

# Jemena Gas Networks (NSW) Ltd

## 2015-20 Access Arrangement

### Response to the AER's draft decision and revised proposal

#### Appendix 3.4 - Frontier Economics review of AER demand forecasts

Public

27 February 2015



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# **Gas consumption forecasts for JGN's Tariff V customers**

REPORT PROVIDED TO GILBERT + TOBIN FOR THE PURPOSES  
OF PROVIDING LEGAL ADVICE TO JGN

26 February 2015



# Gas consumption forecasts for JGN's Tariff V customers

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# Gas consumption forecasts for JGN's Tariff V customers

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## Executive Summary

- 1 Gilbert + Tobin acts for Jemena Gas Networks (NSW) Ltd (**JGN**), the owner of the principal gas distribution network in NSW. Gilbert + Tobin has requested that Frontier Economics provide an expert report in relation to gas consumption forecasts for JGN's volume market customers (Tariff V customers).
- 2 As part of JGN's Access Arrangement (AA) proposal, JGN submitted gas demand forecasts for its network based on forecasts prepared by Core Energy Group (**Core**).<sup>1</sup> Relevantly, for Tariff V customers, Core's consumption per connection forecasts were based on weather-normalised historical trends in gas consumption, adjusted for the expected impact on future gas consumption of future changes in gas prices (based on an estimate of own-price elasticity) and future changes in electricity prices (based on an estimate of cross-price elasticity).
- 3 The Australian Energy Regulator (**AER**) engaged Deloitte Access Economics (**DAE**) to advise on JGN's demand forecasts and to assist it in developing alternative demand forecasts. Relying upon DAE's advice,<sup>2</sup> the AER has not approved demand forecasts for Tariff V customers in JGN's AA proposal on the basis that the forecasts do not comply with Rule 74(2) of the National Gas Rules. A key component of the AER's rejection of the demand forecasts for Tariff V customers was that Core's approach did not include a variable for future economic activity (for example, State Final Demand (**SFD**) or Gross State Product (**GSP**)). For Tariff V Residential customers and Tariff V Industrial and Commercial customers, the AER adopted demand forecasts derived from the application of annual estimated rates of change in gas consumption per connection based on regression models of gas consumption per connection developed by DAE (**DAE Regression Models**).
- 4 Frontier Economics has been requested by Gilbert + Tobin to provide a report, for submission to the AER in response to its draft decision in respect of JGN's AA proposal, setting out Frontier Economics' expert opinion as to:
  1. whether the DAE 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);

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<sup>1</sup> Core Energy Group, *Gas Demand and Customer Forecasts*, Jemena Gas Networks NSW Gas Access Arrangement 2015-2020, Final Draft, April 2014 (**Core Report**).

<sup>2</sup> Deloitte Access Economics, *Gas demand forecast for Jemena's NSW network*, Report for the Australian Energy Regulator, 24 November 2014 (**DAE Report**).

2. 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
3. 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 forecasts of gas consumption in the circumstances.

Our responses to these three questions are summarised in the following sections of this Executive Summary.

### **Economic activity as a driver of gas consumption for JGN's Tariff V customers**

- 5 Our opinion is that the argument put forward in the DAE Report that the absence of a specific variable to capture future economic activity (e.g. GSP or SFD) means that Core's forecasts are likely to underestimate gas consumption per connection for Tariff V customers (in particular, for residential customers) rests on two propositions:
  1. Economic activity is a driver of gas consumption for Tariff V customers.
  2. Economic activity over the forecast period is likely to be greater than economic activity over the historical period (which is used by Core to support the trend analysis).
- 6 On the first of these propositions, our review of the DAE analysis and data, and our own econometric analysis of this data, leads us to the opinion that the DAE regression modelling and analysis do not provide a reliable basis to conclude that economic activity is a driver of Tariff V gas consumption per connection for the Jemena network. Based on our review of the DAE analysis and data, our opinion is that there are serious problems with DAE's econometric modelling that mean that the modelling cannot be relied upon to conclude that economic activity is a driver of gas consumption per connection for Tariff V customers. The problems that we have identified are the following:
  1. DAE uses historical data from 2002 to 2010 in specifying its regression equations, but it is our opinion that the full historical data set that was available at the time, from 2002 to 2013, should be used.
  2. Our opinion is that the model specifications that DAE has used for Tariff V consumption per connection have not uncovered meaningful economic relationships between gas consumption and economic activity. The reason for this is that we can see no plausible *ex ante* explanation for

gas consumption being related to the economic activity variables that DAE includes in its models.

3. DAE uses residential gas prices to specify their econometric model for gas consumption per connection for Tariff V Industrial and Commercial customers, but uses non-residential gas prices to forecast consumption per connection for these customers. Our opinion is that if there are reasons to expect that different factors that drive residential and non-residential gas prices, then non-residential gas prices should be used both in developing the econometric model for gas consumption per connection for Tariff V Industrial and Commercial customers and in using the model to forecast gas consumption per connection.
4. DAE has made a data error in the historical gas price data that it uses in specifying its preferred model for Tariff V Residential customers.

We have corrected what we consider to be errors in DAE's approach and examined a number of alternative model specifications that we consider to be more plausible *ex ante*. The alternative models that we have considered include models with variables for economic activity (both SFD and GSP) as well as models with variables for household income. Our opinion is that none of these alternative models is reliable for assessing the relationship between economic activity and gas consumption.

7 We have also reviewed other work, referred to by DAE, which DAE appear to rely on in support of the proposition that economic activity is a driver of gas consumption per connection for Tariff V customers. The other work referred to by DAE, and our assessment of it, is as follows:

1. DAE refers to a report by ACIL Allen Consulting (**ACIL Allen**) for the Australian Energy Market Operator (**AEMO**), which suggests that residential gas consumption is likely to be related to household income (for which GSP may be used as a proxy).

We note that other than the suggestion that GSP could be a proxy for household income, the report by ACIL Allen does not suggest that residential gas consumption is likely to be related to economic activity in general, as measured, for instance, by SFD or GSP. Furthermore, AEMO's preferred econometric model for Tariff V consumption does not include household income (or GSP) as an independent variable, or the electricity price as an independent variable, because "the coefficients display poor statistics or have coefficients outside the expected range."<sup>3</sup>

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<sup>3</sup> AEMO, *Forecasting Methodology Information Paper*, National Gas Forecasting Report 2014, December 2014 (**AEMO Methodology Report**), page 10.

2. DAE refers to previous work by Core, which identified household income as being a primary driver of residential gas consumption in Victoria and Albury, on the basis of regression analysis.

In our opinion, Core's conclusion (even if it applies to Jemena's residential customers) is not inconsistent with using a trend analysis: it is only if future household income is inconsistent with the historical trend for household income that Core's trend analysis would fail to adequately account for this driver.

- 8 In regards to the second of the propositions in paragraph 5, even if it is accepted that economic activity is a driver of residential gas consumption, in order to establish that Core's forecasts are likely to underestimate gas consumption per connection it would need to be established that economic activity over the forecast period is likely to be greater than over the historical period. DAE contends that historical economic activity since 2008 has been affected by the global financial crisis, and forecasts that both SFD and GSP over the forecast period will return to higher levels. In regard to these contentions we note the following:

1. In our opinion, whether Core's trend provides forecasts that are relevant to expected economic conditions over the forecast period should not be assessed by considering historical economic conditions over only part of the historical period used to support the trend analysis (for instance, over the period of the last determination or over the period since the global financial crisis), but should be assessed by considering economic conditions over the full historical period used to support the trend analysis (2002 to 2013).<sup>4</sup>
2. Furthermore, we note that DAE's own forecasts do not uniformly support its proposition that growth in SFD and GSP will return to higher levels (when compared with the full historical period from 2002 to 2013). For NSW SFD, DAE's forecast is for lower average annual growth over the period 2014 to 2019 than was observed over the period 2002 to 2013. It is only for NSW GSP that DAE's forecast is for higher average annual growth over the period 2014 to 2019 than was observed over the period 2002 to 2013.
3. Finally, we note that recently released data from the Australian Bureau of Statistics on growth in NSW SFD and growth in NSW GSP for 2014 are

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<sup>4</sup> We also note that the evidence that the global financial crisis had a material and sustained impact on the NSW economy is mixed. For NSW SFD, the historical data shows that the average of the annual change over the period 2009 to 2013 was materially lower than the average of the annual change over the period 2002 to 2013. However, for NSW GSP, the historical data shows that the average of the annual change over the period 2009 to 2013 was only slightly lower than the average of the annual change over the period 2002 to 2013.

lower than DAE forecast for 2014. Indeed, for both NSW SFD and NSW GSP, using the average of the annual change over the period 2002 to 2013 would have provided a better forecast of outcomes in 2014 than using DAE's forecasts.

- 9 For these reasons, our opinion is that DAE's analysis and data does not provide a reliable basis to conclude that the absence of a specific variable to capture future economic activity means that Core's forecasts are likely to underestimate gas consumption per connection.

### **Forecasting gas consumption of JGN's Tariff V customers using the DAE regression model**

- 10 There are two elements to the question of 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:

1. Are the regression models of gas consumption per connection for Tariff V customers developed by DAE reasonable and reliable in the circumstances?
2. Is the method used to apply the results of these models to forecast gas consumption per connection for Tariff V customers reasonable and reliable in the circumstances?

- 11 On the first of these questions, our opinion is that there are serious problems with DAE's econometric modelling, summarised in the previous section, which mean that the modelling cannot be relied upon to forecast gas consumption per connection for Tariff V customers.

- 12 On the second of these questions, our opinion is that the AER's approach of forecasting gas consumption per connection based on a starting value that is the latest historical observation (from 2013) is not the best approach. We recommend forecasting using the trend, or econometric model, to provide both the starting point for the forecast and the change in the forecast over time.

### **Alternative forecasting approaches**

- 13 As discussed in the previous sections, our opinion is that there are serious problems with DAE's econometric modelling. Further, we have addressed the issues that we have identified with DAE's econometric modelling and estimated a number of alternative models that we consider to be more plausible *ex ante*. None of these alternative models is reliable. This leads us to the opinion that econometric modelling of the data used by DAE is unlikely to produce reasonable and reliable forecasts of gas demand in these circumstances. One

reason for this is likely to be the limited data, with only 12 data points available for historical gas consumption per connection.

- 14 In our opinion, in these circumstances, trend analysis is likely to provide a more reasonable and / or reliable basis for producing forecasts of gas demand than forecasts based on DAE's econometric models. This is the approach adopted by Core, and accepted by DAE and the AER, for Tariff V Small Business customers.
- 15 The principal objection that DAE appears to have to the forecasting approach adopted by Core is that the approach does not reflect broader economic activity. We note however, that trend analysis of the type adopted by Core will account for any impact of trend economic activity over the historical period on gas consumption per connection, and can also account for circumstances in which key drivers of gas demand are expected to be above (or below) outcomes that occurred during the historical period used to support the trend analysis (in the case of Core's analysis, the period from 2002 to 2013).

# 1 Introduction

16 Gilbert + Tobin acts for Jemena Gas Networks (NSW) Ltd (**JGN**), the owner of the principal gas distribution network in NSW. Gilbert + Tobin has requested that Frontier Economics provide an expert report in relation to gas consumption forecasts for JGN's volume market customers (Tariff V customers).

## 1.1 Background

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

18 As part of JGN's AA proposal, JGN submitted gas demand forecasts for its network based on forecasts prepared by Core Energy Group (**Core**).<sup>5</sup> Relevantly, for Tariff V customers, Core's consumption per connection forecasts were based on weather-normalised historical trends in gas consumption, adjusted for the expected impact on future gas consumption of future changes in gas prices (based on an estimate of own-price elasticity) and future changes in electricity prices (based on an estimate of cross-price elasticity).

19 The AER's draft decision in respect of JGN's AA was published on 27 November 2014. The AER engaged Deloitte Access Economics (**DAE**) to advise on JGN's demand forecasts and to assist it in developing alternative demand forecasts. Relying upon DAE's advice,<sup>6</sup> the AER has not approved demand forecasts for Tariff V customers in JGN's AA proposal on the basis that the forecasts do not comply with Rule 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.

20 While DAE concluded that Core's approach "was transparent, clear and generally sound in terms of methodology", a key component of the AER's rejection of the demand forecasts for Tariff V customers was that Core's approach did not include a variable for future economic activity (for example, State Final Demand (**SFD**) or Gross State Product (**GSP**)).

21 For Tariff V Residential customers and Tariff V Industrial and Commercial customers, the AER adopted demand forecasts derived from the application of annual estimated rates of change in gas consumption per connection based on regression models of gas consumption per connection developed by DAE (**DAE**

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<sup>5</sup> Core Energy Group, *Gas Demand and Customer Forecasts*, Jemena Gas Networks NSW Gas Access Arrangement 2015-2020, Final Draft, April 2014 (**Core Report**).

<sup>6</sup> Deloitte Access Economics, *Gas demand forecast for Jemena's NSW network*, Report for the Australian Energy Regulator, 24 November 2014 (**DAE Report**).

**Regression Models**). The DAE regression models include both the gas price and state macroeconomic variables (SFD for Tariff V Residential customers and GSP for Tariff V Industrial and Commercial customers). DAE then modified the forecast annual changes in forecast gas consumption obtained from its regression models to allow for the impact of future changes in electricity prices. However, DAE applied a smaller cross-price elasticity for the impact of electricity prices than that proposed by Core.

## 1.2 Frontier Economics' engagement

22 Frontier Economics has been requested by Gilbert + Tobin to provide a report, for submission to the AER in response to its draft decision in respect of JGN's AA proposal, setting out Frontier Economics' expert opinion as to:

1. whether the DAE 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);
2. 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
3. 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.

23 In producing the report, we have relied upon the following documents:

1. Jemena Gas Networks (NSW) Ltd, *2015-20 Access Arrangements Information*, 30 June 2014, Chapter 5.
2. Core Energy Group, *Gas Demand and Customer Forecasts*, Jemena Gas Networks NSW Gas Access Arrangement 2015-2020, Final Draft, April 2014 (**Core Report**).
3. Deloitte Access Economics, *Gas demand forecast for Jemena's NSW network*, Report for the Australian Energy Regulator, 24 November 2014 (**DAE Report**).
4. ACIL Allen Consulting, *Gas consumption forecasting: A methodology*, Report to Australian Energy Market Operator, 24 June 2014 (**ACIL Allen Report**).

5. Core Energy Group, *Demand, Energy and Customer Forecasts*, Envestra Limited – Gas Access Arrangement Review Victoria and Albury Networks (2013 to 2017), March 2012 (**Core Envestra Report**).
6. Australian Energy Market Operator, *Forecasting Methodology Information Paper*, National Gas Forecasting Report 2014, December 2014 (**AEMO Methodology Report**).

24 We have also been provided with, and reviewed, the following documents:

1. Deloitte Access Economics, *Review of Core Energy Group gas demand forecast for Jemena's NSW network*, Report for the Australian Energy Regulator, 11 August 2014.
2. Core Energy Group, *Response to Deloitte Report: Australian Energy Regulator, Review of Core Energy Group gas demand forecast for Jemena's NSW network*, August 2014.
3. AER, Jemena Gas Networks (NSW) Ltd Access arrangements 2015-2020, Attachment 13 – Demand, November 2014.

25 In producing the report, we have relied upon the following Excel files:

1. JGN, Core modelling (**Core Model**).
2. *Deloitte\_s regression working - data for regression 211014* (**Deloitte regression model**).
3. *Deloitte version of the Core Demand forecasting model - AER - draft decision JGN - Deloitte Access Economic Alternative demand forecast 221014* (**Deloitte version of the Core Model**).
4. Australian Bureau of Statistics, *5220.0 Australian National Accounts: State Accounts*, 2013-14, Table 1. Gross State Product, Chain volume measures and current prices.
5. Australian Bureau of Statistics, *5220.0 Australian National Accounts: State Accounts*, 2013-14, Table 2. Expenditure, Income and Industry Components of Gross State Product, New South Wales, Chain volume measures and current prices.
6. Australian Bureau of Statistics, *3101.0 Australian Demographic Statistics*, Jun 2014, Table 4. Estimated Resident Population, States and Territories (Number).

26 In providing our expert opinion on the matters raised by Gilbert + Tobin we have focused on DAE's analysis, data and models for Tariff V Residential customers and Tariff V Industrial and Commercial customers. For Tariff V Small Business customers, DAE adopted the same approach as Core: extrapolation of the historical trend with adjustments.

27 The analysis that we have undertaken for this report is subject to the following limitations:

1. Except where specifically noted, our analysis is based on the data contained in the Deloitte regression model. We have not attempted to verify this data, but only assessed the way that this data has been used by DAE in its analysis.
2. We have not undertaken a detailed review or audit of the Core Model or the Deloitte version of the Core Model. We have made limited use of these models, as specifically noted in this report.

### 1.3 About the authors of this report

28 The authors of this report are Professor Robert Bartels and Andrew Harpham, both employees of Frontier Economics in Australia. Brief biographies of the authors are provided below and more detailed CVs are provided in Appendix A to this report.

#### ***Professor Robert Bartels***

29 Bob Bartels has over 25 years experience in applying econometric and statistical methods across a diverse range of applications in business and government, with a strong focus on energy demand modelling, legal and competition support, and electricity load research.

30 Bob joined Frontier in 2006, having worked as an Academic Associate with Frontier Economics and London Economics since 1990. He was appointed Emeritus Professor in Business Analytics at the University of Sydney in 2006, having previously held various full-time academic positions at that university, including Professor in Econometrics and Business Statistics and Head of the School of Business. He is an elected member of the International Statistical Institute and has held visiting research positions at the universities of Bonn, Munich, Tilburg, the London School of Economics and the Institute for Energy Economics in Cologne.

#### ***Andrew Harpham***

31 Andrew is a Director of Frontier Economics Pty Ltd and has 15 years experience as an economic consultant. He works in Frontier Economics' energy practice and its legal and competition practice. Andrew's work in the energy sector has included advice to Governments, regulators and businesses in areas such as commercial and strategic analysis, tariff regulation, energy security and energy market design and operation.

32 Prior to joining Frontier, Andrew worked as an economist at Freehills for several years. A major focus of his work at Freehills was the analysis of economic issues associated with competition law matters.

### ***Support with preparation of this report***

33 The authors of this report have been supported in the preparation of this expert report by Fulvio Bondiolotti, an employee of Frontier Economics in Australia who holds a Masters Degree in Economics and Social Sciences from Bocconi University in Milan. Notwithstanding the assistance received, the opinions expressed in this report are wholly those of the authors.

## **1.4 This report**

34 This report is structured as follows:

- Section 2 addresses the first of the matters raised by Gilbert + Tobin, relating to the need for a specific variable to capture future economic activity.
- Section 3 addresses the second of the matters raised by Gilbert + Tobin, relating to whether DAE's model and its application produces forecasts that are reasonable based and reliable in the circumstances.
- Section 4 addresses the third of the matters raised by Gilbert + Tobin, relating to whether there are alternative approaches likely to produce forecasts that are more reasonable or reliable.

Appendix A provides CVs for the authors.



## 2 Economic activity as a driver of gas consumption for JGN's Tariff V customers

35 This section addresses the first question from Gilbert + Tobin: whether the DAE 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).

### 2.1 Overview of DAE's analysis

36 In its review of the Core Report, DAE notes that:<sup>7</sup>

In preparing the JGN forecasts Core did not include Gross State Product (GSP) (or state final demand) as an explanatory variable, noting that although it is possible some statistical correlation may exist between usage and GSP in the current period, many other factors – the decline of manufacturing, changing energy policies, more efficient houses, the installation of solar panels, etc. – were logically likely to have a more material impact. Thus in Core's view any GSP impact was likely to be swamped by these other factors.

37 In assessing the forecasting approach adopted by Core, DAE notes that it has concerns that the approach does not reflect broader economic activity.<sup>8</sup> The consequence of this, according to DAE, is that Core has likely under-forecast consumption over the Review period.<sup>9</sup> The reason given by DAE for this concern is that during the historical period used to support the trend analysis (2002 to 2013) NSW gas consumption was subject to the economic changes brought on by the global financial crisis; over the forecast period, however, DAE expects that NSW's economy will strengthen and return to trend growth.<sup>10</sup>

38 The argument put forward in the DAE Report that the absence of a specific variable to capture future economic activity (e.g. GSP or SFD) means that Core's forecasts are likely to underestimate gas consumption per connection for Tariff V customers (in particular, for residential customers) rests on two propositions put forward by DAE:

1. Economic activity is a driver of gas consumption for Tariff V customers.

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<sup>7</sup> DAE Report, page 9.

<sup>8</sup> DAE Report, page 11.

<sup>9</sup> DAE Report, page 11.

<sup>10</sup> DAE Report, page 11.

2. Economic activity over the forecast period is likely to be greater than economic activity over the historical period (which is used by Core to support the trend analysis).

39 The sections that follow assess the evidence for these two propositions.

## 2.2 DAE's proposition 1: Economic activity is a driver of gas consumption

40 DAE does not explicitly explain the basis for their proposition that economic activity is a driver of gas consumption for Tariff V customers. It would appear, however, that the proposition is based on the following:

1. DAE's review of a report by ACIL Allen Consulting (**ACIL Allen**) for the Australian Energy Market Operator (**AEMO**) that proposes a methodology for forecasting gas consumption in eastern and south-eastern Australia.<sup>11</sup>
2. DAE's review of previous work by Core for Envestra, in which Core has included economic activity as a variable in its forecasts.
3. DAE's econometric models of gas consumption for Tariff V customers.

### 2.2.1 AEMO's approach to forecasting gas consumption for Tariff V customers

41 DAE notes that the ACIL Allen Report suggests that economic activity (measured by GSP) and population are typically the most relevant drivers of gas demand, and that Core has not explicitly included an economic activity variable in its forecasts.<sup>12</sup>

42 It is the case that the ACIL Allen Report suggests that gas consumption by residential and commercial customers is likely to be related to economic activity. The ACIL Allen Report suggests that the nature of this relationship would be expected to be different for commercial customers and residential customers. For commercial customers, the ACIL Allen Report suggests that gas consumption is likely to be related to economic activity (measured using GSP), weather and the gas price.<sup>13</sup> For residential customers, the ACIL Allen Report suggests that gas consumption per connection is likely to be related to the heating requirement, the

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<sup>11</sup> ACIL Allen Consulting, *Gas consumption forecasting: A methodology*, Report to Australian Energy Market Operator, 24 June 2014 (**ACIL Allen Report**).

<sup>12</sup> DAE Report, page 10.

<sup>13</sup> ACIL Allen Report, page 30.

age of a customer's home (and therefore its energy efficiency), the gas price and household income.<sup>14</sup> The ACIL Allen Report goes on to note that since household income is not measured regularly, GSP may be used as a good proxy.<sup>15</sup> The ACIL Allen Report does not specifically suggest that gas consumption would be related to SFD for either commercial customers or residential customers.

43 Importantly, while the ACIL Allen Report sets out a recommended methodology for AEMO, ACIL Allen recognises that candidate drivers of gas consumption need to be tested empirically. For instance, in respect of the relationship between GSP and gas consumption for the average residential customer, the ACIL Allen Report states:<sup>16</sup>

Household income is also a candidate driver [for gas consumption of the average residential customer]. However, household income is not measured regularly so GSP is used as a good proxy. Further, GSP is a fairly direct measure of the activity of small *non-residential* customers that may be included in the dataset.

However, to the extent that gas usage is non-discretionary, it may also be unresponsive to household income. This means that the driver may not prove to be statistically significant and may be omitted from the final model on empirical grounds, though this does not mean that it should not be tested.

44 When implementing the recommended forecasting methodology to forecast gas consumption for the National Gas Forecasting Report (**NGFR**) 2014, AEMO tested the inclusion of a number of drivers in an econometric model for the gas consumption of Tariff V customers (both residential and commercial customers) in each of New South Wales, South Australia, Victoria and Queensland.<sup>17</sup> The drivers tested by AEMO include:<sup>18</sup>

- measures of economic activity such as GSP, GSP per capita, household disposable income and employment
- retail gas prices
- retail electricity prices
- heating degree days (**HDD**) and effective degree days (**EDD**)
- an energy efficiency index.

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<sup>14</sup> ACIL Allen Report, page 28.

<sup>15</sup> ACIL Allen Report, page 28.

<sup>16</sup> ACIL Allen Report, pages 28-29, emphasis added.

<sup>17</sup> AEMO, *Forecasting Methodology Information Paper*, National Gas Forecasting Report 2014, December 2014 (**AEMO Methodology Report**).

<sup>18</sup> AEMO Methodology Report, page 9.

AEMO tested both leads and lags on price and the economic variables. AEMO did not test SFD as a driver of gas consumption.

45 Among the various models that AEMO investigated, the preferred model was chosen having regard to both the expected theoretical relationship between gas consumption and the drivers that were tested (for instance, gas consumption would be expected to increase with real state-wide income) and a statistical assessment of the models.<sup>19</sup>

46 AEMO's final model structure for New South Wales, South Australia and Queensland is:<sup>20</sup>

$$\log(EVC_t) = c_1 + c_2 \log(P_{t-1}) + c_3 HDD_t$$

where:

$EVC_t$  represents Tariff V energy consumption per connection

$P_{t-1}$  represents retail gas price in the previous year

$HDD_t$  represents heating degree days.

AEMO's final model structure for New South Wales, South Australia and Queensland does not include a household income variable (or an electricity price variable) in the final model structure because "the coefficients display poor statistics or have coefficients outside the expected range."<sup>21</sup>

47 In short, the ACIL Allen Report to AEMO does suggest that household income is a candidate driver of gas consumption for residential customers, and that economic activity is a candidate driver of gas consumption for commercial customers. Further, the ACIL Allen Report suggests that GSP may be a good proxy for household income. However, the ACIL Allen Report recognises the importance of empirically testing whether gas consumption is indeed related to economic activity, and when AEMO did empirically test this relationship the evidence was not sufficient for AEMO to include economic activity as a driver of gas consumption for Tariff V customers.

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<sup>19</sup> AEMO Methodology Report, page 10.

<sup>20</sup> AEMO Methodology Report, page 11.

<sup>21</sup> AEMO Methodology Report, page 10.

## 2.2.2 Core's forecasts for Envestra

48 DAE notes that in the gas demand forecasts that Core prepared for Envestra's Victoria and Albury gas networks,<sup>22</sup> Core included GSP in its forecasting model as a driver of gas demand.

49 DAE quotes the following from the Core Envestra Report on the drivers of gas demand:<sup>23</sup>

Core has identified GSP as being a primary driver of future commercial and industrial gas demand. As such projections of GSP are used as a basis for projected demand per connection ...

It is clear from the Core Envestra Report that Core used GSP as a driver of gas demand per connection for commercial and industrial customers, but not for residential customers. For residential customers, Core identifies household income as a driver of gas demand per connection:<sup>24</sup>

Core has identified GHDI [gross household disposable income] as being a primary driver of future residential gas demand. As such projections of GHDI are used as a basis for projected demand per connection ...

Core did not use SFD as a driver of gas demand per connection for either commercial and industrial customers or residential customers, and the Core Envestra Report makes no mention of Core considering SFD as a candidate driver in developing their preferred models.

50 The fact that Core identified GSP and GHDI as drivers of gas demand for Envestra's gas networks in Victoria and Albury, and developed econometric models with GSP and GHDI as variables, is not inconsistent with Core using trend analysis to forecast gas demand for Jemena's network area. Even assuming that the evidence were to support the conclusion that GSP and GHDI are drivers of gas demand for Jemena's network area, the historical trend that Core identifies for gas consumption per connection for Tariff V Residential customers will reflect the historical impact of GHDI, and the historical trend that Core identifies for gas consumption per connection for Tariff V Industrial and Commercial customers will reflect the historical impact of GSP. Trend analysis will naturally account for all factors that cause the historical trend, and specific variables are required only to adjust the trend projections for future out-of-trend changes to one or more relevant drivers.

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<sup>22</sup> Core Energy Group, *Demand, Energy and Customer Forecasts*, Envestra Limited - Gas Access Arrangement Review Victoria and Albury Networks (2013 to 2017), March 2012 (**Core Envestra Report**).

<sup>23</sup> Core Envestra Report, page 33.

<sup>24</sup> Core Envestra Report, page 32.

### 2.2.3 DAE's econometric models of gas consumption for Tariff V customers

51 DAE uses an econometric approach to develop forecasts of consumption per connection for Tariff V Residential customers and for Tariff V Industrial and Commercial customers.<sup>25</sup> DAE's preferred econometric models include measures of economic activity as explanatory variables for gas consumption per connection; if these models can be accepted as reasonable, therefore, we can conclude that the empirical evidence supports the proposition that economic activity is a driver of gas consumption per connection.

52 DAE's preferred model for gas consumption per connection for Tariff V Residential customers is the following:

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

where:

$Y_t$  is Tariff V Residential consumption per connection

$P_t$  is the gas price

$P_{t-1}$  is the gas price in the previous year

$\Delta SFD_{t-1}$  is the percent change in NSW State Final Demand in the previous year

53 DAE's preferred model for gas consumption per connection for Tariff V Industrial and Commercial customers is the following:

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

where:

$Y_t$  is Tariff V Industrial and Commercial consumption per connection

$P_t$  is the gas price

$\Delta GSP_{t-1}$  is the percent change in NSW Gross State Product in the previous year<sup>26</sup>

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<sup>25</sup> DAE attempted a similar approach for Tariff V Small Business customers but concluded that the approach did not produce reliable and robust results.

<sup>26</sup> We note that DAE's description of the preferred model for gas consumption per customer for Tariff V Industrial and Commercial customers is ambiguous on whether the economic driver is the

54 We have reviewed DAE's models, and the data<sup>27</sup> used in developing these models, and have identified a number of issues with the data that DAE has used and the regression models that DAE has specified.

55 These issues are discussed in the sections that follow.

### **Issue 1 – time period for historical data**

56 The first issue that we have identified with DAE's econometric models is that DAE uses historical data from 2002 to 2010 in specifying its regression equations. However, historical data from 2002 to 2013 was available at the time.

57 It appears that the reason that DAE uses historical data from 2002 to 2010 is that DAE initially used this data to develop a forecast of outcomes for 2011 to 2013 to validate against actual outcomes. The DAE report states that:<sup>28</sup>

... the regressions were conducted on 2002 to 2010 data, with the model coefficients used to 'forecast' 2011-2013 consumption. This in-sample forecast period was then compared against actual consumption in 2011-2013.

While this is a technique commonly used in model development, there is no reason why the historical data for the full period to 2013 should not be used once a model specification has been settled on. Indeed, our opinion is that the better approach would be to use the historical data for the full period to 2013. Particularly given that limited historical data is available, more reliable results will be achieved by using the full dataset, unless there are sound statistical reasons to exclude specific data points (for instance, because specific data points are identified as outliers). DAE has not discussed the reason for excluding the data points for 2011 to 2013 (other than by reference to forecasting 2011-2013 for comparison with actual 2011-2013 consumption) and we can see no sound reasons to exclude them.

58 We have tested DAE's models with historical data for the full period to 2013. For Tariff V Residential customers, a comparison between the results of the

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lagged level of NSW GSP or the lagged percent change in NSW GSP; in some cases the DAE report refers to the former, in other cases to the latter. We have reviewed the data that DAE use and have confirmed that the economic driver is the lagged percent change in NSW GSP.

<sup>27</sup> As discussed in one of the following sections, we have identified a material error in the data that DAE uses in specifying the model for Tariff V Residential customers. This material error means that the results reported by DAE are incorrect (with the forecast for residential gas demand being overstated as a result of the data error).

<sup>28</sup> DAE Report, page 11. Note that the in-sample forecast period referred to by Core is more commonly referred to as out-of-sample, since the data for 2011 to 2013 is not used in specifying the model.

DAE model using the shorter data period to 2010 and the results of the DAE model using historical data for the full period to 2013 is provided in Table 1.

Table 1: Tariff V Residential – Regression results for DAE's model using DAE's sample period (2002 to 2010) and the full sample period (2002 to 2013)

Variable Variables	DAE's sample 2002 – 2010		Full sample 2002 – 2013	
	Coefficient	p-value	Coefficient	p-value
Constant	5.8754***	0.0030	4.3085***	0.0000
Log of gas bills (price)	-0.3202	0.2735	0.0562	0.5270
Log of gas bills (price), lagged one year	-0.1278	0.2587	-0.2590***	0.0033
Annual change in State Final Demand, lagged one year	0.0116**	0.0143	0.0128***	0.0045
R-squared	0.8963		0.8569	
F-statistic (p-value)	0.0068		0.0010	

Source: DAE Report, page 26 and Frontier Economics analysis.

Note: \* Denotes statistical significance at the 10% level, \*\* denotes statistical significance at the 5% level, \*\*\* denotes statistical significance at the 1% level.

59 It is clear that the results of the DAE model for Tariff V Residential customers using historical data for the full period to 2013 are quite different to the results using the shorter data period. We also note that the results using the full dataset are counter to expectations, with the current own-price gas elasticity now having the wrong sign. Because the results of DAE's model are not robust when using the full data set, our opinion is that DAE's model for Tariff V Residential customers is not reliable and, by extension, that DAE's results from this model do not provide a basis for concluding that economic activity is a driver of gas consumption per connection for Tariff V Residential customers.

60 For Tariff V Commercial and Industrial customers, a comparison between the results of the DAE model using the shorter data period to 2010 and the results of the DAE model using historical data for the full period to 2013 is provided in Table 2.

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Table 2: Tariff V Commercial and Industrial – Regression results for DAE’s model using DAE’s sample period (2002 to 2010) and the full sample period (2002 to 2013)

Variable Variables	DAE’s sample 2002 – 2010		Full sample 2002 – 2013	
	Coefficient	p-value	Coefficient	p-value
Constant	8.5207***	0.0001	8.8725***	0.0000
Log of gas bills (price)	-0.3559**	0.0550	-0.4132***	0.0002
Annual change in Gross State Product, lagged one year	0.0272	0.1744	0.0319*	0.0863
R-squared	0.5395		0.8052	
F-statistic (p-value)	0.0977		0.0006	

Source: DAE Report, page 27 and Frontier Economics analysis.

Note: \* Denotes statistical significance at the 10% level, \*\* denotes statistical significance at the 5% level, \*\*\* denotes statistical significance at the 1% level.

- 61 The results of the DAE model for Tariff V Commercial and Industrial customers using historical data for the full period to 2013 provides a much better fit to the data, but the estimated coefficients are again somewhat different to DAE’s estimates (although the changes in the coefficients are less than the changes for the Tariff V Residential model). We do not consider that this change in coefficients suggests, in itself, that DAE’s model for Tariff V Commercial and Industrial customers is unreliable. However, in the absence of sound reasons to exclude the data points for 2011 to 2013, our opinion is that the full data period should be used in any econometric model in preference to the shorter data period.
- 62 To be clear, this is not to suggest that our opinion is that the results for the full sample set out in Table 2 (or in Table 1) are reliable (there are other issues with these models that are discussed in the section that follows), only that the full data period should be used in any model (in the absence of sound reasons to exclude specific data points).

### **Issue 2 – model specification**

- 63 The second issue that we have identified with DAE’s econometric models relates to the specification of these models. As a general point we note that DAE provides very little discussion of its choice of independent variables for its regression models, and no *ex ante* explanation of why it would expect gas consumption to be related to the variables included in its models. Our review of DAE’s models has revealed some issues with these independent variables. Some

of these issues relate only to DAE's econometric model for Tariff V Residential gas consumption per connection, while other issues relate to both that model and DAE's econometric model for Tariff V Industrial and Commercial gas consumption per connection. We will begin by discussing the issues with the model for Tariff V Residential gas consumption per connection, in particular the specification of the variable for economic activity.

64 As discussed above, DAE's preferred model for gas consumption per connection for Tariff V Residential customers is the following:

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

where:

$Y_t$  is Tariff V Residential consumption per connection

$P_t$  is the gas price

$P_{t-1}$  is the gas price in the previous year

$\Delta SFD_{t-1}$  is the percent change in NSW State Final Demand in the previous year

65 Our opinion is that this model specification is unlikely to uncover a meaningful economic relationship between gas consumption and economic activity and so does not provide a basis for concluding that economic activity is a driver of gas consumption per connection for Tariff V Residential customers. Our concerns about this model specification are related to the use of the lagged percentage change in total SFD as the independent economic driver of consumption:

1. The use of SFD rather than another measure of economic activity more likely to be relevant to gas consumption per connection for Tariff V Residential customers. A common expectation is that gas consumption for residential customers may be driven by household income: as household income increases gas consumption may also increase. In its report to AEMO, ACIL Allen suggest that in the absence of historical data on household income GSP could be investigated as a driver for residential gas consumption, on the grounds that GSP might be a reasonable proxy for household income.<sup>29</sup> We are not aware of any instance of residential gas demand forecasting in Australia in which SFD has been used as a driver of residential gas consumption.

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<sup>29</sup> ACIL Allen Report, page 28.

The Excel file *Deloitte regression model* contains historical data on both household income and GSP, but neither of these has been included as a driver for residential gas consumption in DAE's preferred model. Instead, SFD is used as a driver for residential gas consumption. DAE does not explain the rationale for using SFD as a driver for residential gas consumption; it may be that DAE investigated and used SFD as a driver of residential gas consumption on the grounds that SFD is a proxy for household income. However, SFD is really a measure of expenditure rather than income. The Australian Bureau of Statistics (**ABS**) notes that it is not a measure of the value of production activity occurring within a state.<sup>30</sup>

Using the historical data from DAE,<sup>31</sup> we have tested the use of the use of GSP and Household Disposable Income (HHI) as alternative economic drivers in the DAE model (making no other changes to DAE's model or data) and the estimation results are shown as Model 1 and Model 2, respectively, in Table 3. The statistical fits of models using GSP or HHI as economic drivers are considerably worse than when using SFD. Moreover, for HHI the coefficient has the wrong sign and is statistically highly insignificant.

2. The use of the **change** in SFD rather than the **level** of SFD. There might be reason to expect that the change in SFD would affect the change in gas consumption, or that the level of SFD would affect the level of gas consumption, but it is unclear why a change in SFD would affect the level of gas consumption. DAE does not discuss the rationale for using the change in SFD rather than the level of SFD in its model.

Using the historical data from DAE, we have tested the use of the lagged level of SFD (in logs) instead of the lagged change in SFD as an alternative economic driver in the DAE model (making no other changes to DAE's model or data) and the estimation results are shown as Model 3 in Table 3. The statistical fit is considerably worse than when using the

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<sup>30</sup> The Australian Bureau of Statistics defines SFD as follows:

*State final demand measures the total value of goods and services that are sold in a state to buyers who wish to either consume them or retain them in the form of capital assets. It excludes sales made to buyers who use them as inputs to a production activity, export sales and sales that lead to accumulation of inventories.*

*Measures of state final demand make no distinction between demand that is met by goods and services produced within the state in question, or by supplies sourced from another state, or from overseas. State final demand is therefore not a measure of the value of production activity occurring within a state.*

<http://www.abs.gov.au/ausstats/abs@.nsf/Products/F4BE61A2C2641B49CA25750700142CBF?opendocument>

<sup>31</sup> From the Excel file *Deloitte regression model*.

lagged change in SFD and the coefficient on the SFD variable has the wrong sign.

3. The use of lagged SFD but not current SFD. While the use of lagged price is relatively common in econometric models for forecasting demand, the use of lagged measures of economic activity is less so. We are not aware of any instance of residential gas demand forecasting in Australia in which a lagged measure, but not a current measure, of economic activity has been used as a driver of residential gas consumption. DAE does not discuss the reason for using the lagged change in SFD in its model. It may be that DAE use lagged SFD as an independent variable as a proxy for a measure of household income (although as discussed above we are not aware of any other instances in which this has been done, and SFD is a measure of expenditure rather than income), and that DAE's expectation is that customers respond to changes in their household income over time in much the same way that they may respond to changes in prices over time. Even if this is the case, however, it would be expected that current SFD would also be included in DAE's model, just as the current gas price is included in the model. DAE does not discuss the rationale for using lagged SFD but not current SFD in its model.

Using the historical data from DAE and population data from the ABS,<sup>32</sup> we have tested the use of the current value of the change in SFD instead of the lagged change in SFD as an alternative economic driver in the DAE model (making no other changes to DAE's model or data) and the estimation results are shown as Model 4 in Table 3. The statistical fit is considerably worse than when using the lagged change in SFD, and the coefficient on the SFD variable has the wrong sign and is statistically highly insignificant.

4. The use of total SFD rather than SFD per capita. Given that the dependent variable in the regression model is gas consumption per connection, it would be expected that SFD per household (or SFD per capita) would be a better measure: to the extent that total SFD is driven, in part, by population growth it is unclear why this population growth would drive gas consumption per connection. DAE does not discuss the rationale for using total SFD rather than SFD per capita in its model.

Using the historical data from DAE, we have tested the use of the lagged change in SFD per capita instead of the lagged change in SFD as an alternative economic driver in the DAE model (making no other changes

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<sup>32</sup> ABS, *3101.0 Australian Demographic Statistics*, Jun 2014, Table 4. Estimated Resident Population, States and Territories (Number).

to DAE's model or data) and the estimation results are shown as Model 5 in Table 3. The results show that, although all the coefficients have the expected signs, the statistical fit of the model is somewhat poorer than when using the lagged change in SFD.

66 In short, none of these alternative models (Model 1 through Model 5) is a good fit for the data. A number of the models have coefficients of the wrong sign (Model 1 through Model 4), all models have at least one coefficient that is statistically highly insignificant and all of the models have a statistical fit that is worse than DAE's model. Moreover, the estimates of the own-price elasticities vary widely across the different models and are, with one exception, statistically not significant even at the 10% level. This indicates that the models are not robust. Our opinion is that none of these models provides a reliable basis for assessing the relationship between economic activity and gas consumption for Tariff V Residential customers.

Table 3: Tariff V Residential – Regression results for alternative specifications for the economic driver variable in DAE's model

	DAE's model	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	5.8754***	6.9784***	5.4683*	7.0737**	7.2229**	5.1852***
Annual change in SFD, lagged one year	0.0116**					
Annual change in GSP, lagged one year		0.0374**				
Annual change in HHI, lagged one year			-0.0051			
Log of SFD, lagged one year				-0.3004		
Annual change in SFD					-0.0016	
Annual change in SFD per capita, lagged one year						0.0107**
Log of gas bills (price)	-0.3202	-0.6811*	-0.3704	-0.0164	-0.7465	-0.1654
Log of gas bills (price), lagged one year	-0.1278	0.0544	-0.0047	-0.0084	0.094	-0.1721
Number of observations	9	9	9	9	9	9
Adjusted R <sup>2</sup>	0.8341	0.7801	0.4960	0.4828	0.3920	0.8043
F-statistics	14.4082	10.4578	3.6246	3.4895	2.7194	11.9563

Source: DAE Report, page 26 and Frontier Economics analysis.

Notes:

1. \* Denotes statistical significance at the 10% level, \*\* denotes statistical significance at the 5% level, \*\*\* denotes statistical significance at the 1% level.
2. We have also calculated the BIC and AIC information criteria, and these lead to the same conclusions regarding the fit of the models as the adjusted R-squared measure.

- 67 A number of these issues with the model specification for Tariff V Residential customers are also relevant to the model specification for Tariff V Industrial and Commercial customers, although in the latter case with regard to the use of the lagged change in total GSP as the independent economic driver of consumption.
- 68 As discussed above, DAE's preferred model for gas consumption per connection for Tariff V Industrial and Commercial customers is the following:

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

where:

$Y_t$  is Tariff V Industrial and Commercial consumption per connection

$P_t$  is the gas price

$\Delta GSP_{t-1}$  is the percent change in NSW Gross State Product in the previous year<sup>33</sup>

69 Our opinion is that this model specification is unlikely to uncover a meaningful economic relationship between gas consumption and economic activity and so does not provide a basis for concluding that economic activity is a driver of gas consumption per connection for Tariff V Industrial and Commercial customers. Our concerns about this model specification are related to the use of the lagged percentage change in total GSP as the independent economic driver of consumption:

1. The use of the **change** in GSP rather than the **level** of GSP. There might be reason to expect that the change in GSP would affect the change in gas consumption, or that the level of GSP would affect the level of gas consumption, but it is unclear why a change in GSP would affect the level of gas consumption. DAE does not discuss the rationale for using the change in GSP rather than the level of GSP in its model.

Using the historical data from DAE,<sup>34</sup> we have tested the use of the lagged level of GSP (in logs) instead of the lagged change in GSP as an alternative economic driver in the DAE model (making no other changes to DAE's model or data) and the estimation results are shown as Model 1 in Table 4. The statistical fit is considerably worse than when using the lagged change in GSP, and the coefficient on the GSP variable is large but with the wrong sign.

2. The use of **lagged** GSP but not **current** GSP. While the use of lagged price is relatively common in econometric models for forecasting demand, the use of lagged measures of economic activity is less so. The relationship between economic activity and gas consumption by commercial and industrial customers is generally expected to be more

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<sup>33</sup> We note that DAE's description of the preferred model for gas consumption per customer for Tariff V Industrial and Commercial customers is ambiguous on whether the economic driver is the lagged level of NSW GSP or the lagged percent change in NSW GSP; in some cases the DAE report refers to the former, in other cases to the latter. We have reviewed the data that DAE use and have confirmed that the economic driver is the lagged percent change in NSW GSP.

<sup>34</sup> From the Excel file *Deloitte regression model*.

immediate: an increase in production is expected to require an increase in inputs to the production process, including gas. Even if lagged measures of economic activity are used to explain gas consumption, it would be expected that current GSP would also be included in DAE's model. DAE does not discuss the rationale for using lagged GSP but not current GSP in its model.

Using the historical data from DAE, we have tested the use of the current value of the change in GSP instead of the lagged change in GSP as an alternative economic driver in the DAE model (making no other changes to DAE's model or data) and the estimation results are shown as Model 2 in Table 4. The statistical fit is considerably worse than when using the lagged change in GSP, and the coefficient on the GSP variable has the wrong sign and is statistically highly insignificant.

3. The use of total GSP rather than GSP per capita. Given that the dependent variable in the regression model is gas consumption per connection, it would be expected that GSP per capita would be a better measure: to the extent that total GSP is driven, in part, by an increase in population it is unclear why this increase would drive gas consumption per connection. DAE does not discuss the rationale for using total GSP rather than GSP per capita in its model.

Using the historical data from DAE and population data from the ABS,<sup>35</sup> we have tested the use of the lagged change in GSP per capita rather than the lagged change in total GSP as an alternative economic driver in the DAE model (making no other changes to DAE's model or data) and the estimation results are shown as Model 3 in Table 4. The statistical fit is considerably worse than when using the lagged change in GSP and the coefficient on the GSP variable is statistically highly insignificant.

70 In short, none of these alternative models (Model 1 through Model 3) is a good fit for the data. A number of the models have coefficients for the economic activity variable with the wrong sign (Model 1 and Model 2), all models have at least one coefficient that is statistically highly insignificant and all of the models have a statistical fit that is worse than DAE's model. In particular, the economic activity variable is statistically not significant, even at the 10% level, in any of the models. Our opinion is that none of these models provides a reliable basis for assessing the relationship between economic activity and gas consumption for Tariff V Commercial and Industrial customers.

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<sup>35</sup> ABS, 3101.0 *Australian Demographic Statistics*, Jun 2014, Table 4. Estimated Resident Population, States and Territories (Number).

Table 4: Tariff V Industrial and Commercial – Regression results for alternative specifications for the economic driver variable in DAE's model

	DAE's model	Model 1	Model 2	Model 3
Constant	8.5207***	9.9668**	8.3493***	8.3061***
Annual change in GSP, lagged one year	0.0272			
Log of GSP, lagged one year		-0.2221		
Annual change in GSP			-0.0044	
Annual change in GSP per capita, lagged one year				0.0068
Log of gas bills (price)	-0.3559*	-0.1236	-0.3191	-0.3147
Number of observations	9	9	9	9
Adjusted R <sup>2</sup>	0.386	0.1808	0.1494	0.1765
F-statistics	3.5144	1.8829	1.7026	1.8572

Source: DAE Report, page 27 and Frontier Economics analysis.

Notes:

1. \* Denotes statistical significance at the 10% level, \*\* denotes statistical significance at the 5% level, \*\*\* denotes statistical significance at the 1% level.
2. We have also calculated the BIC and AIC information criteria, and these lead to the same conclusions regarding the fit of the models as the adjusted R-squared measure.

71 In summary, our opinion is that DAE's models for Tariff V consumption per connection have not uncovered meaningful economic relationships between gas consumption and economic activity. The reason for this is that we can see no plausible *ex ante* explanation for gas consumption being related to the economic activity variables that DAE includes in its models. Furthermore, as set out in Table 3 and Table 4, we have examined a range of other models with different specifications for the economic driver of gas consumption which we consider to be more plausible *ex ante* than DAE's economic drivers, and found that none of these models provide good results in the sense that they have a good statistical fit, and that the coefficients are statistically significant and have the expected sign.

72 As a general point, DAE provides very little discussion of its choice of independent variables for its regression models, and no *ex ante* explanation of why it would expect gas consumption to be related to the specified variables for economic activity that it includes in its models. Given this, and the poor results for other models that are more plausible *ex ante*, we suspect that the unusual specification of the economic drivers in DAE's regression equations for gas consumption per connection for Tariff V Residential customers and Tariff V Industrial and Commercial customers is a result of DAE testing a wide range of candidate models and finding that each of its preferred models is one of the few

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models, or the only model, that provides acceptable results. However, the mere fact that DAE's models provide results that they consider acceptable (notwithstanding that some of the coefficients are statistically highly insignificant) does not mean that the models can be relied upon to establish that economic activity is a driver of gas consumption. To the contrary, our opinion is that DAE's models cannot be relied upon for the following reasons:

1. The specification of the economic activity variable means that the model is unlikely to have uncovered genuine economic relationships. Rather, our opinion is that the results of DAE's models reflect spurious correlation between gas consumption and the economic activity variables that DAE uses, which cannot be relied upon to continue in future.
2. DAE's results are not stable with respect to changes in input assumptions (for instance, using all the data up to 2013) or to minor changes in model specification. This indicates that the models are not robust.

### ***Issue 3 – historical and forecast gas price data***

73 The third issue that we have identified with DAE's econometric models is that in specifying the econometric model for gas consumption per connection for Tariff V Industrial and Commercial customers, DAE uses historical data on residential gas prices as an independent variable. However, in forecasting gas consumption per connection for these customers, DAE uses forecasts of what is referred to as non-residential gas prices (which differ from the forecasts of residential gas prices).

74 If there are different factors that drive residential gas prices and non-residential gas prices, and there is reason to believe that there are, then non-residential gas prices should be used both in developing the model for Tariff V Industrial and Commercial customers and in using the model results to forecast gas consumption per connection.

### ***Data error with historical gas prices***

75 In addition to the above three issues that we have identified with DAE's econometric models, we have also noted that DAE has made an error in the historical gas price data that it uses in specifying its preferred model for Tariff V Residential customers.

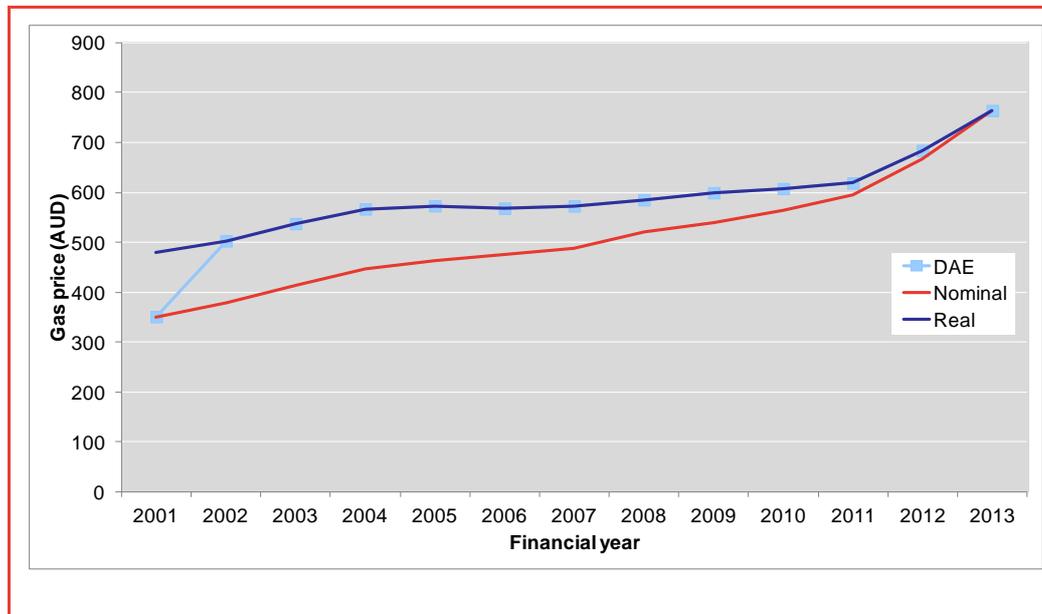
76 As discussed above, DAE's preferred model for Tariff V Residential customers includes both the current gas price and the gas price in the previous year as explanatory variables. This means that the DAE model requires historical data on gas prices for each year from 2001 to 2010.

77 The issue arises because DAE has combined real gas prices and nominal gas prices in estimating its regression equation: for the first year (2001) DAE uses a

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nominal gas price and for each subsequent year (2002 to 2010) DAE uses real gas prices. This appears to be a simple error in transcribing data, the effect of which is illustrated in Figure 1.

Figure 1: Historical gas prices – real, nominal and DAE



Source: Frontier Economics analysis, and the Excel file Deloitte regression model

78 We have corrected this data error and re-run DAE's regression equation for Tariff V Residential customers without making any other changes. A comparison between the results of the DAE model and the results of the DAE model after correcting this data error is provided in Table 5.

79 The effect of correcting the data error is that the coefficients for all the independent variables change quite materially while, broadly speaking, the statistical significance of the updated model is not worse than DAE's original model. This highlights the fact that, in general, the parameter estimates are sensitive to the data error. In the corrected model:

1. The coefficient for the log of gas bills is much lower, implying that the effect of current prices on gas consumption per connection for Tariff V Residential customers is considerably smaller than reported in the DAE report.
2. The coefficient for the log of gas bills lagged one year is much higher, implying that the effect of lagged prices on gas consumption per

connection for Tariff V Residential customers is considerably larger than reported in the DAE report.

- The coefficient for the lagged annual change in the level of SFD is much lower, implying that the effect of the lagged annual change in SFD on gas consumption per connection for Tariff V Residential customers is considerably smaller than reported in the DAE report.

To be clear, this is not to suggest that our opinion is that the results with the corrected gas price set out in Table 5 are reliable (there are other issues with this model that have been discussed in the previous sections), only that the corrected gas price should be used in any model.

Table 5: Tariff V Residential – Regression results for DAE’s dataset compared with results with corrected gas price for 2001

Variable Variables	DAE’s regression with incorrect gas price		Regression result with corrected gas price	
	Coefficient	p-value	Coefficient	p-value
Constant	5.8754***	0.0030	6.2494***	0.0002
Log of gas bills (price)	-0.3202	0.2735	-0.0579	0.8543
Log of gas bills (price), lagged one year	-0.1278	0.2587	-0.4483	0.1043
Annual change in State Final Demand, lagged one year	0.0116**	0.0143	0.0084**	0.0144
R-squared	0.8963		0.9231	
F-statistic (p-value)	0.0068		0.0032	

Source: DAE Report, page 26 and Frontier Economics analysis.

Note: \* Denotes statistical significance at the 10% level, \*\* denotes statistical significance at the 5% level, \*\*\* denotes statistical significance at the 1% level.

- 80 There is a second question raised by this incorrect gas price: if DAE had used the correct gas price for 2001, is it likely that DAE would have favoured a different model for gas consumption per connection for Tariff V Residential customers? Since the coefficient on the current gas price in the model with the corrected gas price is highly insignificant (as seen in Table 5), one could drop that variable from the model and include only the lagged gas price. The results for this model are shown in Table 6. The modified model has better statistical properties than DAE’s original model; the adjusted R-squared value indicates a markedly better

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fit to the data and all the coefficients are statistically highly significant. This modified model has parameter estimates that are somewhat different to the corrected model in Table 5: in particular, removing the current gas price from the model results in a coefficient for the lagged gas price that is larger. Again, to be clear, this is not to suggest that our opinion is that the results with the corrected gas price and only a lagged gas price, as set out in Table 6, are reliable (there are other issues with this model that have been discussed in the previous sections).

Table 6: Tariff V Residential – Regression results for DAE’s model compared with a model using the corrected gas price for 2001 and only the lagged gas price

Variable Variables	DAE’s regression with incorrect gas price		Regression result with corrected gas price and only lagged gas price	
	Coefficient	p-value	Coefficient	p-value
Constant	5.8754***	0.0030	6.1474***	0.0000
Log of gas bills (price)	-0.3202	0.2735		
Log of gas bills (price), lagged one year	-0.1278	0.2587	-0.4903***	0.0002
Annual change in State Final Demand, lagged one year	0.0116**	0.0143	0.0083***	0.0061
Adj R-squared	0.8341		0.8967	
F-statistic (p-value)	0.0068		0.0005	

Source: DAE Report, page 26 and Frontier Economics analysis.

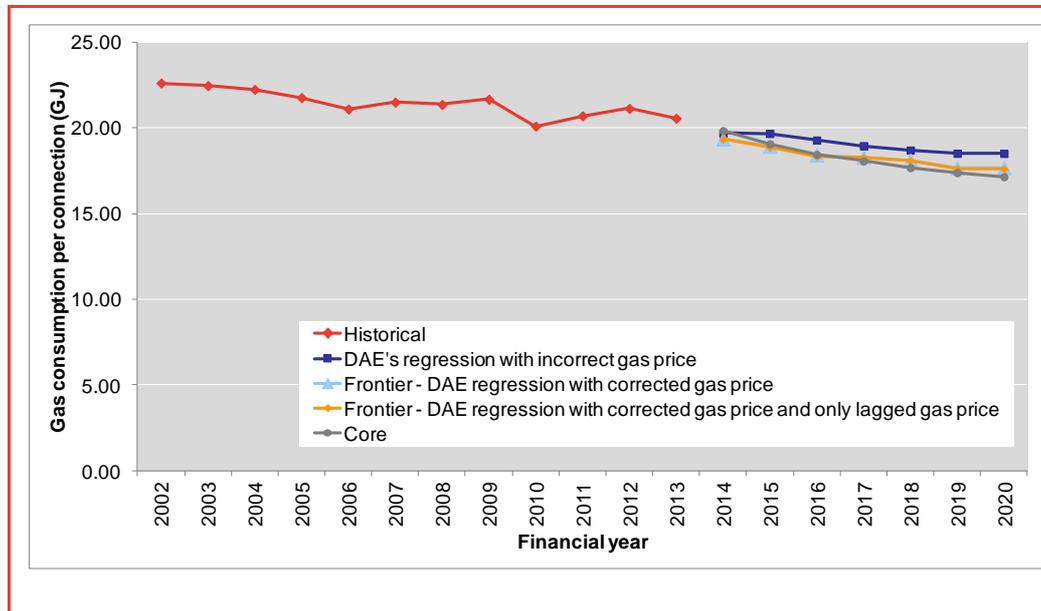
Notes:

1. \* Denotes statistical significance at the 10% level, \*\* denotes statistical significance at the 5% level, \*\*\* denotes statistical significance at the 1% level
2. In this table we report the adjusted R-squared values since the models being compared have different numbers of explanatory variables. The adjusted R-squared for the model in Table 5 with the corrected gas price is 0.877 which is a worse fit than the model without the current gas price

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We note that correcting for the data error has a material effect on the forecast for residential gas consumption per connection. Using the corrected regression model (from Table 5) or the modified regression model (from Table 6) results in a higher estimate of the own-price elasticity of demand (after accounting for both immediate and lagged effects) and a smaller coefficient for the lagged annual change in the level of SFD. When we use these regression models to forecast gas consumption per connection we obtain forecasts for gas consumption per connection that are lower than the forecasts from DAE’s regression model and that are quite close to Core’s forecasts, as seen in Figure 2.

Figure 2: Forecast residential gas consumption per connection



Source: Frontier Economics analysis, the Excel file Deloitte regression model and the Excel file Deloitte version of the Core Model.

Notes: The two 'Frontier' forecasts were developed using the following steps:

1. The fitted estimates of gas consumption per connection for the models was forecast using the same forecast values of the independent variables used by DAE (from the Deloitte regression model).
2. The annual percentage changes in these fitted estimates were calculated, using the same calculations used by DAE (from the Deloitte regression model).
3. The annual percentage changes were applied to the forecast model (by replacing the values in cells S38 to Y38 of the "Residential" sheet in the Deloitte version of the Core Model). No other changes were made to this file.
4. The two Frontier models produce almost identical forecasts which can't be distinguished on the graph.

82 The correction to the gas price for 2001 does not have any direct effect on DAE's econometric model of gas consumption per connection for Tariff V Industrial and Commercial customers. Since DAE's econometric model of gas consumption per connection for Tariff V Industrial and Commercial customers does not use a lagged gas price, the data error for 2001 does not affect DAE's model for these customers.

### **Improved models of gas consumption for Tariff V customers**

83 In the preceding sections we have identified a number of problems with DAE's econometric models of gas consumption per connection for Tariff V customers. We have also corrected what we consider to be errors in DAE's approach and examined alternative model specifications which we consider to be more plausible *ex ante*. The alternative results that we have set out in the preceding section, however, have addressed the issues that we identified with DAE's model one at a time, in order to isolate the impact of each of these issues.

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84 However, there is a further question that needs to be addressed: if all the issues that we have identified, and which we think should be addressed, are addressed, will this result in econometric models of gas consumption per connection for Tariff V Residential and Tariff V Commercial and Industrial customers that we consider to be reliable. We have estimated a number of additional models to answer this question.

85 For Tariff V Residential customers we have estimated four alternative models, taking the following approach:

1. We have used alternative specifications for the economic activity variable that we consider to be more plausible *ex ante*. Specifically, we have investigated the log of the current level of GSP and the log of the current level of HHI (in Model 1 and Model 3 respectively), and have also investigated including lagged values of the logs of GSP and HHI (in Model 2 and Model 4 respectively).
2. In each of the four alternative models we have used the gas price and the lagged gas price as independent variables.
3. In each of the four alternative models we have used the correct gas price for 2001.
4. In each of the alternative models we have used the full data set from 2002 to 2013.
5. For each of the alternative models that include HHI as an independent variable (Model 3 and Model 4), we have changed the HHI data in the Excel file *Deloitte regression model*. First, the HHI value for 2001 was nominal rather than real (the same issue that applied to the gas price for 2001). Second, DAE converted nominal HHI into real HHI using changes in nominal HHI over time. Instead of using this approach we have used CPI to convert nominal HHI into real HHI. Note that these changes do not affect DAE's econometric models since DAE does not use HHI as an independent variable in its models.
6. We have otherwise used the same data that DAE has used.

86 The results of these alternative models are shown in Table 7. Our opinion is that none of these models is reliable for assessing the relationship between economic activity and gas consumption since the combined elasticity for the economic drivers in each model is negative.<sup>36</sup> This implies that an increase in economic activity in a particular year leads to a decrease in gas consumption in the same year with no ongoing impact (Model 1 and Model 3), or that an increase in

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<sup>36</sup> Where the current and the lagged value of the economic driver is included in a model, we take the combined elasticity to be the sum of the coefficients on the current and lagged variables.

economic activity in a particular year leads to an aggregate decrease in gas consumption over two years (Model 2 and Model 4). This is contrary to expectation.

Table 7: Tariff V Residential – Alternative models addressing each of the issues that we have identified

	Model 1	Model 2	Model 3	Model 4
Constant	7.7857***	7.7136***	5.8149***	6.3420***
Log of GSP	-0.2978	-0.6908		
Log of GSP, lagged one year		0.4024		
Log of HHI			-0.1046	0.4056*
Log of HHI, lagged one year				-0.5803**
Log of gas bills (price)	0.3108*	0.3148*	0.2849	0.4172***
Log of gas bills (price), lagged one year	-0.4487*	-0.4593*	-0.5132**	-0.5931***
Number of observations	12	12	12	12
Adjusted R <sup>2</sup>	0.7592	0.7283	0.7352	0.8785
F-statistics	12.5581	8.3713	11.181	20.8766

Source: Frontier Economics analysis.

Notes:

1. \* Denotes statistical significance at the 10% level, \*\* denotes statistical significance at the 5% level, \*\*\* denotes statistical significance at the 1% level.
2. We have also calculated the BIC and AIC information criteria, and these lead to the same conclusions regarding the fit of the models as the adjusted R-squared measure.

87 For Tariff V Industrial and Commercial customers we have taken a similar approach:

1. We have used alternative specifications for the economic activity variable that we consider to be more plausible *ex ante*. Specifically, we have investigated the log of the current level of GSP (Model 1), and also investigated including the lagged value of the logged GSP variable (Model 2).
2. In each of the two alternative models, we have used the full data set from 2002 to 2013.
3. We have otherwise used the same data that DAE has used.

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88 The results of these alternative models are shown in Table 8. Our opinion is that neither of these models is reliable for assessing the relationship between economic activity and gas consumption since the combined elasticity for the economic drivers in each model is negative.<sup>37</sup> This implies that an increase in economic activity in a particular year leads to a decrease in gas consumption in the same year with no ongoing impact (Model 1), or that an increase in economic activity in a particular year leads to an aggregate decrease in gas consumption over two years (Model 2). This is contrary to expectation.

Table 8: Tariff V Industrial and Commercial – Alternative models addressing each of the issues that we have identified

	Model 1	Model 2
Constant	10.6894***	10.6524***
Log of GSP	-0.2257	-0.8756
Log of GSP, lagged one year		0.6541
Log of gas bills (price)	-0.2300	-0.2307
Number of observations	12	12
Adjusted R <sup>2</sup>	0.6883	0.6543
F-statistics	13.1451	7.939

Source: Frontier Economics analysis.

Notes:

1. \* Denotes statistical significance at the 10% level, \*\* denotes statistical significance at the 5% level, \*\*\* denotes statistical significance at the 1% level.
2. We have also calculated the BIC and AIC information criteria, and these lead to the same conclusions regarding the fit of the models as the adjusted R-squared measure.

## 2.3 DAE's proposition 2: Future economic activity will be greater than historical economic activity

89 DAE's proposition that economic activity over the forecast period is likely to be greater than economic activity over the historical period is based on analysis of historical economic activity and DAE's forecasts of future activity.

<sup>37</sup> Where the current and the lagged value of the economic driver is included in a model, we take the combined elasticity to be the sum of the coefficients on the current and lagged variables.

90 It is unclear what historical period DAE is considering in arguing that future economic activity will be greater than historical economic activity. At various points in its report DAE refer to historical economic activity during the period used by Core to support the trend analysis (2002 to 2013),<sup>38</sup> historical economic activity during the period of the most recent determination<sup>39</sup> and historical economic activity since the global financial crisis.<sup>40</sup> On balance, however, it would seem that economic conditions since 2008 were most important in DAE forming the view that a trend analysis of the type that Core adopted was inappropriate in the circumstances:<sup>41</sup>

Given the expected changes to gas prices over the next five years, as well as the considerable economic changes that have occurred since 2008, the structural approach was deemed more appropriate for developing gas consumption forecasts over the Review Period.

91 In our opinion, whether Core's trend provides forecasts that are relevant to expected economic conditions over the forecast period should not be assessed by considering historical economic conditions over only part of the historical period used to support the trend analysis (for instance, over the period of the last determination or over the period since the global financial crisis). Rather, in order to assess whether Core's trend provides forecasts that are relevant to expected economic conditions over the forecast period, economic conditions over the full historical period used to support the trend analysis should be considered.

92 In any case, the evidence that the global financial crisis had a material and sustained impact on the NSW economy is mixed:

1. For NSW SFD, the evidence suggests that the global financial crisis had a material effect. This is apparent in Figure 3, which shows the annual change in NSW SFD over the period from 2000 to 2013 (the red line) as

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<sup>38</sup> See, for instance, page 11 of the DAE Report:

*In particular, during the historical period used to support the trend analysis (2002 to 2013), NSW gas consumption was subject to considerable economic changes brought on by the global financial crisis ...*

This could be taken to suggest that DAE's consideration of historical economic activity is focused on the period 2002 to 2013 or just the period since the global financial crisis.

<sup>39</sup> See, for instance, page 12 of the DAE Report:

*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.*

And:

*... Deloitte Access Economics is expecting both GSP and SFD to be generally higher over the Review Period than has been seen over the last five years ...*

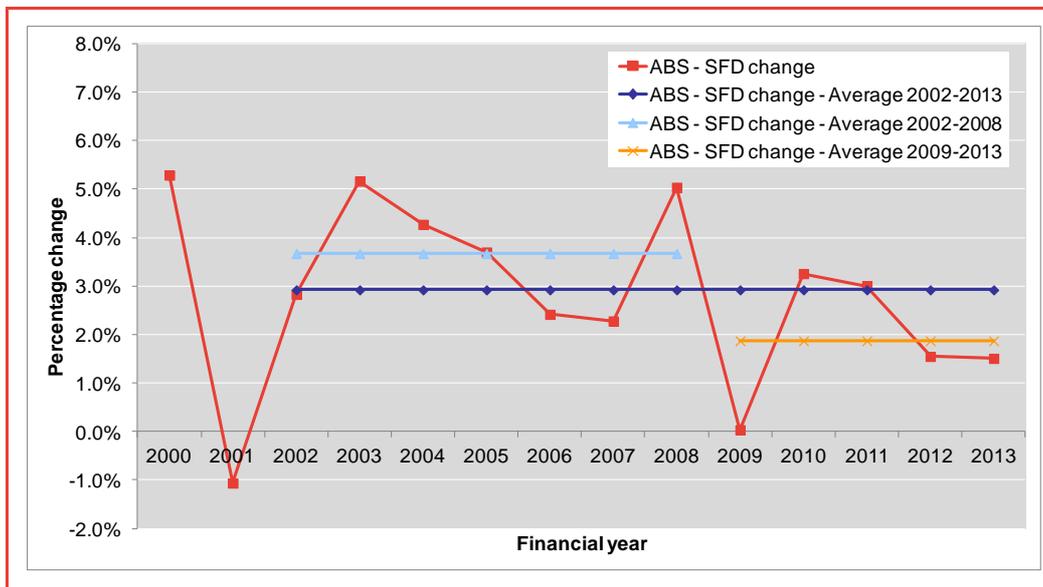
<sup>40</sup> See footnote 38.

<sup>41</sup> DAE Report, page 11.

well as the average of the annual change in NSW SFD over various shorter periods (the navy, light blue and orange lines). It is apparent from Figure 3 that the average of the annual change in NSW SFD over the period since the global financial crisis (2009 to 2013) is materially lower than the average of the annual change in NSW SFD over the full historical period that is used by Core to support the trend analysis (2002 to 2013). The average for the period since the global financial crisis is 1.87 per cent and the average for the full historical period that is used by Core is 2.92 per cent.

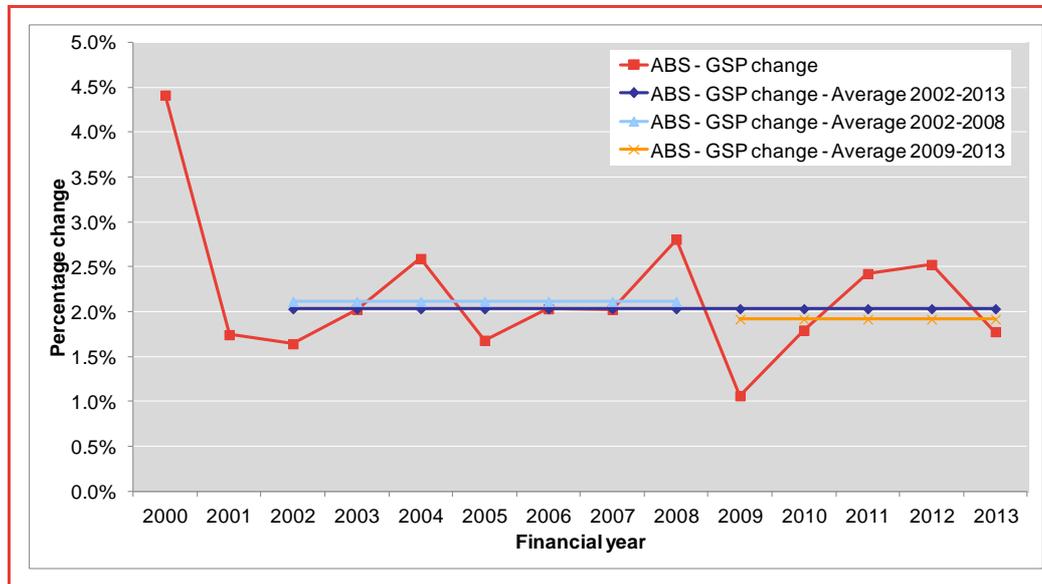
- For NSW GSP, at best the evidence suggests that the global financial crisis caused a brief reduction in GSP. This is apparent in Figure 4, which shows the annual change in NSW GSP over the period from 2000 to 2013 (the red line) as well as the average of the annual change in NSW GSP over various shorter periods (the navy, light blue and orange lines). It is apparent from Figure 4 that the average of the annual change in NSW GSP over the period since the global financial crisis (2009 to 2013) is only slightly lower than the average of the annual change in NSW GSP over the full historical period that is used by Core to support the trend analysis (2002 to 2013). The average for the period since the global financial crisis is 1.92 per cent and the average for the full historical period that is used by Core is 2.03 per cent.

Figure 3: NSW SFD for the period 2000 to 2013



Source: Frontier Economics analysis of ABS data: 5220.0 Australian National Accounts: State Accounts, 2013-14, Table 2. Expenditure, Income and Industry Components of Gross State Product, New South Wales, Chain volume measures and current prices, Series ID A2336211C.

Figure 4: NSW GSP for the period 2000 to 2013



Source: Frontier Economics analysis of ABS data: 5220.0 Australian National Accounts: State Accounts, 2013-14, Table 1. Gross State Product, Chain volume measures and current prices, Series ID A2336346L.

- 93 Regardless of whether the global financial crisis had a material and sustained impact on the NSW economy, in order for Core's trend analysis to under-forecast consumption over the forecast period it must at least be the case that economic activity over the forecast period is expected to be greater than trend economic activity over the historical period used by Core in its trend analysis. Core's trend analysis will naturally reflect any effect of economic activity over the period 2002 to 2013, so would only need to be adjusted if economic activity is expected to differ from what occurred over this period 2002 to 2013.
- 94 DAE presents its own forecasts of NSW SFD and NSW GSP in its report. These forecasts, together with equivalent historical data, are presented in Figure 5 and Figure 6 respectively. Figure 5 and Figure 6 reveal the following about the relationship between outcomes over the historical period used by Core in its trend analysis and DAE's forecasts:
1. For NSW SFD, DAE's forecasts are for weaker growth in economic activity over the forecast period than the average over the period from 2002 to 2013. DAE forecasts that the average of the annual change in SFD over the period 2014 to 2019 will be 2.59 per cent, compared with the average of the annual change in SFD over the period 2002 to 2013 of 2.92 per cent.

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2. For NSW GSP, DAE's forecasts are for stronger growth in economic activity over the forecast period than the average over the period from 2002 to 2013. DAE forecasts that the average of the annual change in GSP over the period 2014 to 2019 will be 2.51 per cent, compared with the average of the annual change in GSP over the period 2002 to 2013 of 2.03 per cent.

In short, at least for SFD, Core's trend analysis is based on an historical period of growth in economic activity that was, on average, stronger than is forecast by DAE.

95 In any case, there are significant uncertainties associated with forecasting future economic activity. These uncertainties are highlighted by DAE's forecast of the change in SFD and the change in GSP for 2014, seen in Figure 5 and Figure 6 respectively:

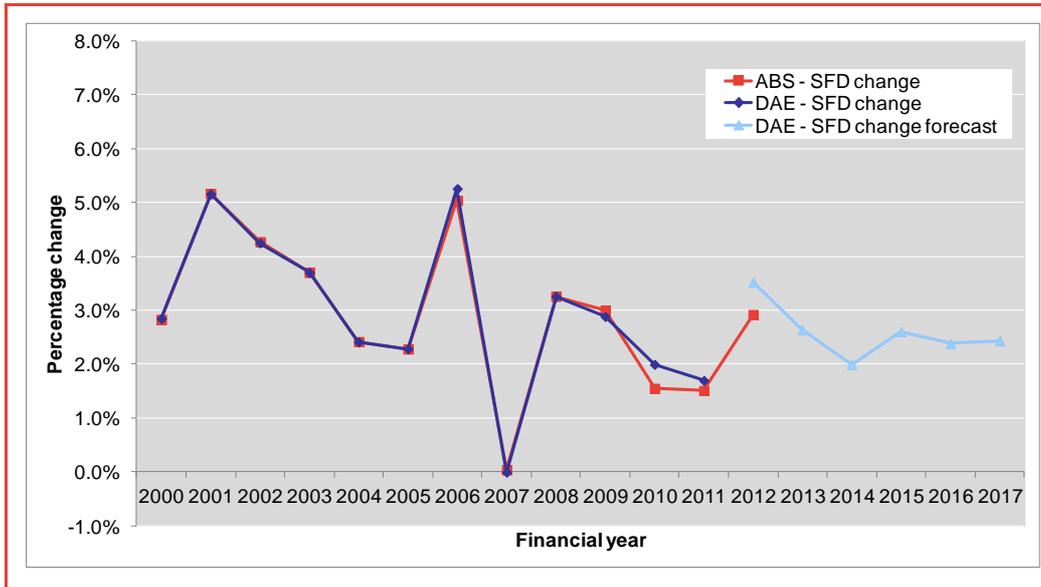
1. For NSW SFD, the DAE Report has a forecast of the annual change in SFD for 2014 of 3.52 per cent,<sup>42</sup> while the outcome for 2014 reported by the ABS is 2.92 per cent, which is the same as the average outcome over the period 2002 to 2013 (2.92 per cent). In other words, using the average of the annual change in NSW SFD over the period 2002 to 2013 (which is the historical period used by Core in its trend analysis) would have provided a much better forecast of growth in NSW SFD for 2014 than adopting DAE's forecast. We have no reason to believe that DAE's forecast of average SFD growth over the period 2014 to 2019 would be more reliable than its forecast for 2014.
2. For NSW GSP, the DAE Report has a forecast of the annual change in GSP for 2014 of 2.76 per cent,<sup>43</sup> while the outcome for 2014 reported by the ABS is 2.08 per cent, which is close to the average outcome over the period 2002 to 2013 (2.03 per cent). In other words, using the average of the annual change in NSW GSP over the period 2002 to 2013 (which is the historical period used by Core in its trend analysis) would have provided a much better forecast of growth in NSW GSP for 2014 than adopting DAE's forecast. We have no reason to believe that DAE's forecast of average GSP growth over the period 2014 to 2019 would be more reliable than its forecast for 2014.

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<sup>42</sup> We also note that the AER refers to the NSW Budget, which forecasts growth in NSW SFD of 3.25 per cent for 2014.

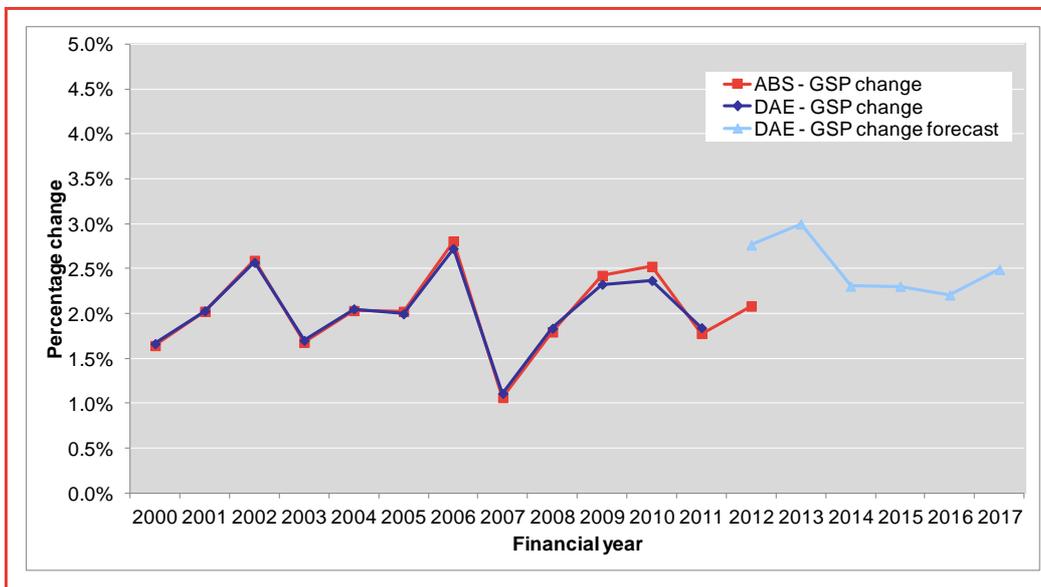
<sup>43</sup> We also note that the AER refers to the NSW Budget, which forecasts growth in NSW GSP of 3.0 per cent for 2014.

Figure 5: Historical and forecast NSW SFD for the period 2002 to 2019



Source: DAE Report, Frontier Economics analysis of ABS data: 5220.0 Australian National Accounts: State Accounts, 2013-14, Table 2. Expenditure, Income and Industry Components of Gross State Product, New South Wales, Chain volume measures and current prices, Series ID A2336211C.

Figure 6: Historical and forecast NSW GSP for the period 2002 to 2019



Source: DAE Report, Frontier Economics analysis of ABS data: 5220.0 Australian National Accounts: State Accounts, 2013-14, Table 1. Gross State Product, Chain volume measures and current prices, Series ID A2336346L.

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## 2.4 Summary of our assessment of DAE's propositions

96 To reiterate our opinion, we consider that the argument put forward in the DAE Report that the absence of a specific variable to capture future economic activity (e.g. GSP or SFD) means that Core's forecasts are likely to underestimate gas consumption per connection for Tariff V customers (in particular, for residential customers) rests on two propositions:

1. Economic activity is a driver of gas consumption for Tariff V customers.
2. Economic activity over the forecast period is likely to be greater than economic activity over the historical period (which is used by Core to support the trend analysis).

97 On the first of these propositions, our review of the DAE analysis and data, and our own econometric analysis of this data, leads us to the opinion that there is not a reliable econometric basis to conclude that economic activity is a driver of Tariff V gas consumption per connection for the Jemena network. For both Residential customers and Industrial and Commercial customers, these problems include that the DAE models use data for 2002 to 2010 (rather than data for 2002 to 2013) without any apparent justification for limiting the data set, and that the specification of the models is in a form that we consider cannot be relied upon to uncover genuine economic relationships. For Tariff V Residential customers there is the additional problem that the model uses the incorrect gas price for 2001. For Tariff V Industrial and Commercial customers there is the additional problem that historical residential gas prices are used to specify the model but non-residential prices are used for forecasting. We have attempted to resolve these issues and, in doing so, have not found a model that supports the contention that household income or GSP are drivers of residential gas consumption.

98 We have also reviewed other work referred to by DAE which DAE appear to rely on in support of the proposition that economic activity is a driver of gas consumption per connection for Tariff V customers. The other work referred to by DAE, and our assessment of it, is as follows:

1. DAE refers to a report by ACIL Allen for AEMO, which suggests that residential gas consumption is likely to be related to household income (for which GSP may be used as a proxy).

We note that other than the suggestion that GSP could be a proxy for household income, the report by ACIL Allen does not suggest that residential gas consumption is likely to be related to economic activity in general, as measured, for instance, by SFD or GSP. Furthermore, AEMO's preferred econometric model for Tariff V consumption does

not include household income (or GSP) as an independent variable, or the electricity price as an independent variable, because "the coefficients display poor statistics or have coefficients outside the expected range."<sup>44</sup>

2. DAE refers to previous work by Core, which identified household income as being a primary driver of residential gas consumption in Victoria and Albury, on the basis of regression analysis.

In our opinion, Core's conclusion (even if it applies to Jemena's residential customers) is not inconsistent with using a trend analysis: it is only if future household income is inconsistent with the historical trend for household income that Core's trend analysis would fail to adequately account for this driver.

99 On the second of the propositions in paragraph 96, even if it is accepted that economic activity is a driver of residential gas consumption, in order to establish that Core's forecasts are likely to underestimate gas consumption per connection it would need to be established that economic activity over the forecast period is likely to be greater than over the historical period. DAE contends that historical economic activity since 2008 has been affected by the global financial crisis, and forecasts that both GSP and SFD over the forecast period will return to higher levels. In regard to these contentions we note the following:

1. In our opinion, whether Core's trend provides forecasts that are relevant to expected economic conditions over the forecast period should not be assessed by considering historical economic conditions over only part of the historical period used to support the trend analysis (for instance, over the period of the last determination or over the period since the global financial crisis), but should be assessed by considering economic conditions over the full historical period used to support the trend analysis (2002 to 2013).<sup>45</sup>
2. Furthermore, we note that DAE's own forecasts do not uniformly support its proposition that growth in SFD and GSP will return to higher levels (when compared with the full historical period from 2002 to 2013). For NSW SFD, DAE's forecast is for lower average annual growth over the period 2014 to 2019 than was observed over the period 2002 to 2013.

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<sup>44</sup> AEMO, *Forecasting Methodology Information Paper*, National Gas Forecasting Report 2014, December 2014 (**AEMO Methodology Report**), page 10.

<sup>45</sup> We also note that the evidence that the global financial crisis had a material and sustained impact on the NSW economy is mixed. For NSW SFD, the historical data shows that the average of the annual change over the period 2009 to 2013 was materially lower than the average of the annual change over the period 2002 to 2013. However, for NSW GSP, the historical data shows that the average of the annual change over the period 2009 to 2013 was only slightly lower than the average of the annual change over the period 2002 to 2013.

It is only for NSW GSP that DAE's forecast is for higher average annual growth over the period 2014 to 2019 than was observed over the period 2002 to 2013.

3. Finally, we note that recently released data from the ABS on growth in NSW SFD and growth in NSW GSP for 2014 are lower than DAE forecast for 2014. Indeed, for both NSW SFD and NSW GSP, using the average of the annual change over the period 2002 to 2013 would have provided a better forecast of outcomes in 2014 than using DAE's forecasts.

100 To conclude, our opinion is that DAE's regression models and analysis do not provide a reliable basis to conclude that the absence of a specific variable to capture future economic activity means that Core's forecasts are likely to underestimate gas consumption per connection.



### 3 Forecasting gas consumption of JGN's Tariff V customers using the DAE regression model

101 This section addresses the second question from Gilbert + Tobin: 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.

102 There are two elements to this second question:

1. Are the regression models of gas consumption per connection for Tariff V customers developed by DAE reasonable and reliable in the circumstances?
2. Is the method used to apply the results of these models to forecasting gas consumption per connection for Tariff V customers reasonable and reliable in the circumstances?

#### 3.1 DAE's regression model

103 Our review of DAE's econometric models of gas consumption per connection for Tariff V Residential customers and for Tariff V Industrial and Commercial customers is set out in Section 2.

104 In summary, we found three material issues with DAE's econometric model for Tariff V Residential customers:

1. DAE's econometric model does not account for the most recent three years of historical data (from 2011 to 2013). The most recent years of data should be used in DAE's modelling unless there is a sound statistical reason to exclude these data, which DAE does not provide in its report. Given this, and given that the results of DAE's model are not robust when using the full dataset, our opinion is that the results of DAE's econometric model cannot be used to produce forecasts that are reasonable and / or reliable.
2. The specification of DAE's econometric model means that the model is unlikely to uncover meaningful economic relationships between gas consumption and economic activity. In our opinion, these problems with the specification do not only mean that no reliable conclusions can be drawn from the model about the relationship between gas consumption

and economic activity, but also mean that the model cannot be used to produce forecasts that are reasonable and / or reliable.

3. DAE's econometric model of consumption per connection for Tariff V Residential customers includes a data error for historical gas prices in 2001. When this data error is corrected the results of the econometric model are materially different. In our opinion, this means that the results of DAE's econometric model cannot be used to produce forecasts that are reasonable and / or reliable.

105 We also found three material issues with DAE's econometric model for Tariff V Industrial and Commercial customers:

1. DAE's econometric model does not account for the most recent three years of historical data (from 2011 to 2013). The most recent years of data should be used in DAE's modelling unless there is a sound statistical reason to exclude these data, which DAE does not provide in its report. Given this, and given that the model produces different results when using the full dataset, our opinion is that the results of DAE's econometric model cannot be used to produce forecasts that are reasonable and / or reliable.
2. The specification of DAE's econometric model means that the model is unlikely to uncover meaningful economic relationships between gas consumption and economic activity. In our opinion, these problems with the specification do not only mean that no reliable conclusions can be drawn from the model about the relationship between gas consumption and economic activity, but also mean that the model cannot be used to produce forecasts that are reasonable and / or reliable.
3. DAE's econometric model for gas consumption per connection for Tariff V Industrial and Commercial customers uses historical residential gas prices as an independent variable but the forecasts of gas prices for Tariff V Industrial and Commercial customers are based on forecasts of non-residential gas prices. If gas consumption per connection for Tariff V Industrial and Commercial customers is driven by non-residential gas prices then a reliable econometric model for these customers should make use of historical data on non-residential gas prices.

106 In our opinion, these issues are sufficiently material to mean that DAE's regression models of gas consumption per connection for Tariff V customers are not reasonable and are not reliable in the circumstances.

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## 3.2 Using DAE's regression model to forecast gas consumption per connection

107 Aside from these issues with DAE's econometric models, there may also be issues related to how these econometric models are used to develop forecasts of gas demand. Based on our review of the documents we have identified one issue.

### *The starting value for forecast gas consumption per connection*

108 There are two approaches to determining the starting value for the forecast of gas consumption per connection:

1. The starting value for the forecast can be determined by the most recent historical data point.
2. The starting value for the forecast can be determined by the fitted value of an historical trend, or an econometric model, for the relevant year.

109 The forecasts used by the AER adopt the former approach: the forecasts for gas consumption per connection have a starting value that is the gas consumption per connection that was observed in 2013. From this starting point, the forecasts are generated by applying the annual rate of change implied by fitting DAE's econometric models to each of the years of the forecast period.

110 However, in general, we would recommend using the latter approach: forecasting using the trend, or econometric model, rather than 'rebasing' the forecast so that its starting point is the most recent historical data point. For instance, when using an econometric model, if the model is robust and reliable then using the fitted value produced by the econometric model as the starting point, rather than the last year of historical data, is likely to provide better results. An historical data point for any given year is likely to differ from the fitted value for that year, in part because there is an idiosyncratic random error associated with each data point. If we rebase the forecast to start with actual data from 2013 then we are locking in the random error associated with the data point for 2013 for the entire forecast period.



## 4 Alternative forecasting approaches

- 111 This section addresses the third question from Gilbert + Tobin: 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 forecasts of gas consumption in the circumstances.
- 112 As discussed in our review of DAE's regression model, there are a number of significant issues with DAE's models. Our attempts to find improved econometric models, as set out in Table 7 and Table 8, have been unsuccessful. This leads us to the opinion that econometric modelling of the data used by DAE is unlikely to produce reasonable and reliable forecasts of gas demand in these circumstances. One reason for this is likely to be the limited data available, with only 12 data points for historical gas consumption per connection available.
- 113 In the event that econometric modelling of the available data does not provide a reasonable and reliable basis for forecasting gas demand, there remains the question of whether there is an alternate approach that is likely to produce more reasonable and / or reliable forecasts. In our opinion, in these circumstances trend analysis is likely to provide a more reasonable and / or reliable basis for producing forecasts of gas demand than forecasts based on DAE's econometric models. This is the approach adopted by Core, and accepted by DAE and the AER, for Tariff V Small Business customers.
- 114 The principal objection that DAE appears to have to the forecasting approach adopted by Core is that the approach does not reflect broader economic activity. The consequence of this, according to DAE, is that Core has likely under-forecast consumption over the Review period because DAE expects NSW's economy will strengthen over the forecast period relative to recent years.
- 115 We note however, that trend analysis of the type adopted by Core will account for any impact of trend economic activity over the historical period (as well as any impact of trends in other drivers of gas consumption over the historical period, which may include the impact of appliance efficiency and choice). Trend analysis of the type adopted by Core can also account for circumstances in which key drivers of gas demand are expected to be above (or below) outcomes that occurred during the historical period used to support the trend analysis. For instance, if growth in GSP is accepted to be a driver of gas demand, and growth in GSP is accepted to be higher over the forecast period than during the historical period used to support the trend analysis, then the effects of this out-of-trend GSP growth can be accounted for as a post-modelling adjustment. In doing so, however, it is important to recognise that the effects of GSP growth over the historical period are already reflected in the historical trend in gas demand; hence it is necessary to isolate the out-of-trend GSP growth in performing the post-modelling adjustment, and adjust the trend forecasts only for the share of GSP growth that is out-of-trend, not all the GSP growth.

- 116 We also note that where there is reason to expect that future trends for a number of other drivers of gas demand may differ from historical trends, adjustments to trend might, with sufficient data, be desirable. For instance, increases in the efficiency of gas appliances in excess of those that occurred during the historical period could also be accounted for as a post-modelling adjustment to the trend analysis.

## 5 Declaration

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



Andrew Harpham  
26 February 2015



Robert Bartels



## Appendix A: CVs

NAME:	ROBERT BARTELS
Profession:	Econometrician and Statistician



Bob leads Frontier's econometrics team, which assists clients with the analysis and use of quantitative data to meet their strategic objectives. He has over 25 years experience in applying econometric and statistical methods across a diverse range of applications in business and government, with particular strengths in litigation support and energy demand modelling.

Bob's strength in advising clients lies in his:

- Knowledge and familiarity with the application of statistical and econometric modelling techniques to answer questions of commercial or policy value.
- Ability to explain statistical and econometric concepts simply and clearly.
- Extensive experience as a modeller, model reviewer, and model auditor.
- Ability to provide frank and independent advice to clients.

Bob joined Frontier in 2006, having worked with Frontier as an Academic Associate since 1999. He is an Emeritus Professor in Business Analytics at the University of Sydney, and is an elected member of the International Statistical Institute. Prior to joining Frontier, he held various full-time academic positions at the University of Sydney, including Head of the School of Business and Professor in Econometrics and Business Statistics. He has published over 50 refereed academic papers and has served on the editorial boards of the international journals *Energy Economics*, *Statistical Papers* and *Utilities Policy*.

## KEY EXPERIENCE

### Econometric and statistical modelling

- ***Analysis of load data collected in Smart Grid Smart City trials.*** Currently undertaking statistical analysis to estimate the impact on residential consumer load profiles of various tariff, rebate and feedback technology options trialled in the Smart Grid Smart City (SGSC) project. The SGSC is a major initiative by the Australian Government, supported by a \$A100 million government

contribution, to test various technological, tariff and feedback options for a smart electricity grid. (2013 - ongoing)

- ***Estimation of Damages Caused By International Air Cargo Cartel.***  
Frontier has been retained by lawyers for the class action to undertake quantitative analysis and econometric modelling for a class action claimant against an international cartel that had been successfully prosecuted overseas. (2007 - ongoing)
- ***Review of electricity demand forecasting procedures (AEMO).***  
Undertook a detailed independent review of the forecasting procedures and assumptions that underpin the electricity forecasts of the Australian Energy Market Operator (AEMO). (2013)
- ***Review of electricity demand forecasting procedures (Energex).***  
Undertook a detailed independent review of the forecasting procedures and assumptions as part of Energex's preparations of submissions to the Australian Energy Regulator (AER) for the next regulatory review. (2013 - ongoing)
- ***Review of electricity demand forecasting procedures (3 NSW distributors).*** Undertook a high-level review of the forecasting procedures and assumptions as part of Endeavour's preparations of submissions to the Australian Energy Regulator (AER) for the next regulatory review. (2013)
- ***Review of electricity demand forecasting procedures (Endeavour).***  
Undertook a detailed independent review of the forecasting procedures and assumptions as part of Endeavour's preparations of submissions to the Australian Energy Regulator (AER) for the next regulatory review. (2012 - ongoing)
- ***Validation of Models for Loan "Probability of Default" Models.***  
Frontier was engaged by the Commonwealth Bank to undertake peer reviews of several "Probability of Default" models as part of its validation and regulatory approval processes. The reviews examined conceptual, statistical, mathematical and computational issues arising in the development of the models, in the application of the models to predict future default rates, and in the stress testing of the models that the Bank undertook using simulation methods. (2010 - 2012)
- ***Class Action for Damages Caused By Alleged Cardboard Cartel:***  
Frontier was retained by solicitors for Visy to calculate damages caused by an alleged cartel in cardboard fibre packaging. Philip Williams and Bob Bartels submitted witness statements for the trial. The witness statements reported the results of detailed econometric work using Visy's internal cost and revenue data. The matter was settled shortly after the trial began. (2009 - 2011)

- ***Validation of "Loss Given Default" Models.*** Frontier was engaged by the Commonwealth Bank to undertake peer reviews of several "Downturn Loss Given Default" models as part of its validation and regulatory approval processes. The reviews examined conceptual, statistical, mathematical and computational issues arising in the development of the models and in the application of the models to predict future losses for defaulting loans. (2010 - 2011)
- ***Sample design for Smart Grid Smart City trials.*** Undertook peer review of the sample design for the roll out of smart meters in the Smart Grid Smart City (SGSC) project. (2011)
- ***Review of Forecasting Models used in Australia Post's 2010 Pricing Notification.*** Frontier advised the Australian Competition and Consumer Commission (ACCC) on the reasonableness of forecasts used by Australia Post in its 2010 Pricing Notification. Frontier's role included:
  - reviewing the revised demand forecasting methodologies employed by Australia Post, which included advanced time-series forecasting techniques overlaid with specific management intelligence
  - analysis and commentary on whether cost forecasts were consistent with expectations that costs should fall in line with volumes. Frontier's analysis was a critical input into the ACCC's analysis of the Notification. (2010)
- ***Audit of Advertising Forecasting Models.*** Frontier undertook an audit of the econometric forecasting models used by an international advertising company to forecast the billings in different channels of advertising in Australia. The audit included replication of the estimation results, investigating the robustness of the models, and making recommendations for model improvement. (2010)
- ***Impact of Time of Use (TOU) Metering.*** Frontier assessed the impact of time of use (TOU) pricing on EnergyAustralia's customers' coincident maximum demand (CMD). Frontier used half-hourly electricity consumption data for over 170,000 residential and business customers to investigate whether there was a statistically significant difference in the CMDs between customers on TOU and inclining block tariffs (IBT) in the period Winter 2006 to Winter 2009, and what some of the drivers of those differences were. (2010)
- ***Valuing Number Plate.*** Frontier was requested by solicitors acting for a private motorist to estimate the market value of a special car number plate (2010).
- ***Review of National Institute of Economic and Industry Research Forecasts.*** Frontier undertook an independent peer review of the forecasting procedures and assumptions that underpin the forecasts

contained in Powercor and CitiPower's submissions to the Australian Energy Regulator for the 2011-15 regulatory review. (2010)

- ***Review of Forecasting Methodologies.*** Frontier provided support for ETSA's 2010-2015 regulatory proposal by reviewing its forecasting methodologies. (2010)
- ***Dynamic Peak Pricing.*** Frontier advised Energy Australia on the statistical design and econometric analysis of an electricity metering study to determine the impact of dynamic peak pricing on the pattern of electricity demand. (2006-2010)
- ***Equitable Remuneration for Use of Sound Recordings in Exercise Classes.*** Frontier was retained by solicitors for collecting society Phonographic Performance Company of Australia (PPCA) to evaluate equitable remuneration for playing of sound recordings in exercise classes. Frontier used an advanced statistical approach called applied choice analysis to estimate the willingness to pay for recorded music. The results of the applied choice analysis were an input into an economic model of bargaining to determine equitable remuneration. (2005-2009).
- ***Review of Electricity Forecasting Models for South Australia.*** Frontier was engaged to review electricity forecasting models commissioned by the Australian Energy Regulator (AER) for South Australia as part of the AER's assessment of a utility's regulatory proposal. (2009)
- ***Dynamic Peak Pricing.*** Frontier advised EnergyAustralia on the statistical design and econometric analysis of the Strategic Pricing Study (SPS). The SPS investigated the impact on consumption patterns of a number of experimental electricity tariffs and information options, including dynamic peak price tariffs. The SPS is the most comprehensive, statistically designed tariff experiment conducted in Australia to date. The results indicate that dynamic peak price tariffs can reduce peak demand by as much as 30%. (2006-2009)
- ***Review of Methodology for Forecasting Customer Initiated Connections to Electricity Distribution Network.*** Frontier undertook a review of the methodology used to forecast customer initiated capital expenditure for a Victorian electricity distribution company. Frontier also assessed the accuracy of the forecasting procedures. (2008)
- ***Inside Trading in Gas Assets.*** Proceedings were issued in the High Court of New Zealand alleging insider trading concerning the sale of oil and gas rights at the Mangahewa Prospect. The applicants claimed damages estimated with the aid of stock market data. Frontier provided an opinion about the econometric modelling of the applicants. (2008)
- ***Westpac-St George.*** Frontier was retained by the solicitors for Westpac to undertake an econometric analysis of patterns of substitution among banking

products. The merger proposal was cleared by the Australian Competition and Consumer Commission (ACCC). (2008)

- ***International Transfer Pricing.*** Frontier assisted lawyers advising a client challenging a decision by the Australian Taxation Office. Frontier undertook detailed analysis of prices paid by a range of international distributors to obtain arms-length "comparable unencumbered prices (CUP)" for goods imported by the client into Australia. (2008)
- ***Review of Electricity Demand Forecasting in Western Australia.*** Frontier undertook a detailed review of the electricity demand forecasting procedures used in the South West Integrated System in Western Australia and advised the Independent Market Operator (IMO) on the appropriateness of these procedures. (2007-2008)
- ***Woolworths New Zealand versus Commerce Commission.*** Frontier advised Woolworths throughout both its application to the Commerce Commission for clearance to acquire The Warehouse Group and subsequent appeals. Frontier performed both econometric and economic analysis to determine the effect of previous mergers in New Zealand supermarkets and the likely effects on The Warehouse Group's food operations. (2007-2008)
- ***Electricity Demand Elasticities.*** Frontier wrote an extensive review of the literature on the price elasticity of electricity demand for a distribution utility. The review covered both traditional demand studies as well as studies of the demand response to time-of-use, dynamic peak pricing and real time pricing tariffs. (2007)
- ***Review of Backcasting Approach.*** Frontier undertook a review on behalf of NEMMCO, the electricity market operator, of the backcasting approach used by TransGrid to validate their forecasts of electricity demand. (2007)
- ***Customer Response Trials Project.*** Frontier was engaged to undertake quality assurance on a major customer response trial in Victoria designed to estimate the response to a number of innovative tariffs and information display options. (2006-2007)
- ***Nestle and Aldi - Analysis of Scanner Panel Data.*** Nestle had a dispute with Aldi over Aldi's sale of imported Nescafe coffee that was similar in appearance but different in taste from locally-produced Nescafe coffee. Frontier estimated econometric demand systems for a number of consumer product markets using scanner panel data, including the markets for instant coffee and for alcoholic mixed drinks. Approaches used include multi-stage budgeting incorporating the Almost Ideal Demand System (AIDS), as well as the use of multidimensional scaling (MDS) to develop a map of competing products in product space. (2006)
- ***Proposed Joint Venture Between Qantas and Air New Zealand.*** Frontier undertook econometric modelling for the Australian Competition

and Consumer Commission to assess the likely impact of the proposed agreement between Qantas and Air New Zealand. The demand for trans-Tasman passenger journeys was modelled using dynamic, seemingly unrelated regressions (SUR) models, as well as residual demand models. Qantas and Air New Zealand withdrew their application. (2006)

- ***Diageo – IDL/Analysis of Scanner Panel Data.*** Frontier was retained by solicitors for Diageo which sought clearance to bid for the ready-to-drink business of IDL. Frontier undertook econometric analysis of the patterns of substitution between Diageo's Ready-to-Drink products and those of IDL. Diageo was cleared to participate in the bidding. (2006)

## CAREER

2006 - present	Consultant, Frontier Economics
2006 - present	Emeritus Professor in Business Analytics, University of Sydney
2006	Head, School of Economics and Political Science, University of Sydney
2000 - 2002	Head, School of Business, University of Sydney
1996 - 1997	Director and principal of Decision Vision, a market research company
1989 - 1998	Senior Associate, London Economics
1987 - 1988	Head, Department of Econometrics, University of Sydney
1983 - 2006	Academic consultant to the government and private sectors
1975 - 2006	Various positions, from Lecturer to Professor, in Econometrics and Business Statistics, University of Sydney
1972 - 1974	Lecturer in Statistics, Macquarie University

## EDUCATION

1969 - 1972	PhD (Syd) in Economic Statistics (Thesis Topic: Stable Distributions in Economics)
1965 - 1968	BA (Hons 1) (Syd). University Medal in Mathematical Statistics. Majors in Mathematical Statistics and Pure Mathematics

## OTHER PROFESSIONAL ACTIVITIES

### Visiting Appointments

2003	Visiting Professor, Department of Economics, University of Maastricht, The Netherlands
2001	Visiting Professor, Institute of Statistics, University of Munich, Germany
2001	Visiting Scholar, University of New South Wales
1998	Visiting Professor, Centre for Economic Research, Tilburg University, The Netherlands
1990 - 1991	Visiting Professor, Institute of Energy Economics, University of Cologne, Germany
1989 - 1991	Visiting Professor, Department of Econometrics, University of Bonn, Germany
1981	Visiting Professor, Department of Econometrics, University of Munich, Germany

1978	Visiting Scholar at London School of Economics, U.K.
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### Positions held in academic societies and institutes

2011 - present	Invited Member, The University of Sydney Business School's Panel of ARC Readers
1999 - 2000	Co-Chair, Program Committee, 23rd International Association of Energy Economists Annual International Conference
1999 - 2000	Council Member, International Association of Energy Economists
1996 - 1997	Council Member, Australian Asia-Pacific Institute of Retailing and Services Studies (AURASS), University of Sydney
1980	Council Member, Australian Statistical Society, NSW Branch.

### Editorial boards

1999 - 2006	Associate Editor, <i>Energy Economics</i>
1992 – 2014	Editorial Board, <i>Utilities Policy</i>
1986 - 2006	Editorial Advisor, <i>Statistical Papers</i>

### Refereeing

Referee for: American Economic Review, Review of Economics and Statistics, Journal of Econometrics, Journal of Applied Econometrics, American Statistician, Energy Economics, The Energy Journal, Energy Policy, Empirical Economics, Economic Record, Journal of Productivity Analysis, Linear Algebra and its Applications, Australian Journal of Agricultural Economics, Journal of Official Statistics, Communications in Statistics, Quality Control, Applied Statistics, Statistical Papers, Psychological Bulletin, Australian Research Council, Netherlands Organisation for Scientific Research.

### Professional awards and distinctions

2005 - present	Elected Member, International Statistical Institute
1989 - 1990	Humboldt Fellowship. Awarded by the Federal Republic of Germany
1981	Humboldt Fellowship. Awarded by the Federal Republic of Germany
1969	University Medal in Mathematical Statistics, University of Sydney
1969	Australian Statistical Society Prize

### Declaration

## Research grants

2001 - 2003	ARC Large Grant; \$A 132,000. "Asynchronous trading induced biases in observed asset returns: Further econometric theory and research applications to Australian Capital markets". (Joint with Jay Muthuswamy and Terry Walter)
1997 - 1999	ARC Large Grant; \$A 252,000. "A stated preference based market structure model of supply and demand of household water heaters". (Joint with Benedict Dellaert and Denzil Fiebig)
1997 - 1998	ARC Institutional Grant; \$A 20,000. "Specification, estimation and testing of an ordered beta model for ordered categorical data". (Joint with Murray Smith)
1996 - 1998	ARC Large Grant; \$A 140,000. "Testing sources of variability in forecasting trial and repeat rates for new products in marketing experiencing technological change". (Joint with Jordan Louviere)
1994 - 1996	ARC Large Grant; \$A 118,000. "A regional end-use energy demand model". (Joint with Denzil Fiebig and Alan Woodland)
1994 - 1995	ARC Small Grant; \$A 25,000. "The demand for energy in Australian industry". (Joint with Denzil Fiebig)
1994	University of Sydney Research Grant; \$A 8,500. "The effect of sample size on the measurement of economic efficiency"
1993	ARC Small Grant; \$A 9,000. "An econometric analysis of Australian energy demand by end use". (Joint with Denzil Fiebig)
1986 - 1988	ARGS grant; \$A 37,000. "Residential electricity demand; An econometric investigation into the nature and stability of the factors influencing demand"
1985	Australian Department of Resources of Energy grant; \$5,000. "Survey of energy modelling in Australia"

## PUBLICATIONS

### Refereed articles

1. Bartels, R., Fiebig, D.G. and van Soest, A. (2006), "Consumers and experts: An econometric analysis of the demand for water heaters", *Empirical Economics*, 31(2), 369-391.
2. Bartels, R., Fiebig, D.G. and McCabe, A. (2004), "The value of using stated preference methods: a case study in modelling water heater choices", *Mathematics and Computers in Simulation*, 64 (3&4), 487-495.
3. Bartels, R. and Islam, T. (2002), "Supply restricted telecommunications markets: The effect of technical efficiency on waiting times", *Journal of Productivity Analysis*, 18(2), 161-169.
4. Bartels, R. and Fiebig, D.G. (2000), "Residential end-use electricity demand: results from a designed experiment", *The Energy Journal*, 21(2), 51-81.
5. Zhang, Y. and Bartels, R. (1998), "The effect of sample size on the mean efficiency in DEA with an application to electricity distribution in Australia, Sweden and New Zealand", *Journal of Productivity Analysis*, 9, 187-204.
6. Sharma, D. and Bartels, R. (1997), "Distributed electricity generation in competitive energy markets: A case study in Australia", *The Energy Journal, (Special Issue), Distributed Resources: Toward a New Paradigm of the Electricity Business*, 17-40.
7. Bartels, R., Fiebig, D.G., and Plumb, M. (1996), "Gas or electricity, which is cheaper?: An econometric approach with application to Australian expenditure data", *The Energy Journal*, 17(4), 33-58.
8. Bartels, R., Fiebig, D.G., and Nahm, D. (1996), "Regional end-use gas demand in Australia", *Economic Record*, 72, 319-331.
9. Bartels, R. and Fiebig, D.G. (1996), "Metering and modelling residential end-use electricity load curves", *Journal of Forecasting*, 15, 415-426.
10. Fiebig, D.G., Bartels, R. and Krämer, W. (1996), "The Frisch-Waugh theorem and generalised least squares", *Econometric Reviews*, 15, 431-443.
11. Krämer, W., Bartels, R. and Fiebig, D.G. (1996), "Another twist on the equality of OLS and GLS", *Statistical Papers*, 37, 277-281.
12. Bartels, R. and Fiebig, D.G., (1995), "Optimal design in end-use metering experiments", *Mathematics and Computers in Simulation*, 39, 305-309.
13. Fiebig, D.G., McAleer, M. and Bartels, R. (1992), "Properties of OLS estimators in regression models with non-spherical disturbances", *Journal of Econometrics*, 54, 321-334.

14. Bartels, R., Fiebig, D.G., Garben, M. and Lumsdaine, R. (1992), "DELMOD: An end-use simulation model", *Utilities Policy*, 2(1), 71-82.
15. Bartels, R. (1992), "On the power function of the Durbin-Watson test", *Journal of Econometrics*, 51, 101-112.
16. Bartels, R. and Fiebig, D.G. (1991), "A simple characterization of seemingly unrelated regressions models in which OLS is BLUE", *American Statistician*, 45, 137-140.
17. Fiebig, D.G., Bartels, R. and Aigner, D.J. (1991), "A random coefficient approach to the estimation of residential end-use load profiles", *Journal of Econometrics*, 50, 297-328.
18. Bartels, R. Cohen, R. and Hoehn, T. (1991), "Das neue Elektrizitätssystem in Grossbritannien: Erste Erfahrungen und Perspektiven", *Zeitschrift für Energiewirtschaft*, 1/91, 27-36.
19. Bartels, R. and Fiebig, D.G. (1990), "Integrating direct metering and conditional demand analysis for estimating end-use loads", *The Energy Journal*, 11(4), 79-97.
20. Bartels, R., Murray, J., and Weiss, A.A. (1988), "The role of consumer and business sentiment in forecasting telecommunications traffic", *Journal of Economic Psychology*, 9, 215-232.
21. Andrews G., Hall W., Goldstein G., Lapsley H., Bartels R., and Silove D. (1985), "The economic costs of schizophrenia: Implications for public policy", *Archives of General Psychiatry*, 42, 537-543.
22. Hall W., Goldstein G., Andrews G., Lapsley H., Bartels R. and Silove D. (1985), "Estimating the economic costs of schizophrenia", *Schizophrenia Bulletin*, 11, 598-611.
23. Bartels, R. (1985), "Identification in econometrics", *American Statistician*, 39, 102-104.
24. Bartels, R. (1984), "The rank von Neumann test as a test for autocorrelation in regression models", *Communications in Statistics*, A13(20), 2495-2502.
25. Bartels, R. (1984), "Estimation in a bidirectional mixture of von Mises distributions", *Biometrics*, 40, 777-784.
26. Bartels, R., Bornholt, G. and Hanslow, K. (1982), "The polynomial trend model with auto-correlated residuals", *Communications in Statistics*, A11(12), 1393-1402.
27. Bartels, R. (1982), "The rank version of von Neumann's ratio test for randomness", *Journal of the American Statistical Association*, 77, 40-46.
28. Bartels, R. (1981), "Truncation bounds for infinite expansions for the stable distributions", *Journal of Statistical Computation and Simulation*, 12, 293-302.

29. Bartels, R. and Goodhew, J. (1981), "The robustness of the Durbin-Watson test", *The Review of Economics and Statistics*, 63, 136-139.
30. Bartels, R. (1979), "Fractiles for the non-symmetric stable distributions", *Journal of Statistical Computation and Simulation*, 9, 127-132.
31. Bartels, R. (1978), "Generating non-normal stable variables using limit theorem properties", *Journal of Statistical Computation and Simulation*, 9, 199-212.
32. Bartels, R. (1977), "Estimation in a first order autoregressive scheme with non-normal stable disturbances", *Journal of Statistical Computation and Simulation*, 6, 35-48.
33. Bartels, R. (1977), "On the use of limit theorem arguments in economic statistics", *American Statistician*, 31, 85-87.

### Contributions to refereed books

34. Bartels, R. (2002), "Seemingly unrelated regressions", in A. El-Shaarawi and W. Piegorisch (eds), *Encyclopedia of Environmetrics*, 1959-1961.
35. Bartels, R. Cohen, R. and Hoehn, T. (1992), "Markets for Electricity: The British system", in E. Hope and S. Strom (eds), *Energy Markets and Environmental Issues*, Scandanavian University Press, 87-114.
36. Bartels, R. and Fiebig, D.G. (1992), "Efficiency of alternative estimators in generalized seemingly unrelated regression models", in R. Bewley and T.V. Hoa (eds), *Contributions to Consumer Demand and Econometrics: Essays in Honour of Henri Theil*, Macmillan, 125-139.

### Monographs

37. Bartels, R. (1988), *Household Energy Consumption: Analysis of the 1984 Energy Survey*, Department of Energy of NSW and the Electricity Commission of NSW, DOE88/102.
38. Bartels, R., D. Fiebig, D. Aigner and T. leRoux (1988), *Domestic End-Use Study*, Electricity Commission of New South Wales, PD 88/5.
39. Bartels, R. (1986), *Energy Modelling in Australia: A Constructive Analysis*, Department of Resources and Energy, WS86/021.
40. Bartels, R., P. Lopert and S. Williamson (1986), *The Residential Demand for Electricity*, Energy Authority of New South Wales, EA85/9.
41. Bartels, R. (1985), *Appliance Penetration and Household Energy Consumption*, Energy Authority of New South Wales, EA85/50.
42. Bartels, R., G. Goldstein, R. Resnick and H. Lapsley (1984), *The Cost of Acute Myocardial Infarction in New South Wales: An Incidence Based Study*, Report to Department of Health, Australian Government Printing Service.

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## Published conference proceedings

43. Bartels, R., D.G.Fiebig, and A.McCabe (2001), "The Value of Using Stated Preference Methods: A Case Study in Modelling Water Heater Choices," in F. Ghassemi, M. McAleer, L.Oxley and M. Scoccimarro, *MODSIM 2001: Modelling and Simulation Society of Australia and New Zealand*, ANU, Canberra, 1421-1426.
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46. Bartels, R. (1999), "The contribution of electricity demand to the CO2 emissions by Australian industry", *22nd International Association of Energy Economists Annual International Conference*, Rome, 318-326.
47. Bartels, R., M. Smith and J. Louviere (1996), "The ordered beta model: Specification and estimation", *Econometric Society Australasian Meeting, Vol 2*, 663-676.
48. Bartels, R. and Y. Zhang (1996), "Are Australian electricity distributors more efficient?", *Econometric Society Australasian Meeting, Vol 4*, 149-186.
49. Bartels, R., D.G. Fiebig, and M. Plumb (1996), "Gas or electricity, which is cheaper?: An analysis of household energy expenditures", *Econometric Society Australasian Meeting, Vol 4*, 1996, 187-212.
50. Bartels, R. (1993), "The economic efficiency of electricity distribution in Australia", *Proceedings, DISTRIBUTION 2000, 2nd International Electricity Distribution Conference*, 7 pages.
51. Bartels, R., N. Crabb, P. Tang, G. Gangopadhyay, and D. Fiebig (1993), "Residential end-use study in NSW", *1993 ESAA Forecasting Forum*, 18 pages.
52. Bartels, R (1992), "The effect of a carbon tax on Australian industry", *Coping with the Energy Future: Markets and Regulations (Proceedings, 15th Annual Conference, International Association for Energy Economics)*, I1-I6.

## Book reviews

53. Review of: Pesaran, M.H. and Schmidt, P., *Handbook of Applied Econometrics. Volume II: Microeconomics*, 1997, Blackwell, in *Statistical Papers*, 40, 1999, 239.
54. Review of: Lütkepohl, H., *Handbook of Matrices*, 1996, Wiley, in *The Statistician*, 47(1), 1998, 225.

55. Review of: Davidson, F., *Principles of Statistical Data Handling*, 1996, Sage, in *The Statistician*, 47(1), 1998, 220-221.
56. Review of: Pollitt, M.G., *Ownership and Performance in Electric Utilities*, 1995, Oxford UP, in *The Energy Journal*, 17, 1996, 105-107.
57. Review of: Härdle, W. et al, *XploRe: An Interactive Statistical Computing Environment*, 1995, Springer-Verlag. in *The Statistician*, 45, 1996, 388-389.
58. Review of: Mumford, E. and Sackman, H., *Human Choice and Computers*, in *Australian Journal of Public Administration*, 37, 1978, 88-89.
59. Review of: Shubik, M., *The Uses and Methods of Gaming*, 1975, Elsevier, and Shubik, M., *Games for Society, Business and War: Towards a Theory of Gaming*, 1975, Elsevier, in *Australian Journal of Public Administration*, 36, 1977, 96-97.

### Other articles and book contributions

60. *Statistical Basis for the Determination of Checktesting Validity Criteria*, prepared for the National Appliance and Equipment Energy Efficiency Committee, <http://www.energyrating.gov.au/pubs/validity-statistics.pdf>, 2004, 1-27 (with Lloyd Harrington).
61. "Electric motors and industry energy efficiency", *Electricity Supply Magazine*, No17, Dec 1994, 4-5.
62. "Residential end-use electricity forecasting" in *Electricity Generation Planning in an Uncertain Environment*, G. McColl (ed.), Centre for Applied Economic Research, University of NSW, 1988, 113-122.
63. "Comments on two energy models" in *Energy Modelling in Australia*, Centre for Applied Economic Research, University of NSW, 1985, 128-132.
64. "The Donovan study of atomic test personnel: a critique", *Sana Update*, 19, 1984, p.16.

### Unpublished conference papers

65. "Consumers and experts: An econometric analysis of the demand for water heaters", *2001 Econometric Society: Australasian Meetings*, Auckland NZ, 2001. (with D. Fiebig and A. van Soest).
66. "The residential demand for electricity in New South Wales", *Annual Conference of the Electricity Supply Engineers' Association of NSW*, Sydney, 1985. (with P. Lopert and S. Williamson).
67. "Interest rates, the money supply and inflation", *Third Conference of Economists, Adelaide*, 1973. (with D.J. Jüttner).

### Discussion papers (not published elsewhere)

68. "Constrained estimation of the Hildreth-Houck random coefficient model", *Sydney University, Department of Econometrics*, Discussion Paper 90-02, January 1990 (with D. Fiebig).
69. "More on the grouped heteroskedasticity model", *Tilburg University, The Netherlands*, CentER Discussion Paper 9058, October 1990 (with D. Fiebig).
70. "Interest rates and price expectations", *Macquarie University, School of Economic and Financial Studies*, Research Paper No. 30, May 1973 (with D.J. Jüttner).
71. "Interest rates and the money supply", *Macquarie University, School of Economic and Financial Studies*, Research Paper No. 26, April 1973 (with D.J. Jüttner).

NAME:	ANDREW HARPHAM
Profession:	Economist



Andrew is a Director of Frontier Economics Pty Ltd and works in Frontier Economics' energy practice and its legal and competition practice. Andrew has advised public and private sector clients on a range of policy, regulatory commercial and competition law issues.

Clients benefit from Andrew's advice through his:

- clear and independent economic analysis
- detailed knowledge of energy markets
- concise communication of complex issues
- ability to provide advice from the perspective of governments, regulators and private sectors clients.

Andrew's work in the energy sector has included advice to Governments, regulators and businesses in areas such as commercial and strategic analysis, tariff regulation, energy security and energy market design and operation. Recent work has included advice to state governments on energy reform in gas and electricity markets, advice to the Government in Australia and Malaysia on energy security in electricity and gas markets, and advice to a number of regulators, governments and regulated entities in on gas and electricity tariffs. Andrew also regularly provides advice on energy market transactions in Australia.

Andrew's work in Frontier's legal and competition practice has involved advice to clients and their lawyers on a range of issues. Andrew has provided advice in relation to mergers and trade practices issues in a variety of industries including energy, telecommunications and financial services. Andrew has also advised lawyers and their clients on contract disputes, particularly in relation to long-term fuel price contracts.

Prior to joining Frontier, Andrew worked as an economist at Freehills for several years. A major focus of his work at Freehills was the analysis of economic issues associated with competition law matters, including mergers and acquisitions, and litigation support.

## KEY EXPERIENCE

### Market/Institutional design and implementation

- ***Benchmarking gas demand forecasting:*** Andrew was responsible for Frontier Economics' advice to the Australian Energy Market Operator (AEMO) comparing AEMO's gas demand forecasting methodology with international best practice. Frontier compared AEMO's methodology with the approach adopted by distribution network service providers throughout eastern Australia as well as a number of national and international organisations (2014 to 2015).
- ***Western Australia Electricity Market Review:*** Andrew was part of the Frontier team that advised the Public Utilities Office in Western Australia on network planning and regulation arrangements in Western Australia. Frontier's work included an international review of network planning and regulation arrangements and an assessment of options for Western Australia (2014).
- ***WEM Market Review:*** Andrew was part of the Frontier team that conducted an analysis that sought to estimate the costs of actual investment outcomes in the Wholesale Energy Market (WEM) in Western Australia, and to compare these to an efficient benchmark. The analysis focused on issues related to demand forecasting and the mix of plant built since market inception. The study identified potential policy objectives that would reduce the economic costs of the WEM (2014).
- ***Smart Grid, Smart City:*** Andrew managed Frontier Economics' contribution to a consortium that assessed and reported on the results of Ausgrid's *Smart Grid, Smart City* trial. Frontier's advice was focused on assessing the customer response to the trial based on detailed meter data and modelling the impacts of trial technologies and outcomes on the wholesale electricity market (2013 to 2014).
- ***Improving the efficiency of government held assets:*** Andrew was part of the Frontier team that provided advice to Infrastructure Australia in support of the development of a report on Government balance sheet reform. Specific areas of input from Frontier included advice on the benefits to infrastructure sectors of reform, and the relationship between reform and regulation (2012 to 2013).
- ***Advice on Reform Proposals in Western Australia:*** Andrew was part of the Frontier team commissioned by the WA Independent Power Association to analyse the consequences of proposals to re-aggregate Synergy, the state-owned energy retailer, and Verve Energy, the state-owned generator. Frontier Economics' report found that the re-aggregation would not address any of the substantive concerns held by the proponents of re-aggregation.

Moreover, the re-aggregation would have the likely consequences of lessening competition in the wholesale market, and of preventing the development of retail competition. In the longer-term, it would damage prospects for private investment in energy supply, and require that the government take on more of the cost of ensuring Western Australia's energy security (2012).

- ***Power sector fuel mix study for Malaysia:*** Andrew was part of the Frontier team that advised MyPOWER on the fuel mix for the power sector in Peninsula Malaysia. A key focus of Frontier's advice was advising on the energy security implications of the fuel mix for the power sector. Frontier modelled outcomes in the Asia-Pacific LNG market and in the Peninsula Malaysia power sector in order to advise on policies consistent with the achievement of energy security (2011 to 2012).
- ***Western Australian Wholesale Market Review:*** Andrew advised the Economic Regulation Authority (ERA) in the preparation of their first, second, third and fifth reports to the Minister on the effectiveness of the WEM in Western Australia. Andrew provided advice in regard to a number of key issues facing the WEM, including the operation of the Reserve Capacity Mechanism and Short Term Energy Market, the potential merger of Verve Energy and Synergy and the effects of the Commonwealth introducing carbon pricing. Frontier also provided a quantitative analysis of market outcomes since the market commenced (2007 to 2012).
- ***Future development of Tasmania's electricity industry:*** Andrew was project manager for Frontier's advice to the Tasmanian Electricity Supply Industry Expert Panel (the Panel) on its investigation into the current position and future development of Tasmania's electricity industry. There were two key aspects to Frontier's advice:
  - An assessment of the effectiveness of the wholesale electricity sector. Frontier examined historic outcomes in the wholesale sector, and undertook market modelling, to assess the extent of market power in the Tasmanian wholesale electricity sector. Frontier found that there was no evidence of sustained market power being exercised in the wholesale sector even though there is significant potential for sustained market power to be exercised.
  - Advice on structural, regulatory and governance options to reform Tasmania's electricity industry, and analysis of anticipated changes in the performance of the market. Among other things, Frontier found that disaggregating bidding control of generation assets in Tasmania would diminish the potential for sustained market power to be exercised (2011 to 2012).
- ***National Energy Security Assessment:*** Andrew led Frontier's advice to the Department of Resources Energy and Tourism (DRET) on the

development of their 2011 National Energy Security Assessment (NESA). Frontier modelled hypothetical interruptions to gas infrastructure using *WHIRLYGAS*, our gas market model, and modelled hypothetical interruptions to electricity infrastructure using *WHIRLYGIG* and *SPARK*, our electricity market models. Adopting this modelling framework enabled us to advise DRET on the interactions between gas and electricity markets, particularly in regard to security of supply (2011).

- ***Introduction of the Short Term Trading Market for Gas:*** Andrew advised Industry and Investment NSW on the interaction of the NSW Gas Continuity Scheme and the Short Term Trading Market (STTM) for gas. Frontier was asked to review the updated design of the STTM and assess the extent to which the STTM could effectively replace the existing NSW Gas Continuity Scheme and to assess the implications for the Gas Continuity Scheme if it continued to operate once the STTM was introduced (2010).
- ***New South Wales Electricity Asset Sale:*** Andrew was a key member of the Frontier team that assisted the New South Wales (NSW) Government design and implement the Government's Energy Reform Strategy, which involved the sale of Government-owned electricity retail assets and the sale of trading rights to the Government-owned generation assets. Frontier's involvement included input on the development of the sales strategy and model, which ultimately led to the NSW Government's adoption of the GenTrader model.

Frontier was involved in the detailed implementation of the GenTrader model, including the design and implementation of the Generation Trading Agreements for each Government-owned power station. Frontier also provided detailed advice on market conditions using our electricity market models *STRIKE*, *WHIRLYGIG* and *SPARK*, and assisted the Government in its involvement with the ACCC (2008 to 2010).

- ***Short Term Trading Market for Gas:*** Andrew advised the NSW Department of Water and Energy on the proposed design for the STTM for gas. Frontier was asked to assess the proposed design of the STTM with regard to the incentives provided by the proposed market, and the extent to which the proposed market could effectively replace existing balancing arrangements and the existing NSW Gas Continuity Scheme (2009).
- ***Western Australia Electricity Retail Market Review:*** Andrew led Frontier's advice to the Western Australia Office of Energy in regard to the Electricity Retail Market Review. The Review had three aspects:
  - Cost-reflective retail electricity tariffs. Frontier estimated the appropriate wholesale energy cost, retail operating cost and retail margin for regulated tariffs, and advised on the structure and level of regulated tariffs. Frontier also advised on future arrangements for tariff regulation (2007 to 2008).

- Costs and benefits of Full Retail Competition (FRC). Frontier advised on the extent to which the electricity market in Western Australia had met the pre-requisites for FRC, and assessed the extent of the likely costs and benefits of FRC once these pre-requisites were achieved (2007 to 2008).
- Costs and benefits of rolling out smart meters. Frontier undertook a peer review of the Ministerial Council of Energy's analysis of the costs and benefits of rolling out smart meters, and assessed the relevance of this analysis for Western Australia (2008).
- ***NSW Gas Continuity Scheme:*** Andrew advised the NSW Department of Water and Energy (DWE) on the arrangements for the Gas Continuity Scheme to be introduced in NSW in 2008. Frontier assessed the proposal from the Gas Continuity Scheme Working Group and advised the DWE on elements of the design of the scheme (2008).

## Commercial investment, strategic and risk analysis

- ***QCLNG pipeline due diligence:*** Andrew led the Frontier team that advised a potential bidder for the QCLNG pipeline on the market risks and opportunities facing the owner of the transmission pipeline supplying gas to the QCLNG project in Queensland. Frontier forecast outcomes in the Asia-Pacific LNG market and the Queensland gas sector using our gas market model – *WHIRLYGAS* (2014).
- ***Residential gas consumption decisions:*** Andrew led the Frontier team that developed a model of residential consumers' gas consumption decisions for a gas distribution business. A focus of Frontier's work was to model the financial implications for residential gas consumers of decisions about whether to use electric or gas appliances for cooking, space heating and water heating. The modelling of financial implications took account of current and future electricity and gas prices as well as the capital costs of appliances (2014).
- ***Economic life of power stations:*** Andrew advised the Independent Pricing and Regulatory Tribunal (IPART) on the economic life of a number of large coal-fired power stations in NSW. This advice was used by IPART in its review of the rate of return for a number of rail track sectors that are used to transport coal to these power stations (2014).
- ***SWIS modelling framework:*** Andrew was part of the Frontier team that was engaged by Synergy to develop an electricity market modelling framework that could be used to assess the possible re-merger of Synergy and Verve Energy in that market. Working with Synergy we developed a market model that could review a number of different scenarios to guide Synergy's decision making around the potential such a re-merger could offer (2013).

- ***Sydney Desalination Plant – regulatory due diligence:*** Andrew advised a bidder for the Sydney Desalination Plant on the regulatory risks associated with ownership of the asset (2012).
- ***Australian generation assets – due diligence:*** Andrew was part of the Frontier team that provided market advice relating to a number of Australian generation assets. Frontier's advice included institutional and structural background information as well as detailed reviews of financial models and their inputs (2012).
- ***Insurance value of Tamar Valley Power Station:*** Andrew led Frontier's advice to the Tasmanian Electricity Supply Industry Expert Panel on the value of the insurance against low rainfall in Tasmania that is provided by Tamar Valley gas-fired generation plant. Frontier developed a modelling framework that reflected the importance of hydro generation in Tasmania and assessed the insurance value of Tamar Valley gas plant in a way that accounted for future uncertainty about both electricity demand levels and rainfall levels (2011).
- ***Vendor due diligence – Industry Information Memorandum:*** Andrew led the Frontier team that prepared a broad and detailed public report providing an overview of the market design, institutional, regulatory, governance and policy aspects of the electricity and gas markets in Australia (2009 to 2010).
- ***Australian generation assets – due diligence:*** Andrew was part of the Frontier team that provided market advice relating to a number of Australian generation assets. Frontier's advice included reviewing vendor due diligence reports and providing independent forecasts of future cashflows (2009).
- ***Western Australia electricity and gas markets – due diligence:*** Andrew advised a potential acquirer of energy assets in Western Australia on electricity and gas market arrangements in Western Australia, including the regulatory and policy environment and the impact of these on valuations (2008 to 2009).
- ***Developing a risk framework:*** Andrew led Frontier's advice to an energy retailer on the development of a framework to measure the systematic risk associated with writing long-term wholesale contracts while offering shorter-term retail contracts. The framework was developed in conjunction with SFG Consulting (2008).
- ***Valuing wholesale energy contracts:*** Andrew led Frontier's development of a framework for valuing wholesale energy contracts for a large retailer. The framework made use of Frontier Economics' proprietary models – *WHIRLYGIG* and *STRIKE*. Using this framework, Frontier modelled the least cost mix of long term contracts given the retailer's existing contract book and retail load (2008).

- ***Western Australia energy market policy:*** Andrew provided advice on likely policy directions for energy markets in Western Australia and the implications of these for electricity generators and retailers in the State (2008).
- ***Regional gas demand forecasts:*** Andrew was part of the Frontier team that undertook analysis of regional gas demand for a major Australian energy company. The analysis involved forecasting gas demand for electricity generation, industrial and residential users. Forecasts were prepared under a range of future greenhouse policies, to test the impact on gas demand (2007).
- ***Implementation of transfer pricing:*** Andrew was part of the Frontier team that provided advice to a National Electricity Market (NEM) retailer on the implementation of arrangements to improve the robustness and transparency of transfer pricing arrangements, including the development of policies and procedures (2005).

## Utility regulation and pricing

- ***Analysis of retail electricity tariffs:*** Andrew led the Frontier team that analysed data on retail electricity tariffs available to residential customers in Victorian for the Department of State Development, Business and Innovation (DSDBI). Frontier also provided a model to the DSDBI which summarises key retail pricing outcomes in Victoria on an ongoing basis (2014 to 2015).
- ***Network pricing report:*** Andrew was part of the Frontier team that was retained by the NSW Government to advise on the regulatory regime that applies to electricity distribution businesses in the NEM. Frontier's report provided an overview of current arrangements for network regulation, as well as a brief overview of key outcomes under the regulatory regime. Frontier's report was publicly released by the NSW Government as part of the Rebuilding NSW Plan: <http://www.nsw.gov.au/rebuilding/reports-and-papers> (2014).
- ***AEMC – future retail electricity prices:*** Andrew was a key part of the Frontier team that advised the Australian Energy Market Commission (AEMC) on their 2014 review of possible future trends in retail electricity prices in 2012 and 2014. Andrew has provided expert input into this work, including in regard to input assumptions for Frontier's modelling (particularly gas prices and capital costs) and in regard to the construction of tariff models for each state in Australia (2012 and 2014).
- ***Advice to AEMO on electricity and gas tariffs:*** Frontier Economics advised the Australian Energy Market Operator (AEMO) on retail electricity and gas tariffs for residential and business customers in each jurisdiction of the NEM. Our advice on included estimating historic tariffs since 1980 and forecasting future tariffs out to 2030, including providing a breakdown of

tariffs into the key components of retail costs: energy costs, network costs, green costs, retail operating costs and retail margin. Andrew was responsible for developing the historic and forecast gas retail tariffs, and provided expert input on the development of historic and forecast electricity retail tariffs (2014).

- ***New South Wales regulated retail tariffs for electricity:*** Andrew led Frontier's advice to the Independent Pricing and Regulatory Tribunal (IPART) for its determination of regulated retail tariffs for electricity for 2013-14 to 2015-16 and its annual review of these tariffs for 2014-15 to 2015-16. Frontier advised IPART on the costs of electricity generation, including generator capital costs, coal costs and gas costs. These forecasts were based on Frontier's energy cost databases and Frontier's fuel market models. Based on these inputs assumptions, Frontier used its energy market modelling framework to estimate the long run marginal cost of energy and the cost of purchasing energy for New South Wales retailers. Frontier's estimates were used by IPART as an input into the regulated retail price in NSW for 2013/14. Frontier's estimates were also used to inform indicative tariffs for 2014/15 and 2015/16, which will be subject to IPART's annual review process (2012 to 2014).
- ***Fair and reasonable value of Solar PV:*** Andrew was responsible for Frontier's advice to IPART for its reviews of Solar PV feed-in tariffs in 2012, 2013 and 2014. Frontier analysed half-hourly generation and consumption data for a large number of NSW customers to determine patterns of electricity export. Combining these data on electricity exports with Frontier's forecast half-hourly electricity prices, Frontier calculated that the market value of electricity generated by rooftop panels (2012 to 2014).
- ***Early termination fees:*** Andrew was responsible for Frontier's advice to IPART on its determination of the maximum fee that retailers can charge customers for early termination of an electricity contract (2013).
- ***South Australian retail electricity price regulation:*** Andrew led Frontier's advice to the Essential Services Commission of South Australia (ESCOSA) as part of its review of regulated retail electricity prices in the state for the period 2012/12 to 2013/14. Our advice included load profile forecasting and the estimation of wholesale energy purchase costs under a range of approaches, including cost and market based methodologies (2012).
- ***Electricity tariff review in Western Australia:*** Andrew led Frontier's advice to the Economic Regulation Authority (ERA) in regard to its Synergy Review. This work included:
  - Advice to the Authority on the long-run marginal cost (LRMC) of energy to meet Synergy's regulated loads. Frontier used our proprietary energy market model – *WHIRLYGIG* – to determine the hypothetical least cost

mix of new plant to serve each of Synergy's regulated loads and to calculate the LRMC of that mix of new plant (2012).

- Advice to the Authority on the efficiency of Synergy's contracting process. Frontier undertook a desktop review of the assessment procedures that Synergy adopted prior to entering a number of long-term contracts, and advised the Authority on the appropriateness of these procedures (2012).
- Advice to the Authority on the efficient retail operating costs for an electricity retailer in Western Australia. Frontier reviewed cost forecasts provided by Synergy and assessed regulatory benchmarks from other jurisdictions to advise on efficient retail operating costs (2012).
- ***New South Wales regulated retail tariffs for electricity:*** Andrew led Frontier's advice to IPART on its determination of regulated retail tariffs for electricity for 2010-11 to 2012-13, and its two annual reviews of these tariffs. Frontier used its energy market modelling framework to estimate both the long run marginal cost of energy and the cost of purchasing energy for New South Wales retailers over the period to 2012-13.

Frontier's modelling took account of the expanded Renewable Energy Target, the proposed introduction of the Carbon Pollution Reduction Scheme and the interaction between these two schemes. Frontier also advised IPART on the process for periodic reviews of regulated tariffs (2009 to 2012).

- ***Sydney Desalination Plant prices:*** Andrew was responsible for Frontier's advice to IPART on its review of prices that Sydney Desalination Plant can charge for its water. Frontier advised IPART on the long term costs of electricity, including renewable energy certificates (2011).
- ***Retail operating costs:*** Andrew advised Ergon Energy Queensland on an appropriate benchmark for retail operating costs to inform Ergon Energy's CSO submission to Queensland Treasury (2010).
- ***New South Wales regulated retail tariffs for electricity:*** Andrew was part of the Frontier team that advised IPART on its review of regulated retail tariffs and charges for electricity for 2007/08 to 2009/10. There were two related projects:
  - Advising on energy costs. This required an estimation of Long-Run Marginal Cost and market-based energy costs for each standard retailer, including the costs of complying with greenhouse obligations. Frontier used its suite of electricity market models to develop the cost estimates.
  - Advising on retail costs and margin. This required an assessment of the retail costs and margin appropriate to a new entrant. Frontier worked in

conjunction with SFG Consulting to estimate the return that a new entrant would require.

Andrew subsequently led Frontier's advice to IPART on its two annual reviews of energy costs for the period 2007/08 to 2009/10. (2006 to 2009)

- ***Country Energy regulated retail tariffs for gas:*** Andrew advised IPART on the application by Country Energy to increase gas retail tariffs under the special provisions clause of the Voluntary Transitional Pricing Arrangements. Frontier assessed the evidence supporting an increase in wholesale prices and considered the impact of wholesale price increases on retail tariffs (2008).
- ***AGL regulated retail tariffs for gas:*** Andrew advised IPART on the applications by AGL and ActewAGL to increase gas retail tariffs under the special provisions clause of the Voluntary Transitional Pricing Arrangements. Frontier assessed the evidence supporting an increase in wholesale prices and considered the impact of wholesale price increases on retail tariffs (2008).
- ***Western Australia Gas Tariff Review:*** Andrew advised the Office of Energy on the determination of cost reflective gas tariffs for regulated customers in Western Australia. Frontier advised on the appropriateness of Alinta's proposed tariffs for the interim tariff increase that was put in place for 2008/09. This involved a preliminary assessment of the costs of retailing gas to regulated customers. (2007 to 08).
- ***Review of Capacity Price Limits:*** Andrew provided advice to the ERA on its assessment in 2007 and 2008 of the capacity price limits to apply in the Wholesale Electricity Market in Western Australia (2007 to 2008).
- ***Access to Australian Stock Exchange:*** Frontier was asked for advice about appropriate charges that the Australian Stock Exchange (ASX) should levy on other exchanges that wish to use particular services produced by ASX with the aid of its various systems (2007).
- ***Queensland regulated retail tariffs for electricity:*** Andrew was part of the Frontier team that provided advice to Origin Energy on the determination of the Benchmark Retail Cost Index for setting regulated prices to small electricity customers in Queensland. Frontier's primary involvement was to advise on the appropriate methodology for assessing energy costs (2007).
- ***Relationship between GDP and electricity demand:*** Andrew was part of the Frontier team that advised IPART on the relationship between GDP growth and electricity demand. This empirical investigation was used to inform Frontier's advice to IPART on the appropriate retail margin to incorporate in regulated retail tariffs. Frontier worked in conjunction with SFG Consulting (2007).
- ***Efficiencies in retail operating costs:*** Andrew was part of the Frontier team that advised IPART on the potential improvements in respect of retail operating costs of electricity retailers. This constituted part of Frontier's

advice to IPART on the appropriate retail operating cost allowance to incorporate in regulated retail tariffs (2007).

- ***Future regulatory roles:*** Andrew was part of the Frontier team that identified and assessed possible future roles for a State-based economic regulatory agency (2007).
- ***Tasmanian regulated retail tariffs for electricity:*** Andrew was part of the Frontier team that advised Hydro Tasmania on the electricity retail price determination in Tasmania. Frontier's advised on the cost of energy, assessing these costs on the basis of both Long Run Marginal Cost and the market-price of energy (2006).
- ***Form of regulation:*** Andrew was part of the Frontier team that advised the New Zealand Commerce Commission on the form of regulation in the gas and electricity distribution industries. This involved providing an overview of key forms of regulatory controls, examining the relative merits of each form of control and reviewing the experiences in applying these regulatory controls in various jurisdictions worldwide (2006).

## Legal and competition

- ***Retail electricity pricing in South Australia:*** Andrew was a key part of the Frontier team that advised lawyers for AGL in regard to the ACCC's allegations that AGL engaged in misleading or deceptive conduct, or made false or misleading statements, in respect of discounts to residential electricity customers in South Australia. Andrew was involved in preparing an expert report from Frontier Economics' Managing Director – Danny Price – that provided information on the retail electricity market in South Australia (2014).
- ***Potential merger in energy retail sector:*** Andrew was part of the Frontier team that advised lawyers for Elgas on its application for clearance by the ACCC of its proposed acquisition of Kleenheat's east-coast LPG business. The ACCC granted the clearance, subject to undertakings (2013 to 2014).
- ***Gas price arbitration:*** Andrew was a key member of the Frontier team that provided economic advice to the lawyers for a major gas buyer to assist in a contract price renegotiation and potential arbitration. Frontier's advice included providing an economic interpretation of the relevant clauses of the contract and developing forecasts of regional demand for, and supply of, gas. The use of these demand and supply forecasts in Frontier's gas market model – *WHIRLYGAS* – enabled the analysis of a number of gas market outcomes (2013).
- ***Expert advice in relation to contract dispute:*** Andrew was a key member of the Frontier team that provided advice in relation to a contractual dispute between parties in the power sector (2013).

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- ***Application for authorisation of co-insurance:*** Andrew was a key member of the Frontier team that provided advice on the application by the NSW Government for authorisation of its proposed co-insurance scheme, which was to operate as a way to manage risk for the Government-owned generators (2009 to 2010).
- ***Judicial review of QCA tariff decision:*** Andrew was a key member of the Frontier team that provided advice to Gilbert + Tobin and their client, AGL, in regard to the judicial review of the Queensland Competition Authority (QCA) decision on the Benchmark Retail Cost Index (BRCI) for electricity tariffs in 2008-09. Frontier Economics Managing Director, Danny Price, gave expert evidence on behalf of AGL before the Supreme Court of Queensland (2009).
- ***ASX access:*** Andrew was part of the Frontier team that advised on prices for access to ASX clearing and settlement services (2009).
- ***Merger in the hot water heater industry:*** Andrew was part of the Frontier team that advised on the impact of imports on competitive outcomes in the water heater industry (2007 to 2008).
- ***Bank market definition:*** Andrew was part of the Frontier team that provided preliminary advice to solicitors for Westpac over market definition (2007).
- ***Equitable remuneration for use of sound recordings in exercise classes:*** Andrew was part of the Frontier team that was retained by solicitors for collecting society PPCA to evaluate equitable remuneration for playing of sound recordings in exercise classes. Frontier used applied choice analysis to estimate the willingness to pay for recorded music (2005 to 2007).
- ***Australian Stock Exchange – SFE Merger:*** Andrew was a key member of the Frontier team that was retained by solicitors for the Australian Stock Exchange to prepare submissions and analysis of trading data for its application to the Australian Competition and Consumer Commission for clearance of its merger with SFE. The merger was cleared. Cointegration analysis was used to determine the relationships between different types of products traded on the two markets (2006).
- ***Diageo/IDL – analysis of summer data panel:*** Andrew was part of the Frontier team that was retained by solicitors for Diageo which sought clearance to bid for the ready-to-drink business of IDL. Undertook econometric analysis of patterns of substitution between Diageo Ready To Drink products and those of IDL. Diageo was cleared to participate in the bidding (2006).
- ***Alleged tying behaviour:*** Andrew was part of the Frontier team that was retained by solicitors for Mulgrave Central Sugar Mill to advise on possible anticompetitive tying behaviour of CSL (2006).

- ***Exclusive dealing:*** Thoroughvision and Sky Channel had a dispute over certain first and last rights in contracts. Andrew was part of the Frontier team that was retained by solicitors for Sky Channel to advise on Trade Practices issues. The matter was settled (2006).
- ***Competition analysis of pricing and contracting strategies:*** Andrew was part of the Frontier team that, working with Gilbert + Tobin, provided advice to Synergy, a newly established energy retailer in Western Australia (created out of the disaggregation of Western Power) on the competition consequences of long-term contracts. This advice was presented in the form of trading protocols to assist the organisation satisfy Trade Practices Act compliance (2006).
- ***Sale of Boots Pharmaceutical business:*** Andrew was part of the Frontier team that was retained by solicitors for one of the bidders. Frontier undertook an econometric estimation of cross elasticities of demand that showed that a merger of the product ranges of the two relevant businesses would not lessen competition. The bidder was unsuccessful in the tender for the assets (2005).

While working at Freehills, Andrew worked on a wide range of competition matters in a variety of industries including telecommunications, media, pharmaceuticals, financial services, manufacturing, wholesaling, tourism and the airline industry. Specific matters that Andrew worked on included the Qantas/Air NZ merger and joint venture, the Metcash/Foodland merger, a merger of private hospitals in Launceston, a pay TV access arbitration on behalf of C7, a PSTN access arbitration on behalf of AAPT, a variety of submissions to the ACCC on behalf of AAPT and the scoping study for the sale of the government's remaining stake in Telstra.

## CAREER

2014 – current	Director, Frontier Economics
2005 – 2014	Consultant, Frontier Economics
2001 – 2005	Economist, Freehills

## EDUCATION

1998	Bachelor of Economics (Honours – First Class), University of Sydney
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## Declaration

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