunities to lower costs including forestry, floral, meat, and supermarkets.
- 2011 National Heavy Vehicle Regulator Project Office, Economic Advisor to the development of the project business case**
 Adrian acted as the principal economic advisor to the National Heavy Vehicle Regulatory Project Office, to guide the development of the business case. His focus

in this task was on examining how alternative delivery options might influence the size and allocation of benefits amongst stakeholders.

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| 2011 | <p>National Transport Commission, Examining options for estimating the cost base for heavy vehicle charging</p> <p>Adrian worked with the NTC to examine alternative options for estimating the cost base used for determining heavy vehicle charges. In particular, he focused on examining how the building block methodology or a discounted cash flow methodology might create different incentives to promote efficiency use of and investment in road infrastructure.</p> |
| 2010 | <p>National Heavy Vehicle Regulator Project Office, Development of funding options</p> <p>Adrian advised the NHVR Project Office on the principles that should be applied to, and the subsequent design of, the funding arrangements for the new NHVR. The project involved working with the High-Level Reference Group, and examining how decisions about the allocation of roles and responsibilities might impact on the choice of funding approach.</p> |
| 2010 | <p>COAG Road Reform Plan, Benefits and Costs of Supply Side Reform Options</p> <p>Adrian led a project that developed a number of reform options for road agency funding from heavy vehicle charges, and considered the likely benefits arising from those reforms. The project included the development of a model of the benefits and costs, to estimate the range of net benefits likely from reform.</p> |
| 2010 | <p>Transport NSW, Applying marginal cost pricing principles to heavy vehicle charges design</p> <p>Adrian developed a brief paper explaining how the principle of marginal cost pricing should be practically applied when designing heavy vehicle charges. Importantly, the paper highlighted the need to consider the opportunity for road users to respond to marginal prices, in order to achieve any benefits from setting variable road charges linked to marginal cost.</p> |
| 2010 | <p>Productivity and Efficiency Standing Sub Committee of the Australian Transport Council, The importance and rational for examining 'supply side' reforms</p> <p>Adrian has provided detailed advice on the relative merits of examining detailed heavy vehicle road funding and investment reforms. The paper highlighted the anticipated benefits from focusing on reforms to funding relative to direct heavy vehicle pricing reform.</p> |
| 2010 | <p>Productivity and Efficiency Standing Sub Committee of the Australian Transport Council, Principles of an Economic Framework to Guide Land Transport Reforms</p> <p>This paper followed on from Adrian's earlier work developing a framework for reform in the land transport sector by highlighting the principles for that framework. It discussed the opportunities from reforms to funding and strategic transport planning and investment.</p> |
| 2010 | <p>Essential Services Commission, Review of fees for Accident Towing and Storage Services</p> <p>Accident Towing and Storage Service fees are determined by the Minister for Roads and Ports in Victoria, based on advice provided by the Essential Services Commission. Adrian advised the ESC on methodological approaches to determining fees in circumstances where data is limited. This included the appropriate use of</p> |

benchmarking and cost survey results to infer the rate of change in costs for providing these services.

- 2010** **COAG Road Reform Plan, Development of a policy framework for implementing direct heavy vehicle road charges**
 Adrian advised the policy work stream of the COAG Road Reform Plan, which is developing a Feasibility Study of direct heavy vehicle road charges. This included extensive consultation with jurisdictional transport and road agencies and the identification of reform opportunities within the existing charging and funding arrangements.
- 2009** **Roads and Traffic Authority, Development of Policy Papers**
 Adrian led a project team that developed the principal project planning tasks to be undertaken as part of policy development within the COAG Road Reform Plan.
- 2009** **Essential Services Commission, Elasticity of substitution - Ports**
 Adrian undertook a statistical assessment of the elasticity of substitution between the Ports of Brisbane, Sydney, Melbourne and Adelaide. The analysis involved estimating pair-wise functions using non-linear estimation techniques. The results demonstrated that there was likely to be little scope for substitution between the Ports of Melbourne and either Adelaide or Sydney. However, the results also supported greater opportunities for substitution between the Port of Sydney and the Port of Brisbane.
- 2009** **Essential Services Commission, Review of port access arrangements**
 Adrian provided expert advice to the Essential Services Commission as part of its review of port access arrangements. This included assessing the regime against the requirements of the Competition Principles Agreement for certification of the regime as a state-based access regime, and consideration of the scope for competition between ports.
- 2009** **Ministerial Taskforce for an Efficient Land Transport Marketplace, Provision of expert advice**
 Adrian developed a new economic framework for the land transport marketplace, focusing on improving efficiency in the use of and investment in land transport infrastructure. This role included developing the principal elements of the proposed framework, stakeholder consultation, Taskforce report drafting.
- 2008** **Essential Services Commission, Review of certification criteria for the grain handling and storage access regime**
 Adrian led a project team that assessed the Victorian grain handling and storage access regime against the criteria for certification as a 'state-base' access regime in accordance with the requirements of the *Trade Practices Act (1974)*.
- 2008** **National Transport Commission, Participation in an expert panel on rail productivity**
 Adrian participated in an expert panel workshop to identify the key issues for the NTC's rail productivity review. Specifically, he outlined the key features of a rail regulatory framework focused on improving efficiency in the use of, and investment in, rail infrastructure, particularly given the potential for avoided road cost benefits arising from rail investments.

- 2008** **Australian Transport Council Ministerial Taskforce, An economic framework for an efficient land transport marketplace – Challenges for land transportation**
 Adrian completed a study for the Australian Transport Council's Ministerial Taskforce, which identified the key features of an economic framework, the challenges facing land transportation, and described the frameworks that apply in other industries such as energy and water.
- 2008** **COAG Road Reform Taskforce, Identifying, defining and quantifying road-related community service obligations**
 Adrian completed a study for the Council of Australian Governments Road Reform Taskforce, to identify and define road-related community service obligations. The project also involved the development of a methodology for quantifying road-related CSOs and the application of the methodology to five case studies.
- 2008** **COAG Road Reform Taskforce, Direct charging for road-related externalities**
 Adrian provided a peer review role to the Taskforce's consideration of charging approaches to address road-related externalities. The focus was on determining in what circumstances direct charging may be an appropriate and feasible approach to addressing the identified externality.
- 2008** **Essential Services Commission, Review of port access arrangements**
 As part of the Essential Services Commission's review of port access arrangements Adrian was engaged to provide technical advice and assistance on the key issues likely to arise in the review.
- 2006** **National Transport Commission, Provision of expert advice relating to transport reforms**
 Adrian considered a number of issues relating to the anticipated transport pricing reforms including approaches to incorporating capital values in the pricing methodology and institutional reform.
- 2006** **Australasian Railway Association, Assistance with the development of a submission in response to the Draft Productivity Commission Report**
 Adrian reviewed and evaluated the Draft Productivity Commission Report investigating road and rail pricing, for the purpose of developing the ARA's submission in response.
- 2006** **Qantas Airways Limited, Effectiveness of the regulation of airport services**
 Adrian undertook an evaluation of the effectiveness of the current regulatory arrangements for the negotiation and monitoring of aeronautical services at Australia's major airports. The report was prepared for submission to the Productivity Commission's inquiry into the economic regulation of airport services.
- 2006** **Australasian Railway Association, Comparative assessment of road and rail regulatory regimes**
 Adrian undertook a comparative study of the regulatory approaches, and institutional structures for road and rail infrastructure. The aim of the study was to draw out relevant features and inconsistencies between road and rail infrastructure in each of the key jurisdictions in Australia.
- 2006** **Australasian Railway Association, Principles for an efficient freight charging regime in Australia**
 Adrian undertook a study that outlined the principles necessary for an efficient freight charging regime in Australia. The study focused on the implications from

access price setting in road and rail infrastructure, for competitive neutrality, competition and efficiency in the freight market.

2006 **Gilbert + Tobin/AWB, Access to bottleneck facilities**
Adrian assisted with the development of an expert report in an arbitration in relation to the imposition of throughput fees for grain received at port in South Australia.

2006 **Pacific National, Rail industry structure and efficiency**
Adrian assisted with the finalisation of a report that examined options for addressing issues arising in vertically-separated rail industries. This involved examining a number of case study countries including the UK, US and Canada.

Water regulatory analysis

2014 **Power and Water Corporation, Development of Regulatory Models**
Adrian led a project team that developed regulatory building block models to determine prices for water and wastewater services in the Darwin-Katherine region. This model included customer impact and financial viability assessment components.

2013 **SA Water, Review of Proposed Access Regime**
Adrian undertook a review, on behalf of SA Water, of the implications arising from the SA Treasury proposed water and wastewater infrastructure access regime.

2012 **Hunter Water, Review of the Cost Recovery Strategy for the Kooragang Industrial Water Scheme**
Adrian undertook an independent review of the cost recovery strategy for Hunter Water's Kooragang Industrial Water Scheme. The review was undertaken to ensure that the methodology was consistent with best regulatory practice.

2011 **SA Water, Investigation into Alternative Options for Providing Third Part Access to Water and Wastewater Infrastructure**
Adrian was retained by SA Water to provide advice on the risks and opportunities for third party access to water and wastewater infrastructure, and the implications of these circumstances for access pricing.

2009 **Department of Planning, Cost benefit analysis of the Building Sustainability Index**
Adrian conducted a cost benefit evaluation of the performance of the Building Sustainability Index (BASIX) scheme, which was implemented in New South Wales in 2005. This involved examining the actual water and energy savings achieved across NSW as a consequence of the introduction of the scheme.

2008 **Alinta LGA Ltd, Assessment of IPART's estimate of long run marginal cost for Sydney Water**
Adrian undertook a study outlining the methodologies that can be used to estimate long run marginal cost for water services, and assessed estimates developed by the Independent Pricing and Regulatory Tribunal of New South Wales for Sydney Water.

2008 **Essential Services Commission of South Australia, Benefits of incentive regulation for government owned water businesses**
Adrian advised the Essential Services Commission of SA on the benefits that can arise from incentive regulation for government owned water businesses. The advice included outlining a number of case studies from within Australia.

- 2008** **Yarra Valley Water, A blueprint for water reform in Victoria**
 Adrian developed a blueprint for new water reforms in Victoria to address the challenges created by investments designed to create a Victorian water grid. The focus was on developing the arrangements for a proposed Water Grid Manager, highlighting the importance of promoting competition in bulk water supply and the features of the economic framework that are necessary to promote competitive bulk water supply.
- 2008** **Department of Treasury and Finance (DTF), Victoria, Third Party Access Arrangements for the Water Sector**
 This report involved an assessment of options for, and issues associated with, the development of an effective state-based access regime for Melbourne's water and wastewater infrastructure. This included assessing the compatibility of alternative access arrangement options with Victoria's reform objectives, and the merits and shortcomings of each approach.
- 2008** **Essential Services Commission of South Australia, Review of water pricing processes consistent with the National Water Initiative**
 This review examined the appropriate principles to be applied in determining water prices consistent with the requirements of the National Water Initiative.
- 2007** **Economic Regulation Authority, Review of options for bulk water procurement**
 Adrian led a project team reviewing a number of alternative options for competitive bulk water procurement, through a competitive water market. These options included a competitive tendering model and the development of an independent bulk water market operator, purchasing water based on an administrative pricing formula.
- 2007** **ActewAGL, Review of prices for water and wastewater service provision in the ACT**
 Adrian provided ongoing advice in relation to the 2007 review of prices for water and wastewater service provision in the ACT, including approaches to asset valuation, third party contracts, the asset roll forward methodology and operating and capital expenditure incentive mechanisms.
- 2006** **World Bank, Regulating publicly-owned water and sanitation utilities in developing countries**
 This project involved considering the issues surrounding developing effective economic regulation to drive performance improvements for publicly-owned water and sanitation utilities in developing countries.

Commercial damages assessment

- 2007** **Meerkin & Apel/SteriCorp, Australia, Assessing the Reasonableness of Damages Assumptions**
 Adrian assisted in the preparation of an expert report assessing the reasonableness of assumptions underlying the calculation of damages arising in the context of the purchase and subsequent construction by SteriCorp of proprietary medical waste treatment and recycling technology known as electro thermal deactivation technology from a United States-based firm, Stericycle Inc.

Conference Presentations

- 2014** **'Road Data and the Search for Truth'**
 Presentation to the 26th ARRB Conference – Research Driving Efficiency - 20 October 2014.

- 2013** **‘Freight Transport Regulation Overview and Outlook’**
Presentation at the National Transport Regulation Conference, 20 June 2013.
- 2011** **‘Using value capture mechanisms to finance local road infrastructure’**
Presentation at the Australasian Transport Research Forum, 29 September 2011.
- 2009** **‘Moving Australia towards a single national transport market’**
Presentation to the Committee for the Economic Development of Australia (CEDA),
14 October 2009.
- 2009** **‘Reforming water provision’**
Chair of the session at the Australian Economic Forum, 19-20 August 2009.
- 2006** **‘Is pricing an effective demand management tool?’**
Presentation to Water '06, 1 to 3 March 2006, Brisbane.