CONGESTION MANAGEMENT ISSUES:

HOW SIGNIFICANT IS THE MIS-PRICING IMPACT OF INTRA-REGIONAL CONGESTION IN THE NEM?

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1. This paper presents the results of one possible methodology for measuring the significance of the intra-regional congestion "problem" in the NEM. This methodology is based on measuring the frequency, duration and magnitude of the deviation in the "local" or "nodal" price at each generator connection point from the regional reference price in the same region.

2. The key conclusions emerging from this study are as follows:

- Mis-pricing is a frequent and enduring issue at a relatively large number of connection points. Around 95 generator connection points in the NEM have been mis-priced for more than 100 hours per year on average over the last three years.[1]

- The number of mis-priced connection points and the average number of hours of mis-pricing per connection point has been increasing quite rapidly over the past three years.

- This generator mis-pricing cannot be eliminated through a small number of region boundary changes. For example, a move to 17 ANTS zones[2] would reduce the frequency and duration of mis-pricing slightly in QLD and SA, but would have virtually no impact on mis-pricing in NSW and TAS. If creating new regions were the only mechanism for managing intra-regional congestion, the number of pricing regions in the NEM would need to be much larger to effectively eliminate the mis-pricing problem.

Introduction

3. In an efficient liberalized electricity market, the price for electricity will, on occasions, vary across different locations on the network due to the presence of transmission constraints or "congestion". The Australian National Electricity Market allows for a degree of differentiation of the price for electricity at different geographic regions – at present, the NEM computes different prices for six different geographic regions.

4. However, at present the NEM forces electricity prices to be uniform[3] within each of those regions. Unsurprisingly, when the market rules "force" the price at a given location to be above or below the true locational or nodal price at a location, the behaviour of market participants is distorted. Two particular problems have been highlighted:

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[1] According to NEMMCO's document "List of Regional Boundaries and Marginal Loss Factors for the 2005/06 Financial Year" (version 2.3), there are 284 generator connection points in the NEM. There are another 406 load connection points in the NEM. However, since these do not normally appear on the left-hand side of the constraint equations, it is not possible to determine when these loads are "mis-priced".

[2] The ANTS zones are used by NEMMCO for modelling purposes in the context of the Annual National Transmission Statement. This is published annually as part 2 of the NEMMCO "Statement of Opportunities".

[3] Apart from fixed intra-regional "marginal loss factors". Uniform geographic pricing is sometimes known as "postage stamp" pricing.

(a) Generators which are paid a price which is above or below the correct locational price for their location (these generators are sometimes said to be "constrained on" or "constrained off") no longer have an incentive to offer their output at a price which reflects their true marginal cost, but instead have an incentive to offer their output at a price which is significantly above or below their true cost.

Importantly, these generators have commercial incentives to use whatever mechanisms are available to them to increase or decrease the amount for which they are dispatched. For example, generators have been known to declare themselves "inflexible"[4], to use their ancillary services bids in a way which prevents their output in the energy market being reduced, or to reduce their ramp rates to slow the rate at which their output can be scaled down.[5] The AER (and its predecessor, NECA) has prosecuted a generators for these actions[6] and is considering its options to clarify and strengthen its powers to prevent similar actions in future.[7] Unfortunately, generators face strong continuing commercial incentives to innovate in developing new techniques to prevent their output being reduced (or increased) when they are constrained off (or on, respectively).

Importantly, from an overall economic welfare perspective, this behaviour reduces the short-term efficiency of dispatch. More-expensive generation is dispatched to meet the total load in the system, even when less-expensive generation remains available.

(b) In the longer term, price signals for location or expansion decisions at different locations on the network are distorted – generators and large loads may choose to locate at a point on the network which exacerbates congestion and may choose to forego opportunities to invest in locations which alleviate congestion.

Importantly, the failure to send effective location signals has a "chilling effect", on investment in low-cost generation which is remote from major load centres. Such generation faces a risk that subsequent investment (even when less efficient) will exacerbate congestion and hinder the ability of the first generator to get its product "to market".[8] This problem is particularly acute when the first generator is locating in a separate pricing region – in this case it faces the risk

[4] That is, to bid "fixedload". For example, as a result of investigation into the events of 22 March 2006, AGL was issued with an Infringement Notice, for the mis-use of "fixedload" bidding for purely commercial reasons. The AER has stated: "It is critical that the inflexibility provisions are used only where abnormal operating conditions exist", AER, October 2006, "The events of 31 October 2005: Investigation Report", page 36.

[5] The AER has stated that: "The AER is concerned that the practice of rebidding reduced ramp rates for commercial reasons jeopardised system security. This is because the market systems are prevented from being able to quickly adjust power flows to respond to issues that emerge in the market. The AER is aware that other physical bid parameters (including frequency control ancillary service trapeziums) have also been used for commercial reasons, with a detrimental impact on power system security management. AER, October 2006, "The events of 31 October 2005: Investigation Report", page 36.

[6] For example, Macquarie Generation was found in breach of the code for misuse of the inflexibility provisions on 19 and 20 December 2001.

[7] The AER notes: "In general there are two possible approaches. One is to remove or reduce the incentive for generators to reduce the ramp rate for commercial reasons. The second is an administrative requirement for ramp rate bids to reflect actual generator capacity. The AER intends to develop and submit a Rule change proposal late this year or early next year. In considering this issue the AER will assess whether other physical bid parameters may be used for commercial reasons to the detriment of power system security management.". AER, October 2006, "The events of 31 October 2005: Investigation Report", page 36

[8] Conversely, there may be an "over encouragement" of high-cost generation to choose locations remote from the regional reference node.

that its entire output may be "constrained off", even by a less efficient new entrant, locating closer to the major load centre. Concerns of this kind have been expressed about new investment in generation in south-east South Australia blocking flows from VIC and southern NSW, blocking flows from the Snowy region.[9]

5. These problems are sometimes collectively known as the problem of "intra-regional congestion". This terminology is not strictly correct since the same problems can arise in networks with loops even in the absence of intra-regional constraints.[10] These problems are not the only problems that arise in the current NEM arrangements – there are also problems with the use of inter-regional settlement residues as a hedging device. This paper, however, focuses on the problem of generator "mis-pricing" in the NEM.

6. That the current arrangements in the NEM on occasion give incorrect price signals to generators, giving rise to inefficient behaviour, is undisputed. But just how big is this problem? Is it worth introducing new mechanisms for improving the price signals for generators?

7. How should we go about assessing the magnitude of the mis-pricing problem?

8. One way of answering this question is to compute the "correct" locational price for electricity at each "node" or "connection point" on the national transmission network. If the correct locational price for a given connection point differs very little or very rarely from the price forced on that location by the market rules, we might conclude that the problem is immaterial. Conversely, if we determine that the correct locational price at a given location differs very often or very significantly from the price enforced by the market rules, we might conclude that the problem of intra-regional congestion is significant.

9. As we will see, this methodology has the advantage that it is simple and straightforward to implement. However, it is important to keep in mind that this methodology does not directly measure the short-term economic harm arising from intra-regional congestion. To assess the economic harm from intra-regional congestion it is not sufficient to simply measure the number of hours of mis-pricing in the NEM – rather we need to know the extent to which that mis-pricing reduces the efficiency of dispatch. It is theoretically possible that (if the elasticity of supply is very low) even a relatively large mis-pricing at a location in the NEM might induce relatively little reduction in the short-term efficiency of dispatch.

10. Unfortunately, answering the question of the impact of intra-regional congestion on dispatch requires a considerably more sophisticated what-if analysis. In part, we would need to explore how generators *would have bid* if they had faced the correct locational price. This would require a large number of assumptions, or a considerably more sophisticated model.

11. This paper does not attempt to measure the magnitude of the short-term loss in economic welfare from mis-pricing. Rather this paper simply seeks to measure the frequency and duration of mis-pricing events. The analysis presented here is therefore best viewed as a "first cut" at assessing the magnitude of the intra-regional congestion problem. However, the mis-pricing revealed in this analysis will have a direct impact on longer-term generator and load location and expansion decisions which may, in the long term, have a much larger impact on efficiency than a reduction in the short-term efficiency of dispatch.

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[9] See, for example, Snowy Hydro's submission to the Congestion Management Review. Snowy Hydro highlights, as an example of "obviously inefficient investment" : "the proposed Wagga gas generation plant (that will not add any single MW of additional supply to NSW demand … and simply substitute existing Tumut generation plant in the same physical transmission location but artificially defined to a different market region". Snowy Hydro, letter to the AEMC, 11 April 2006.

[10] This problem is more correctly described as the problem of "mis-pricing of intra-regional nodes".

12. Fortunately, it is very straightforward to compute the correct locational price for each connection point in the NEM, using information which is regularly produced by the NEM dispatch engine.[11] In fact, for any connection point in the NEM, the correct locational price is equal to the regional reference price for that connection point less, for every binding constraint equation, the constraint "marginal value" times the coefficient of that connection point in that constraint equation.

13. The correct locational price at the *k*th connection point can be expressed mathematically as follows (ignoring intra-regional losses):

$$\text{CP\_Price}_k = \text{RRP} - \sum_n \text{Coeff}_k^n \times \text{Marginal\_Value}^n$$

Where

CP_Price_k is the location marginal price at the *k*th connection point; RRP is the regional reference price at the corresponding regional reference node; Coeff_k^n is the coefficient on the *k*th connection point in the *n*th constraint equation; and Marginal_Value^n is the "marginal value" of the *n*th constraint equation.[12]

14. Once we have calculated the correct locational price for every connection point in the NEM over a period of time, we are in a position to answer a number of interesting questions:

(a) *How many* connection points are affected? Which connection points are most affected? Which constraints are the primary drivers of the mis-pricing?

(b) *How often* does each connection point price differ from the regional reference price? The more hours that a given connection point price differs from the regional reference price, the greater the argument for correcting the price signals at that connection point[13].

(c) *How large* is the deviation of the locational price from the regional reference price?

(d) Is the problem getting better or worse over time?

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[11] Strictly speaking, this approach can only determine the correct connection point price for those connection points which are included in the dispatch engine constraint equations. Since loads are not (usually) directly controllable by the NEM dispatch engine, they do not normally appear in the constraint equations. Neither do the connection points for non-scheduled generators. This analysis therefore focuses on mis-pricing at connection points linked to scheduled generation.

[12] Exactly the same equation can be found in other documents. For example, the part of the National Electricity Rules which deals with the Snowy CSP/CSC trial (Part 8(j)) defines the "substitute price" SPd_p (for p = the power stations: Lower Tumut and Upper Tumut) as follows: $SPd_p = DP_{Snowy} \times TLF_p - \sum_k CSP_{ak} \times Coeff_{p,k}$, where: DP_{Snowy} is the dispatch price that applies to the Snowy region for the relevant dispatch interval; TLF_p is the transmission loss factor for power station "p"; CSP_{ak} is the constraint marginal value ($/MWh) as determined by the dispatch engine for each dispatch interval of relieving binding constraint "k" by a marginal amount; and $Coeff_{p,k}$ is the coefficient assigned to element "p" in constraint "k" from the Murray/Tumut constraint list.

[13] Either by some form of congestion management mechanism (such as the constraint-based residues approach) or by putting that connection point in a separate region from the regional reference node.

(e) Would the mis-pricing be eliminated with just one or two region boundary changes? Would the mis-pricing be eliminated with a move to, say, the 17 ANTS zones? How many pricing regions would we require if we were to eliminate all historical mis-pricing?

(f) Who gains and who loses from this mis-pricing?

15. The box below sets out the methodology in a little more detail.

Some Theory

Mathematically, the formula for the correct locational price for each connection point in the NEM can be written as follows:

$$p_i = P_{region(i)} LF_i - \sum_n \lambda_n \alpha_i^n$$

Where p_i is the nodal or connection point price for the *i*th connection point, $P_{region(i)}$ is the regional reference price for the corresponding region, LF_i is the (static) intra-regional marginal loss factor for the *i*th connection point, λ_n is the marginal value of the *n*th constraint equation and α_i^n is the coefficient on the *i*th connection point in the *n*th constraint equation.

Therefore, ignoring static intra-regional losses, a connection point will have a locational price different from the regional reference price if and only if the sum of each constraint marginal values times the coefficient of that connection point in that constraint equation is non-zero.

We can say that a connection point is *mis-priced* if the correct locational price for that connection point is different from the regional reference price. In other words a given connection point *i* is *mis-priced* in a given dispatch interval if and only if $\sum_n \lambda_n \alpha_i^n \neq 0$ in that interval.

We can compute the number of hours for which a connection point is mis-priced by simply adding up the number of dispatch intervals for which that connection point is mis-priced and dividing by 12.

Another question we can ask is whether or not two connection points should be placed in the same region? This is equivalent to asking: for a given set of binding constraint equations, are these connection points ever subject to a different connection point price? Two connection points will only be subject to a different connection point price if for one of those binding constraints, these two connection points have a different coefficient in the constraint equation. Ignoring intra-regional losses, two connection points *i* and *j* should be in a different region from each other if and only if for some constraint equation *n* in the set $\alpha_i^n \neq \alpha_j^n$.

For example, suppose that a simple network has three nodes remote from the regional reference node, called A, B and C. There are three binding intra-regional constraint equations:

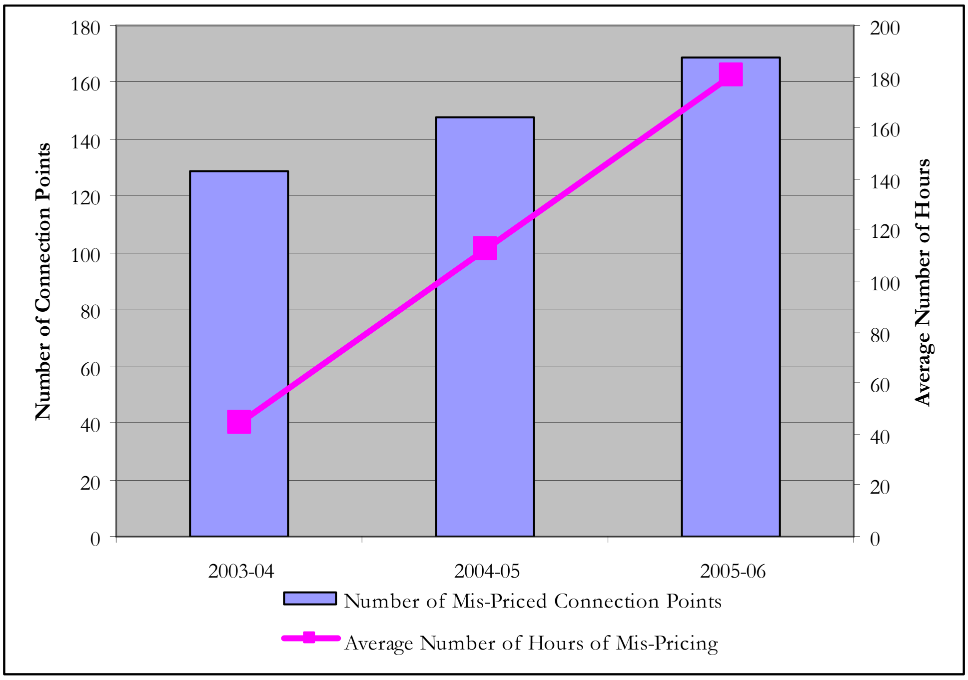
Constraint Equations	Hours binding
$0.731Q_A + 0.731Q_B + 0.256Q_C \leq RHS_1$	10 hours
$0.731Q_A + 0.256Q_B + 0.256Q_C \leq RHS_1$	100 hours
$0.502Q_A + 0.256Q_B + 0.256Q_C \leq RHS_1$	60 hours

Let's suppose that we only care about constraints which bind for more than 20 hours. In this case, we need only focus on the 2nd and 3rd constraints. These two constraints give rise to the need for two additional regions – with node A in one region and nodes B and C in the other. Nodes B and C can be in the same region because under all the relevant constraints, nodes B and C have the same coefficient in the corresponding constraint equations. If we care about all mis-pricing, a 3rd region is required, to account for the fact that equation 1 also induces separate pricing between nodes B and C. With nodes A, B and C in separate regions, all mis-pricing is eliminated.

How many connection points are mis-priced and for how long?

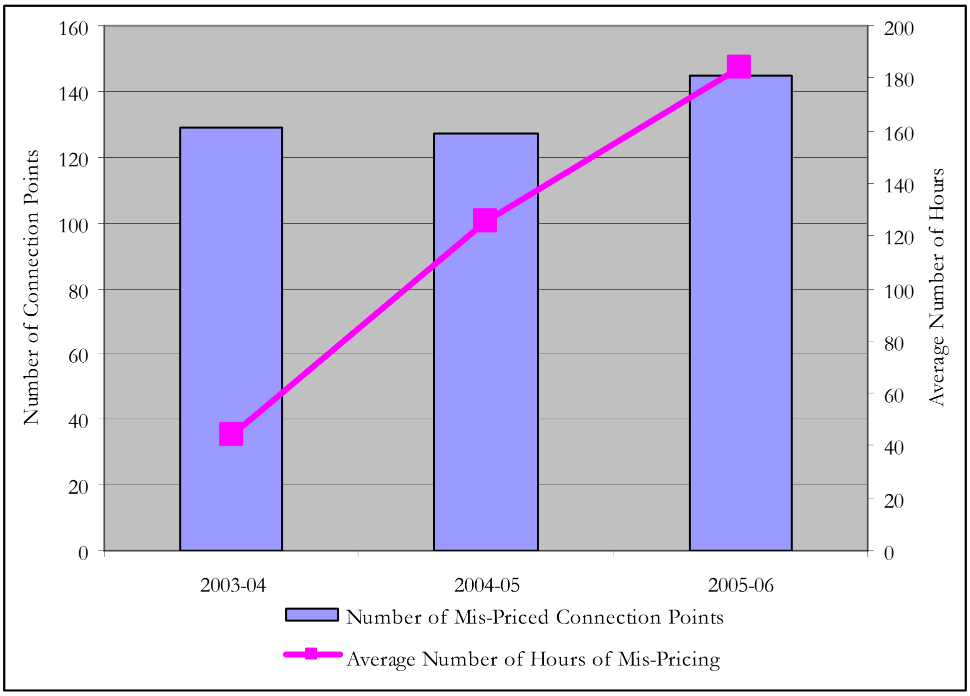
16. Figure 1 below shows the number of mis-priced connection points in the NEM and the average number of hours that these connection points have been mis-priced for the 2003-04, 2004-05 and 2005-06 financial years.. Clearly, both the number of mis-priced connection points and the average number of hours of mis-pricing per annum has increased over time. In 2003-04 there were 129 mis-priced connection points, each mis-priced for an average of 44 hours. In 2004-05 there were 148 mis-priced connection points, mis-priced on average for 112 hours. In 2005-06 there were 169 mis-priced connection points, mis-priced on average for 169 hours each.

Figure 1: Number and Average Duration of Mis-Priced Connection Points (All Regions)



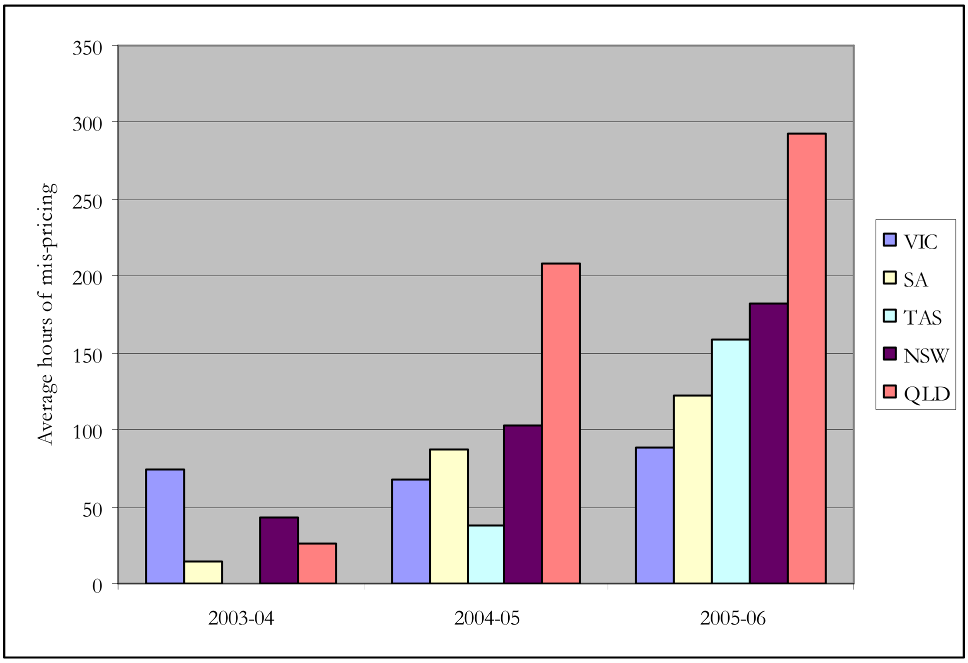
17. One source of the increase in the number of mis-priced connection points in the NEM was the accession of Tasmania to the NEM during the 2004-05 financial year. Figure 2 shows the evolution of mis-priced connection points in the NEM excluding Tasmania. As can be seen, excluding Tasmania, the number of mis-priced connection points has increased more slowly, but there has been a much more significant increase in the average number of hours of mis-pricing per connection point.

Figure 2: Number and Average Duration of Mis-Priced Connection Points (Excluding Tasmania)



18. Figure 3 shows the same results, broken down by region. The average number of hours of mis-pricing per connection point has increased in all regions over these three years, but the increase has been smallest in VIC and has been particularly significant in QLD, where the average number of hours of mis-pricing has reached almost 300 hours over the 52 connection points which were mis-priced in 2005/06. This was primarily due to mis-pricing at the five Collinsville connection points, which were each mis-priced for 1500 hours (or almost 18% of the hours in that year).

Figure 3: Average Duration of Mis-Priced Connection Points by Region



19. As a point of reference (although it was never in fact implemented), the original designers of the NEM used the threshold of 50 hours of mis-pricing per year as a trigger for region boundary review. The National Electricity Rules state that:

> "Where practicable significant generation and/or load centres separated by network constraints should be located in separate regions where those network constraints are likely to influence the optimal dispatch of generation and/or scheduled load in the order of 50 hours or more in the financial year".[14]

20. Although this is only one possible guide, this analysis shows that around 95 connection points in the NEM have been mis-priced by more than 100 hours per annum average over the last three years. This suggests that there is a need for some form of mechanism to improve the locational price signals in the NEM.

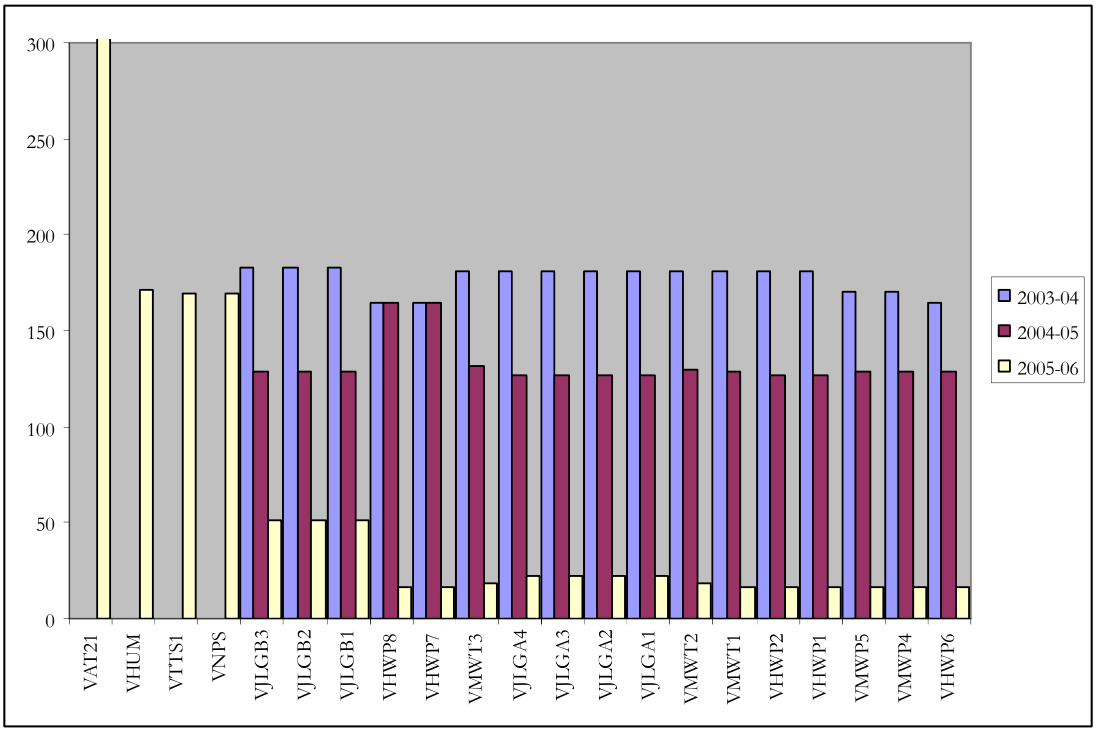
Which connection points are most affected and by which constraints?

21. Let's now look more closely at which connections points are the most mis-priced in each region.

Victoria

22. Figure 4 shows the Victorian connection points which were mis-priced by 100 hours or more on average over the past three years.

Figure 4: Connection points in Victoria with more than 100 hours mis-pricing per annum



23. There are 21 such connection points. During 2003-04 and 2004-05 the connection points most affected by mis-pricing corresponded to Jeeralang B (VJLGB1-3), Jeeralang A (VJLGA1-3), some Hazelwood units (VHWP1-2,6-8), Morwell (VMWT1 and VMWP4-5), and Bairnsdale (VMWT2, VMWT3). Further investigation shows that these connections points were

[14] Section 3.5.1 (b)(2)(ii). Of course, this section of the Rules is being reconsidered by the AEMC in the course of the Region Boundary Review.

particularly affected by the “V>V1NIL” and “V>V2NIL” constraints, which were binding for around 60 hours and 120 hours respectively. These constraints limit the output of generators in the Latrobe Valley to protect against an overload on a Hazelwood 500/220 kV transformer.[15]

24. During the 2005-06 period, other connection points, notably Newport (VNPS), Somerton (VTTS1), Hume (VHUM) and Laverton (VAT21) were all significantly affected. In the case of Laverton, there was almost 500 hours of mis-pricing due to a discretionary constraint imposed on Laverton output. The other connection points were primarily affected by a constraint “V>>H_NIL_2_R” which is designed to control flows on the South Morang 500/330kV transformer. These connection points were also affected by constraints of the form “V::H_NILQ”, designed to control transient instability in the event of a trip of a Hazelwood to Sth Morang 500kV line, which were also binding for more than 60 hours.

25. Table 1 sets out all of the connection points in VIC which were mis-priced during the 2005-06 financial year and the number of hours of mis-pricing, in descending order:

Table 1: Connection points mis-priced in VIC during 2005-06 FY

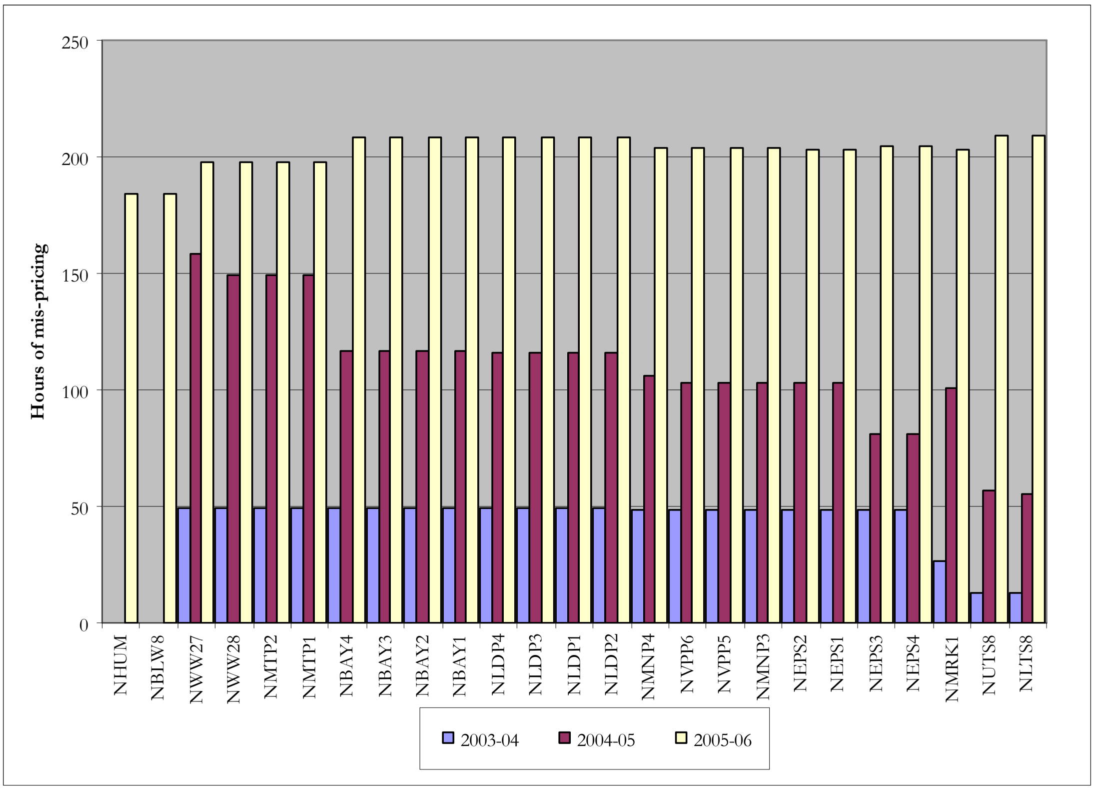
Connection Point (or group)	Duration of mis-pricing 2005-06 FY (hours)
Laverton PS	498.8
West Kiewa PS	238.9
McKay Ck PS	238.5
Dartmouth PS	231.3
Eildon PS	214.8
Hume PS (VIC share)	171.7
Yallourn PS units 2-4	169.9
Newport PS, Somerton PS	169.2
Hazelwood PS units 3-5	93.9
Anglesea PS	87.9
Jeeralang B PS	50.8
Valley Power	41.1
Loy Yang A unit 4	31
Jeeralang A PS	21.8
Loy Yang B PS unit 1	21.5
Bairnsdale PS	18.75
Yallourn unit 1	16.75
Hazelwood PS units 1-2, 6-8 and Morwell PS	16.3
Loy Yang A PS units 2-4 and Loy Yang B PS unit 2	2

New South Wales

26. Figure 5 shows those connection points in NSW which were most mis-priced in the sense that over the three year period of this study, the mis-pricing for each connection point averaged more than 100 hours per year. There were 25 such connection points, corresponding to the generators Wallerawang, Mt Piper, Bayswater, Liddell, Munmorah, Vales Point, Eraring, Redbank, Hume, Blowering and Upper and Lower Tumut in the Snowy Region.

[15] “V>V1NIL” has the description “Outage = Nil, limit Yallourn unit 1+Hazelwood units 1,2,6,7,8+Jeeralang+ Bairnsdale+ Morwell to avoid overload on Hazelwood 500/220kV No.2,3,4 transformers for loss of one transformer, Yallourn unit 1 in 500kV mode, Hazelwood in radial mode”. “V>V2NIL” has the description “Outage = Nil, limit Hazelwood units 1,2,6,7,8, Jeeralang, Bairnsdale, Morwell generation to avoid overload on Hazelwood 500/220kV No.2,3,4 transformers for loss of one of these transformers, Yallourn unit 1 in 220kV mode and Hazelwood in radial mode.”

Figure 5: Connection points in NSW with more than 100 hours mis-pricing per annum



27. These connection points were principally affected by four groups of constraints:

(a) constraints with the prefix "N>>N-81" (and formerly "N>N-81"), which relate to an outage on the Liddell-Newcastle (81) line and which protect against an overload on the Liddell-Tomago (82) line.

(b) constraints with the prefix "N>>N-NIL_" which protect against an outage on the 82 line in the event of an 81 line trip (with both lines in service).[16]

(c) constraints between Murray and Tumut, with the prefix "H>>H-64"; and

(d) constraints with the prefix "N>N-22", which relate to an outage of the Vales point – Sydney North (22) line and which protect against overload of the Vales point – Munmorah (23) lines.

28. Table 2 shows the connection points in NSW which were mis-priced during the 2005-06 FY, in descending order:

[16] TransGrid, like other TNSPs, has an on-going programme of investment in its network which may impact on the significance of these constraints in the future. In particular, TransGrid has commenced the regulatory consultation process on a project to upgrade the "core" or "backbone" of its network which will reduce the frequency of some constraints in the future. However, these works are not expected to be completed until 2009/10.

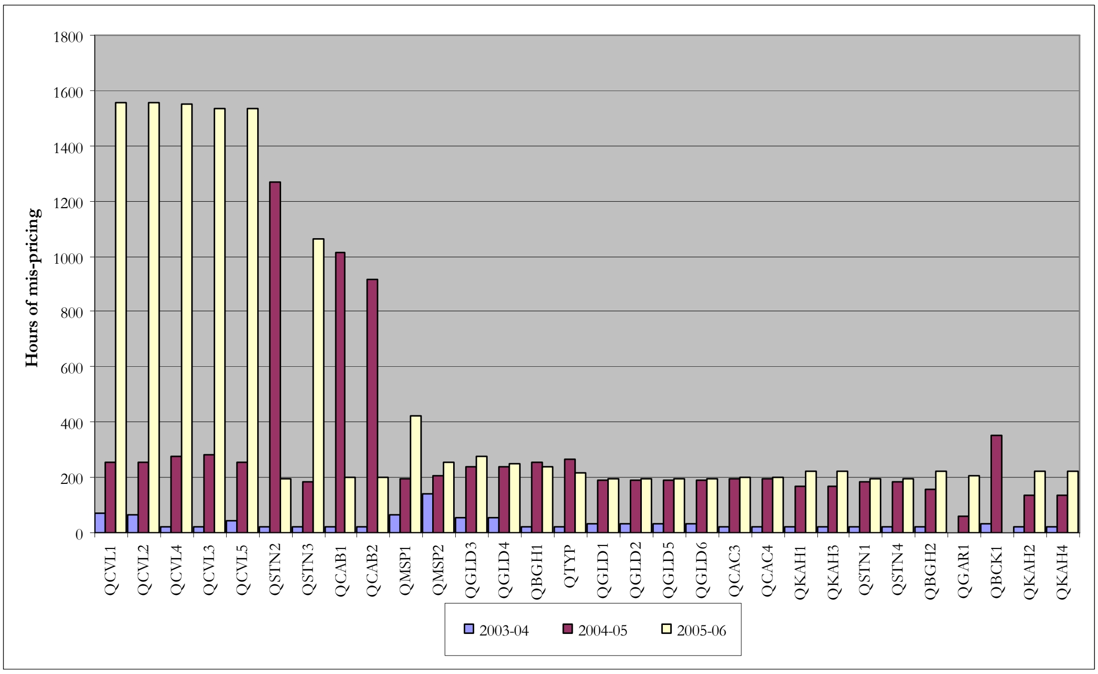
Table 2: Connection points mis-priced in NSW during 2005-06 FY

Connection Point (or group)	Duration of mis-pricing 2005-06 FY (hours)
Upper Tumut PS	209.3
Lower Tumut PS	209.2
Bayswater PS, Liddell PS	208
Eraring PS units 3,4 (500 kV)	204.6
Munmorah PS, Vales Point PS	203.5
Eraring PS units 1,2 (330 kV)	204.6
Redbank PS	202.7
Mt Piper PS, Wallerawang PS	197.9
Blowering, Hume (NSW share)	184.25
Murray	73.6
Guthega	70.4
Shoalhaven PS	39.6
Shoalhaven pump	31.5

Queensland

29. Figure 6 shows the connection points in Queensland which were mis-priced for more than 100 hours per annum on average over the three-year period of this study.

Figure 6: Connection points in QLD with more than 100 hours mis-pricing per annum



30. These connection points correspond to the generators: Mt Stuart, Collinsville, Stanwell, Callide B and C, Yabulu, Kareeya, Gladstone, Barron Gorge and Milmerran.

31. During 2005-06 Collinsville generation was constrained on by a number of NEMMCO discretionary constraints, such as the constraint "@Q-CVL>=NSA", which presumably reflect the operation of a network support agreement. This network support agreement is necessary due to a physical limit on the flows from central to north Queensland. Similarly, Mt Stuart was also

constrained on for a large number of hours by constraints of the form "Q:CN1QMSP1" which also relate to a Powerlink network support agreement. Stanwell unit 3 was constrained on for a number of hours to provide FCAS services in response to an outage of a Stanwell Power Station 275 kV line.

32. In addition, during this period, constraints of the form "Q_CS_XXXX" were binding for a large number of hours. These constraints affect a large number of connection points in northern Queensland, and are designed to limit flows from central to southern Queensland.

33. The following table sets out all of the connection points in QLD which were mis-priced during the 2005-06 FY, in descending order:

Table 3: Connection points mis-priced in QLD during 2005-06 FY

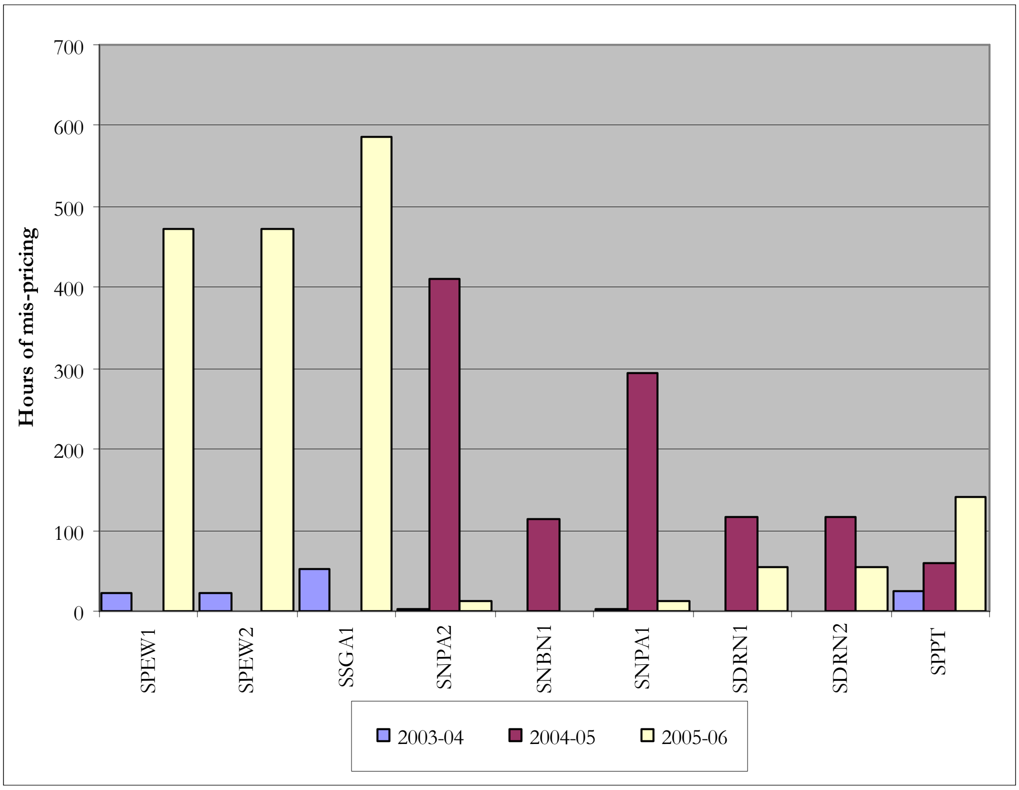
Connection Point (or group)	Duration of mis-pricing 2005-06 FY (hours)
Collinsville PS	1540-1560 (varies with each unit)
Stanwell PS unit 3	1061
Mt Stuart PS unit 1	425.3
Gladstone PS unit 3	276.7
Mt Stuart PS unit 2	255.3
Gladstone PS unit 4	247.5
Barron Gorge PS	222.6-240.5
Kareeya PS	220.6
Yabulu PS	218.9
Mackay GT	213.9
Yabulu Steam Turbine	206.4
Callide B PS, Callide C PS,	200.7
Stanwell PS units 1,2,4	196.4
Gladstone PS units 1,2,5,6	196.3
Barcaldine PS	188.6
Callide A PS	183.1
Wivenhoe PS, Wivenhoe pump	33.8
Braemar PS	24.75-27
Roma PS	4.3-7.8
Swanbank E PS	4.2
Milmerran PS, Oakey PS	1.8
Tarong North PS, Tarong PS	0.5

South Australia

34. There were relatively fewer connection points in South Australia which were mis-priced for more than 100 hours during the three years of this study – in fact there were only six. Figure 7 below sets out all the connection points in SA which were mis-priced for more than 50 hours on average.

35. These connection points correspond to Ladbroke Grove, Snuggery (unit 1), Northern PS, OCPL (unit 1), Angaston PS, and Pelican Point.

Figure 7: Connection points in SA with more than 50 hours mis-pricing per annum



36. During 2005-06 these connection points were primarily affected by the following constraints:

(a) "V>>S_NIL" and "V::S_NIL" which represent thermal and stability limits on flows between VIC and SA with no outages;

(b) "V>>S_BNSG" which protects against overload on Kincraig to Keith line during an outage on the Blanche-Snuggery 132 kV line.

(c) Constraints of the form "S_PPTXXX" which limit the output of Pelican Point to protect against an overload on the Lefevre 275/6 kV transformer, during an outage on the Torrens Island to Lefevre line.

37. As before, table 4 shows those connection points in SA which were mis-priced during the 2005-06 FY, in descending order:

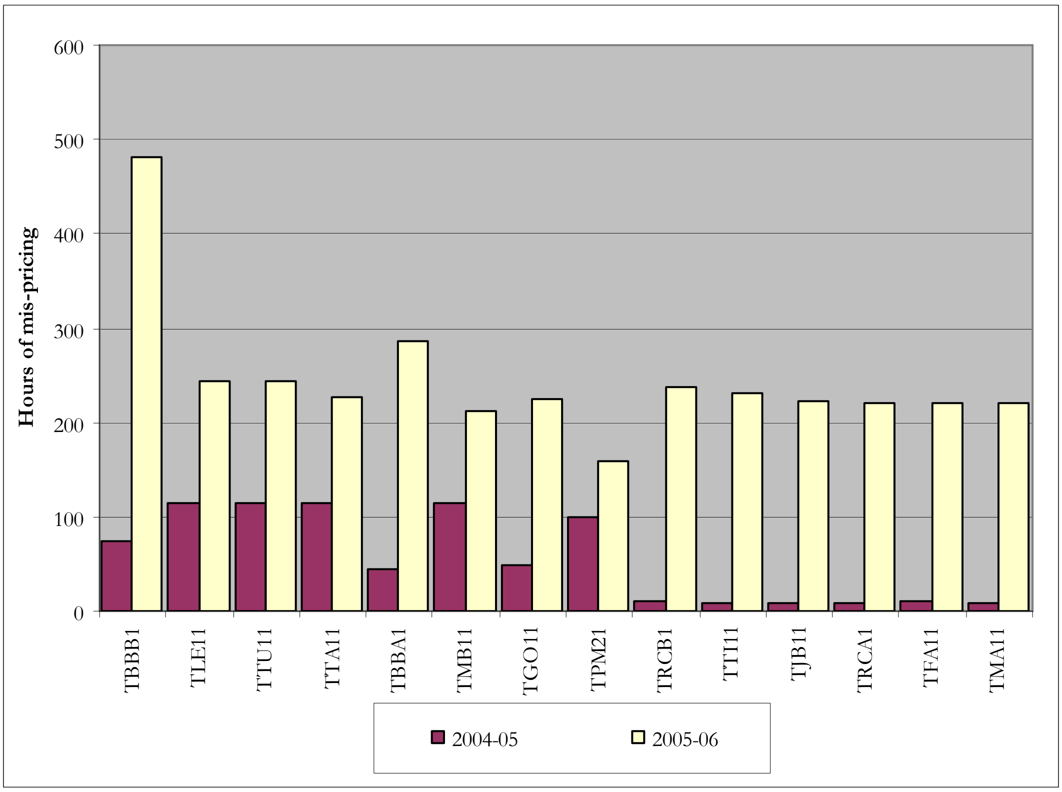
Table 4: Connection points mis-priced in SA during 2005-06 FY

Connection Point (or group)	Duration of mis-pricing 2005-06 FY (hours)
Snuggery PS unit 1	587.3
Ladbroke Grove PS	471.8
Pelican Point PS	142.1
Angaston PS	55.6
Port Lincoln PS	46.8
Dry Creek PS unit 2	44.6
Playford PS	18.4
Mintaro PS	15.6
Northern PS	12.4
Torrens Island B PS unit 1	10.3
Hallet PS	5.3
Torrens Island B PS units 2,3	1

Tasmania

38. There were 14 connection points which were mis-priced for at least 100 hours on average during 2004/05 and 2005/06 (Tasmanian joined the NEM during 2004/05). These connection points are set out in figure 8:

Figure 8: Connection points in Tasmania with more than 100 hours mis-pricing per annum



39. These connection points correspond to Bell Bay, Tungatinah, Tarraleah, Meadowbank, Gordon, Poatina, Reece No. 1 and 2., Tribute, John Butters, Bastyan and Mackintosh generators.

40. Table 5 shows the connection points in TAS which were mis-priced during the 2005-06 FY, in descending order:

Table 5: Connection points mis-priced in TAS during 2005-06 FY

Connection Point (or group)	Duration of mis-pricing 2005-06 FY (hours)
Bell Bay No. 2	482
Bell Bay No. 1	286.9
Lake Echo, Tungatinah	244.8
Reece No. 2	236.5
Tribute	230.8
Tarraleah	227.3
Gordon	224
John Butters	223.25
Reece No. 1	221.1
Bastyan	220.5
Mackintosh	220
Meadowbank	212.3
Wayatinah	159
Poatina (110 kV)	158
Trevallyn	83.8
Devils Gate	57.4
Poatina (220 kV)	42.5
Fisher	27
Cethana	7.2
Lemonthyme	1.6
Bells Bay No. 3	0.8

Could this mis-pricing be solved through a small number of region boundary changes?

41. The data presented above suggest that mis-pricing is a relatively frequent occurrence at a relatively large number of connection points. Is it the case, however, that this mis-pricing could be eliminated with a relatively small number of region boundary changes?

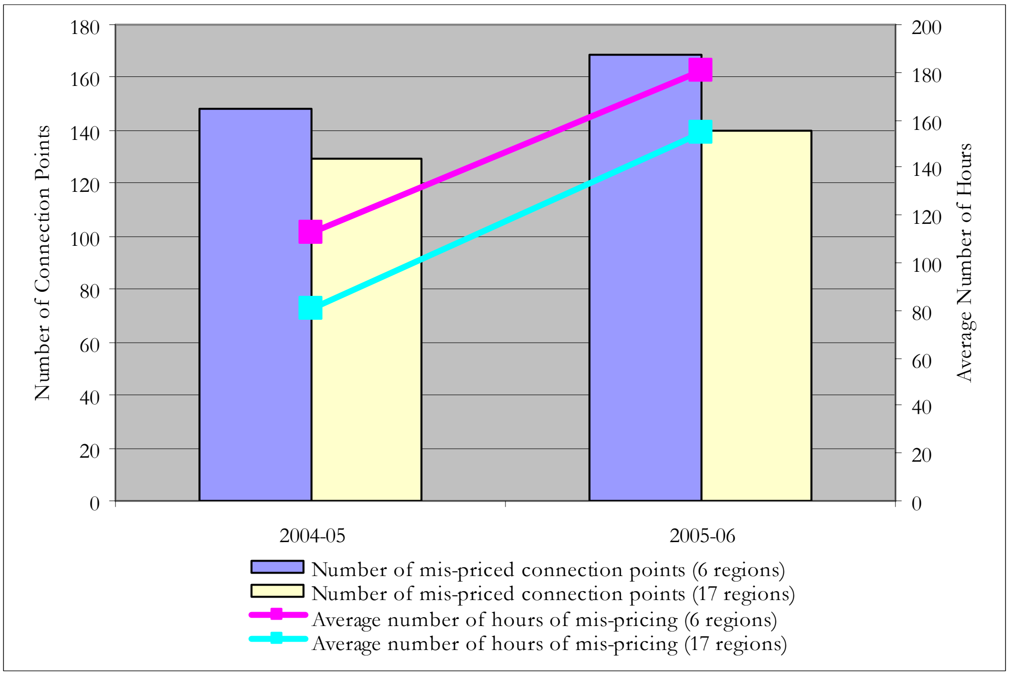
42. It is theoretically possible that even if there were a large number of mis-priced connection points, it may arise that the mis-pricing could be eliminated with just a single region boundary change. However, in order for this to occur it must be that all of those mis-priced connection points had exactly the same coefficient in all of the binding constraint equations.

43. A quick glance at the data above reveals that this cannot possibly be the case – if this were the case, all of the mis-priced connection points would be mis-priced for exactly the same number of hours. In fact, the data above shows that there are relatively few groups of connection points which are mis-priced for exactly the same number of hours, so there are no simple region boundary changes which will eliminate this mis-pricing.

44. What if we move to many more regions? For example, since the ANTS zones are a cornerstone of NEMMCO's modelling in the Annual National Transmission Statement, it seems logical to examine whether or not a move to the 17 ANTS zones would largely eliminate this mis-pricing.

45. It turns out, as the following charts show, that a move to the 17 ANTS regions would reduce the extent of mis-pricing, but only by a relatively small amount. Figure 9 shows that a move from 6 regions (currently) to 17 regions would reduce the number of mis-priced connection points in 2005-06 from 169 to 140 and reduces the average number of hours of mis-pricing per connection point from 180 hours to 154 hours.

Figure 9: Comparison of mis-pricing with 6 and 17 regions, 2004-05 and 2005-06

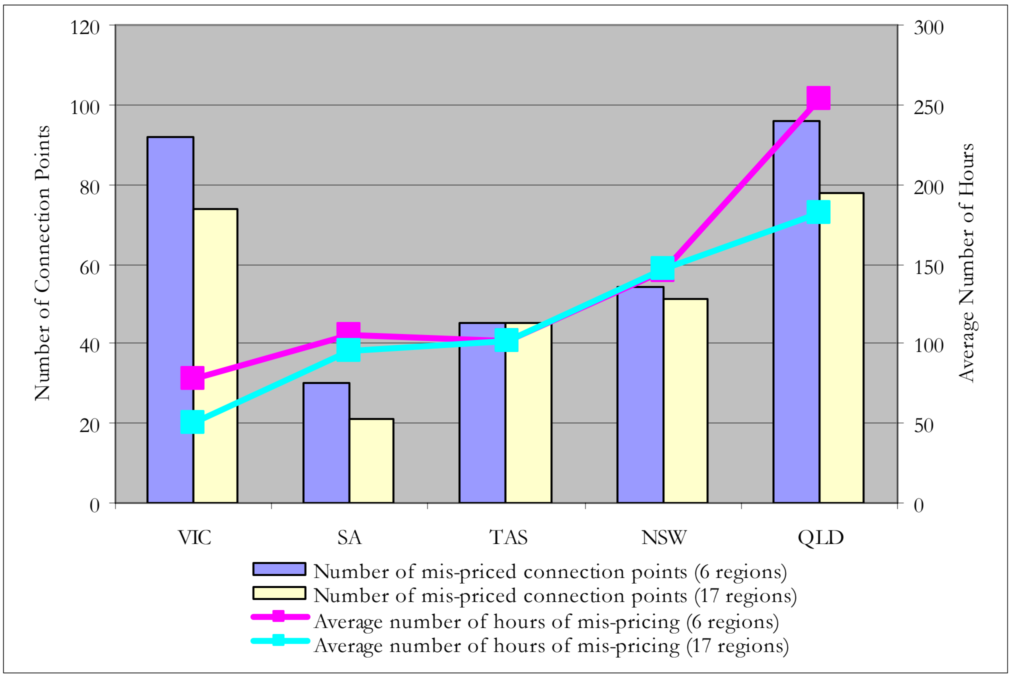


46. Breaking this data down into regions reveals that the use of the ANTS zones has the greatest impact on reducing mis-pricing in QLD and SA (where the ANTS zones roughly correspond to pricing regions induced by the relevant constraints) but the ANTS zones have no impact on reducing mis-pricing in Tasmania (which is only one ANTS zone anyway) and NSW

(where all of the connection points identified above as requiring separate pricing, including all of the major generators on the central ring, are in the same ANTS region).

47. Figure 10 shows the number of mis-priced connection points and the average hours of mis-pricing per connection point for 6 and 17 regions, broken down by state:

Figure 10: Comparison of mis-pricing with 6 and 17 regions, broken down by state, 2005-06



48. In other words, a move to 17 ANTS zones would reduce the degree of mis-pricing somewhat, but there would still remain substantial mis-pricing. How many zones would be required to eliminate all mis-pricing in the NEM?

49. The appendix sets out the pricing zones that would be required to eliminate all mis-pricing in the NEM. It turns out that around 70 pricing zones would be required. Alternatively, if a "congestion management regime" were implemented for correcting the price signals to generators, this regime would need to be able to differentiate prices geographically into at least 70 different regions to be able to eliminate all mis-pricing.[17]

Who gains and who loses from the existing regime?

50. It is also interesting to explore which generators stand to gain and which generators stand to lose from a move to more accurate price signals in the NEM. One way to attempt to answer this question is to look at the difference between the average price at each connection point and the average price at the regional reference node. If the local connection point price is, on average, lower than the average regional reference price, a generator located at that connection point could be said to be benefiting from the existing regime (i.e., would lose from a move to better locational price signals). Similarly, if a local connection point price is, on average, higher than the average RRP a generator at that location is losing out from the current lack of accurate price signals in the NEM.

[17] The elimination of all mis-pricing is, however, not necessarily a desirable goal. Although this question is beyond the scope of this paper, it is likely that some degree of mis-pricing in the NEM can be tolerated on an on-going basis. The threshold as to what constitutes "material" mis-pricing is something which will need to be addressed.

51. However, there are several problems with the use of average connection point prices as an indicator of who wins and who loses from the current regime:

- First, and most obviously, generating firms often own generating plant at many different connection points. A generating firm may benefit from over-pricing at one location and be harmed by under-pricing at another. Overall it is hard to assess whether the generating firm is a net winner or loser without information on its actual production at all its locations at all times. The situation of Hydro Tasmania is the clearest illustration of this.

- Second, the use of average prices conceals features of the distribution of prices which is also important. For example, a peaking generator cares more about the frequency and duration of particularly high prices than about the level of average prices. It is theoretically possible that a firm may benefit from a change in the market even though the average price at its connection point declines.

- Third, correcting the mis-pricing would also correct the distortion in dispatch. It is theoretically possible that, with an increase in the efficiency of dispatch, the output of a generator might increase more than enough to offset any decline in average price.

- Fourth, it is also a theoretical possibility that the current regime of uniform pricing is masking the exercise of market power at particular connections, which would be exercised more freely in a regime with more accurate locational signals.

- Fifth, even if a generator would obtain a lower average price under a new regime, it may still prefer the change if that lower price comes with greater assurance that the generator will not be constrained off by new entry which faces imperfect or ineffective location signals.

- Finally, it is important to note that, even putting aside the concerns noted above, there is at least a theoretical possibility that all generators would receive less revenue under a move to more accurate locational prices. In general, generators which are constrained off are (on average) benefiting from the current regime (since a generator which is constrained off receives a regional reference price which is higher than its correct locational price). On the other hand, generators which are constrained on are (on average) losing from the current regime (since these generators would receive a higher price with more accurate price signals. However, it may be the case that all those generators which are "constrained on" in the current regime are already adequately compensated through either compensation for NEMMCO "directions" or through an explicit network support agreement. In this case, a move to more correct locational prices would not increase the revenue for constrained on generators and would reduce the revenue of constrained off generators.

52. Furthermore, there are methodological issues associated with measuring the magnitude of the deviation of the connection point price from the regional reference price, for the following reasons:

- First, when mis-pricing occurs it is known that generators no longer have an incentive to bid their true marginal cost. As a result, the local or connection point price (which reflects local generator offers) can be significantly distorted away from the "true" price which would arise if each generator was paid the correct locational price.

- Second, and even more importantly, when a constraint is "violated", the corresponding constraint marginal value is equal to a very large value known as the "constraint violation penalty". These values seriously distort the computed locational prices, which can easily be many times higher than VoLL. In the figures presented in the tables in the appendix I have separately presented the impact on the average price with and without the constraint violation penalties so as to give a feel for the impact of these figures.

53. Overall, although the magnitude of the deviations in prices is reported in the tables in the appendix, it is important not to place too much weight on the reported figures.

54. Despite these caveats it is possible to draw at least some tentative conclusions about who gains and who loses from the current regime based on the difference in the average connection point price at a location and the average regional reference price.

55. In VIC (Table 6), it appears that the large baseload generators (TruEnergy, International Power, Loy Yang) all benefit from the current regime (since they are all, on average, constrained off). (Of course, they also face dispatch risk under the status quo and the risk that further expansion in the Latrobe valley due to imperfect location signals will increase the risk of not being dispatched).

56. In NSW (Table 7), it appears that Macquarie Generation benefits from the current regime (since Bayswater and Liddell are, on average, constrained off) while Delta loses at some plants (Munmorah and Vales Point) and benefits at others (Mt Piper and Wallerawang). Eraring seems to be made worse off by the current arrangements.

57. In the Snowy region (Table 8), Snowy Hydro appears to be worse off under a regional pricing arrangement than it would be under a regime with more accurate price signals. However, of course, Snowy Hydro is currently the beneficiary of a CSP/CSC arrangement at the Tumut nodes which restores the correct price signals at that location.

58. In QLD (Table 9), it appears that generators in far north Queensland, including Mt Stuart, Collinsville and Barron Gorge, would all benefit from a move to more locational prices. (However, some of these generators receive compensation for producing at those times when they would otherwise be "constrained on" through a network support agreement with Powerlink). Generators in central Queensland, such as Stanwell, Gladstone and Callide A, B and C (CS Energy) would seem to benefit from the current regime. InterGen (Milmerran) in southwest Queensland would also seem to be better off under the current regime.

59. In SA (Table 10) the analysis suggests that the only significant impact of the current regime is at Snuggery (Synergen) and, at the other end of the network, Port Lincoln PS, which both seem to lose from the current regime (i.e., both would benefit from more accurate locational prices).

60. In Tasmania, of course, there is only a single generator. It is not possible at this stage to assess whether or not Hydro Tasmania would be better off by a move to more locational price signals.

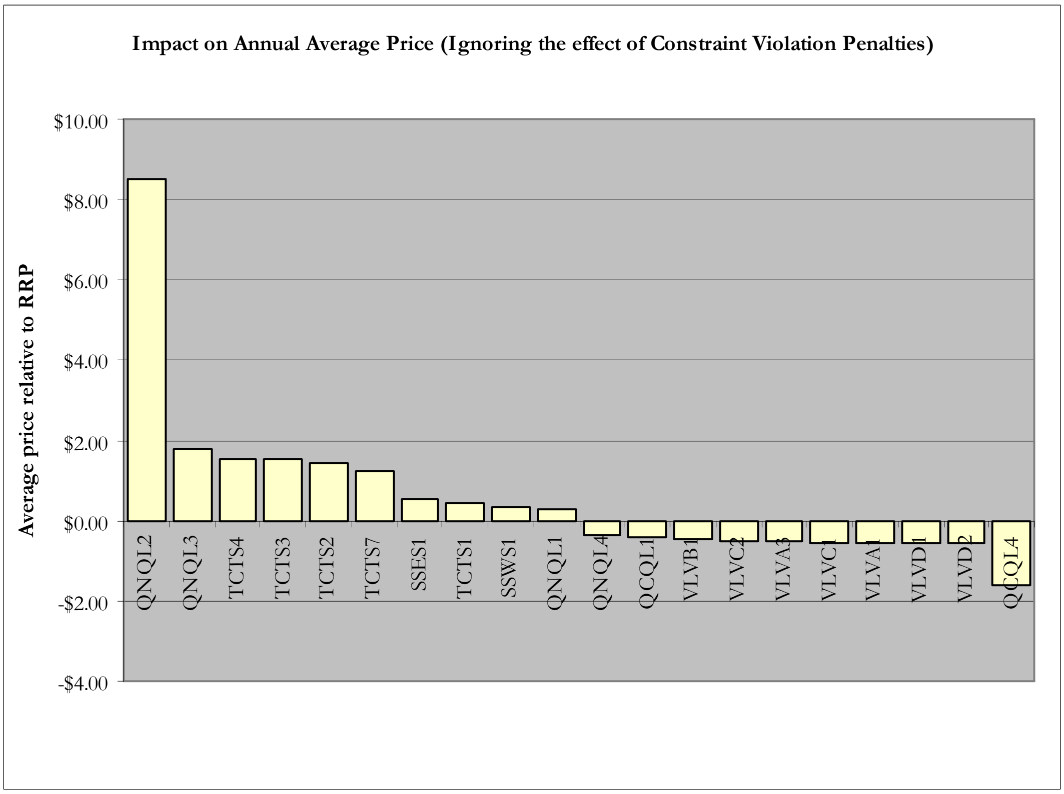
61. Figure 9 shows the ten pricing regions (based on the analysis above) which were the most "under-compensated" in the sense that the RRP was the most below the "correct" locational price for that connection point, together with the ten pricing regions which were the most "over-compensated".

62. Unsurprisingly, generators in northern Queensland (particularly Mt Stuart and Collinsville) were the most under-compensated at present, with an annual average price paid possibly more than $8/MWh less than the "correct" locational price.[18] A number of generators in Tasmania were also undercompensated (especially: Tarraleah, Tungatinah, Meadowbank, Lake Echo and Poatina). Snuggery and Port Lincoln in SA were also under-compensated.

[18] Here I am ignoring any compensation from a network support agreement.

63. On the other side of the ledger, the Callide B and C generators in Queensland were the most over-compensated. This appears to be due to the fact that these units were "constrained off" for a large number of hours to control flows on lines from central to southern Queensland. Generators in the Latrobe Valley were also mostly over-compensated, with an annual average price which is roughly 50 cents higher than their "correct" locational price.

Figure 11: Ten most under-priced and ten most over-priced sub-regions



Key to figure 11:

QNQL1: North QLD 1 region (Barron Gorge, Kareeya, Mackay Ck, Yabulu); QNQL2: North QLD 2 region (Mt Stuart); QNQL3: North QLD 3 region (Collinsville); QNQL4: North QLD 4 region (Barcaldine); TCTS1: Central TAS 1 region (Gordon); TCTS2: Central TAS 2 region (Lake Echo); TCTS3: Central TAS 3 region (Meadowbank); TCTS4: Central TAS 4 region (Tarraleah, Tungatinah); TCTS7: Central TAS 7 region (Poatina); SSES1: South east SA region (Snuggery); SSWS1: South west SA region (Port Lincoln); VLVA1: Latrobe Valley A1 region (Hazelwood 1-2); VLVA3: Latrobe Valley A3 region (Hazelwood 6-8); VLVB1: Latrobe Valley B1 region (Yallourn 1); VLVC2: Latrobe Valley C2 region (Morwell, Bairnsdale); VLVD1: Latrobe Valley D1 region (Jeeralang A); VLVD2: Latrobe Valley D2 region (Jeeralang B).

Conclusion

64. As noted at the outset, the current NEM market rules impose uniform pricing on electricity produced or consumed within a region. When the "correct" locational price at a connection point differs from this uniform region-wide price, mis-pricing occurs. This mis-pricing has two effects: In the short term, it distorts generator bidding behaviour, inducing inefficient dispatch and reducing the firmness of inter-regional settlement residues. In the longer term it distorts generator and load location and expansion decisions, thereby threatening existing investments.

65. This study did not attempt to quantify the magnitude of the short-term economic harms from mis-pricing. This study merely sought to assess the frequency and magnitude of this effect. It is expected that mis-pricing will have a direct impact on generator and load location and expansion decisions, but further research is needed to quantify the magnitude of this impact.

66. This analysis suggests that mis-pricing at connection points in the NEM is both relatively frequent and growing in significance over time. The number of connection points affected by mis-pricing at least once in the year has grown at the rate of about 11% per year. The average number of hours that each connection point is mis-priced has increased even faster – increasing from 40 hours per year to more than 180 hours per year over the three years of this study. Overall, this analysis is suggestive that there is a need for some kind of mechanism to manage material intra-regional congestion as and when it arises.

67. The analysis has also further highlighted two considerations in the choice of region boundaries:

- First, a single constraint equation can give rise to the need to separately price a large number of different connection points – in other words, one constraint equation can give rise to many separate pricing "regions". This occurs frequently in NSW where several constraint equations induce differentiated pricing at a dozen or more connection points. There is no necessary relationship between the location of these connection points and the location of the physical constraint. The notion that region boundaries, placed at the "pinch points" or the locations of physical constraint in the NEM, will automatically correct generator mis-pricing, is simply misguided.

- Second, region boundaries designed to mitigate generator mis-pricing should reflect the electrical and not the geographical locations of generators. This study shows that where different generating units in the same building are connected to different parts of the transmission network they may have different electrical "locations" and therefore different locational prices even when they are physically located at the same geographic location. Put another way, if new regions were to be created, a region boundary could pass between different generating units located in the same building. Region boundaries should reflect electrical characteristics of the network not geographic locations.

Appendix: Region boundaries to eliminate mis-pricing

68. This appendix explores the question of exactly how many regions we would need to eliminate all historical mis-pricing. It is not intended to argue for a large number of regions in the NEM. Rather, it merely demonstrates that if creating new regions were the only mechanism available for managing mis-pricing, and if it were considered desirable to eliminate that mis-pricing, then, as we will see from the discussion below, many small regions would need to be created to achieve that aim.

Victoria

69. How might we divide up the Victorian region in order to eliminate all except *de minimis* mispricing over this three-year period? To answer this question we need to look at the coefficients on each of the connection points in each of the constraints which bound during this period. If a given group of connection points have the same (or almost the same) coefficients amongst the constraint equations which were binding in the period, it follows that these connection points must have had the same price during the period.

70. Table 6 shows the number of regions necessary to eliminate virtually all mis-pricing in the Victorian region over the past three years. This table proposes dividing the Victorian region into 17 parts. This is considerably more regions than is modelled in the ANTS, which uses 17 zones for the entire NEM, and which groups the entire Latrobe Valley into one zone (rather than the ten proposed here).

71. The last two columns in Table 6 present a rough guide as to the extent of the mis-pricing in each of these sub-regions. The first column presents the average deviation of the local price from the regional price during the hours in which mis-pricing occurred. The final column presents the impact on the annual average price for that location. For example, if a sub-region is over-priced by $50 for 200 hours, the effect is to increase the annual (time-weighted) average price received by generators at that location by $1.14/MWh.

72. However, as noted earlier, these price measurements are notoriously unreliable. Part of the problem is that the connection point price may be significantly affected by "constraint violation penalties" which may increase the local price in one interval to hundreds of times VoLL.

73. Precisely the same problem can affect the regional reference price in current NEM. However, when the RRP is affected by constraint violation penalties NEMMCO invokes an automatic procedure which re-runs the dispatch engine, with the violated constraint relaxed by just enough to no longer be violated. This is the so-called "over-constrained dispatch" re-run. If a regime of locational pricing were implemented, the same principle would need to be applied to the prices computed at all connection points, to eliminate the impact of constraint violation penalties in the same way.

74. The AER, in the course of computing the Marginal Cost of Constraints ("MCC")[19] indicator, has carried out precisely this task, to eliminate the impact of constraint violation penalties from the MCC indicator. In the future it may be possible to more accurately compute the correct prices at each connection point using the AER's data. However, this data is not yet available for all three years of this period. Therefore, to eliminate the impact of the constraint violation penalties, I have simply set a price which exceeds $10,000 in absolute value to be equal to zero. However, by presenting both prices (with and without the constraint violation penalties) it is hoped to provide an indication of the range within which the "correct" price will fall.

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[19] See the discussion in the AER report on :Market Impact Indicators of Transmission Congestion, http://www.aer.gov.au/content/index.phtml/itemId/702392

75. In any case, it is worth bearing in mind that these prices will also be affected by the distorted bidding incentives that arise when connection points are mis-priced. The prices presented here should therefore be used with caution.

76. As can be seen Table 6, most of these Victorian sub-regions would receive a local price which is, on average, below the regional reference price, with the exception of the Newport, Somerton and Hume generators, which would receive a slightly higher average price from correcting mis-pricing. The most mis-priced generators in Victoria appear to be Hazelwood (but not units 3-5), Yallourn (unit 1 only), Morwell, Bairnsdale and Jeeralang A and B. These generators would likely face a small decrease in their annual average price from improved pricing in Victoria.

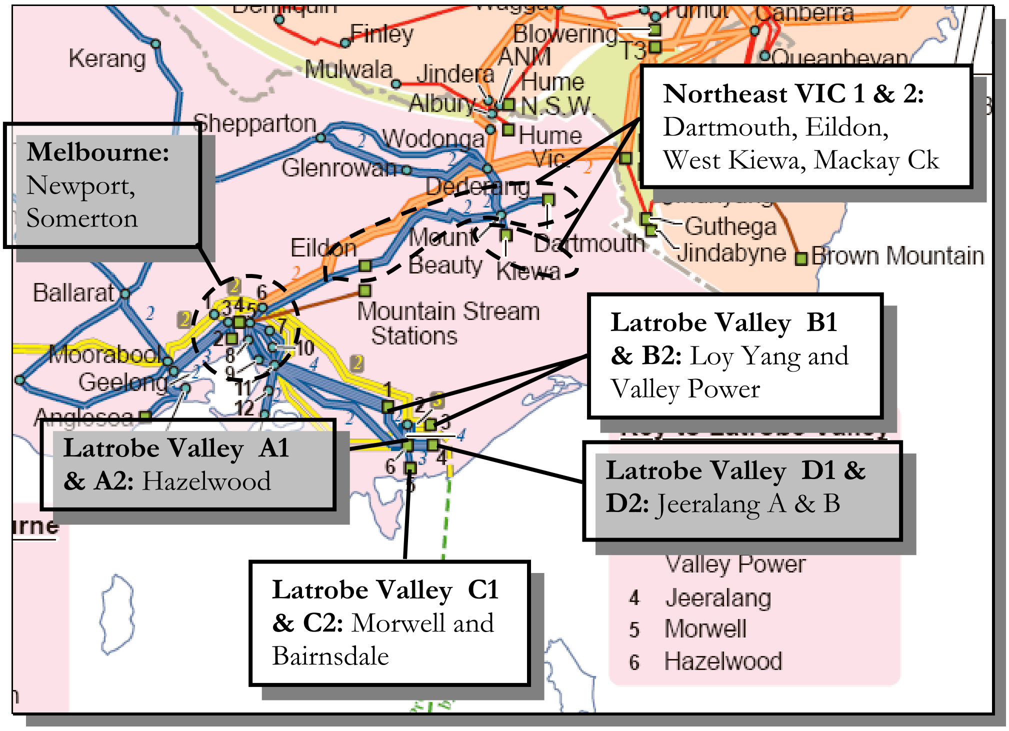
Table 6: Victorian regions necessary to eliminate mis-pricing

Sub-region	Connection points	Average difference from RRP when mis-priced	Annual average price difference compared to RRP
Latrobe Valley A1	VHWP1, VHWP2, (Hazelwood units 1-2),	$-43.35 to $-79.67	$-0.57 to $-1.10
Latrobe Valley A2	VHWP3, VHWP4, VHWP5 (Hazelwood units 3-5)	$-11.68 to $-531.31	$-0.01 to $-2.14
Latrobe Valley A3	VHWP6, VHWP7, VHWP8 (Hazelwood units 6-8)	$-41.17 to $-889.54	$-0.52 to $-16.39
Latrobe Valley B1	VYP21 (Yallourn unit 1)	$-44.61 to $-295.35	$-0.46 to $-1.30
Latrobe Valley B2	VYP22, VYP23, VYP24 (Yallourn units 2-4)	$-15.18 to $-815.50	$-0.00 to $-0.82
Latrobe Valley B3	VLYP10, VLYP11, VLYP12, VLYP7, VLYP8, VLYP9, (Valley Power), VLYP1, VLYP2, VLYP3, VLYP4, VLYP5, VLYP6, (Loy Yang A and B),	$-28.55 to $-3399.46	$-0.02 to $-14.89
Latrobe Valley C1	VMWP4, VMWP5 (Morwell units 4 and 5)	$-42.83 to $-82.29	$-0.54 to $-1.12
Latrobe Valley C2	VMWT1, (Morwell units 1-3), VMWT2, VMWT3 (Bairnsdale units 1 and 2)	$-28.28 to $-182.30	$-0.33 to $-0.51
Latrobe Valley D1	VJLGA1, VJLGA2, VJLGA3, VJLGA4, (Jeeralang A),	$-39.80 to $-1486.49	$-0.57 to $-4.74
Latrobe Valley D2	VJLGB1, VJLGB2, VJLGB3, (Jeeralang B)	$-33.83 to $3943.96	$-0.58 to -$23.62
Northeast VIC A1	VMKP1, VMKP2, (Mackay Ck), VWKP1, VWKP2, (West Kiewa), VDPS, (Dartmouth PS)	$-8.19 to $-881.76	$-0.02 to $-23.55
Northeast VIC A2	VEPS1, VEPS2, (Eildon PS)	$-9.25 to $-666.37	$-0.02 to $-17.09
Northeast VIC A3	VHUM (Hume)	$+0.44 to $+10.29	$+0.01 to $+0. 20
Western VIC	VAPS (Anglesea)	$-43.22 to $-44.64	$-0.02 to $-0.04
Melbourne	VNPS (Newport), VTTS1 (Somerton)	$+0.20 to $+3.38	$+0.00 to $+0.07
Victoria	The remaining connection points		

77. It is important to emphasise that – as this table shows – *the boundaries between pricing regions should, on occasions, pass through individual generating stations*. Intuitively, the reason is clear. The correct price for electricity from a given generating unit depends not so much on the geographic location of that generating unit as it does on the electrical location in the network of that generating unit. Since different generating units (even if physically located in the same building) are sometimes connected to different parts of the transmission network, it follows that those generating units should receive a different price for their output.

78. In fact, it may be inappropriate to think of pricing regions in the NEM as referring to geographic regions at all. Rather, the pricing regions in the NEM should reflect the electrical realities of the network, regardless of the geographic implications. This could, in theory, imply overlapping regions or, as we have seen, region boundaries which pass through a single generating plant.

79. The following map roughly illustrates the pricing regions that would be required to eliminate virtually all mis-pricing in Victoria in this period:



NSW

80. How many regions we would need in order to eliminate the mis-pricing in NSW? Analysis of the binding constraints shows that fourteen regions would be sufficient, as set out in Table 2 below.

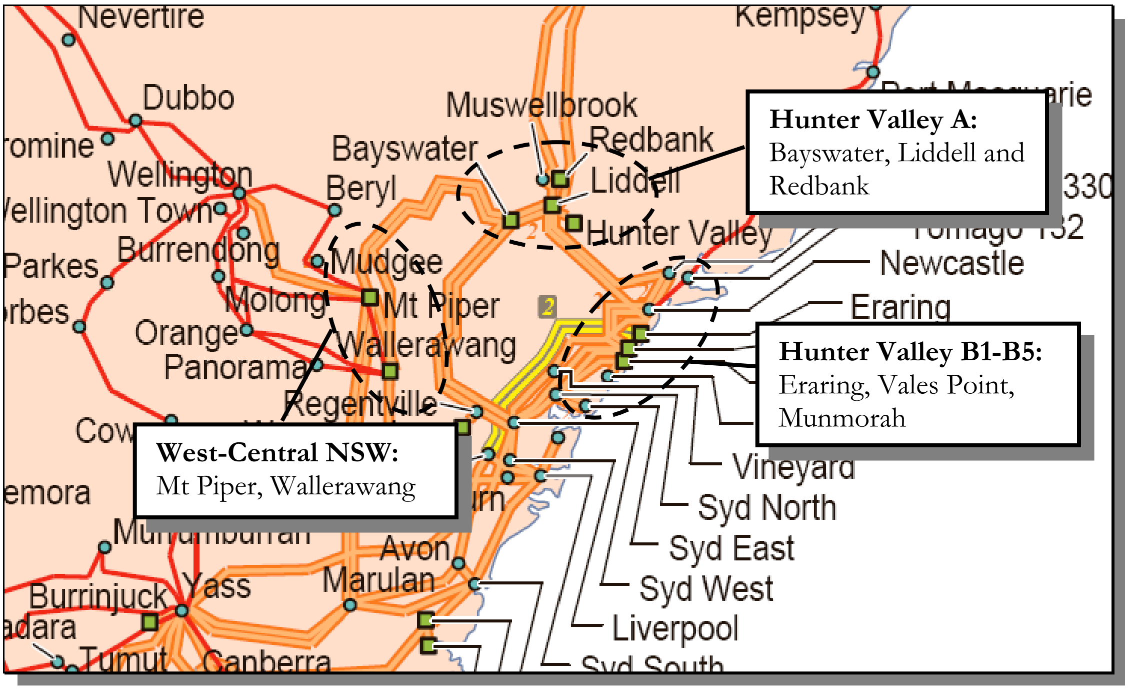
81. Again we see that this analysis implies quite different region boundaries to those chosen for the ANTS process. In fact, *all* eight of the Hunter Valley regions set out in the table below would fall within the ANTS zone known as NCEN (North Central NSW). The ANTS zones would not be sufficient to eliminate all mis-pricing because they do not reflect the underlying electrical characteristics of the network.

Table 7: NSW regions necessary to eliminate mis-pricing

Sub-region	Connection points	Average difference from RRP when mis-priced	Annual average price difference compared to RRP
Hunter Valley A1	NBAY1, NBAY2, NBAY3, NBAY4 (Bayswater)	$-29.43 to $-763.43	$-0.35 to $-10.12
Hunter Valley A2	NLDP1, NLDP2, NLDP3, NLDP4, (Liddell units 1-4)	$-28.82 to $-789.51	$-0.34 to $-10.37
Hunter Valley A3	NMRK1 (Redbank unit 1)	$-35.30 to $-807.99	$-0.32 to $-9.12
Hunter Valley B1	NEPS1, NEPS2 (Eraring 330 kV units 1 and 2),	$+25.86 to $+214.90	$+0.23 to $+2.51
Hunter Valley B2	NEPS3, NEPS4 (Eraring 500 kV units 3 and 4)	$+19.93 to $+147.31	$+0.15 to +$1.43
Hunter Valley B4	NMNP3, NMNP4 (Munmorah units 3 and 4)	$+28.68 to $+192.79	$+0.28 to $+2.28
Hunter Valley B5	NVPP5, NVPP6, (Vales Pt 330 KV units 5,6 -0.092)	$+30.42 to $+215.14	$+0.30 to $+2.51
Central-West NSW	NMTP1, NMTP2 (Mt Piper units 1 and 2, 0.107), NWW27, NWW28 (Wallerawang, units 7 and 8, 0.105)	$-18.24 to $-231.30	$-0.25 to $-4.03
Southern NSW 1	NSHL (Shoalhaven), NSHP1 (Shoalhaven Pump)	$+10.28 to $+8249.15	$+0.02 to $+5.16
Southern NSW 2	NBLW8 (Blowering)	$-2.45 to $-72.82	$-0.05 to $-1.53
Southern NSW 3	NGUT8 (Guthega)	$+3.06 to $+3.06	$+0.02 to $+0.02
Southern NSW 4	NHUM (Hume)	$-4.74 to $-71.64	$-0.10 to $-1.51
NSW	All other connection points		

82. From this table we can see that Bayswater, Liddell, Redbank and Mt Piper tend to be over-compensated under the current regime, whereas Eraring, Munmorah and Vales Point tend to be under-compensated under the current arrangements.

83. The zones above are illustrated in outline on the map below. As before, of course, it is important to keep in mind that the actual region boundaries will, on occasions, pass through individual generating stations.

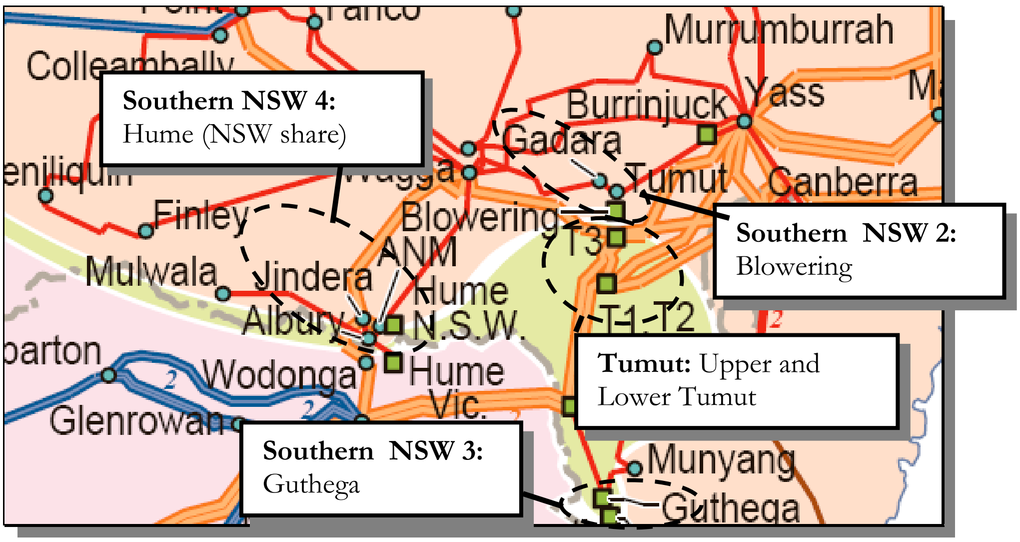


84. In addition, the most recent version of the Murray-Tumut constraint in the Snowy region would also require a separate region around Lower Tumut and Upper Tumut (i.e., dividing the Snowy region into 3) and separate pricing at NBLW8 (Blowering) and NHUM (Hume NSW share). As can be seen, these pricing regions would, on average, increase the price paid to Upper and Lower Tumut generation (as occurs under the CSP/CSC scheme currently in place).

Table 8: Snowy regions necessary to eliminate mis-pricing

Sub-region	Connection points	Average difference from RRP when mis-priced	Annual average price difference compared to RRP
Upper Tumut	NUTS8 (Upper Tumut)	\$+9.99 to \$+23.42	\$+0.11 to \$+0.20
Lower Tumut	NLTS8 (Lower Tumut)	\$+10.83 to \$+20.61	\$+0.12 to \$+0.18

85. This is illustrated on the map below:



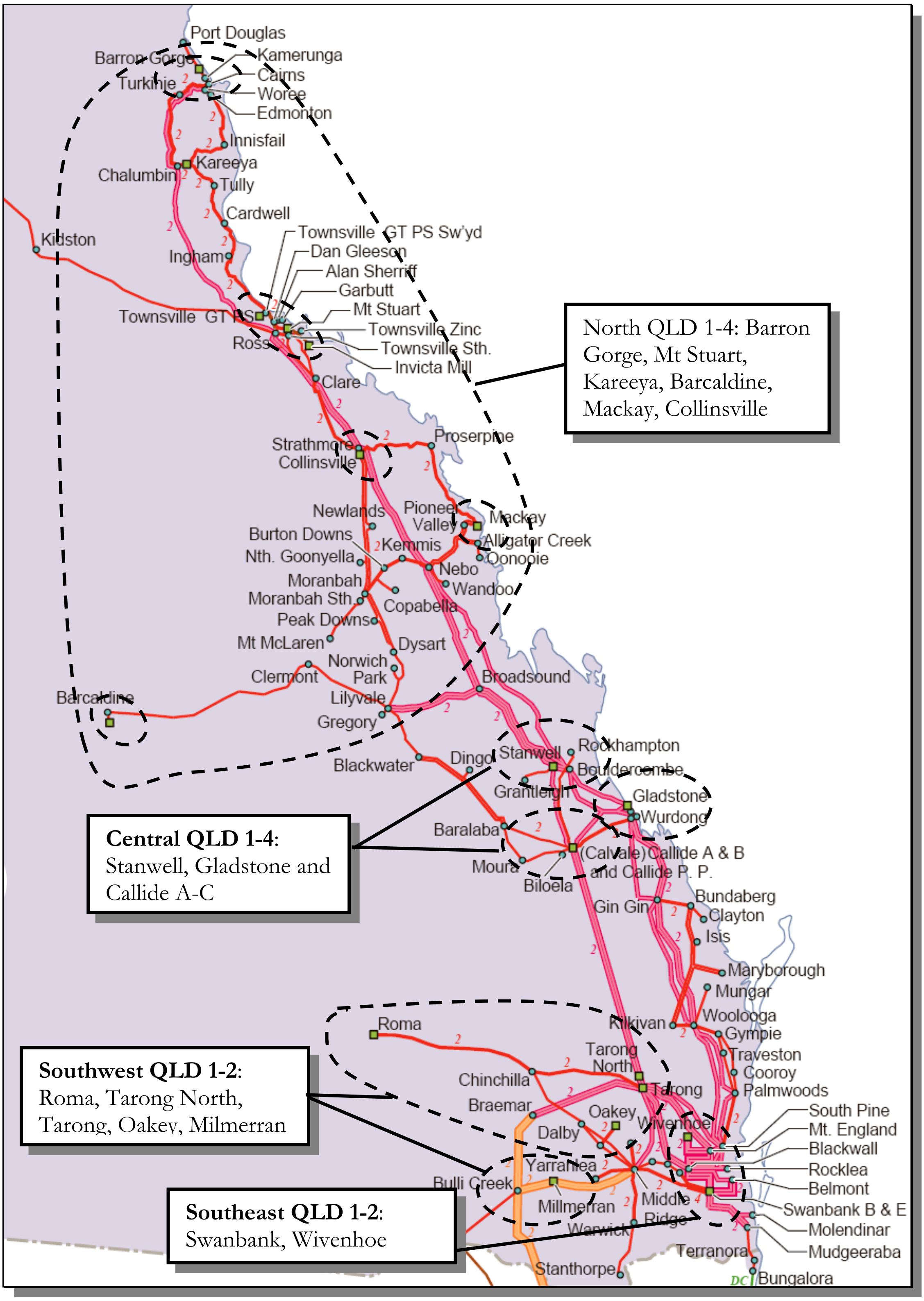
Queensland

86. How many regions would we need to eliminate all (or virtually all) the mis-pricing in Queensland? From examination of the binding constraint equations, it appears that this could be achieved with around thirteen Queensland regions, as set out in the following table:

Table 9: QLD regions necessary to eliminate mis-pricing

Sub-region	Connection points	Average difference from RRP when mis-priced	Annual average price difference compared to RRP
North QLD 1	QBGH1, QBGH2, (Barron Gorge), QKAH1, QKAH2, QKAH3, QKAH4, (Kareeya), QMKG, (Mackay), QTYP (Yabulu), QGAR1 (Yabulu Steam Turbine)	$+103.98 to $-8408.68	$+0.30 to $-243.24
North QLD 2	QMSP1, QMSP2, (Mt Stuart)	$+387.12 to $-3836.39	$+8.51 to $-12.23
North QLD 3	QCVL1, QCVL2, QCVL3, QCVL4, QCVL5, (Collinsville)	$+59.49 to $-34902.37	$+1.77 to $-142.61
North QLD 4	QBCG (Barcaldine),	$-25.16 to $-6848.07	$-0.37 to $-22.67
Central QLD 1	QGLD1, QGLD2, QGLD3, QGLD4, QGL5, QGLD6, (Gladstone).	$-18.18 to $-188.89	$-0.44 to $-5.53
Central QLD2	QSTN1, QSTN2, QSTN3, QSTN4, (Stanwell),	$-13.74 to $-1318.97	$-0.34 to $-191.75
Central QLD 3	QCAA1, QCAA2, QCAA3, QCAA4, (Callide A),	$-20.34 to $-23.69	$-0.33 to $-0.40
Central QLD 4	QCAB1, QCAB2, (Callide B), QCAC3, QCAC4, (Callide C),	$-27.88 to $-85.26	$-1.59 to $-3.40
Southwest QLD 1	QOKY1, QOKY2, (Oakey),	$-17.41 to $-67591.78	$-0.01 to $-45.26
Southwest QLD 2	QBCK1, QBCK2 (Milmerran), QRMA7, QRMA8, (Roma), QTRN1, QTRN2, QTRN3, QTRN4 (Tarong), QTNT (Tarong North), QBRA1, QBRA2, QBRA3 (Braemar)	$-16.07 to $-22481.50	$-0.15 to $-65.82
Southeast QLD 1	QSWB1, QSWB2, QSWB3, QSWB4, QSWE (Swanbank)	$-0.11 to $-75,000.11	$-0.00 to $-115.23
Southeast QLD 2	QWIV, QWIP1, QWIP2 (Wivenhoe and pumps)	$+21.86 to $-210602.63	$+0.06 to $-306.68
QLD	All other connection points		

87. The corresponding regions are indicated on the following map. These regions are broadly similar to the four QLD regions identified for the purposes of the ANTS. However, the analysis of the constraint equations shows the need for a finer geographic differentiation of regions – for example, separating the prices for Stanwell, Gladstone and Callide A, B & C.



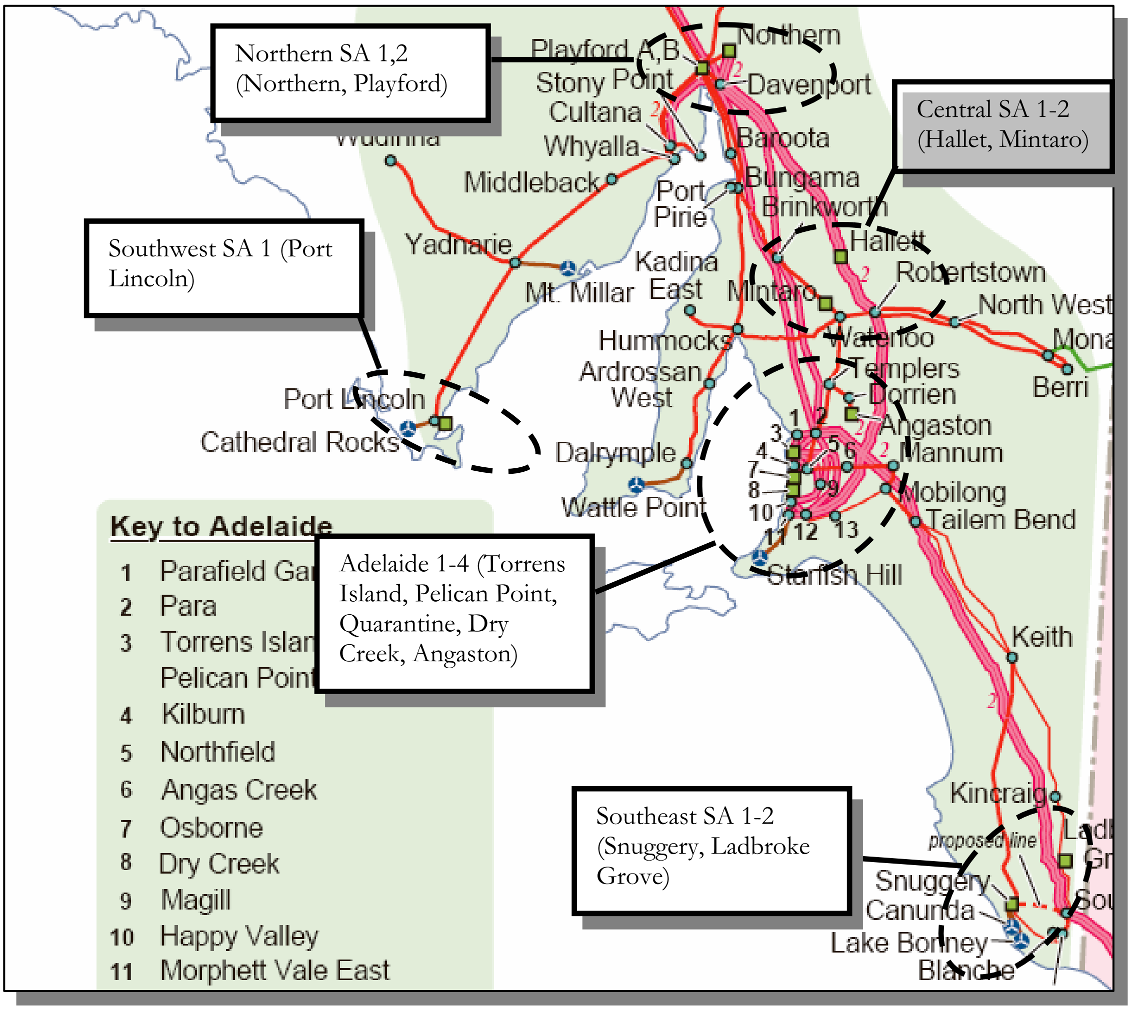
North QLD 1-4: Barron Gorge, Mt Stuart, Kareeya, Barcaldine, Mackay, Collinsville
Central QLD 1-4: Stanwell, Gladstone and Callide A-C
Southwest QLD 1-2: Roma, Tarong North, Tarong, Oakey, Milmerran
Southeast QLD 1-2: Swanbank, Wivenhoe
Port Douglas
Barron Gorge
Kamerunga
Cairns
Turkinje
Woree
Edmonton
Innisfail
Kareeya
Chalumbin
Tully
Cardwell
Kidston
Ingham
Townsville GT PS Sw'yd
Dan Gleeson
Alan Sherriff
Garbutt
Mt Stuart
Townsville GT PS
Townsville Zinc
Ross
Townsville Sth.
Invicta Mill
Clare
Proserpine
Strathmore
Collinsville
Newlands
Pioneer Valley
Mackay
Burton Downs
Kemmis
Alligator Creek
Nth. Goonyella
Nebo
Oonooie
Moranbah
Wandoo
Moranbah Sth.
Copabella
Peak Downs
Mt McLaren
Dysart
Norwich Park
Clermont
Broadsound
Barcaldine
Lilyvale
Gregory
Rockhampton
Stanwell
Bouldercombe
Blackwater
Dingo
Grantleigh
Gladstone
Wurdong
Baralaba
(Calvale) Callide A & B and Callide P. P.
Moura
Biloela
Gin Gin
Bundaberg
Clayton
Isis
Maryborough
Mungar
Kilkivan
Woolooga
Gympie
Roma
Tarong North
Traveston
Cooroy
Chinchilla
Tarong
Palmwoods
Braemar
Oakey
South Pine
Dalby
Wivenhoe
Mt. England
Blackwall
Yarranlea
Rocklea
Bulli Creek
Belmont
Millmerran
Middle Ridge
Swanbank B & E
Warwick
Molendinar
Terranora
Mudgeeraba
Stanthorpe
Bungalora
DC

South Australia

88. The analysis shows that the elimination of mis-pricing in South Australia would require dividing the SA region into eleven regions, as set out in Table 10 below, and illustrated in the following map:

Table 10: SA regions necessary to eliminate mis-pricing

Sub-region	**Connection points**	**Average difference from RRP when mis-priced**	**Annual average price difference compared to RRP**
Adelaide 1	SPPT (Pelican Point)	$-1.07 to *	$-0.01 to $-687.71
Adelaide 2	STSB1, STSB2, STSB3 (Torrens Island B)	$0.91 to *	$0.00 to $-74.15
Adelaide 3	SDRN1, SDRN2 (Angaston)	$0.00 to *	$0.00 to $-2960.90
Adelaide 4	SDCA1, SDCA2, SDCA3 (Dry Creek)	$0.00 to *	$0.00
Northern SA 1	SNPA1, SNPA2 (Northern PS)	$-0.26 to *	$-0.02 to $-1044.74
Northern SA 2	SPSD1 (Playford, unit 1)	$-0.58 to *	$0.00 to $-5.73
Central SA 1	SMPS (Mintaro)	$-26.57 to *	$0.05 to $-131.77
Central SA 2	SHPS1 (Hallet)	$2.06 to $2.06	$0.00 to $0.00
Southeast SA 1	SSGA1 (Snuggery, unit 1)	$231.07 to *	$+0.53 to $-972.42
Southeast SA 2	SPEW1, SPEW2 (Ladbroke Grove)	$-0.02 to $-3207.28	$0.00 to $-78.55
Southwest SA 1	SPLN1 (Port Lincoln)	$-200.70 to $-7171.33	$+0.33 to $-36.21



Tasmania

89. Table 11 shows that 14 regions would be necessary in Tasmania to eliminate mis-pricing during this period, as illustrated in outline in the following map.

Table 11: Tasmania regions necessary to eliminate mis-pricing

Sub-region	Connection points	Average difference from RRP when mis-priced	Annual average price difference compared to RRP
Northern TAS 1	TBB11, TBB12, TBB13 (Bell Bay unit 3?)	$0.40	$0.00
Northern TAS 2	TBBA1, TBBB1, (Bell Bay units 1 and 2)	$-9.21 to $-3307.40	$-0.30 to $-19.90
Northern TAS 3	TCE11 (Cethana), TFI11 (Fisher), TSH11 (Lemonthyme)	$-1.59 to $-9023.47	$-0.01 to $-28.41
Northern TAS 4	TDG11 (Devils Gate)	$91.42 to $-7078.09	$+0.04 to $-37.86
Central TAS 1	TGO11 (Gordon),	$+27.25 to $-119.16	$+0.43 to $-5.40
Central TAS 2	TLE11 (Lake Echo)	$102.88 to $504.71	$1.44 to $6.31
Central TAS 3	TMB11 (Meadowbank),	$109.69 to $650.75	$1.51 to $10.21
Central TAS 4	TTA11 (Tarraleah), TTU11, Tungatinah,	$107.82 to $446.12	$1.53 to $5.88
Central TAS 5	TLI11 (Liapootah),	$1.29 to $320.14	$0.02 to $0.22
Central TAS 6	TPM11 (Poatina 110kV)	$0.39 to $-179.09	$0.00 to $-0.87
Central TAS 7	TPM21 (Poatina 220 kV)	$105.29 to $489.10	$1.23 to $5.21
Central TAS 8	TTR11 (Trevalyn),	$0.12 to $1329.36	$0.00 to $-0.08
West TAS 1	TFA11 (Bastyan), TJB11 (John Butters), TRCA1 (Reece No. 1), TRCB1, (Reece No. 2), TTI11, (Tribute),	$-3.74 to $-4645.39	$-0.04 to $-39.92
West TAS 2	TMA11 (Mackintosh),	$-6.16 to $-671.73	$-0.03 to $-4.10