Unaccounted for gas – Updated coefficients

Report for Jemena | 31 July 2023

Contents

Executive Summary

Jemena Gas Networks' (JGN) is developing its proposed Access Arrangement (AA) for submission to the Australian Energy Regulator (AER). A key element of the proposed AA is the forecast of unaccounted for gas (UAG). The cost of replenishing gas that is lost, or unaccounted for, during distribution through the network is a material component of Jemena Gas Networks' (JGN's) operating costs.

The methodology that has been used is based on advice from Frontier Economics and is consistent with the methodology developed by Frontier Economics for the 2015-20 AA and 2020-25 AA, and which were accepted by the AER[1] [2]. In the 2020–25 AA, JGN forecast UAG costs based on the product of:

- The target rate (loss rate) of UAG (split into two markets: the demand market and the volume market)
- Total gas receipts
- The cost of replacement gas.

For the 2025-30 AA, Jemena has engaged Frontier Economics to;

- Update the analysis on the strength of the statistical correlation between UAG and withdrawals for the two separate markets
- Determine the corresponding UAG rates/coefficients for the two markets from available data
- Calculate those rates and statistical relationships for the purposes of inclusion in JGN's AA proposal.

Our estimates of efficient rates for UAG are based on econometric analysis of historical data on UAG and customer withdrawals. Frontier Economics used the methodology applied in its previous analysis as set out in our report, *UAG methodology – Update to coefficients, May 2019*.

The total UAG rate as a proportion of receipts over the five-year period from January 2018 to December 2022 was 3.035%. The UAG rate as a proportion of withdrawals over this period was 3.133%.

The updated estimates of the UAG coefficients are the following:

for forecasting UAG costs:

  - 1.647% of forecast withdrawals for the demand market
  - 4.952% of forecast withdrawals for the volume market

for annual true-ups:

1 AER, *Draft decision for Jemena Gas Networks (NSW) Ltd Access Arrangement 2015-20, Attachment 7*, November 2014, pp. 7-26 to 7-28.

2 AER, *Draft decision for Jemena Gas Networks (NSW) Ltd Access Arrangement 2020-25, Attachment 6*, November 2019, pp. 40.

  - 1.569% of withdrawals for the demand market
  - 4.718% of the tariff market residual (comprising volume market withdrawals and total UAG).

1 Introduction

Jemena Gas Networks (JGN) is currently in the process of preparing its Access Arrangement (AA) proposal for the forthcoming AA period from 1 July 2025 to 30 June 2030 (the 2025–30 AA). As part of its proposal JGN forecasts the cost of replenishing gas that is lost, or unaccounted for, during delivery through the distribution network (i.e., unaccounted for gas or UAG).

The AER's approach in the 2015 and 2020 Access Arrangements for determining JGN's allowed unaccounted for gas (UAG) costs was the product of 'efficient' forecast UAG volumes (split into the demand market and volume market shares of forecast withdrawals) and forecast unit rates to buy replenishment gas each year.

These target rates for the 2020 Access Arrangement were as follows:

- for forecasting UAG costs:
  - 0.705% of forecast withdrawals for the demand market
  - 5.925% of forecast withdrawals for the volume market
- for annual true-ups:
  - 0.665% of withdrawals for the demand market
  - 5.593% of the balance of total market receipts for non-daily metered market (comprising volume market withdrawals and UAG).

JGN intends to maintain this approach for the 2025-2030 access arrangement by:

- justifying the operating efficiency of UAG levels using the 5 year historical average of level for 2018 through 2022.
- expressing the forecast rate of UAG as two different rates:
  - one applied to withdrawals by daily metered customers (Demand market) and
  - the other applied to withdrawals by non-daily metered customers (Volume market).

1.1 Our terms of reference

To assist in assessing and updating the above approach, JGN has engaged Frontier Economics to advise on:

- updating Frontier Economics' 2019 analysis on the strength of the statistical correlation between UAG and withdrawals for the two separate markets with the most recent data up to December 2022
- determining the corresponding UAG rates/coefficients for the two markets
- calculating those rates and statistical relationship for the purposes of inclusion in JGN's 2025–30 AA proposal.

This report presents our findings.

1.2 Structure of the remainder of this report

The remainder of this report is structured as follows:

- In Section 2, we present the data used for the analysis and we discuss possible approaches to treat measurement errors identified in the historical data
- In Section 3, we present the updated analysis and results using the latest data

2 Data

2.1 Description of data

JGN has provided us with monthly data series up to December 2022, which has been used to update Frontier Economics' 2019 analysis for estimating the UAG rates. The analysis in the present report uses data covering the period July 2002 to December 2022.[3]

The monthly data series provided include the following:

- **Receipts (R):** Gas volumes received by JGN from suppliers.
- **Daily metered (i.e. demand market) withdrawals** (D). Gas volumes delivered to customers metered daily, which constitute the demand market. These are mainly large industrial customers.
- **Estimated unaccounted for gas (U)**. JGN's UAG data.
- **Non-daily metered (i.e. volume/mass market) withdrawals (V).** Gas volumes delivered to customers not metered on a daily basis, which constitute the volume market (also referred to as mass market). Monthly observations for this series estimated from billing data.

We also use the following data series, which is derived from the data series provided by JGN:

- **Tariff market residual (T).** This series has been calculated as the residual between receipts and daily metered withdrawals. This consists of the volumes delivered to the market segment of customers who are not metered on a daily basis (i.e. the volume market) plus U.[4]

The following relationships hold between these variables:

$T = R - D = V + U.$

By re-writing this equation we obtain:

$U = T - V = R - D - V.$

Figure 1 to **Figure 3** below plot these series from July 2002 to December 2022. The figures show that all the series have a strong seasonal pattern, though this is less pronounced for the demand market. Receipts have trended slightly down over the period due to a decline in demand market withdrawals. However, demand market withdrawals and receipts seem to have stabilised since 2015 and there has been a slight upturn in the last few months. Withdrawals by the volume market have a slight positive trend that also seems to have flattened out in the last few years.

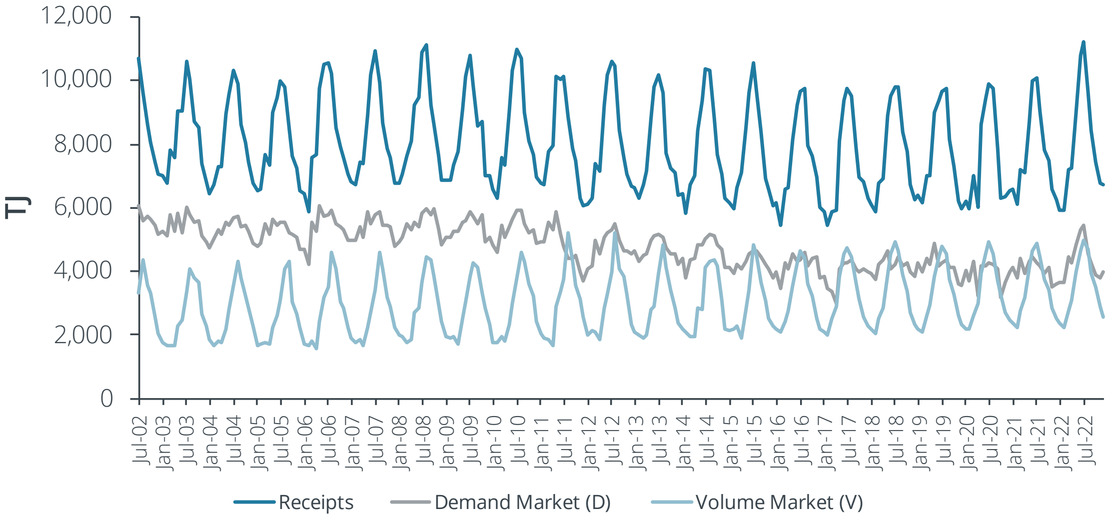
Figure 2 shows that UAG is quite variable, with a slight positive trend and a strong seasonal pattern. There is an outlier in July 2015, and the following months also seem to have a different pattern to corresponding months in other years. We discuss this issue in more detail in the next section.

[3] There may be minor discrepancies compared to the data used in the 2020 AA due to adjustments made to the billing data.

[4] The tariff market residual includes all of UAG, not only the UAG attributable to the volume market.

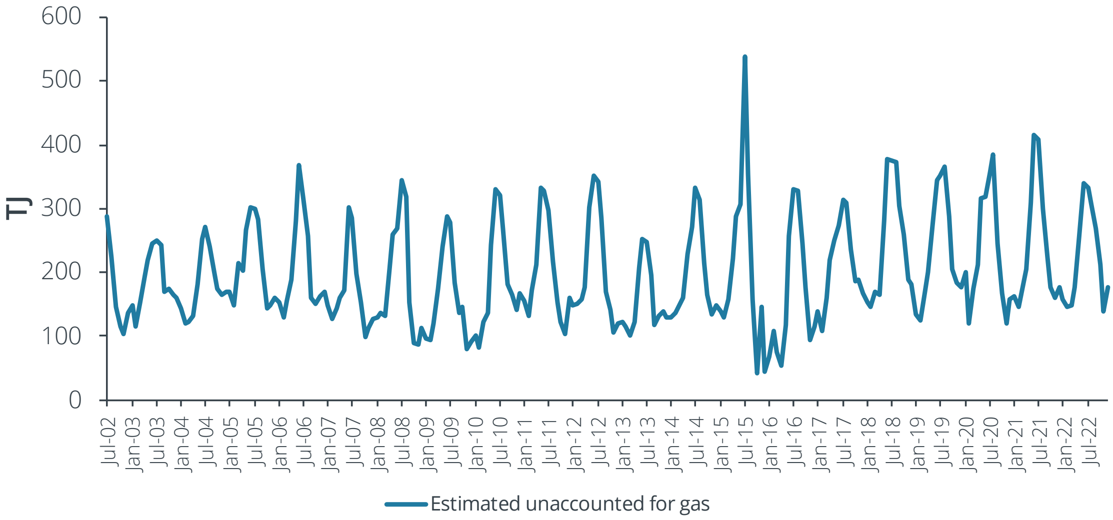
Figure 4 plots monthly UAG as a proportion of receipts over the last five years, which is the period used for calibrating the UAG coefficients. The figure shows that over this period the UAG rate has had a fairly flat trend but with strong seasonality. With respect to seasonality, the month with the highest average UAG rate is June, at 3.7%, while the month with the lowest average UAG rate is February, at 2.3%. The horizontal line shows the UAG rate over the whole five-year period which is 3.035%.[5]

Figure 1: Receipts, demand market withdrawals, and volume market withdrawals by month for July 2002 to December 2022



Source: Frontier Economics analysis using JGN data

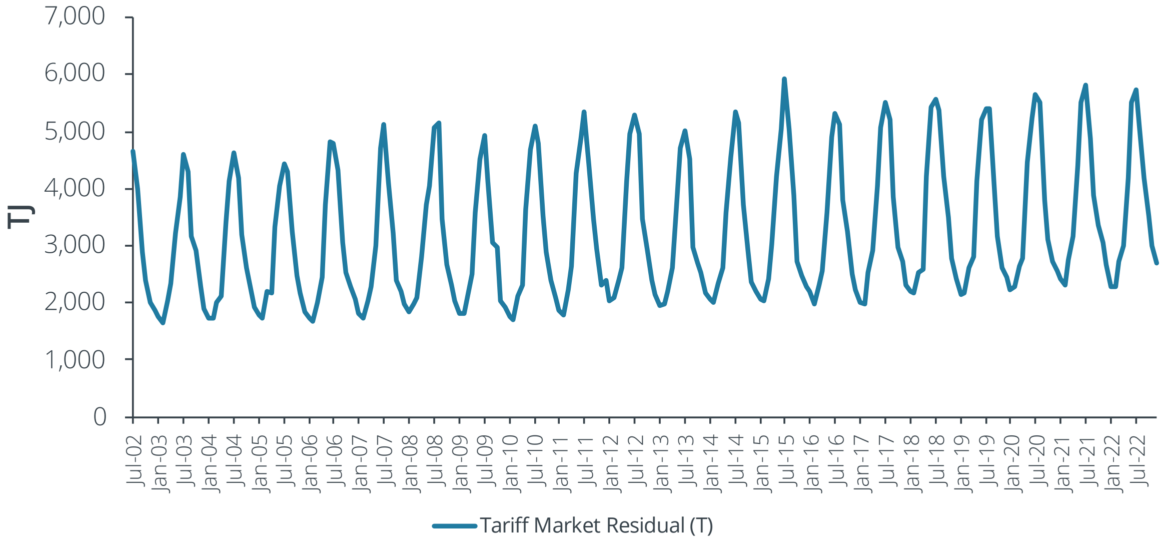
Figure 2: Estimated unaccounted for gas by month for July 2002 to December 2022



Source: Frontier Economics analysis using JGN data

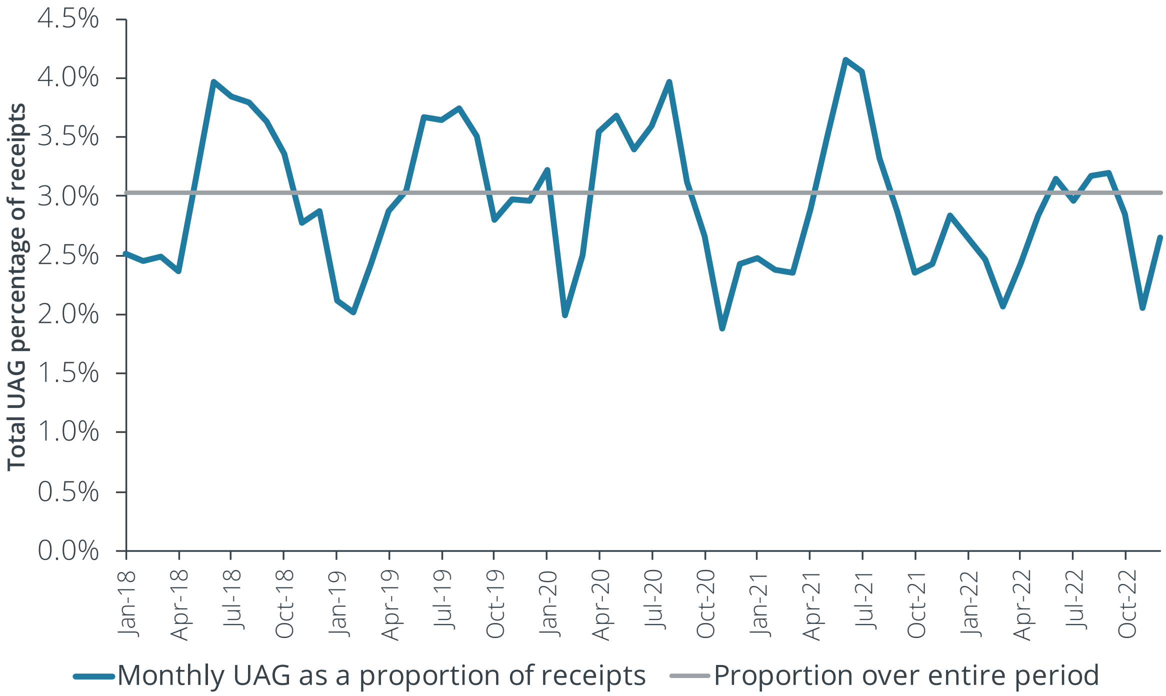
5 The UAG rate, as a proportion of receipts over the whole five-year, is 3.035%. This differs slightly from the average of the monthly UAG proportions, which is 2.953%.

Figure 3: Tariff market residuals by month for July 2002 to December 2022



Source: Frontier Economics analysis using JGN data

Figure 4: UAG as a proportion of receipts for 2018 to 2022



Source: Frontier Economics analysis using JGN data

2.2 Data issues

JGN has advised us that the following two issues have affected the historical time series data:

- In 2015 JGN transitioned its IT systems from GASS+ to SAP. This transition was accompanied by changes in the reporting of UAG from July 2015 onwards.
- In March 2017, APA Group installed a new orifice plate[6] at the receipts point for APA's Moomba to Sydney pipeline at Wilton (henceforth, *Wilton APA*). JGN informed us that the new orifice plate is more accurate at measuring lower flow ranges.

In Frontier Economics' 2019 report, we assessed the likely impact of these two issues on the reported UAG data series.

2.2.1 Change in reporting of UAG from July 2015

The change in reporting UAG from July 2015 appears to have affected the UAG monthly volumes for several months after the transition date. In particular, we observe that:

- the UAG volume in July 2015 (538 TJ) is an outlier, being the highest volume measured over the whole historical period, almost 1.5 times larger than the second highest volume since July 2002 (378 TJ recorded in June 2018).
- the five UAG volumes in October 2015, December 2015, April 2016, January 2016, and March 2016 are the five smallest volumes recorded over the whole historical period. In particular, the October and December volumes (42 TJ and 44 TJ, respectively) are more than 40% smaller than the sixth smallest volume since July 2002 (79 TJ recorded in November 2009).

These observations are likely to influence results from models that use monthly data.

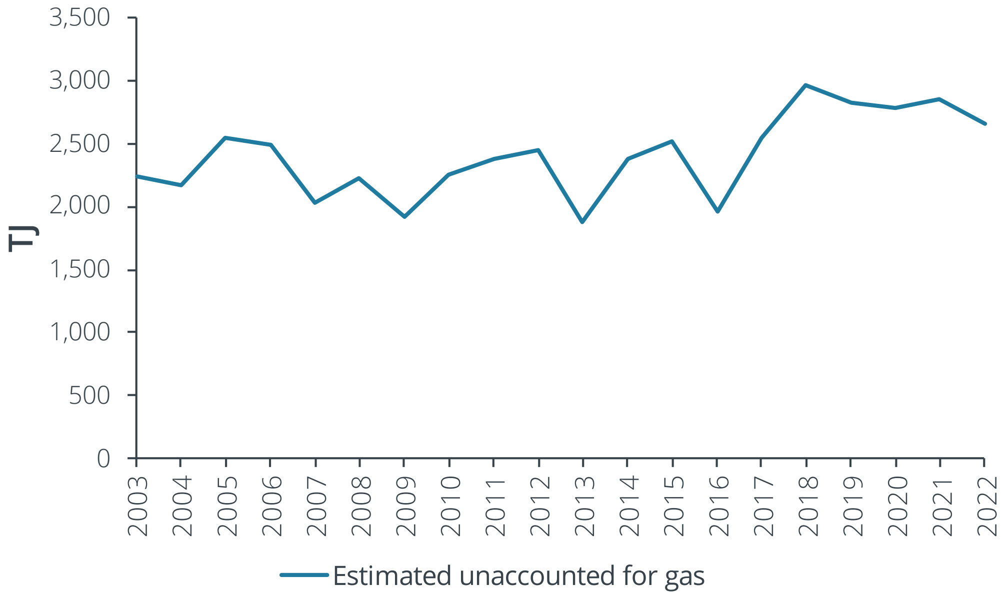
However, once the monthly data is aggregated by year, the annual UAG volumes for 2015 and 2016 do not particularly stand out, as can be seen from **Figure 5** below. This suggests that the effect of the change in reporting UAG in July led to a period of a few months of adjustment after which the reporting of UAG resumed a regular pattern.

2.2.2 Installation of more precise meter at Wilton APA in March 2017

The new orifice plate installed at Wilton APA in March 2017 is more precise than the previous orifice plate at measuring flow rates in the low flow-rate range. Experience with the new orifice plate indicates that historical receipts, UAG, and tariff market residuals before March 2017 are likely to have been under-measured, especially in periods of low flows.

6 An orifice plate is a device used for measuring flow rates.

Figure 5: UAG by calendar year



Source: Frontier Economics analysis using JGN data

2.3 Data used for analysis

The data issues identified in Section 2.2 can affect the estimates of the UAG rates for the two market segments. To address these issues, we have made the following decisions about the datasets and model specifications used in our analysis.

Estimation of UAG rates for the two market segments

- The data used to estimate the model used to obtain the UAG rates for the two market segments covers the period July 2002 to December 2022. To remove the impact of the affected observations identified in the previous section we have omitted 13 observations from the estimation sample: 12 observations corresponding to the 12-month period which starts in July 2015 when UAG reporting transitioned from GASS+ to SAS reports, and 1 observation corresponding to March 2017, when the more precise orifice plate was installed. These are the same data exclusions applied in our 2019 analysis.
- We have specified models that make an allowance for the undermeasurement prior to March 2017. These are the same model specifications used in our 2019 report. Details are provided in Section 3.1.

Overall UAG rate

- The overall UAG rate used for calibration is based on data for the last five calendar years, from January 2018 to December 2022. This period is not affected by the data issues discussed above. Moreover, as seen in **Figure 5**, the annual UAG observations do not appear to be greatly affected by these data issues.

3 Statistical methodology

The methodology used to estimate the UAG rates for the two markets segments is the same as that used in our 2019 report, but using data up to December 2022.[7] The methodology can be divided into three main steps:

3.1 Step 1 – Estimation of UAG rates for the two market segments

As in the Frontier Economics 2019 analysis, we have estimated three models that could be used to estimate the UAG rates for the two market segments. The simplest model is shown in Equation (1).

$$U_t = \beta_D D_t + \beta_V V_t + \eta_t \qquad (1)$$

Equation (1) shows the relationship between UAG in month t, (U_t), withdrawals by the daily metered demand market, (D_t), and withdrawals by the volume market, (V_t). The term η_t is the residual term in the model. The coefficients β_D and β_V represent the UAG rates for the two market segments as a proportion of withdrawals by the respective market segment.

Since UAG was subject to undermeasurement before March 2017 (see Section 2.2.2), the estimated coefficients from model (1) are likely to be biased downwards if the undermeasurement is not accounted for in the model.

The undermeasurement of UAG before March 2017 would lead to observed UAG prior to March 2017 being lower than actual UAG. To account for this, we have specified a variation of model (1) in which the coefficients β_D and β_V are allowed to be lower before March 2017 than after March 2017. This is achieved by interacting the coefficients with a dummy variable which is equal to 1 for each month before March 2017 and 0 otherwise. The model allows for the predicted values for UAG before March 2017 to be lower than the predicted values after March 2017 by a fraction equal to γ, which is constrained to be non-negative. The algebraic specification of this model is:

$$U_t = (\beta_D D_t + \beta_V V_t) \cdot \left(1 - \gamma \cdot d_{preMarch2017}\right) + \eta_t, \quad \gamma \geq 0. \qquad (2)$$

Since the undermeasurement rate at Wilton APA prior to March 2017 varies according to the gas flow rate (i.e. a higher undermeasurement rate at lower flow rates), and the flow rate is seasonal, we have also specified a model in which the rate of undermeasurement is allowed to differ by the month of the year. This is achieved by interacting the beta coefficients with two types of dummy variables: the pre-March 2017 dummy variable used in model (2), and 12 monthly dummy variables m_i which are equal to 1 if the observation falls in a particular month of the year and 0 otherwise. The coefficients of the monthly dummies have been constrained to be non-negative. The algebraic specification of this model is:

$$U_t = (\beta_D D_t + \beta_V V_t) \cdot \left(1 - d_{preMarch2017} \cdot \sum_{i=1}^{12} \gamma_i \cdot m_i\right) + \eta_t, \quad \gamma_i \geq 0. \qquad (3)$$

7 Frontier Economics, *UAG methodology – Update to coefficients, May 2019.*

Table 1: Estimated models

Coefficient	Model 1	Model 2	Model 3
β_D	0.00998***	0.0187***	0.0177***
β_V	0.0511***	0.0483***	0.0532***
γ=undermeasure		0.196***	
γ_1			0.263***
γ_2			0.318***
γ_3			0.239***
γ_4			0.0371
γ_5			0.000
γ_6			0.000
γ_7			0.000
γ_8			0.251***
γ_9			0.447***
γ_{10}			0.486***
γ_{11}			0.485***
γ_{12}			0.312***
Sample size	233	233	233
AIC	2577.6	2554.4	2365.9
BIC	2584.5	2564.8	2403.9
Adjusted R^2	0.921	0.929	0.969
p-values	* p<0.05	** p<0.01	*** p<0.001

Source: Frontier Economics analysis of data provided by Jemena

Note: 1. The estimation period is from Jul-2002 to Dec-2022. FY2016 and Mar-2017 have been excluded from the estimation sample. 2. The coefficients of the dummy variables have been constrained to be non-negative since they capture the rate of undermeasurement.

We have estimated the models specified in equations (1), (2), and (3) using monthly data from July 2002 to December 2022 but excluding the observations in FY2016 and March 2017 affected by data issues for the reasons indicated in Section 2.3. The estimated coefficients with their significance levels are shown in **Table 1** below. The table also reports three commonly used measures of goodness of fit of the model to the data, [8] which can be used to select the best fitting model.

There are significant differences in the estimated coefficients for the demand market, ranging between 0.998% for model 1 to 1.87% for model 2. This is not unexpected since model 2 and model 3 take into account undermeasurement, and the estimated coefficient for the demand market is similar between them. The variation in the estimated coefficient for the volume market is much smaller, ranging between 4.83% and 5.32%. The UAG rates are much smaller for the demand market, which reflects the fact that the demand market makes a smaller contribution to UAG.[9]

All three models produce statistically plausible results, as the coefficients for the demand market and volume market have the expected sign and relative magnitude, and are statistically very highly significant. The large values for the adjusted R^2 show that all models fit the data well.

The relative performance of the three models can be assessed by comparing the three different measures of goodness of fit reported in the last rows of the table. Models (2) and (3), which estimate the undermeasurement before March 2017, fit the data better than the simpler model (1). However, Model (2) fits the data only slightly better than model (1). But contrast, the fit of model (3) is far superior to the fit of both models (1) and (2). For this reason, Model (3) is our preferred model for estimating the UAG rates for the demand market and the volume market for the 2025–30 AA.

Hence, our preferred estimate for the UAG rate for the demand market is $\beta_D = 1.77\%$ and for the volume market is $\beta_V = 5.32\%$. These are the estimates before calibration, which is undertaken in in the next step. The demand market coefficient is larger than the estimated coefficient for the 2020 AA (0.706%), and the volume market coefficient is smaller the previous estimate (6.079%).

3.2 Step 2 – Calibration of UAG rates

To ensure that the estimated market-specific UAG rates used in the 2025–30 AA produce predictions of the total UAG rate that are consistent with the total rate in recent years we have calibrated the coefficients so that predicted average monthly UAG over the last five year is equal to actual average monthly UAG over this period. This can be achieved by calculating the ratio of actual average monthly UAG to predicted average monthly UAG, say, $r = \bar{U} / \hat{U}$, and multiplying the coefficients by this ratio. Algebraically, the calibrated coefficients can be written as $\beta_D^* = r\,\beta_D$ and $\beta_V^* = r\,\beta_V$.

Using the calibrated coefficients ensures that when the values (in TJ) for total demand and volume market withdrawals over the last five years are substituted in $U = \beta_D^* D + \beta_D^* V$, the resulting prediction for $U =$ UAG is equal to actual UAG for the last five years. Similarly, when average monthly values for withdrawals over the last five years are substituted in this equation, the resulting prediction will be equal to actual average monthly UAG over the last five years.

8 The goodness of fit criteria are adjusted R^2, AIC, BIC. The higher the value of Adjusted R^2 the better the fit. AIC and BIC are the Akaike and the Bayesian information criterion, respectively. The smaller values of these criteria the better the fit.

9 We understand from JGN that the majority of demand market customers are served by JGN's high pressure network, which is not affected by the same level of leakage and metering uncertainty as the network supplying volume market customers. Hence, the UAG rate for the demand market is expected to be lower than the UAG rate for the volume market. This is consistent with the estimated coefficients across the three models.

This also ensures that when the predicted UAG values are used to calculate the predicted total UAG rate over the last five years as a proportion of either total withdrawals or of total receipts, the resulting predicted total UAG rate is equal to the actual total UAG rate over this period.

The total UAG rate as a percentage of withdrawals over the past five years is 3.133% and the total UAG rate as a percentage of receipts is 3.035%.

We have applied the approach described above to calibrate the estimated coefficients obtained from model (3). This ensures that the predicted overall UAG rate over the last five years as a proportion of either withdrawals or receipts is equal to rates above. The calibrated coefficients are:

- $\beta_D^* = 1.647\%$ of forecast withdrawals for the demand market
- $\beta_V^* = 4.952\%$ of forecast withdrawals for the volume market

These are the coefficients we recommend be used for forecasting UAG costs.

3.3 Step 3 – True-up rates

As shown in our previous reports, the equation for calculating the true-ups is:

$$U = \alpha_D D + \alpha_T T$$

where T is the total market residual, which is equal to receipts less demand market withdrawals. The α coefficients in this equation are related to the β coefficients used to forecast UAG costs as follows:

$$\alpha_D = \frac{\beta_D^*}{1 + \beta_V^*}$$

$$\alpha_T = \frac{\beta_V^*}{1 + \beta_V^*}$$

On substituting the calibrated values for the β coefficients we obtain the following values for the true-up rates:[10]

- $\alpha_D = 1.569\%$ of forecast withdrawals by the demand market
- $\alpha_T = 4.718\%$ of the tariff market residual (comprising volume market withdrawals and total UAG).

10 In the 2019 report we calibrated the true-up coefficients derived from the uncalibrated β's rather than using the calibrated β's to obtain calibrated α's. Using the 2019 approach produces slightly different calibrated values for the α coefficients, namely $\alpha_D = 1.567\%$ and $\alpha_T = 4.713\%$. The differences are very small and only affect the third decimal place.

4 Conclusion

In this report we have updated our 2019 analysis to include the latest data available. In our opinion, after accounting for the same measurement errors and anomalies in the data as in our 2019 analysis, the 2020–25 AA approach for estimating constant rates of UAG for the two market segments remains valid for the purpose of the 2025–30 AA proposal. Namely, the undermeasurement of historical UAG and receipts before March 2017 and influential observations in FY2016.

The updated estimates of the UAG coefficients are the following:

for forecasting UAG costs:

- 1.647% of forecast withdrawals for the demand market
- 4.952% of forecast withdrawals for the volume market

for annual true-ups:

- 1.569% of withdrawals for the demand market
- 4.718% of the tariff market residual (comprising volume market withdrawals and total UAG).

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