

# I Review of ROAM Consulting Report

## I.1 Introduction

The Southern Generators submitted a report by ROAM Consulting as part of their “Congestion Pricing and Negative Residue Management Arrangements for the Snowy Region” Rule change proposal (ROAM report).<sup>526</sup> The ROAM report also supplemented the Southern Generators’ submission on the Commission’s Abolition of Snowy Region draft Rule determination (Abolition proposal draft Rule determination). According to the ROAM report, its purpose was to seek to replicate the dispatch and pricing modelling undertaken by the Commission’s consultants, Frontier Economics (Frontier), in order to test the veracity of those results. Those modelling results informed the Commission’s draft decision on Snowy Hydro Limited’s Abolition of Snowy region proposal (Abolition proposal).<sup>527</sup>

The following sections discuss the options modelled by ROAM, the key results they obtained, the assumptions and methodology ROAM applied, the similarities and differences between the ROAM report and the modelling prepared by Frontier for the Commission, and presents the Commission’s conclusions.

## I.2 Options modelled by ROAM

ROAM modelled the following regional boundary configurations and scenarios:<sup>528</sup>

- BAU (Business as Usual): The existing regional boundaries excluding implementation of the Tumut Constraint Support Pricing/Constraint Support Contract Trial (Tumut CSP/CSC Trial) and the Southern Generators Rule. Clamping was implemented to manage counter-price flows on interconnectors;
- BAU-CSP: The Business As Usual case but with the Tumut CSP/CSC Trial in effect as well as the Southern Generators Rule – this reflects the current market structure;
- SHP (Snowy Hydro proposal): The Abolition proposal to abolish the Snowy region, excluding clamping intervention on the Victoria to NSW interconnector;
- SHP-CLAMP: The Abolition proposal but with clamping activated on the Victoria to NSW interconnector; and
- SRD (Split Snowy Region proposal – Dederang): The Split Snowy Region proposal with Dederang included in the Murray region and designated the RRN.

---

<sup>526</sup> ROAM Consulting, *Report to Southern Generators’ Coalition, Analysis of the AEMC Draft Rule Determination to Abolish Snowy Region – Appendix A Modelling*, 3 April 2007 (ROAM report).

<sup>527</sup> AEMC 2007, *Abolition of Snowy Region, Draft Rule Determination*, 19 January 2007, p.13 and section 5, pp.29-67.

<sup>528</sup> ROAM report, pp.8-10.

The BAU, SHP, and SRD scenarios were designed to mimic those scenarios considered in the Frontier modelling for the Commission’s Abolition proposal draft Rule determination in January 2007. The BAU-CSP and SHP-CLAMP scenarios were intended to reflect options that ROAM considered more realistic than the corresponding BAU and SHP options. The BAU-CSP reflects the Southern Generators’ Congestion Pricing proposal, which was submitted as a proposed Rule change to the Commission on 15 March 2007 and the SHP-CLAMP reflects what the Southern Generators considered a more realistic implementation of the Abolition proposal.

### I.3 Key results

ROAM modelled the different cases using two different assumptions about Snowy Hydro’s bidding behaviour. The first assumption involved Snowy Hydro engaging in “typical” bidding while the second assumption involved Snowy Hydro engaging in “strategic” bidding.<sup>529</sup> These assumptions are discussed in more detail in the following section.

For typical Snowy Hydro bidding, ROAM found that the SRD (Split Snowy Region) option gave the lowest production costs of all the options, with the BAU option yielding the highest costs. The results are summarised in the Table below.

**Table I.1: Production cost results with Snowy Hydro typical bidding**

Case	NEM Cost (\$ millions)
BAU	2,098.8
BAU-CSP	2,096.7
SHP	2,096.7
SHP-CLAMP	2,096.5
SRD	2,096.5

Source: ROAM report, Executive Summary, p.I.

For strategic Snowy Hydro bidding, ROAM found that the BAU-CSP (Southern Generators’ Congestion Pricing) option gave the lowest production costs of all the options, with the SRD option yielding the highest costs.<sup>530</sup> ROAM suggested that the CSP/CSC scheme removed the benefit of strategic operation of Tumut, which existed under the BAU case, to constrain the Snowy intra-regional link, thereby decreasing Snowy Hydro’s incentives to “import the [high] VIC pool price into Snowy”.<sup>531</sup> ROAM found that in the BAU case, Snowy Hydro had incentives to offer low levels of Murray output with varying levels of Tumut output to achieve this end. The removal of clamping in the BAU-CSP case also promoted more efficient dispatch by not limiting flows from region to region.

<sup>529</sup> Ibid, pp.4-6.

<sup>530</sup> Ibid, Executive Summary, p.II and p.18.

<sup>531</sup> Ibid, p.11.

By contrast, under the SHP (Abolition) option, Snowy Hydro had a strong incentive to withdraw Tumut output at times of low reserve and high southerly flows.<sup>532</sup> This could cause the NSW-Snowy interconnector to bind, allowing Murray to optimise output. Finally, ROAM found that the SRD option led to the highest (most inefficient) production cost outcomes despite the fact that this option involved pricing Murray and Tumut “correctly” more frequently.<sup>533</sup>

The results are summarised in the Table below.

**Table I.2: Production cost results with Snowy Hydro strategic bidding**

Case	NEM Cost (\$ millions)
BAU	2,095.8
BAU-CSP	2,094.8
SHP	2,094.7
SHP-CLAMP	2,094.0
SRD	2,093.7

Source: ROAM report, Executive Summary, p.11 and p.18.

ROAM pointed out that its strategic bidding results conflicted with Frontier’s results, in that Frontier found that:

- the BAU case led to \$2 million higher production costs than the SHP case; and
- the SRD option led to \$3.5 million lower production costs than the BAU option.

ROAM concluded that appropriate dynamic and static loss factors were included in Frontier’s modelling for the Abolition proposal draft Rule determination. However, it also noted that in the real market, during times when Snowy Hydro will bid in a manner so as to set the price, the change from dynamic inter-regional loss factors to static intra-regional loss factors will create market inefficiencies.<sup>534</sup> The modelling undertaken for this draft Rule determination uses static and dynamic loss factors prepared by NEMMCO, and therefore captures the efficiency effects of changing loss factors.

ROAM also highlighted that Frontier’s results were highly dependent on the outcomes from a particular demand point (demand point 29) and that ROAM could not find the benefits identified by Frontier under those sorts of demand conditions.<sup>535</sup>

---

<sup>532</sup> Ibid, p.13.

<sup>533</sup> Ibid, p.16.

<sup>534</sup> Ibid, p.24

<sup>535</sup> Ibid, pp.24-29.

In conclusion, ROAM found that the SHP option was inferior to a number of other options, including both the BAU and the BAU-CSP option that the Southern Generators have proposed as a Rule change to the Commission.<sup>536</sup>

## **I.4 Assumptions and methodology**

This section outlines the key assumptions and methodology used by ROAM in its modelling. ROAM modelled only one financial year - 2008-09 - which it said was representative of several future years ahead.<sup>537</sup> ROAM also used the "2-4-C" modelling software to undertake its modelling, which it said has been used on behalf of National Electricity Market Management Company (NEMMCO) to establish minimum reserve levels for all regions of the National Electricity Market (NEM) since 2004.<sup>538</sup>

### **I.4.1 Network, load and plant entry assumptions**

ROAM employed a 19 zone interconnected model of the NEM in its modelling.<sup>539</sup> Eleven of those 19 zones were in Queensland, with two each in NSW, Snowy, and Victoria and one each in South Australia and Tasmania. ROAM stated that it applied the interconnector limit equations from the 2005 Annual National Transmission Statement (ANTS) workbook, and used transmission limit equations for the SHP and SRD consistent with those used in the Abolition proposal draft Rule determination.<sup>540</sup> ROAM also stated that it applied relevant dynamic and static loss factor assumptions in all cases, obtained from either NEMMCO or the Commission.

ROAM developed half-hourly load trace forecasts for the NEM corresponding with the 2006 NEMMCO Statement of Opportunities (SOO) medium economic growth, 50% probability of exceedence forecasts for regional energy and demand. The 2005-06 load trace was used to develop the 2008/09 forecast load traces.<sup>541</sup>

All existing NEM plant was included in the modelling, with no plant retirements. New plant assumed to be commissioned by 2008-09 were Kogan Creek (750MW) in Queensland (by Q3, 2007), Hallet B (120MW) in South Australia (by Q3, 2008) and Tallawarra (400MW) in NSW (by Q3, 2008).<sup>542</sup>

Generator forced and planned outage rates were based on the NEMMCO 2006 Minimum Reserve Level studies, except for Snowy Hydro units. ROAM was

---

<sup>536</sup> Ibid, p.30.

<sup>537</sup> Ibid, p.1.

<sup>538</sup> Ibid, p.1.

<sup>539</sup> Ibid, p.2.

<sup>540</sup> Ibid, p.3.

<sup>541</sup> Ibid, p.3.

<sup>542</sup> Ibid, p.6.

concerned that subjecting Snowy Hydro units to outages could interact adversely with the strategic modelling of those units.<sup>543</sup>

Finally, all short-run marginal cost (SRMC) and long-run marginal cost (LRMC) assumptions for plant were as published in the 2006 Minimum Reserve Levels Assumption report.<sup>544</sup> The value of loss load (VoLL) was assumed at \$10,000/MWh, but NEM production costs under the different cases did not reflect this value in the event of load shedding.<sup>545</sup> To the extent that the volume of load shedding varied across cases, this may have distorted the relative production cost savings of the different options.

#### **1.4.2 Bidding assumptions**

All baseload and intermediate plant in the NEM were offered at SRMC and all peaking plant were offered at LRMC, except for Snowy Hydro's Murray and Tumut plant.<sup>546</sup> In the strategic bidding scenarios, ROAM allowed Murray and Tumut to offer different levels of capacity into the market (at \$1/MWh) based on 12.5% capacity increments. This led to 81 potential different bidding combinations. Murray and Tumut were given an energy budget of up to 4,900 GWh per annum.<sup>547</sup>

ROAM's approach to determining the optimal Murray and Tumut bids involved the following steps:<sup>548</sup>

- For each half-hour, Snowy Hydro's revenue per MWh was compared for each of the 81 potential Murray and Tumut bidding combinations against the "typical" bid for the half-hour. The typical bid was based on ROAM's analysis of Snowy Hydro's historical bidding behaviour, and reflects annual, monthly, weekly and daily energy limitations;<sup>549</sup>
- For each half-hour, the best combination of potential bids was selected as the effective bid so long as:
  - The Snowy Hydro spot revenue (in \$/MWh) for that combination exceeded the "typical" bid revenue by an adjustable margin; and
  - The outcome for the combination increased Snowy Hydro's gross revenue (in \$) for that half-hour.

This meant that Snowy Hydro could increase or decrease output compared to the typical situation provided the half-hourly revenue increased (in both \$/MWh and

---

<sup>543</sup> Ibid, p.6.

<sup>544</sup> Ibid, p.7.

<sup>545</sup> Ibid, p.7.

<sup>546</sup> Ibid, pp.4-5.

<sup>547</sup> Ibid, pp.5 and 11.

<sup>548</sup> Ibid, p.5.

<sup>549</sup> Based on a discussion between AEMC staff and ROAM Consulting, 30 July 2007.

overall \$). ROAM found that for more than 75% of hours, the typical bid was retained.<sup>550</sup>

ROAM stated that its approach to dynamic bidding was consistent with Frontier's approach.<sup>551</sup>

### **1.4.3 Clamping assumptions**

ROAM stated that its modelling of the BAU option incorporated NEMMCO management of negative inter-regional residues on the Victoria-Snowy and Snowy-NSW interconnectors. ROAM referred to NEMMCO's Operating Procedure but gave a fuller explanation of its approach in section 5 of its report. This section explained that in the BAU case, clamping was implemented if the dispatch was expected to cause a negative settlement residue greater than \$1,500 in any single trading interval. ROAM's results showed that the strategic bidding of Snowy Hydro caused a greater incidence of negative settlement residues than under typical bidding.<sup>552</sup>

However, ROAM applied clamping rather than re-orientation for southward flows on the Victoria-Snowy interconnector in the BAU case.<sup>553</sup> This appears to have been an oversight and may explain some of the differences between the results obtained by ROAM and those produced by Frontier.

## **1.5 Discussion of ROAM methodology, results and explanation**

The Commission acknowledges and supports the effort made by the Southern Generators to analyse the different region boundary change proposals by commissioning independent modelling analysis. The ROAM modelling provided a useful counterpoint to the Frontier results.

The Commission has identified a number of areas of difference between the ROAM modelling and the Frontier modelling. The Commission also noted there were some results that did not accord with intuition and these the ROAM report did not elaborate on reasons for the difference.

### **1.5.1 Areas of difference between the ROAM methodology and Frontier methodology**

The key points of difference between the ROAM and Frontier modelling methodologies relate to the use and meaning of "strategic" bidding. Strategic bidding refers to any situation where a generator does not offer all its available capacity to the market at its marginal or avoidable costs. Strategic bidding includes a generator offering some or all its available capacity above cost, withholding a proportion of its available capacity from the market, or some combination of the two.

---

<sup>550</sup> ROAM report, p.5.

<sup>551</sup> Ibid, p.5.

<sup>552</sup> Ibid, pp.8 and 11.

<sup>553</sup> Based on a discussion between AEMC staff and ROAM Consulting, 30 July 2007.

The ROAM modelling allowed only the Murray and Tumut generators to bid at prices diverging from their costs. All other plant were bid at some measure of their marginal cost. In contrast, Frontier assumed that the Murray and Tumut generators, as well as a number of other large generation portfolios, could bid strategically. These other portfolios were Delta Electricity, International Power, LYMMCO, Macquarie Generation, Enertrade, and TRU Energy.<sup>554</sup> These non-Snowy Hydro participants were able to withhold between 10% and 30% of their portfolio capacities in order to maximise their profits. This difference in assumptions alone may explain the different results obtained by ROAM from those obtained by Frontier.

Another key difference in the methodologies was in respect of the nature of each consultant's approach to finding equilibrium dispatch outcomes under strategic bidding. Frontier's methodology applied a game-theoretic approach to determine optimal plant bids. This game-theoretic approach utilised the Nash Equilibrium solution concept to find sets of bids in which no strategic "player" was able to increase its profits – taking account of both its spot and contract position – by unilaterally changing its bid or offer. The merit of this approach is that it yields bidding combinations that are theoretically robust and sustainable across all relevant players.

By contrast, the ROAM approach to strategic bidding only involved one player (Snowy Hydro) having the freedom to make or change bids in order to maximise its revenue. The bids and offers of all other participants were fixed at SRMC or LRMC, allowing those other participants no ability to respond to the strategy chosen by Snowy Hydro or the resultant market price outcomes. The bidding strategies resulting from this approach would only coincidentally be mutually consistent (i.e. would only coincidentally be Nash Equilibria).

From this point of view, the modelling exercises undertaken by Frontier and ROAM are not directly comparable. While it is unclear, at this stage, which approach has better predictive qualities, the Commission considers that for this type of analysis, a modelling approach that accounts for a greater number of strategic players is likely to be more consistent with market outcomes than an approach that focuses on a single strategic player.

A related issue to the approach to defining strategic bidding was the approach that ROAM used to find the optimal Snowy Hydro bidding combination. ROAM's approach involved first finding the Murray/Tumut bid combination (out of the 81 possible combinations) that led to the highest \$/MWh revenue, and then checking whether this exceeded the revenue obtained (in both \$/MWh and absolute \$ terms) compared to the typical bid combination for that half hour.<sup>555</sup> However, it is not clear why a given bid combination for Murray and Tumut need necessarily increase the \$/MWh revenue in order for it to be regarded as "optimal". Assuming zero fuel costs, the objective of Snowy Hydro would presumably be to maximise the revenue from its energy budget over a given year.

---

<sup>554</sup> Abolition Draft Rule Determination, Appendix A, pp.97-99.

<sup>555</sup> See ROAM report, p.5.

In some cases, such as at extremely high demand times, it may be worthwhile for Snowy Hydro to offer more capacity to the market to increase its total \$ revenue, even though that may reduce its \$/MWh revenue at that time. The opportunity cost of such behaviour would be to reduce available energy for dispatch at other (non-super-peak) times. However, that may well be the optimal strategy for Snowy Hydro since prices are likely to be much lower outside the super-peak times.

By contrast, Frontier's approach to Snowy Hydro bidding involved removing the energy budget constraint from Snowy Hydro at "super-peak" summer and winter times, thereby allowing their model to find the fully optimal bidding strategy at these times.

The Commission has discussed this matter with ROAM and ROAM has acknowledged that the approach it adopted may not produce Snowy Hydro's optimal strategy in certain high-demand situations. ROAM highlighted that the approach it adopted was chosen in part to enable its work to be completed within the required timeframe.<sup>556</sup> The way in which ROAM modelled clamping of the Victoria-Snowy and Snowy-NSW interconnectors was also different to the approach adopted by Frontier. In the Abolition proposal draft Rule determination Frontier's approach implemented clamping of the Victoria-Snowy interconnector (northward) and the Snowy-NSW interconnector (in both directions) based on a zero threshold for negative settlement residues and perfect foresight. That is, the relevant interconnector limit was immediately set to zero when there would otherwise have been any negative settlement residues accruing on the interconnector for the given set of bids. NEMMCO's actual implementation of clamping involves the use of a \$6,000 threshold. ROAM's approach used a \$1,500 per trading interval threshold as an approximation for NEMMCO's implemented approach.

The Frontier's zero threshold perfect foresight approach to clamping applied in the modelling for the Abolition proposal draft Rule determination has been modified to better reflect NEMMCO's implemented approach for the modelling undertaken for this determination. These revised assumptions can be found in Appendix [B].

The Commission considers that differences in modelling methodology explain many of the differences between the Frontier and ROAM modelling results. For example, ROAM's finding that demand point 29 was not significant in driving dispatch efficiency benefits is likely to be a function of differences in strategic bidding assumptions. Similarly, the change in the rankings of the options modelled by ROAM with the introduction of strategic bidding assumptions highlights the importance of bidding assumptions on the results produced. However, the limitations in ROAM's treatment of strategic bidding make it difficult for the Commission to confidently rely on the ROAM report results.

---

<sup>556</sup> Based on a discussion between AEMC staff and ROAM Consulting, 30 July 2007.



### **I.5.2 Areas where ROAM results were inconsistent with intuition, and therefore required additional explanation**

The Commission found the commentary of some of the production costs presented by ROAM did not provide a clear explanation of what was driving those results. Where modelling results do not align with economic intuition, a full explanation is required to reconcile the differences. The lack of explanation of several key results made it difficult for the Commission to reconcile the departure from intuition, and therefore confidently rely on the results.

An example is the explanation for the beneficial predicted impacts of the BAU-CSP option. ROAM suggested that the reason why this option led to the most efficient dispatch was that it priced Tumut generation correctly, reducing Snowy Hydro's incentives to bid Tumut strategically in forcing constraints between Murray and Tumut.<sup>557</sup> ROAM observed that:

“...the CSP/CSC trial has been successful through application of ‘pseudo-nodal pricing’ for the Tumut node in alleviating the incentive for Snowy Hydro to exercise market power. Since its implementation, binding constraints on the Murray-Tumut intra-regional interconnector [sic] have significantly reduced.”<sup>558</sup>

However, the Commission's conceptual analysis suggests it is likely that *all* the options would reduce the incentives for Tumut to “flood” the lines south to Murray at times of high Victorian demand, as *all* the alternative options would lead to Tumut being settled at a different price to the Murray price when constraints between Murray and Tumut bound. Furthermore, the other option that involved pricing Tumut correctly in all cases was the SRD option. However, ROAM found this option produced the worst dispatch results, even worse than the BAU case. This suggests that the “correct” pricing of Tumut generation alone cannot explain why the BAU-CSP ought to produce the most efficient dispatch results.

Having discussed this matter with ROAM, the Commission understands that ROAM's justification for the positive results for the BAU-CSP case was based on the fact that it correctly priced *both* Tumut *and* Murray. However, as discussed by the Commission in its current and previous modelling appendices, correct nodal pricing of generation may not necessarily lead to the most efficient dispatch results in the presence of transient market power – generators' desire to leave “headroom” on downstream lines may mitigate against the positive efficiency implications of overcoming mis-pricing.<sup>559</sup>

Another example of where the results did not accord with intuition, and the difference was not appropriately explained, was where the SHIP option was criticised by ROAM on the basis that it gave Snowy Hydro incentives to withhold Tumut

---

<sup>557</sup> ROAM report, p.19.

<sup>558</sup> Ibid, p.22.

<sup>559</sup> Abolition Draft Rule Determination, p.32.

generation at times of high southward flows and low reserve levels.<sup>560</sup> ROAM likewise criticised the Frontier modelling for not discussing the possibility of Snowy Hydro bidding strategically by withholding output.<sup>561</sup>

However, ROAM does not explain why Snowy Hydro would be incentivised to withhold Tumut output at these times to a greater degree than under the BAU-CSP or SRD options. In all cases, Snowy Hydro may be able to import the Victorian price north to Tumut by bidding Tumut in such a way as to ensure that the lines between Tumut and Murray do not bind.

What may be possible is that under the SHP option, Snowy Hydro can swap Tumut output for Murray output, as constraints south of Murray under the SHP option would not reduce the price at which Murray output would be settled. However, this explanation is not proffered by ROAM in its report. Based on later discussions with ROAM, it appears that this may have been the intended explanation. However, even if it is, it is not clear why this behaviour ought to necessarily lead to less efficient outcomes than the BAU-CSP and SRD options, in which Snowy Hydro has an incentive to leave some headroom on the lines south of Murray to avoid being constrained-off from the (high) Victorian price at these times.

Finally, as noted above, the Frontier modelling did explicitly allow for Snowy Hydro to engage in the type of withholding strategies mentioned in the ROAM report. Therefore, the claim that Frontier's modelling did not allow for the possibility of this outcome is unfounded.

The failure to satisfactorily explain the inconsistency between the conceptual analysis and the modelling results makes it difficult for the Commission to confidently rely on the ROAM analysis.

## **1.6 Conclusion**

The Commission welcomes the contribution made by the Southern Generators and ROAM to the analysis of the Frontier modelling presented in the Abolition proposal draft Rule determination. The ROAM modelling provides a useful counterpoint to the Frontier modelling. It is clear to the Commission that all simulation modelling contains limitations and can thus only ever provide an indication of likely results rather than definitive predictions. The Commission also appreciates that ROAM undertook its modelling exercise within a very short time period.

However, it appears that the assumptions made within the ROAM modelling are more limiting than those made by the Commission's consultants. In addition, there were several cases where the ROAM modelling analysis produced results that were inconsistent with intuition, and this inconsistency was not satisfactorily explained. The narrower treatment of strategic bidding, the lack of a Nash Equilibrium approach, the limited explanation for some of the results, and the use of only a single

---

<sup>560</sup> ROAM report, p.13.

<sup>561</sup> Ibid, p.23.

year of analysis suggests that the Commission should place limited weight on these results when compared to those prepared by Frontier.

This is the last page of this draft determination.