Un-Accounted for Gas (UAfG) Strategy

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ISSUE/AMENDMENT STATUS

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1	December 2009	Strategy developed from a combination of sources. Structure of document build around the existing draft document “Unaccounted for Gas – Avenues for Mitigation”.		
2	November 2011	Strategy updated to contain reconciled 2009 UAfG data and updated Recommends and Actions.	M. Cooper	N. Nithianandan
3	August 2017	Reviewed.	M. Horomidis	L. Burridge
4	August 2017	Additional detail on AusNet Services' approach.	M. Horomidis	L. Burridge

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Contact

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1 Purpose

This document aims to provide the reader with a sound understanding of un-accounted for gas (UAfG) in general. It also aims to detail AusNet Services' historical performance and context of approach to UAfG minimisation.

In general the strategy aims to reduce and account for methane emissions from the gas distribution network installation and provide economic benefits via benchmark incentives.

It outlines options AusNet Services could employ during the fifth regulatory period (2018-22) with regards to the reduction/mitigation of UAfG, if the business decided that it was a priority based on actual performance trends and comparisons to existing benchmarks.

This strategy demonstrates that AusNet Services has a number of levers available to pull to minimise methane emissions and therefore limit the impact of carbon emissions, in-line with the Federal Government's global commitment to the COP21 Paris Agreement[A]

2 References

AMS 30-01	Asset Management Strategy – Gas Networks
AMS 30-51	Network Regulator Strategy
AMS 30-52	Mains and Services Strategy
AMS 30-57	Supervisory Control And Data Acquisition (SCADA) Strategy
Asset Integrity Australasia P/L	RP030 UAfG Phase B Short Report: Review of SP AusNet Strategy and Data Requirements for Desktop UAfG Review, 31 May 2011 RP031 UAfG Phase B Report: Review of SP AusNet Strategy and Data Requirements for Desktop UAfG Review, 5 October 2011

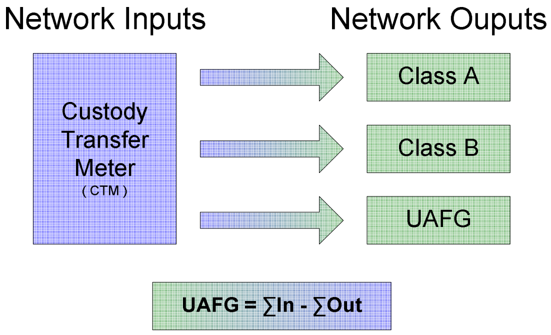
3 Introduction

Un-Accounted for Gas or UAfG is the difference between the total measurements of gas injected into a pipeline system and the total measurements of gas withdrawn from the same pipeline system with a correction for any changes in the quantity of gas stored in the pipeline over the measurement period. The gas stored (under pressure) in the pipeline at any instant is called the "linepack".

Specific to AusNet Services, UAfG is the difference between the amount of gas injected into the distribution network via Custody Transfer Meters (CTM's) and the amount of gas withdrawn by end consumers via individual consumer gas meters (refer to Figure 1). In relation to the number of these metering points there are a total of 40 CTM's or measurement injection points and a fleet of approximately 691,800 consumer meters. These consumer meters are broken into two classes; Class A and Class B (Refer to Section 4.1 for an explanation).

[A] The agreement was made at the 21st Conference of the Parties (COP21) held in Paris from 30th November – 12th December 2015.

Figure 1: Un-Accounted for Gas flow diagram



The difference or unaccounted amount is currently calculated and reconciled on an annual basis from data supplied by the Australian Energy Market Operator (AEMO) and retailer consumer usage data. The Distribution Tariff Agreement (DTA) requires AMEO to calculate the Reconciliation Amount in accordance with the formula and methodology as defined in the Gas Distribution System Code (GDSC).

This strategy presents some of the main contributors to the distribution network's UAfG and explores potential avenues for mitigation. It also details AusNet Services' approach to UAfG.

4 Background

4.1 UAfG Regulatory Benchmarks

The Gas Distribution System Code (GDSC) Version 11.0 currently sets out UAfG benchmarks for each Victorian gas distributor in Schedule 1, Part C and also stipulates the responsibilities of a gas distributor with respect to UAfG in Clause 2.4. The benchmarks express UAfG as a percentage of the aggregate quantity of gas injected into the distribution system for each Victorian gas distributor. Separate benchmarks are applied in respect of customer volumes.

The UAfG benchmarks are subject to a 5-yearly review and update by the Essential Services Commission (ESC), as formally requested by the Australian Energy Regulator (AER). The review deliberately coincides with a new regulatory period and as such applies to all three Victorian gas distribution businesses. As a result, this affects the cost of gas supply to retailers and ultimately impacts every Victorian household and business supplied with natural gas.

The Victorian gas distribution businesses are required to make submissions to the ESC on its proposed methodology prior to the new benchmarks being set. The UAfG requirements in the GDSC are intended to incentivise the gas distributors to *"…use all reasonable endeavours…"*[B] to minimise the level of UAfG.

There are currently two classes of UAfG benchmarks applied on the Declared Transmission System (DTS) and Non-DTS (see sections 8.5 & 8.6 for maps), based on whether a customer's annual consumption is greater than or less than 250TJ (250,000 GJ).

Class A: >= 250,000 GJ/pa

Class B: < 250,000 GJ/pa

Class A customers use more than 250 TJ's per annum and are typically serviced by the transmission/high pressure networks. Class B customers use less than 250 TJ's per annum and are typically serviced by high, medium and low pressure networks.

[B] Gas Distribution System Code Version 11, Section 2.4 (a) Unaccounted for gas.

Under the current Victorian UAfG model, retailers are required to purchase sufficient gas from producers to cover customer consumption and actual UAfG. Distributors are not funded for UAfG in their revenue requirements, consequently, retailers initially bear the cost of all UAfG. However if actual UAfG is greater than the benchmark, then the distributor pays an amount to the relevant retailer(s) equal to the cost of the additional gas lost. Where UAfG is lower than the benchmark, the relevant retailer(s) pay the distributor an amount equal to the cost of the gas that would have been required to meet the benchmark.

Specific to AusNet Services are the following benchmarks for the current access arrangement period, 2013 to 2017 taken from the GDSC.

Table 1: DTS and non-DTS system Un-Accounted for Gas benchmarks applicable to AusNet Services effective from 1 July 2013

	Class A benchmarks ≥ 250,000 GJ/pa	Class B benchmarks < 250,000 GJ/pa				
	2013-2017	**2013**	**2014**	**2015**	**2016**	**2017**
DTS	0.3%	5.4%	5.4%	5.4%	5.4%	5.4%
Non-DTS[C]	Same as Class B	5.8%	5.6%	5.3%	5.1%	4.9%

The reconciliation amount calculation between the retailers and distributors is performed annually by AEMO in accordance with the current UAfG Reconciliation Amount formula which is stated in the GDSC. (Part C). An extract of the Reconciliation Amount formula is provided in Section 8.2 of this document along with a working example of the Reconciliation Amount and Actual UAfG percentage in Section 8.3..

4.2 National Greenhouse and Energy Reporting System (NGERS)

The *National Greenhouse and Energy Reporting Act 2007*, the Regulations under that Act and the National Greenhouse and Energy Reporting (Measurement) Determination 2008 establish the legislative framework for a national greenhouse and energy reporting system.

The Australian Government's Department of the Environment and Energy publish NGER Technical Guidelines which describe the latest methods for estimating emissions and are based on the National Greenhouse and Energy Reporting (Measurement) Determination 2008 as amended ('the Determination') through the periodic public consultation and review process.

The Technical Guidelines provide additional guidance and commentary to assist reporters in estimating greenhouse gas emissions for reporting under the NGER system. The most current publication applies to the 2016-2017 reporting year.

The NGER Scheme's objectives are set out in the *National Greenhouse and Energy Reporting Act 2007*.

These comprise of:

- informing government policy formulation and the Australian public
- meeting Australia's international reporting obligations
- assisting Commonwealth, state and territory government programs and activities
- avoiding the duplication of similar reporting requirements in the states and territories.

[C] Non-DTS benchmarks do not distinguish between Class A and Class B.

For AusNet Services, the National Greenhouse and Energy Reporting System (NGERS) calculation will be based on asset count with emissions estimated and adopted from the American Petroleum Institute & American Gas Association.

As such, based on the NGERS calculation no direct correlation exists between the calculation of emissions and UAfG.

4.3 AusNet Services' Historical UAfG Performance

In relation to historical UAfG rates, between 2003-2011, AusNet Services had exceeded the benchmark. From 2012 onwards, the DTS UAFG benchmark has not been exceeded, as demonstrated by the figure and table below. The non-DTS benchmark has been exceeded for a number of years. Strategies to understand and potentially mitigate the causes of non-DTS UAFG are discussed in Section 8.5.2

Table 2: DTS – Past UAfG actuals and payments

	2010	2011	2012	2013	2014	2015	2016[D]
Class A Benchmark	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%
Class B Benchmark	5.00%	5.00%	4.90%	4.9% / 5.4%	5.40%	5.40%	5.40%
Weighted Average Benchmark	3.27%	3.26%	3.28%	3.50%	3.67%	3.87%	3.94%
Actual UAfG %	**3.53%**	**3.30%**	**2.92%**	**2.85%**	**3.18%**	**3.41%**	**3.04%**
UAfG Above Benchmark	0.26%	0.04%	-0.36%	-0.64%	-0.49%	-0.46%	-0.89%
Reconciliation Amount $'000	**-713**	**-121**	**1,053**	**1,759**	**1,244**	**1,472**	**2,711**

[D] Note, 2016 data had not been settled at the time of writing.

Figure 2: Actual DTS UAfG percentage[E] for the period 2010 to 2016 including Weighted Average Benchmark.

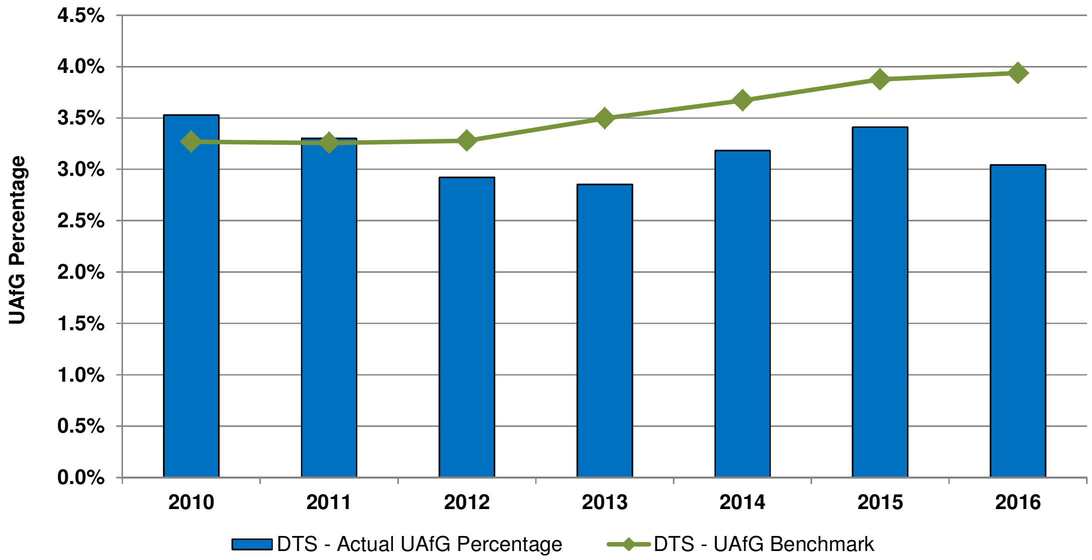


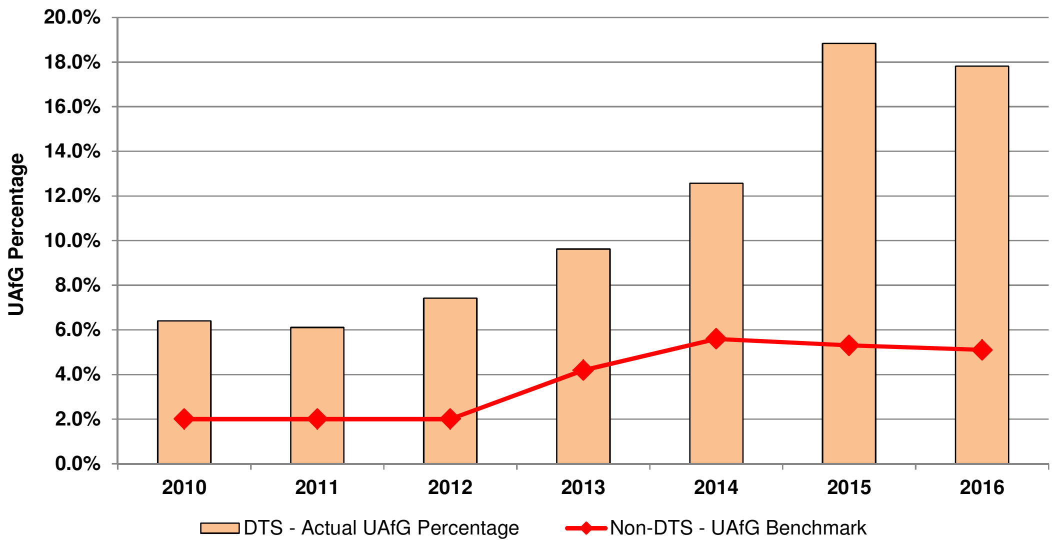
Table 3: Non-DTS Past UAfG actuals and payments

	2010	2011	2012	2013	2014	2015	2016[F]
Class A Benchmark	2.00%	2.00%	2.00%	0.30%	0.30%	0.30%	0.30%
Class B Benchmark	2.00%	2.00%	2.00%	2.0%/5.8%	5.60%	5.30%	5.10%
Weighted Average Benchmark	2.00%	2.00%	2.00%	4.19%	5.60%	5.30%	5.10%
Actual UAfG %	**6.40%**	**6.11%**	**7.43%**	**9.62%**	**12.57%**	**18.84%**	**17.82%**
UAfG Above Benchmark	4.40%	4.11%	5.43%	5.43%	6.97%	13.54%	12.72%
Reconciliation Amount $'000	**-143**	**-133**	**-190**	**-198**	**-261**	**-680**	**-1,146**

[E] Values displayed as positive numbers but are calculated as negative for loss from network.

[F] Note, 2016 data had not been settled at the time of writing.

Figure 3: Actual non-DTS UAfG percentage for the period 2010-2016 including Weighted Average Benchmark.



5 Sources of UAfG and Implementation Activities

This section is a summary of the findings of the AIA report mentioned in Section 2.

An explanation of the context of the report is provided in Section 6.

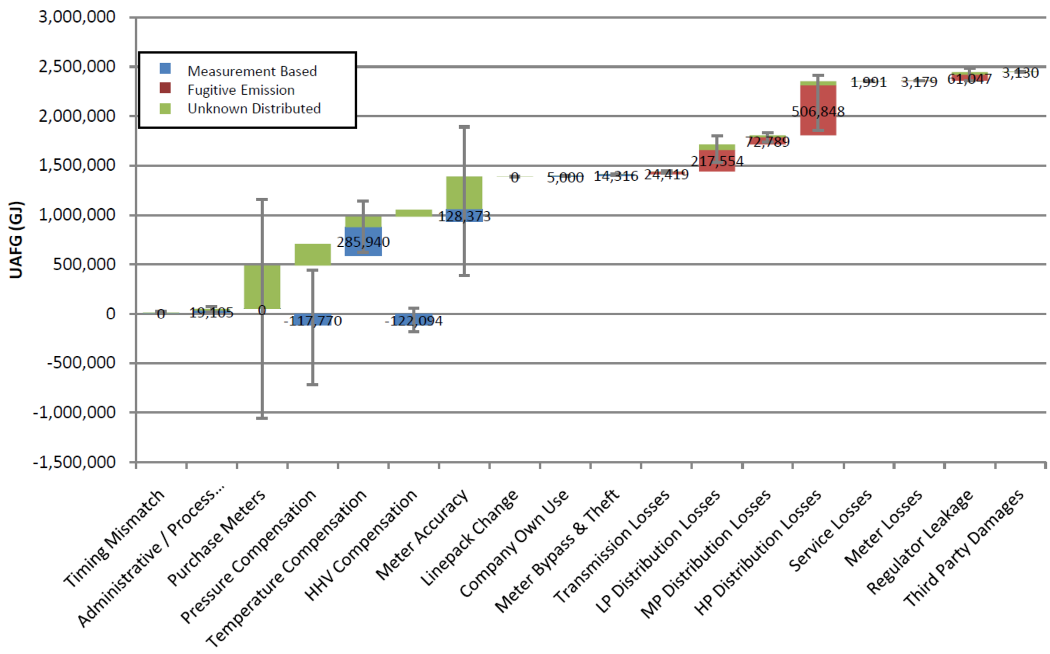
In general, sources that contribute to the value of the gas networks' UAfG can be divided into two categories:

1. *Measurement based* - Discrepancies in readings from various metering equipment, along with the various assumptions made during calculations of supply (i.e. heating values).
2. *Fugitive emissions* - These emissions comprise mainly leakage of gas, smaller amounts of leaked CO_2 and CO_2 produced via the oxidation of methane as it seeps through soil, before being released into the atmosphere.

Figure 4 shows the breakdown of AIA's assessment of the expected UAfG contribution for each category. Analysis was undertaken to assess the uncertainty surrounding each of the values. Each category had consistently different uncertainty based on the assumptions for each calculation. The uncertainty 'band' for some categories is significant (e.g. meter accuracy), indicating the high degree of uncertainty surrounding UAFG causes.

The UAfG estimation to each category results in 54% of actual UAfG not attributed to any category. This further emphasises the uncertainty associated with UAfG.

Figure 4: Annual Reconciled UAfG Breakdown[G]



The following sections discuss the identified UAfG sources.

5.1 Measurement Based

Discrepancies in measurement of gas provided by metering equipment can be attributed to the age, condition and operating limits of meters, as well as the mismatch in the timing of when meters are read. Pressure and temperature compensation also needs to be considered when comparing measurements made at meters, to measurements made at CTMs on the supply side.

These contributing factors are covered below. Also included are AusNet Services' current activities, along with an implementation plan if the decision is made during the 2018-22 access arrangement period to focus on the particular cause.

5.1.1 Timing Mismatch

Timing mismatch is caused by the difference in period of measurement between input and output collected meter data over a defined UAfG period.

Timing is particularly relevant for non-daily metered sites. Daily readings are available for CTMs and interval meters. For example, residential and commercial meters are read on a quarterly basis (and registered in the measurement system) in the middle of the third month, leaving the remainder of that month billed (and registered in the accounting system) as part of the following quarter. A difference between the two values can arise if there is a notable change in consumption in the latter part of the month.

Timing mismatch may affect UAfG by increasing or decreasing levels. Over multiple years the timing error will net out. That is a number of meter readings that are not included in one year will be incorporated in the UAfG calculation for the next year. For each UAfG calculation the total error is the sum of the timing errors from the beginning and end of the UAfG period.

The key factors that will lead to a UAfG error due to timing mismatch are:

[G] Source: *Review of SP AusNet Strategy and Data Requirements for Desktop UAfG Review,* Asset Integrity Australasia P/L, May 2011.

1. Basic (non-daily) meters that are have been not been read for part or all of the UAfG period;
2. Basic (non-daily) meters that have readings allocated to different UAfG periods; and,
3. Adjusted meter readings (for all classes of meters) that require post read adjustments.

Implementation Plan:

1. An indication of the number of estimated meter reads within AusNet Service' network area should be established. This would confirm that UAfG due to timing mismatch is at a negligible level and provide a benchmark for AusNet Services to compare periodically.
2. The process for estimating readings could be audited in detail to ensure that the estimation follow the process required by AEMO. Auditing may also determine a more accurate estimate of the associated errors. Any large adjustments uncovered after UAfG reconciliation should be adjusted to the time period in which they occurred when analysing UAfG trends for regulatory or other purposes.

Current Activities:

AusNet Services has addressed Part 1 of the implementation plan above and is satisfied that the current number of estimated meter reads on its network is not a contributor to UAfG.

Part 2 would be addressed if the number of estimated meter reads compared to actual meter reads reaches a concerning level.

5.1.2 Purchase Meter (Custody Transfer Meter - CTM) Compensation

The AusNet Services UAfG calculation is based on the simple concept of :

Network Input – Network Output = Losses (UAfG)

The network input is measured in volume or mass units, before conversion to an energy value in Giga Joules (GJ). This is computed from the sum of each Custody Transfer metered (CTM) volume multiplied by the appropriate Higher Heating Value (HHV) associated with the CTM measurement point, thus giving the summed total as an energy value in GJ.

Similarly the network output in GJ is the sum of the metered energy values computed for both the Class A and Class B meters connected to the network. The summed meter volumes are multiplied by an appropriate HHV to convert the volume into energy. See section 5.1.6 for comments on the use of HHV values.

Implementation Plan:

Gas purchased and metered at injection points has uncertainties of ±2.0% (energy basis). The values for supply from CTMs should be adjusted accordingly in UAfG calculations, in conjunction with known CTM accuracy. Where possible, CTMs should be up-to-date and kept within tolerance to minimise the value of UAfG.

Current Activities:

With the exception of the CTM supplying the non-DTS network, all CTM's supplying gas to AusNet Services' downstream networks are maintained and calibrated by APA Group on an annual basis.

5.1.3 Company's Own Use

AusNet Services' own gas consumption from the network is metered but not declared as sales. This amount of gas is overlooked if consumption values in UAfG calculations are based purely on gas sales. The company's own use needs to be accounted for.

Current areas which account for this type of use are City Gate gas heater facilities. Network gas is used to fuel the heater burners, which in turn heat the gas before its pressure is regulated. These facilities differ in the degree to which gas is been metered and billed.

The UAfG caused by unmetered system own use gas is estimated to be 5,000 GJ (maximum).

Implementation Plan:

All water bath heaters, and any other sites or installations where Own Use Gas is not metered, should be separately metered, and hence remove this element from UAfG.

Current Activities:

Approximately 50% of AusNet Services' own gas use metering at city gate heaters are actual reads.

5.1.4 Inclusion of High-Volume Meters

Although there are only a small number of high-volume meters on AusNet Services' network, they are responsible for measuring large volumes of gas, and so a small error can have a significant impact on UAfG.

Implementation Plan:

Include high-volume meters in any calibration/maintenance audit using the same criteria applied to CTM's.

Current Activities:

AusNet Services has no current activities related to a Class A customer audit. However, the meter/regulator units at large industrial plants are subject to regular maintenance checks to ensure their continued safe operation.

5.1.5 Pressure and Temperature Compensation for Meters

The gas purchased from Longford is supplied at 15℃ and 101.325kPa – metric standard temperature and pressure. The volume of gas sales measured at a customer meter, now at a much lower pressure and temperature, is multiplied by a factor of 1.010856 (1.0856%) to correct the value to the metric standard conditions at the supply source. This 1.0856% discrepancy forms part of the network's overall UAfG.

Changes in metering pressure and atmospheric pressure affect the volume of gas that is metered. These changes are more profound at lower metering pressures (i.e. 1.1kPa). To compensate for the change in atmospheric pressure based on ground elevation, the following calculation could be performed to correct the values for UAfG volume:

$$UAFG_{atm} = V_m \left[\frac{(P_a - P)}{1013.25} - 1 \right]$$

$UAfG_{atm}$	= UAfG due to variation in atmospheric pressure at elevation
V_m	= volume of gas metered
P_a	= atmospheric pressure at sea level (mB)
P	= pressure correction at elevation (mB)

Assuming the average ground elevation of Melbourne is 70m above sea level, a pressure correction of 8.24mB in atmospheric pressure is applied. Modelling of the elevation at the meter locations where UAfG readings are taken, could be performed to further refine this estimate.

Temperature compensation is required since the temperature of the gas supplied will vary depending on the soil temperature. It is assumed that the gas temperature is the same as the soil temperature at the pipe depth. For UAfG due to the temperature variation between Longford and the meter:

$$UAFG_{temp} = V_m \left[\frac{288.15}{(T_m + 273.15)} - 1 \right]$$

$UAFG_{temp}$ = UAfG due to temperature variation of gas

V_m = volume of gas metered

T_m = temperature of gas metered (degrees Celsius)

A potential solution to incorporating UAfG due to the pressure variations at consumer meters is to gather altitude data for network areas and calculate the overall $UAfG_{atm}$.

For a value of $UAfG_{temp}$, measurements of soil temperature at pipe depth can be taken at various locations within a network and then used in the above calculation for a general value for that particular network.

It is to be noted that current pressure and temperature correction factors are determined and set by AEMO and gas distributors have limited ability to alter these values.

Implementation Plan:

Assuming the industry is willing to change the current framework for pressure and temperature correction factors, the calculation of values for UAfG due to pressure and temperature compensation could be performed in an automated fashion. This could occur. via SCADA monitoring at field and district regulators, or by performing on-the-spot measurements with mobile equipment at fringe points, during the collection of fringe pressure chart recordings.

Current Activities:

AusNet Services has no current activities to influence industry change on pressure and temperature correction values to implement automated correction.

5.1.6 Higher Heating Value (HHV) Compensation

Unaccounted for gas is generally specified in GJ. This value is based on the volume metered at CTM's, and the HHV for the source gas that is injected at each location. This calculation is performed at each CTM, resulting in the GJ of gas that is supplied into the network at that CTM location. On the customer side, the average HHV for all CTMs across the entire network is used to calculate the consumption in GJ. With all other factors constant, a discrepancy remains between the total amounts of gas metered at CTMs, and the total customer consumption (in GJ).

Implementation Plan:

The implementation of HHV compensation involves a review of the application of HHV values in the calculation of metered energy values at CTM's fitted with coriolis meters. This should be undertaken or included with the proposed audits of these sites.

Current Activities:

AusNet Services has no current activities relating to the review of the application of HHV values. A Heating Value (HV) review was undertaken in 2008 which showed that application of a statewide HV is the best economic option for AusNet Services.

5.1.7 Meter Accuracy and Regulator Settings

Inaccuracies in UAfG estimates can arise due to incorrectly set customer regulators. The magnitude of this error is expressed by the following:

$$\%Error = \frac{(P_m - P_b) \times 100}{(P_m + 101.325)}$$

P_m	= actual metering pressure (kPa)
P_b	= correct metering pressure (kPa)

If customer metering pressure is set too high (e.g. 0.5% higher), the result is a metering error of 0.5% which contributes excessively to UAfG. This error increases for large customers that have incorrectly calibrated regulators with a greater deviation between actual and correct metering pressure.

The accuracy of meter readings is also affected by the age and model of meters. The detection of out-of-range meters can lead to a replacement scheme and contribute to a more accurate estimate of UAfG. Meters should also be correctly matched to operating conditions, to ensure that the maximum possible accuracy is achieved across the entire range of measurement.

Calibration of industrial and commercial meters can also account for UAfG.

Implementation Plan:

The performance of all CTM and Class A meters should be included in a meter audit to assess their current performance against initial design standards to ensure that there has been no change in performance over time.

A review of the procedures and techniques used by AusNet Services to identify faulty or problematic batches of Class B meters should be undertaken to ensure they meet current operation needs.

Current Activities:

In line with Regulatory requirements stipulated in the GDSC, AusNet Services is required to test families of meters for accuracy on an annual basis as per the requirements set out in AS/NZS 4944. Any meter families that fall out of the acceptable error range are subject to a proactive meter replacement program This ongoing testing and replacement program enables meter accuracy to be maintained within a range and assists in bounding UAfG related to meter inaccuracy to a range.

In addition, large industrial and commercial customers' metering units undergo regular maintenance checks to ensure their continued safe and reliable operation.

5.1.8 Meter Bypass and Theft

Although uncommon, theft of gas can occur, whereby industrial customers can open the bypass around a meter to reduce the metered consumption. Similarly, domestic customers could disconnect their meters and turn them around to make them run backwards.

Implementation Plan:

Measures can be taken to reduce the incidence of both of these modes of theft, by placing tamper-proof seals on valves and changing the design of couplings so that everyday tools cannot be used to disconnect meters. Another scheme involves incentivising meter readers to identify and report evidence of meter or bypass tampering.

Current Activities:

AusNet Services relies on its gas meter readers to identify and report instances of meter bypass and theft. Instances are found but they are of a very small number and, hence, theft is understood to be having an immaterial impact on UAFG levels.

5.2 Fugitive Emissions

The fugitive emissions level offers arguably the greatest potential for reduction in the value of UAfG. Historic data has shown that a large amount of UAfG can be attributed to direct losses in the distribution network. These fugitive emissions from the distribution network comprise general leakage, theft and other instances of unintended release of gas. Some sources of UAfG on the fugitive emissions level are mentioned below, accompanied by strategies for reduction.

5.2.1 Mains Renewals

A component of UAfG can be attributed to leaks within the distribution system. The completion of mains renewal programs, to replace old, leak-prone cast iron pipes with high pressure-rated, polyethylene pipes will act to curb the number of gas leaks originating from pipes in the distribution system.

Moreover, as LP networks are replaced by HP, decreasing the overall demand in the remaining LP network, the outlet pressure from the district regulators which feed the LP networks can be reduced, which in turn reduces the rate of leakage from the remaining LP cast iron pipes. It also includes decommissioning of district regulators which can be a potential source of UAfG.

AusNet Services notes that the correlation between the mains renewal program and its effect on UAfG is unclear. AusNet Services' submission to the ESC regarding the 2013-17 benchmark review stated:

> *SP AusNet's (AusNet Services') analysis shows that if the implied relationship of leak rate per km is assumed to be true, replacing the entire low pressure network would only achieve a UAfG saving of $1 million per annum compared to a capital cost of $275 million. This analysis illustrates that the current incentive mechanism cannot drive the LPMR program [low pressure mains replacement], instead, its focus must remain the safety of the network.*

In accordance with AusNet Services' Mains and Services strategy, renewal programs are performed in areas considered to be 'high risk and high benefit'. Strategic analysis is used to identify areas that fit these criteria, including areas with high rates of pipe breakage (High Breakage Zones) and low pressure (LP) areas with cast iron pipes that are within close proximity to existing high pressure (HP) networks. Also taken into account is the density and land use of surrounding areas to determine the consequence of a leak.

Implementation Plan:

If UAfG minimisation was the only driver for the mains renewal program, AusNet Services should prioritise replacement based on the following factors:

- Focus on the cast iron and unprotected steel networks;
- Prioritise the above where economical the MP network which has the greatest leakage rates; and,
- Prioritise the above on high risk mains which are of greatest risk of failure, and at locations that are of greatest risk to the public and property.

Current Activities:

AusNet Services' Low and Medium Pressure Replacement Programs already take the above recommendations into account when prioritising areas of the network for upgrade to high pressure.

5.2.2 Leakage from Valves and Regulators

Faulty valves, CTMs and customer regulators also contribute to UAfG. Leaks can occur from some domestic meter regulator models, which vent gas to atmosphere as part of normal operation as well as when faulty. The volume of vented gas is not a significant proportion of overall UAfG.

Implementation Plan:

Faulty customer regulators should be replaced in a timely manner to minimise possible leakage losses.

Current Activities:

AusNet Services received regulatory approval in the upcoming access arrangement period 2018-22 to implement a proactive domestic regulator replacement program. Its aim is to proactively replace domestic regulators before they become faulty.

5.2.3 Third Party Damages

Third party damages are a common occurrence on gas distribution assets. Some damage can be superficial without any detrimental long term damage to the asset, while other damage can result in release of gas which results in UAfG. While third party damages can occur on any part of the network, the majority are related to service damages by consumers and contractors (i.e. fencing contractors) working in the vicinity of buried gas assets without adequately ascertaining their location.

Implementation Plan:

AusNet Services will endeavour to reduce the number of third party damages by vigilant management and following through with the party responsible for the damage and gas loss to provide compensation.

Current Activities:

AusNet Services monitors and reports internally on the rate of third party damages on mains and services on a monthly basis. This also includes trending analysis from a safety perspective. Trending indicates that the rate of third party damages on mains and services in AusNet Services' network is decreasing.

AusNet Services provides a free asset locating service for members of the public, and also provides asset location maps to the free industry-wide Dial-Before-You-Dig (DBYD) service.

5.2.4 SCADA Pressure Control

The leakage from a gas network as a consequence of through wall corrosion or faulty joints or material failure is the main source of UAfG in a distribution network, especially if it contains significant amounts of older metallic pipes. The leakage rate from the low pressure networks increases linearly with increasing pressure. One of the most effective methods of reducing UAfG is, therefore, to reduce the average pressure in the network.

The network requires a minimum operating pressure at the inlet of the customers' meter for the safe and efficient operation of appliances. This will require a source pressure at the regulator supplying the network that is sufficient to maintain the minimum pressure at the extremity of the network at times of peak demand.

The critical factor for managing UAfG is how the source pressure at the upstream regulator is managed at lower gas demand, when the source pressure, if not properly managed, will provide excessive pressures at the extremities of the network, and hence increased levels of UAfG.

Technology is now available that can manage the source pressure at the upstream regulator on a smooth profile that matches the network pressure differential, and does not require weekly attention. The technology (Profile Controllers) is well established in the UK and incorporates “learning algorithms” that overcome weekend and seasonal effects on demand. There are also fail safe options should emergency conditions arise that require the normal pressure profile to be over-ridden.

Implementation Plan:

AusNet Services identifies low pressure networks that would benefit the most from the application of Profile Controllers, especially networks that are not prioritised for replacement and have large pressure differentials at times of peak demand.

Current Activities:

As AusNet Services progresses with its mains renewal programs, low pressure mains are removed from the networks. This means that upstream regulators supplying them are being steadily decommissioned. There would be little benefit in installing new equipment (Profile Controllers) to these regulators if they are to be decommissioned in the near future.

The pressures in the majority of AusNet Services’ high pressure networks can be increased or decreased remotely. In an emergency situation (i.e. damaged main) this would reduce the amount of gas lost to atmosphere. The driver of network control is safety to the public but a secondary benefit is UAfG reduction.

6 AusNet Services’ Approach to UAfG

As described in Section 4.3, historically AusNet Services did not outperform the UAfG benchmarks set by the ESC. From 1999 to 2011 the actual amount of gas unaccounted for from the distribution system was greater than the allowable amount. During this time period AusNet Services was financially compensating retailers to reconcile the gas loss.

In 2010, AusNet Services engaged Asset Integrity Australasia P/L (AIA) to undertake a review of UAfG relevant to AusNet Services. This was split into two stages and involved a review of AusNet Services’ current UAfG strategy, benchmark methodology and data acquisition to establish the major sources of UAfG in AusNet Services’ distribution network. The final report was received in May 2011 with a detailed version received in October of the same year.

The content of the report firstly broke down the sources of UAfG and attempted to quantify them by estimating based on assumptions. Figure 4 shows all the potential sources of UAfG on AusNet Services’ network and also the uncertainty associated with them based on the assumptions for each calculation. Importantly, there is no single contributor to UAfG that AusNet Services could focus on minimising to have a significant benefit and reduce UAfG. The other important conclusion of the AIA report was that 54% of actual UAfG was not able to be attributed to any category. This emphasised the uncertainty associated with UAfG. In Figure 4, the ‘Unknown Distributed’ UAfG component was redistributed to categories based on their relative uncertainty.

The AIA report made four key recommendations:

1. *Purchase Meters (Custody Transfer Meters) Accuracy.*
   Further investigate the largest meters to ensure they are set up correctly and calibrations are being correctly conducted by APA Group / AEMO. This requires analysis of the processes and rights used to calibrate and maintain CTM’s and may include site analysis of key CTM sites.

2. *Large Tariff D Customer Uncertainty.*

Review these meters to ensure that all aspects of metering design, operation and maintenance are correctly undertaken by AusNet Services. Priority should be given to the largest Tariff D meters.

3. *Temperature Compensation for Basic Meters.*
   Review of the method and ability to change fixed correction factors for basic meters to reflect the actual weighted average temperature of gas being measured. Consideration needs to include the regulatory position and ability to change. This is likely to include a fuller assessment of temperature data over the network. Alternatives should be determined for the use of meter correction in certain locations that are known to have colder gas.

4. *Classification of Class A Meters*
   Review in conjunction with the GAAR to determine the effect of enhancing the definition of Class A customers and changing the definition to either:
   a. Remove Class A benchmark.
   b. Modify so that the benchmark applies to customers on transmission pipelines only.
   c. Consider other pressure based UAfG benchmarks.

Appendix 8.1 provides an assessment of the AIA recommendations, including the costs and timeframes involved and potential UAFG impacts.

Having regard to these recommendations and their potential to reduce UAfG, AusNet Services' initial focus was on the first recommendation (CTM accuracy) and establishing the current calibration and confirmation of uncertainty. A request was sent to APA (who perform the maintenance and calibration) to notify AusNet Services of upcoming activities. APA now notify AusNet Services when CTM's are planned to be calibrated. AusNet Services can then have an on-site presence.

An investigation was performed on the larger Tariff D customers to identify metering accuracy and any anomalies that could influence UAfG. The outcome of this investigation was that the total amount of gas lost was negligible from Tariff D customer meters and accordingly minimal economic benefit.

However in 2012, as shown in Figure 2, for the first time since the Victorian gas network was disaggregated in 1999, AusNet Services' UAfG percentage was below the benchmark. This was the first time that AusNet Services received financial compensation from retailers. Accordingly, internal business priorities shifted away from a direct focus on minimising UAfG through specific projects or investments. This approach was recognised by the ESC at the last UAFG Review in 2013, where it stated that, *"…UAfG is not necessarily a big enough 'problem' to drive investment decisions – the GDBs' (gas distribution businesses') primary obligations relate to safety and reliability"*[H]. We agree with the Commission that maintain safety and reliability are the primary drivers of our asset replacement programs, rather than reducing UAFG.

On the basis that AusNet Services was seeing a positive UAfG reconciliation outcome through lower UAFG outcomes relative to the efficient benchmark, there was limited incentive for the business to continue investing resources to minimise further UAfG reductions, particularly given the uncertainty inherent in UAFG causes. Again, this is consistent with the views expressed by the ESC in relation to initiating specific projects to reduce UAFG: "*Further, it may not always be cost effective to, for example, significantly improve meter accuracy or deter theft.*"[H].

Under this approach, AusNet Services continued to have positive UAfG outcomes in the DTS during the current 2013-17 access arrangement period. Accordingly, a shift in focus and resources to UAfG minimisation has not been considered prudent during this period.

However, UAfG in the non-DTS network (see Section 8.5 for an explanation of AusNet Services' non-DTS network) began to worsen in recent years, reaching 18.8% of gas lost in 2015. Due to the usual time-lag in data

[H] Source: *Gas Distribution System Code. Review of unaccounted for Gas Benchmarks. Final Decision*, Essential Services Commission, June 2013.

settlement from a number of stakeholders,[i] AusNet Services kicked-off an internal investigation into the reason behind the increase in early 2017.

Details of the investigation workings and current activities are in Section 8.5.2. Early on in the investigation the focus was on determining whether the non-DTS UAfG was due to fugitive emissions or measurement error. The conclusion was that the loss was measurement-related and so subsequent investigations focused on proving this.

AusNet Services' approach to UAfG in the current regulatory period (2013-17) has been different for the two different portions of the network depending on their actual UAfG performance. The DTS UAfG has been below the benchmark since 2012, indicating that a continuation the current approach was appropriate. The non-DTS actual UAfG has recently worsened, triggering an internal investigation.

The approach outlined above is consistent with AusNet Services' gas network objectives:

1. **Maintain network safety in accordance with the Gas Safety Case**

   Maintain the alignment to AusNet Services' commitment to 'Mission Zero'. The objective to maintain network safety is in recognition of AusNet Services' current safety performance and design of the gas network.

2. **Maintain top quartile operating efficiency**

   Alignment to AusNet Services' Corporate Business Plan with the aspiration to operate "all three core networks in the top quartile of efficiency benchmarks".

3. **Undertake prudent and sustainable network investment**

   Alignment to AusNet Services' obligation to undertake prudent and sustainable network investment, as defined in the National Gas Rules and Gas Distribution System Code.

4. **Delivery of valued services to our customers**

   Establishes the need to better understand our customers (their needs and behaviours) and deliver the services they value.

Additional information can be found in AMS 30-01 *Asset Management Strategy – Gas Networks.*

Of note is the internal treatment of UAfG as a 'Monitor' metric to maintain consistency with the third gas network objective of 'Undertake prudent and sustainable network investment'. This is consistent with the recent actual UAfG performance of the DTS network.

7 Summary

Future management of UAfG will involve review of the measurement of gas supply and consumption within the distribution network, and the minimisation of fugitive emissions.

Improvements in measurement equipment could be implemented gradually to supplement these refined techniques to arrive at an improved estimate for UAfG. Cost of such equipment requires additional work to derive whether such capital investment would yield substantial benefits to be economically justified. We also

[i] We received the 2014 UAFG Injection, NSL and pricing data from AEMO on 26 October 2015. But, there was a discrepancy between our data and AEMO data. This took a significant time to address (multiple follow ups with AEMO). This was resolved in Aug 2016. The 2015 UAFG injection, NSL and pricing data was received on 19 July 2016. We questioned the AEMO injections data in August because we had some differences and then in September we asked AEMO to confirm the non-DTS injections because they were so high. AEMO responded in Jan 2017 that the injections data was correct, according to its records.

note that our current meter replacement strategy is consistent with our regulatory obligations, and that meter accuracy is not a current area of concern.

On the fugitive emissions level, a number of longer-term measures can be taken to reduce UAfG, including the renewal of old, leak-prone mains, replacement of equipment that is out-of-calibration, and reducing third party damages.

Consideration should be given to all of these measures along with other emerging techniques and technologies, to form a cost-effective approach to reducing UAfG. Importantly, AusNet Services' ongoing strategy will be influenced by current UAfG trends on our network, and the incentive properties of the UAfG benchmark regime. Under this regime, gas distributors will only incur expenditure to reduce UAfG where doing so will result in a financial reward that exceed this expenditure.

In the upcoming regulatory period 2018-2022, AusNet Services will continue with its current approach to UAfG of undertaking prudent and sustainable network investment. The costs and benefits of activities specifically targeted at reducing UAFG will continue to be assessed, particularly if UAFG increases are observed. Appendix 8.1 demonstrates the framework that is used to evaluate the merits of such activities (in this case the actions identified by AIA).

8 Appendix

8.1 AIA Report Top Four Findings Matrix

	Cost	Economic Benefit	Degree of Difficulty	Time Required	Comments
	High/Low	High/Low	High/Low	Short/Long	
CTM Accuracy	**Medium** The cost would be internal resource availability and workload prioritisation, along with engaging someone with specialist technical knowledge.	**Uncertain** According to AIA study it has the greatest uncertainty of all UAfG sources.	**Low** Requires calibration and maintenance data. **High** Requires specialist technical knowledge of how CTM's are designed and operated.	**Medium** Depends on data availability. APA performs calibration and maintenance activities because they own the CTM asset.	Economic benefits unclear. Will take a long time to obtain APA data and implement.
Large Tariff D Meters Uncertainty	**Low** The only cost would be internal resource availability and workload prioritisation.	**Uncertain** According to AIA study it has the second greatest uncertainty of all UAfG sources.	**High** Requires a person with sound technical knowledge of how large Tariff D meters should be designed and operated.	**Long** Will need to treat each Tariff D meter individually.	Economic benefits unclear. Requires sound technical knowledge and long time frame to implement.
Temperature Correction for Basic Meters	**High** Requires industry process change and additional measurement equipment.	**High** Potentially high benefit according to AIA study. Highest proportion of measurement-based gas loss.	**High** Need to link ground and gas temperature depending on customers' location requiring extensive data collection. Would also require extensive regulatory/industry stakeholder engagement and change (i.e. AEMO, other Victorian DB's, ESC, AER etc.)	**Long** Need to set up, collect and analyse at least 1yr worth of data.	Economic benefit is potentially high, but high degree of difficulty is a barrier to implementation.
Class A Customer Classification	**Low** The only cost would be internal resource availability and workload prioritisation.	**High** Potential to be high if a large number of current Class A customers should actually be Class B.	**High** If AusNet Services go down the path of changing 'Class A' classification to 'any customer supplied from the transmission network' this would be an industry change & require extensive [illegible] engagement and change management. **Medium** Classification is based on initial load, need to gather and analyse real-time data.	**Long** Only available timeframe to change classification definitions would be every 5 years at the reset time. All upfront internal work would need to have been completed before then.	Economic benefit is potentially high, but high degree of difficulty and large timeframe is a barrier to implementation.

8.2 UAfG Reconciliation Amount

Reconciliation Amount

The reconciliation Amount is:	(X+Y) x (B-A)
Where:	
X =	the quantity annual price of Gas, using spot and contract prices and quantities, as determined by AEMO for the previous calendar year expressed in $ per gigajoule.;
Y =	the average transmission tariff for the previous calendar year expressed in $ per gigajoule as calculated under the transmission provider's prevailing reference tariffs.;
A =	D – (E/(1-G))
Where:	
D =	the quantity of Gas withdrawn from the Transmission System by the Distributor for Retailer at the Connection Points for the previous calendar year;
E =	the quantity of Gas withdrawn by Distributor for Retailer at all Class A Supply Points from the previous calendar year.
B =	H/(1-F)
H =	the quantity of Gas withdrawn by Distributor for Retailer at all Class B Supply Points for the previous calendar year;
F =	the benchmark flow rate for gas for Class B Supply points set out above.
G =	the benchmark flow rate of Gas for Class A Supply Points set out above.

8.3 Working Example of UAfG Reconciliation Amount

Reconciliation Amount

The reconciliation Amount is:	(X+Y) x (B-A)
Where:	
X =	$2.956400
Y =	$0.337600
D = (CTM)	71,833,005 (GJ)
E = (Class A Usage)	28,826,726 (GJ)
G = (Class A Benchmark)	0.3%
H = (Class B Usage)	40,499,032 (GJ)
F = (Class B Benchmark)	4.5%
Calculations	
A =	D – (E/(1-G)) = 71,833,005 – (28,826,726/(1-0.003)) = 42,919,539 (GJ)
B =	H/(1-F) = 40,499,032/(1-0.045) = 42,407,363 (GJ)

Reconciliation Amount is: (X+Y) x (B-A)

(2.956400+0.337600) x (42,407,363-42,919,539)

(3.294000) x (-512,176)

-$1,687,108

Actual UAfG is: ((E+H)/D)-1

((28,826,726+40,499,032)/ 71,833,005)-1

(69,325,758/71,833,005)-1

0.965096-1

-0.0349 or -3.49%

8.4 Working Example of Gas Consumed During Mains Commissioning

This quantity of gas can be estimated using the following equation:

$$UAFG_{com} = V\left(\frac{P_{avg} + 101}{101}\right) \times \frac{1}{Z} \times HV \times 10^{-6}$$

UAfG	= quantity of gas used to commission main (TJ)
V	= internal volume of the main (m^3)
P_{avg}	= average operating pressure of the main (kPa)
Z	= supercompressibility of gas at average pressure, P_{avg}
HV	= heating value of gas = 38.7 MJ/m^3

$UAfG_{\text{quantity of gas used to commission main}}$ = 0.0837 + 0.0335 + 0.0111 = **0.1283 (TJ) or 1,283 (GJ)**

Assumptions:

Mains Breakdown based on 220km.pa

Small Diameter:

- 200km @ 63mm Polyethylene
- Internal Diameter 50mm
- Volume 393m^3

Large Diameter:

- 20km @ 125mm Polyethylene
- Internal Diameter 100mm
- Volume 157m^3

Services Breakdown

- Based one service per 10m of main laid
- Equates to 22,000 services/annum
- Service size 16mm Polyethylene
- Internal Diameter 11mm
- Volume 52m^3

Where:

V = 393+157+52=602 m^3

P_{avg} = 450kPa

Z = 0.99

HV = 38.7 MJ/m^3

8.5 Non-DTS System: Carisbrook

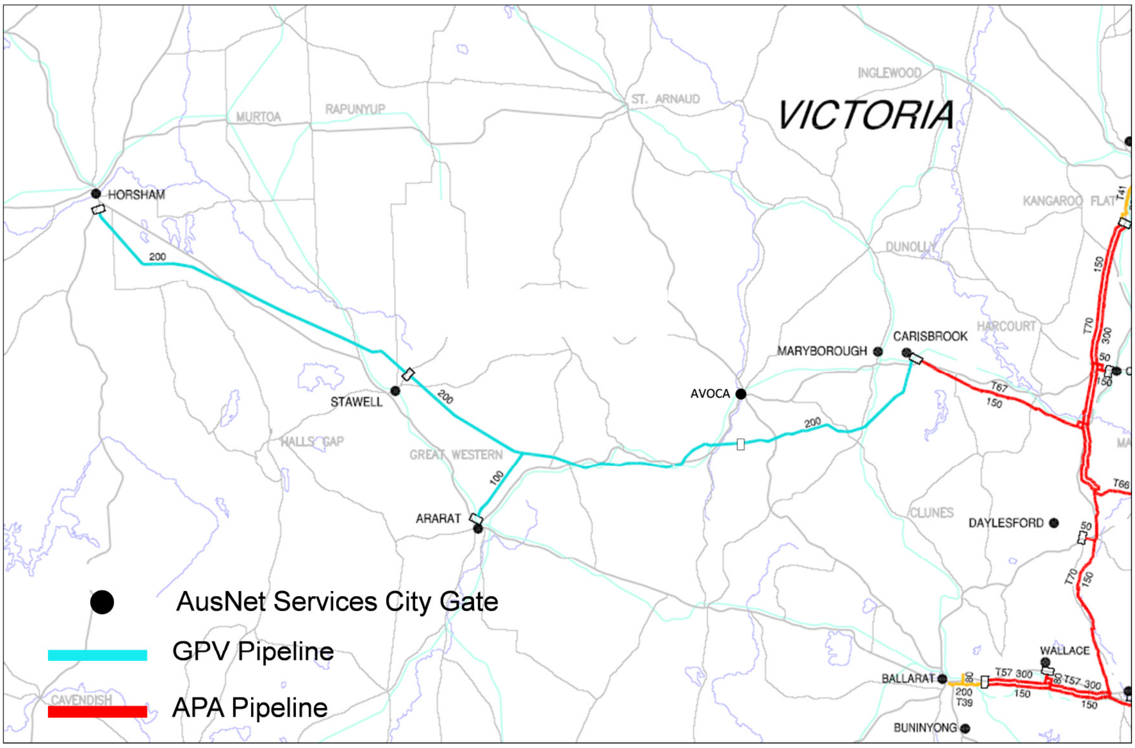
8.5.1 Network Background and Map

AusNet Services currently has four townships, Avoca, Ararat, Stawell and Horsham, fed from an intermediate pipe-line known as the Carisbrook to Horsham Gas Transmission Pipeline. This pipeline is in-turn fed from the 150mm DTS (T67-18) at Carisbrook. The Carisbrook to Horsham Gas Pipeline System encompasses the Carisbrook Custody Transfer Station (CTS), the Ararat Takeoff Station (ATO), the connecting pipelines between the CTS, the ATO and the city gates at Avoca, Ararat, Stawell and Horsham (plus valves, pig receiver/launchers etc). The majority of the transmission pipeline is 168.8km of DN200 (8”) with an additional 13.8km of DN100 (4”) pipeline from the ATO to Ararat City Gate.

Built in 1998, the Carisbrook to Horsham pipeline operates around 6800kPa and is reduced to distribution pressures of approximately 450kPa at Avoca, Ararat, Stawell and Horsham city gates.

In terms of ownership the Carisbrook to Horsham Gas Transmission Pipeline is currently owned and operated by Gas Pipelines Victoria Pty Ltd (GPV). GPV is a wholly-owned subsidiary of the Energy Infrastructure Trust which is managed by ANZ Infrastructure Services Limited ("ANZIS").

Figure 5: Carisbrook Pipeline and AusNet Services City Gates



8.5.2 Non-DTS Investigation into causes of UAfG increase

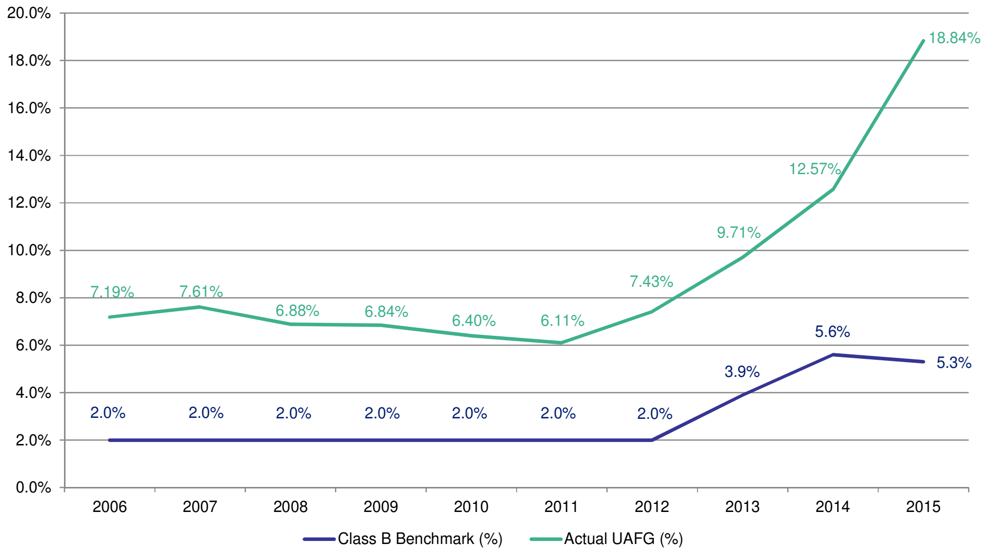
Background

Non-DTS UAfG consistently fell each year between 2007 and 2011. The ESC determined that this downward trend was indicative of "efficiencies" AusNet Services was experiencing in relation to this network and adjusted the 2013-2017 UAfG benchmarks to (1) first bring the benchmark into line with recent actual UAfG and (2) continue the downward trend. AusNet Services did not agree with the ESC's approach to setting this forward benchmark.[J]

In 2012 and 2013, non-DTS UAfG increased from 6.11% to 9.71%. Whilst this was higher than previous years, it was more in line with historical actuals (UAfG had historically been around 7% in 2006 and 2007) and although 2013 was high, UAfG is known to fluctuate year-on-year.

Final 2014 UAfG data was not received from AEMO until May 2016 and final 2015 UAfG data was not received until September 2016. This data showed that non-DTS UAfG increased to 12.57% in 2014 and 18.84% in 2015, per Figure 6.

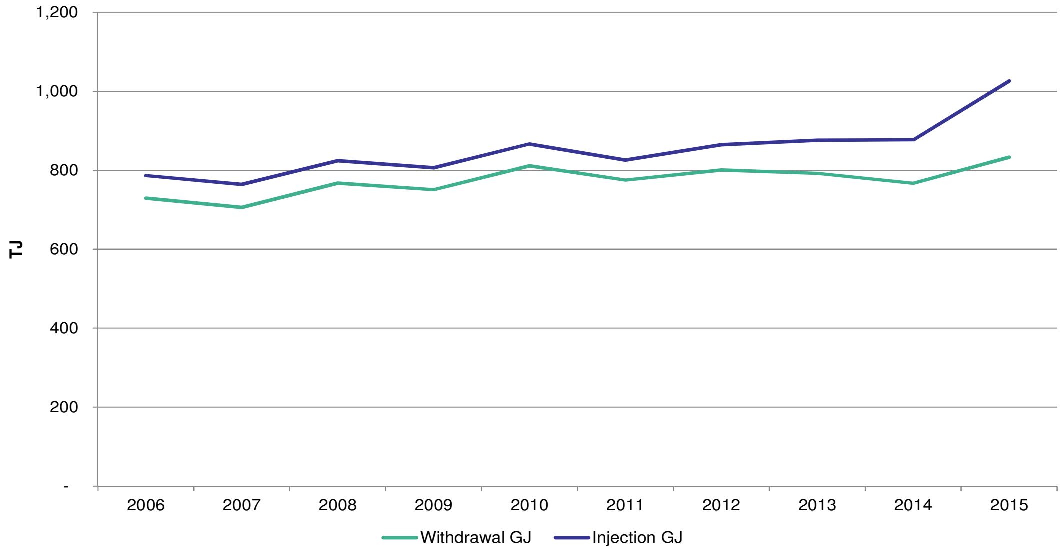
Figure 6: Non-DTS UAfG v. Benchmark 2006-2015



UAfG represents the difference in injections into the distribution network (via a Custody Transfer Meter (CTM) operated by the transmission pipeline operator APA) and withdrawals from the distribution network, as measured by meters at the distribution customers' premises. Figure 7 presents the injections into and withdrawals from the non-DTS network over the past decade.

[J] SP AusNet, *UAFG Benchmarks Submission: Attachment*, December 2012, p.7

Figure 7: Non-DTS injections and withdrawals 2006-2015



The sharp increase in non-DTS UAfG has led AusNet Services to undertake several investigations of the potential causes for the increase. These are described in the sections below.

Investigations

Actual v. measured loss -

At the outset, it is important to note that the recorded UAfG can either be an *actual* loss or a loss associated with a *measurement error*. That is, if the injection and withdrawal figures accurately reflect the physical amount of gas flowing into and out of the network, the loss is an *actual* one – the gas is in fact escaping from the distribution network.

On the other hand, if either (or both) of the measured injection or measured withdrawal values are incorrect, there can be UAfG, but no *physical*, or *actual*, loss of gas from the network.

In practice, UAfG is usually a combination of both a physical loss of gas and a loss due to measurement error. One of the questions that needed to be answered by AusNet Services was whether the spike in non-DTS UAfG represented an actual or measured loss.

Actual loss:

The volume of UAfG depicted in Figure 2 is significant, at approximately 200 TJ. This is the equivalent of 5,000 residential customers' annual consumption lost in a network that only has approximately 12,000 residential customers connected. Put another way, it is almost the entire annual consumption of the eight large industrial users in the non-DTS network.

On this basis, AusNet Services is of the firm opinion that the UAfG in the non-DTS network is not an actual loss, rather it is a loss associated with a measurement error.

In support of this view, AusNet Services consulted the leakage surveys that were conducted on the three towns in the non-DTS network and these confirmed that leaks were minor in nature.

In addition, if a leak was to occur on the network it would be heard and visible due to the volume and pressure of the gas.

The combination of the leakage surveys, engineering assessments and engineering experience has led AusNet Services to rule out an actual leak in the network as being the cause of the high UAfG.

Unauthorised consumption (theft):

Unauthorised consumption, or theft, of gas is part-actual and part-measured loss. In one sense, it is an actual loss of gas because gas is being physically withdrawn from the network. On the other hand, the only reason this gas consumption is undetected is because there is not a measurement device (a meter) connected to the off take point.

Theft, as a reason for the increase in UAfG, faces the same issues as the actual losses referred to above. The amount of gas that would need to have been illegally withdrawn from the network is significant. Due to the high variance in losses, it would be unusual that theft would be due to a single source of theft. Conversely a large development with no gas metering within the distribution network would also be easily identified.

Injection measurement error:

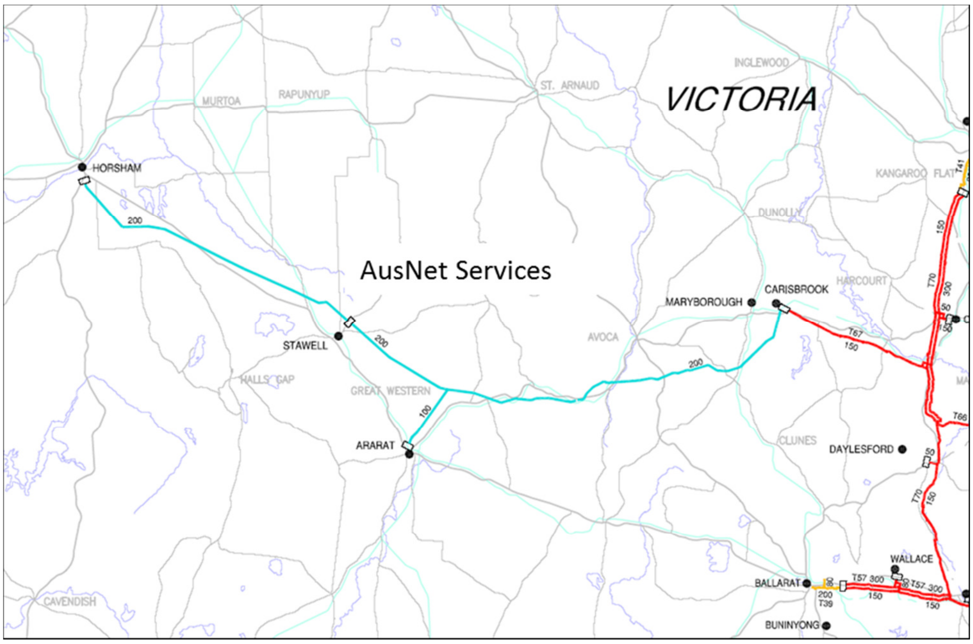
The time series presented in Figure 2 suggests that it is the injection volume, rather than the withdrawal volume, which may have a measurement error associated with it. This is because the injection value in 2015 is significantly higher than any other year in the time series.

The injection point for the non-DTS network is the Carisbrook CTM. The injections data from this CTM is received by AusNet Services from AEMO. On noting that the injections figure in Carisbrook was at historically high levels, AusNet Services requested that AEMO confirm that the injection value in its database was correct. In an email to AusNet Services, AEMO confirmed that the value was accurate.

AusNet Services then requested that the party responsible for calibrating the Carisbrook CTM (IM&C Engineering send the details of the most recent calibration. These calibration reports all showed the Carisbrook CTM to be measuring flow within the expected level of accuracy.

The towns of Horsham, Stawell and Ararat, which comprise the non-DTS network, are located some 100-170km from the Carisbrook CTM. The pipeline connecting the Carisbrook CTM to AusNet Services' distribution network in those towns is the Carisbrook to Horsham Gas Transmission Pipeline (see Figure 8), owned by Gas Pipelines Victoria (GPV).

Figure 8: Non-DTS Network map



It is possible that the increase in UAfG is not associated with AusNet Services' distribution network in Horsham, Stawell and Ararat, but rather associated with GPV's pipeline connecting those towns to the Carisbrook CTM.

In 2014, AusNet Services installed meters at the city gate site, which is the interface between GPV's pipeline and the entry point to each of the three towns. As a way of checking the volume recorded at Carisbrook, AusNet Services summed the metered energy at each of the three towns and compared it to the AEMO-reported energy at Carisbrook. The results are presented in Table 1 and as can be seen, the difference in energy is marginal. The flow from 2016 is included in the below table, although 2016 values have not been settled between AusNet Services, AEMO and the retailer and therefore do not form part of the ESC's review.

Table 4: Comparison of Carisbrook (AEMO) and non-DTS towns (AusNet Services), GJ

Injection point	2015	2016
Carisbrook (AEMO)	1,025,893	1,054,327
Non-DTS towns (AusNet Services)	1,014,665	1,032,500
% variance	-1.1%	-2.1%

AusNet Services also requested that AEMO provide the Carisbrook flow in cubic meters, rather than energy, so it could compare the volumetric flow. This allows the flow to be compared without the interim step of converting volume to energy. As Table 5 demonstrates, the volumetric flow was again very close.

Table 5: Comparison of Carisbrook (AEMO) and non-DTS towns (AusNet Services), m³

Injection point	2015	2016
Carisbrook (AEMO)	26,573,495	27,552,283
Non-DTS towns (AusNet Services)	26,218,727	26,679,587
% variance	-1.3%	-3.2%

As an additional test, AusNet Services compared the daily flow at Carisbrook CTM with the daily flow at the three towns, to determine if the two data series were in alignment at the daily level, as well as the annual level. Due to the large distance between the three towns and Carisbrook, one would not expect the daily values to be identical, as there can be days where the line pack in the GPV pipeline is used to supply the three towns, rather than flow via Carisbrook.

However, one would expect there to be an evident relationship between the two data series and this was in fact found. Figure 9 shows the daily flow at Carisbrook and the three towns, whilst Figure 10 overlays a 4 day moving average of the Carisbrook flow, which aligns almost perfectly with the flow at the three towns.

Figure 9: Carisbrook and non-DTS towns daily flow (MJ)

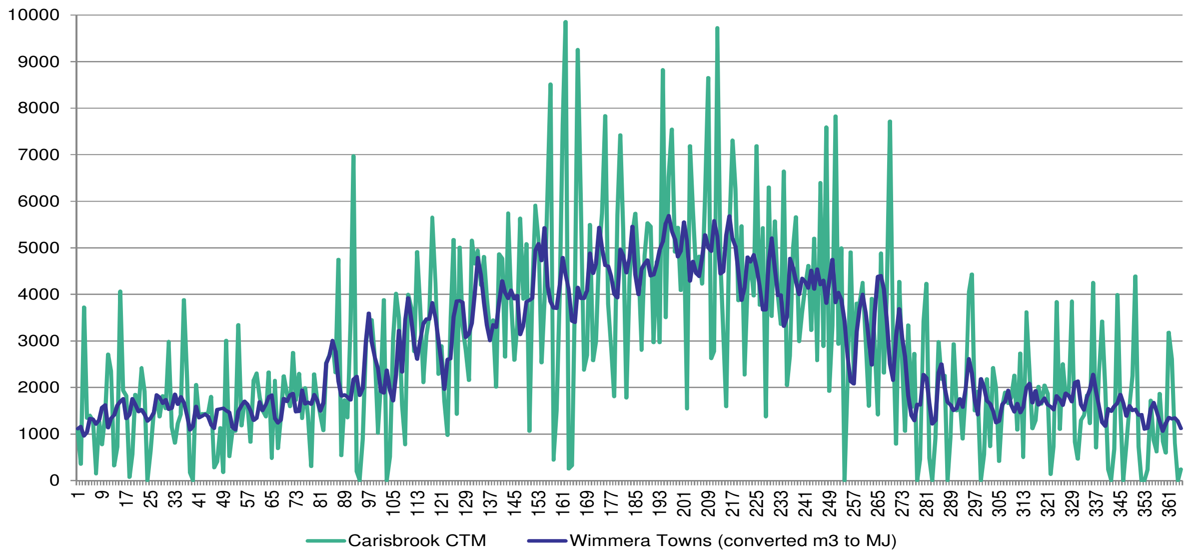
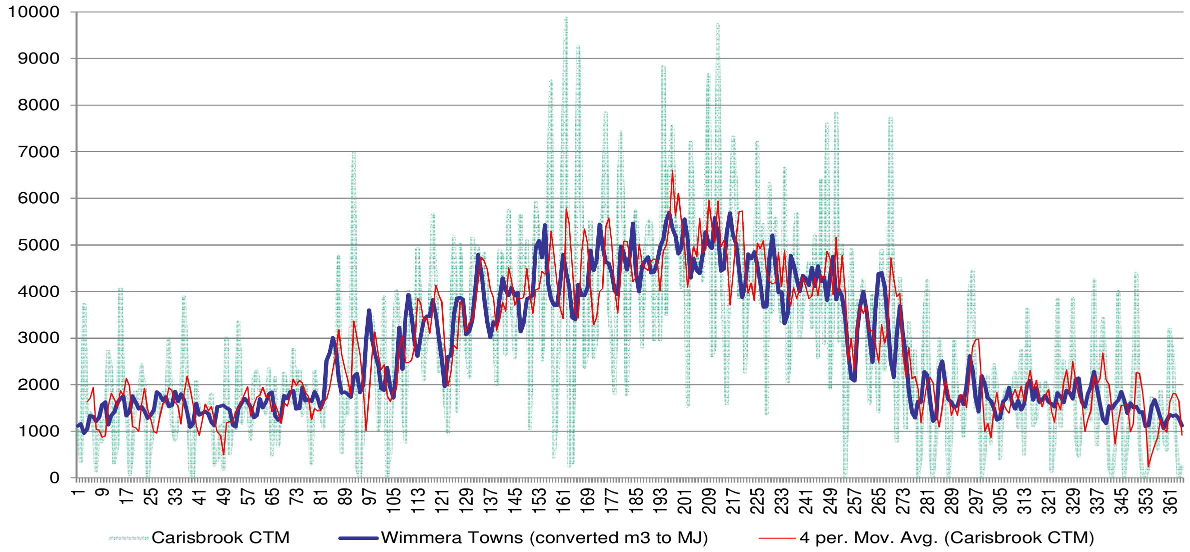


Figure 10: Carisbrook (incl. 4 day moving average) and non-DTS towns daily flow (MJ)



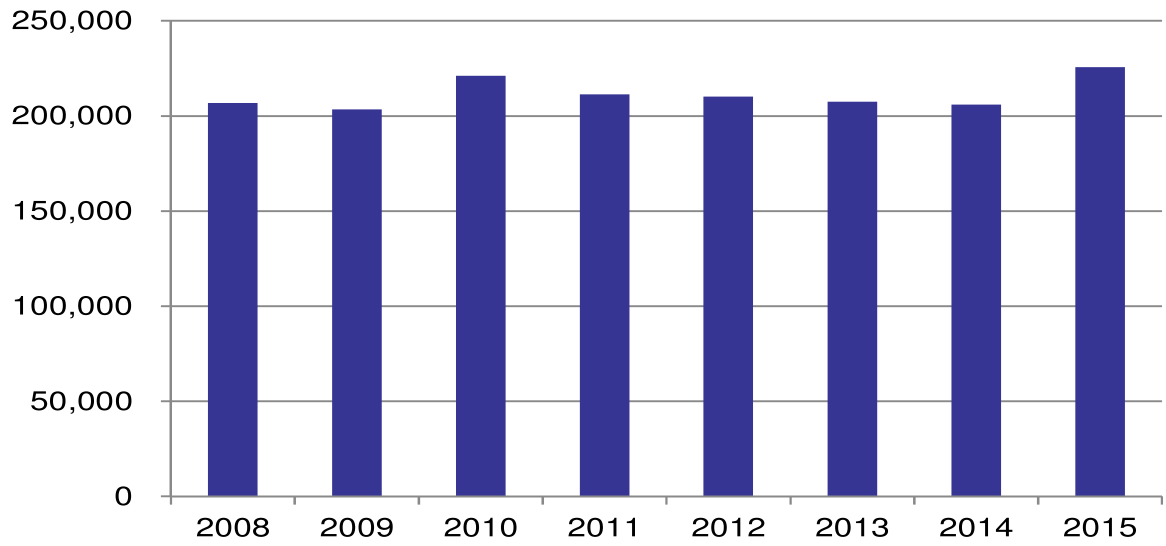
AusNet Services' investigations into the injection value described above offered strong evidence that the injection at Carisbrook, used in the UAfG calculation, was materially correct, despite the suggestion in Figure 2 that the increasing injection value could have been the cause of the measurement error. The strongest piece of evidence that the 2015 Carisbrook injection was correct was that the sum of the flow through the meters in three non-DTS towns was within 1% of the flow at Carisbrook, using either energy (GJ) or volume (m^3).

With the injections seemingly verified, AusNet Services undertook a number of discrete analyses on the withdrawals value.

Withdrawals

Because of the size of the UAfG, the first thing AusNet Services did was to make sure all of the major industrial users were included in the UAfG dataset. This was confirmed and the consumption from these eight major users was consistent year-on-year, as shown in Figure 11.

Figure 11: Major non-DTS customer consumption 2008-2015 (GJ)

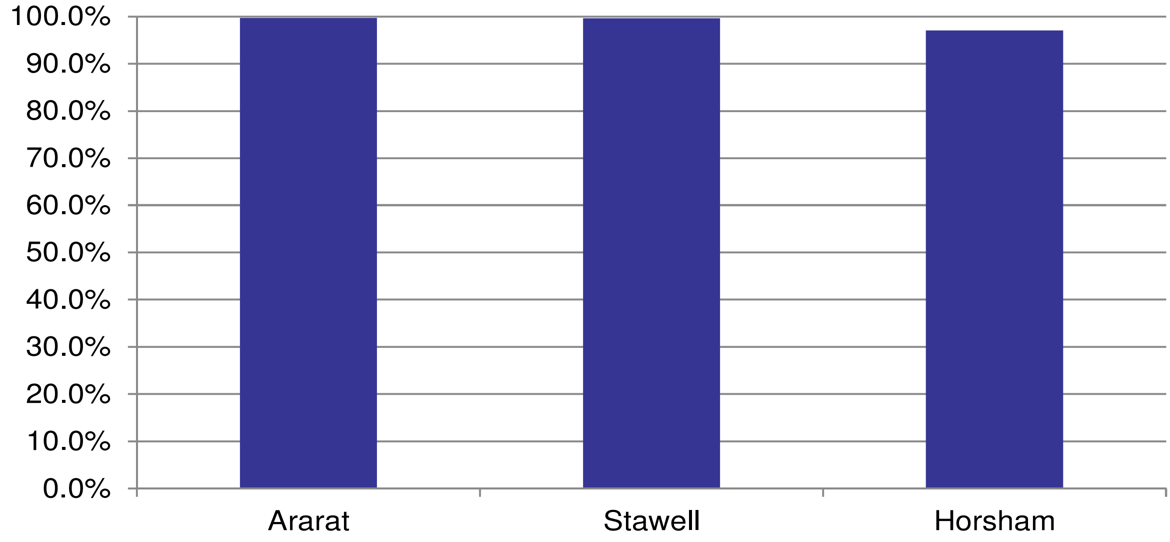


To confirm that no additional major users had been connected, but hadn't made their way into the data, AusNet Services contacted field staff in the non-DTS network and confirmed there were no additional major users. AusNet Services also contacted the electricity distribution business that services the area (Powercor) and asked whether they had recently connected any major electricity users in these towns. Powercor advised that it had not.

The withdrawals data used by AusNet Services in the UAfG calculation is sourced from billing records. To ensure that the billing database was not missing any customers, AusNet Services compared the list of MIRNs in the billing system, Kinetiq, to the list of MIRNs in AusNet Services' outage management system, PowerOn Gas. The two databases reconciled, which proved that there were no MIRNs missing from the withdrawals data used in the UAfG calculation. As a separate exercise, PowerOn Gas was also reconciled to the meter database (Hansen) and again, all MIRNs were accounted for. In addition, the recent annual growth in the number of customers is in line with expectations – around 1.2% per annum since 2011.

Given that withdrawals data is based on billing data and this billing data is in turn based on meter reads, the reliability of the meter reads was next investigated. In most circumstances, a meter read is based on an actual value, read by a meter reader. In some instances, however, a meter reader is unable to gain access to a meter and has to insert an estimated read for the billing cycle. AusNet Services determined that the billed volumes were overwhelmingly based on actual meter reads (Figure 12).

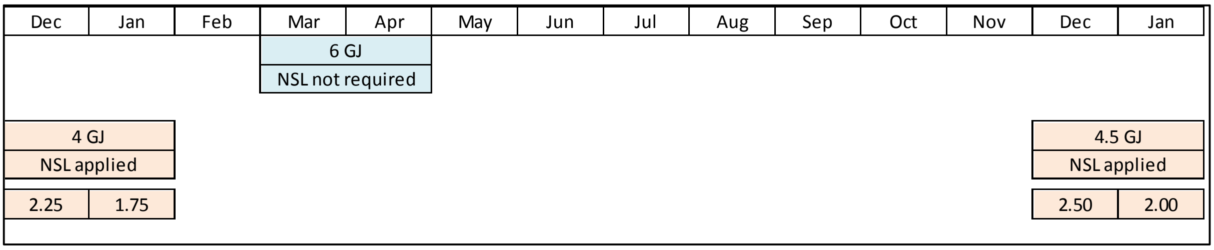
Figure 12: Proportion of billed volume based on actual meter reads, by town



Gas meter reading cycles are typically around 60 days. UAfG is calculated on a calendar year basis. This means that for any period within a calendar year that is not 100% covered by a single meter reading cycle, AusNet Services must apply an assumption about how much energy was consumed within the calendar year in question. For example, a meter read on 31 January 2015 might cover the period 1 December 2014 – 31 January 2015, but the UAfG calculation must include an assumption about how much energy was used in January only.

To perform this calculation, AusNet Services uses the Net System Load (NSL) profile prepared by AEMO. This is depicted in Figure 13, below.

Figure 13: Application of the NSL profile (example only)

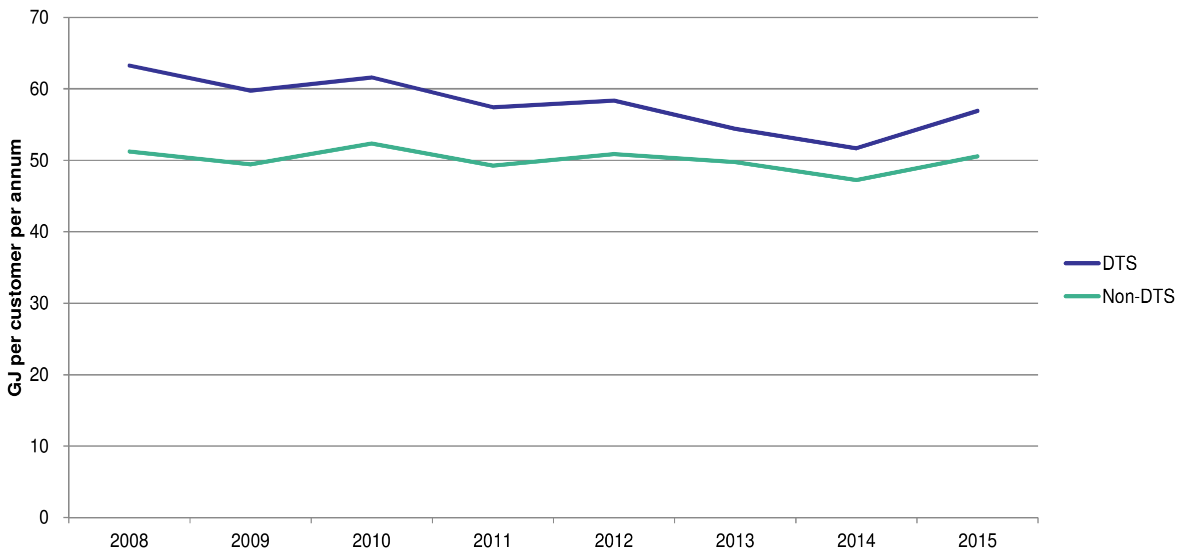


If the NSL published by AEMO does not actually align with the actual daily consumption in the non-DTS network, this could introduce an error in the withdrawal volume.

AusNet Services determined that 95% of consumption in the non-DTS network did not use the NSL profile because those meter reads fell entirely within the calendar year. AusNet Services then tested an unrealistic and extreme scenario where it took the total volume that had the NSL applied to it and apportioned 100% of the volume to the 2015 calendar year. This would be the equivalent of including 4GJ and 4.5GJ in the above example, instead of 1.75GJ and 2.50GJ. This sort of error is practically impossible,[K] but even if it was possible, the non-DTS UAfG would still be 15% - nearly 3 times the benchmark and 2.5 times what it was in 2011.

AusNet Services next looked at the trends in consumption for small to medium users (major user trends have already been discussed). As presented in Figure 14, average consumption per customer in the non-DTS network has moved more or less in line with the rest of AusNet Services' network (the DTS network). This again provides evidence that the meter reads in the non-DTS network are not in error.

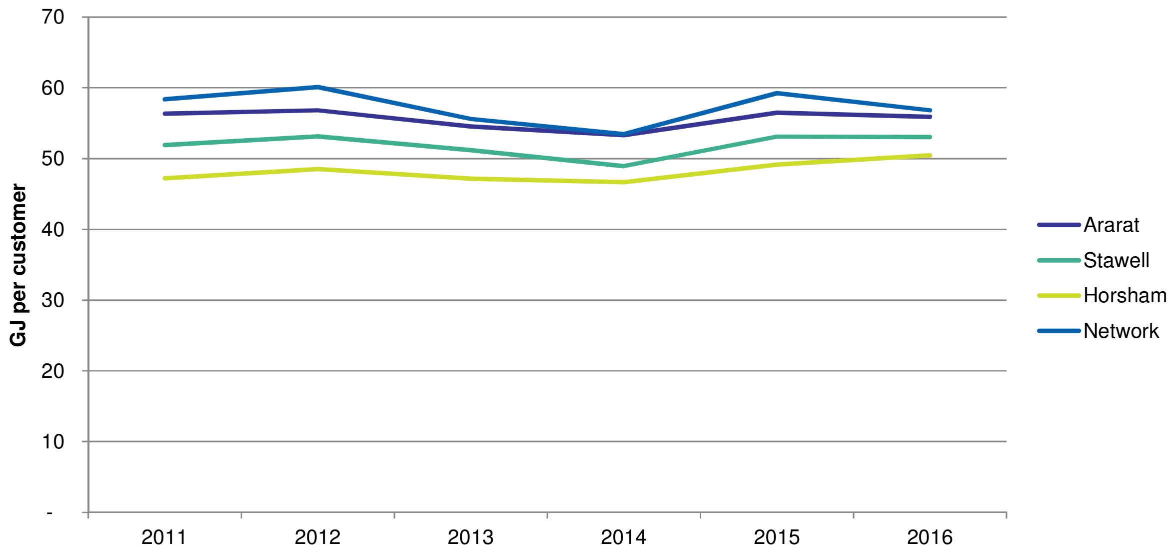
Figure 14: Average consumption per residential and commercial (R&C) customer



A similar pattern exists within each town. Figure 15 depicts the last six years of average consumption per customer in each non-DTS network town compared to the overall DTS network. Whilst the average consumption is lower in the non-DTS network, each town has maintained a similar relationship to the DTS network, at odds with the spike in the non-DTS network UAfG.

[K] In reality, even if there was an error in the NSL – it would be symmetrical. That is, if the NSL resulted in the 4GJ coming into the 2015 year, it would also result in the 4.5GJ being pushed into the next year.

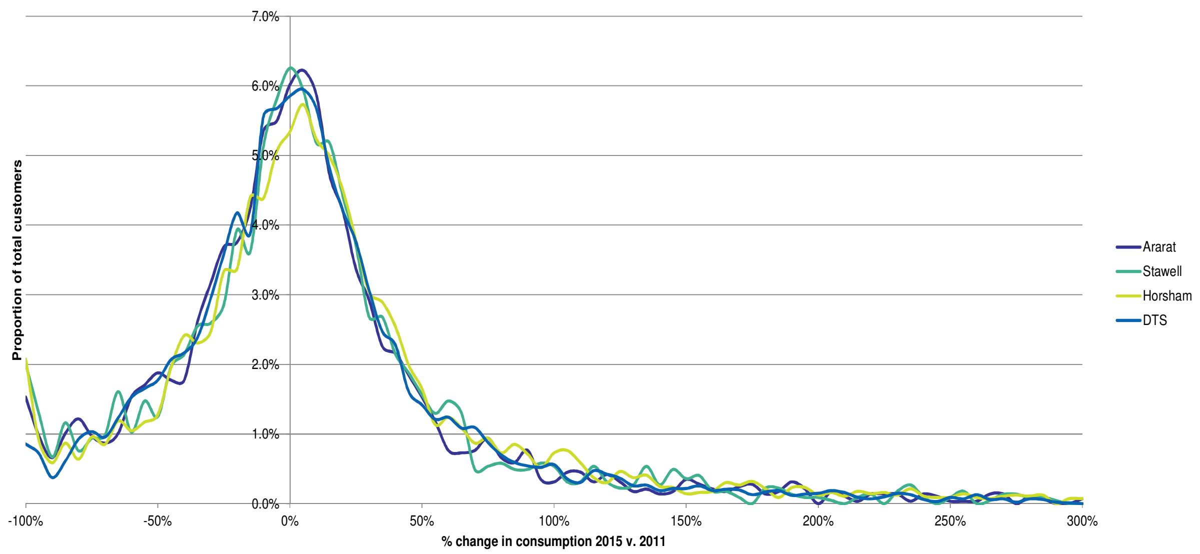
Figure 15: Average consumption per R&C customer: non-DTS towns v. DTS



As a further check on the consumption trend over time and how it compared to the rest of the network (which has not experienced a spike in UAfG above historic levels), AusNet Services compared the percentage change in consumption between two years: 2011 and 2015. UAfG in the non-DTS network has tripled over this timeframe, whilst UAfG in the DTS network has remained fairly constant.

The distribution of changes in consumption is presented in Figure 16. It shows that consumption at the customer level has changed more or less consistently across the whole network. If the non-DTS withdrawals in 2015 were for some reason understated, causing the spike in UAfG, one would expect the non-DTS distribution to be skewed to the left, relative to the DTS network.

Figure 16: Consumption change 2011 – 2015 by customer



Whilst the above analysis strongly suggested that the withdrawal values used in the UAfG calculation were complete and accurate, AusNet Services undertook further analysis on the withdrawals. The first analysis compared consumption trends by street in each of the towns. The reason for doing this was to see if there were pockets within each town in which consumption had fallen by more than other areas of the town. This analysis did not identify any such pockets – some streets had recorded declines in consumption, but these streets were not clustered together, offering evidence that UAfG was not driven by faulty sections of the distribution network.

Using the injections and withdrawals data referred to above, AusNet Services was able to calculate an estimated UAfG in each of the three non-DTS towns. Both Ararat and Stawell have a high proportion of low pressure mains (63% and 70% respectively), whilst Horsham has a lower proportion (29%). Since low pressure mains are one of the potential causes of higher UAfG, calculating UAfG at the town level may show a correlation between UAfG and low pressure mains.

The results of this analysis are presented in Table 6. In fact, Horsham, which has the lowest proportion of low pressure mains, has the highest UAfG.

Table 6: Low pressure mains and UAfG by non-DTS town

	Ararat	Stawell	Horsham
% of low pressure mains	63%	70%	29%
2015 UAfG	9.8%	6.8%	28.7%
2016 UAfG (estimate)	12.3%	11.3%	28.3%

The calculated UAfG for Horsham, which is near 30%, is close to six times the non-DTS UAfG benchmark. The town meters did not exist for a full year prior to 2015, so it is not possible to determine whether the recent increase in UAfG in these towns is solely due to Horsham or not.

Finally, to ensure that the energy billed to customers (and therefore reported as withdrawals) matched the underlying meter reads, AusNet Services obtained the raw meter reads for each of the non-DTS customers. The energy billed to customers is derived from meter reads, however the meters themselves do not measure energy, they measure flow in cubic meters. This volumetric value is converted to an energy value (e.g. GJ) using a number of factors, including pressure correction and a heating value.

Using the raw meter reads (in m^3), AusNet Services was able to calculate UAfG in both volumetric (m^3) and energy (GJ) terms. If the reason for the spike in UAfG was due to the conversion between volume and energy, the calculated UAfG for m^3 and GJ should be different, e.g. UAfG in m^3 would be normal whilst UAfG in GJ would be high.

The analysis, however, showed that UAfG based on m^3 was reasonably consistent with UAfG based on GJ. This was true at both the network level and at the town level.

Table 7: 2015 non-DTS UAfG by town, by measurement method

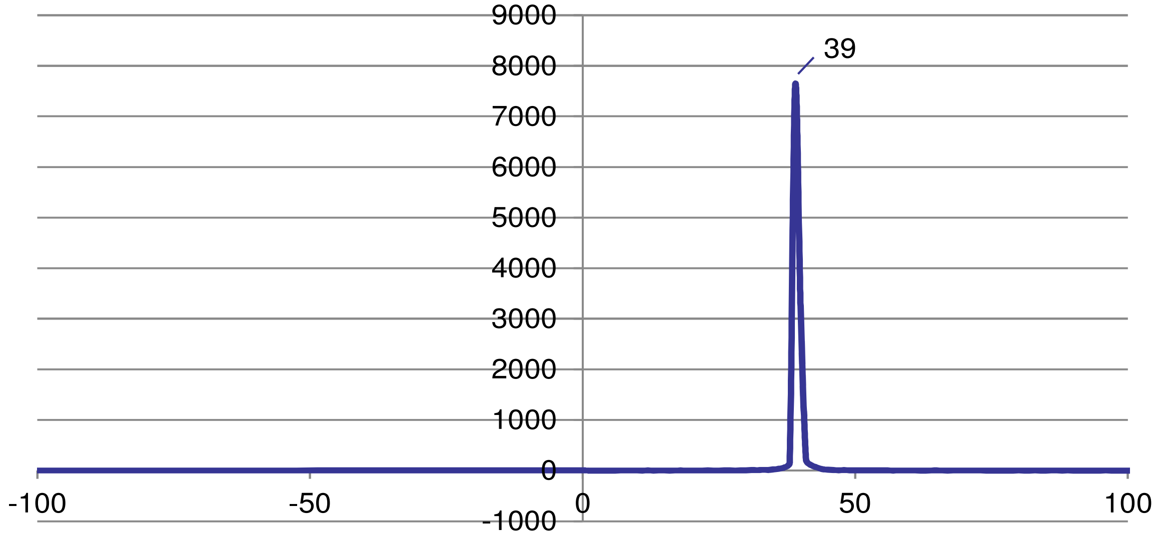
	Non-DTS network	Ararat	Stawell	Horsham
UAfG – GJ	18.8%	9.8%	6.8%	28.7%
UAfG – m^3	20.0%	12.0%	7.0%	30.3%

The results presented in Table 7 seem to rule out an error in the parameters used to convert volume to energy for billing and UAfG purposes. This is further supported by a detailed analysis of the meter reads and their corresponding billed energy values.

AusNet Services compared the annual flow in m^3 for each meter to the annual amount of billed energy for each meter. The expected multiplier between m^3 and MJ is around 38-40 as a combination of heating value and pressure correction. That is, if a meter has recorded a $1{,}000m^3$ increase over the course of a year, the expected energy would be somewhere between 38,000 MJ and 40,000 MJ, given the knowledge of the appropriate pressure correction factors and heating values.

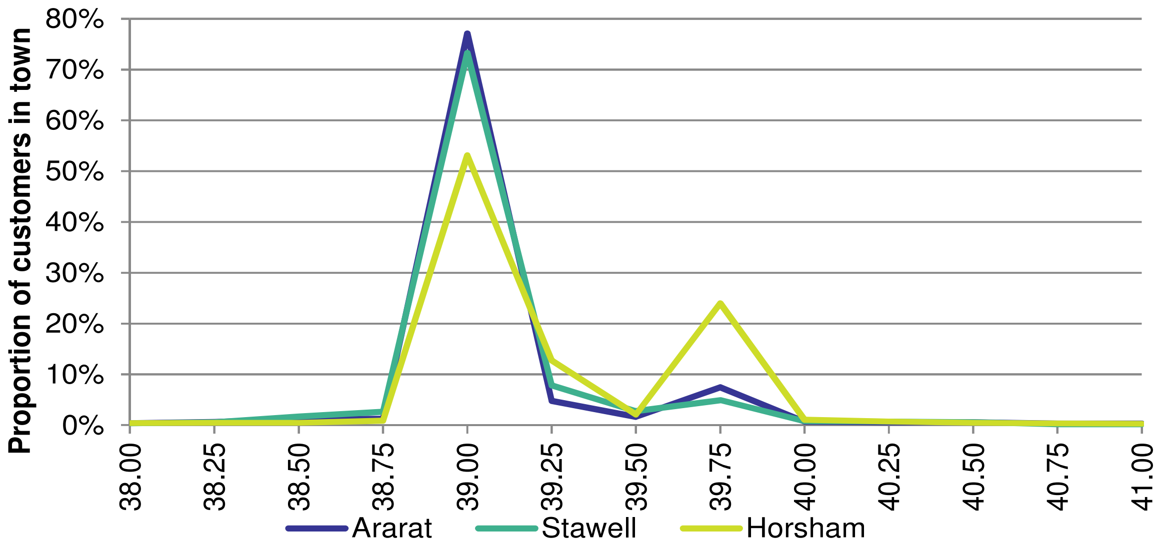
Figure 17 shows the distribution of conversion factors for the ~12,000 non-DTS customers. Whilst there are a very small number of outliers, around 92% of customers had a conversion of between 38-40 and 97% were between 36-42.

Figure 17: Distribution of conversion multiple between m^3 and MJ



Zooming in on the area of the curve where most customers are gathered, and looking separately at each of the towns, it is clear that the large majority of customers have conversion factors of 39.00 or 39.75 (Figure 18). Horsham, with a higher proportion of high pressure mains, has relatively more customers with the higher conversion factor.

Figure 18: Non-DTS towns' distribution of conversion multiple between m^3 and MJ



In summary, AusNet Services' investigation into the withdrawals used in the UAfG calculation:

- Confirmed that all known major users were accounted for in the data and that major user consumption was in line with historical patterns
- Confirmed that the number of MIRNs used to derive the withdrawal value was complete and consistent with the outage management and meter systems
- Confirmed that the vast majority of consumption used in the UAfG calculation was based on actual, rather than estimated, reads
- Ruled out the possibility that the Net System Load profile used in the UAfG calculation could be responsible for the UAfG result

- Confirmed that consumption trends in the non-DTS towns matched those in the broader DTS network
- Could not find any evidence of unusual consumption patterns within specific pockets of the non-DTS towns
- Cross-checked UAfG with the proportion of low pressure mains and, counterintuitively, found that the town with the lowest proportion of low pressure mains had the highest UAfG
- Confirmed that UAfG was broadly the same whether it was calculated on a GJ or m^3 basis
- Confirmed that the conversion from m^3 to MJ was consistent with engineering expectations.

These findings strongly support a conclusion that the withdrawal value used in the UAfG calculation is complete and accurate.

Conclusions

The investigations undertaken by AusNet Services have so far returned a set of conclusions which are on face value inconsistent:

1. The reported UAfG is too high to be an actual loss, therefore it must be due to a measurement error in the injection value or withdrawal value
2. The injection value reconciles to three independent downstream meters operated by AusNet Services and therefore the injections measurement seems to be correct
3. The withdrawal value comprises a full set of customers, consumption has been reconciled to the underlying meter reads and consumption trends are consistent with the DTS network. Therefore the withdrawal measurement seems to be correct.

In an attempt to overcome these seemingly inconsistent conclusions, AusNet Services is undertaking a series of further investigations. These are described below

Ongoing investigations

AusNet Services on-going strategies to understand the discrepancies in the network include the following:

- An independent review of the Carisbrook CTM in terms of calibration, performance and operation. This will confirm that the source supply of gas metering is correct and accurate. This will then isolate the issue to AusNet Services network rather than the GPV pipeline.
- Confirm that conversion characteristic applied for billing purposes (Pressure and Heating Value) is aligned with the DTS network. This will confirm that the end to end billing process in the non-DTS network is accurate and consistent with the DTS network.
- Complete asset audit of meters installed in the three towns to determine if there are any new meters that have not been accounted for.
- Perform downstream flow balance on the Horsham network to understand if there are any un-accounted for losses on the network. This will identify the location of network of potential losses that have not been accounted for.

The figure below sets out an indicative timeline for these activities.

Figure 19: Indicative timeline of ongoing investigations

	2017				2018			
	September	October	November	December	January	February	March	April
Indepent Review of Carisbrook CTM								
Review of conversion factors, alignment with DTS network								
Complete meter audit (Horsham in November)								
Flow Analysis of Horsham								
Review of Winter Perfomance on non DTS network								

8.6 Victorian DTS Map