METHODOLOGY FOR DETERMINING MOS ESTIMATES

PREPARED BY:	Gas Real Time Operations
DOCUMENT REF:	#298317
VERSION:	3.0
DATE:	1 May 2014
STATUS:	FINAL

Disclaimer

This Methodology has been prepared by AEMO under clause 5.2(f) of the STTM Procedures, for the purpose of MOS estimates under rule 397 of the National Gas Rules (Rules). It has effect only for the purposes set out in the STTM Procedures. The STTM Procedures and National Gas Rules prevail over this Methodology to the extent of any inconsistency.

Document History

VERSION	FINAL EDIT DATE	AUTHORS	CHANGES AND COMMENTS
1.0	27 April 2010	STTM Establishment Project	First version published
1.1	10 June 2010	Gas System Operations	Amendments to reflect change in the STTM commencement date from 4 June 2010 to 1 September 2010, which resulted in extending the Market Trial to 31 August 2010.
1.2	27 June 2011	Qld STTM Project	Timings generalised to apply to the commencement of any new STTM hub. Content revised for improved clarity and to conform with AEMO style. Changes reviewed by Paddy Costigan.
2.0	3 October 2011	Qld STTM Project	Consultation concluded and approved for publication.
3.0	1 May 2014	Gas Real Time Operations	Amendments to reflect MOS timing changes

Contents

Abbreviations and Symbols

Abbreviation	Term
AEMO	Australian Energy Market Operator Ltd
BB	National Gas Market Bulleting Board
GJ	gigajoule
GPG	gas power generation
MOS	market operator service
MOSA	MOS allocation
MOSE	MOS estimate
MOSEI	initial MOS estimate
MWh	megawatt hour (also MW·h)
NGR	National Gas Rules
STTM	Short Term Trading Market

1. Introduction

Rule 397 of the National Gas Rules (NGR) requires the Australian Energy Market Operator (AEMO), prior to each market operator service (MOS) period, publish MOS estimates for each STTM pipeline. Clause 5.2(f) of the STTM Procedures also requires AEMO to publish the methodology AEMO will employ to derive the MOS estimates. To guide this process, the NGR and STTM Procedures present the process that AEMO must follow and data it must use, if available, to derive and publish the MOS estimate for each pipeline and for each MOS period. In particular:

- If pipeline operators provide AEMO with forecasting patterns of MOS allocations for a MOS period, AEMO is required to validate and accept these forecasts if they are satisfactory.
- Or, if pipeline operators do not provide AEMO with forecast patterns of MOS allocations, AEMO is to determine the MOS estimates using the data specified in Clause 5.2(b) of the STTM Procedures.

This paper:

- Presents the methodology that AEMO will use to determine MOS estimates or assess the forecast patterns of MOS allocations provided by STTM pipeline operators.
- Provides details to be included in the published MOS estimates and the format in which they are presented.

The MOS methodology presented in this paper has been developed based on the MOS framework outlined in the NGR and STTM Procedures and on the basis that a MOS period, as required by the NGR, is for a one month period.

2. NGR and STTM Procedures Requirements

Rule 397[1] of the NGR, and Clauses 5.1, 5.2 and 12.1 of the STTM Procedures set out the relevant requirements relating to the development and publication of the MOS estimates and the publication of the MOS methodology.

Rule 397 requires AEMO to publish, within the time specified in the STTM Procedures, the maximum quantity of MOS (increase and decrease) and the range of daily MOS quantities. In accordance with Clause 5.2 of the STTM Procedures, AEMO must publish its MOS estimates not later than 40 business days before the start of a MOS period and may publish updated MOS estimates not later than 20 business days before the start of a MOS period.

[1] See Schedule 1, Part 3, Rule 18 of the National Gas Rules, which sets out transitional provisions that apply for the first MOS period.

To develop and publish the MOS estimate, the STTM Procedures require AEMO to publish the methodology employed to determine the MOS estimates for each STTM pipeline. The STTM Procedures also require AEMO to, before making changes to the MOS methodology, consult with trading participants and parties affected by the change (STTM Procedures, Clause 5.2(f)).

To guide both the development of the MOS estimates and MOS methodology, the STTM Procedures specify the potential sources of input data that AEMO must use to derive the MOS estimates for a given MOS period and an STTM pipeline (STTM Procedures, Clause 5.2(b)). These include, in order of use:

1. Forecast patterns of MOS allocations provided by the relevant STTM pipeline operator for that MOS period.
2. Historical MOS allocation data for an STTM pipeline for the same MOS period in the prior year.
3. Historical MOS allocation data for an STTM pipeline for other MOS periods in previous years which have similar flow characteristics as the dates included in the relevant MOS period.
4. Historical pipeline nominations and allocations data provided by the relevant STTM pipeline operator.
5. Historical pipeline flow data from the Natural Gas Services Bulletin Board (BB) which has been appropriately adjusted for differences in temporal and geographical coverage between the BB and STTM demand hubs.
6. AEMO's MOS estimates for other STTM pipelines adjusted for differences in the relevant pipelines' capacity and whether it is a pressure or flow controlled pipeline.

Where AEMO receives data from STTM pipeline operators (i.e. forecast patterns of MOS allocations provided under STTM Procedure Clause 5.2(b)(i) or historical data provided under STTM Procedure Clause 5.2(b)(iv)), the STTM Procedures require that AEMO accepts the data if it is received 50 business days prior to the start of a MOS period and AEMO considers that the information provided is reasonably adequate for estimating MOS for that MOS period.

3. An Overview of the MOS Methodology

The method that AEMO will use to determine MOS estimates for each MOS period and each STTM pipeline depends on whether the MOS estimate is provided by the STTM pipeline operator or derived by AEMO.

Figure 1 provides an overview of the steps involved in developing the MOS estimates for an STTM pipeline for a MOS period.

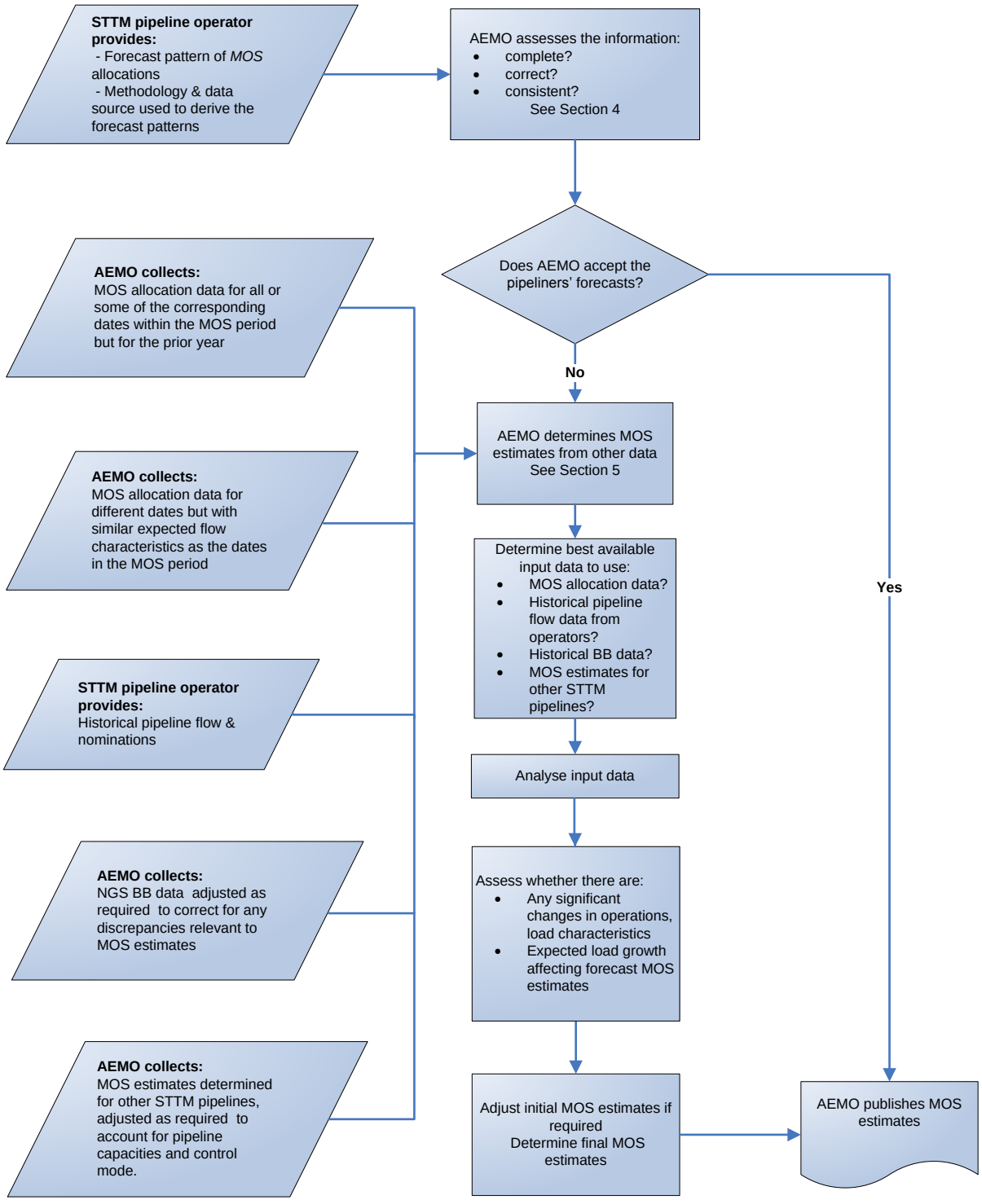


Figure 1. The steps for determining MOS estimates

If an STTM pipeline operator provides to AEMO the MOS estimates (and other related information as per STTM Procedures Clause 5.2(c)) for that pipeline and for a MOS period, then AEMO must validate and accept (or reject) the information provided. See Section 4 for more details.

If the operator of an STTM pipeline does not provide the required forecast MOS quantities or if AEMO rejects the STTM pipeline operator's MOS forecasts, then AEMO must determine the MOS estimates for that MOS period. AEMO will use a methodology that most suits the type of input data available and the amount of actual MOS allocation data available to AEMO when the MOS estimates are prepared. The general approach includes the following steps (see Section 5 for more details):

- Analyse the input data.
- Determine whether the MOS estimates for the forecast MOS period are likely to be affected by any one of:
    - Projected significant changes in the operation of that pipeline or the relevant distribution system during the forecast MOS period. For example, if the operation of an STTM pipeline supplying a hub is expected to change over the forecast MOS period such that the ratio of gas supplies to that hub from the flow and pressure control pipelines is expected to change, then the MOS estimates for that pipeline should be adjusted to reflect these operational changes.
    - Projected significant changes in the load characteristics of the relevant hub during the forecast MOS period (for example, a large gas power generation demand newly connected to a STTM hub).
    - Projected growth (or fall) in annual and peak load in the hub supplied by the relevant pipelines. This adjustment is only necessary if the MOS estimates for the relevant STTM pipeline are expected to increase (or decrease) as the gas demand in the hub that it supplies increases (or decreases).
- Derive the initial MOS estimates using the selected input data incorporating the effects of the factors mentioned above.
- Determine the final MOS estimates if further adjustments to the initial MOS estimates are required.

4. Assessing Forecast MOS Quantities Provided by STTM Pipeline Operators

4.1 Information provided by pipeline operators

STTM pipeline operators providing forecast MOS quantities to AEMO must include all of the following information in their submissions for the relevant MOS period and the related STTM pipeline:

- The maximum quantity for MOS increase and decrease.
- The range of daily quantities of MOS increase or decrease and the number of gas days in the MOS period to which each of these quantities applies.
- Details of the methodology used to derive these forecasts.
- Historical day-ahead nominations and allocations for that pipeline used to derive the forecast MOS quantities.
- The forecast model in a spreadsheet that AEMO can use to validate the forecast MOS quantities included in the STTM pipeline operator's submission.

4.2 AEMO's assessment of pipeline operator's submitted information

Upon receiving the above information from the relevant STTM pipeline operator, AEMO will conduct an assessment of the following.

4.2.1 Data accuracy and completeness

AEMO will check that the pipeline operator's submission:

- Is for the correct MOS periods and the relevant pipeline.
- And includes all the information specified in Section 4.1.

AEMO will reject the submission if the missing or incorrect information is not re-submitted within the timeframe specified by AEMO. This is to enable AEMO to meet its obligations under the NGR to publish a MOS estimate for each STTM pipeline 40 business days prior to a MOS period.

4.2.2 Consistency between the forecast MOS quantities and historical data

AEMO may seek further clarification from the submitting pipeline operators and can reject the submission if the MOS forecasts are significantly different from historical MOS allocations for the same period in the prior year, and there is no explanation provided for these differences. A significant difference means that both of the following conditions are met:

- A difference of ±5% (or ±5,000 GJ) or more between the average forecast MOS increase (or decrease) and the corresponding average MOS allocations for MOS increase (or decrease) for the same MOS period in prior years. This tolerance threshold is believed to be adequate to accommodate the average random year-on-year variations in MOS estimates for a given MOS period. A difference greater than this tolerance range needs further investigation.
- A difference of ±20% (or ±10,000 GJ) or more between the forecast maximum MOS quantity (for MOS increase or decrease) and the maximum MOS allocation for the same period in prior year(s). This tolerance threshold is believed to be adequate to accommodate the random year-on-year variations in the maximum MOS quantity (for MOS increase or decrease) for a given MOS period. A difference greater than this tolerance threshold needs further investigation.

AEMO can revise these tolerance ranges as required.

4.3 Timing for provision of information

As required by Clause 5.2(f) of the STTM Procedures, the forecast MOS quantities must be submitted by STTM pipeline operators not less than 50 business days prior to the start of the MOS period. This is to enable AEMO to assess the submitted information and determine whether to use the MOS estimate provided by the STTM pipeline operator or develop its own estimate, while meeting its timing obligation to publish the MOS estimates for each STTM pipeline 40 business days prior to the MOS period.

As noted previously, the NGR enable AEMO to publish updated MOS estimates not later than 20 business days before the start of a MOS period. If STTM pipeline operators provide forecast MOS quantities within 50 business days prior to the start of the MOS period, AEMO can use this information and republish a MOS estimate if the submitted information meets the requirements outlined in Section 4.2 of this document and AEMO is able to appropriately process the information and meet its requirements to publish a revised MOS estimate 20 business days before the start of the MOS period.

5. Methods for Determining MOS Estimates by AEMO

AEMO generates the MOS estimates for initial periods of operation of a new STTM hub because insufficient historical information is available for the pipeline operator to forecast MOS quantities.

If an STTM pipeline operator does not provide the forecast MOS quantities for that pipeline, or if AEMO rejects the pipeline operator's MOS forecasts, AEMO must generate the MOS estimates.

AEMO will use the methods described in this paper to generate the MOS estimates. The method used takes account of the input data and the amount of MOS allocation data available to AEMO at the time when the relevant MOS estimates are prepared.

5.1 Year 1 of an STTM hub

5.1.1 Sources of input data

For the first 12 months of the STTM hub, there is limited historical MOS allocation data available to AEMO for generating the MOS estimates for each STTM pipeline associated with that hub. Consistent with the requirements of the STTM Procedures, STTM pipeline operators' historical flow data (historical pipeline nomination and allocation data) or historical National Gas Market Bulletin Board (BB) data will be used. These might be used in conjunction with historical MOS allocation data (if available) to derive the MOS estimates for the first year of the STTM hub. STTM pipeline operators' historical flow data, if provided to and accepted by AEMO, is used in preference to the BB data.

Note that although it might be possible to retrieve MOS estimates from market trial activities that occur prior to the commencement of an STTM hub, these estimates will not be used to validate the MOS estimates derived from the historical BB data or pipeline operators' pipeline flow data. This is because the MOS allocation data obtained during a market trial is artificially generated to comply with the requirements of the market trial scenarios (for example, over-forecasting and under-forecasting demand), which have been specifically designed to test the designated STTM processes and systems. Furthermore, trading participants might use the market trial to test various forecast methods and assess the likely impact of each forecast approach on market outcomes before they settle on the best strategy to use on commencement of the STTM.

5.1.2 Method for the market trial

MOS estimates for the purpose of a market trial are generated with the method used for the first MOS period (see Section 5.1.3).

5.1.3 Method for MOS periods 1-3

The MOS estimates for MOS periods 1-3 are derived using either historical BB data or pipeline flow data provided by pipeline operators according to the following formula:

daily MOS estimate = daily pipeline allocation – daily pipeline nomination

Positive MOS estimates indicate the requirements for a forecast increase in MOS. Negative MOS estimates indicate the requirements for a forecast decrease in MOS.

See Appendix A for the methodology for determining indicative MOS estimates using historical BB data.

5.1.4 Method for MOS periods 4-6

The MOS estimates for MOS periods 4-6 are calculated according to the formula in Section 5.1.3 using either historical BB data or pipeline flow data provided by pipeline operators.

5.1.5 Method for MOS periods 7-9

Data from MOS periods 1-3 is used to refine MOS estimates for MOS periods 7-9.

5.1.5.1 Approach

If an STTM pipeline operator provides flow data to AEMO (including pipeline nomination and allocation data) for the corresponding MOS period of the previous year, then the MOS estimates for MOS periods 7-9 are calculated according to the formula in Section 5.1.3.

If, however:

- An STTM pipeline operator does not provide to AEMO the pipeline operator's flow data.
- And, BB data was used to derive the MOS estimates for MOS periods 1-3.
- And, MOS allocation data for the MOS periods 1-3 is available for validating the MOS estimates for MOS periods 7-9.

Then the BB data is used to derive the MOS estimate for MOS periods 7-9 as follows:

1. Derive the initial MOS estimates for MOS periods 7-9 using the BB data.
2. Estimate the forecasting errors in MOS estimates for MOS periods 1-3. To this end, calculate:
    - The ratios of the maximum and minimum MOS allocation to the corresponding maximum and minimum MOS estimate for MOS periods 1-3.
    - The ratio of the average of the positive (or negative) MOS allocations to the average of the corresponding MOS positive (or negative) estimates for MOS periods 1-3 excluding the maximum and minimum values from the computations.[2]
3. Adjust the initial MOS estimates for MOS periods 7-9 (derived in step 1) by applying the ratios calculated in step 2 to correct for the forecasting errors in MOS estimates for MOS periods 1-3. Note that this step will not apply if the initial MOS estimates for MOS periods 1-3 and 7-9 are derived using different sources of input data—for example, historical BB data is used for the MOS periods 1-3 and historical pipeline operators' flow data is used for MOS periods 7-9 or vice versa.

[2] Positive MOS estimates indicate the requirements for a forecast increase in MOS, whereas negative MOS estimates indicate the requirements for a forecast decrease in MOS. The minimum MOS estimate refers to the maximum forecast value in MOS decrease.

4. If the ratio to be applied to the maximum (or minimum) value of the initial MOS estimates is significantly smaller than that to be applied to other positive (or negative) initial MOS estimates—that is, the adjusted maximum (minimum) MOS estimate is no longer the highest (or lowest) MOS estimate in the data set—then the initial maximum (or minimum) MOS quantity is adjusted by applying the ratio of the average positive (or negative) MOS allocations and estimates.

These adjustments are intended to correct the MOS estimates for MOS periods 7-9 (derived from BB data) for systematic forecasting bias, if any, inherent in the forecast MOS estimates for MOS periods 1-3. The forecasting errors in MOS periods 1-3 might otherwise carry through to MOS periods 7-9 and thereby cause the MOS estimates for MOS periods 7-9 to be either consistently over- or under-stated compared with the MOS allocations for MOS periods 7-9. These adjustments do not modify the shape of the distribution of the MOS estimates.

5.1.5.2 Worked example

Table 1 illustrates the steps for adjusting the initial MOS estimates (derived from BB data) for MOS period 7 (of periods 7-9) when the MOS estimates for MOS period 1 (of periods 1-3) are also derived from historical BB data. For simplicity, it is assumed, for this worked example, that there are only 10 gas days in each sample MOS period. The data for MOS periods 1 and 7 and their resulting ratios are shown in Table 1.

Table 1 Determining MOS estimates for MOS periods 7-9 in year 1 of an STTM hub

Year 1	MOS period 1			MOS period 7	
Day	$MOSE_1$ (GJ)	$MOSA_1$ (GJ)		$MOSEI_7$ (GJ)	$MOSE_7$ (GJ)
1	6.7	5.3		4.7	3.7
2	4.6	2.1		4.3	2.2
3	4.5	–0.9		4.0	2.0
4	3.5	–1.0		2.4	1.2
5	–0.4	–1.0		–1.2	–1.6
6	–0.6	–2.1		–2.4	–3.2
7	–1.8	–2.8		–3.1	–4.2
8	–2.2	–3.5		–3.9	–5.3
9	–3.0	–3.8		–5.7	–7.7
10	–3.6	–4.8		–6.8	–9.1
			Ratio		
Maximum	6.7	5.3	79%		
Minimum	–3.6	–4.8	133%		
Average positive	4.2	2.1	50%		
Average negative	–1.6	–2.2	135%		

$MOSE_1$ = MOS estimates for MOS period 1 (of periods 1-3)
$MOSA_1$ = MOS allocations for MOS period 1 (of periods 1-3)
$MOSEI_7$ = initial MOS estimates for MOS period 7 (of periods 7-9)
$MOSE_7$ = adjusted MOS estimates for MOS period 7 (of periods 7-9)

Calculating ratios for MOS periods 1-3

Referring to Table 1, the maximum MOS estimate ($MOSE_1$) and MOS allocations ($MOSA_1$) for MOS period 1 occur on day 1, and the minimum occurs on day 10. The ratio of the maximum $MOSA_1$ to the maximum $MOSE_1$ is 79%, and the ratio of the minimum $MOSA_1$ to the minimum $MOSE_1$ is 133%.

Excluding the maximum $MOSE_1$ (6.7 GJ, in this example), the average positive $MOSE_1$ (on days 2, 3, and 4) is 4.2 GJ. And, excluding the maximum $MOSA_1$ (5.3 GJ in this example), the average positive $MOSA_1$ (on day 2) is 2.1 GJ. Hence the ratio of the average positive $MOSA_1$ (2.1 GJ) to the average positive $MOSE_1$ (4.2 GJ) is 50%.

Similarly, the average negative $MOSE_1$, excluding the minimum, is –1.6 GJ (on days 5 through 9). And the average negative $MOSE_1$, excluding the minimum, is –2.2 GJ (on days 3 through 9). Hence the ratio of the average negative $MOSA_1$ to the average negative $MOSE_1$ is 135%.

Figure 2 compares the MOS estimates and MOS allocations for MOS period 1 from Table 1. This shows that:

- The MOS estimates (MOSE) derived from historical BB data are consistently overstated.
- The MOS allocations (MOSA) tend to be negative (70% of the time).

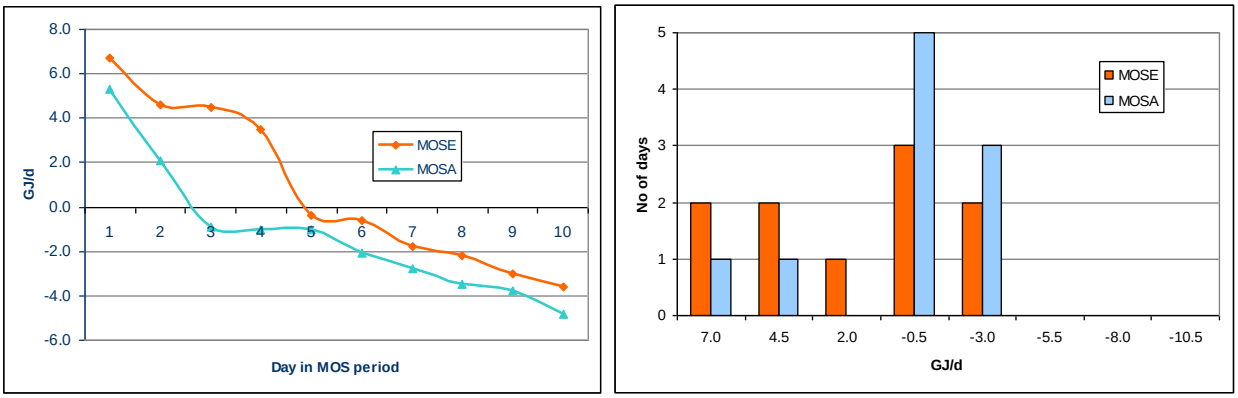


Figure 2. MOS estimates and allocations for the MOS period 1

Adjusting MOS estimates for MOS periods 7-9

Again referring to Table 1, the adjusted MOS estimates for MOS period 7 ($MOSE_7$) are obtained by adjusting the initial MOS estimates for MOS period 7 ($MOSEI_7$) by the ratios calculated above from MOS period 1. In this example, the adjusted values are calculated by:

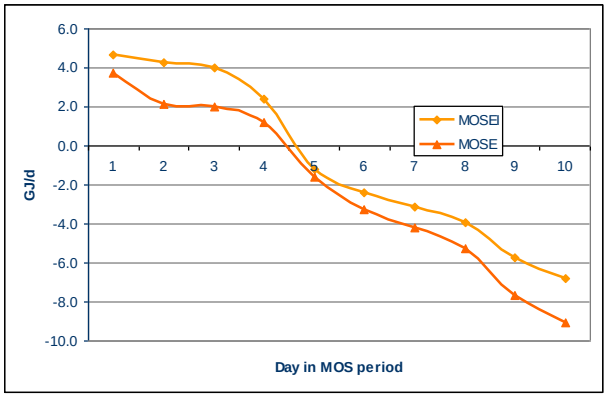
maximum $MOSE_7$ = maximum $MOSEI_7$ × maximum ratio = 4.7 × 79% = 3.7 GJ

minimum $MOSE_7$ = minimum $MOSEI_7$ × minimum ratio = –6.8 × 133% = –9.1 GJ

positive $MOSE_7$ = positive $MOSEI_7$ × average positive ratio
= (day 3, for example) 4.0 × 50% = 2.0 GJ

negative $MOSE_7$ = negative $MOSEI_7$ × average negative ratio
= (day 8, for example) –3.9 × 135% = –5.3 GJ0 displays both the initial (MOSEI) and the

adjusted MOS estimates (MOSE) for MOS period 7, which have been corrected for the forecasting bias in MOS period 1. This has resulted in a relative shift, with no change in the shape, of the distribution of the MOS



estimates.

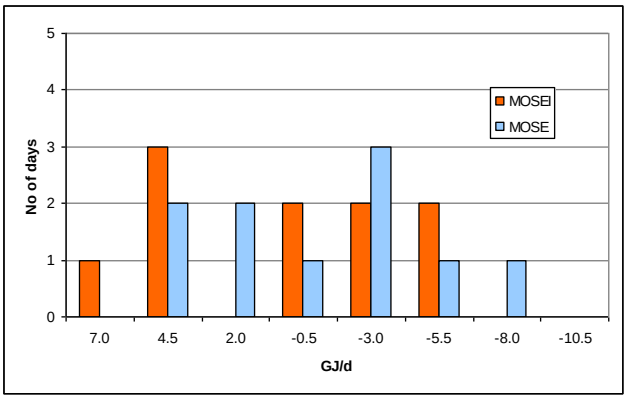


Figure 3. Initial and adjusted MOS estimates for the MOS period 7

The same process should be carried out for MOS estimates in MOS periods 8 and 9 using ratios calculated from MOS periods 2 and 3.

5.1.6 Method for MOS periods 10-12

5.1.6.1 Approach

The forecasting approach for MOS periods 10-12 is similar to that used for MOS periods 7-9 with the following changes:

- If an STTM pipeline operator provides AEMO with flow data (including the provision of pipeline nomination and allocation data) for MOS periods 10-12, the MOS estimate for this period is calculated using the formula in Section 5.1.3.
- If an STTM pipeline operator does not provide the required pipeline flow data for MOS periods 10-12, then historical BB data for the corresponding period in the previous year is used to derive the initial MOS estimates for MOS periods 10-12. These initial MOS estimates are adjusted if the MOS estimates for MOS periods 1-3 and 4-6 are also derived from BB data.

- If the MOS estimates for MOS periods 1-3 and 4-6 are not derived from historical BB data, then the MOS estimates for MOS periods 10-12 are not adjusted. This is because the MOS forecasts are derived using input data of a different type.
- If the estimates for MOS periods 1-3 and/or 4-6 are derived from historical BB data, then those periods that are derived from historical BB data are used to correct for forecasting errors in the initial estimates for MOS periods 10-12. In this case, the MOS estimates for MOS periods 10-12 are adjusted according to steps 2, 3, and 4 of Section 5.1.5.1. The data used to generate the ratios for this calculation is determined as follows:
  - If only the MOS estimates for MOS periods 1-3 are derived from historical BB data, then the ratios are derived from the MOS estimate and MOS allocation data in MOS periods 1-3.
  - If only the MOS estimates for MOS periods 4-6 are derived from historical BB data, then the ratios are derived from MOS estimate and MOS allocation data in the second MOS period.
  - If the MOS estimates for MOS periods 1-3 and 4-6 are derived from historical BB data, then ratios are derived from MOS estimate and MOS allocation data in MOS periods 1-3 and 4-6. The ratios for MOS periods 1-3 and 4-6 are calculated separately and then averaged to give the final adjustment factors.

5.1.6.2 Worked example

Tables 2 and 3 illustrate how the initial MOS estimates for MOS periods 10-12 (derived from the BB data) are adjusted when the MOS estimates for MOS periods 1-3 and 4-6 are also derived from historical BB data (the final case in Section 5.1.6.1).

For simplicity, it is assumed, for this example, that there are only 10 gas days in each sample MOS period and MOS period samples include MOS period 1 (of periods 1-3), MOS period 4 (of periods 4-6) and MOS period 10 (of periods 10-12). The relevant estimates (MOSE) and allocations (MOSA) for MOS periods 1 and 4 and resulting ratios are shown in Table 2. For details on how the adjustment ratios are calculated in this table, refer to the worked example in Section 5.1.5.2.

Table 2 Determining forecast ratios from MOS periods 1-3 and 4-6

Year 1	MOS period 1			MOS period 4		
Day	$MOSE_1$ (GJ)	$MOSA_1$ (GJ)		$MOSE_4$ (GJ)	$MOSA_4$ (GJ)	
1	6.7	5.3		3.5	4.2	
2	4.6	2.1		2.2	0.5	
3	4.5	–0.9		0.5	0.0	
4	3.5	–1.0		–0.5	–0.4	
5	–0.4	–1.0		–0.5	–0.8	
6	–0.6	–2.1		–0.7	–2.1	
7	–1.8	–2.8		–0.9	–2.7	
8	–2.2	–3.5		–1.8	–3.7	
9	–3.0	–3.8		–2.1	–4.0	
10	–3.6	–4.8		–2.6	–6.8	
			Ratio 1			Ratio 2
Maximum	6.7	5.3	79%	3.5	4.2	120%

Minimum	–3.6	–4.8	133%	–2.6	–6.8	262%
Average positive	4.2	2.1	50%	1.4	0.3	19%
Average negative	–1.6	–2.2	135%	–1.1	–2.3	211%

$MOSE_1$ = MOS estimates for MOS period 1 (of periods 1-3)
$MOSA_1$ = MOS allocations for MOS period 1 (of periods 1-3)
$MOSE_4$ = MOS estimates for MOS period 4 (of periods 4-6)
$MOSA_4$ = MOS allocations for MOS period 4 (of periods 4-6)

Table 3 Determining MOS estimates for MOS periods 10-12 from the average ratio

Year 1	MOS period 10		
Day	$MOSEI_{10}$ (GJ)	$MOSE_{10}$ (GJ)	
1	6.7	6.7	
2	3.8	1.3	
3	3.0	1.0	
4	1.0	0.3	
5	–0.8	–1.4	
6	–1.0	–1.7	
7	–1.4	–2.4	
8	–3.1	–5.4	
9	–4.0	–6.9	
10	–4.9	–9.7	
	Ratio 1	Ratio 2	Avg. Ratio
Maximum	79%	120%	100%
Minimum	133%	262%	197%
Average positive	50%	19%	34%
Average negative	135%	211%	173%

Ratio 1 = ratio of the MOS allocation to the MOS estimate in MOS period 1 (see Table 2)
Ratio 4 = ratio of the MOS allocation to the MOS estimate in MOS period 4 (see Table 2)
$MOSEI_{10}$ = initial MOS estimates for MOS period 10 (of periods 10-12) derived from BB data
$MOSE_{10}$ = adjusted MOS estimates for MOS period 10 (of periods 10-12)

Referring to Table 3, the average ratio is the average of the ratios for MOS period 1 (Ratio 1) and MOS period 4 (Ratio 4). The adjusted MOS estimates for MOS period 10 ($MOSE_{10}$) are obtained by adjusting the initial MOS estimates for MOS period 10 ($MOSEI_{10}$) by these average ratios. In this example, the adjusted values are calculated by:

maximum $MOSE_{10}$ = maximum $MOSEI_{10}$ × maximum avg. ratio = 6.7 × 100% = 6.7 GJ

minimum $MOSE_{10}$ = minimum $MOSEI_{10}$ × minimum avg. ratio = –4.9 × 197% = –9.7 GJ

positive $MOSE_{10}$ = positive $MOSEI_{10}$ × average positive avg. ratio
= (day 3, for example) 3.0 × 34% = 1.0 GJ

negative $MOSE_{10}$ = negative $MOSEI_{10}$ × average negative avg. ratio
= (day 8, for example) –3.1 × 173% = –5.4 GJ

The same process should be carried out for MOS estimates in MOS periods 11 and 12 using ratios calculated from MOS periods 2, 3, 5 and 6.

5.2 Year 2 of an STTM hub

The initial MOS estimates for each MOS period in year 2 are determined using the MOS allocation data for the corresponding period in year 1. Adjustments to the allocation data to account for pipeline operational changes or changes in load characteristics can apply, if required.

5.3 Year 3 to year 6 of an STTM hub

5.3.1 Input data for determining MOS estimates

Historical MOS allocation data for previous years (up to 5 years) is used to generate the initial MOS estimates. Either of the following two methods can be used.

5.3.2 Method 1

With method 1, the MOS allocation data for a given MOS period in the prior year is used to determine the initial MOS estimates for the same MOS period in the following year. Hence, the MOS allocations for MOS period 1 in year 1 become the initial MOS estimates for the same MOS period in year 2. Similarly, the MOS allocations for MOS period 1 in year 2 become the initial MOS estimates for the same MOS period in year 3. Appropriate adjustments to historical MOS allocations to account for pipeline operational changes or changes in load characteristics can apply.

This method is simple to implement and can apply to each MOS period beyond year 2 of the STTM hub. However, this method can produce volatile MOS estimates across the forecast years. This is demonstrated in later examples.

5.3.3 Method 2

5.3.3.1 Approach

With method 2, historical MOS allocation data from the same MOS period in recent years (up to the previous five years) is combined to create a larger and more representative sample of MOS allocations from which the initial MOS estimates for the forecast MOS period can be derived. The process involves the following steps:

1. Obtain the MOS allocation data for the relevant MOS period in previous years—that is, MOS period 1 in year –1, year –2, year –3, and so forth up to year –5, if available.
2. Adjust the MOS allocation data if required—that is, for operational changes or load growth.
3. Combine the adjusted allocation data.
4. Sort the combined set of data in descending order.

5. Select a subset of data points to adjust the initial MOS estimates for the current year according to the following equation:

   $n_k = 1 + (j \times k)$

   Where,

   j = number of years of historical data in the combined data set

   k = day of the MOS period (k = 0, 1, 2, ...,l–1)

   l = number of days in the MOS period

   For example, for 2 years of MOS allocation data (j = 2) and 10 gas days per MOS period (l = 10):

   $n_0 = 1 + (2 \times 0) = 1$

   $n_1 = 1 + (2 \times 1) = 3$

   and so forth, through to l–1 (= 9)

   $n_9 = 1 + (2 \times 9) = 19$

6. Replace the smallest value in the selection from step 5 with the minimum MOS allocation from the combined data set. This step is necessary because the selection performed in step 5 will always exclude the smallest historical MOS allocation from the combined data set.

5.3.3.2 Worked example

The following examples demonstrate and contrast the MOS estimates for years 3 and 4 using methods 1 and 2 (see Section 5.3).

Table 4a MOS allocations for the same MOS period in years 1, 2, and 3

	MOS Allocations (MOSA)		
Day	Year 1	Year 2	Year 3
1	5.3	4.2	3.4
2	2.1	0.5	2.0
3	–0.9	0.0	1.4
4	–1.0	–0.4	0.7
5	–1.0	–0.8	–0.1
6	–2.1	–2.1	–0.3
7	–2.8	–2.7	–0.3
8	–3.5	–3.7	–1.1
9	–3.8	–4.0	–2.0
10	–4.8	–6.8	–2.8

Table 4a shows the MOS allocations for a hypothetical MOS period in years 1, 2, and 3 of the STTM hub. For simplicity, it is assumed that there are 10 gas days in each MOS period. These values are used in the following tables to determine MOS estimates for year 3 (Table 4b) and year 4 (Table 4c)

Determining MOS estimates for year 3

With method 1, the year 2 allocations are used as the year 3 estimates (see method 1 column in Table 4b).

With method 2, MOS allocations for years 1 and 2 (j = 2) are used. There are 10 days in the MOS period (I = 10), hence there are 20 values in the combined data set. In Table 4b, the # column shows the sorted order (from maximum to minimum) of the MOS allocations for years 1 and 2.

Applying the selection formula (see step 5 in Section 5.3.3.1), the selected days (#1, #2, #3,…#19) are shown in the initial selection column. Data point #19 (the minimum of all the selected MOS allocation values) is then substituted by the smallest MOS allocation value in the combined data set (#20) to give the final selection of estimates for year 3.

The estimates determined with both methods are compared in 0.

Table 4b Determining MOS estimates for year 3

	MOS Allocations				Method 1		Method 2			
							Initial		Final	
Day	#	MOSA Year 1	#	MOSA Year 2	#	MOSE Year 3	#	MOSE Year 3	#	MOSE Year 3
1	1	5.3	2	4.2	2	4.2	1	5.3	1	5.3
2	3	2.1	4	0.5	4	0.5	3	2.1	3	2.1
3	8	–0.9	5	0.0	5	0.0	5	0.0	5	0.0
4	9	–1.0	6	–0.4	6	–0.4	7	–0.8	7	–0.8
5	10	–1.0	7	–0.8	7	–0.8	9	–1.0	9	–1.0
6	11	–2.1	12	–2.1	12	–2.1	11	–2.1	11	–2.1
7	14	–2.8	13	–2.7	13	–2.7	13	–2.7	13	–2.7
8	15	–3.5	16	–3.7	16	–3.7	15	–3.5	15	–3.5
9	17	–3.8	18	–4.0	18	–4.0	17	–3.8	17	–3.8
10	19	–4.8	20	–6.8	20	–6.8	19	–4.8	20	–6.8

Determining MOS estimates for year 4

With method 1, the year 3 allocations are used as the year 4 estimates (see method 1 column in Table 4c).

With method 2, there are 30 data points in the combined data set, and points #1, #4, #7,… #28 are initially selected from the sorted data values. Data point #28 is the minimum of all the selected values and is substituted by the minimum MOS allocation value in the combined data set (#30). This gives the final selection of estimates for year 4 with method 2.

The estimates determined with both methods are compared in Figure 4.

Table 4c Determining MOS estimates for year 4

	MOS Allocations						Method 1		Method 2			
									Initial		Final	
Day	#	MOSA Year 1	#	MOSA Year 2	#	MOSA Year 3	#	MOSE Year 4	#	MOSE Year 4		MOSE Year 4
1	1	5.3	2	4.2	3	3.4	3	3.4	1	5.3	1	5.3
2	4	2.1	8	0.5	5	2.0	5	2.0	4	2.1	4	2.1
3	15	–0.9	9	0.0	6	1.4	6	1.4	7	0.7	7	0.7
4	16	–1.0	13	–0.4	7	0.7	7	0.7	10	–0.1	10	–0.1
5	17	–1.0	14	–0.8	10	–0.1	10	–0.1	13	–0.4	13	–0.4
6	20	–2.1	21	–2.1	11	–0.3	11	–0.3	16	–1.0	16	–1.0
7	23	–2.8	22	–2.7	12	–0.3	12	–0.3	19	–2.0	19	–2.0
8	25	–3.5	26	–3.7	18	–1.1	18	–1.1	22	–2.7	22	–2.7
9	27	–3.8	28	–4.0	19	–2.0	19	–2.0	25	–3.5	25	–3.5
10	29	–4.8	30	–6.8	24	–2.8	24	–2.8	28	–4.0	30	–6.8

Comparison of estimates from methods 1 and 2

The MOS estimates for year 3 and year 4 determined with methods 1 and 2 are compared in Figure 4. This shows that the MOS estimates generated with method 2 are more stable than those derived with method 1. Method 2 also ensures that the range of MOS estimates remains unchanged across the forecast years.

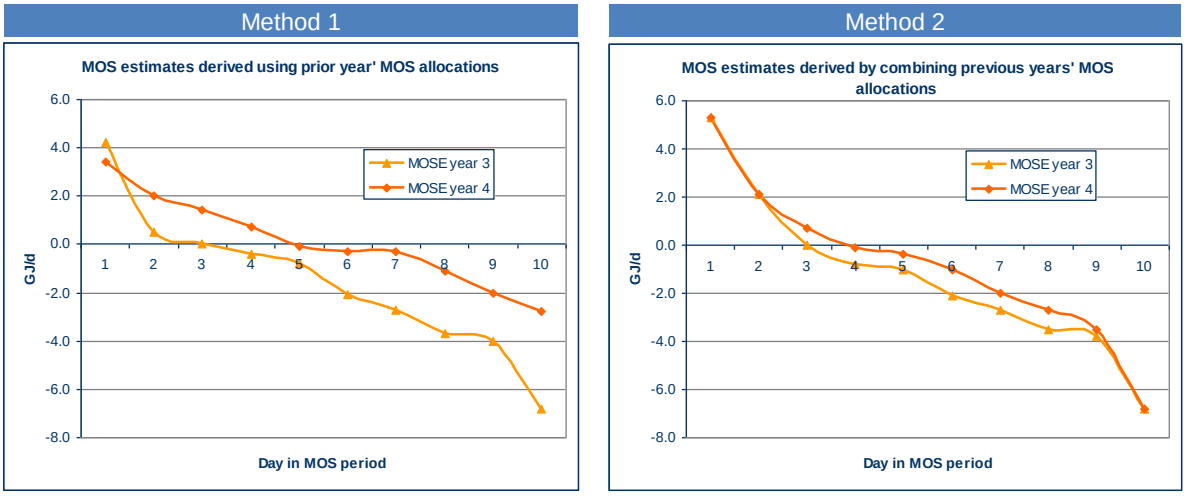


Figure 4. Example of MOS estimates derived using methods 1 and 2

5.3.4 Deciding which method to use

Method 1 is easy to implement but can generate volatile MOS estimates across the forecast years. This is because method 1 does not account for any variability in load from one year to another. However, if there is an underlying trend in historical MOS allocations for a given STTM pipeline that suggests a continuous increase or decrease in the actual MOS allocations for that pipeline, then method 1 can produce more accurate MOS estimates. Otherwise, method 2 is usually preferred to method 1 because the estimates are based on a larger sample data set, which will smooth out any year-to-year variability in the allocation data.

5.4 Forecasting methods after year 6 of an STTM hub

5.4.1 Input data for determining MOS estimates

MOS allocation data for the most recent five years is used to generate the initial MOS estimates. The data can be adjusted, if required. Any of the following three methods can be used.

5.4.2 Method 1

The MOS allocation data for a given MOS period in the previous year is used to determine the initial MOS estimates for the same MOS period in the following year. Adjustments to historical MOS allocations to account for pipeline operational changes or changes in load characteristics can apply. This is the same method 1 described in Section 5.3.

5.4.3 Method 3

Method 3 is a variant of method 2 described in Section 5.3 in which the sample is taken on a rolling five-year basis. Specifically, the MOS allocation data for the relevant MOS period in the most recent five years is combined, sorted, and then selected to generate the initial MOS estimates for the forecast MOS period. For example, in year 7, MOS allocations for years 2 to 6 are combined to generate the initial MOS estimates.

5.4.4 Method 4

Method 4 uses a Monte Carlo simulation. This requires a longer history of MOS allocation data (a minimum of five years) to enable a detailed analysis of the annual trend, seasonality, and natural variability of MOS allocations. As such, at this time, there is currently insufficient historical data to perform a meaningful simulation with method 4.

A simulation model will be developed at the appropriate time.

Advantages of a Monte Carlo simulation

If historical MOS allocations reveal that the range of MOS allocations have reduced over the years due to improved users' demand forecasts, then the observed trend can be built into the simulation model. Similarly, if it is known that users' demand forecast errors tend to be larger in a particular MOS period, then this seasonal pattern can also be factored in the simulation model when the forecast MOS quantities are produced.

The advantage of a Monte Carlo simulation model is that it can generate a large distribution of daily forecast MOS quantities for a given MOS period and an STTM pipeline by running the model many times. Each run represents a possible scenario of supply-and-demand balance pertinent to that pipeline and MOS period. However, the downside of using the simulation approach is the higher cost of developing and maintaining the model. This approach is only recommended if the simpler methods are unsatisfactory.

6. Format and Details of the Published MOS Estimates

The MOS estimates for each MOS period are published in the following format. Sample reports are shown for pipelines at Sydney and Adelaide STTM hubs:

Table 5 Maximum estimated MOS quantity (GJ/d)

	Sydney EGP	Sydney MSP	Adelaide MAP	Adelaide SEA Gas
MOS increase	43,400	25,900	20,987	32,175
MOS decrease	10,400	39,700	13,561	35,612

Table 5 shows the maximum quantity for MOS increase and decrease. AEMO will use these maximum values to determine the MOS service payments for overrun MOS.

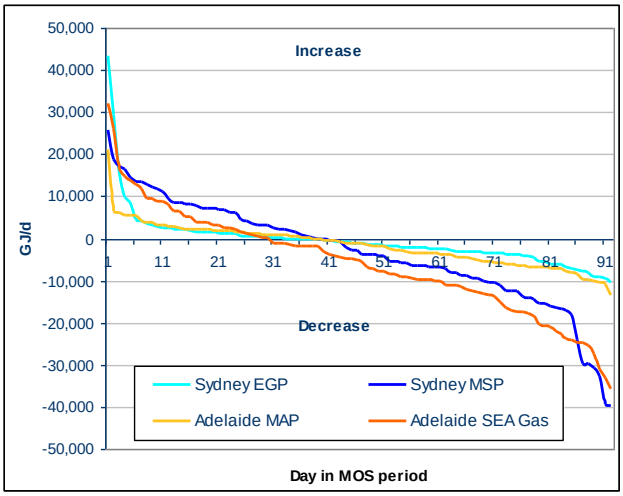


Figure 5. MOS estimates curves

Figure 5 shows the curves of daily MOS estimates sorted in descending order from the highest to the lowest values.

Table 6 Summary statistics of daily MOS estimates[3]

	Summary statistics GJ/d			
	Sydney EGP	Sydney MSP	Adelaide MAP	Adelaide SEA Gas
Maximum	43,400	25,900	20,987	32,175
95%	6,245	13,905	5,335	13,349
75%	1,025	6,075	1,510	2,228
50%	-1,250	-3,200	-1,148	-5,352
25%	-3,425	-10,150	-5,359	-13,246
5%	-7,945	-29,800	-9,778	-25,080
Minimum	-10,400	-39,700	-13,561	-35,612
Mean	-533	-3,435	-1,711	-5,948
Std deviation	6,908	12,594	4,990	12,552
% days positive	38%	42%	40%	33%
% days negative	62%	58%	60%	67%

Table 6 shows the summary statistics of the distributions of MOS quantities, including a measure of central location (median), two measures of dispersion/spread (the range and the inter-quartile range).[4] The means, standard deviations, and the 5 and 95 percentiles of the distributions are also shown together with the proportions of days in the MOS period with positive and negative MOS estimates.[5]

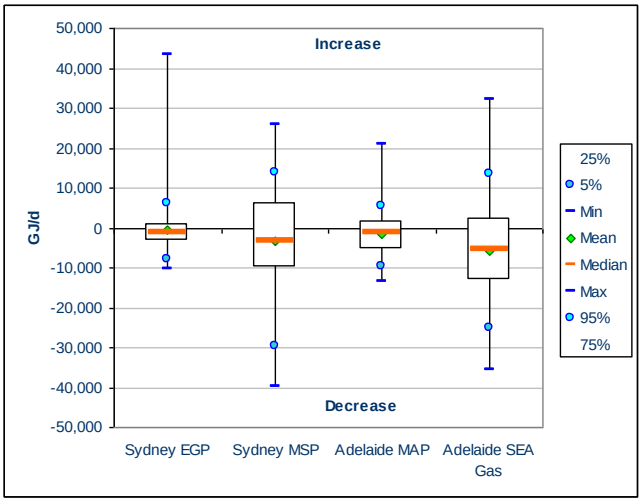


Figure 6. Distribution of daily MOS estimates

Figure 6 shows box plots that provide a graphical summary of the data sets and are useful tools for comparing MOS estimates for the different STTM pipelines.

[3] The minimum value in Table 6 represents the "maximum" forecast value for MOS decrease.

[4] The inter-quartile range is the range of values between the first (25%) and third quartiles (75%).

[5] Positive MOS estimates indicate an increase in MOS, whereas negative MOS estimates indicate a decrease in MOS.

Table 7 Daily MOS estimates (GJ/d)

No of days	Sydney EGP	Sydney MSP	Adelaide MAP	Adelaide SEA Gas	No of days	Sydney EGP	Sydney MSP	Adelaide MAP	Adelaide SEA Gas
1	43,400	25,900	20,987	32,175	1	–1,300	–3,700	–1,187	–5,415
1	29,300	18,700	6,598	26,234	1	–1,500	–3,900	–1,448	–6,730
1	15,900	17,100	5,991	16,309	1	–1,500	–3,900	–1,709	–7,147
1	9,700	16,600	5,573	14,825	1	–1,600	–4,200	–1,816	–7,652
1	8,500	14,400	5,340	13,876	1	–1,800	–4,300	–1,847	–7,709
–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–
1	–1,200	–2,700	–1,108	–5,290	1	–10,400	–39,700	–13,561	–35,612

Table 7 shows the daily MOS quantities sorted in descending order and the number of days associated with each estimated quantity.

7. Accuracy of MOS estimates

MOS provides a mechanism for maintaining supply and demand balance at the STTM hub. MOS allocations for each STTM pipeline reflect deviations in that pipeline schedule and its ability to absorb the supply and demand imbalance in the hub that it supplies. Like all forecasts, MOS estimates are subject to forecasting errors. In the early days of an STTM hub, there is a short history of MOS allocations, which AEMO can use to validate the MOS estimates and the MOS methodology. Consequently, the discrepancies between these forecast MOS quantities and the corresponding MOS allocations are expected to be large. However, the MOS methodology can be validated and improved over time when AEMO has access to more MOS allocation data. The accuracy of the forecast MOS quantities are expected to improve over time.

AEMO will monitor the performance of the MOS methodology and make the necessary changes if and when required. As required by the STTM Procedures, AEMO will consult with trading participants and any other relevant parties before making these changes.

Appendix A Determining Indicative MOS Estimates Using National Gas Market Bulletin Board Data

The analysis of indicative MOS estimates using historical National Gas Market Bulletin Board (BB) data was first undertaken in May 2009 and again in January 2010 for the purpose of producing indicative MOS estimates for the STTM Establishment Market Trial MOS periods. [6] This approach is used for determining indicative MOS estimates from BB data on an ongoing basis.

Both analyses use historical BB data and gas usage from Pelican Point and Torrens Island gas power generators.

Data sources

Actual and forecast BB pipeline flow data, and intraday nominations were obtained for the:

- Moomba to Adelaide pipeline (MAP) and the SEA Gas pipeline (SEA Gas) connected to the Adelaide hub; and
- Moomba to Sydney pipeline (MSP) and the Eastern Gas Pipeline (EGP) supplying gas to the Sydney hub.

Daily actual and (pre-dispatch at 6:00 AM EST) energy was obtained for each generating unit at the Torrens Island and Pelican Point gas power generators.

Data processing

The gas power generation (GPG) data was converted to Terajoules by applying an average thermal efficiency rate (7.35 GJ/MWh for Pelican Point and 12.39 GJ/MWh and 11.40 GJ/MWh for Torrens Island A and B respectively).[7] Both generators operate on either natural gas or fuel oil. This means that the calculated gas usage may have been overstated for some days when fuel oil was used instead of natural gas.

Although the BB Sydney hub aligns reasonably well with the STTM Sydney hub, this is not the case for the Adelaide hub. One of the major differences is that Torrens Island and Pelican Point gas power generators are part of the BB Adelaide hub but are excluded from the STTM Adelaide hub. The combined gas usage of these two generators accounts for approximately 70% of the total demand at the BB Adelaide hub and can be supplied by either or both pipelines connecting to the STTM Adelaide hub. For the purpose of estimating MOS estimates for the STTM pipelines, the Adelaide hub BB data must be adjusted to exclude historical GPG usage.

Either of the gas generators can be supplied from SEA Gas or MAP or both pipelines on a daily basis. In order to estimate the daily MOS required for each pipeline it is necessary to estimate the

[6] See details outlined in the paper *Indicative MOS estimates derived from Bulletin Board data (Sep 2008 – Nov 2009)*, AEMO, VENDocs #295738.

[7] Acil Tasman, *Fuel resource, new entry and generation costs in the NEM*, draft report data set, 25 February 2009

actual and forecast GPG supplied by each pipeline and subtract these quantities from the actual and forecast daily flows of the relevant supplying pipelines. Allocations of GPG demand to each pipeline was achieved by pro rata of the total hub GPG forecast and actual demand to each pipeline in proportion of each pipeline's forecast and actual flow on the day.

Calculations of indicative MOS estimates

MOS estimates for each STTM pipeline and each gas day are calculated by:

Daily MOS estimate = actual BB daily pipeline flow – forecast BB daily pipeline flow (or intraday nomination[8])

This formula applies equally to the calculations of MOS estimates when either the BB data or pipeline operators' data is used.

Positive MOS estimates indicate the requirements for a forecast increase in MOS and a tendency to under-forecast whereas negative MOS estimates indicate the requirements for a forecast decrease in MOS and a tendency to over-forecast.

[8] Intraday nominations were used in place of forecast flows if the data was available.