F Historical congestion between Victoria, Snowy, and NSW regions

This Appendix assesses the historical frequency, type, and location of congestion between the Snowy region and the regional reference nodes (RRNs) in Victoria and New South Wales (NSW) over the four year period from financial year 2003/04 to 2006/07, inclusive.

The Commission has undertaken this analysis of binding constraints on a historical basis with the aim of better understanding the historic level of congestion at the existing regional boundaries, and the proposed borders of the new regions. This analysis will provide some insight into the possible consequences of changing regional boundaries around the Snowy region.

However, the Commission recognises the limitations of using historical data on network congestion at particular points of the network to assess potential future congestion. Information on the historical frequency and location of congestion between Victoria, Snowy and NSW must be used with caution, because past congestion is not an indicator of future congestion unless circumstances are unchanged. Because of this, forward looking modelling that accounts for changed circumstances and economic incentives is required to assess the potential economic efficiency impacts of potential changes in the location of region boundaries. The forward looking modelling undertaken by the Commission to inform its assessment of the three Rule change proposals is presented in Appendix B.

F.1 Summary

The historical analysis considered flows on the Snowy to NSW interconnector and the Victoria to Snowy interconnector. Key findings from the examination of the historical pattern of congestion over the period between 1 July 2003 to 30 June 2007 can be summarised as follows:

1. Snowy-NSW interconnector:

   (a) In simple terms the transfer capability on the Snowy-NSW interconnector is limited by a series of key cutsets, including the Murray-Tumut cutset, the North Tumut cutset, and the north and south Marulan cutsets.[487]

   (b) Binding constraints on the Snowy-NSW interconnector have increased from 137 dispatch intervals (11.4 hours) in 2003/04 to 2,164 dispatch intervals (180.3 hours) in 2006/07.

   (c) The vast majority of binding cutset constraints that limit Snowy-NSW interconnector flows in both directions arise under system normal conditions.

[487] Cutsets are defined in Section F.2.2 of this Appendix.

(d) Constraints on the Murray-Tumut cutset are the most frequent limitation on the interconnector flow capacity under system normal conditions. These constraints account for almost 74% of all binding constraints on the Snowy to NSW interconnector.

(e) During 2005/06 and 2006/07, constraints on the Liddell-Tomago cutset were the second most frequent limitation on the flows between Snowy and NSW.

(f) Discretionary constraints are the third most frequent limitation on Snowy-NSW interconnector flows.[488] However, there has been a significant reduction in the use of discretionary constraints in the past year.

(g) Together, constraints north and south of Marulan are the next most frequent limitation on Snowy-NSW interconnector flows. However, these only tend to bind under outage conditions, possibly because generators south of the constraint (e.g. Snowy Hydro, Wallerawang, and Mount Piper) adjust their output to maintain "headroom" on the cutset constraints under system normal conditions.[489]

(h) Constraints on the North Tumut cutset (i.e. between Tumut and Canberra/Yass) rarely limit interconnector flows. This result is at odds with the Split Snowy Region proposal, which maintains the existing Snowy region boundary across that cutset on the basis that it is a major "pinch point".

2. Victoria-Snowy interconnector:

(a) In simple terms the transfer capability on the Victoria-Snowy interconnector is limited by cutsets south of the Victorian RRN, cutsets between South Morang and the Snowy RRN, cutsets to the north of Murray, and transformers located at South Morang and Dederang.

(b) Binding constraints on the Victoria-Snowy interconnector have varied over the period considered, ranging from 5,924 dispatch intervals (493.7 hours) in 2005/06 to 12,734 dispatch intervals (1,061.2 hours) in 2003/04.

(c) Around 80% of all binding cutset constraints that limit Victoria-Snowy interconnector flows in both directions arise under system normal conditions.

(d) Stability constraints are the most frequent limitation on flows along the Victoria-Snowy interconnector.

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[488] Discretionary constraint sets are used to limit flows on an interconnector to less than or equal to a fixed value. NEMMCO advises that these sets are invoked at the discretion of operating staff, and are not necessarily associated with any specific outage or system condition. Discretionary constraints are used by NEMMCO to manage negative settlement residues by "clamping".

[489] The practice of generators limiting output with the aim of avoiding constraining lines that would cause their settlement price to fall is known as maintaining headroom. This is discussed in more detail in Appendix A.

(e) South Morang transformer constraints, discretionary constraints and voltage constraints were, respectively, the three next most frequent limitations on interconnector flows over the three years.

(f) Constraints between Dederang and South Morang very rarely represent the most limiting factor on interconnector flows. This result is at also odds with the Split Snowy Region proposal, which maintains the existing southern Snowy region boundary, with the exception of relocating Dederang into Murray, on the basis that it is a major "pinch point".

F.2 Historic data on the incidence of congestion between Victoria and NSW

The Commission's analysis of historical congestion between Victoria and NSW was based on statistical data provided by the National Electricity Market Management Company (NEMMCO). The data covered four directional interconnectors: Victoria-Snowy, Snowy-Victoria, Snowy-NSW and NSW-Snowy. For each directional interconnector NEMMCO provided the frequency of binding constraints, according to a number of criteria: by cutset, by constraint type, by financial year, by season (summer, autumn, winter, spring), and time of day (peak, off-peak).

The data was extracted from NEMMCO's Market Management Systems (MMS) and covers the period between 1 July 2003 and 30 June 2007. NEMMCO calculated the most binding constraint on each interconnector in each 5-minute dispatch interval, and then used this data to calculate the frequency of binding constraints across each financial year.

Before analysing this data, it is important to have a clear understanding of:

- the various network elements that make up the interconnectors;
- how these elements can be grouped into geographic "cutsets";
- the types of limits and constraints that affect cutsets; and
- how different types of cutset limits affect the overall transfer capacity of an interconnector.

This is discussed in more detail below.

F.2.1 Network elements making up interconnectors

The interconnection between the RRNs of Victoria (Thomastown), Snowy (Murray), and NSW (Sydney West) comprises many individual transmission lines at various voltages. Figure F.1 illustrates these transmission lines, showing the lines with capacities of 330kV (orange), 220kV (blue) and 132kV (red). The backbone is the 330kV network, which also links with the 500kV networks (yellow) of Victoria and NSW. Associated with these lines are transformers, switching stations, and network support and control infrastructure.

Figure F.1 Transmission network elements – Victoria-Snowy and Snowy-NSW Interconnectors

Data source: NEMMCO

For dispatch and pricing purposes, the National Electricity Rules (Rules) group these lines into two "notional interconnectors", along which power flow is measured at the region boundary. By convention, the direction of flow from Victoria to NSW is assigned a positive sign and the reverse flow a negative sign. These flow conventions allow each interconnector to be divided into two individual "directional interconnectors"— one for each direction of power flow. Table F.1 shows the notional and directional interconnectors between the Victorian and NSW RRNs.

Table F.1: Interconnectors & directional interconnectors, Victoria to NSW

Notional Interconnector	Direction of flow on interconnector	Sign convention for flow direction	Directional interconnector
V-Snowy	Victoria to Snowy	+	VIC-SNY
	Snowy to Victoria	-	SNY-VIC
SNOWY1	Snowy to NSW	+	SNY-NSW
	NSW to Snowy	-	NSW-SNY

Each interconnector can also be divided into a series of "cutsets" (or "flow paths").

F.2.2 Cutsets

A cutset is a group of transmission lines that limits power transfers from one area to another and whose removal from the network's topology (via switching or an outage) would split the network in two, one on each side of the cutset.[490] The maximum power that can be transferred across a cutset is limited by thermal and stability constraints. The power transfer limitations applying to a cutset mean that the cutset is sometimes referred to as a "transmission pinch point".

The National Electricity Market's (NEM's) very long alternating current (AC) transmission network (over 4,000km), widely dispersed and unbalanced centres of generation and load, all contribute to stability constraints (rather than thermal constraints) often being the most significant limitation on power transfers across cutsets.

Each notional interconnector in the NEM comprises the group of cutsets affecting power flows between two RRNs. Limits on each cutset in the group limit the power transfer capability between two segments of the notional interconnector, and hence limit the transfers across the entire interconnector.

The following Section considers the key cutsets forming the Snowy-NSW and Victoria-Snowy interconnectors in turn.

F.2.2.1 Snowy-NSW interconnector (Snowy1)

Figure F.2 is a simplified representation of the Snowy-NSW interconnector, which comprises five cutsets of lines between the Snowy RRN (Murray) and the NSW RRN (Sydney West). This box, containing all the cutsets, comprises the notional interconnector, as does the single diagonal line running from the south-west corner of the box to the northeast corner. This single line is a simplification of the many lines that make up the cutsets that together form the interconnector. Significant connection points used to define the cutsets are shown next to the diagonal line, for example Canberra and Marulan.

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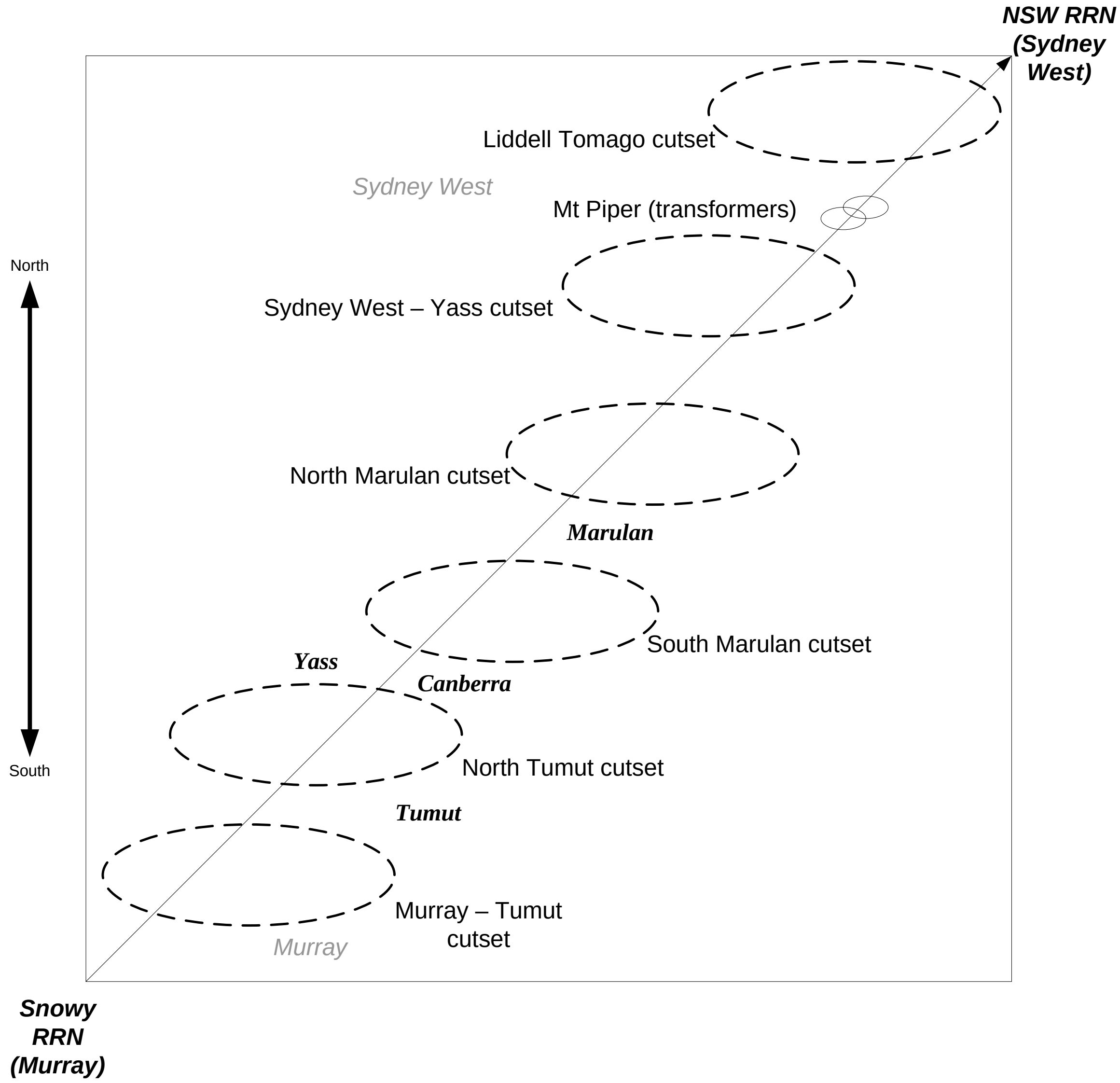
490 In strict terms, an electricity cutest is defined as a set of branches of a network such that the cutting of all the branches of the set increases the number of separate parts of the network, but the cutting of all the branches except one does not.

Importantly, the Liddell-Tomago cutset and Mount Piper transformers, which lie geographically to the north of Sydney West, can also limit flows from Murray to Sydney West.

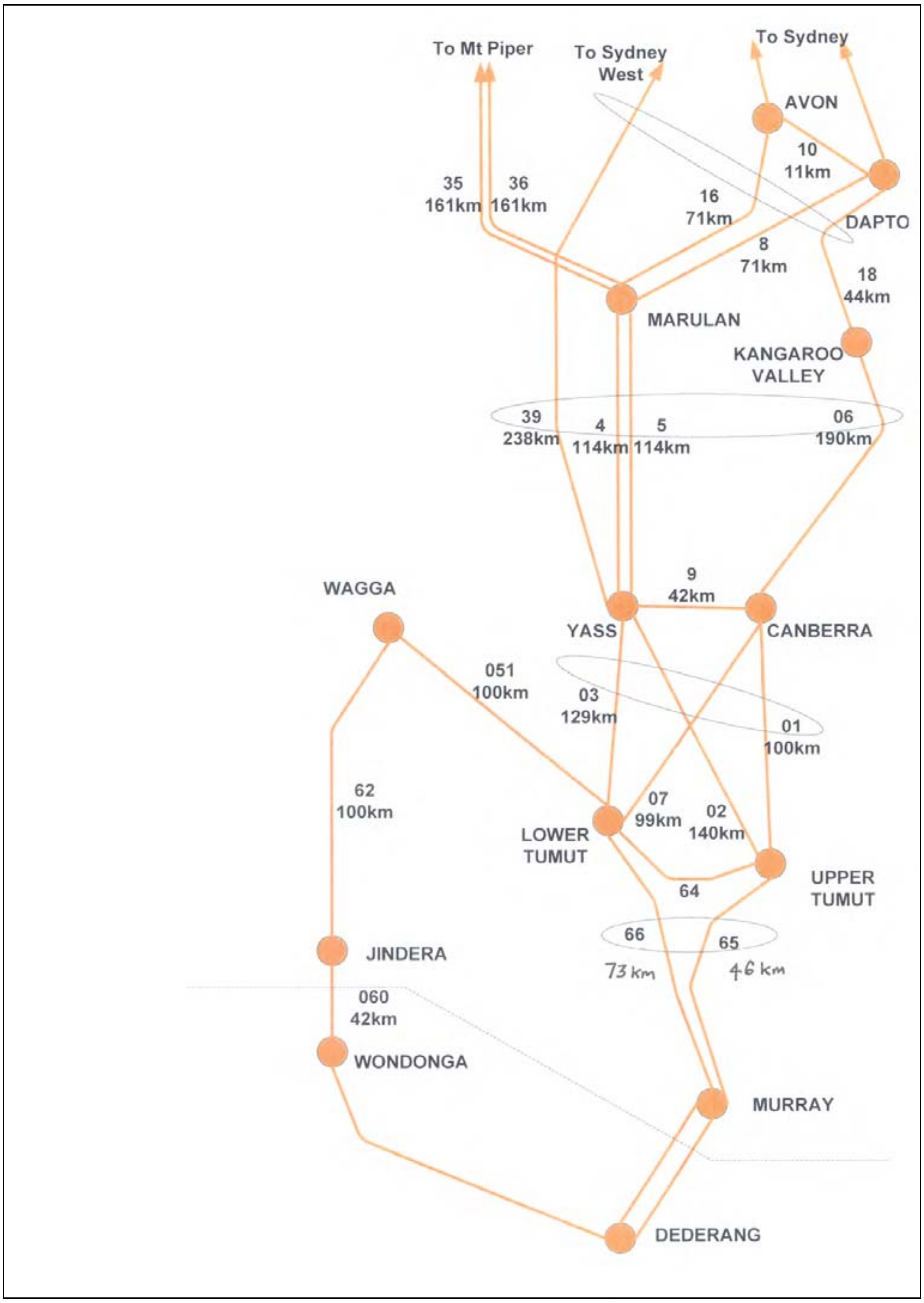
These cutsets closely correspond to those in the 17-zone Annual National Transmission Statement (ANTS) model in NEMMCO's 2005 *Statement of Opportunities*.

Figure F.2 Simplified representation of Snowy-NSW notional interconnector



A more detailed picture of the transmission lines that form the five southern cutsets on the Snowy-NSW interconnector is shown in Figure F.3. The lines are numbered and their length is shown. For example, in Figure F.3, the line from Murray to Upper Tumut is the "65 line", whose length is 46km. The length of a line affects its electrical impedance and degree to which voltage drops along the line as power flows from one end to the other. In general, the longer the line, the greater its impedance (i.e. losses) and voltage drop.

Figure F.3 Snowy-NSW interconnector – transmission lines and cutsets, detail



Data source: TransGrid

TransGrid's 2006 and 2007 Annual Planning Reports (APRs) state that limitations on the Snowy-NSW interconnector's transfer capability are affected by five factors:

1. thermal limits on lines in the South Marulan cutset, which restrict the level of flows both north and south. At present, the limits predominantly restrict southwards flows;[491]

2. thermal ratings of lines in the Murray-Tumut cutset;[492]

3. transient stability limits that apply in the "event of a fault on a critical 330kV transmission line in southern NSW (i.e., the Wagga to Darlington Point line)";[493]

4. "thermal ratings of plant in southern NSW" around Wagga and between Wagga and Yass;[494] and

5. voltage control and reactive power limitations around Canberra.[495]

NSW import capability along the Snowy-NSW interconnector is currently determined at different times by factors (1), (2), (4) and (5) above.

NSW export capability to the Snowy and Victorian regions is currently determined at different times by factors (1), (2), (3) and (4) above.

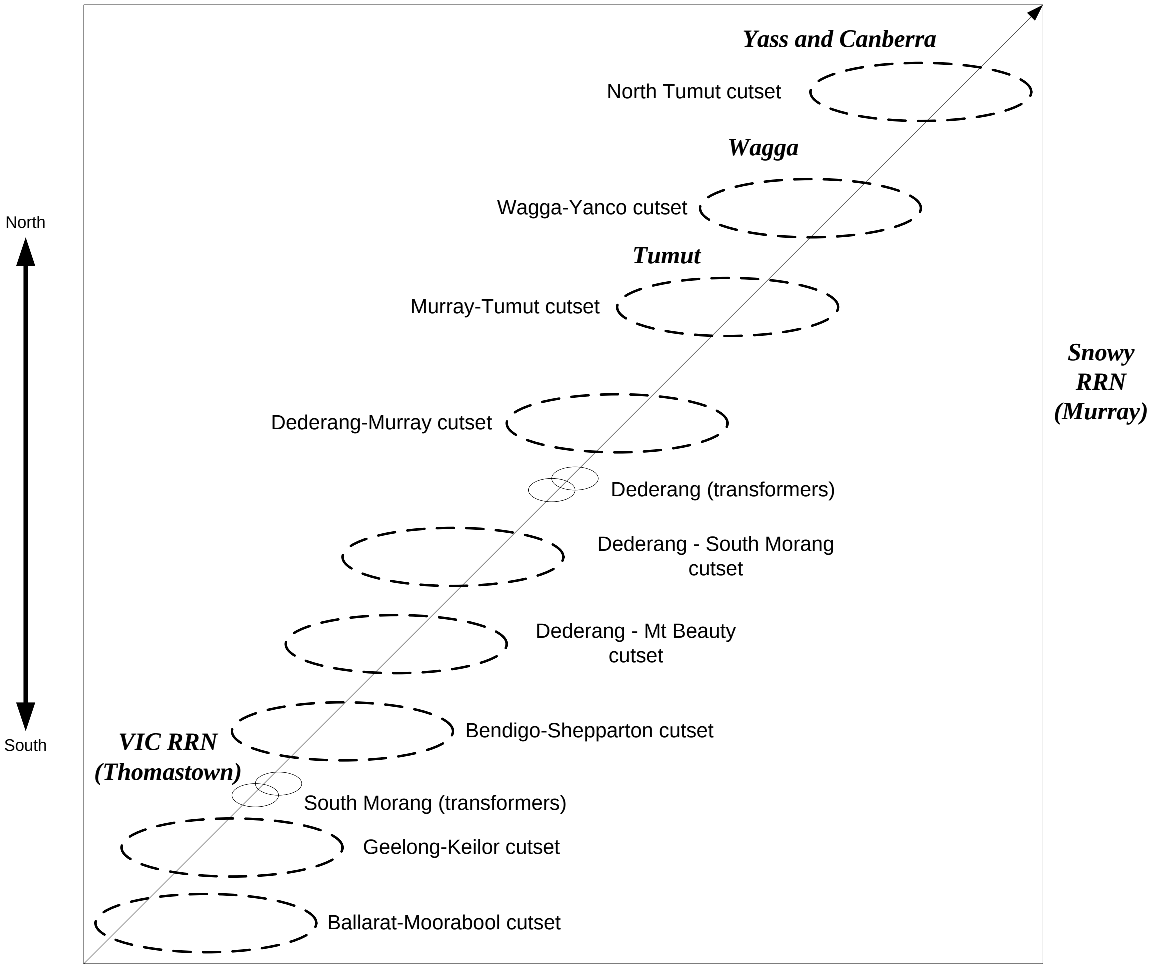
F.2.2.2 Victoria-Snowy Interconnector

Figure F.4 is a simplified representation of the Victoria-Snowy interconnector, whose transfer capability is limited by:

- two cutsets of lines south of the Victorian RRN (Thomastown);
- four cutsets of lines between South Morang (near the Victorian RRN) and the Snowy RRN (Murray);
- four cutsets to the north of Murray; and
- transformers located at South Morang and Dederang. The South Morang transformers convert power from the Latrobe Valley from 220kV to 330kV and 500kV to 330kV. The three Dederang transformers alter voltages from 220kV to 330kV.

[491] TransGrid, APR 2007, p.48.
[492] TransGrid, APR 2006, p.78.
[493] TransGrid, APR 2006, p.78, p88.
[494] TransGrid, APR 2006, p.78-80.
[495] TransGrid, APR 2006, p.79.

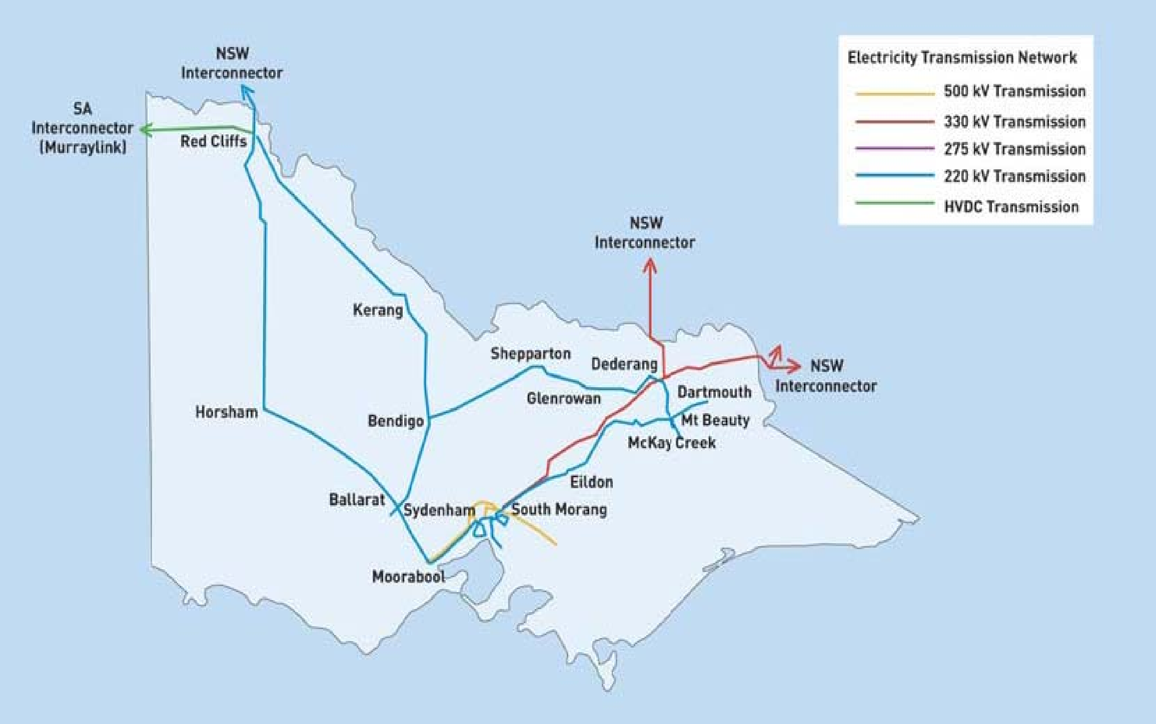
Figure F.4 Simplified representation of Victoria-Snowy notional interconnector



As with the Snowy-NSW interconnector, the cutsets on the Victoria-Snowy interconnector are similar to those in NEMMCO's 17-zone ANTS model.

Figure F.5 shows the 330kV and 220kV lines that make up the Victoria-Snowy interconnector. The South Morang Terminal Station is the key point where power from the Latrobe Valley's 500kV and 220kV lines is injected into the Victoria-Snowy interconnector.

Figure F.5 Victoria-Snowy – main transmission elements



Data source: VENCorp 2006 APR (Electricity), p. 61

VENCorp's 2007 APR states that Victorian import capability on the Victoria-Snowy interconnector is determined by:[496]

1. Thermal limits on the 330kV lines in the Dederang-Murray cutset, which largely define the "system normal" upper import limit of 1,900MW;

2. Overlapping voltage collapse and thermal constraints (on the Dederang transformers constraints and Eildon to Thomastown 220kV line) that apply in the event of an outage to one of the lines in the Dederang-South Morang cutset;

3. Thermal constraints on the three Dederang 330/220kV transformers. Under system normal conditions and no generation from Kiewa or Eildon, constraints on the Dederang transformers limit Victorian imports from Snowy to around 1,200MW. Under system normal and more than 60% of Kiewa or Eildon generation dispatched, import capability of up to 1,900MW is possible. An outage of one of the Dederang transformers can reduce Snowy-Victoria import capability to between 100 and 1400MW, depending on Kiewa and Eildon generation;

4. Thermal constraints on the Eildon to Thomastown 200kV line when there is an outage of one of the 330kV lines in the Dederang-South Morang cutset, can (in

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[496] VENCorp 2006, *Electricity Annual Planning Report 2007*, VENCorp, Melbourne, pp. 60-63.

combination with other constraints) restrict Victorian imports from Snowy to around 1,200MW; and

5. Thermal limits on the South Morang 220/330kV and 500/330kV transformers.

Victorian export capability on the Victoria-Snowy interconnector is determined by:[497]

1. Thermal limits on the 330kV lines in the Dederang-South Morang cutset, which restrict exports to between 1,000MW and 1,150MW when all other plant is in service;

2. In the event of an outage to one of 300kV lines in the Dederang-Murray cutset, the Victoria-Snowy export limit is reduced by around 130MW; and

3. Thermal limits on the South Morang 220/330kV and 500/330kV transformers.

F.3 Analysis of Historic Pattern of Constraints — 2003/04 to 2006/07

In the period 2003/04 to 2006/07, according to NEMMCO data, binding constraints on six cutsets affected flows on the Snowy-NSW interconnector. In the same period, binding constraints on ten cutsets affected flows on the Victoria-Snowy interconnector.

Table F.2 identifies three broad types of constraints that restrict power flows along the cutsets that comprise each interconnector. Stability and voltage constraints generally apply to the whole interconnector and are difficult to assign to a particular cutset, so are separately categorised.

[497] VENCorp 2006, *Electricity Annual Planning Report 2007*, VENCorp, Melbourne, pp.60-63.

Table F.2: Constraint types

Constraint types	Snowy-NSW Interconnector	VIC-Snowy Interconnector
Cutset thermal limitations or contingency constraints for loss of lines in the cutset	Liddell-Tom	Yass-Control
	Sydney West-Yass	Nth Tumut
	Nth Marulan	Wagga-Yanco
	Sth Marulan	Murray-Tumut
	Nth Tumut	Ded-Murray
	Murray-Tumut	Ded-Sth Morang
		Ballarat-Moorabool
		Geelong-Keilor
Transformer overloading or loss contingency constraints	Mt Piper Tx	Dederang Tx
		Ded-Mt Beauty
		Bendigo-Shepparton
		Sth Morang Tx
Other security constraints on interconnectors		Voltage
	Stability	Stability
	Discretionary	Discretionary

Note: Tx is an abbreviation for transformer

The frequency and location of binding constraints differs depending on whether the flow is northwards or southwards along an interconnector. The following Section considers the frequency and location of binding constraints for the Snowy-NSW and Victoria-Snowy interconnectors.

F.3.1 Snowy-NSW interconnector

Table F.3 shows the frequency and location of binding constraints along the Snowy-NSW interconnector between 1 July 2003 and 30 June 2007, for flows both to and from the Snowy region. The data shows the number of 5-minute dispatch intervals in which a cutset constraint was both binding and the most restrictive constraint on the entire interconnector. The data includes all times of the day (peak and off-peak), all four seasons (summer, autumn, winter, spring), and outage conditions (system normal, network outage).

It should be noted that on many occasions, multiple constraints are binding in a way that affects interconnector flows. By focussing on the most restrictive binding constraint in a dispatch interval, it is possible to characterise the location and type of constraint that is having the greatest influence in limiting flow along the interconnector. The more frequently a particular constraint sets the overall flow-limit of an interconnector, the greater its effect on dispatch outcomes.

Table F.3: Frequency of most binding constraints (Number of binding dispatch intervals), Snowy-NSW interconnector (Snowy1), System normal and outage conditions, 1 July 2003 to 30 June 2007

Frequency for Snowy-NSW	Year				
Key	2003/04	2004/05	2005/06	2006/07	Total
Liddell-Tom			199	430	629
Mt Piper Tx				5	5
SydWest-Yass			3		3
Nth Marulan			20	2	23
Sth Marulan		17	14	27	58
Nth Tumut	11	12	4		27
Murray-Tumut	91	416	1,190	1,554	3,251
Stability	11	28	3	144	186
Discretionary	24	45	158	1	228
Grand Total	137	518	1,591	2,164	4,410

Note: In 2005/06 and 2006/07 stability data was divided into stability, transient stability and voltage stability. For the purposes of consistency, data for these years have been combined to a single stability figure.

Data source: NEMMCO

The following observations can be made about the data in Table F.3:

1. Binding constraints on the Snowy-NSW interconnector have increased from 137 dispatch intervals (11.4 hours) in 2003/04 to 2,164 dispatch intervals (180.3 hours) in 2006/07;

2. Constraints on the Murray-Tumut cutset are the most frequent limitation on the interconnector flow capacity. There has been a large increase in the frequency of Murray-Tumut constraints binding between 2003/04 and 2006/07. These constraints bound for 91 dispatch intervals (or 7.6 hours) in 2003/04, rising to 1,554 dispatch intervals (or 130 hours) in 2006/07;

3. Liddell-Tomago constraints are the second most frequent limitation on interconnector flows;

4. Discretionary constraints are the third most frequent limitation on interconnector flows, however, in 2006/07 there was only one instance of this type of binding constraint;

5. Together, constraints north and south of Marulan are the fourth most frequent limitation on interconnector flows; and

6. Constraints on the North Tumut cutset (i.e. between Tumut and Canberra/Yass) rarely limit interconnector flows. This result is at odds with the Split Snowy Region proposal, which locates a region boundary at this cutset on the basis that it is a major “pinch point”.

The increased level of congestion on the Murray-Tumut cutset is likely to be associated with a number of factors, including: i) increasing application of "fully optimised" constraint formulations by NEMMCO; ii) changes in Snowy Hydro's contract position; and iii) implementation of the Tumut CSP/CSC Trial and its impacts on Snowy Hydro's incentives and bidding behaviour.

Similarly, the reduction in the use of discretionary constraints could be linked to: i) different patterns of line outages over time; and/or ii) increased network control arising from the use of "fully optimised" constraint forms.

Table F.4 splits the data in Table F.3 into the frequency of binding constraints limiting:

- flows north from the Snowy region to the NSW region (exports from Snowy); and
- flows south from the NSW region to the Snowy region (imports to Snowy).

This information enables further insights into constraints on the interconnector.

Table F.4: Frequency of most binding constraints by direction of flow (Number of binding dispatch intervals), Snowy-NSW interconnector (Snowy1), System normal and outage conditions, 1 July 2003 to 30 June 2007

		Year				
Key	Data	2003/04	2004/05	2005/06	2006/07	Total
Liddell-Tom	Export (SN to NSW)			198	430	628
	Import (NSW to SN)			1	0	1
Mt Piper Tx	Export (SN to NSW)				5	5
	Import (NSW to SN)				0	0
SydWest-Yass	Export (SN to NSW)			0		0
	Import (NSW to SN)			3		3
Nth Marulan	Export (SN to NSW)			20	3	23
	Import (NSW to SN)			0	0	0
Sth Marulan	Export (SN to NSW)		0	0	0	0
	Import (NSW to SN)		17	14	27	58
Nth Tumut	Export (SN to NSW)	1	12	4		17
	Import (NSW to SN)	10	0	0		10
Murray-Tumut	Export (SN to NSW)	14	293	788	960	2,055
	Import (NSW to SN)	77	123	402	594	1,196
Stability	Export (SN to NSW)	0	0	0	18	18
	Import (NSW to SN)	11	28	3	126	168
Discretionary	Export (SN to NSW)	15	39	9	1	64
	Import (NSW to SN)	9	6	149	0	164
Total Export (SN to NSW)		30	344	1,019	1,417	2,810
Total Import (NSW to SN)		107	174	572	747	1,600

Data source: NEMMCO

Table F.4 shows the following:

1. Constraints on the Murray-Tumut cutset constrain flows both north and south, but northward flows are more frequently affected by these constraints;

2. Liddell-Tomago cutset constraints nearly always restricted flows from Snowy to NSW;

3. Discretionary constraints mainly affect northward flows from Snowy to NSW;

4. Binding constraints on the North Marulan cutset limit exports from Snowy to NSW. Constraints on the South Marulan cutset limit southward flows from NSW to Snowy;

5. North Tumut cutset constraints restrict flows from Snowy to NSW more than flows in the reverse direction; and

6. In total, there is significantly greater frequency of constraints that limit flows from the Snowy region (Snowy to NSW) than flows from NSW (NSW to Snowy).

F.3.2 Victoria-Snowy Interconnector

Table F.5 shows the frequency and location of binding constraints along the Victoria-Snowy interconnector over the period 1 July 2003 to 30 June 2007, for flows both to and from the Snowy region. As before, the data shows the number of 5-minute dispatch intervals in which a cutset constraint was both binding and the most restrictive constraint on the entire interconnector. The data includes all times of the day (peak and off-peak), all four seasons (summer, autumn, winter, spring), and outage conditions (system normal, network outage).

Table F.5: Frequency of most binding constraints (Number of binding dispatch intervals), Victoria-Snowy interconnector (V-Snowy), System normal and outage conditions, 1 July 2003 to 30 June 2007

Frequency for VIC-Snowy	Year				
	2003/04	2004/05	2005/06	2006/07	Total
Yass Control		12			12
Nth Tumut	3				3
Wagga-Yanco			28	113	141
Murray-Tumut	425	45	146	910	1,526
Ded-Murray	122	64	65	2	253
Dederang Tx	5	2	470	456	933
Ded-Sth Morang		3			3
Ded-Mt Beauty				7	7
Bendigo-Shepparton				4	4
Sth Morang Tx	2,227	1,097	944	3,772	8,040
Geelong-Keilor				115	115
Ballarat-Moorabool				431	431
Voltage	516	194	889		1,599
Stability	7,945	6,426	2,511	5,685	21,637
Discretionary	1,491	1,008	871	307	3,677
Grand Total	12,734	8,921	5,924	10,803	38,382

Data source: NEMMCO

The following observations can be made about the data in Table F.5:

1. Binding constraints on the Victoria-Snowy interconnector have varied over the period considered, ranging from 5,924 dispatch intervals (493.7 hours) in 2005/06 to 12,734 dispatch intervals (1,061.2 hours) in 2003/04;

2. Stability constraints are the most frequent limitation on flows along the Victoria-Snowy interconnector. For example, in 2003/04 these constraints affected 7,945 dispatch intervals (or 662 hours), representing 62% of the total 12,734 dispatch intervals in which the interconnector was constrained;

3. South Morang transformer constraints were the second most frequent limitation on interconnector flows;

4. Discretionary constraints represent the third most frequent restriction on Victoria-Snowy transfers. The frequency of discretionary constraints has been decreasing significantly since 2003/04;

5. Voltage constraints represent the fourth most frequent restriction on Victoria-Snowy transfers;

6. The Murray-Tumut constraint was the next most frequent limiting factor on interconnector flows over the four years. However, in 2006/07 constraints on this cutset were the third most frequent determinant of interconnector flows — comprising 8% of the occasions (i.e. 910/10,803 dispatch intervals) when interconnector flow was at its limit;

7. Constraints between Dederang and South Morang are very rarely the most limiting factor on interconnector flows. This result is at odds with the Split Snowy Region proposal, which locates a region boundary at this cutset on the basis that it is a major “pinch point”;

8. Binding constraints on the Dederang-Murray cutset determine the limit on interconnector flows around 1% of the time per year in each of the first three years;

9. South Morang transformer constraints were the second most frequent limitation on interconnector flows in each year; and

10. Constraints associated with “Yass Control”, North Tumut, Wagga Yanco, Dederang-South Moran, Bendigo-Shepparton, Dederang-Mt Beauty and Geelong-Keilor are very rarely the most limiting factor on flows on the Victoria-Snowy interconnector.

Table F.6 segments the data in Table F.5 into the frequency of binding constraints limiting:

- flows north from the Victorian region to the Snowy region (exports from Victoria); and
- flows south from the Snowy region to the Victorian region (imports to Victoria).

Table F.6: Frequency of most binding constraints by direction of flow (Number of binding dispatch intervals), Victoria-Snowy interconnector (V-Snowy), System normal and outage conditions, 1 July 2003 to 30 June 2007

Key	Data	Year				Total
		2003/04	2004/05	2005/06	2006/07	
Yass Control	Export (VIC to SN)		0			0
	Import (SN to VIC)		12			12
Nth Tumut	Export (VIC to SN)	0				0
	Import (SN to VIC)	3				3
Wagga-Yanco	Export (VIC to SN)			0	3	3
	Import (SN to VIC)			28	110	138
Murray-Tumut	Export (VIC to SN)	10	4	13	645	672
	Import (SN to VIC)	415	41	133	265	854
Ded-Murray	Export (VIC to SN)	21	0	0	0	21
	Import (SN to VIC)	101	64	65	2	232
Dederang Tx	Export (VIC to SN)	0	0	0	41	41
	Import (SN to VIC)	5	2	470	415	892
Ded-Sth Morang	Export (VIC to SN)		0			0
	Import (SN to VIC)		3			3
Dederang-Mt Beauty	Export (VIC to SN)				7	7
	Import (SN to VIC)				0	0
Bendigo-Shepparton	Export (VIC to SN)				1	1
	Import (SN to VIC)				4	4
Sth Morang Tx	Export (VIC to SN)	1,461	1,072	850	3,631	7,014
	Import (SN to VIC)	766	25	94	141	1,026
Geelong-Keilor	Export (VIC to SN)				110	110
	Import (SN to VIC)				5	5
Ballarat-Moorabool	Export (VIC to SN)				366	366
	Import (SN to VIC)				65	65
Voltage	Export (VIC to SN)	0	0	0		0
	Import (SN to VIC)	516	194	889		1,599
Stability	Export (VIC to SN)	7,945	6,426	1,545	2,284	18,135
	Import (SN to VIC)	0	70	966	2,466	3,502
Discretionary	Export (VIC to SN)	309	678	362	169	1,518
	Import (SN to VIC)	1,182	330	509	138	2,159
Total Export (VIC to SN)		9,746	8,180	2,770	7,192	27,888
Total Import (SN to VIC)		2,988	741	3,154	3,611	10,494

Data source: NEMMCO

The following observations can be made about the data in Table F.6:

1. Stability constraints overwhelmingly limit export flows from Victoria and more rarely limit import flows to Victoria;

2. South Morang transformer constraints are also predominantly a restriction on Victorian exports, rather than imports;

3. Voltage constraints only appear to restrict imports of power into Victoria from the Snowy region;

4. Murray-Tumut cutset constraints were often associated with restrictions of import into Victoria rather than exports;

5. Constraints between Dederang and South Morang were only a limiting factor on Victorian imports;

6. Dederang-Murray cutset constraints limit imports;

7. South Morang transformer constraints tend to limit Victorian exports much more than Victorian imports;

8. "Yass Control", North Tumut, and Wagga-Yanco constraints limit power flows from Snowy to Victoria; and

9. Discretionary constraints affect imports more than exports from Victoria.

F.3.3 Controlling for network outages

Network outages change the topology of the transmission network and alter the constraints and limits used to manage the network that remains in service. Network outages can be planned (for maintenance), forced (by fire, mechanical failure), or as a result of routine circuit switching to clear faults.

It is possible to divide the data on the frequency of binding constraints into classes to enable congestion to be characterised as relating to the physical design limits of the network with, either:

- all network elements in operation (i.e. system normal); or
- one or more network elements out of operation (i.e. outage conditions).

It is well known that binding constraints on one part of an electrical network can affect dispatch and pricing all across the entire network. The economic consequences of this depend on how persistently the constraints affect the efficiency of economic dispatch, the reliability of supply, and power system security and control.

System normal constraints that bind frequently may be having a material effect on dispatch, but may not necessarily be economic to build out. That is, these types of binding constraints are likely to reflect that both the network's design and its capacity are economically efficient. However, the existence of persistently binding system normal constraints in a regional pricing market structure may also indicate a location of material congestion. Such material congestion relating to system normal conditions may warrant consideration being given to a region boundary being located at that location—in order to explicitly price the congestion and improve economic efficiency of dispatch—especially if a network upgrade either fails to pass the Regulatory Test or is not physically feasible (e.g. the easement cannot accommodate additional lines).

Although specific outage conditions may occur relatively infrequently, they can have a significant effect on the location of congestion, its severity, the efficiency of dispatch, and the financial risks faced by market participants. Congestion at a particular part of the network that arises under outage conditions may not justify a region boundary, because although it might cause significant changes in the economic efficiency of dispatch, the outage conditions are of such limited duration or occur rarely enough, that the creation of a new pricing region is not warranted. That is, market participants accommodates the economic inefficiencies and financial risks associated with congestion that arises from rare outage conditions.

Table F.7 and Table F.8 below contain data on the frequency of congestion on the Snowy-NSW (Snowy1) and Victoria-Snowy (V-Snowy) interconnectors, by cutset constraint type, for “modified system normal” conditions. Modified system normal conditions means that there are no outages of the usual system normal transmission topology, apart from the 64-line (between Lower Tumut and Upper Tumut) being switched out of service. NEMMCO has advised that the 64-line is normally switched out of service during dispatch in order to avoid the stability problems on the Victoria-Snowy and Snowy-NSW interconnectors that arise when the 64-line is switched in and Snowy region generation is high (which generally coincides with high interconnector flows). Recognising this, the ANTS constraint set also assumes the 64-line is normally out of service.

The mathematical difference between the data in Table F.7 and Table F.4 equals the congestion attributable solely to network outage conditions. Based on this comparison, Table F.7 reveals that for the Snowy-NSW (Snowy1) interconnector:

1. The vast bulk of binding cutset constraints that limit Snowy-NSW interconnector flows in both directions arise under system normal conditions. Across the four years, 45% of the total instances (i.e. 1271/2810 instances) in which Snowy-NSW (export) flows were restricted occurred under system normal conditions. However, 87% of the total most limiting binding constraints NSW-Snowy (import) flows occurred under system normal conditions (i.e. 1,397/1,600 instances);

2. Binding constraints on the North Marulan and South Marulan cutsets were the most limiting constraint on interconnector flows only under outage conditions. This is why North Marulan does not appear in Table F.7 and South Marulan shows very few incidences;

3. In only one dispatch interval under system normal conditions did the Liddell-Tomago cutset limit flows from Snowy to NSW. Outage conditions were associated with 91% (573/628) of the binding constraints on the Liddell-Tomago cutset that limited export flows on the Snowy-NSW interconnector. There were no outages in the only time that flows from NSW to Snowy were limited by Liddell-Tomago cutset;

4. Binding constraints on the North Tumut cutset are associated with outage conditions. For exports, across the three years, only 1/17 constraints occurred under system normal conditions. For imports, the figure is 1/10;

5. Almost half of the binding constraints on the Murray-Tumut cutset that determined the interconnector flow limit from Snowy to NSW and nearly all binding constraints on flow from NSW to Snowy, occurred under system normal conditions. For exports (i.e. Snowy to NSW flow), 55% (i.e. 1,136/2,055) instances of binding constraints in the four years occurred in system normal conditions. For imports, the corresponding figure is 92%(i.e. 1,101/1,196);

6. The bulk (91%) of stability constraints affecting imports in 2003/04 were related to outage conditions, with only 1/11 occurring under system normal conditions. In 2006/07, 25% (i.e. 43/168) of the stability constraints that determined NSW to Snowy flow limits arose under system normal conditions; and

7. Across the three years, nearly all the binding discretionary constraints (i.e. 58/64 instances) that determined Snowy-NSW export flows arose under system normal conditions. In 2005/06 and 2006/07, all discretionary constraints occurred under system normal conditions.

Table F.7: Frequency of most binding constraints by direction of flow (Number of binding dispatch intervals), Snowy-NSW interconnector (Snowy1), Modified system normal conditions, 1 July 2003 to 30 June 2007

		Year				Grand Total
Key	Data	2003/04	2004/05	2005/06	2006/07	
Liddell-Tom	Export (SN to NSW)			55		55
	Import (NSW to SN)			1		1
Mt Piper Tx	Export (SN to NSW)				3	3
	Import (NSW to SN)				0	0
Sth Marulan	Export (SN to NSW)				0	0
	Import (NSW to SN)				11	11
Nth Tumut	Export (SN to NSW)	1				1
	Import (NSW to SN)	1				1
Murray-Tumut	Export (SN to NSW)	9	249	694	184	1,136
	Import (NSW to SN)	77	107	395	522	1,101
Stability	Export (SN to NSW)	0	0		18	18
	Import (NSW to SN)	1	14		110	125
Discretionary	Export (SN to NSW)	15	33	9	1	58
	Import (NSW to SN)	9	0	149	0	158
Total Export (SN to NSW)		25	282	758	206	1,271
Total Import (NSW to SN)		88	121	545	643	1,397

Data source: NEMMCO

Table F.8 focuses on Victoria-Snowy interconnector congestion under modified system normal conditions. Comparing Table F.6 and Table F.8 reveals the following:

1. Around 80% of all binding cutset constraints that limit Victoria-Snowy interconnector flows in both directions arose under system normal conditions;

2. Binding constraints around Wagga-Yanco, Yass Control, and Dederang-Mt Beauty cutsets only determined Victoria-Snowy interconnector flows under outage conditions – neither appear in Table F.8;

3. All the instances in which constraints on the North Tumut cutset determined Victoria-Snowy flows occurred under system normal conditions;

4. Across the four years, Victoria to Snowy flows were limited by the Murray-Tumut constraint for 672 dispatch intervals, 656 of which were associated with system normal conditions. Over the three years, 61% of the instances in which flows from Snowy to Victoria were determined by the Murray-Tumut cutset constraint occurred under system normal conditions;

5. Dederang transformer limits rarely set the Victoria-Snowy interconnector flow limits under system normal conditions;

6. All the instances of the Dederang-South Morang cutset determining Victoria-Snowy interconnector flow limits (north and south) relate to system normal conditions;

7. All the instances in which constraints on the Bendigo-Shepparton cutset determined Victoria-Snowy flows occurred under system normal conditions;

8. In 2005/06 and 2006/07 nearly all binding constraints on the South Morang transformers on flows from Snowy to Victoria occurred under system normal conditions. In total across the four years, 87% of these binding constraints occurred on exports to Snowy and 79% occurred on imports to Victoria;

9. In total across the four years, 78% of the stability constraints on Victoria-Snowy exports (14,223/18,135) occurred under system normal conditions. In the same period, 76% the stability constraints determining Snowy-Victoria flows occurred under system normal conditions (2,693/3,502); and

10. 99% of both the import and export discretionary constraints that determined Victoria-Snowy interconnector flow limitations occurred under system normal conditions. These discretionary constraints include those used to manage negative residues by "clamping" the Victoria-Snowy interconnector.

Table F.8: Frequency of most binding constraints by direction of flow (Number of binding dispatch intervals), Victoria-Snowy interconnector (V-Snowy), Modified system normal conditions, 1 July 2003 to 30 June 2007

Key	Data	Year				Grand Total
		2003/04	2004/05	2005/06	2006/07	
Nth Tumut	Export (VIC to SN)	0				0
	Import (SN to VIC)	3				3
Murray-Tumut	Export (VIC to SN)	1	4	12	639	656
	Import (SN to VIC)	116	41	132	239	528
Ded-Murray	Export (VIC to SN)	21	0	0		21
	Import (SN to VIC)	25	64	61		150
Dederang Tx	Export (VIC to SN)		0	0	3	3
	Import (SN to VIC)		2	53	40	95
Ded-Sth Morang	Export (VIC to SN)		0			0
	Import (SN to VIC)		3			3
Bendigo-Shepparton	Export (VIC to SN)				1	1
	Import (SN to VIC)				4	4
Sth Morang Tx	Export (VIC to SN)	1,447	722	715	3,224	6,108
	Import (SN to VIC)	564	15	94	140	813
Geelong-Keilor	Export (VIC to SN)				21	21
	Import (SN to VIC)				5	5
Ballarat-Moorabool	Export (VIC to SN)				69	69
	Import (SN to VIC)				13	13
Voltage	Export (VIC to SN)	0	0	0		0
	Import (SN to VIC)	204	157	759		1,120
Stability	Export (VIC to SN)	6,963	4,741	863	1,656	14,223
	Import (SN to VIC)	0	70	864	1,759	2,693
Discretionary	Export (VIC to SN)	309	676	356	169	1,510
	Import (SN to VIC)	1,182	328	503	138	2,151
Total Export (VIC to SN)		8,741	6,143	1,946	5,782	22,612
Total Import (SN to VIC)		2,094	680	2,466	2,338	7,578

Data source: NEMMCO

F.4 Limitations of historical data on the frequency of congestion[498]

The above information on the historical frequency and location of congestion between Victoria, Snowy and NSW should be used with caution. There are several reasons for this.

498 Drawn from: D. Biggar, "On the use of Information on the Historical Frequency and Location of Constraints to Determine Region Boundaries", 26 June 2006.

First, under the existing region boundary structure, there may exist significant points of congestion that do not appear in the historical data because generators that can affect whether the constraint binds may have the incentive and ability to adjust their generation in such a way that the constraint does not bind.

Second, past patterns of congestion may not be a good indicator of future congestion if circumstances change. Changed circumstances may arise from:

- Changes in supply conditions, such as generator outages, changes in generation capacity or changes in market power, transmission outages, changes in transmission capacity and so on;

- Changes in demand conditions due to economic growth, changes in weather, changes in appliance mix (e.g. increased penetration and use of air-conditioning), or changes in demand-side responsiveness; and

- Changes in the formulation of the constraint equations used in dispatch (in particular, the re-writing of constraint equations in the "fully optimised" form).

Third, changing region boundaries will change the bidding incentives on generators, thereby changing the flows on the network and the resulting pattern of constraints. A change in region boundaries could make existing persistent, material constraints disappear and/or reappear in other parts of the network.

Consequently, forward looking market modelling incorporating potential boundary options and the network constraints applying to those options is required to understand the likely patterns of congestion under a new NEM regional pricing structure and its impact on dispatch efficiency. NEMMCO-Transitional Inter Regional Committee (TIRC) applied this modelling approach in 1997 (as discussed in Appendix E) and the Commission has also committed to this approach to evaluate the various options for region boundary changes.