D Incidence and location of congestion in the NEM

D.1 Purpose

This Appendix considers the incidence and location of congestion in the National Electricity Market (NEM). It reviews historical data on congestion within the NEM in order understand trends in the incidence of congestion, and locate the congested parts of the network. Past patterns of congestion may not be a good indicator of future congestion if circumstances change. This Appendix therefore also assesses possible future trends in congestion, by analysing the factors that have influenced the prevalence of congestion in the past and reviewing committed generation and transmission investments projects.

Data has been published by both Australian Energy Regulator (AER) and the National Electricity Market Management Company (NEMMCO) on the number of binding hours and cumulative marginal values (CMVs) for constraints. In addition, the Australian Energy Market Commission (the Commission) has requested NEMMCO to provide data on the level of "mis-pricing" across the NEM.

[240] Although such data can help to inform on the materiality of the congestion, the purpose of this Appendix is to further investigate the trends in and location of significant constraints across the NEM.

D.1.1 Key findings of the review

The key results from this analysis are:

- Inter-regional constraints bind far more often than intra-regional constraints. In 2005/06 inter-regional constraints bound in total for 7,958 hours compared to 1,830 hours for intra-regional constraints;
- The incidence of both intra- and inter-regional congestion has been increasing since 2002/03. The increasing trend in congestion is driven mainly by the increasing incidence of binding constraints at times of outages;
- The incidence of inter-regional congestion at times of both system normal and outage events is increasing. The frequency of binding intra-regional constraints at times of outages is increasing compared to system normal constraints;
- The average hours of mis-pricing due to system normal constraints in the NEM has been constant between 2003 to 2006. However, there is significant variation across the regions, with mis-pricing due to system normal constraints increasing in South Australia and Queensland, but decreasing in Victoria;
- There is a difference between the number of hours a constraint is binding and the market impact of a constraint. Some constraints can bind for long durations but

[240] Mis-pricing is defined in Section A.2.1 of this Appendix.

have little material impact on dispatch, while other constraints bind for a short time but have a significant market impact;

- Specific events can greatly affect the level of binding constraints reported. For example, the drought in Victoria during 2005/06 lead to increase transfers from Snowy to Victoria, which in turn lead to more binding on the Snowy to Victoria interconnector. Similarly, significant network outages can result in sharp increases in the incidence of binding constraints in one year compared to the next;
- Generators are more likely to be constrained off than constrained on;
- There is variation in the trends and incidence of congestion across the NEM regions. The incidence of binding congestion is decreasing in Victoria, while in New South Wales (NSW), South Australia and Queensland the incidence of binding constraints is increasing;
- The area where congestion has had the most material impact is the Snowy Region. This has now been addressed through the Abolition of the Snowy Region Rule Determination;
- There are a few locations where congestion has been material and persistent. However, these areas appear to be being addressed through planned investment by Transmission Network Service Providers (TNSPs); and
- There are also a few locations where congestion has remain persistent (e.g., Heywood interconnector), but where the market impacts of these constraints are not large enough to justify investment.

D.1.2 Structure of this Appendix

This Appendix supplements Chapter 3 of the Draft Report. The appendix is structured as follows:

Section D1: Purpose:	
D.1.1	Key findings of the review
D.1.2	Structure of the Appendix
Section D2: Data:	
D.1.3	The incidence of congestion in the NEM
D.1.4	Data sources

D.1.5	Limitations on the data
Section D3: Review of historical congestion in the NEM	
D.3.1	Inter-regional congestion
D.3.2	Intra-regional congestion
Section D4: NEMMCO mis-pricing analysis	
D.4.1	Distribution of positive and negative mis-pricing
D.4.2	Magnitude of mis-pricing impact
D.4.3	Classification of mis-Pricing between transmission outages and system normal
D.4.4	Mis-priced intervals with regional reference price > $1000/Mwh
Section D5: Summary on prevalence of congestion in the NEM	
Section D6: Factors influencing the level of congestion	
Section D7: Outlook for future trends in the incidence of congestion	
D.7.1	Intra-regional
D.7.2	Inter-regional

D.2 Data

D.2.1 The incidence of congestion in the NEM

Broadly speaking, congestion occurs when there is a bottleneck on the transmission network. Congestion can be caused by a number of factors including transmission or generation outages, weather conditions and peak demand. Demand growth, changing patterns of demand and new or discontinued generation can also influence congestion levels.

Network limitations are reflected in dispatch and settlement through information provided to the NEM dispatch engine (NEMDE). NEMDE is a linear program that dispatches the market to maximise the value of spot market trading, subject to inter-and intra-regional network limitations.[241] Each physical network limitation is represented to NEMDE as a mathematical equation, known as a constraint equation.

The purpose of the constraint equation is to ensure that the pattern of dispatch reflects the physical and security limitations of the network.[242] The Left Hand Side (LHS) of the equation contains all elements that affect flows on the constraint line (i.e., generating units, inter-connectors). The values of these variables can be determined by the dispatch algorithm. The Right Hand Side (RHS) contains all fixed elements, such as network limits and other constants.

The constraint equation binds when flow across the constraint is equal to or exceeds the transfer limit of the constraint and hours of binding gives an indication on the frequency of congestion occurring on the network limitation represented in the constraint.

The constraint equation binds when flow across the constraint is equal to or exceeds the transfer limit of the constraint. The hours of binding constraints gives an indication of the frequency of congestion occurring due to the network limitation represented in the constraint.

In an electric power grid, network limits can be broadly described as thermal or stability limits:

- *Thermal limits* are closely linked with the losses of power. Some of the power flowing across network lines is converted to heat, and consequently lost.[243] As power is sent through the line, the temperature increases causing the line to sag closer to the ground. The clearance above ground level must exceed certain minimum heights to ensure both public safety and power system security. Thermal limits depend on both real and reactive power; and

- *Stability limits* refer to the need to keep the transmission system operating within design tolerances for voltage, with ability to recover from disturbances, taking into account the interaction of control systems and other technical characteristics that are important to keep the power system intact. For example, Stability limits can result from the voltage difference between the generation and the load, and this difference is increased with the withdrawal of electric power. Unlike the thermal limit, the stability limits also depends on the length of the lines - the longer the lines, the lower the stability limits.

The current NEM network configuration of long distances between generation and load centres means that stability limits are most relevant in Australia, compared to a

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241 There are a number of other types of constraints, such as constraints to manage FCAS (FCAS constraint equations allow interconnector transfers to be limited to co-optimise the FCAS and energy markets), implement power system directions, to manage grid support, and manage negative residues accumulating.

242 NEMMCO uses a co-optimised constraint formulation which enables NEMMCO to optimise all LHS terms. Hence dispatch is optimised for a constraint within a region, regardless of whether that generation is in the same region, or in a different region.

243 The amount of power lost is proportional to the resistance of the line and to the square of the quantity of power transmitted.

more meshed network. For example, in South Australia and Queensland, stability limits contribute to most of the incidences of binding constraints.

When there are no binding constraints the NEM is dispatched in merit order, based on market participants' bids and offers, to meet demand. However, if merit order dispatch results in a network limit being exceeded, the constraint will be binding and the dispatch will be modified, by increasing or decreasing the dispatch of plant on either side of the constraint, to maintain security and balance supply and demand.

When a constraint equation binds, and therefore has an impact on dispatch, the marginal value of that equation becomes positive. The marginal value is a measure of the change, at the margin, in the cost of producing electricity to meet demand brought about by a particular constraint. It equals the difference in generation bids between the generator whose output has to increase and the generator whose output is decreased as a consequence of the constraint binding. For constraints that are inter-regional, the marginal value usually equals the difference between the Regional Reference Node (RRN) prices of the importing region and the exporting region. The CMV for a constraint is the sum of the constraint's marginal values arising when the constraint binds over the period.

Mis-pricing occurs when the shadow price at a particular node, which reflects local supply and demand conditions, differs from the regional reference price (RRP). The locational price for each connection point is calculated within NEMDE as the RRP less, for every binding constraint equation, the constraint marginal value times the coefficient for the connection point in that constraint equation.[244] Hence mis-pricing occurs when a generator's output is directly controlled by a binding constraint, and therefore dispatched at a price other than the RRN.

D.2.2 Data sources

The following three sources provide information the location and incidence of congestion in the NEM:

- AER, 'Indicators of the market impact of transmission congestion' reports for 2003/04, 2004/05 and 2005/06;
- NEMMCO, Statement of Opportunities – Annual National Transmission Statement (SOO-ANTS), October 2006; and
- NEMMCO, Impact of intra-regional constraints on Pricing study, March 2007 plus NEMMCO, Impact of intra-regional constraints on Pricing: Additional Results, September 2007.

Each of these data sources is discussed briefly in turn below.

[244] Biggar, D., How significant is the mis-pricing impact of intra-regional congestion in the NEM?, 25 October 2006 (available on the AEMC website).

D.2.2.1 AER reports

The AER[245] has published a series of historical indicators of the dispatch costs of congestion for the years 2003/04 to 2005/06. In additional to its Total Cost of Constraint (TCC) and Outage Cost of Constraint (OCC) indicators, AER also published detailed information on individual constraints that have significantly impacted market dispatch. The AER separates each constraint event into either system normal or outage conditions, and provides a brief explanation of the cause of the constraint binding.

For each network constraint that affects inter-regional flows, the AER published the cumulative marginal value and the total hours binding over the year. For network constraints that affect intra-regional flows, the AER only publishes total hours binding. It considers that marginal values for intra-regional flows will have little meaning because of strategic bidding behaviour by a generator when faced with the prospect of being either constrained on or off (i.e. bidding at either -$1000 or the value of lost load (VOLL)).

D.2.2.2 NEMMCO SOO-ANTS

In its Annual SOO-ANTS, NEMMCO publishes a series of indicators measuring flow path utilisation and historical congestion. One of these indicators is the number of hours of binding constraints within each region and the hours of inter-regional constraints (by inter-connector and direction). NEMMCO also divides hours of binding between system normal and outages events.

The number of hours binding reported by NEMMCO is based on the assumption that a binding constraint with multiple interconnectors on the LHS of the constraint equation contributes to the binding hours reported for each associated interconnector. Constraints containing both generator and interconnector terms on the LHS are counted against the interconnectors only.

D.2.2.3 NEMMCO: impact of intra-regional constraints on pricing

In response to a request from the Commission, NEMMCO undertook analysis of mis-pricing at generation connection nodes. This followed from analysis by Dr. Biggar into the extent of congestion within regions. Dr. Biggar sought to measure the materiality of congestion within regions by calculating the frequency, duration and magnitude of deviations between the theoretically "correct" locational price (or nodal shadow price) at each connection point and the RRP.[246] NEMMCO agreed to extend the analysis to cover a larger study period (from 2001/02 to 2005/06) and to perform some analysis to identify the causes behind any trends in mis-pricing. NEMMCO's report was published on the Commission website on 9 March 2007.

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245 Australian Energy Regulator, *Indicators of the market impact of transmission congestion*, Report for 2003/04, 9 June 2006; Report for 2004/05, 10 October 2006, and Report for 2005/06, February 2007.

246 Biggar, D., How significant is the mis-pricing impact of intra-regional congestion in the NEM?, 25 October, 2006 (available on the AEMC website).

NEMMCO calculated two measures of mis-pricing:

1. The hours of mis-pricing for each generation connection points; and
2. The average duration of mis-pricing for each region over the period 2001/02 to 2005/06.

NEMMCO removed any constraint not relevant to congestion from the study dataset, which included frequency control ancillary service (FCAS) and identified Network Support Agreement (NSA) constraints.[247]

Following publication of this analysis, the Commission requested NEMMCO to extend the analysis in order to develop a more comprehensive picture of intra-regional mis-pricing and its causes. NEMMCO's further analysis looked at three particular questions:

- Has a move to option 4 constraint formulation systematically affected the recorded incidence of mis-pricing?
- What is the distribution of positive and negative distribution of mis-pricing?
- What are the proportions of mis-pricing when comparing outage and system normal constraints?

NEMMCO's further analysis takes five particular areas of the network as case studies to examine the impacts and causes of binding constraints in areas where congestion is considered to be an issue:

1. Bayswater, in North NSW;
2. Hazelwood in the Latrobe Valley, Victoria;
3. Ladbroke Grove for South Australia;
4. Gladstone in Central Queensland; and
5. Townsville in Northern Queensland.

NEMMCO's additional analysis on mis-pricing is published in conjunction with this Draft Report.

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[247] In a submission to the Commission, Powerlink stated that constraints associated with the implementation of Network Support Agreements should be excluded from the analysis since network support is an efficient response to network congestion under the Regulatory Test. Powerlink noted that if the constraints associated with NSA within the Queensland Region are excluded, then the incidence of "mis-pricing" reduces from 300 hours to 160 hours for the 2005/06 year. Powerlink, Submission to AEMC, Congestion Management Review, 6 November 2006.

D.2.3 Limitations of the data

Before presenting the review of data it is important to understand its limitations. Examining the duration of constraints can provide a broad indication of the extent of transmission congestion. However, the Commission recognises that it provides little insight into the effect of congestion on the economic efficiency of dispatch. In some cases a binding constraint may have little impact on the cost of meeting demand, and in other cases it may have a very significant impact. This impact might be unrelated to the duration of the constraint binding. The cumulative marginal value can give some indication of the impact of a binding constraint on market outcomes, but figures are only published for inter-regional constraints.

Similarly, the presence of mis-pricing is not an indicator of whether mis-pricing is having a significant adverse impact on the overall level of economic welfare. In some cases, a particular number of hours of mis-pricing may have a negligible impact on total economic welfare, while in other cases, the same or fewer hours of mis-pricing can have much more severe implications

Moreover, the data does not include situations where congestion arises but is already being addressed by means which avoid transmission constraints binding through the dispatch process. Possible mechanisms include the use of NSAs to avoid constraints, such as those used in North Queensland, or operational measures by market participants to avoid a constraint binding and causing price separation. Generators that can affect whether a particular constraint binds may have the incentive and ability to adjust their generation in such a way to ensure that the constraint does not bind. For example, under the current regional structure generation at Tumut may have an incentive to withhold output to prevent the Tumut to NSW interconnector from binding, allowing it to access the relatively higher NSW price. In these circumstances, the actual incidence of congestion might understate the issue.

Furthermore, the Commission recognises that specific events can have significant influence on the data, which affects the ability to draw conclusions about the long term trends. For example, transmission outages can influence the number of hours a constraint binds. Similarly, the drought is currently affecting generation patterns across the NEM and is also likely to affect the incidence of binding constraints. In this context, Powerlink wrote to the Commission noting that the drought has lead to reduced water allocations to South Queensland generators which will lead to an increase in the incidence of binding constraints on the Queensland network, particularly the Tarong limit and Central Queensland to South Queensland limit.[248] Such events need to be noted when interpreting the data.

D.3 Review of historical congestion in the NEM

The data on constraints is categorised as either inter-regional or intra-regional constraints. Transmission line constraints that cause price separation between

[248] Powerlink letter to John Tamblyn, 13 March 2007. "Output restrictions by SQ generators and Transmission constraints". Available on AEMC website.

regions are labelled as being inter-regional constraints, while constraints that relate to network limitations only within regions are classified as intra-regional constraints.

Since mid 2005, following a direction from the Ministerial Council on Energy (MCE), NEMMCO has been changing the formulation of a number of constraints to "fully co-optimised constraints". This form of constraint blurs the distinction between inter-regional and intra-regional, as the constraints can simultaneously restrict the flow across numerous interconnectors and generation in several regions. A number of the constraints with significant market impacts are fully co-optimised and therefore difficult to assign to either one interconnector or one region. For the purposes of the AER Reports and NEMMCO SOO-ANTS, constraints of this type have been attributed to the interconnector most affected by the constraint.

NEMMCO's mis-pricing analysis relates to congestion occurring between the generators connection node and the RRP. Although this analysis has been labelled as intra-regional, mis-pricing at the generator connection node could reflect inter-regional congestion. There is therefore some inconsistency in terminology between the NEMMCO mis-pricing analysis and the AER and NEMMCO SOO-ANTS data.

The data also categorises constraints between system normal and outage constraints. This categorisation may also lack precision, as there are situations when a binding system normal constraint has been caused by an outage event elsewhere on the network.

D.3.1 Inter-regional congestion

The trends in congestion on flows between regions can be examined from data contained in the SOO-ANTS and the AER reports.

Table 5 in Appendix F from the 2006 SOO-ANTS shows the historical occurrence of hours of constrained intra-regional and inter-regional flows since the commencement of the NEM in 1998.[249] Hours of constrained flows reported in this table are assigned according to the defining limit rather than the direction of actual flow for each directional interconnector.[250] The directional interconnector is a conceptual term for the grouping of all network lines connecting the two regions. The historical data shows:

- An increase in the total hours of binding constraints since start of NEM. Hours of binding constraints rose steeply between 1998/99 to 2000/01 from 2,139 hours to

[249] Hours of constrained flow have been reported separately for the Directlink inter-connector (up to 21 March 2006), and the Terranora inter-connector (from March 21 2006). Basslink hours of constrained flow have only been reported for the period of its commercial operation (since 29 April 2006). Murraylink operated as a market network service provider (MNSP) until 9 October 2003, and since then as a regulated inter-connector.

[250] For example, if the Queensland-NSW interconnect is constrained by a NSW to Queensland transfer limit, and that limit is -100MW (i.e. the limit requires flow from Queensland into NSW to avoid violating the limit), this is counted as binding in the NSW to Queensland direction, even though the flow is into NSW at the time. In cases where the limits in both directions are equal (i.e. a particular flow is required to avoid violating one or other of the limits), hours of constrained flow are reported in both directions.

9,925 hours, followed by a sharp fall to 2,398 hours in 2001/02 which was caused by a reduction in outages hours binding on the Queensland-NSW interconnector (QNI) of 6,400 hours. Since then there has been a steady constant rise from 6,781 hours in 2002/03 to 7,958 hours in 2005/06 (or 7,716 hours excluding Tasmania);

- Constraints binding under both system normal and outages conditions have increased since 2001/02. Hours of binding for inter-regional system normal constraints rose significantly over 2001/02 to 2003/04 (from 1,351 to 4,965) and has been relatively constantly at around 4,750 hours since then. Hours of outage constraints binding have oscillated between 3,913 and 2,530 since 2002/03. Outage events have accounted for less than 40% of the total hours of binding constraints for the years 2003/04 to 2005/06;

- There is variation in trends amongst the hours binding for each directional inter-connector since NEM start, and also the split between outage and system normal constraints binding. Flows between Victoria and South Australia on the Heywood interconnector have consistently accounted for the highest number of hours binding, while flows between Snowy and NSW in both directions have the lowest incidence of binding. After the Heywood interconnector, Murraylink and Directlink have the next highest incidence of binding of inter-regional constraints; and

- Between 2003/04 and 2005/06, system normal constraints have consistently accounted for approximately 60% of binding duration on inter-regional flows. For 2005/06, Murraylink and Directlink are the only inter-connectors where outage events account for a higher proportion of hours binding.

We consider he incidence of binding constraints between each NEM region in turn below.

D.3.1.1 Queensland – NSW (QNI and Directlink)

Since QNI was commissioned on 18 February 2001 the transfer capability has increased progressively, through a series of oscillatory stability tests, from 300MW (from Queensland to NSW) to the current capability of 1,078MW (from 12 November 2003). Over the same time there was a significant increase in generation in Queensland, with the commissioning of around 1,300MW of new generation.

The incidence of Queensland export constraints grew significantly from 2001/02 to 2003/04. There was a slight decrease in congestion in 2004/05 but this was then followed by an increase in congestion in 2005/06.

Since completion of the QNI interconnector there has been a significant rise in the hours of system normal constraints binding, increasing from 3 hours in 2000/01 to 1,061 hours in 2005/06. The duration of constraints binding on southern flows due to outages fell from 3,252 hours in 2000/01 to 120 hours in 2003/04; however since then there has been a steady rise to 301 hours in 2005/06. Flows from NSW to Queensland on QNI rarely bind, for example only 40 hours in 2005/06.

The prevalence of binding on Directlink is similar to QNI, in that it binds more in the southward direction flows than northflows and that binding system normal constraints dominate. However, unlike QNI, there is a significant incidence of binding constraints on flows northwards from NSW to Queensland, especially in 2005/06 (767 hours[251]). Total hours of binding constraints on Directlink southwards flows have been constantly been above 1,200 each year between 2003/04 to 2005/06. During this period, the relative proportion between system normal binding and outage is shifting towards more outage events (from 25% to 40% of total binding constraints).

Flows from Queensland to NSW are increasingly being constrained in order to maintain oscillatory stability for the loss of QNI, or to prevent overloading on the 82 line between Liddell and Tomago in the event of the unplanned loss of the 81 line between Liddell and Newcastle. The system normal constraint used to maintain oscillatory stability for the loss of QNI[252] bound on 194 days during 2005/06 for a total of 484 hours. However, the CMV of this constraint was only $46,819 over the year (down from $312,176 in 2004/05), which suggests a relatively low market impact. The outage 81 line constraint bound for 54 hours in 2005/06 (an increase from 5 hours in the previous year), but had a higher market impact with a CMV of $370,045.

A number of network outage events that have a low number of hours of binding constraints between Queensland and NSW can have significant market impacts. For example, on 31 October 2005/06 two outages of the 77 line south of Sydney lasted for a total of 3 hours, but had a CMV of $190,633. Flows on the Snowy to NSW interconnector were also affected.

In summary, flows southwards on the QNI are increasingly become constrained due to system normal conditions. There is a significant level of binding on Directlink in both northwards and southward conditions, with the relative frequency of outage caused binding increasing.

D.3.1.2 NSW – Snowy

The limit for flows from Snowy to NSW varies between 3,500MW in winter and 2,800MW in summer and is dependent upon line ratings, Snowy generation profile and the magnitude of loads in southwest NSW. The limits for flows from NSW to Snowy are determined by thermal and transient stability limits. This limit is highly dependent on loads in southwest NSW. For example, the Snowy to NSW flows were constrained for short periods at levels of 500MW and 800MW, less than the 3,000MW nominal limit to avoid overloading lines in southern NSW.

[251] Includes hours following Terranora conversion.

[252] The limit is set at either 950MW or 1078MW depending on the status of the Millmerran units. With both units online, the higher limit of 1078MW applies.

The lowest incidence of binding inter-regional constraints in the NEM occurs between NSW and Snowy. However, whilst of short duration, significant price separation can occur when the interconnector is constrained.[253]

There has been an increase in the incidence of binding constraints in both directions under system normal conditions, which account for most of the majority of constraints. Hours of system normal binding in the Snowy to NSW direction has increased from 2 hours (2003/04) to 117 hours in 2005/06. In the opposite direction, from NSW to Snowy, the hours of binding constraints have increased for both system normal and outages events from none in 2002/03 to 73 in 2005/06. Analysis for the Abolition of Snowy Region Rule Determination[254] shows that there has been a large increase in the frequency of Murray-Tumut constraints binding in both system normal and outage conditions between 2003/04 and 2006/07, affecting flows in both directions.

Outage events within NSW can also influence the incidence of binding on the interconnector. For example, outages increased by 50 hours between 2004/05 and 2005/06 on Snowy-NSW interconnector. This was due to an incident on the 77 line south of Sydney.[255]

Flows between Snowy and NSW are also influenced by the incidence of binding between Victoria and Snowy.

D.3.1.3 Snowy-Victoria

The incidence of binding constraints at times of southward flows on the Snowy-Victoria interconnector increased from 62 hours in 2004/05 to 318 hours in 2005/06, due to an increase in the binding of both system normal and outage constraints. The increasing instances of binding for constraints associated with transfer from Snowy to Victoria in 2005/06 are due to higher power transfers into Victoria. It is likely that this increase is due, at least in part, to the impact of the drought on Victorian hydro generation.

In the two year period between 2001 and 2003 outage events dominated, accounting for over 80% of total hours of binding constraints. Since that time system normal events have accounted for over 60% of total hours of binding constraints. On flows south, there was a significant rise in system normal binding constraints between 2004/05 and 2005/06 from 41 to 207 hours.

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253 AER, Indicators of the market impact of transmission congestion, Report for 2005 -2006, February 2007, p.5.

254 Australian Energy Market Commission 2007, Abolition of the Snowy Region, Rule Determination, Appendix F Historical Congestion between Victoria, Snowy and NSW Regions, 30 August 2007.

255 On 31 October two outages of the 77 line south of Sydney (to repair damage to the 76 line) saw imports across the Snowy interconnector restricted to as little as 300MW over each outage. Imports from Queensland were also reduced. Extreme prices were experienced in NSW during these outages, largely as a result of the reduced import capability.

Analysis for the Abolition of Snowy Region Rule Determination[256] found that stability constraints are the most frequent limitations on flows along the Victoria to Snowy interconnector, and that 80% of the binding constraints that limit flows in both directions arise under system normal conditions.

Historically, there has been a significantly higher incidence of binding constraints on flows north from Victoria to Snowy than flows south into Victoria, except for 2005/06 when for the first time the Snowy to Victoria interconnector was constrained more often. Hours binding for the Victoria to Snowy directional interconnector rose steadily from 207 hours in 1998/99, peaking at 1,201 in 2003/04. Since then there has been a significant fall to 312 hours. Most of the decrease in hours binding can be accounted for by a lower incidence of system normal constraints binding.

Discretionary constraints have been applied over 2003/04 to 2005/06 and have a high market impact. In 2005/06 the most significant market impacts occurred on three days: 9 November, 7 December and 2 February. Prices in NSW on all three days exceeded $5000/MWh, whilst the Victoria to Snowy interconnector was limited to as low as zero by constraints invoked by NEMMCO to manage counter price flows. Prices in Victoria and South Australia at the time were often as low as $30/MWh.

A number of measures have been implemented recently to address counter price flows around the Snowy region including: the Constraint Support Contracts and Constraint Support Pricing (CSC/CSP) trial that commenced in October 2005; an increase in the threshold for intervention by NEMMCO to better manage the accumulation of negative residues from July 2006; and the Southern Generator's Rule, which came into effect in September 2006, which alters the distribution of settlement residues between the two Snowy interconnectors. In August 2007 the Commission released its decision to abolish the Snowy region.[257] Of these measures only the CSC/CSP trial was in place in time to affect the indicators in this data.

D.3.1.4 South Australia - Victoria

The most frequently binding inter-regional constraint in the NEM is the Heywood interconnector between Victoria to South Australia. System normal constraints bind for over 1,400 hours in the previous two years (around 16% of the time each year).[258] However, the average CMV is relatively low on binding constraints on Heywood.[259]

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256 Australian Energy Market Commission 2007, Abolition of the Snowy Region, Rule Determination, Appendix F Historical Congestion between Victoria, Snowy and NSW Regions, 30 August 2007.

257 Australian Energy Market Commission 2007, Abolition of the Snowy Region, Rule Determination, Appendix F Historical Congestion between Victoria, Snowy and NSW Regions, 30 August 2007.

258 In 2005/06 the nominal Heywood limit of 460MW bound for 1,008 hours. In addition, a fully optimised constraint, which came into effect on 29 December, bound for 391 hours at slightly lower import levels. Together these constraints limited imports across the Heywood interconnector for 1,400 hours or 16 per cent of the time.

259 [AER, Indicators of the market impact of transmission congestion, Report for 2005 -2006, February 2007, p.5.

On the Heywood interconnector, the incidence of system normal binding constraints is increasing while the duration of outages caused by congestion is decreasing. In 2005/06 there was a large decrease in hours of outage constraints binding from 1,426 hours to 377 hours.

Several major outage events resulting in constraints on the Heywood interconnector occurred during the period 14 March to 1 June 2005. On 14 March, Northern Power Station units 1 and 2 simultaneously tripped, resulting in an overload on the Heywood interconnector, which subsequently tripped. This simultaneous loss was re-classified as a credible contingency event by NEMMCO which resulted in a lower import capability into South Australia, binding for 918 hours. The re-classification was removed on 1 June.

The increase in wind farm output has led to a reduction in the Victoria to South Australia transient stability limit. The revised co-optimsed formulations and increased output from wind farms have resulted in the system normal transient equation producing a much lower transfer limit on the interconnector than had previously been the case.

Murraylink also binds significantly in the Victoria to South Australia direction. Since its commissioning in 2002/03 it has consistently bound for over 1,100 hours each year. System normal binding constraints have fallen over the previous three years, while outage binding has increased over the same period (from 365 to 814 hours). Both planned and unplanned outages have significant impacts on the availability of Murraylink.

Flows from South Australia to Victoria rarely bind on the Heywood interconnector but can bind significantly on the Murraylink interconnector, with total hours of 446 in 2005/06; an increase from 318 hours in 2004/05. This increase was driven primarily by outages (91% of total hours in 2005/06).

In late 2002 and early 2003, tests were undertaken to assess the oscillatory stability performance of the power system, following augmentation of the Victoria to Snowy interconnector and the commissioning and operation of the Murraylink interconnector. Throughout the period of the tests, the capability of the Victoria to Snowy interconnector, and the combined capability of the Heywood and Murraylink interconnectors, were progressively increased. On 7 March 2003, the oscillatory stability limits of the Victoria to Snowy, Heywood and Murraylink interconnectors were increased to the present levels. However, this increase did not result in a fall in hours binding on either the Murraylink or Heywood interconnectors.

The capability from Victoria to South Australia was increased in January 2006 with service of a very fast runback scheme, and installation of 270 MVA of capacitor banks throughout Victoria. These works remove several constraints due to voltage stability and thermal network limits. TransGrid have installed a System Protection Scheme to manage the outage of the Wagga-Darlington pt 330KV line, removing this contingency as a constraint on Murraylink. These developments should help to reduce binding between Victoria and South Australia.

D.3.1.5 Tasmania to Victoria

Basslink commenced transferring power in November 2005 and entered into commercial operation in April 2006. Accordingly, a relatively low level of binding occurred in the 2005/06 financial year on Basslink. The number of hours of binding constraints on flows south from Victoria to Tasmania was 205, which is significantly more than the 37 hours of binding constraints on flows from Tasmania to Victoria. Most of the binding constraints in both directions happened under system normal conditions.

D.3.1.6 High impact inter-regional constraints

Table D.1 contains the summary data on those inter-regional network constraints that the AER has classified as having a high market impact (i.e. with CMV of more than $30,000/MWh in a year) over the last three financial years.[260] The data in Table D.1 shows that the measured effects of high impact inter-regional constraints have increased seven-fold over the previous three years from a CMV of around $1 million in 2003/04 to $7.6 million in 2005/06.

The significant increase in high impact CMV between 2004/05 to 2005/06 from $2.7m to $7.6m was mainly driven by two outage events that affected flows on Murraylink. The two outages were the loss of the Robertson transformer in South Australia and the outage of the Wagga to Yanco line in NSW, which jointly accounted for $3.7million of the total $7.6 million CMV.

Table D.1 High Impact Inter-regional Constraints from 2003/04 to 2005/06

	2003/04		2004/05		2005/06	
Number of high impact constraints	5 (0 outages)		15 (7 outages)		32 (10 outages)	
Total hours binding	1,802		1,963		3,195	
CMV	$1,035,473		$2,768,162		$7,568,731	
	System normal	**Outages**	**System normal**	**Outages**	**System normal**	**Outages**
Hours binding	1,802	0	1,332	631	2,551	644
% of total hours binding %	100%	0%	67.86%	32.14%	79.84%	20.16%
CMV ($ million)	$1.035m	$0m	$2.157m	$0.611m	$3.002m	$4.567m
% of total CMV	100.0%	0.0%	77.9%	22.1%	39.7%	60.3%

Data source: AER, Impact of the Market impact of transmission congestion Reports

260 In terms of total hours binding, these high impact constraints represent approximately 30% of all inter-regional constraints each year.

D.3.1.7 Consistent high impact inter-regional constraints

The AER reports covering the three years between 2003/04 to 2005/06 enable the identification of those network constraints which have consistently bound for a significant duration over this period.

Table D.2 details those inter-regional constraints that have consistently affected market outcomes over the three years 2003/04 to 2005/06. Of the six constraints identified, four are system normal, one is a discretionary constraint used to manage negative residues on the Victoria-Snowy interconnector, and the remaining one is an outage constraint.

It is possible to make a number of observations based on a review of the data presented in the table:

- The low number of consistent high impact constraints compared to the total number of high impact constraints reported by the AER in 2005/06 compared to previous years (15 in 2004/05 and 32 in 2005/06) demonstrates that many constraints have a relatively short life-cycle and the location and nature of constraints that have a high market impact can vary across years. There are also significant variations in the market impact, as measured by the CMV, of the constraints reported over the last three years. For example, the system normal limit on the Heywood interconnector for flows from Victoria to South Australia continues to bind for around 1,000 hours each year, although its CMV has fallen from $423,129 to $221,371. [261]

- The system normal limit on Victorian exports caused by the South Morang limit in the Latrobe Valley continues to binds for around 100 hours each year, but its market impact has diminished significantly over the period 2003/04 to 2005/06 from $439,527 to $6,139.

- The incidence of binding of the system normal limit on QNI managing oscillatory stability has trebled over the three years presented. However, the market impact of this constraint binding has varied greatly each year, with the smallest CMV reported for 2005/06 which has the highest incidence of binding constraints.

- The two consistent high impact constraints related to inter-regional flows through the Snowy region are both binding for more hours with raising CMV. In

[261] Previously the constraints managing the flow across the Hazelwood transformers (V>V1NIL & V>V2NIL) accounted for most of the hours binding within the Victoria region, which caused significant congestion on the dispatch of the 2,600MW generation located in the Latrobe Valley to Melbourne. However, there was a dramatic decrease in 2005/06 in the number of hours binding for these constraints; the total hours decreased from 163 hours in 2003/04 and 100 hours in 2004/05 to 14 hours in 2005/06. This was driven by a change in generation ownership which improved the coordination of the operation of the affected generation. A further constraint (V>V4NIL) was binding for 91 hours in 2005/06 but did not bind in any of the years before then. This was caused by the reconfiguration of the Hazelwood power station buses connecting to the transformer following the commissioning of the fourth 500KV line between Latrobe and Melbourne in August 2005. VENCorp is planning to complete work at the Hazelwood power station by December 2008 which should result in an improved bus arrangement and alleviate this issue.

terms of CMV per hour of binding, these two constraints have by far the highest market impact of these reported consistent high impact constraints.

- The CMV of the set of system normal constraints relating to the contingencies of managing an outage on line 64 (connecting Lower and Upper Tumut) has increased by over forty times from the 2003/04 amount. This constraint set has been classified as system normal because NEMMCO assumes under normal conditions that the 64 line between Upper and Lower Tumut is out of service.

- The Murraylink outage constraint manages the outage of a control scheme in NSW. This control scheme allows greater flows from Victoria into South Australia across Murraylink. In both 2004/05 and 2005/06, this constraint set was invoked to manage a number of outages in south western NSW, in particular elements of the 132 kV and 330 kV network around Wagga. When binding, the transfer limit on Murraylink can vary widely, decreasing to zero.

The South Morang constraint and the X5 tripping outage constraint in NSW are examples of how constraints within regions can affect the flows on interconnectors between regions.

Table D.2 Consistent high impact inter-regional constraints

		2003/04	2004/05	2005/06	*constraint name*
System normal - Heywood 460MW limit on Victoria to South Australia – thermal limit on the 275 KV lines from Heywood to South East substation	hrs (% of year)	1321 (15.08)	975 (11.13)	1399 (15.97)	*VS_460; S>VML_NIL1*
	CMV	$423,129	$468,818	$261,950	
	CMV / hr	$320.31	$480.84	$187.24	
System normal - Victoria exports - manage thermal limit on Hazelwood transformers (South Morang)	hrs (% of year)	162 (1.85)	93 (1.06)	131 (1.50)	*VH>V3,4 NIL*
	CMV	$439,527	$38,919	$6,139	
	CMV / hr	$2,713.13	$418.48	$46.86	
System normal – Queensland to NSW on QNI - avoid oscillatory instability affects flows from between North NSW and SW QLD	hrs (% of year)	113 (1.29)	170 (1.94)	484 (5.53)	*Q:N_NIL_OSC &A*
	CMV	$64,853	$312,176	$46,819	
	CMV / hr	$573.92	$1,836.33	$96.73	
System Normal - Snowy Exports -64 line outages, 65,66 line contingencies	hrs (% of year)	1.7 (0.02)	35 (0.40)	87 (0.99)	*H>>H-64*
	CMV	$11,511	$247,482	$476,524	
	CMV / hr	$6,771.18	$7,070.91	$5,477.29	
Discretionary -Victoria to Snowy to manage negative residues	hrs (% of year)	21.3 (0.24)	49 (0.56)	27 (0.31)	*VH_XXX*
	CMV	$78,425	$583,868	$385,440	
	CMV / hr	$3,681.92	$11,915.67	$14,275.56	
Outage - Murraylink (into SA) caused by outage of the X5 tripping scheme in NSW	hrs (% of year)	-	61 (0.70)	154 (1.76)	*V^SML_X5TR*
	CMV	-	$213,573	$132,832	
	CMV / hr	-	$3,501.20	$862.55	

Data source: AER, Impact of the Market impact of transmission congestion Reports.

D.3.2 Intra- regional congestion

The trends and incidence of congestion within the NEM regions is informed by the mis-pricing analysis provided by NEMMCO, the hours binding data contained in the SOO-ANTS and the assessment contained in the AER reports.

D.3.2.1 NEM wide

According to data contained in Table 5 in Appendix F of NEMMCO, 2006 SOO-ANTS, the NEM initially suffered significant intra-regional binding with 7,485 hours in 1998/99 and 12,763 hours in 1999/00. This was mostly caused by significant outage events in Queensland. The total hours of binding intra-regional constraints across the NEM then fell from 1,960 in 2000/01 to 392 in 2002/03, and rose steadily to 2,082 in 2004/05. In 2005/06 the total hours fell slightly to 1,830.

In terms of hours binding, the proportion of binding caused by outage events has risen steadily from 50% in 2002/03 to 75% in 2005/06.

The NEMMCO mis-pricing analysis shows a similar trend. The average annual duration of mis-pricing at each of those connection points mis-priced showed a big fall from about 160 hours in 2001/02 to 40 hours in 2002/03. This was followed by a gradual increase to just over 60 hours in 2004/05 to about 110 hours in 2005/06.

Over the period from 2001/02 to 2005/06, the number of connection points being mis-priced was fairly steady. Across all regions, the NEM-wide number of mis-priced connection points remained within a band of 120-140, compared to a total 278[262] generation connection points in the NEM. This means that just under half of all generation connections points experienced some mis-pricing each year.

Both sets of data show that there is significant variation in the incidence and trends of congestion across the NEM regions. The trend and incidence of congestion within each region is discussed below.

Queensland

The majority of Queensland's generating capacity is located in Central and South West Queensland. The main power transfers are from Central Queensland to the north and south and from South West Queensland to the major load centres in South East Queensland. Since January 2002, the Central - North limit has predominately been managed via a NSA between Powerlink and generators in Northern Queensland.

Total hours of binding intra-regional constraints in Queensland initially fell from 1,774 hours in 2001/02 to 141 hours 2002/03. The hours of binding intra-regional constraints has steadily increased from 2002/03, peaking at 1,133 in 2004/05. Since

262 According to NEMMCO's document, "List of Regional Boundaries and Marginal Loss Factors for the 2007/08 Financial Year", there are 278 generator connection points. This includes ancillary services, and generation load connection points plus embedded generators; after excluding these categories there are 212 generation connection points.

2002/03 there has been a significant rise in the incidence of binding constraints relating to outages, with outage events now accounting for the majority of hours binding.

The average hours of mis-pricing followed a similar trend, with the lowest number of hours over the period recorded in 2003/04, followed by a moderate increase since that time. The number of generation connections being mis-priced is constant at around 40 to 50 each year. With 73 generation connection points in Queensland in total, this means that the majority of generation connection points experience some mis-pricing over each year.

The increase in congestion over the period considered is predominately due to increased constraints on flows from Central to South Queensland during both system normal and network outage conditions. The increase in outage constraints binding between 2004/05 and 2005/06 was predominantly accounted for by both the constraint to limit flows in the presence of storm activity or lightning in Central Queensland[263], and the constraint used to manage the outage of the Gladstone Bus Tie Transformer.[264]

There were several major augmentation projects in North Queensland over the period of investigation which enabled limits between Central and North Queensland to be increased. The limit for flows from Central to North Queensland was increased from 780MW to 800MW in late 2001. In February 2003, the limit for flows from Central to North Queensland was changed from an 800MW static limit to a dynamic limit ranging from 925MW to 985MW, and the instances of binding for flows from Central to North Queensland consequently reduced. However in 2006, Powerlink decreased the limit back to 810MW following the Townsville gas turbines becoming base load units, and the list of critical contingencies being reviewed.

In 2006, the transfer limit in Far North Queensland increased from 192 to 286MW as a result of the installation of the Woree static var compensator. However, the effects of Cyclone Larry also caused Powerlink to reconfigure the network to overcome long term damage, resulting in a decrease in the transfer limit to 268 MW for 2007.

Electricity usage in Queensland has grown strongly recent years. Over the past 5 years, state-wide growth in summer maximum demand was 31%, including a record growth of 42% in South East Queensland. In response to the growth in electricity demand, Powerlink has implemented many projects and over the course of the last

263 This system normal constraint limits flows from Central to South Queensland to a maximum of 1,200MW in the presence of storm activity or lightning in Central Queensland. This condition leads to the reclassification of the loss of the double circuit between Tarong and Calvale as a credible event. The constraint directly affects around 5,700MW of generation in Central and North Queensland or around 60 per cent of the total registered capacity for the region. The constraint bound for a total of 24 hours over 14 days during 2005/2006 . On 30 November 2005 the constraint bound for 5 hours. The AER TCC measure reached $2.2 million on this day.

264This constraint limits flows from Central to South Queensland to a maximum of 1,700MW. It is used in conjunction with Q_GLD34_500 to manage the outage of the Gladstone Bus Tie Transformer. The constraint directly affects around 5,700MW of generation in Central and North Queensland or around 60 per cent of the total registered capacity for the region. The constraint bound for a total of 63 hours over 15 days during 2005/2006.

decade has built 25 new substations and more than 2,600km of new transmission lines.

The rapid growth in demand, development of transmission and commissioning of new generation mean that the pattern of intra-regional constraints is rapidly changing. For example, the Tarong constraint contributed to 16.8% of the total hours of binding constraints in 2001/02, but has not bound since. This can be attributed to the many augmentations (such as capacitor banks, line - rearrangements and new lines) in South East Queensland.

Powerlink's investment, plus the NSA which is operating in Northern Queensland, have dampened the increasing trend in congestion over the period.

NSW

The NSW high voltage transmission network was designed to transfer power from the coal-fired power stations in the Hunter Valley, Central Coast and Lithgow areas to the major load centres. The network was also designed to transmit the NSW/ACT share of Snowy generation towards Canberra and Sydney. The development of the NEM and interconnection with Queensland has increasingly imposed a wider range of loading conditions on the network than was originally planned.

NSW imports a significant share of its generation from the surrounding regions. Hence, as shown in Appendix F of the SOO-ANTS, NSW has a relative low incidence of intra-regional hours binding compared to the other regions. Most of the congestion on the NSW network affects flows being imported into the region. Appendix F of the SOO-ANTS also demonstrates that most of the intra-regional hours binding are attributable to outage conditions. The total hours of binding intra-regional constraints have varied between 180 and 40 during the period 2000/01 to 2005/06.

The mis-pricing analysis for NSW shows a similar trend to that of Queensland. The level of mis-pricing reached the lowest level over the period considered in 2003/04, at around 50 hours on average for each mis-priced generation point and then steadily increased over the following years to over 170 hours in 2005/06. The number of generation points affected by mis-pricing is relatively constant, ranging between 22 to 25 points over the sample period. This means that around half of the 52 generation points in NSW Experience mis-pricing each year. There are 20 of these generation points that have consistently experienced more than 50 hours of mis-pricing between 2001/02 to 2005/06.

Between 2003/04 and 2005/06 constraints managing flow on the 82 line (and to a lesser extent the 81 line) dominated. The majority of binding dispatch intervals occurred during planned network outages on the 81 line between Liddell and Newcastle. This constraint is discussed further in Section D.3.2.2 of this Appendix.

Outages elsewhere on the network contributed to the incidence of binding intra-regional constraints in NSW over the period considered. In 2003/04, planned outages of the 22 line between Vales Point and Sydney North occurred on nine days of the year. In 2004/05, the Regentville to Sydney West line was taken out of service on five days. In 2005/06, the constraint managing the unplanned outages of the 76 line between Wallerawang and Sydney South and the emergency outage of the 77 line between Wallerawang and Ingleburn (probably due to a lightning strike) bound for only three hours, but had a significant market impact.

Also in 2004/05, the system normal constraint which manages flows along the Western Sydney transmission ring had significant impact, affecting dispatch for 41 hours during the year. The constraint causes generation at Mount Piper to be constrained off and constrains on generation at Wallerawang. There was little incidence of this constraint binding in either 2003/04 or 2005/06.

The incidence of intra-regional congestion in NSW is increasing, and is primarily driven by outage events. Outage of the 81 line between Liddell and Newcastle has consistently occurred during the past three years. Appendix B4 of the NEMMCO additional results report details the annual hours binding of each outage constraint in NSW.

Snowy

The Snowy region provides a crucial transmission link in the middle of the NEM. Snowy Hydro is the major provider of peaking generation during periods of high Victoria and NSW demand. The transmission grid within the Snowy region and between NSW and Victoria was designed to deliver energy from the Snowy Mountains to major load centres and to connect the state-based power systems in NSW and Victoria. A key feature of the Snowy Region is that it only contains generation and very little demand. Hence, virtually all the electricity generated by the Snowy generators is exported to other NEM regions. The critical transmission elements between Murray and Tumut are the 65 and 66 lines. Thermal limits on these lines mean that loading of one line has to be protected against the potential loss of the other. These thermal limits largely determine the typical 1,350MW transfer limit across the Murray–Tumut cut-set of lines. There are multiple lines from the Snowy region into NSW and Victoria, with a substantially higher transfer capacity from Snowy to NSW (commonly 3,100MW) than from Snowy to Victoria (in extreme circumstances up 1,900MW).

Mis-pricing has been increasing in the Snowy Region since 2003/04 from an average of 30 hours to over 135 hours in 2005/06. Most of this increase has been due to increased outage events, which dominate the amount of mis-pricing at Snowy generation points. The Upper and Lower Tumut connection points constantly experience mis-pricing each year, while the incidence of mis-pricing at Murray and Guthega varies between years. Although there is an increase in mis-pricing in the 2005/06 period the market settlement impact was mitigated by the CSP/CSC financial arrangements.

Victoria

The Victorian transmission system operates at voltages of 500kV, 330kV, 275kV and 220kV. The 500kV network primarily transports bulk electricity from generators in the Latrobe Valley to the major load centre of Melbourne, and then on to the major smelter load at Portland and the Heywood interconnection with South Australia. A strongly meshed 220kV transmission network supplies the metropolitan area and the major regional cities of Victoria. The 330kV network interconnects with the Snowy region and NSW. The 275kV transmission line from Heywood interconnects with South Australia. The key intra–regional constraint is between the Latrobe Valley and Melbourne.

Hours of binding intra-regional constraints in Victoria has been relatively consistent and low over the period considered, peaking at 255 hours in 2004/05. In 2005/06 there were 111 hours of binding intra-regional constraints in total, of which 106 were at times of system normal operation.

The mis-pricing data also shows a relatively low incidence of congestion within Victoria. The trend in mis-pricing in Victoria is quite different to Queensland and NSW, with the average hours of mis-pricing peaking at around 75 hours in 2003/04 and then falling to 20 hours in 2005/06. Of the 64 generation points in Victoria, 45 experience mis-pricing in 2003/04, with 18 generation points experiencing over 160 hours of mis-pricing. In 2005/06, the number of generators experiencing mis-pricing had decreased to 30 and no generator suffered more than 20 hours of being mis-priced in that year. The predominant constraints resulting in mis-pricing were those that manage flow across the Hazelwood Terminal Station 500/220 kV transformers. These constraints are discussed in more detail in Section D.3.2.2 below.

South Australia

South Australia's transmission network can be viewed as four main power transfer corridors: the north distributor, the port distributor, the central distributor and the south distributor. The north distributor provides power transfers between the Adelaide metropolitan area and the northern parts of the State, in particular the power stations at Port Augusta. The port distributor provides power transfers between the power stations located in the Port Adelaide area and Adelaide's northern metropolitan area. The central distributor provides power transfers between the northern and southern regions of metropolitan Adelaide. The south distributor provides power transfers between the Adelaide metropolitan area and the lower south eastern areas of the State.

The considerable generation capacity at the main load centre in Adelaide, combined with the robust transmission network, means that there is little system normal intra-regional congestion in South Australia.

Network outages account for most of the hours binding of intra-regional congestion in South Australia. In the SOO-ANTS data, outages accounted for all the hours of intra-regional constraints binding between 2001/02 to 2004/05 and 80% of binding intra-regional constraints in 2005/06.

The NEMMCO analysis showed a very low level for the average duration of mis-priced connection points between 2001/02 to 2003/04, which increased significantly to over 100 hours in 2005/06. The low number of mis-pricing incidents in the initial years is because many of the South Australian constraints were formulated as interconnector only or option 8 constraints. The change in constraint formulation from interconnector only constraints to fully co-optimised constraints has lead to an increase in the reporting of binding constraints. This issue is discussed further in Section D.6.1.

During the period 2001/02 to 2005/06, the number of South Australian generation connection points experiencing mispricing, fluctuated between 6 and 16. Compared to the other regions, this represents a relatively low share of the region's total of 41 generation connections points.

NEMMCO reported an increase in mis-pricing in 2004/05, primarily to a significant increase in NSA/Direction constraints binding on the Snuggery and Port Lincoln units to manage line loading. The number of instances of Snuggery generation being constrained on dropped considerably in 2005/06, due to the adoption of a higher 15-minute rating on the Keith – Snuggery line in December 2004, and reduction in line flows due to increasing generation from the Lake Bonney and Canunda wind farms. Constraining on Port Lincoln through NSA/Direction also reduced in 2005/06, probably due to output from the Cathedral Rocks wind farm, which commenced generation in June 2005.

In 2005/06 intra-regional constraints bound for around 115 hours, and 14 generators experienced a degree of mis-pricing. The recent addition of significant remote wind generation is contributing to congestion on the Heywood interconnector, and this is affecting the level of mis-pricing at generators in South East South Australia.[265] A significant planned outage of the LeFerve to Pelican Point line added to the level of mis-pricing in 2005/06, with this constraint binding for a total of around 134 hours over 16 days.

<u>Tasmania</u>

The Tasmanian transmission system, consists of a 220kV bulk transmission network with some parallel 110kV transmission circuits. It provides power transfer corridors from several major generation centres to load centres, and power transfers between major load centres.

The most common constraints experienced in Tasmania are thermal constraints. To alleviate this problem, Transend have installed weather stations around the grid which enables it to use dynamic ratings.[266] To a lesser extent, lines also have voltage constraints, which occur mostly in the south of the region. In the north, there are

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[265] There are currently 6 wind-farms in South Australia with a further 3 being built. The increase in wind farm output has lead to a reduction in the Victoria to South Australia transient stability limit.

[266] These stations provide real time measurements every minute. Using real time measurements, particularly temperature and wind (as they found hot days often correlated with windy days), has improved the line ratings. This data is sent to NEMMCO to give dynamic real time ratings. In the case of a weather station failure, NEMMCO uses a backup ratings table with 5 degree Celsius increments. Transend also monitors the tension in the lines, particularly in the south, to assess whether the lines have iced. If this is the case, a small current is transmitted to melt the ice.

limits on the transmission from the Woolnorth windfarm. There are also dynamic stability limits between Farrell and Sheffield during credible events. There is currently a NSA with the Gordon generator to increase generation to meet demand in the south.

The commissioning of Basslink has also introduced significant changes to the transmission system loading patterns. Transend lines are operated at N security, rather than N-1. They use an Automated System Protection Scheme to shed load when necessary which enables the network to facilitate Basslink exports up to its 600MW limit. Data on intra-regional congestion only exists from when Tasmania joined the NEM in May 2005. The total hours binding was 505 in 2005/06, the second highest incidence of intra-regional congestion (after Queensland). Most of these hours were due to planned network outages.

D.3.2.2 Consistent high impact intra-regional constraints

The AER labelled high impact intra-regional constraints as those constraints which bind for more than 10 hours in the year. The number of high impact intra-regional constraints has increased from 7 in 2003/04 to 9 in 2005/06. For each of the three years the number of high impact constraints caused by outages has been 4.

The majority of these constraints are only labelled high impact for one year and there is a lot of variation in the location and nature of high impact intra-regional constraints within the three year sample. Only 4 intra-regional constraints are consistently presented as being high impact for each of the three years. Out of the four identified, three are system normal, and the remaining one is an outage constraint. Table D.3 details the intra-regional constraints that consistently affect market outcomes over the three years. A description of each of these constraints is provided below.

Table D.3: Consistent high impact intra-regional constraints (Number of hours binding annually)

	2003/04 (Hours)	2004/05 (Hours)	2005/06 (Hours)	Effect
System Normal - Victoria: Latrobe Valley - avoid overload of Hazelwood transformer	163	101	105	Limits generation to 2,080MW behind transformer
System Normal - Queensland: Line 871 in central QLD; Constrains Gladstone, Stadwell on and Callide B & C off	20	190	30	Significant mis-pricing of generation units in central QLD
Outage - NSW (Newcastle-Liddell) manage overloads on line 82 when line 81 is out	29	94	13	Affects up to 1,1000MW of NSW generation
System normal - Queensland: limits flows from Central to South QLD	9	44	83	Limits 5,700MW generation

Data source: AER, Impact of the Market impact of transmission congestion Reports

Hazelwood Transformers, Latrobe Valley, Victoria.

Previously the constraints managing the flow across the Hazelwood transformers (V>V1NIL & V>V2NIL) accounted for most of the hours of binding constraints within the Victoria region. These constraints caused significant congestion on the dispatch of the 2,600MW generation located in the Latrobe Valley. However, there was a dramatic decrease in 2005/06 in the number of hours binding for these constraints, with the total hours decreasing from 163 hours in 2003/04 and 100 hours in 2004/05 to 14 hours in 2005/06. This was primarily driven by a change in generation ownership, which improved the coordination of affected generation.

A further constraint (V>V4NIL) bound for 91 hours in 2005/06 but did not bind in any of the years before then. This equation limits output from the Hazelwood No: 3, 4, and 5 generation units to ensure pre-contingent flows on the Hazelwood transformer do not exceed its continuous rating. Binding of this constraint was caused by the reconfiguration of the Hazelwood power station buses connecting to the transformer following the commissioning of the fourth 500KV line between Latrobe and Melbourne in August 2005. VENCorp is planning to complete work at the Hazelwood power stations by December 2008, which should result in an improved bus arrangement and alleviate this congestion issue.

Central Queensland – Line 871

Line 871 is a feeder line running between Calvale and Wurdong in central Queensland. Constraints to manage thermal flows along the 871 line for the unexpected loss of the 855 line between Calvale and Stanwell have bound consistently over the three year period to 2005/06, with a peak of 190 hours of 2004/05. The two constraints equations that manage these flows constrain on local generation at Gladstone and Stanwell and constrain off generation at Callide B and C.

The Commission understands that in 2003 Powerlink did a market benefit assessment of a reconfiguration of the transmission lines in the Gladstone Area to relieve this constraint. The constraint does not present a reliability of supply concern for Powerlink. The benefits of the proposal would be to reduce the incidences when Callide generation is constrained off. However, since reductions in Callide generation are replaced by an increase in Gladstone generation, and both these power stations are coal fired with broadly similar fuel costs,[267] Powerlink found that the market benefits were minimal and hence insufficient to satisfy the Regulatory Test.

<u>NSW – Liddell to Newcastle 81 line</u>

Outages of the 81 line between Liddell and Newcastle are managed by a number of constraints. These constraints manage overloads of the 82 line between Liddell and Tomago when there is an outage on the 81 line. These constraints impact on a significant proportion of NSW generation, ranging from around 4,500 MW[268] and to as much as 11,520 MW (or more than 95% of the total registered generation in NSW). As a result, when these constraints bind, significant generation is dispatched out of merit.

There has been a relatively high level of outages on this line over the three year period to 2005/06, with the level peaking at 94 hours in 2004/05. Planned outages on the 81 line occured on 55 days during 2005/06, which compares to 42 days for the previous year and 20 days in 2003/04. Planned outages in NSW between Newcastle and Liddell can have significant market impact on days of high demand.

The main driver for the increase in outages was the increasing flow on QNI towards NSW, and increasing output from Bayswater and Liddell power stations, which resulted in higher flows on these lines. Load growth in the Newcastle area has also contributed to higher flows on the 81 and 82 lines.

The rating of the 82 line was increased by 170MVA in December 2006. However, the commissioning of Kogan Creek power station in early to mid 2007 is likely to increase power flows south from Queensland. It is therefore expected that the binding of constraints required to manage flows on the 81 and 82 lines will continue in the short term. TransGrid is planning to develop a 500kV transmission line between Bayswater and Mt Piper in 2008/09 which should transfer power away from these lines and consequently reduce the incidence of constraints binding in the longer term.

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[267] In the most recent update on generator costs prepared by ACIL - Tasman for the NEMMCO ANTS studies the SRMC of Gladstone is estimated as $14.58/MWh (07/08) compared to $12.73/MWh for Callide B, a difference of around $2/MWh.

[268] For constraints N>N_8107 and N>N + LDNC_07.

Queensland – Central to South transfers

This system normal constraint limits flows from central Queensland to south Queensland to a maximum of 1,900 MW to avoid transient instability. The constraint affects around 5,700 MW of generation in central and north Queensland (around 60% of the total registered capacity for the region).

The incidence of this constraint binding has increased over the three years to 2005/06 from 9 hours to 83 hours. Powerlink commissioned two capacitor banks in November 2005 to address this limit.

Binding of this constraint can have significant market impact. On 1 and 2 February 2006, the constraint bound for 12 hours each day and the AER calculated a TCC of $12.7million for the 2 February event.

In 2005/06, flows between Central and South Queensland were affected by weather events and outages. On 13 October, 30 November and 1 December the flow limit was reduced from 1,900MW to 1,200MW due to presence of storm activity or lightning in central Queensland. The constraint used to manage transfers in the presence of storm activity bound for a total of 24 hours during that year. Outages in central Queensland can lead to the flow limit decreasing to 1,700MW. This constraint bound for a total of 63 hours over 15 days in the year. Neither of these constraints bound in the previous year.

D.4 NEMMCO mis-pricing analysis

This section of the Appendix discusses the additional analysis done by NEMMCO into the nature and extent of mis-pricing across the NEM.

D.4.1 Distribution of positive and negative mis-pricing

The NEMMCO analysis of mis-pricing is categorised according to the impact on pricing:

- **Positive mis-pricing**: When a generation connection point is paid more than its marginal offer price, and hence typically will be required to be constrained off when a constraint binds.

- **Negative mis-pricing**: When a generation connection point is paid less than its marginal offer price, and hence is likely to be constrained on.[269]

As noted in the Draft Report, the Commission is particularly concerned with negative mis-pricing because it indicates a situation where a generator must be dispatched even though its offer price is in excess of the RRP.

[269] This study was not able to classify negative or positive mis-pricing for situations when a generator is constrained by an equality constraint. This type of constraints are unclassifiable since the sign of marginal costs of the constraint are not stored in the NEM databases. Equality constraints are tend to be applied for operational reasons to control one generators output (i.e. for non-conformance or system security reasons).

NEMMCO calculated the distribution of positive and negative mis-pricing over the period 2003/04 to 2005/06 and provided data on following aspects of positive and negative mis-pricing:

- Annual hours of positive and negative mis-pricing per region and generation connection point;
- Number of connection points experiencing either positive or negative mis-pricing per region;
- Annual average magnitude of positive and negative mis-pricing, by region;
- The average mis-pricing amount per binding dispatch interval, and the standard deviation of that amount; and
- Average mis-priced amount per binding dispatch interval separated between system normal and outage conditions, plus the corresponding standard deviations.

The key results from NEMMCO's analysis of positive and negative mis-pricing are:

- NEM wide, a generator is much more likely to be constrained off (hence experienced positive mis-pricing). In 2005/06 the ratio between average hours of constrained off and constrained on mis-pricing was approximately 2.5 to 1;
- There is an increasing trend in both the average hours of positive and negative mis-pricing over the three year period considered; and
- The number of generator connection points subject to positive mis-pricing is roughly twice the number subject to negative mis-pricing during each year. It is important to note that a connection point could be subject to both positive and negative mis-pricing during the year.

The distribution of positive and negative mis-pricing varies considerably across the NEM regions:

- In Victoria, all mis-pricing is positive with the Latrobe Valley generators always being constrained off. During the period, there was a dramatic decrease in the average hours of mis-pricing from over 170 hours to under 20 hours for those generators included in this sample. All the Latrobe Valley generators are subject to the approximately the same level of mis-pricing except for Yallourn;
- In the NSW, most generators are more likely to be subject to significant positive mis-pricing (constrainted off), with the exception of Eraring, Munmorah and Vales Point who are likely to be subject to negative mis-pricing (constrainted on). The average hours of both positive and negative mis-pricing have increased over the period, with positive mis-pricing accounting for all of the increase in 2005/06;
- In South Australia, the average hours of positive mis-pricing increased from 0 in 2003/04 to 250 hours in 2005/06. Average hours of negative mis-pricing over the three years remained at a relatively low level. Hence the distribution of mis-pricing events in South Australia has shifted from generators being

predominately negatively mis-priced (constrained on) to being positively mis-priced (constrained off). This is driven by significant levels of positive mis-pricing at Ladbroke Grove for the first time in 2005/06;

- In the Snowy region Lower and Upper Tumut were predominantly positively mis-priced in 2003/04, but this changes to predominantly negative mis-pricing (being constrained on) in the two succeeding years;

- Queensland saw a massive increase in the average hours of positive mis-pricing over the three year period to over 180 hours in 2005/06. Positive mis-pricing now accounts for most of mis-pricing in Queensland. Queensland generators experienced some level of both positive and negative mis-pricing, with the exception of Callide and Stanwell who were subjected to only positive mis-pricing during the period; and

- In Tasmania, generation at Mackintosh experienced positive mis-pricing and generation at John Butters experienced both categories of mis-pricing during 2005/06.

D.4.1.1 Magnitude of mis-pricing impacts for generators

In order to quantify the magnitude of positive and negative mis-pricing NEMMCO calculated the average difference between the nodal price and RRN price. The data is presented with an upper and lower bound to account for the impact of constraint violations. This analysis is contained in section 3 of NEMMCO Report.

NEMMCO calculated two measures of the average capped mis-pricing amounts for generation connection points:

1. Average capped mis-priced amount for all dispatch intervals in year; and

2. Average capped mis-priced amount for those dispatch intervals when the generator was mis-priced.

The data contained in a) is very interesting, as it is an estimation of the impact of congestion on generators over the whole year. For example, in 2005/06 NSW generators who are constrained off tend to benefit, on average, by between $2 and $6 per MWh (a decrease when compared to the benefit of between $6 and $12 per MWh in the previous year). However, these results require careful interpretation as they are influenced by the degree disorderly bidding by the generator (i.e., bidding at either VOLL or -$1000 to prevent being constrained on or off).

Similar patterns of variability are evident at other generators' connection points. As an indication, only a small number of connection points in the NEM were mis-priced by more than $5/MWh for all three years of the study. These connection points all related to small gas or hydro plants in Queensland. No connection points in NSW were mis-priced by more than an average of $5 (taking the middle of the upper and lower bounds) for more than one year of the study. A large number of Victorian connection points did experience more than $5/MWh of mis-pricing for the first two years of the study, but these impacts were almost all reduced to less than $1/MWh by 2005/06.

The magnitude of the average capped mis-priced amount for those dispatch intervals when the generator was mis-priced is significantly greater than the average amounts over the year. For example, in 2005/06 the Victorian generators, who are typically constrained off, have a positive mis-priced amount of over $550/MWh for those instances where they are subject to mis-pricing. This compares to less than a $1/MWh average for the whole year.

This data clearly shows the prevalence of dis-orderly bidding in the market. When a generator is faced with either being constrained off or constrained on it has incentives to bid in a manner consistent with seeking to be dispatched (e.g. -$1,000) or seeking to avoid dispatch (e.g. VOLL). The magnitude of dis-orderly bidding varies across regions.

NEMMCO also calculated the standard deviation for the average capped mis-pricing amounts per incidence of mis-pricing. These figures are very high, showing that there is a high variation in generation bids when constraints bind.

D.4.2 Classification of mis-pricing between transmission outages and system normal events

NEMMCO also categorised the mis-pricing data according to whether mis-pricing arises under:

- System normal conditions – where a generator is constrained by a constraint classified by NEMMCO as a system normal constraint;
- Outage conditions – where a generator is constrained by a constraint classified by NEMMCO as an outage constraint; and
- Unclassifiable conditions – where a generator is constrained by a constraint where there is no direct method to identify the cause of the constraint. Some discretionary constraints fall within this category.

For the period 2003/04 to 2005/06, this analysis splits the incidence of mis-pricing between transmission outages and system normal constraints. This analysis is limited in the sense that:

- the classification is based on the current constraint text descriptions, while earlier constraint descriptions may not strictly conform to present naming conventions; and
- a system normal constraint binding may have been caused by a outage elsewhere on the network.

The key results from this analysis are:

- The average hours of mis-pricing due to system normal events has been constant at 50 hours per year over the three years;

- The average number of mis-priced connection points under system normal constraints has remained relatively steady over the three years, increasing marginally from about 110 to just over 120;

- There has been a substantial increase in the amount of mis-pricing due to transmission outages, from 20 hours in 2003/04 to over 120 hours in 2005/06. The average number of mis-priced connection points under outage events has increased from around 80 to 100;

- In 2005/06, outages account for the majority of intra-regional mis-pricing. In previous years system normal constraints accounted for the majority of mis-pricing; and

- The increased incidence of outage events appears to have been responsible for the overall increase in average hours of mis-pricing;

- Most generators are likely to be subject to both system normal and outage caused constraints each year.

There is significant variation in the proportion of outages/system normal mis-pricing across NEM regions. The results for each region are discussed in more detail below.

D.4.2.1 Queensland

Queensland experienced an increase in the average number of hours of mis-pricing per mis-priced connection point due to system normal constraints from 2003/04 to 2005/06. The number of mis-priced connection points under system normal conditions remained steady at about 35 per year.

However, average hours of mis-pricing under outage conditions spiked dramatically, increasing from about 10 in 2003/04 and 2004/05 to 160 in 2005/06. As discussed above, this increase was principally due to lightning events affecting flows from Central to South Queensland. At the same time, the average number of connection points mis-priced due to outage conditions remained relatively constant between 2004/05 and 2005/06 at about 35.

D.4.2.2 NSW

NSW continues to be dominated by outages caused congestion, although system normal constraints are accounting for an increasing proportion of congestion in this region over time. NSW experienced a significant increase in the average number of hours of mis-pricing per mis-priced connection point due to both system normal and outage constraints from 2003/04 to 2005/06. Generators in NSW are likely to experience both system normal and outage caused constraints.

D.4.2.3 Snowy

For the Snowy region, outage events account for most of the mis-pricing during the three year period considered. The Snowy region experienced a significant increase in the average number of hours of mis-pricing per mis-priced connection point due to both system normal and outage constraints from 2003/04 to 2005/06. The number of mis-priced connection points under system normal conditions and outage conditions doubled from 2 in 2004/05 to 4 in 2005/06.

D.4.2.4 Victoria

Over the three year period to 2005/06, over 95% of Victoria intra-regional congestion was caused by system normal constraints. Victoria experienced a sharp drop in the average number of hours of mis-pricing per mis-priced connection point due to both system normal and outage constraints from 2003/04 to 2005/06, with the average number of connection points mis-priced due to outage conditions falling to nil. However, the number of mis-priced connection points under system normal conditions remained steady at about 18 per year. The overall trend in Victoria is a declining amount of mis-pricing.

D.4.2.5 South Australia

The majority of mis-pricing in South Australia is caused by system normal constraints. South Australia experienced a dramatic increase in the average number of hours of mis-pricing per mis-priced connection point due to both system normal and outage constraints from 2003/04 to 2005/06. As noted above, this may be explained by a) the move from option 8 constraint formulation to option 4, and b) the effect of the increase output from windfarms. The average number of connection points mis-priced due to both system normal and outage conditions went from 2 in 2003/04 to 6 in 2005/06 under system normal conditions and from 3 to 6 under outage conditions over the same period.

D.4.2.6 Tasmania

In Tasmania, only the generation connection points at John Bulters and Mackintosh have a total duration of mis-pricing of more than 50 hours in a year. For these generators, mis-pricing was predominately caused by system normal constraints in 2005/06.

D.4.3 Mis-priced intervals with regional reference price > $1000/Mwh

NEMMCO also presented analysis on the number of dispatch intervals where mis-pricing occurred while the RRP was more than $1000/MWh (section 2 of NEMMCO's report). Data is presented for each connection point over the three years between 2003/04 to 2005/06 for each NEM region.

This purpose of this data is to provide further information on the magnitude of the impact of mis-pricing by considering the incidence of mis-pricing events when the RRP was relatively high. This followed an earlier NEMMCO report which showed that the vast majority of mis-pricing occurs when the RRP is less than $300/MWh.

The additional analysis shows that the trend in the incidence of mis-pricing occurring at the times when the RRP is more than $1000/MWh is increasing across the NEM regions, with the exception of Victoria (there was no mis-pricing when the

RRP was more than $1000/MWh in 2005/06 in Victoria). The data also shows that generators within a region tend to be equally affected by mis-pricing in this high price band.

D.5 Summary of findings on prevalence of congestion in the NEM

The historical data shows that:

- Inter-regional constraints bind far more often than intra-regional constraints;

- While some constraints have declined in significance, in general the hours of binding inter- and intra-regional constraints in the NEM is increasing over time;

- The annual average duration of mis-pricing has increased since 2002/03 from just over 45 hours to over 110 hours in 2005/06, but remains less than the 2001/02 level. Across all regions, the NEM-wide number of mis-priced congestion points remained steady within a band of 120 to 140;

- The trend in intra-regional congestion varies markedly across NEM regions. Intra-regional congestion in Victoria is decreasing, while in NSW and Queensland the incidence of binding intra-regional constraints is increasing;

- There is a difference between the hours a constraint binds, and the market impact of a constraint. Some constraints can bid for long durations but have little material impact on dispatch, while other constraints bind for a short time but have a significant market impact;

- The split between system normal and outage constraints also varies across region and interconnector. Binding inter-regional constraints occur more often at times of system normal conditions than at times of outage events;

- In 2005/06 outages accounted for a higher proportion of intra-regional congestion. This was by caused one or two significant individual events (e.g., lightning in Central Queensland). The incidence of mis-pricing caused at times of system normal conditions has been steady since 2003/04;

- Specific events can greatly affect the level of binding reported. For example, the drought in Victoria during 2005/06 lead to increased transfers from Snowy to Victoria. This in turn led to more binding on the Snowy to Victoria inter-connector; and

- Taken as a whole, the evidence suggests that many constraints have a relatively short life-cycle, in that they may cause some mis-pricing for one or two years before being largely addressed by investment in transmission or generation infrastructure. The NEMMCO case studies also highlight the various causes behind mis-pricing and demonstrate how the incidence of binding for a particular constraint can vary significant over a five year period. Constraints can have a 'life cycle' over which there are changes in the frequency of the constraint binding and the economic impacts of such binding.

The increased use of fully optimised (or option 4) constraints may also have affected this analysis of historical data, so monitoring of future trends is warranted before reaching definitive conclusions on intra-regional congestion. Use of option 4 constraints has blurred the distinction between inter and intra-regional constraints and in a small number of cases has seen intra-regional constraints merged with inter-regional constraints.

D.5.1 Queensland

Intra-regional congestion occurs primarily between the main generator locations (in Central Queensland and the South West) and the main load centres (in Central and South East Queensland). Since January 2002, the Central – North limit has predominately been managed via a NSA between Powerlink and generators in northern Queensland.

Congestion resulting from both network outages and the system normal constraints has increased over the period. A key factor behind this increase has been the strong growth in electricity demand over the period. 2005/06 saw an huge increase in constraints due to outage conditions. Cyclone Larry affected flows in far North Queensland and lightning and outages at the Gladstone Transformer affected flows between Central and South Queensland.

The majority of Queensland generators experienced some mis-pricing each year and are more likely to experience positive mis-pricing and be constrained off than constrained on.

There is an increasing incidence of binding constraints on export flows from Queensland to NSW. This is due to inherent transfer capability limit of the interconnector and the system normal capability of the north NSW network.

D.5.2 NSW

Congestion in the NSW network is driven primarily by network outages affecting the transmission ring that loops around the Sydney and Newcastle areas. Planned outages on the 81 line between Liddell and Newcastle have consistently caused a significant share of the congestion in NSW during 2003/04 to 2005/06.

The incidence of mis-pricing is increasing in NSW, caused both increasing outage and system normal events. Most NSW generators experienced some mis-pricing each year with the significant majority more likely to experience positive mis-pricing and be constrained off than constrained on.

D.5.3 Snowy

Outage events account for most of the mis-pricing over the last three years. In 2004/05 and 2005/06, generation at Lower and Upper Tumut experienced more negative mis-pricing than positive mis-pricing.

There is significant congestion for flows between Snowy and Victoria, generally driven by system normal constraints, including discretionary constraints to manage counter price flows.

Congestion is also increasing between Snowy and NSW caused by inherent limits of the NSW network, and limits on flows south to Victoria. The increased incidence of binding constraints on flows south to Victoria in 2005/06 was due to higher power transfers into Victoria caused by the drought.

D.5.4 Victoria

There has a significant decrease in the incidence of mis-pricing in Victoria over the period considered. The main congestion points have been between generation in the Latrobe Valley and Melbourne. Generators in Victoria experience positive mis-pricing, with no constrained on generation during 2003/04 to 2005/06.

There has been a large decrease in the number of hours of binding constraints on exports to the Snowy region. However, flows on the Heywood interconnector continue to bind for around 16% of the year. Congestion on the Heywood interconnector does not have a significant impact on market dispatch costs.

D.5.5 South Australia

South Australia saw a significant increase in the incidence of mis-pricing during 2003/04 to 2005/06. Most of the increase was caused by constraints under system normal conditions, although there has a number of significant outage events in the region during the period. The reformulation of constraint equations to a co-optimised form and increased output from wind generation are the primarily drivers behind this increasing trend. However, the considerable generation capacity at the main load centre in Adelaide combined with robust transmission means that South Australia experiences relatively little intra-regional congestion.

D.5.6 Tasmania

In Tasmania, a number of smaller generators are distributed across the transmission network with relatively little transmission redundancy. Congestion is primarily driven by planned outages.

D.6 Factors influencing the level of congestion

The extent and nature of congestion in the NEM is a function of a number of factors, including the location and size of load, generation and network capacity; the National Electricity Rules (the Rules) for operating the system and market; and the interaction of those Rules with the bidding behaviour of participants.

From its analysis of the data, the Commission considers that there are five factors that have influenced the incidence of congestion in the NEM over the period 2001 to 2006. This is not an exhaustive list and the Commission also recognises that other factors have influenced the extent of congestion in the market. The five factors are:

1. Changes to Option 4 constraint formulation;
2. Transmission investment;
3. Transmission rating reviews;
4. NSAs; and
5. wind farm generation.

Each of these factors is discussed in turn below.

D.6.1 Changes to Option 4 constraint formulation

In its initial analysis NEMMCO commented that the progressive conversion of option 8 constraints to a fully optimised formulation would have contributed to the increase in incidence of mis-pricing in the NEM. Following this, the Commission asked NEMMCO to investigate this issue further as part of its additional analysis into mis-pricing. NEMMCO's findings are presented in Section 5 of its additional results report.

NEMMCO's selected the 5 constraints in each region (except Queensland and Tasmania) with the highest incidence of mis-pricing in 2004/05, which were translated into option 4 constraints during 2005/06. The majority of these constraints were option 8 constraints, with a few being jointly option 1 and option 8 conversions. For these constraints, NEMMCO then compared the level of binding pre-change in 2004/05 to the reported level of binding in 2005/06. In total, NEMMCO assessed 19 changes in constraint formulation.

It is important to recognise that the assessment of the impact of constraint re-formulation was not a controlled experiment, and there could be other factors influencing the difference in the incidence of binding constraints between the two years. Hence it is difficult to make any strong statement on the basis of this analysis.

NEMMCO found that conversion from interconnector only constraints (option 8) to fully co-optimsed constraints (option 4) resulted in an increase in the incidence of binding constraints. However, when intra-regional constraints (option 1) are converted, the impact on binding incidence varies. For some of the conversions, the increase is very significant. For example, in NSW N>>N-NIL_1N which increased from 14 to 632; and in South Australia, V::S_NIL, which increased from 308 to 4687.

The analysis from NEMMCO focussed on the incidence of binding constraints, rather than mis-pricing. The degree of mis-pricing experienced by a generator is dependent upon the co-efficient assigned to the generator in the constraint equation. It is possible that the conversion to fully co-optimised constraints may also have changed the constraint equation coefficients for generators.

Evidence suggests that the conversion to option 4 constraint formulation has had a marked impact on the level of mis-pricing experienced in South Australia. South Australian constraint equations were progressively converted to fully co-optimised formulations commencing July 2005. At the same time, ElectraNet SA also updated a number of limit equations to include the impact of the Lake Bonney and Canunda wind farms. The revised formulations and increased output from the wind farms resulted in the system normal transient stability equation producing a much lower limit than had previously been the case. The V::S_NIL constraint equation consequently bound for 4,700 dispatch intervals in 2005/06. A number of other equations that had been converted to fully co-optimised formulations continued to bind for a similar number of dispatch intervals as in previous years. However, because of the conversion to fully co-optimised formulations these binding dispatch intervals began to contribute to the incidences of mis-pricing, resulting in the significant increase in 2005/06 compared to 2004/05.

Accepting the limitations with NEMMCO analysis, the evidence does suggest that conversion to fully co-optinised constraint formulation has led to increased levels of mis-pricing being recorded, especially for the South Australia.

The Commission understands that NEMMCO has now nearly finished the process of conversion of constraint equations, with a limited number of outage constraints still needed to be re-formulated.[270] The re-formulation of constraints is therefore unlikely to lead to further increases in mis-pricing in the future.

D.6.2 Transmission investment and rating reviews

Transmission network congestion occurs when the available network capacity cannot accommodate the dispatch of the least cost combination of available generation to meet demand across the network. Measures implemented that increase the amount of transfer capability across the network will aid congestion management through decreasing the probability of constraints binding.

The he Rules, and state imposed obligations, set out the requirement for TNSPs to plan and develop their transmission grids. In general TNSPs are required to ensure that power quality and reliability are met for normal and outage conditions, and that the power transfer available through the network will be adequate to supply the forecast peak demand immediately following the most critical single network element or generation unit outage.

The planning process undertaken by TNSPs starts with analysis of emerging limits in the transmission system as the load grows over time. This process involves a review of load and generation across the network and includes detailed load-flow analysis. The options to remove or relieve those limits are then developed and compared. The most economic option (which would be least cost in the case of a reliability obligation) is then determined and implemented, subject to it meeting the mandatory requirements of the AER Regulatory Test.

Possible options to alleviate a network constraint can include transmission investment or upgrading the ratings of the network element. Each of these options is discussed in turn below.

[270] NEMMCO Communication No. 2351 – Conversion of constraint equations to a fully co-optimised formulation.

D.6.2.1 Transmission investment

Network and generation investments have the potential to either alleviate or exacerbate congestion.

Macquarie Generation[271] commissioned a report by McLennan Magasnik Associates (MMA) to determine whether TNSPs are adequately managing intra-regional congestion in the NEM. MMA reviewed the Annual Planning Reports (APRs) for each NEM region and other relevant documents to assess how TNSPs managed major intra-regional constraints. The reporting and action on each constraint was tracked from 2001 to 2006. MMA's conclusions were:

- Transmission system reliability indicators show that system reliability has been improving and the regional networks are performing well;
- These indicators, as well as the development of network projects described in the APRs, show that intra-regional constraints in each region have been managed a ppropriately; and
- TNSPs are anticipating emerging constraints and responding appropriately such that no material congestion emerges.

MMA's analysis focussed on whether TNSPs are responding adequately to the reliability requirements of their respective networks. MMA's report noted that it did not specifically consider augmentations undertaken for market benefit reasons. It commented that it would be incumbent on market participants who perceive that they are being disadvantaged by network conditions to seek the support of TNSPs to identify cost effective options.

Network augmentations for market benefit reasons are an important mechanism to deal with congestion. The Commission notes that participants would only initiate change from a TNSP if they had adequate information and understanding of the constraint and the likely market benefit from investment.

D.6.2.2 Transmission rating reviews

A transfer limit is defined as the maximum power which can be transferred across that element such that all important system conditions will remain within acceptable limits following the worst credible contingency. Transfer limits form the basis of the constraint equations used to determine the efficient dispatch. These limits are designed to dynamically deliver the maximum flow capability, whilst preserving power system security.

A key aspect of the transfer limit is the thermal ratings of the network element. Overhead line thermal ratings are determined to ensure that the line maintains a minimum distance from the ground. Thermal ratings can depend upon such factors as ambient temperature, wind speed, cooling, etc and can vary across different

[271] Macquarie Generation, Supplementary Submission to Congestion Management Review, 25 September 2006.

seasons. The rating assigned to the network element balances the desirability of using the highest possible rating (in order to defer system augmentation) against the risk of exposing the network element to damage, excessive ageing, or disconnection due to the operation of protection systems.

TNSPs regularly audit and analyse their network element ratings. This can result in changes to the transfer limits, which in turn will affect the incidence of congestion. The assessment could identify opportunities where the rating of a limiting element could be improved at a low to modest cost (e.g. CT ratio changes, protection setting changes). The methods used to achieve improvements in network capacity may also include the application of temporary overload in some circumstances where risk is clearly understood.

The Commission has sought data from the TNSPs on their MVA element rating review since 1 April 2001. There have been frequent changes to network element ratings, with rating reviews tending to affect transfer capability by around 20 – 100 MW. Such small changes to the transfer capability can have a significant effect on the incidence of binding constraints. This is one of the key conclusions contained in Charles River Associates modelling report to the MCE.[272] Since 1 April 2007:

- In Tasmania, there were in total 34 transmission line upgrades that have a direct impact on the improvement of thermal ratings of network elements. Most of these lead to a substantial increase in line ratings; and
- In South Australia, the ratings of 71 network elements were amended.

An example of where a rating review has assisted in a drop in the incidence of binding is the line between Vales Point and Munmorah in NSW. There was some binding of this line during outage events in 2002/03 and 2003/04. The emergency rating on this line increased from 1,370 MVA to 1,429 MVA in late 2004. This rating review, plus increased output from Munmorah, has lead to no more incidents of binding constraints on this line.

The implementation of real time thermal ratings using actual weather data on transmission lines by TNSP (for example, ElectraNet) will also improve congestion management in the future. However, in many situations across the NEM voltage or stability limits are more important than thermal line rating limits.

D.6.3 Network Support Agreements

NSAs aid congestion management by providing a mechanism for TNSPs to contract with generation or load to assist in the management of network limits where this is more efficient than engaging in transmission investment. Under the NSA, the generator (or load) gives the TNSP the ability to either constrain on or off the generator (or load) to prevent network becoming congested.[273] In return, the

[272] CRA 2004, NEM Regional Boundary Issues: Modelling Report, report to MCE, 16 September 2004.

[273] Network Support Agreements can also include generators agreeing to provide reactive power capability.

generator (or load) receives a payment. If proved to be efficient under the Regulatory Test, TNSPs are allowed to recover the costs of NSAs in their revenue determinations.

There were 6 NSAa in place in the NEM in 2005/06, including one in South Australia which covered three separate sites. The agreements were in use in three regions: Tasmania, Queensland and South Australia. There were no NSA in either Victoria or NSW.

The total annual cost of the service under these agreements was more than $25 million, most of this in Queensland. The Commission understands there were only a few Regulatory Test assessments which resulted in a NSA being the preferred option.

Powerlink is the largest purchaser of network support in the NEM. It purchases the bulk of its required network support in North Queensland, with a small amount also required in South East Queensland for reactive power support. Electricity demand in North Queensland and Far North Queensland exceeds the capacity of transmission network into those areas at times of high demand. This means that local generation is required to meet demand and maintain the transmission network in a secure operating state.[274] When power flows are approaching the capacity of transmission lines between Central Queensland and North Queensland Powerlink instructs these local generators to generate under the terms of the contracts. This in turn, prevents the constraint from binding. In 2001, when there were no NSAs in place, the constraint bound for over 1,000 hours in the last three months of the year. However, since NSAs were signed in 2002 the incidence of the constraint binding has fallen significantly. For example, from October 2004 to March 2005 the constraint between central Queensland and north Queensland bound for only 15.5 hours. However, generation was dispatched under contract to avoid this constraint from binding for 365 hours (8% of the time).

The NSA in South Australia involves constraining on generation at Snuggery and Port Lincoln in order to manage line loading.

D.6.4 Wind farm generation

The amount of intermittent generation participating in the NEM has grown rapidly over the last few years, particularly wind farm development in South Australia. This trend is expected to continue, supported by the financial incentives made available through various government renewable energy initiatives. The increasing penetration of intermittent generation affects NEMMCO's ability to efficiently manage the operational of a secure power system, and hence can influence the incidence of binding constraints in the NEM.

Since the start of the NEM all generation with an intermittent output has been able to be classified as non-scheduled under the Rules. Non-scheduled generation is hence exempted from control by NEMMCO's central dispatch, on the basis that their

[274] Powerlink has entered into NSAa with Collinsvilee, Mt Stuart and Townsville Power Stationss and the Pioneer Sugar Mill.

electrical output cannot be controlled "on demand" as their available energy source is inherently uncontrollable. Non-scheduled generation therefore effectively has firm network access and dispatch priority over scheduled generation unless and until directed by NEMMCO or their agents to operate otherwise. This leads to the risk of non-scheduled generation overloading a network element. To mitigate against this risk of violating network limits, NEMMCO may be required to increase the operating margin for network limits in order to create more spare transfer capacity. This will reduce the allowed flow on the network limit which will increase the probability of the constraint binding.[275]

At the moment, wind farms with an aggregate nameplate rating of ≥ 30MW accounted for 611MW of the total installed wind farm generation in the NEM, with 388MW in South Australia, 83MW in Victoria, and 140MW in Tasmania.

In addition there is a further 5,185MW of significant wind farm generation across the NEM that is either under construction, with or seeking planning approvals or subject to feasibility studies, as follows:

- South Australia: 344MW under construction, 610MW with planning approval, and 890MW in feasibility stages (total 1,844MW):

- Victoria: 357MW under construction, 725MW with or seeking planning approval, and 667MW in feasibility stages (total 1,749MW);

- Tasmania: 130MW with planning approval, and 190MW in feasibility stages (total 320MW);

- NSW: 581MW with or seeking planning approval, and 515MW in feasibility stages (total 1,096MW); and

- Queensland: 124MW with planning approval and 52MW in feasibility stages (total 176MW).

In South Australia alone, the currently installed plus future committed wind farm projects (those under construction or with planning approvals) would amount to a total installed capacity of 1,342MW, or around 40% of the total South Australian generating capacity of 3,260MW assumed available for summer 2006/07.

Generation from wind farm developments is likely to have a significant and growing influence over the operation of the NEM in the foreseeable future, and is therefore likely to have an increasing influence on the level of binding constraints in the NEM.

However, the market is aware of these issues. On 23 April 2007 the Commission received a Rule change proposal from NEMMCO that attempts to address the problems of intermittent generation on network limits. The Rule change proposal seeks to require significant intermittent generators (such as wind farms) to participate in the central dispatch and projected assessment of system adequacy (PASA) processes, and limit their output at times when that output would otherwise

275 Network operating margins are generally implemented as a static value on the RHS of the constraint equation, and apply at all times that the relevant network constraint equation is invoked.

violate secure network limits. The proposal also includes changes to the existing requirements for scheduled and non scheduled generation as a result of the review of the central dispatch and PASA processes to integrate intermittent generators.

In their Rule change proposal, NEMMCO presented evidence on the incidence on binding network constraints equations involving significant intermittent generation for the six month period from 1 March 2006 to 31 August 2006 in the South East area of South Australia. NEMMCO concluded that in this area, wind farm generation has materially contributed toward the MW amount of network congestion in that area, resulting in constraining off interconnector flows into South Australia and (to a lesser extent) constraining off local scheduled generation involved in those constraints.

The Commission is currently considering the proposal under section 94 of the NEL.

D.7 Outlook for future trends in the incidence of congestion

This Appendix has surveyed the historical data on the incidence of congestion. The evidence shows that the incidence and impact of a binding constraint can vary over time.

However, as noted above, past patterns of congestion may not be a good indicator of future congestion. The incidence of congestion will vary 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;
- Changes in the formulation of the constraint equations used in dispatch (in particular, the re-writing of constraint equations in the "fully optimised" form); and
- Changes to region boundaries – especially merging connection points into new regions, will change the bidding incentives on generators, thereby changing the flows on the network and the resulting pattern of constraints. A mere change in region boundaries could make existing persistent, material constraints disappear and/or reappear in other parts of the network.

This section comments on the outlook of future congestion, by considering the existing data on future demand growth and generation projects. Possible future constraints and options to address intra- and inter-regional constraints are are described in turn below.

D.7.1 Intra-regional

D.7.1.1 Queensland

In the latest SOO, maximum energy demand in Queensland is forecast to increase by an average of 3.5% in winter and 3.6% in summer (under a medium growth scenario) per year over a 10 year period, which is higher than any other region in the NEM. Over the same period, the scheduled energy is projected to increase by an average of 3.5% per year (medium growth scenario).

In the Queensland region, there are a number of proposed generation projects which are expected to be commissioned between 2008 and 2009. In the Southwest region, there are proposed generation plants in Spring Gully (1,000MW), Chinchilla (242MW) and Braemar (up to 480MW). In the Central West region, there are projects for new generation in Stanwell Energy Park of up to 640MW.

There are a number of existing areas within Queensland where transfer capability is tight, and this increasing demand and new generation will place more pressures on the Queensland network. In response to this, Powerlink have been given a total capital expenditure over the next five years of $2.6 billion.

The staged Central to North Queensland (CQ-NQ) transmission project due for completion between 2007 and 2009 will improve transfer capability to meet forecast electricity demand in North Queensland.

The Central Queensland to South Queensland (CQ-SQ) limit bound for 4.7% of the time over the summer period due to the capacity across this grid section being fully utilised during opportunities to export electricity to NSW. Commissioning of new generating plant in Southern Queensland since the 2006/07 summer is expected to reduce flows on this grid section in the 2007/08 summer; however this may be affected by reductions in generation due to water shortages.

The Tarong limit in South Queensland experienced minor binding over the 2006/07 summer. To keep pace with the high load growth in South East Queensland, the Middle Ridge to Greenbank transmission reinforcement along with additional shunt compensation has been committed for the 2007/08 summer.

In 2006/07 the Gold Coast limit bound for around 11% of the time during winter and 0.7% of the time during summer. Even though Powerlink completed a project, in late 2006, to increase the transfer capability of the Gold Coast grid section, binding events on this grid section occurred during periods when spare capability across this grid section was fully utilised by the Terranora interconnector transferring power into NSW. Powerlink has committed projects underway that increase the transfer capability of the Gold Coast grid section to meet forecast load growth in the Gold Coast and Tweed Heads areas.

D.7.1.2 NSW

Maximum energy demand in NSW is forecast to increase by an average of 2.0% in winter and 2.7% in summer (under a medium growth scenario) per year over a 10 year period. Over the same period, the scheduled energy is projected to increase by an average of 1.7% per year (medium growth scenario). Over the period 2004/05 to 2008/09, TransGrid has a fixed capital allowance of $1.188 billion. Proposed expenditure for the period post 2008/09 has not yet been announced.

Throughout NSW, there are a number of gas turbine generation projects planned, such as Munmorah (600MW, expected to be operational between 2009 and 2010) and Tomago (500MW) on the NSW Central Coast. Also in this area, there are plans for an upgrade and development of the Eraring Power station (up to 3,040MW, operational in stages from 2009). In the South East of the state, there are planned gas turbine developments for Bamarang (300MW by 2010/11) and Marulan (300MW by 2010/11). An upgrade to the existing Mt Piper power station in the Central West area (to 750MW each for Unit 1 and 2) is planned for 2008 and in the South West, there is a proposal for a gas fired plant at Uranquinty (640MW, by summer 2008/09).

TransGrid are proposing to progressively complete a high capacity ring linking the Sydney, Newcastle and Wollongong load centres with major generating centres located in the Central Coast, Western coalfields and Hunter Valley. To date the Eraring – Kemps Creek 500kV line has already been developed. TransGrid are currently committed to the process of converting the existing Bayswater – Mt Piper and the Mt Piper – Marulan lines, which presently operate at 330kV, to operate at their design voltage of 500kV. For the summer of 2008/09 Transgrid has proposed to develop up to 350MW of network support capability for the Newcastle-Sydney – Wollongong area.

The mid-north coast area of NSW has a number of current and emerging constraints primarily as a result of population growth and therefore high load growth. TransGrid is proposing a project to relieve this concern. These works are expected to cost around $62 million and to be completed by mid 2009.

Central Western Sydney is also experiencing high load growth. TransGrid has proposed a new transmission line between Wollar and Wellington to meet this increasing demand. This project is expected to cost $30 million and could be completed by 2010.

D.7.1.3 Victoria

In Victoria, maximum energy demand is forecast to increase by an average of 1.3% in winter and 1.9% in summer (under a medium growth scenario) per year over a 10 year period. Over the same period, the scheduled energy is projected to increase by an average of 0.8% per year (medium growth scenario). SP AusNet proposes that their capital expenditure for the 2008/09 to 2013/14 period will be $928 million. A final decision by the AER regarding this proposal has not yet been made.

There are three major generation projects planned for this region. In the Northern corridor a 130MW hydro station is planned for the Kiewa area. In the Eastern corridor, an upgrade to the Loy Yang A station is planned and will result in increases up to 100MW. In the South West corridor, a 1,000MW gas-fired station is planned near Mortlake.

To support load growth in and around the Melbourne metropolitan area, VENCorp has committed projects underway which will improve the reliability of supply to this region. In their 2007 Annual Planning Report (APR), VENCorp indicated that the committed development of the South Morang Terminal station (expected to be completed early 2009) would help to meet these requirements.

There are a number of constraints that can occur in the Northern corridor, which comprises the Victorian side of the Victoria to Snowy-NSW interconnection. However, in the 2007 APR, VENCorp states that the market benefits associated with the management of the constraint over the next 5 years are insufficient to justify augmentation. Though not yet formally proposed, VENCorp has identified options, such as line up-rating, new transmission lines or wind monitoring schemes, that may become justifiable in the longer term (between 6 and 10 years).

In the Greater Melbourne and Geelong areas, there are a number of smaller constraints as a result of transmission element outages, increased load and changes to generation. In the short term, VENCorp is seeking to economically manage these risks, at least until approximately 2011/12.

Throughout regional Victoria, there are a number of constraints as a result of transmission element outages, high load and bulk power transfer. However, VENCorp states that the market benefits from the alleviation options, such as line up-rating, are insufficient to justify augmentation and that they believe the constraints can be economically managed for the next 4 to 5 years.

D.7.1.4 South Australia

Maximum energy demand in South Australia is forecast to increase by an average of 2.0% in winter and 1.6% in summer (under a medium growth scenario) per year over a 10 year period. Over the same period, the scheduled energy is projected to increase by an average of 0.8% per year (medium growth scenario). Over the next five years, ElectraNet has forecast a capital requirement of $778.1 million. Growth in demand is driving the need for significant transmission investment to meet mandated reliability standards specified in the Rules and the Electricity Transmission Code (ETC).[276] A final decision by the AER regarding this proposal has not yet been made.

There are a number of conventional generation projects under consideration in South Australia. The most advanced of these is the 120MW gas-fired power station announced recently by Origin Energy for construction adjacent to Quarantine Power Station on Torrens Island, which is expected to be operational prior to the 2008/09 summer.

276 New reliability standards resulting from a recent review of the ETC by state regulator ESCOSA also require additional investment. For example, the mandated reinforcement of the Adelaide CBD is expected to cost approximately $138 million during the forthcoming regulatory period. This is a major project and the most significant single reason for the higher capital expenditure requirement in the forecast period (there has been no project of this significance or magnitude in the current regulatory period).

Three new wind farms are currently being built in the State: Lake Bonney Stage 2, the Bluff at Hallett, and Snowtown. These wind farms are all at various stages of construction and, when complete towards the end of 2008, will lift the total wind capacity in the State to 742MW.

While still a net importer of electricity, South Australia has imported less, and exported more electricity than ever before over the 2006/07 year. Increasing volumes of wind energy and higher interstate forward contract prices, the latter as a result of capacity risks associated with the drought, are the two primary causes of the change in import/export balance.

D.7.1.5 Tasmania

In Tasmania, maximum energy demand is forecast to increase by an average of 1.6% in winter and summer (under a medium growth scenario) per year over a 10 year period. Over the same period, the scheduled energy is projected to increase by an average of 1.5% per year (medium growth scenario). Transend has a fixed capital expenditure allowance of $306.8 million for the five and a half year period 2004 to 2008/09. The major capital expenditure project for this period is the works being completed in the south of the state, including the Waddamana and Risdon Vale line (see below), estimated to cost $55 million. Proposed expenditure for the period post 2008/09 has not yet been announced. In the recent SOO[277], NEMMCO noted that there were no new generation projects planned for Tasmania.

The most common constraint in the Tasmanian region is that of thermal constraints. To alleviate this problem, Transend use real time measurements to give dynamic real time line ratings.

One of the major problems in the Tasmanian region is the high demand in the Hobart area. This problem has previously been managed by using a number of NSAs. A major project currently being undertaken by Transend is that of the replacement of the existing transmission line between Waddamana and Risdon Vale with a new higher capacity line to improve power supply to Hobart and Southern Tasmania. This project is due for completion mid 2009. This project will lessen the need for the use of NSAs to meet demand in the south.

D.7.2 Inter-regional

D.7.2.1 Queensland to NSW interconnection

The incidence of congestion between Queensland and NSW has increased. It is recognised that the current transfers of 500MW north and about 1,100MW south on QNI will be impacted by the imminent opening of Kogan North Power station, with NSW exports being reduced.

[277] NEMMCO, Statement of Opportunities for the National Electricity Market, October 2006

The commissioning of the NSW 500kV ring upgrade should help to relieve congestion on QNI through increasing capability in the Northern NSW network.

A QNI upgrade is expected to improve reliability in both states, enable higher interchange when the supply/demand balance is tightening, and reduce the occurrence and size of constraints on QNI. Options being considered range from line series compensation and voltage support at a cost of $100-$120 million with a 300-400MW increase in capacity to new line development at a cost of $600-$800 million and a capacity increase of up to 1,000MW.

In its APR,[278] Powerlink says it expects that studies on the possible augmentation of the QNI interconnector will have progressed to the stage where Powerlink and TransGrid will report the outcomes of the detailed technical and economic studies within the later part of this year. Currently the optimal timing for the QNI upgrade is 2011 (compared to the 2009 timing indicated by earlier pre-feasibility studies). Commitment of additional new generation in NSW (or further south) may further defer the timing of a QNI upgrade. Conversely, the commitment of new generation within Queensland may bring forward the optimum upgrade timing.

D.7.2.2 Snowy to NSW interconnection

The transfer limit on the Snowy to NSW interconnector has been increased by 200MW during daylight hours in January to April. This increase is the result of a NSA put in place by Snowy Hydro, industrial loads, and Transgrid. This arrangement is an Automated Control scheme whereby loads and generation can be rapidly offloaded in the event of a trip in a transmission line making up the Snowy to NSW interconnector.[279] This should help to relieve the increasing congestion on the flow northwards from Snowy.

The Commission's recent decision to abolish the Snowy region will see the Snowy to NSW interconnect become an intra-regional constraint within the NSW region.

D.7.2.3 Victoria to Snowy interconnection

VENCorp has recently committed to an augmentation of the South Morang terminal station. These works at South Morang will improve Victorian export transfer capability hence improving flows between the Victorian, South Australian and Snowy regions. Work is currently being undertaken to develop the South Morang Terminal Station including the establishment of a switchyard and the installation of two transformers. This work will see the transfer of load from Thomastown terminal and Somerton power station. This project will help to meet Melbourne's long term supply requirements and is planned for completion early in 2009.

In the 2007 APR, VENCorp indicated that there was no justifiable solution to the loading on the Dederang – South Morang line in the short term (i.e. 5 year outlook).

[278] Powerlink, Annual Planning Report, 2006

[279] NEMMCO Communication No. 2356 – Change in SNOWY1 Interconnector Transfer Limit.

While options exist to solve this problem, such as the uprating of the lines or the installation of a third line between Dederang and South Morang, the market benefits associated with these options are insufficient to justify augmentation. VENCorp believes that the system normal constraints associated with this line can be economically managed until at least 2011/12.

The Commission's recent decision to abolish the Snowy region will see the Victoria to Snowy interconnect become an intra-regional constraint within the Victorian region.

D.7.2.4 Victoria to South Australia interconnection

The highest incidence of inter-regional congestion occurs on the Heywood interconnector, however as noted above, the market impact – in terms of price difference – is minimal. Current network plans do not include any projects to increase the interconnection capacity to South Australia.

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