CONGESTION MANAGEMENT REVIEW

IES Submission to AEMC's Review

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Intelligent Energy Systems

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1 Introduction

IES welcomes the opportunity to make a submission to the AEMC's review of congestion management in the NEM. Our submission focuses mainly on issues associated with the feasibility of a constraint management scheme such as the proposed regime of constraint support pricing (CSP) and constraint support contracts (CSC's) and issues associated with managing risks and improving market efficiency.

Our submission is relatively short but we would be happy to clarify any points with the AEMC.

2 Security Constraints in the NEM

2.1 Background

The NEM market design was premised on the notion that the main constraints that would affect dispatch and pricing were constraints on the flows between regions while, within regions, constraints would rarely affect dispatch. This premise was not unreasonable given the fact that the NEM was built on state-based transmission systems. As a consequence of this thinking, the NEM's approach to locational pricing was to determine the spot price at each connection point as the regional reference price multiplied by the marginal loss factor of the connection point relative to the regional reference node.

Consequently, the dispatch engine implemented a simple network model with links connecting the four original regions: NSW, Victoria, Snowy and SA. However, this simple network model was insufficient to manage system security in dispatch. This was particularly the case for NSW where approximately 2000 security constraints were incorporated into the dispatch engine SPD (now NEMDE) prior to market start. These constraints did not explicitly model the physical network but attempted to define the envelope within which generation could be dispatched. These security constraints were implemented via a class of SPD constraints called 'generic constraints'. The choice of an implicit[1] network model with a generic constraint overlay for the SPD (now NEMDE) was not driven by the requirements of the National Electricity Code, but by the perception that this was the easiest approach to implementation. An explicit network model could have been readily implemented under the Code then or under the National Electricity Rules now.

The other assumption underlying the Code then and the discussion on constraints and regions now is that there would be a relatively small number of intra-regional constraints that would have a material impact on the market. The Code envisaged that, if these constraints persisted, a new region could be created or a regional boundary could be shifted. The more recent discussions on constraints, constraint support pricing and regional boundaries have made similar underlying assumptions. The Regional Boundary review undertaken by NECA canvassed a variety of options from nodal pricing to no changes in regional boundaries. The review recommended that there be only very gradual change of regional boundaries and that the few 'pinch points' within regions should be managed through constraint support pricing and constraint support contracts; if these 'pinch points' persisted then the relevant regional boundaries would be

[1] The NEM's implicit network model does not model the flows on all transmission branches in the NEM as an explicit network model would. Thus in order to model security constraints that relate to limits on flows or limits on cut sets of flows the implicit model must use linear combination of generator outputs, interconnector flows and regional demands to constrain the flows on the relevant network elements. This implicit model may not always be as accurate as an explicit one as assumptions about (a) how regional demands are spread across various nodes and (b) the impact of generator and interconnector dispatches on transmission branch flows need to be made.

reviewed. Does this underlying conceptual model of a relatively small number of material constraints ('pinch points'), match up with reality?

2.2 Population of Security Constraints

There are now approximately 18,500 constraints that could be used in NEMDE. Some of these constraints are updates of old-form constraints while others are new. The constraints are classified on the basis of the limit that they are managing. That is they are classified as managing one of the following limits: thermal, transient stability, oscillatory stability or voltage stability. Some constraints that are newer versions of old constraints are not classified. In the figures below and in the NEM databases these constraints are categorised as 'undefined'. When IES undertook its review of security constraints for NECA in 2002/03 there were about 9,000 active constraints. The number of constraints has approximately doubled since then.

Figure 1**Error! Reference source not found.** presents the overall population of constraints[2] that are active today and how many of these were in existence at different times since the market began. Very few of the current constraints were in existence in their current form at market start; most of them have been created since 2001. This process of constraint creation is illustrated by Figure 2 and Figure 3. For instance in November 2001 nearly 1200 new constraints were created (720 constraint revisions and 462 new constraints) and in March 2004 over 290 new voltage stability constraints were created.

For each month, between 1/1/2002 and 31/1/2006, there has been an average of 106 completely new constraints created and 154 revisions of existing constraints. That is an average of about 260 new or revised constraints each month.

[2] Excludes ramping, FCAS and 'other' generic constraints

Figure 1 Current constraints which could be used in NEMDE

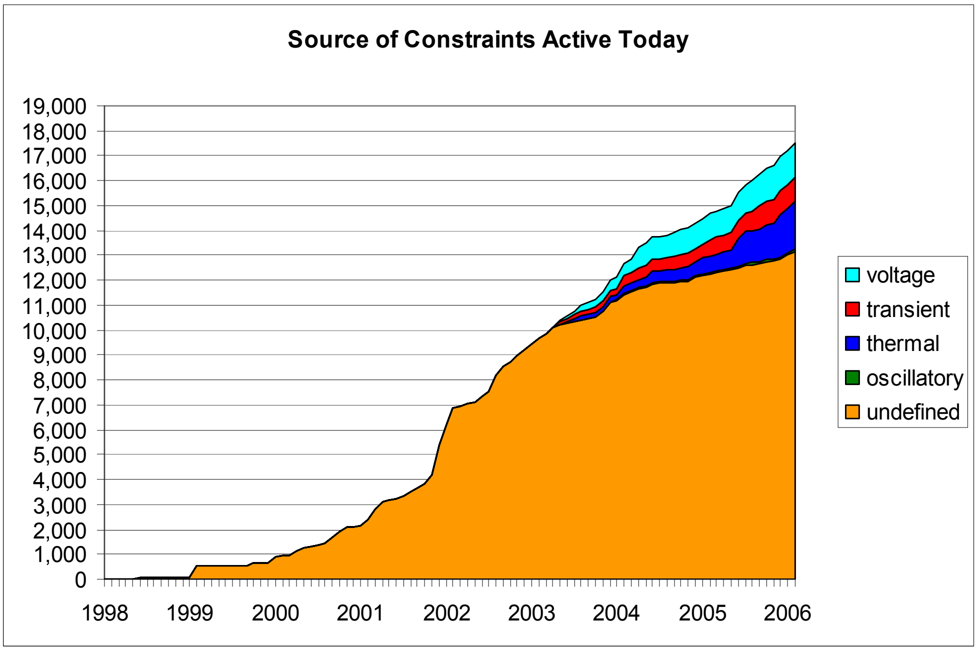


Figure 2 Monthly numbers of totally new constraints

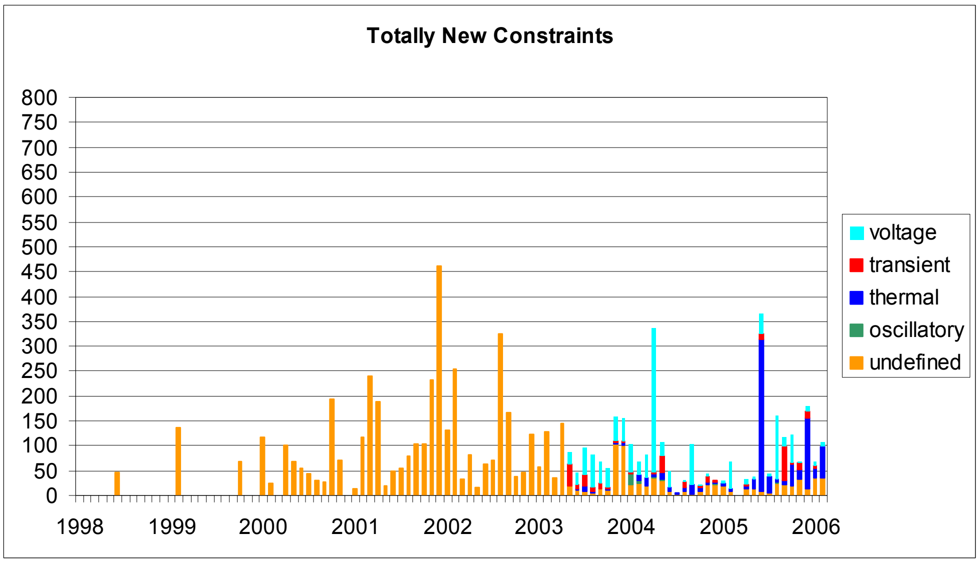
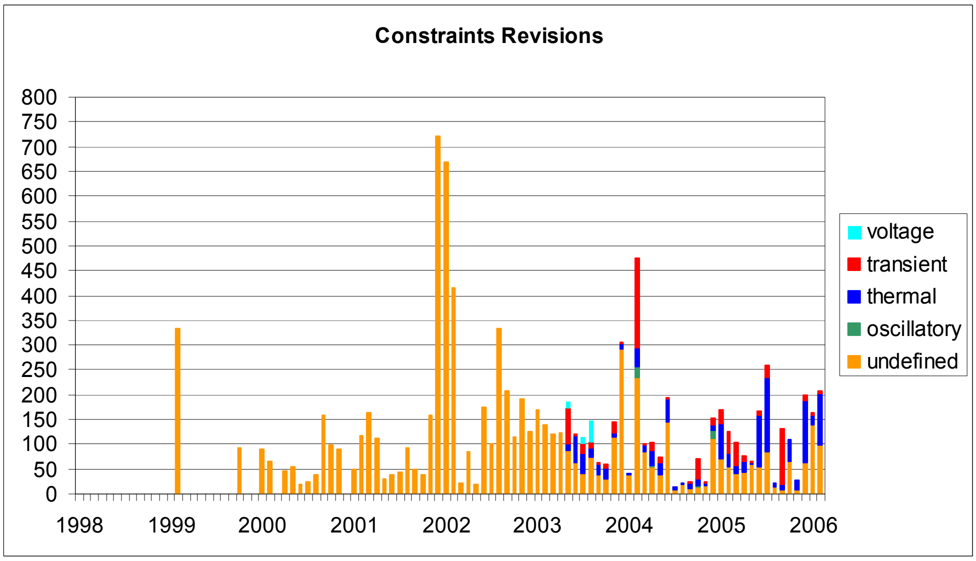


Figure 3 Monthly numbers of constraints that have been revised



2.3 Persistence of Binding Security Constraints

This section briefly looks at the population of constraints that regularly bind in the market and the persistence of the constraints that bind over time. Between January 2004 and March 2006 there have been 128 constraints that have bound for at least one hour in a month. These constraints and the months in which they bound for an hour or more are illustrated in Figure 4. On average there were about 720 constraint hours per month that these 128 constraints did bind.

Because there are so many constraints that have bound for an hour or more in a month it is difficult to see whether some of the constraints consistently bind for months or whether most of the binding constraints are relatively transient. To see if there were any persistent patterns of constraints that bound for extended periods of time, IES selected only constraints that had bound for at least 50 hours in one month over a period of over 2 years.

The number of hours that these constraints bound each month is presented in Figure 5. From this, it is apparent that only a few constraints consistently bind over more than a few months. These constraints are:

- VS_460 (Victoria to SA interconnector upper transfer limit of 460 MW),
- V:H_NILC_R (Vic to Snowy transient stability limit),
- Q>NIL_757+758_B (system normal thermal limit for 110kV feeders (757 and 758) Mudgeeraba to Terranora), and
- Q>NIL_757+758_B_SUMR (same limit as above but for summer ratings).

If we restrict the analysis further by including only intra-regional constraints and those that have already been formulated as option 4 type constraints, and reduce the monthly binding time threshold down to 20 hours, then we find that only a few constraints persistently bind. The results are shown in Figure 6 results. Here, it is apparent that no intra-regional constraint persistently binds for greater than 3 months and the 4 constraints that bind for the longest periods being:

- Q_CLCB_852 (manage line outage in QLD);
- Q_CLCB_851 (manage line outage in QLD);
- Q_STSTN_862 (manage line outage in QLD); and
- Q_STSTN_863 (manage line outage in QLD);

These constraints comprise around 35% of the total binding time.

Figure 4 Hours of Binding Constraints Each Month for constraints that have bound for at least 1 hour in a month

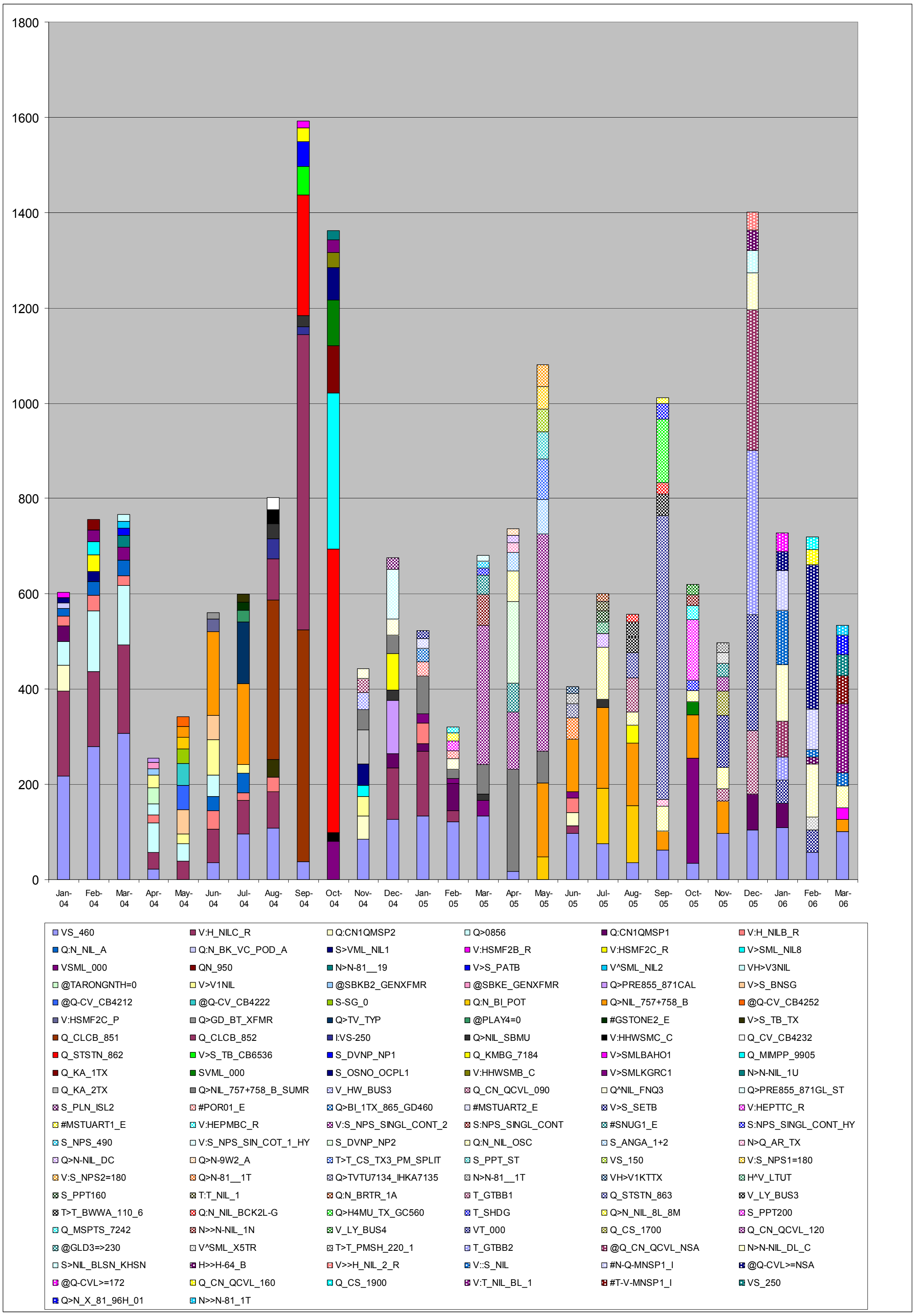


Figure 5 **Hours of binding, for constraints that had one month of 50 or more hours in which the constraint bound**

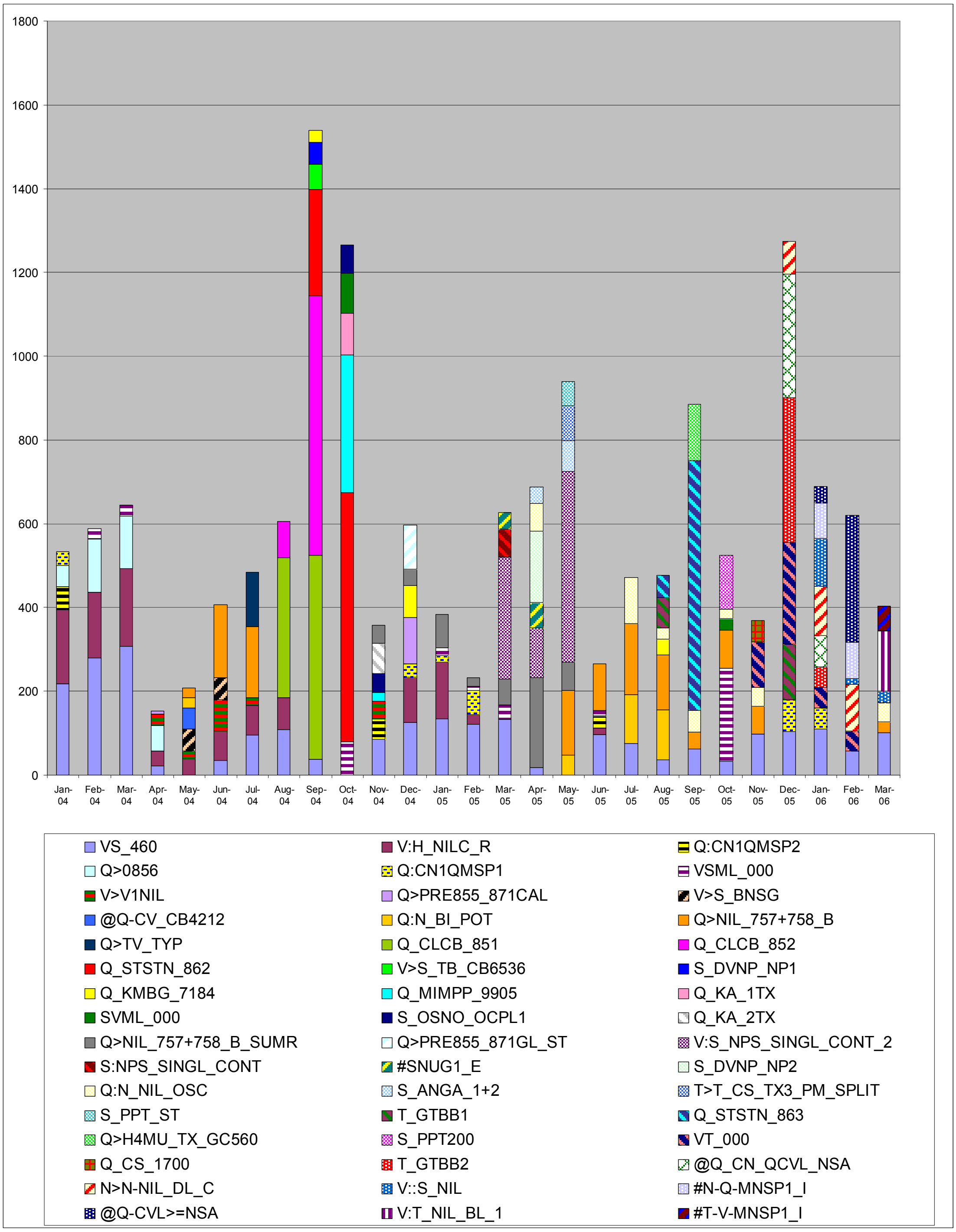
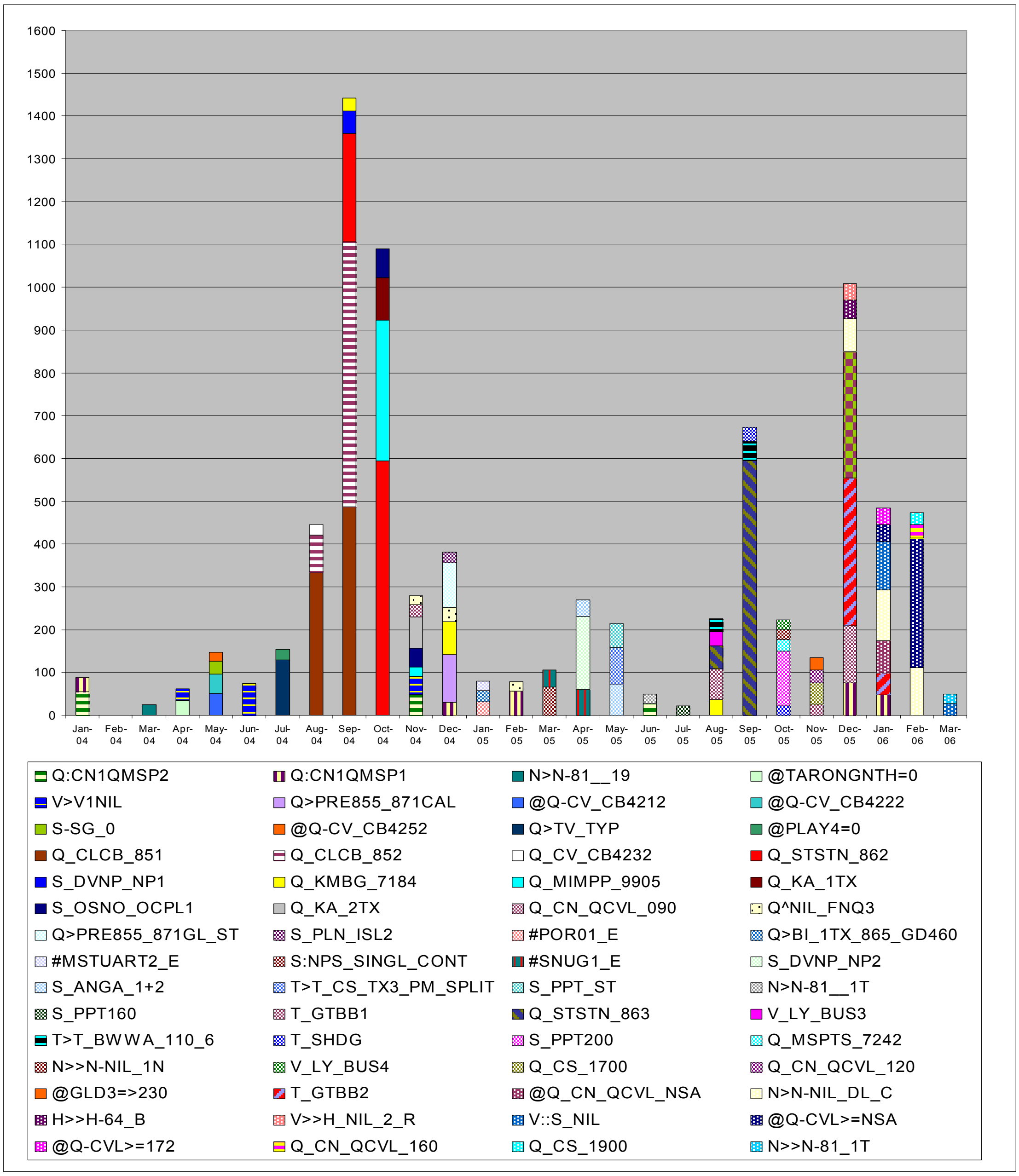


Figure 6 Intra-regional (and "option 4") constraint hours binding for constraints that had one month of 30 or more hours in which the constraint bound



2.4 Impact of Binding Security Constraints

Looking at the hours that a constraint is binding is not sufficient to determine its market impact. For instance Q_CS_1900, a central QLD to south QLD flow constraint, was binding between 2.00 and 5.00 pm EST on 7th of December 2005 with shadow prices of between approximately $1,500/MWh and $9,000/MWh.

These shadow prices were a result of central and north QLD generators wanting to get access to the QLD reference price, which was very high at the time. They were bidding as low as they could to ensure that they maximised their generation volumes. This effectively created underlying nodal prices in central and north QLD of -$1,000/MWh. If some form of constraint support pricing or nodal pricing were in place, then these generators would have been paid, at the margin, -$1,000/MWh. Clearly if this were the case, then these generators would not have behaved in this way. But how do you determine a priori the set of constraints belonging to a CSP regime?

2.5 "Pinch Points"

Is it possible to determine a small set of critical constraints that correspond to 'pinch points' that will manage most of the congestion in the market, or is this an illusory goal?

Conceptually, a simple radial network could be considered to have a few pinch points related to thermal limits, but as a network becomes more meshed and has more loops then this may not be the case. Further, with new network investment directed towards transmission enhancements that would deliver the greatest benefits, one would expect that over time many of the obvious 'pinch points' would be removed. This would leave a few 'pinch points' and many transitory constraints that bind sporadically. Many of these sporadic constraints would relate to network outage conditions.

In the case of the NEM, even though we have a relatively simple radial regional pricing/settlements model, the actual NEM transmission system has many loops and parallel paths. Many of the NEM's constraints are not just in place to manage simple thermal limits but to manage voltage or transient stability limits. Most of the NEM's limits and hence constraints are driven by credible contingencies for various network states (system normal or outage conditions) and hence there could be a large number of constraints that could bind at some stage and have a material impact on the market dispatch of plant. Does it matter if the large number of constraints that bind only occasionally are not included in a congestion management regime?

2.6 "Picking Winners"

There may be some problems if an approach of just selecting a small subset of constraints for a congestion management regime is pursued. For example, in section 0, the impact of the central to south QLD limit was discussed. Suppose, the constraint Q_CS_1900 were to be selected to be part of a congestion management regime but the constraints which are used to manage central QLD to north QLD limit are not included in the regime. Then it would be quite possible to have a situation where flows out of central QLD were binding in both the north and south directions. In this case the regional reference price might be $300/MWh, the shadow prices for the southward constraint (Q_CS_1900) be

$260/MWh and the northward constraint $350/MWh. This would give the underlying nodal prices for south east QLD of $300/MWh, central QLD of $40/MWh and north QLD of $390/MWh. However, if only the central to south QLD constraint were implemented in the congestion management regime then the generators in north QLD would only get paid $40/MWh rather than correct price of $390/MWh or the regional reference price of $300/MWh. In this case the price signal to the northern generators is much worse than would have been the case if no constraint support pricing regime were implemented.

The reason for this undesirable outcome is the fact that some generators stand to benefit from a constraint support pricing regime for some constraints and lose on others and if only some constraints are part of the regime the wins and losses don't get netted appropriately.

This simple example illustrates the care that will need to be exercised in choosing constraints for inclusion in a constraint management regime if not all constraints are automatically included.

2.7 Conclusion

Presently, there is a large number of system security constraints in the NEM with many new constraints being added each month. These two facts, combined with the observation that most of the binding constraint hours are from constraints that do not persistently bind over many months, suggest that it will be difficult to set up an effective congestion management regime that focuses only on a small proportion of constraints. In fact, it would probably be more satisfactory in many ways to have all security constraints incorporated into a congestion management regime. If this were done then the result would be effectively the alternative congestion management regime suggested by the Commission, where generators are settled according to nodal prices and customers according to regional (zonal) prices.

3 Constraint Formulation and Effectiveness

3.1 Constraint Form

In the Commission's discussion on constraint formulation in sections 4.1 and 5.3.3 of the issues paper argues that, if an alternate formulation to the option 4 form were to be used, then either the risk of a network limit being exceeded would increase, or the safety margin would need to be made more conservative, hence reducing the effective network capacity. Either way, the system would be worse off with a non optimised form of the constraints, provided the incentives in the market were such that they encouraged generators to offer prices at which they are willing to generate.

While IES agrees with the Commission's proposition, we would state that the solution need not be restricted only to option 4 style constraints; a full network model can be used to achieve the same outcome. The only requirement is that the dispatch engine be formulated to optimise all dispatchable terms.

3.2 Limits and System Security

The other aspect of constraint and limit formulation that is not addressed in the Commission's issues paper are the inefficiencies in the process of determining TNSP limits and, from these limits, constructing the constraints that will be used in NEMDE.

Both the creation of the generic constraints used to manage system security and their operational use have been problematic areas for the NEM. There have been issues of safety margins, power system modelling, statistical estimation of limit parameter values and determination of which variables should be included in the limits and constraints, the formulation of the constraints to be used in the dispatch engine (NEMDE), the determination of which constraints should be used (invoked) for particular dispatch intervals and so on.

The debate about whether to adopt option 4 constraints only addresses some of the inefficiencies in the overall process of developing and implementing security constraints. It overlooks the point that the current process is probably developing a number of sub optimal constraints. When IES investigated this area for the Reliability Panel and NECA, we estimated that there could be significant benefits to the market in terms of greater utilisation of the network if a better approach were adopted. A better approach to developing limits and constraints would in turn reduce network congestion for the same network capacity.

Two of a number of ways in which the constraint development process could be improved are:

a) Making it easier to develop efficient limits and constraints within the current paradigm of developing constraints and limits well ahead of dispatch time by using an explicit (full) network model in NEMDE; and

b) Developing alternative approaches to constraint determination by which some or most constraints can be developed automatically, immediately before the 5 minute dispatch when the system state is known.

3.2.1 Explicit network model

The current approach to modelling the transmission network in the NEM is one of an implicit network model. Intra-regional flows are not modelled. That is, physical flows on the network are not modelled other than in terms of interconnector flows and even these flows can sometimes be composites of physical flows on a number of different transmission lines.

On the other hand, in an explicit network model, all key transmission line flows are modelled explicitly. That is both inter-regional and intra-regional transmission line flows are modelled explicitly. They are modelled as decision variables in the optimisation.

A large number of network limits in the NEM can be described succinctly as limits on flows on transmission lines or cut sets of transmission lines. An explicit network model would enable them to be modelled directly and in a form that would more closely match the security issue being managed. On the other hand, if an implicit model, like that presently used in NEMDE is used, then intra-regional or hybrid flow constraints can not be simply described in terms of constraints on network flows. They can only be expressed in terms of the dispatch of different generating units, interconnector flows and regional demands. It is not always easy to do this satisfactorily as assumptions have to be made regarding the geographical distribution of regional demand across nodes and the impact of generator outputs on flows on various network elements. Given the uncertainties regarding some of these assumptions, safety margins need to be added.

In conclusion an explicit network model, relative to current implicit one, is likely to:

- reduce the safety margins in some constraints without adversely affecting system security;
- allow constraints to be more easily modelled and more transparently expressed;
- provide participants with greater ability to review and comment on proposed constraints; and
- probably reduce the number of constraints required to manage the system because some limits on flows may not need to change under outage conditions yet the implicit form of the constraints would have to.

3.2.2 Developing constraints in near real time

An alternative approach to constraint generation/formulation is one that does not require all constraints to be developed well before the five minute dispatch. Such an approach would develop them on the fly and overcome the problem of having to develop constraints a long time in advance of the actual dispatch, which, in turn, inevitably leads to constraints being more conservative than necessary at the time to ensure system security.

The reason for this is that constraints developed well ahead of dispatch time must allow for a host of conditions that may or may not apply; consequently to achieve the same level of system security they must be more restrictive than a constraint developed specifically for the actual system conditions at the time. Thus NEM efficiency would be improved if NEMMCO could efficiently generate many of these constraints closer to real time. However, since this work is more of an R&D nature we would not expect NEMMCO to undertake this approach in the immediate future.

3.3 Efficiency of Dispatch

IES has investigated how constraint support pricing might affect some generators using 2005 data. It was observed that if all constraints were to be included in a CSP regime, then on average some generators would have earned significantly below their regional reference price and others would have earned significantly more. Even though the numerical amounts depend on how constraint shadow prices are capped[3], they suggest that a CSP regime would result in changes to generator behaviour at the margin, particularly on occasions like that of the 7th December 2005 (discussed in section 0).

3.4 Efficiency of Investment

IES regularly provides advice to investors and bankers regarding new generation investments. From our discussions with these players and our previous analyses of price outcomes that could occur with a constraint support pricing regime (or nodal pricing regime) we believe some investors would change their investment decisions in terms of generator locations and possibly plant types.

[3]How violation penalties and shadow prices would be managed in a CSP regime is an area that would require considerable thought. Should the shadow prices be capped at Voll when a constraint is violated? Possibly, but there is the issue of constraint scaling that would need to be addressed. Perhaps a more suitable approach would be to ensure that no generator receives a price for energy that is less than -$1000/MWh or higher than Voll. This could be done using an approach somewhat akin to the Voll scaling approach currently used in the NEM.

4 Risk Management and Transparency

The Commission, in its issues paper, has raised the important issues of risk management and transparency in the physical and financial markets.

4.1 Physical market

4.1.1 Provision of dispatch information

One of the key principles adopted in the NEM to allow participants to manage their physical risks has been to provide information ahead of dispatch time and to allow participants to adjust their bids in light of this information in order to optimise their dispatch. The other key principle has been near real-time ex-ante pricing as opposed to ex-post pricing. The ex-ante pricing has allowed participants to be reasonably assured of the price they will be paying or be paid before the dispatch interval is complete.

If a CSP regime were adopted then the logical extension of this approach would be to provide, at the same time as when the five minute dispatch prices are published, pre-dispatch information on which constraints are to be invoked together with their projected shadow prices, and to provide real-time information on which constraints were invoked, also with their shadow prices.

However, even if this information were to be provided in a timely manner, it may still be difficult for generators to quickly assess what the implications would be for their generation portfolios. For instance, there are currently 820 constraints that involve Snowy plant in either the left hand side or the right hand side, 4070 for Delta and 1790 for Enertrade. Consequently, it may be better to provide generators with an effective connection point price that takes into account the impact of all constraints that are involved in a CSP regime.

4.1.2 Predictable application of Congestion Management Regime

The other important aspect of risk management of CSP in the physical market would be a clear and predictable process of determining:

a) which constraints would be included in a CSP regime and

b) how new constraints or revisions of existing constraints would be treated.

Participants would generally prefer to face market risk rather the regulatory risk, all other things being equal.

Further the process of determining and formulating constraints should be open and transparent with interested parties being able to input into the process.

4.1.3 Congestion information for new investments

In order for investors to choose the best locations for new plant, information about the impact of congestion management on the effective spot prices for different locations needs to be available. Perhaps NEMMCO could produce nodal spot prices for all bulk supply points in the NEM based on the constraints subject to constraint support pricing. NEMMCO and the TNSPs may also need to work together to give a view of which locations may be affected by future congestion management.

4.2 Financial market

4.2.1 Hedging Under CSP

The main problem that any congestion management regime will cause from a financial market perspective is that of locational price risk. Generators may face the situation of their contracts being referenced to the regional reference price yet they are being paid a price which approximates a nodal price. Providing a mechanism that will assist in managing this source of basis risk will be critical to the success of any congestion management regime.

Thus if CSP is pursued, then some form of constraint support contracts or financial transmission rights that allow generators to access their regional reference prices will be critical. However setting up some sort regime will not be easy. Will it be firm or not? Will generators be vested or not?

4.2.2 Improving the Existing Inter-regional Regime

The Commission's paper raises several issues relating to the operation of the existing inter-regional hedging regime; namely:

- Future treatment of negative settlement residues.
- How inter-regional hedges can be firmed up to promote longer-term contracting and associated scope for improving investment efficiency.

Negative settlement residues on some inter-regional links have been a problematic feature of the NEM. They arise for two basic reasons. First, there is a complex interaction between the NEM zonal model, the action of generic constraints and the NEM pricing rules that sometimes leads to power flows going against the price difference, therefore giving negative residues. However, such negative residues can arise on some links even in a nodal model without zonal approximations; in this sense they are inherent in a market such as the NEM.

Since NEMMCO has had no means to deal with the financial consequences of negative residues it has acted to remove them if they tend persist, using mechanisms that modify the dispatch in ways that inevitably lead to a loss of dispatch efficiency as well as a redistribution of dispatch income in ways that are essentially arbitrary. A group of generators has recently proposed that NEMMCO need not intervene in the case of a specific set of links (VIC/Snowy/NSW) as long as the surplus on one link is used to offset the negative residue on the other, which, it is argued, will always be sufficient.

If the possibility of negative residues are inherent in a market such as the NEM, a long term solution is required. Nodal pricing theory confirms the possibility of negative residues on some transmission elements, but also confirms the result that, overall, the network should generate a surplus[4]. The solution proposed by the generators and described above therefore has some theoretical support; however, the zonal model and pricing rules of the NEM complicate matters so that the general application of this approach would require more detailed investigation to ensure financial adequacy. A further complication is how the auctioned residue stream would then be allocated to TNSPs. As this allocation is not a major driver for TNSP efficiency, the issue boils down to one of inter-regional equity in network pricing and some solution should be possible, although not necessarily easily arrived at.

The next issue considered in the AEMC paper is more central; how to firm up the auctioned inter-regional revenue streams. After 8 years of NEM experience, it may be time to re-visit some of the original proposals for inter-regional hedging in the NEM which caused widespread debate prior to, during and after the NEM started. The simplest approach could be for NEMMCO to auction near-firm inter-regional hedges up to some "normal" or "safe" capacity, to be determined from studies. By near-firm, we mean that NEMMCO would guarantee to pay out up to the limit of the pool of money available to it. Thereafter, any shortfall would be dealt with by suitably reducing payouts in some way, as is done in the US PJM market. The available pool of money would essentially be the total of the auction income over the period plus any unhedged revenue, or some fraction of that to be determined. In any case, any profits or losses from auctioning the hedges would not have a significant efficiency or financial impact on the TNSPs as this income is netted out of their regulated rate-of-return calculations.

It should be noted that firming up the income stream from these inter-regional instruments would immediately increase their value to market participants and their auctioned value relative to the present. A useful addition would be to implement some form of "causer pays" incentive to the TNSPs to encourage them to schedule their outages away form critical periods if possible. Not all inter-regional constraints are under TNSP control, however, so such a regime would need to be carefully implemented.

[4] There are special cases such as widespread negative prices that would need to be accounted for.

5 Conclusions

This submission has addressed a selection of the issues raised in the AEMC's congestion discussion paper, together with some important additional ones not discussed in the paper. The main conclusions are:

- There a great many practical and possibly insurmountable difficulties that need to be addressed in detail before implanting a general Constraint Support Pricing (CSP) regime.
- The AEMC should also consider the possibility of squeezing more out of the existing network by improving procedures under the existing rules, or with only minor changes. These include:
  - Making it easier to develop efficient limits and constraints within the current paradigm of developing constraints and limits well ahead of dispatch time by using an explicit (full) network model in NEMDE; and
  - Developing alternative approaches to constraint determination by which some or most constraints can be developed automatically, immediately before the 5 minute dispatch when the system state is known.
- There appear to be potentially viable ways of dealing with the negative residue issue in the longer term and also firming up the hedging capability of the inter-regional revenue stream. However, these should be considered in the context of how hedging will be carried out under a CSP regime, if such a regime is to be implemented.