E 1997 Determination on Region Boundaries

This Appendix outlines the location of existing transmission network and region boundaries and explains the historical reasons behind the choice of these boundaries. After briefly summarising the discussion, this Appendix outlines the current regional structure of the National Electricity Market (NEM), and presents the reasoning and analysis behind the 1997 region boundary structure recommendations. It then outlines the limitations with the 1997 analysis, before considering the implications for the Rule changes considered in this draft Rule determination.

E.1 Summary

The National Electricity Market Management Company (NEMMCO) used historical data on congestion and forward looking market simulations in 1997 to inform its decision on the structure of existing region boundaries. Two important factors in its recommendation to implement the existing boundaries were:

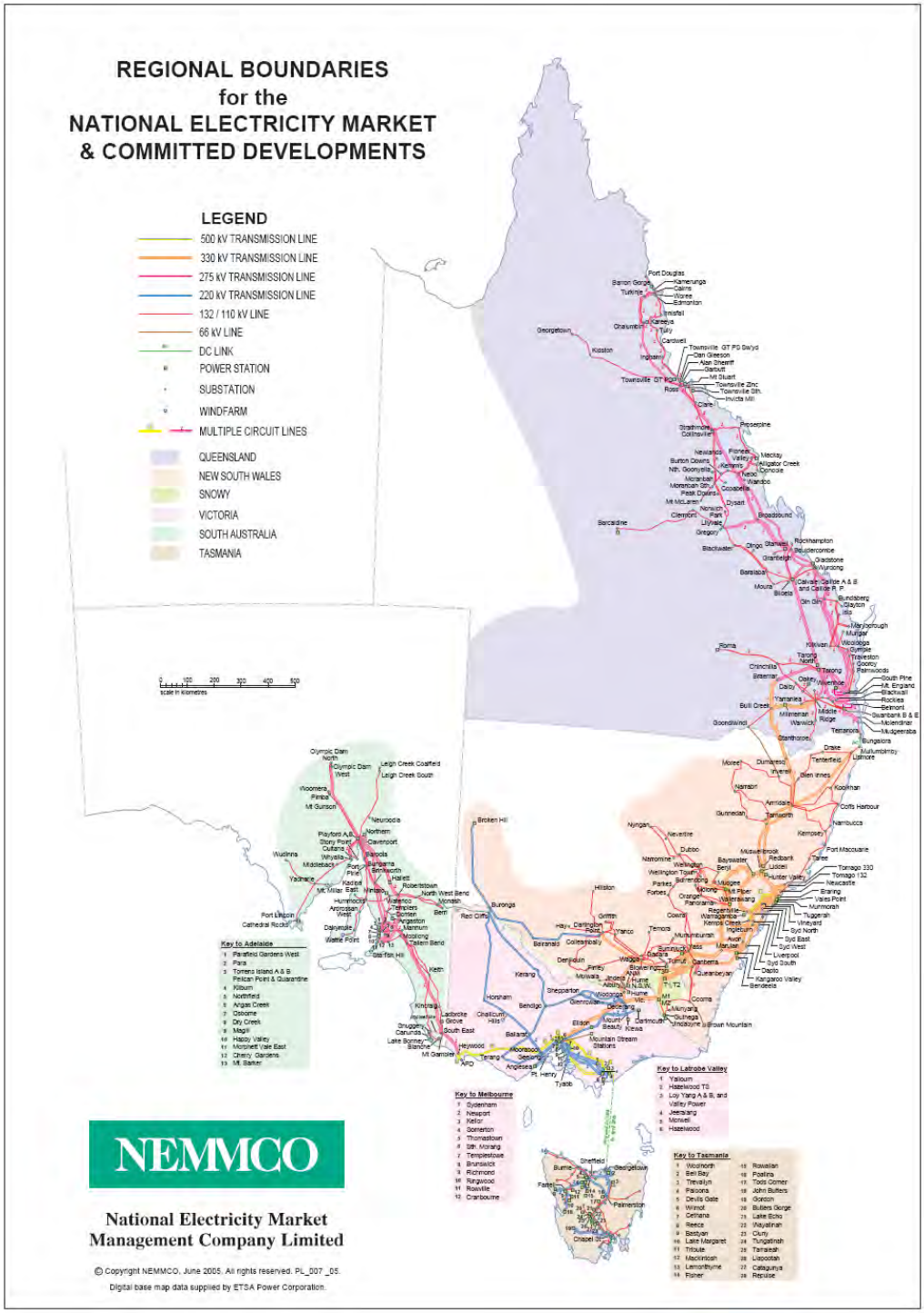
- Significant congestion between Sydney and Murray, in the areas between Tumut and Canberra/Yass (which limited flows from Snowy to NSW) and Yass and Marulan (which limited flows from NSW to Snowy); and

- The potential dispatch inefficiencies arising from the use of static loss factors for Murray and Tumut generation if both were included in the NSW pricing region. Using static loss factors when there are tidal flows of energy (to and from the Snowy area) decreases dispatch efficiency because losses are inaccurately taken into account in dispatch calculations.

E.2 NEM Transmission Network and existing region boundaries

Figure E.1 shows the existing region boundaries of the NEM, together with the transmission network and the points at which generators and loads connect to that network. These boundaries reflect the recommendation of NEMMCO in 1997, discussed in more detail in the next Section.

Figure E.1 NEM Transmission network and region boundaries

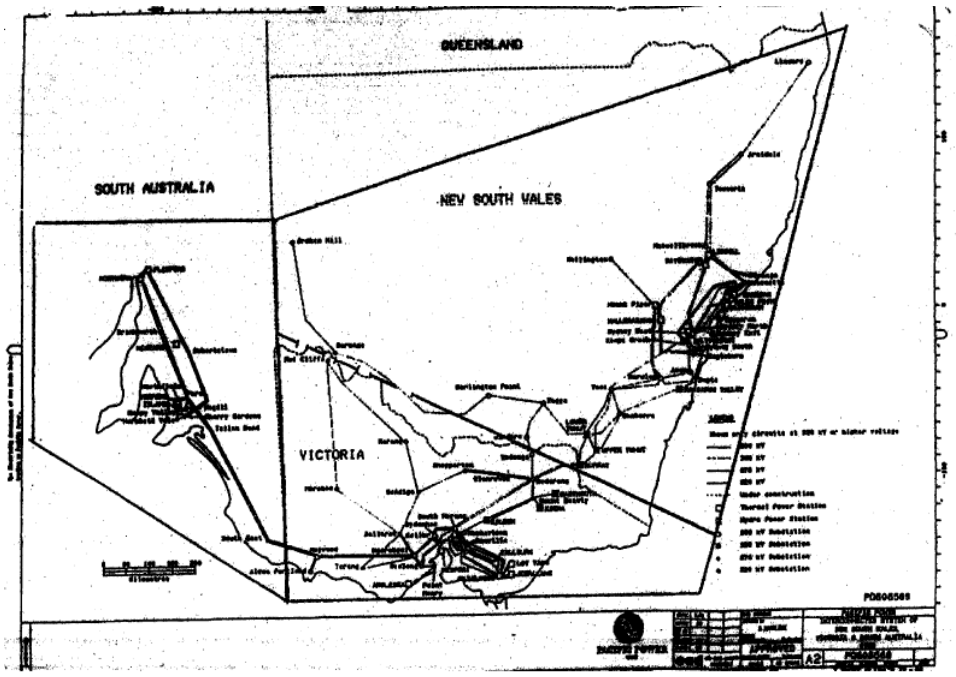


E.3 NEMMCO-TIRC recommendations

E.3.1 The 1997 decision

Following a consultation process in 1997, NEMMCO recommended to the National Electricity Code Administrator (NECA) that the existing structure of boundaries be used for the NEM, based on analysis by the Transitional Inter Regional Committee (TIRC) and Network Losses Working Group.[471] NEMMCO and TIRC considered four possible region boundary configurations and assessed them against the National Electricity Code's (the Code's) criteria for determining region boundaries (clauses 3.5.1, 3.5.2 and 3.5.3) and modelling losses (clauses 3.6.1 and 3.6.2). The four options were:

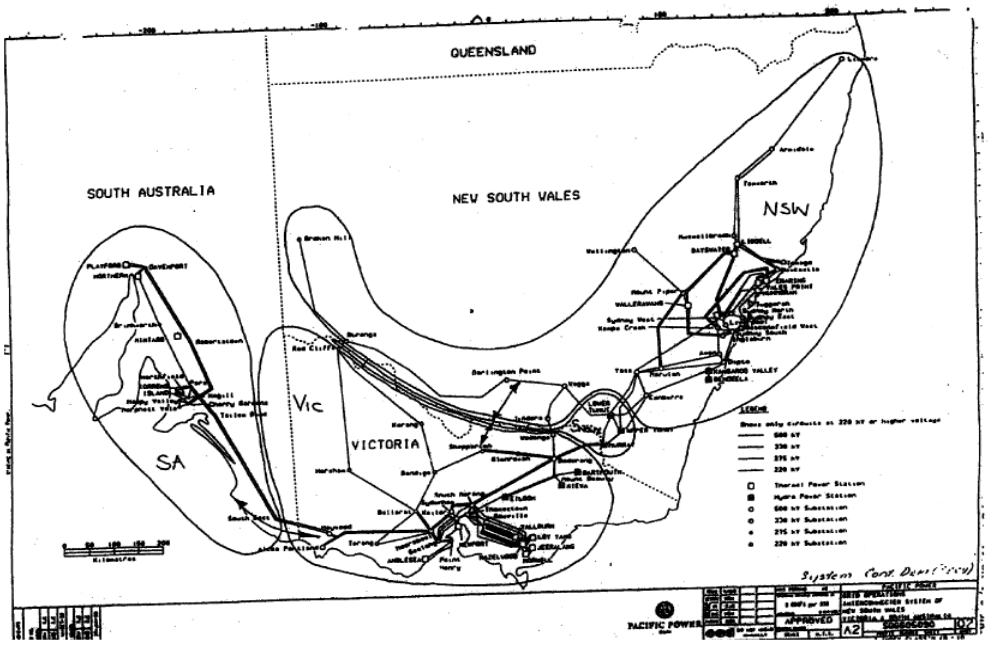
1. Region boundaries aligned with State boundaries (as used in NEM1);



Source: NEMMCO-TIRC 1997, page F.1

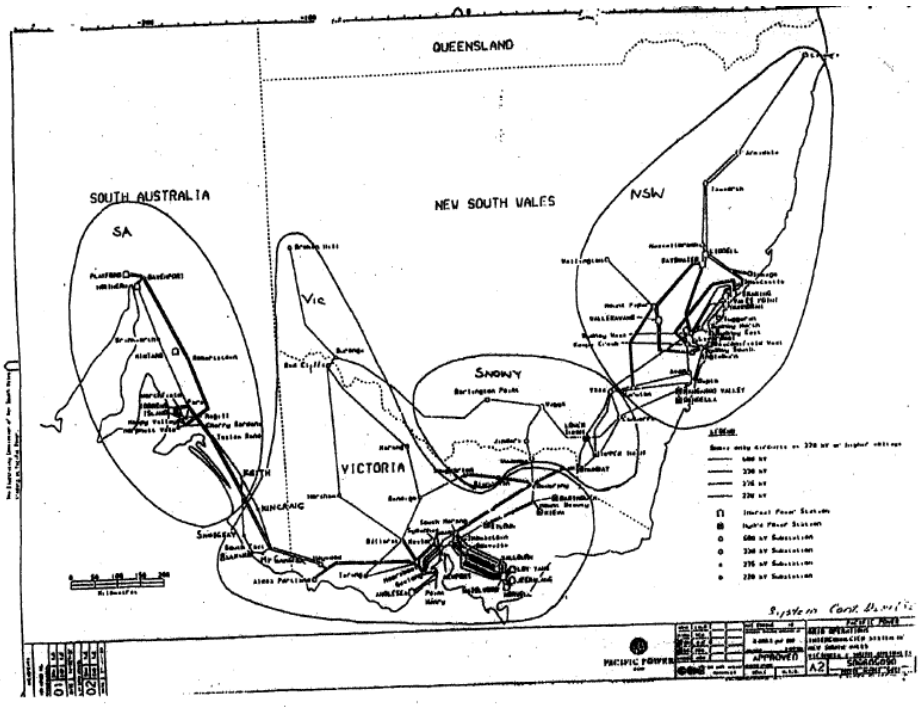
[471] NEMMCO – TIRC 1997, *Report on Marginal Loss Factors and Regional Boundaries for Victoria, South Australia and New South Wales in the National Electricity Market*, NEMMCO, Melbourne, September 1997 (including Recommendation on NEM Regions & MLFs dated 14/08/1998).

2. Four regions based on current transfer flow measurement points i.e. Snowy Generation as a separate region;



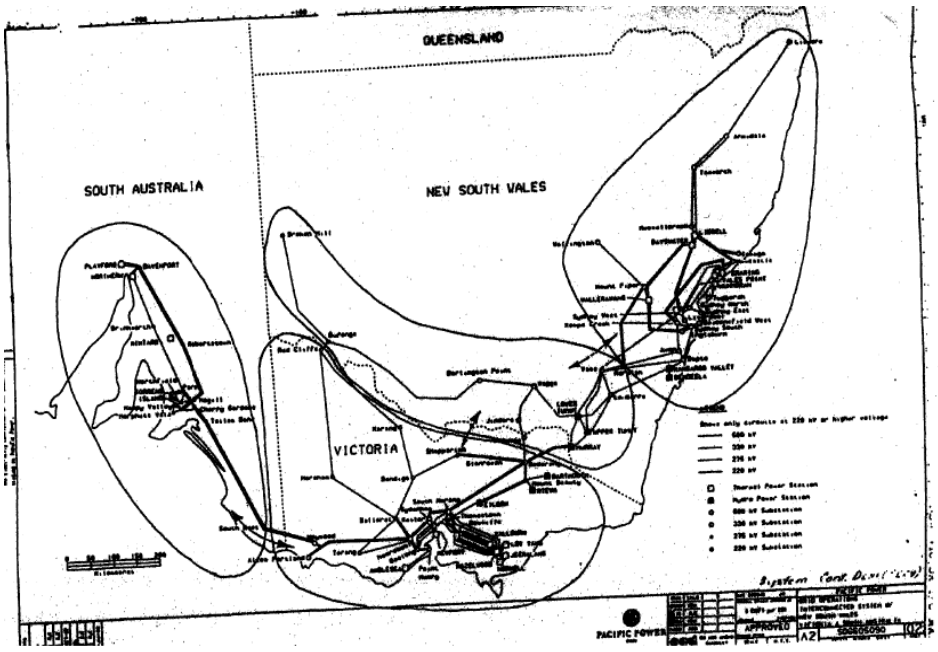
Source: NEMMCO-TIRC 1997, page F.2

3. Four regions based on minimisation of marginal loss factor (MLF) errors;



Source: NEMMCO-TIRC 1997, page F.3

4. Four regions — SA, Victoria (including distribution into NSW), NSW, and Snowy region (including load centres at Wagga, Yass, Canberra).



Source: NEMMCO-TIRC 1997 page F.4

NEMMCO and the TIRC unanimously recommended option 2 (Snowy generation in a separate region), stating:

> "The analysis clearly demonstrates the potential for Network Constraints to occur between NSW and Snowy. This is a major "driver" for the creation of a new region in Southern NSW and (possibly) northern Victoria. Although option 3 is the best technical solution for minimising loss factor variations (as well as recognising constraints), NEMMCO and the TIRC unanimously recommend option 2 (Snowy generation in a separate region).
>
> This option:
>
> - Provides for optimal dispatch of Snowy generation.
> - Fully recognises physical market reality of the potential for Network constraints to occur in southern NSW.
> - Does not bisect the franchise areas of NSW or Victoria distributors.
> - Can be implemented using existing metering infrastructure.

- Existing physical power-flow limits can apply for inter-regional power flows."[472]

There are a number of reasons why the 1997 determination is relevant to the Commission's current assessment of proposals to change the Snowy region boundary:

1. The NEM's pricing model is explained, emphasising the role region boundaries play in allowing the impacts of losses and significant constraints to be factored into the dispatch and pricing;

2. The criteria used to determine region boundaries, their interpretation and weighting are clearly discussed (see below);

3. The location and materiality of congestion on the Snowy-NSW interconnector and VIC-Snowy interconnector is assessed (see below);

4. The economic and engineering principles adopted in allocating generation and loads to specific regions in a "zonal" pricing market design are explained;

5. A central concern was the allocation of Snowy Hydro generation to a pricing region;

6. One of the four options considered in 1997 is similar to the Abolition proposal;

7. Limits placed on the choice of boundaries by jurisdiction-specific derogations are outlined. The derogations typically required a single price region for loads in each state. However, the Victorian jurisdiction later advised that it would consider amending its derogation to allow more than one pricing region in its state;

8. It provides a record of the responses of interested parties on matters including:

   (a) the principles and methodology used;

   (b) the commercial significance of region boundaries; and

   (c) the potential need for generators to have financially firm access to load centres; and

9. The methodology used in the 1997 assessment has a number of limitations.

E.3.2 Principles and weightings used in 1997 region boundary determination

Clause 3.5.1(b) of the Code sets out the principles to be applied by NEMMCO in determining region boundaries and regional reference nodes (RRNs). Given the potential for conflict among these principles, they are listed in priority order.

[472] NEMMCO – TIRC 1997, p.17.

The table below compares each of the four region boundary options with the seven selection criteria detailed in the Code. The weight given by NEMMCO-TIRC to each Code principle is shown, together with the score (in stars) of each option against the principles.

Although region boundary Option 3 scored the highest (135/147), Option 2 (132/147) was recommended, for the reasons discussed below, and has been in use since 1998.

Table E.1: Alignment of options with code principles

CODE PRINCIPLE		OPTION 1		OPTION 2		OPTION 3		OPTION 4	
(i) Enclosed regions	(10)	***	30	***	30	***	30	***	30
(ii) Constraints do not affect dispatch	(9)	*	9	***	27	***	37	***	37
(iii) Limits defined and measurable	(8)	***	24	***	24	**	16	**	16
(iv) Loss factors approximate optimal dispatch	(7)	*	7	***	21	***	21	***	21
(v) Low errors in all loss factors	(6)	*	6	**	12	***	18	**	12
(vi) Low errors in intra-regional loss factors	(5)	*	5	**	10	***	15	**	10
(vii) Minimal number of regions	(4)	***	12	**	8	**	8	**	8
SCORE			93		132		135		124 MAX 147

Note: The numbers in ( ) give the weighting for each Code principle. The 1 to 3 is used to multiply the weighting to give an overall score. E.g. Score for Code Principle (i) is 10 x 3 = 30

Recommended Option 2 has score of 132 out of max 147.

Legend: *** = best alignment

* = worst alignment

Data source: NEMMCO-TIRC 1997, p.15.

E.3.2.1 Reasoning behind the trade-off in dispatch efficiency and the number of regions

The 1997 decision to recommend Option 2 was strongly influenced by considerations regarding the economic efficiency of dispatch arising from the accurate modelling of losses and their impact on prices. The final recommendation sought to balance: a) the economic benefits of higher dispatch efficiency from more accurate pricing; and b) the benefits in terms of simplicity and trading arising from minimising the number of regions. The reasoning was presented as follows:

> "Investigations have shown that distortions in the determination and application of MLFs are minimised if regions are appropriately defined. As is the case with any "zonal" based system there is potential for difficult boundary issues which have the potential to distort outcomes for participants close to region boundaries. There is a trade off between complexity and accuracy in considering the number of regions that should be adopted.
>
> In order that distortions from the ideal nodal pricing arrangement are minimised the following aspects must be considered:
>
> - Separate regions must be declared where significant constraints can allow different prices to apply.
>
> - Within each region there should not be significant changes to loss factors with operating conditions, particularly flows. This requires declaration of a separate region with loss factor variations modelled on a dynamic basis.
>
> - Where a connection point can be assigned to more than one region in terms of network constraints, application of transfer limits and impact on central dispatch, the connection point should be assigned to the region for which the variation of pre-determined intra-regional loss factors and the resultant averaged loss factors is minimised."[473]

E.3.3 Location of binding constraints

With regards to the location of binding constraints at the time of the study, NEMMCO-TIRC made the following observations:

> "It is well documented that network constraints are currently defined in both directions between:
>
> - *Victoria and South Australia:* South Australian import capability is usually determined by transformer rating, but occasionally by transient stability

[473] NEMMCO – TIRC 1997, p.5.

considerations. South Australian export capability is determined by transient stability.

- *Victoria and Snowy*: Victorian import capability is determined by line rating considerations, voltage control constraints in the Melbourne area or by voltage control constraints in southern NSW. Victorian export capability is determined by transient stability limitations.

- *Snowy and NSW*: NSW import capability is determined by the rating of the lines between Snowy and Yass/Canberra. NSW export capability is determined at different times by either transient stability or the rating of the lines between Yass and Marulan.

It should be noted that the limits are, in most cases, not determined by the network elements located at the region boundaries, but are either embedded within networks [i.e., intra-regional limits that affect interconnector flow] or associated with the structure of the networks (viz system stability limits)."[474]

E.3.4 Materiality of congestion and its impact on choice of region boundaries

The materiality of congestion was assessed in 1997 using historical analysis and forward looking modelling that was based on historic bidding behaviour.

NEMMCO-TIRC noted that historic data showed that constraints between Victoria-South Australia and Victoria-Snowy bound frequently, but those between Snowy-NSW rarely bound. In the years leading up to 1998, binding system normal constraints on the Snowy-NSW interconnector primarily occurred in the NSW-Snowy direction, with no binding constraints in the Snowy-NSW direction. Constraints in the NSW-Snowy direction bound for more than 50 hours per year in ways that affected central dispatch — the threshold specified in Clause 3.5.2(b) (ii) of the Code as signifying congestion significant enough to warrant consideration of region boundary. Because of this experience, much of the analysis by NEMMCO-TIRC regarding the region boundaries for the NEM focussed on Snowy-NSW interconnector limits, and the most appropriate region boundary locations for the area containing Snowy Mountains Hydro-electric Scheme's power stations.

The forward-looking modelling carried out by NEMMCO-TIRC tried to assess the effects of the four different region boundary options on the economic efficiency of dispatch. Two independent models were used.[475] Each model tested a range of bidding scenarios and seasonal patterns of demand, based on historic bidding behaviour, "rather than just that which has been experienced since the start of NEM1 and consequently demonstrates the robustness of the conclusions".[476] Only the forward-looking modelling results for the first year of the NEM (i.e. 1998-99) were reported (see Table E.2), with NEMMCO-TIRC reaching the following conclusion:

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[474] NEMMCO – TIRC 1997, p.6.

[475] Neither model is named in the NEMMCO-TIRC paper.

[476] NEMMCO – TIRC 1997, p.6.

"This analysis indicates that it should be expected that the NSW to Snowy constraint will be binding for more than the 50 hours set as the criterion in the Code. The conditions under which this is most likely to occur are those typical of summer, namely high demand in Victoria and South Australia and/or low generator availability in those States or any time of NSW generators bid lower prices than Victorian / Snowy generation."[477]

Table E.2: Estimated hours of binding constraints for typical and atypical bidding scenarios

Constraint	Constraint hours per annum		
	Lower bound	Typical	Upper bound
NSW to Snowy	50	200+	400-1000+
Snowy to NSW	0	15	60

Data source: NEMMCO-TIRC 1997, p.7.

Two other conclusions were made about the financial impacts of having Snowy generation and Southern NSW loads in a separate region. These two conclusions were based on limited modelling that used a single set of historic "typical bids" from the NEM1 market:

- "The effect of Snowy not being in a region separate from other NSW generators may be material (assessed as energy dispatched and income received for a given bid). This is believed to be due to the loss factor averaging not including a price component; and

- The effect of Southern NSW loads not being in a separate region is immaterial, assessed on the basis total annual energy costs." [478]

E.3.5 Impact of tidal flows of energy on loss factors, dispatch efficiency and settlements

A key consideration in the rejection of Option 1 (i.e. both Murray and Tumut generation in NSW) was the distortions to economic dispatch arising from the use of a static MLF when there were significant "tidal flows" of energy (i.e. power switching direction) between Victoria-Snowy-NSW.[479] It was considered that in the presence of tidal flows, the use of a single static MLF at either Murray or Tumut would result in significant dispatch inefficiencies at those times when the actual, dynamic, loss factor diverged substantially from the static MLF. Tidal flows in and out of Snowy area also meant that the variance (i.e. standard deviation) on static

[477] NEMMCO – TIRC 1997, pp.6–7.

[478] NEMMCO – TIRC 1997, p.7 and Attachment 3.

[479] NEMMCO – TIRC 1997, p.5 and p.12.

MLFs for Murray and Tumut generation under Option 1 was considered large enough under the Code's criteria to warrant a separate Snowy region being created, with dynamic marginal loss equations being used on the resulting Victoria-Snowy and Snowy-NSW interconnectors.

These tidal flows can also increase the variance of static MLFs applied to loads in Southern NSW,[480] with the potential to affect the energy purchase costs for these loads. The standard deviation on MLFs for these Southern NSW loads were generally substantially less under region boundary Options 3 and 4 than under Options 1 and 2.[481]

In order to assess the potential settlement impacts of different static MLFs on Southern NSW loads and Snowy generation, NEMMCO-TIRC calculated the settlement outcomes for Snowy generation and a 100MW customer load in Canberra (the largest load centre in Southern NSW). Based on restrictive modelling assumptions, it was concluded that:

- There was potential for Snowy Generation to have a significantly different settlement outcome, depending on whether it was in its own region or included in the NSW region—even when the time-weighted regional reference prices it faced were similar. Snowy Hydro's annual output was 6% higher and its annual income 7% higher when it had its own pricing region rather than being included in NSW; and

- The energy purchase costs for 100MW of customer load in Canberra were unlikely to be different if Snowy generation had its own region or was included in NSW.[482]

E.4 Limitations of NEMMCO-TIRC analysis

With the benefits of hindsight and significant developments in modelling strategic behaviour in electricity markets, the following can be listed as limitations of the NEMMCO-TIRC's 1997 analysis:

- *Simple bidding assumptions* — the modelling used typical bids based largely on NEM1 behaviour, rather than strategic bidding that is responsive to region boundary changes;

- *Inadequate treatment of basis risk* — Dispatch modelling took no account of inter-regional hedging risks and incentives for generator behaviour. This is because IRSRs were not yet designed, yet alone implemented. However, NEMMCO-TIRC mentioned these risks and sought expert advice and input from market participants. Since 1997, IRSR units have been developed and there is increased

480 Load connection points in Southern NSW include: Albury 132, ANM, Broken Hill 22, Broken Hill 220, Burrinjuck 132, Canberra 132, Coleambally, Cooma 132, Deniliquin 132, Finley 132, Goulburn 132, Griffith 132, Hay 132, Mulwala 132, Murrumburrah 132, Queanbeyan 132, Temora 132, Tumut 132,Wagga Town 132, Yanco 132, Yass 132.

481 NEMMCO – TIRC 1997, Attachment 4.

482 NEMMCO – TIRC 1997, Attachment 3.

understanding of: a) the limitations of IRSR units for managing inter-regional trading risks; b) the magnitude of those risks; and c) the firmness of IRSRs on the Victoria-Snowy and Snowy-NSW interconnector; and

- *Marginal Loss Factors* — the calculation of static MLFs and dynamic loss equations relied on historic data on: generation, loads and network limits. NEMMCO-TIRC recommended that all future calculations of losses use a forward-looking approach.

Nonetheless, the 1997 analysis provides a useful reference point for the Commission in 2007 because many of the issues concerning the Snowy region's boundary—and options for addressing them—are the same.

E.5 Similarities between region boundary options in 1997 and 2007

Both the Abolition and Split Snowy Region proposals aim to address the "legacy" issue surrounding the existing Snowy region boundary. These legacies have been discussed elsewhere, but include the following:

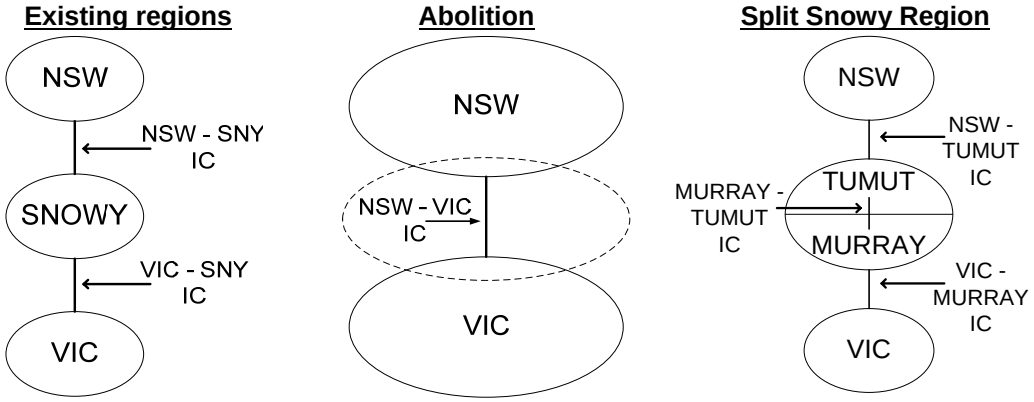
- The existing Snowy region being a separate pricing region, with:
  - a generation only region, with a large monopoly generator and no independent load; and
  - a network loop straddling three pricing regions. This loop can create counter-price flows;
- The ability of Snowy Hydro generation to influence the level of power transfers and congestion within the Snowy region and along interconnectors between Victoria and NSW;
- The partial Tumut CSP/CSC Trial, and its modification arising from implementation of Southern Generators Rule change proposal; and
- The design, topology and operation of the transmission network through the Snowy Mountains.

The difference between the Abolition and Split Snowy Region proposals is the solution put forward to address congestion in the Snowy region:

1. **The Abolition proposal** would abolish the existing Snowy region, allocating Murray generation to the existing Victorian region and Tumut generation to the existing NSW region. The proposal would abolish the Victoria-Snowy and Snowy-NSW interconnectors, replacing them with a Victoria-NSW interconnector.
2. **The Split Snowy Region proposal** would divide the existing Snowy region into two pricing regions – Murray and Tumut, creating a region boundary between Tumut and Murray generation. The proposal would also retain the existing interconnectors between the Victorian region and Murray generation and the NSW region and Tumut generation. The RRN in the Murray region will be at

Dederang, which is relocated from the Victorian region to the new Murray region and at Lower Tumut in the Tumut region.

Figure E.2 Comparison of region boundary proposals



Note. IC – Interconnector, SNY - Snowy

Both proposals are likely to change the way in which congestion costs—arising from least-cost, security constrained, economic dispatch—are reflected in the regional reference prices used to settle the NEM:

- The Abolition proposal eliminates the existing Snowy region and removes the current economic signals arising from explicit, dynamic, pricing of congestion between the existing Snowy region and the NSW and Victorian RRNs.

- The Split Snowy Region proposal continues to dynamically price congestion between the Victorian region and Murray generation and between Tumut generation and the NSW region. It would also dynamically price the congestion across the Murray–Tumut cutset, on the newly defined interconnector between the Murray and Tumut regions.

These changes in the pricing of inter-regional congestion potentially affect the:

- Magnitude of any dispatch efficiency gains arising from any move away from the existing regional structure by changing the economic incentives faced by generation plant within the newly defined regions; and

- Trading risks faced by participants trading across regions, and potentially, within each region.

These factors are discussed in more detail in Appendix A.

Interestingly, option 1 which was considered by NEMMCO and the TIRC in 1997 is similar to the current Abolition proposal. In option 1 there is no separate Snowy region, but it differs from the Abolition proposal in that all Snowy Hydro generation (rather than just Tumut generation) is included in the NSW region.

Two other 1997 observations regarding the impact of Option 1 on constraints are relevant to the Commission's 2007 consideration of the Abolition proposal. The Option 1 regional configuration:

- "Ignores constraints between Snowy and NSW. If constraints between Snowy and NSW remain they will be embedded in the NSW region. This may result in Snowy being dispatched at a price different from its regional price to supply the Victorian or SA regions when intra-regional constraints apply. (This has the potential to increase the complexity of operation of the NEM.)

- There is no requirement for inter-regional hedging contracts between Snowy generators and participants in the NSW region, or between southern NSW loads and NSW generators. (Snowy generators may wish to obtain firm (transmission) access arrangements with TransGrid)."[483]

Both of these issues are also relevant to the assessment of Split Snowy Region proposal. As discussed in Appendix A, the Split Snowy Region proposal, the concerns are: a) the economic efficiency of dispatch; and b) the effectiveness of hedging inter-regional trading risks using IRSRs in a market with a greater number of regions and interconnectors.

[483] NEMMCO-TIRC 1997, p.12.