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Network Congestion and Wholesale Electricity Pricing in the Australian National Electricity Market: An analytical framework for describing different options

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Caveat

This paper has been prepared by Dr E. Grant Read, working for the AEMC, in interaction with AEMC staff. Dr Read is head of EGR Consulting Ltd, Adjunct Professor at the Department of Management, University of Canterbury, and a Senior Consultant with CRA International. In this last role, he was extensively involved in development of the CSP/CSC proposals discussed in this report, and more recently in correspondence with Dr Biggar with respect to his criticisms of that work, both before and after publication of his October 2006 paper on Constraint-Based Residues (CBR).

As noted in Appendix A, a number of points remain in dispute between Dr Biggar and CRA. Some of these relate to the accuracy of the claims made by each party and, in such matters, Dr Read freely acknowledges that his view, which is inevitably reflected in this report, coincides with that of CRA. In other respects, though, Dr Read also freely acknowledges that the earlier CRA work may have been poorly understood or presented at the time, and was partly designed to address issues that may not be critical in the current context. Thus, while no final judgement is attempted here, the attempt has been made to note the strengths and weaknesses of the two approaches in an even-handed manner, and to propose a path towards integrated and/or hybrid approaches that may be better suited to the current situation.

Some elements of subjectivity may be expected to remain, though and, while gratefully acknowledging input from Colin Sausman and Tendai Gregan of the AEMC, and from Dr Biggar, Dr Read takes full responsibility for any remaining bias, and for any other errors or omissions in the report. Still, this document is supplied solely for the purposes of facilitating discussions within the industry. Neither the author nor EGR Consulting Ltd, the AEMC or CRA International, make any representation or warranty as to the accuracy or completeness of the document, or accept any liability for any omissions, or for statements, opinions, information or matters arising out of, contained in or derived from this document, or related communications, or for any actions taken on such a basis.

Executive Summary

1. This report describes a range of options for amending the current NEM pricing and settlement arrangements to create an improved congestion management framework, using a uniform framework and common terminology. We focus particularly on the CBR proposal recently advanced by Dr Biggar, and the CSP/CSC proposal developed by CRA over a series of papers prepared for NEMMCO, and the MCE.

2. These options revolve around how congestion prices (CPs) are set and how congestion rents are allocated. We develop a general framework, and place the options in context by first describing how the status quo NEM market design sets congestion prices and allocates congestion rents. We then move on to describe those mechanisms themselves, in general terms.

3. The approach taken here is not to compare integrated ”proposals”, such as the CSP/CSC, or CBR proposals, as they may have been presented by their respective proponents, but rather to describe and compare the alternative “approaches” implicit in those proposal documents. Accordingly, we have tried to “unpack” those proposals into their essential components, identify common elements, and describe the application of those elements to particular participant groups using new, ‘clean’ terminology.

4. The intention is to describe and identify key design options for consideration, and to point out their implications, without making any final recommendations. Our conclusions are summarised in Chapter 10. Different approaches would seem to be appropriate for different participant groups or situations, within they same broad mathematical and philosophical framework. In each case, though, a Constraint Rental Fund (CRF) would be created for each constraint involved in a CP-based congestion management regime. The fundamental issues are:

   - Which constraints, if any, should be “managed” in this way?
   - Which parties should be “exposed” to CP in those managed constraints?
   - Should rights to the rentals in the associated CRFs be assigned:
     - implicitly (ex post) to match dispatch, as at present;
     - by an “auction” process akin to the SRA, as proposed by Dr Biggar;
     - by an allocation or negotiation process, as proposed by CRA; or perhaps
     - by some hybrid methodology?

5. For simplicity, many discussions in this report refer to various participant groups, generically, as being exposed to CP, and involved in the various mechanisms discussed. But it should be stressed that the intention is NOT to imply that all parties of a particular style must necessarily be involved in whatever regime(s) might ultimately be allowed for in the market design, or that these arrangements would necessarily apply with respect to all constraints in which any particular

party was involved. The intention is merely to describe the characteristics of mechanisms which could be employed selectively to deal with situations in which they are deemed to be appropriate, for whatever period seems appropriate.

6. Specifically, we examine how each congestion management regime might be applied to the treatment of each of the following groups involved in NEM constraints, in turn:

- interconnectors;
- generators;
- ancillary service (NSCS) providers;
- network service providers (TNSPs); and finally
- loads.

7. With respect to interconnectors, we conclude that a CSP/CSC style mechanism would involve minimal disruption to the status quo, involving only re-processing of the IRSR in the settlements system to form firmer inter-regional hedging pools, which could then be auctioned via the current SRA process. This could be considered as a stand-alone proposal. A CBR style approach would involve rather more change, because it would partition the rents in the current IRSR between a number of CRF pools, one for each constraint form which might possibly apply, and the SRA process would have to be extended to include buy/sell auctions for each such pool. The result would be more flexible than under the CSP/CSC scheme, but participants would face greater complexity, with the number of CRF pools potentially being quite large.

8. With respect to generators, either CBR or CSP/CSC could be used to formalise intra-regional access arrangements, and/or the provision of "constraint support", but the regime would probably also involve interconnectors, as above. This would involve a more significant change to the status quo, in that CRF pools would be introduced for each managed constraint, with payments required from/to these pools by generators as well as interconnectors:

- The CBR proposal would simply auction those pools to parties wanting to obtain both intra-regional and inter-regional hedging. This creates great flexibility, but participants (or agents) would face significant complexity, and CRF auctions would need to be constructed so as to allow both purchase and sale of constraint rental rights by participants.

- The CSP/CSC proposal simplifies this situation by first partitioning each CRF between intra-regional and inter-regional pools, then auctioning bundled inter-regional hedges, via the current SRA process. This regime would probably also bundle CRFs to form simpler intra-regional hedging instruments, and allocate long term rights to participants, particularly where they have negative value and/or market power is of concern. But flexibility would be reduced by an ex ante agreement on inter-regional/intra-regional partitioning, and because bundled intra-regional rights would not be readily traded.

9. With respect to NSCS provision, we conclude that a CSP/CSC approach could be applied, and would have the advantage of aligning incentives with market values, and firming the hedging available to participants. This could be considered as a stand-alone proposal, irrespective of whether a similar approach is also applied to generators or interconnectors.

10. With respect to TNSPs, we conclude that CSP/CSC style arrangements, perhaps involving only "partial exposure" to CP, could be applied to improve TNSP incentives with respect to capacity provision. This would have the advantage of aligning incentives with market values, and firming the hedging available from the CRF pools involved, and could also be considered as a stand-alone proposal.

11. With respect to loads, we note that exposure to CP would effectively imply introduction of locational pricing for all load. We understand this to be unacceptable, which implies that neither intra-regional nor inter-regional hedging can be made fully firm for traders. There are situations, though, in which particular loads might wish to be involved in supplying "network support" via negotiated CSP/CSC style arrangements.

12. This report does not make any overall recommendation with respect to acceptance of either the CBR or CSP/CSC proposal, in to. Given the fundamental compatibility between these two approaches, many hybrid proposals are possible, and may be superior. But, given the costs involved we would not recommend wholesale application of any such scheme, at present.

13. But the CP-based framework developed here can be used to describe and assess the impact of a wide variety of options. It also provides a consistent theoretical and philosophical framework within which mechanisms can be readily developed to deal with particular congestion management issues and situations. Several of those mechanisms seem likely to deliver significant value without any major or widespread disruption of the status quo.

14. Much of this merely systematises proposals made previously, but we have also identified some new alternatives that can be described in the same general framework, and which seem worthy of further consideration:

    - First, there may be merit in re-defining the Regional Reference Price applying to loads to be a "Regional Load Hub" price, and possibly defining a similar "Regional Generation Hub' for generators, as discussed in Appendix B. At least conceptually, this would allow the debate about intra-regional access to be simplified by separating the treatment of: locational access for load from that of locational access for generation; and of generic intra- and inter-regional hedging.

    - Second, there may be merit in generalising the current SRA process, and the auction/trading processes to allow simultaneous trading with respect to inter-regional, and possibly intra-regional, hedges, in a single "Integrated Network Based Auction" (INBA). This need not imply any greater complexity for participants, but would combine the relative simplicity of CSP/CSC (from a participant perspective) with the flexibility of CBR. This is effectively how FTRs are bought and sold in nodal markets elsewhere.

CONTENTS

1 Introduction

1. The purpose of this report is to describe the options for amending the current arrangements for pricing and settlement in the NEM as part of an amended congestion management framework, using a uniform framework and common terminology, with a view to:

   - Clarifying the elements which they share in common;
   - Identifying how they differ, and how they would apply to various participant groups; and hence
   - Highlighting some of the issues which would need to be considered in deciding whether any of these options should actually be implemented.

2. We will ignore various aspects that may be described as partial "fixes" for congestion management problems, as discussed in Gregan and Read (2008)[1], and will only consider options based on "congestion prices". We discuss how these are set and how congestion rents may be allocated. And we place the various options in context by first describing how a "pure" NEM market design status quo sets congestion prices and allocates congestion rents. We will refer specifically to two broad approaches which have been proposed by different parties, namely:

   - The CBR proposal recently advanced by Dr Darryl Biggar in Biggar (2006);[2] and
   - The CSP/CSC proposal developed by CRA over a series of papers prepared for NEMMCO, and the MCE, most notably CRA (2003b), (2004c) and (2004a);[3]

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[1] Tendai Gregan and E. Grant Read, *Congestion Pricing Options for the Australian National Electricity Market: Overview*, Paper for the Australian Energy market Commission, February 2008. Available http://www.aemc.gov.au.

[2] Biggar (2006) Solving The Pricing and Hedging Problems in the NEM Using "Constraint-Based Residues By Dr Darryl Biggar 25 October 2006, Released by the AEMC in March 2007

[3] Adopting and extending the referencing convention in Biggar (2006), we will refer to the following papers, most of which are available on the MCE or NEMMCO websites:

CRA(2002) Network Constraint Formulation: Impact on Market Efficiency Released by the National Electricity Market Management Company of Australia, January 2002.

CRA(2003a) Constraint Orientation: Principles and Pricing Implications. Released by the National Electricity Market Management Company of Australia, March 2003.

CRA(2003b) Dealing with NEM Interconnector Congestion: A Conceptual Framework. Released by the National Electricity Market Management Company of Australia, March 2003.

CRA (2004a), NEM Regional Boundary Issues: Theoretical Framework, Released by the Ministerial Council on Energy September 2004.

CRA (2004b), NEM Transmission Region Boundary Structure. Released by the Ministerial Council on Energy, September 2004.

CRA(2004c) NEM Interconnector Congestion: Dealing with Interconnector Interactions. Released by the National Electricity Market Management Company of Australia, October 2004

CRA(2004d) Review of NEM Transmission Region Boundaries: Consultation Draft Presented for MCE on 19&20 October 2004.

CRA (2005), Constraint Support Pricing: Implementation of Snowy Proposal, Report to the National Electricity Market Management Company of Australia March 2005.

3. The report necessarily discusses the motivation behind some of the concepts introduced here, and identifies some of the positive and negative implications of adopting particular options. But it does not attempt to assess the materiality of either costs or benefits. Thus it does not make any definitive recommendations Nor is any detailed consideration given at this stage to some important issues such as:

   - The impact of losses,[4] or situations where offers are tied;
   - The involvement of MNSPs in any of the regimes discussed;[5]
   - The practicalities of allocating "rights" in regimes which require such allocation;[6]
   - The practicalities of re-allocating "rights" in situations where the market or network structure changes as a result of boundary change, or transmission system development;
   - The practicalities of implementing the market-clearing and/or settlements system required by some of these options; or
   - The impacts on incentives for affected participants, and hence on market efficiency.

4. It should be recognised that there are unresolved differences between the work of Dr Biggar and CRA. In part Biggar (2006) presents a critique of, and offers an alternative to, CRA's CSP/CSC proposals. CRA accepts the potential value of the CBR proposal, and considers the underlying mathematical analysis to be sound. But CRA does not agree with the aspects of Dr Biggar's representation of the CSP/CSC proposal, and does not believe that his mathematical analysis entirely supports the conclusions drawn with respect to either CSP/CSC or CBR. CRA is also concerned that the paper uses terminology in a way which differs so much from CRA's usage of the same terminology, and from its understanding of industry usage, that confusion is likely to ensue.

5. The areas of disagreement are briefly summarised in Appendix A. But the purpose of this report is to describe and compare the underlying "approaches" implicit in each proposal rather than to analyse the detail of particular implementations of each approach in the two proposals. Accordingly, we have tried to "unpack" the proposals into their essential components, identify common elements, and describe the application of those elements to particular participant groups using new, "clean" terminology.[7]

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4 See discussion in Section 3.7.

5 Although one of the examples considered by CRA (2004c) did involve an MNSP.

6 We will use the term "allocating" to imply a process where some party determines the allocation of rights to a pt, with or without negotiation. Somewhat arbitrarily, we will refer to "assignment" of rights in other contexts, where that assignment could occur by way of allocation, but might equally result from an auction process, for example.

7 Necessarily, though, developing a mathematical framework and terminology which is internally consistent has involved making judgments with respect to some of the matters listed as being in dispute

6. Specifically, in Chapter 2, we start by introducing the general terminology we will employ to describe the various options for managing congestion. We then apply that terminology to provide a "base-line" description of the status quo in terms that will allow comparisons to be drawn with the other options under consideration. In Chapter 3 we discuss the nature of the risk management problem. The underlying concepts are necessarily mathematical, but we explain the concepts verbally, and illustrate with simple diagrams and examples, making only limited use of mathematical notation.[8]

7. In Chapter 4, we describe the mechanisms themselves, in general terms. We then move on to examine how these concepts might be applied to change the status quo treatment of the following groups of constraint terms, or involved parties, and the interactions between them:

- Interconnectors (Chapter 5);
- Generators (Chapter 6);
- Ancillary service providers (Chapter 7);
- Network service providers (Chapter 8); and finally
- Loads (Chapter 9).

8. Our conclusions are briefly summarised in Chapter 10. It will be seen that there may be good reasons why somewhat different approaches might need to be taken to different participant groups or situations, within they same broad mathematical and philosophical framework. And it will be suggested that a hybrid approach may be developed to capture the best features of both approaches.[9]

9. Finally, Appendix B describes the application of some of these concepts to deal with other actions which may be taken to deal with congestion, including shifting regional reference nodes or boundaries, and/or changing the Regional Reference Price definition.

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in Appendix A. We have endeavoured to take account of the arguments and claims advanced by various parties, but accept that our judgements will most likely be disputed. Our conclusions should thus be treated with some degree of caution, as noted below.

8 We do not attempt to provide a general algebraic framework. And, while the claims made here are based on considerable experience with mathematical analyses of alternative ways of addressing the situations described here, they are all subject to confirmation via a more thorough analysis. Some tentative hypotheses are specifically identified in this regard.

9 Further discussion, and application to NEM situations, may be found in Gregan and Read (2008).

2 Conceptual Framework

2.1 Introduction

10. This chapter introduces the general conceptual framework and terminology we will employ to describe all of the congestion management options considered here, and applies it to describe the status quo. Later chapters move on to describe alternative congestion management mechanisms using this framework, and then describe their application to various participant groups.

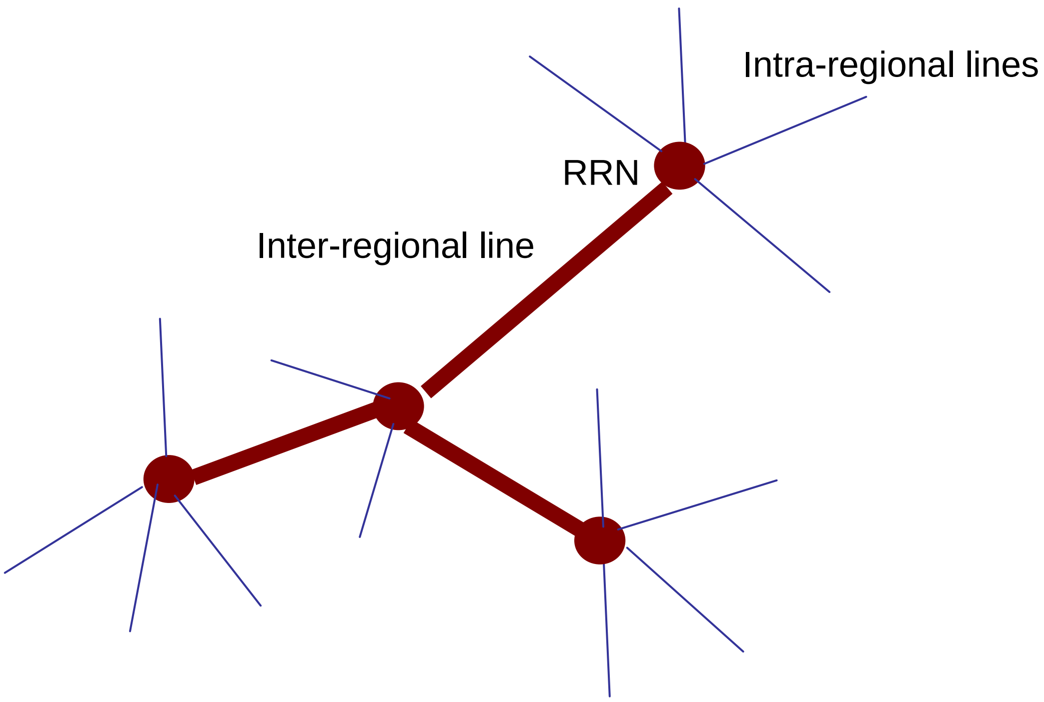
2.2 Basic NEM market design

11. The NEM may be described as having a zonal "hub and spoke" market design, as in Figure 2.1 Irrespective of network realities, it is assumed that no loops are formed between the hubs, and that a clear distinction can notionally be drawn between intra-regional and inter-regional trading. Conceptually:

- All intra-regional trading occurs at the Regional Reference Price (RRP), which is defined to be the marginal cost of meeting load at the Regional Reference Node (RRN); and

- All inter-regional trading occurs across notional links directly joining adjacent Regional Reference Nodes, and hence incurs a per-unit cost measured by the difference between their respective Regional Reference Prices.

Figure 2.1 Basic NEM Structure



12. These "notional links" are a simplification of the actual underlying physical network. The dispatch of the market is subject to the actual physical limitations of the network and physical laws governing electrical flows. The network constraints used for dispatch are designed to enforce the physical limitations of the network, but in such a way as to produce prices which are consistent with the notional "hub & spoke" network structure used to price and settle the market on a regional basis.

13. Congestion management relates to the physical network, but is manifested in the notional network used in zonal markets. The physical network does not generally match the notional design. The difference between the physical and notional networks can result in dispatch and/or pricing outcomes appearing to be inconsistent with the notional network, whereas on closer inspection, they are entirely consistent with the underlying physical network and its limitations.

14. Like most electricity markets, the NEM is cleared using a Linear Programming (LP) model, called NEMDE. Such models always maximise some objective, in this case the value of trade, under a set of "constraints", defining the limits of feasible behaviour.

15. Our concern here is only with network constraints; that is with constraints which impact on the energy transfer capacity of the transmission network that enables participants to trade with one another. NEMDE contains many other constraints which represent, for example, energy balances, FCAS supply and demand, or plant/offer characteristics. The first two are already appropriately priced by the energy and FCAS markets. And the latter are not, and should not be, part of the market, because they merely define the characteristics of private facilities, any rents on which accrue to their owners.[10]

16. If the underlying network topology actually matched this notional design, there would only be two kinds of network constraint in the system:

    - Intra-regional constraints defined as bounds[11] on the notional radial lines joining participants to their own Regional Reference Node; and

    - Inter-regional constraints defined as bounds on the notional lines joining adjacent Regional Reference Nodes.

17. In reality:

    - There will be bounds on the actual lines joining adjacent regions, which may imply binding limits on the corresponding notional interconnectors, and can be referred to as Pure Interconnector Limits (PILs); [12]

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[10] The rent on a generator capacity limit, or offer tranche limit, is just the difference between the offer price for that tranche and the nodal price. This rent is not explicitly calculated but, if the market were nodal, it would be implicit in the payments made to generators, and thus accrue to the generation owner. In the long run, these rents pay for fixed costs. The market is not nodal, but the discrepancy between nodal and regional prices is explained by constraint rents, and this is precisely the issue we are addressing here.

[11] That is, as simple constraints of the form Lowerbound <Flow <upperbound, each applying only to the flow on a single (notional) line.

- There will also be purely intra-regional limits, although these are relatively rare and, even if of radial form, can only be expressed as limits on combinations of generation variables[13]; but

- Most limits, when properly expressed, produce "trans-regional" constraints, involving both intra-regional generation and inter-regional flow terms, and are typically of non-radial form. [14]

18. In a nodal market, most limits can be directly expressed as bounds on a particular line flow. The network configuration (or network topology) is defined by the transmission elements (i.e. lines, transformers, capacitor banks, SVCs) switched into service, and the physical characteristics and limits of those elements. In a nodally priced market, a Full Network Model (FNM) is used. In a FNM underlying physical network is directly represented via mathematical equations. These equations directly express the physical and electrical characteristics of each transmission element in service (e.g. voltage level, impedance, etc) and the limits applying to each element. The impact that these limits may imply, in terms of constraining dispatch at more distant locations, is implicitly expressed via the interaction of these line bounds with a very large set of power flow equations. In a nodal market, the impact of congestion at on location of the network on flows on other parts of the network calculated automatically, and the impact is automatically recalculated in the event of any change in the network configuration.

19. But this is not possible in a zonal market like the NEM, because there is no explicit representation of intra-regional flows, since a full network model is not used. Thus the physical limits must be expressed indirectly using what NEMDE calls 'generic" constraint forms. In principle, this requires an explicit constraint derivation to replicate the mathematical structure implicit in a nodal (i.e. FNM) model. Thus the generic constraint form corresponding to a particular limit can be derived by substitution into the equations describing power flows in the network configuration.

20. The network configuration is not the same in all dispatch intervals, and the derived constraint form will be affected by any outage which impacts on the impedance of any element in any loop in which the constraint may be directly or indirectly involved (see Box 3). Thus a single limit can give rise to a very large number of <u>alternative</u> constraint forms. In practice, a modelling system such as NEMDE can only allow for a finite set of such constraint forms, relating to likely outage conditions on significant constraints at times when they are likely to bind. [15]

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[12] Conceptually, there could also be pure non-radial inter-regional constraints, involving several interconnector terms, but are there any examples?

[13] Because there are no intra-regional flow variables in such a model.

[14] For a discussion of these three broad types of constraints, see Appendix C of AEMC 2007, Congestion Management Review Draft Report, AEMC, Sydney, September.

[15] The actual constraint derivation process need not concern us here, but it should be noted that performing this task accurately, for each period, would be a very large task indeed, particularly if there is no underlying nodal model.

21. Still, NEMDE allows for a very large number of alternative constraints, including quite a large number of constraint forms providing alternative representations of the same flow limit. In any particular interval, though, at most one of the alternative forms will be applicable for each limit, and so each NEMDE run will utilise a particular set of simultaneously applicable constraints, thus defining the network configuration for that particular run.[16]

22. The alternative constraint "forms" referred to above are genuinely different alternatives, with different coefficients for the involved variables, and each representing a different network configuration. But it has also been shown that a large number of alternative representations can be generated for any limit, even for the same network configuration[17]. Each of these is equally valid as a physical representation of that limit in that network configuration, but only the representation which is "correctly oriented" with respect to the relevant Regional Reference Node(s) gives the correct Regional Reference Price(s)[18].

23. Thus the basic market design shown in Figure 2.1 is reflected, mathematically, by using appropriately oriented constraints, and we will assume this throughout. But note that this means that creation of a new Regional Reference Node, or shifting the Regional Reference Node in a region, implies a need to 're-orient" all relevant constraints, thus changing the coefficients or "weights" in those constraints, and fundamentally altering the implied definition and assignment of any constraint based rights.[19]

24. CRA (2004a) also claims that, when such a constraint represents a situation within one region, it will only involve terms for participants in that region, and interconnector flows from adjacent regions, and this will be assumed throughout.[20]

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16 This will later be seen to define a specific "instance" of an LP "feasible region".

17 For example the same limit might be expressed by constraining a set of generators "on", or equally by constraining all other generation in a region "off".

18 This theory was developed for intra-regional constraints in CRA(2003a), then generalised to trans-regional constraints in Appendix A of CRA(2004a)

19 See discussion in Section **Error! Reference source not found.** of the Appendix.

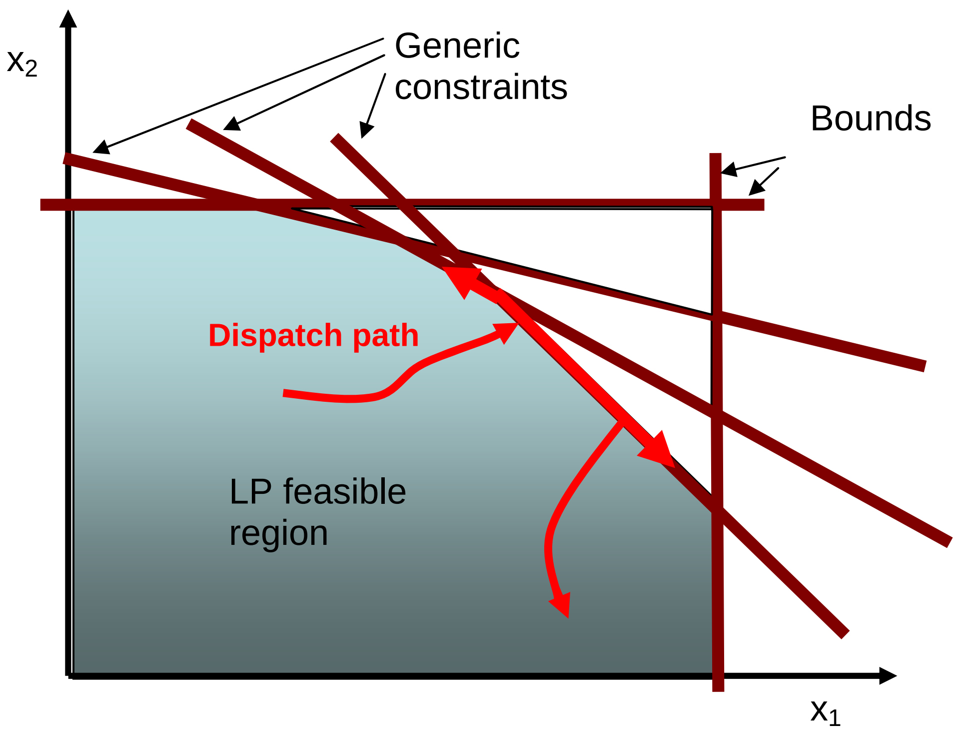
20 This statement applies to what CRA refers to as "NEO effects", that is effects arising as a result of net energy injection at a node, as discussed in Section 7.3. There may be issues with respect to some terms in trans-regional constraints representing more general situations, such as multi-regional stability limits. But these are "non-NEO" effects, as discussed in Section A.3 of Appendix A of CRA(2004a).

2.3 Evolution of the Dispatch

25. If we ignore all of the possible alternative configurations, we can represent the range of dispatch possibilities which are possible with one particular network configuration in terms of a Linear Programming (LP) “feasible region”, defined by the constraints, as in Figure 2.2. Here the two axes represent two dispatch variables, which could be two flows, two generation levels, or one of each, while the constraints represent limits on network capabilities.21

26. In NEMDE, the feasible region is ultimately restricted by the constraint that supply must match demand, but we will represent this by a dispatch point moving, over time, within the “network feasible region” as in the figure. We are concerned with situations such as that illustrated, in which the optimal dispatch point starts off unconstrained, but then encounters a constraint. Having done so it will generally spend some time moving up or down along that constraint, and possibly move on to another constraint, but will eventually become unconstrained again, as shown.

Figure 2.2 LP Feasible Region



[21] In reality there are thousands of such variables, giving the feasible region thousands of dimensions, and thousands of constraints representing limits on each offer tranche, for example. But these two-dimensional diagrams will suffice to illustrate the key points.

27. For the dispatch path shown, there will be no constraints binding at first, and hence no positive constraint shadow prices22. But whenever a single constraint binds, there will be one positive shadow price, and there will be two positive shadow prices when the dispatch lies at the corner point, where two constraints bind[23].

2.4 Constraint Representation and Pricing

28. The constraints in an LP model like NEMDE can be expressed in the general form[24]:

Weighted sum of variable terms ≤ - *Weighted sum of constant terms*

29. The weights in this constraint inequality can be positive or negative, depending on whether a particular term adds to, or subtracts from, congestion. But we have multiplied the weights on the RHS of the equation by -1, so that we can form simple sums when these terms are shifted from the RHS to the LHS of an equation, or vice versa, as will occur in all of these CP-based schemes. The constraint may look more natural expressed in the following equivalent constraint form:

Weighted sum of variable terms + *Weighted sum of constant terms* ≤ *0*

30. Traditionally the *weighted sum of variable terms* is referred to as the "Left Hand Side" (LHS) of the constraint. Some market models include load as a dispatch variable.[25] But NEMDE treats (almost all) load as non-dispatchable. Thus the only terms occurring on the LHS of this equation are generation levels and interconnector flows.

31. Of course a w*eighted sum of constant terms* just defines a constant, and what we have referred to here as the "*-weighted sum of constant terms"* is more normally referred to as "the constant term", or just the "Right Hand Side" of the constraint, RHS_k. But our more general expression will be useful in what follows.[26] Specifically we will assume that the RHS is made up of a sum of terms representing:[27]

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22 See later discussion with respect to the conditions under which it can be assumed that these prices are positive, not negative.

23 More generally, in an N-dimensional feasible region, there can be up to N constraints binding simultaneously, and hence N positive shadow prices.

24 The "weights" referred to here are more commonly referred to as 'coefficients" in LP terminology, and generally represent "shift factors" in power flow terminology.

25 Most markets employing such models also apply nodal pricing to loads, but this need not be the case. Conversely, nodal pricing can be applied to loads even if they are not treated as dispatch variables.

26 To be clear, though, neither this re-arrangement, nor anything else in this report is meant to imply that any change should be made to the dispatch process, to NEMDE, or to the representation of constraints within NEMDE.

27 Normally the RHS will be positive, even though, by convention, we have defined it using negative weights. If net injection at a point (G-L) would have a positive weight on the LHS of a constraint, this implies a negative *weight* for L, with the latter defined as a positive quantity. NEMDE will represent load as making a positive contribution to capacity on the RHS of the constraint. That is, increasing load will relieve congestion. Under our convention this is achieved by having (positive) load multiplied by

- "Raw" line capacity;
- Plus or minus load impacts;
- Plus ancillary service contributions.[28]

32. We will use k to index the constraints, and define $INVOLVED_k$ to be the set of all LHS and RHS terms 'involved" in constraint k. When appropriate we may refer to $INVOLVEDVariables_k$ and $INVOLVEDConstants_k$. Thus a more formal mathematical statement of the constraint would be:

$$\sum_{INVOLVEDcariables_k} weight_{ik} * x_i \quad \leq \quad - \sum_{INVOLVEDCons\tan ts_k} weight_{ik} * x_i$$

33. Much of what follows rests on the very basic observation that binding constraints hold with strict equality. Thus for any binding constraint, that is for any constraint which is of interest for congestion management purposes, in a particular trading interval, we have:

Weighted sum of variable terms = - Weighted sum of constant terms

34. The "shadow price" on a constraint measures the marginal cost which that constraint imposes on the market as a whole. We will refer to the shadow price on constraint k as CP_k.[29]

35. The RHS of a constraint can be thought of as defining a resource which is available to the market. If the optimal market dispatch does not need to use all that resource the constraint will not be "binding"[30]. Such a constraint imposes no costs on the market, and thus has a zero shadow price.

36. But binding constraints do impose costs on the market and they will always have positive shadow prices.[31] When a constraint binds, it generates a "Constraint Rent", CR, which measures the market's valuation of the RHS "resource", and is thus determined by:

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weght X (- *1),* ie by a positive factor, since *weght* is defined to be negative.. Similarly, if line capacity is to make a positive contribution to the RHS, its constraint *weight* must be negative (typically -1).

28 More generally still, we could consider a non-linear expression on the RHS, and this would impact on later discussions about the application of constraint pricing regimes to RHS elements. Generalisation should be possible, providing the RHS is a convex function of these three components, but not all results will follow. In particular, statements made here about topics such as revenue neutrality and allocation rest on the assumption of additivity. A convex non-linear relationship would most likely produce a constraint rent component not directly attributable to any one component. But the level of generality assumed here will suffice to clarify concepts in the present context.

29 This has previously been referred to, particularly in the CRA work, as the CSP, which could stand for either "Constraint Shadow Price", or "Constraint Support Price". This ambiguity was not considered to be problematic because, mathematically, the two were identical in the CRA work, which related to pricing "support" for congested constraints. In this broader context, though, the focus is not necessarily on constraint "support", so the "support price" terminology is less appropriate. Also, at one stage, NEMMCO used CSP to mean "Constraint Support Payment".

30 Ie it will be a strict inequality, with Weighted sum of variable terms ≤ - Weighted sum of constant terms

31 See later discussion.

$$CR_k = CP_k * RHS_k$$

2.5 Regional Reference Prices and Pseudo-Nodal Prices

37. By construction, the Regional Reference Node has zero exposure to congestion prices, because it has a coefficient of zero in all constraints oriented to that node. For all other nodes, the CPs can be thought of as describing the impact of each binding constraint on the (notional) "Pseudo-Nodal Price" at each node, as:

$$PNP_i = RRP - \sum_{ALLConstra\,int\,s,k} weight_{ik} * CP_k$$

38. This definition of PNP is a special case of the definition employed by CRA who used it to refer to the prices which participants at particular nodes would effectively be exposed to if involved in a CP scheme.[32] If we make the simplifying assumption that all generator terms are exposed in any managed constraint, we can refer to CRA's more general concept as an "Adjusted Nodal Price" (ANP), defined with respect to a particular set of managed constraints, and note that PNP is just a special case, in which all constraints are managed.[33]

$$ANP_i = RRP - \sum_{MANAGEDConstra\,int\,s,k} weight_{ik} * CP_k$$

39. Since RRP appears in these equations, it might be thought that PNP (or ANP) would change when the Regional Reference Node was shifted. But as discussed in Appendix B, this is not the case, because constraints are "re-oriented" if the RRP shifts. In fact PNP is a property of the node, independent of the chosen RRN. Provided the NEM constraint representation is an accurate representation of the underlying network realities, PNP is equal to the nodal price that would be calculated by a FNM in a nodal market, given the same offers.[34]

2.6 Constraint Rental Allocation and Exposure

40. The major options we wish to consider here all involve assigning the rents calculated for a particular constraint to a "Constraint Rental Fund" for that constraint, CRF_k. This has been variously referred to as a "Congestion Rental Pool" (CRA), or a CBR pool (Biggar (2006)), and may also be referred to as a "CR pool".

41. These options also all involve the definition and allocation of rights to all or part of this CRF, and we will refer to such right, generically, as "Constraint Rental Rights"

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[32] We treat (positive) generation (not load) as "normal", and the price referred to above is the price paid to a generator. A generator with a positive constraint weight in a ≤ constraint will be "constrained off" when the constraint binds, and thus face a PNP which is less than the Regional Reference Price, as in this equation. A load at the same point in the network would have a negative constraint weight, but that does not mean that it would face a higher PNP when the constraint binds. Since load variables effectively have the opposite sign from generation, the equivalent price equation for loads add sa sum of CP terms to -RRP. This defines exactly the same PNP, but as a price paid by, rather than to, load.

[33] In simple examples, we may assume that all binding constraints are managed, and use PNP, not ANP.

[34] And provided the constraint coefficients relate only to the implications of injecting energy at the node, and not to other possible implications of having generation on-line there, such as reactive support or unit inertia. See discussion of "non-NEO effects" in Section 7.3.

(CRRs). Some of the major issues which need to be resolved relate to the ways in which CRRs are defined and allocated under the alternative proposals.

42. The basic CRR concept can be defined in two ways. If we think of CRRs as corresponding to a share of the (rentals attributed to the) RHS capacity, it seems natural to define the volume of the CRR, *CRRV*, in terms of MWs of RHS capacity, whether those be absolute, or scaled in some way. Where distinctions must be drawn, we will refer to CRRs defined this way as RHS CRRs.

43. But for hedging and contracting purposes, it may be more natural to define CRRs in terms of the implications they have for participant MW generation or flow levels. Where necessary, we will refer to CRRs defined this way as Participant CRRs, and use the abbreviation PRR where the distinction is important, while retaining CRR to refer to CRRs defined in terms of constraint RHS MW.

44. These two definitions are entirely equivalent, though35. Thus, if $CRRV_{ik}$ is the volume of the CRR assigned to party *i* in constraint *k*, and $weight_{ik}$ is the coefficient for that party in that constraint, then $PRRV_{ik}$ the volume of the corresponding PRR, is simply given by36:

$$PRRV_{ik} = CRRV_{ik} / Weight_{ik}$$

45. The CRR concept is quite general, but at times we will also need to refer specifically to CRRs defined in terms of a fixed MW level, rather than, say, as a proportion of a CR pool. Since such CRRs are most relevant in contracting with parties such as TNSPs or ancillary service providers who may supply "network support", we will refer to these as Constraint Rental Contract (CRCs) if defined in terms of MW constraint capacity. Thus CRCs are equivalent to the fixed MW CSCs discussed in CRA's original proposal. CRRs defined in terms of a fixed MW level of participant capacity may be referred to as Participant Rental Contracts (PRCs). These two definitions are mathematically equivalent, relating to one another via the CRR/PRR conversion formula above.

46. Other methodologies will be explored later, but the default method of CRR allocation will be to allocate rights, ex post, to exactly match dispatch quantities, such as flow, generation or load levels. We will call this "Implicit Dispatch Matching Allocation" (IDMA).

47. We will refer to the constraint terms to which IDMA applies as being implicitly "protected", because this implicit allocation exactly cancels out any impact of the CP

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[35] There will obviously be an issue here as to which MW value is assumed to be "firm" if the weight varies. But NEMDE treats variation in the weights as creating a different constraint, which means that this only becomes an issue with respect to the definition of "bundled CRRs" under what we will call "configuration uncertainty".

[36] Note that this formula implies an infinite PRR for any party with a zero constraint coefficient. This just means that a participant not involved in a constraint can ignore it completely and, already having "infinite access", has no need for a PRR. Conversely a PRR would have zero value to this participant, once multiplied by its zero weight in the constraint formula.

on those terms37. Conversely, we will refer to the terms to which IDMA does not apply as being potentially "exposed" to the CP. This does not mean that they are not, or can not become, protected, but rather that such protection does not come automatically as a consequence of being dispatched.

48. At least conceptually, rents are collected from all exposed parties, and contributed to the CRF. Specifically, the rent collected from party *i* will be[38]:

$$rent\ collected\ \ from\ i\ \ for\ CRF_k = CP_k * weight_{ik} * x_i$$

49. Formally, we will consider the issue of CRR allocation on a constraint by constraint basis, and group both LHS and RHS terms for each equation into two mutually exclusive sets, $EXPOSED_k$ and $PROTECTED_k$ Each binding constraint can then be re-arranged from its traditional LHS/RHS form, into one that differentiates and groups terms in accordance with the way they are treated financially, in the settlements system, rather than how they are treated for dispatch purposes, by NEMDE.[39] Specifically, we can represent a binding constraint by the following equation:

$$\sum_{EXPOSED_k} weight_{ik} * x_i \quad = - \sum_{PROTECTED_k} weight_{ik} * x_i$$

50. It will often be convenient to refer to the two sides of this re-arranged equation as the "Exposed LHS" and "Protected RHS"40. To be clear, though, neither this re-arrangement, nor anything else in this report is meant to imply that any change should be made to the dispatch process, to NEMDE, or to the representation of constraints within NEMDE. The equation simply represents the treatment of terms in the settlement process. "Exposed" terms face CP, and need to hedge via explicit CRR purchase, or allocation. "Protected" terms face a Regional Reference Price, or Regional Reference Price difference in the case of interconnectors, by virtue of implicit (IDMA) CRR allocation.

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37 Mathematically, we refer to the "terms" being "exposed", although commercially it is really the parties responsible for managing the assets or processes which give rise to those terms. We believe the meaning is clear, and will use the terminology more-or-less interchangeably.

38 Again, since our discussion treats (positive) generation (not load) as being "normal", Positive x_i represents generation, and a generator with a positive constraint weight in a ≤ constraint will be "constrained off" when the constraint binds, and thus should face an effective PNP below RRP. Thus "exposure" means that the generator must pay back rents implicit in settlement at RRPnet.

39 Most of our discussions will assume that each term is either placed on one side, or the other, of this constraint equation. Thus it is either fully protected, or fully exposed. In certain situations, though, it will be useful to allow the possibility of partial exposure to CP. This may be thought of, mathematically, in terms of splitting the term so that a proportion appears on each side. This does not complicate the mathematics much, and may be useful for TNSP incentivisation, for example. And it can also represent the implications of some CRR allocation rules which have been discussed in previous work, in which dispatch outcomes influence, but do not fully determine, CRR allocation., and hence CP exposure.

40 These terms could cause confusion inasmuch as "Protected RHS" might be thought to refer to a subset of the NEMDE RHS terms, which is not the case. Alternatively, we could just refer to the "Protected" and "exposed" sides of the constraint equation.

51. None of the "financial" reform options discussed here implies any need to change any aspect of the NEMDE LP formulation, either. Thus all of these options would only imply changes to settlements systems, and perhaps to external contracts relating to provision of network support ancillary services, for example.[41]

52. Our principal focus here will be on constraints in which at least some terms are exposed to the CP. This is the set of all constraints to which a congestion management regime applies, and we will refer to these as "managed" constraints. Later we will distinguish between active congestion management, intended to relieve physical congestion, and passive congestion management, which simply makes CRF hedges available for participants to manage their own risk exposure.

53. This distinction is fundamental to understanding the difference between the CBR and CSP/CSC approaches. Basically the CBR approach is focussed on providing passive management of congestion by participants, rather than on active contracting to increase constraint capacity. However, the CSP/CSC proposal was originally intended as a mechanism for active congestion management by some party, such as NEMMCO, which would be made responsible for that function. Thus improvements in the ability of participants to manage their own risk positions were seen as a side benefit, rather than being central to the CSP/CSC approach.

54. Partly because of this contracting focus, CRA also defined their CSCs, primarily, in fixed MW terms, and then discussed the possibility that they might need to be scaled if there was insufficient rent to support them.[42] But the CBR proposal was presented entirely in terms of CRRs which were scaled proportionally to match the available CRF. In other words they were defined as fixed proportions, or "shares", of CRFs, rather than in fixed MW terms. We will refer to a "proportional" CRR, as one which is scaled in proportion to the available CRF, while a "scaled" CRR, is one which is scaled to match the available CRF, according to some scaling rule, which need not necessarily be proportional.[43]

55. One other major distinction between the approaches is that CRA discussed the concept of "bundled" CSCs, which were intended to apply across a specified set of alternative constraints.[44] As discussed by CRA, this concept is a little loose, because bundles could be defined in various ways, and contain CRRs of disparate types. Broadly, the intention is merely to describe a"bundle set" containing a bundle of CRRs, each with their own characteristics, but with some rule defining how they are

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[41] By way of contrast, "physical" congestion management mechanisms so involve changing the NEMDE formulation by adding constraints to "force" generation and/or interconnector flow to desired levels.

[42] This being one of the options considered in Sections 5.2 and 5.4 of CRA(2004a).

[43] See the example in Box , for example. We note that Biggar (2006) does not to refer explicitly to "scaled" or "proportional" CRRs, but this seems the most reasonable way to describe a CRR which is defined as a "share" of a variable RHS. If CRRs were defined in fixed MW terms, for example, like the CSCs defined by CRA, they would not be "shares", and the overall CRR allocation would not be revenue neutral.

[44] This concept is also needed to describe the status quo, where the IRSR pool may be taken as an example of a bundled CRF, with bundled CRRs auction via the SRA.

to be combined.[45] The nature of that rule may be problematic, though, and no universally applicable rule has been proposed.

56. Ideally, we would like to define a rule which allows bundled CRRs to have a common "volume" defined in relation to a particular participant, rather than in relation RHS MW of some particular constraint, for example. That is we would like to define a "bundled CRR", or BRR, over the bundle set, by:

$$BRR_i(\,BundleSet\,) = \{CRR_{ik} \,|\, CRRV_{ik} = weight_{ik} * BRRV_i\,, k \in BundleSet\,\}$$

57. The volume here could be defined in general terms, for example as a fixed proportion of all the CRFs in the bundle set. But, if participants want firm hedging[46], this could only be provided if BRRs were defined in terms of a set of CRCs with the same MW value. Thus we could also define a "bundled CRC", or BRC, by:

$$BRC_i(\,BundleSet\,) = \{CRC_{ik} \,|\, CRCV_{ik} = weight_{ik} * BRCV_i\,, k \in BundleSet\,\}$$

58. There are problems with these definitions, though. If fixed proportions are assumed, bundling effectively reduces the dimensionality of the "hedging space". As discussed in 3.6.1, it is just not possible to partition and assign the full hedging capability of the entire network, which may be described by a feasible region in a hedging space with one dimension for each CRF, using such inflexible instruments:

- If the more rigid BRC definition is adopted, it will be found that much of the network's hedging capacity can not be assigned in the form of firm revenue neutral hedges. The extra capacity may not have much value, because it relates to constraints which are not expected to bind, but it must be treated as "non-firm" and/or revenue neutrality abandoned in favour of revenue adequacy[47].

- If the less rigid BRR definition is adopted, it will be found that the network's hedging capacity can be assigned in the form of firm revenue neutral hedges, but it will not possible to trade them without adjusting the proportions assigned to each CRR in the mix.

59. Accordingly, we will continue to use the term "bundled CRR" rather loosely, in some contexts, recognising that the CRRs within a bundle may each scale in proportion to its own RHS, for example, while defining the type of bundle and bundling rule more carefully in contexts where it is important. Thus general references to "bundled CRRs" should not be taken to imply that either of the volume definitions suggested above can necessarily be assumed, or would be workable.

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45 Again, bundling could be applied to CRRs under CBR, too, but this would make it even more like CRA's proposal. We preserve the distinction in order to describe a representative range of options.

46 See discussion in Section 3.3.

47 See discussion in Section 3.5.

2.7 CRR Characterisation of the Status Quo

60. The above terminology can be used to provide a "base-line" description of the status quo in terms which allow comparisons to be drawn with the other options under consideration. [48] This description shows that the CP concept is not really new, and has always been implicit in the market design. Every time NEMDE solves it must, as a matter of mathematical necessity, calculate a CP for every binding constraint.49 Those CP values are applied to determine the optimal dispatch of each dispatched element on the LHS of the constraint equation, and they value the RHS, and hence implicitly all elements making up the RHS.

61. If all network constraints were managed, and all generator terms exposed to CP in those constraints, then generation would effectively face PNP. And if all load were also exposed they would face PNP, too, in which case the NEM would effectively be a nodal market.[50]

62. Such a "solution" is not advocated here, but it is important to understand that, given the critical assumption that participant offers represent costs, this "exposed" structure reflects the true underlying engineering/economic reality of the market. It is driven by the optimal economic dispatch, and exists independent of any market arrangements. And well designed market arrangements will ensure that this structure is properly reflected, at a greater or lesser level of detail, in signals to market participants. Or, if not, market efficiency will be compromised.

63. The framework developed here allows the market to be conceptually stripped down to its bare essentials, and then rebuilt in various ways, one of which is the status quo, and others of which may represent variants on the status quo that may offer better performance in particular situations when there is congestion. Thus the market design task consists primarily of:

   - Determining which participants should be exposed to which elements of the underlying structure.

   - Deciding how explicit CRRs should be assigned to exposed participants.

64. In fact the way in which the market is conceptually re-built is entirely determined by the way in which CRRs are defined, bundled, and allocated to various parties. The methodology employed to allocate these rights thus essentially defines the market structure.

65. When analysed in terms of this general framework, the defining characteristics of the status quo are simply that:

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48 As noted earlier, various aspects of the status quo that may be described as partial "fixes" for congestion management problems, are discussed by Gregan and Read (2008).

49 This is necessary because an LP can not determine that it has found the optimal dispatch solution unless it can verify that it has found the optimal utilisation of each constrained resource, given its marginal opportunity cost, defined by CP.

50 Leaving aside a minor nuance which may arise if constraint coefficients partially represent "non-NEO" effects, as discussed in Section 7.3.

- CRRs are implicitly defined as proportional shares in CR pools;
- CRRs are implicitly bundled into distinct intra-regional and inter-regional bundles, exactly reflecting the balance between inter-regional and intra-regional flows in each dispatch intervals; and
- CRRs are implicitly all allocated ex post, to exactly match dispatch quantities, such as flow, generation or load levels, via what we have called "Implicit Dispatch Matching Allocation" (IDMA).
- The rent from all CRRs allocated to interconnectors forms a single IRSR pool, which is auctioned via the SRA process for hedging purposes.[51]

66. Thus, using the terminology developed here, no party is exposed to the CP under the status quo. We can imagine each participant as facing the nodal price determined by the NEMDE dispatch; that is the price to which they have been dispatched by NEMDE. But, for each constraint in which they are involved, the IDMA regime ensures that they are implicitly allocated an ex post CRR exactly balancing their implicit obligation to pay rents into that constraint's CRF. Mathematically, rearranging the equation for PNP, we see that[52]:

$$CRR\_rent\_under\_IDMA_i = \sum_{AllConstraints,k} weight_{ik} * CP_k = PNP_i - RRP$$

67. For generation, the net effect is that they simply face their Regional Reference Price on whatever dispatch volume they manage to achieve. Similarly, loads face their Regional Reference Price on whatever volume they choose to consume. Although both are aware that they enjoy some ill-defined form of "access" to their local Regional Reference Price, that access has not previously been conceptualised in terms of an implicit allocation of CRRs.

68. But this implicit allocation is what effectively defines the regional structure of the NEM, because the price ultimately faced by a particular participant is determined by the Regional Reference Node to which it receives access, in the form of an implicit CRR allocation. Conversely, fully exposing participants to PNP, by settling the energy market at the RRP, but requiring them to make payments to the CRFs for each binding constraint they are involved in, would be equivalent to removing their current IDMA allocation of CRRs.

69. For interconnectors the situation is a little more complex. Unlike the generators there is actually an explicit "rental pool" for each interconnector, in the form of the IRSR, which is subsequently auctioned via the SRA process. And, if the network topology actually did match the market design, the IRSR would itself be a CRF in the sense defined above. Specifically it would be the CRF for the relevant PIL, and the logic of the SRA process treats it as if this was the case. But this is a misconception, with significant implications for the firmness of inter-regional hedging.

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51 The shares in this pool thus forming proportional BRRs, in our terminology.

52 This equation works, even though *i* may not be involved in all constraints, because non-involvement implies a zero weight in that constraint. Again, generation is taken to be "normal".

70. In reality, the IRSR for each interconnector reflects the difference between the Regional Reference Prices for the adjacent regions it connects. Thus it may contain some PIL rents, but it also reflects the impact of every constraint which impacts on either Regional Reference Price, or more exactly creates a difference between them. Assuming properly oriented constraints, this means that the IRSR implicitly contains a (positive or negative) rental element for every binding constraint in which that interconnector is involved.

71. Specifically, if we imagine a CRF as existing for each such constraint, and note that the constraint weights applied to $FLOW_{ij}$ can just as easily be positive as negative, we have:

$$rent\ collected\ \ from\ \ ij\ \ for\ CRP_k = CP_k * weight_{ijk} * FLOW_{ij}$$

72. But then the default IDMA assigns CRRs to the interconnector, thus reversing those rental flows, and leaving the relevant rents on all of these constraints in the IRSR pool. We can thus see the IRSR is pool as representing a bundled CRR, where the bundle is defined to include all constraint forms, for all possible network configurations, in which this interconnector is involved.

73. But, crucially, the CRR volume assigned to that bundle is determined differently for each interval, depending on the actual interconnector flow. In fact we have that:

$$IRSR_{ij} = FLOW_{ij} * \sum_{k \in GC} CP_k * Weight_{ijk}$$

74. This IRSR pool is then auctioned in proportional shares, which might be thought of as "bundled" CRRs, "scaled" in proportion to the actual observed flows on the interconnector. As a result, it can not provide firm MW hedging, ex ante.[53]

75. Perhaps surprisingly, though, apart from the fact that the MW volume is not known ex ante, the implicit definition of these bundled IRSR shares actually corresponds to the BRC definition discussed above. In this case, "point X" represents the actual flow position, which is known, ex post, and the proportional share sold by the SRA assigns the holder the same volume, in participant MW (ie Flow) terms, from each binding CRF. But it can also be represented as assigning the holder the same volume, in participant MW terms, from each non-binding CRF, since these are valued at zero, ex post. This leaves unassigned hedging capacity on each non-binding constraint, but that unassigned capacity is also valued at zero, and hence irrelevant, ex post.

76. Finally, all the other terms involved in network constraints are protected. In other words, all terms on the RHS of the NEMDE constraints are protected, including loads, TNSPs, and ancillary service providers.

53 Note this scaling is not proportional to the CRF, as in CBR. By implicitly defining the allocation of each CRR in the input bundle in proportion to $FLOW_{ij}$, the IDMA process ensures that the CRR allocations are not scaled in any particular predictable proportions, relative to the underlying CRFs. Thus an IRSR pool with implicit CRR allocation can not provide proportional hedging, either.

2.8 Implications

77. The chief implication of this characterisation of the situation is that what we have to consider in assessing the various CP-based congestion management options is the merit of replacing the default methodology of implicit CRR allocation by some other allocation methodology. The motivation for doing so is the observation that the status quo gives participants incentives to effectively acquire valuable access rights by manipulating their dispatch offers. This distorts the dispatch, and increases risk for all concerned. And it also means that no party can secure firm financial access to any RRP, either intra-regional or inter-regional, because the underlying CRRs are being continuously re-allocated to match dispatch in each interval.

78. These impacts are evidenced directly when generators compete for intra-regional access, and indirectly through the IRSR/SRA process. Because the auctioned bundle shares do not correspond to any particular constraint rental pool they do not provide firm hedging with respect to any particular constraint, as the actual hedging obtained is driven by the collective dispatch position of the generators influencing the flow. In some cases the IRSR on an interconnector can actually become negative, even though each of the constituent CR pools has positive value.

79. Various measures have been proposed to deal with this phenomenon, but it can be argued that the perceived "problem" is actually just an artefact of a misunderstanding as to what these IRSR pools actually are, and how they should be formed. Thus both CBR and CSP/CSC approaches aim to correct the problem by properly distinguishing, and dealing with, the constituent CRF streams.

80. And the mechanics of moving forward into any alternative regime must also involve some method of translating the rights which are implicitly allocated under the status quo into explicit rights, and addressing the wealth transfer issues which may arise. Not only so, but so do other proposals involving variations on the status quo, even though they may not involve any explicit form of congestion pricing. Specifically, an appendix shows how the concept of CRR re-allocation can be used to describe, and/or manage the transition to:

- A change in Regional Reference Node;
- A change in regional boundary; or
- A change in Regional Reference Price definition to create load and/or generation hubs.

81. This last concept, which is explored further in Appendix B, offers potentially significant advantages, as a way of decoupling much of the debate about the merits of congestion management for generators from any concerns about impact on loads, and may also offer a way to structure a market in congestion management instruments more effectively than either the CSP/CSC or CBR proposals.

3 Risk and Hedging

3.1 Introduction

82. The previous chapter introduced a general congestion pricing framework, and explained how the status quo may be represented in that framework. The basic message of that chapter was that there is an underlying engineering/economic reality, driven by the optimal economic dispatch, which exists independent of any market arrangements. Thus any potential reform of the status quo can be characterised in terms of de-constructing the current arrangements to expose this underlying structure, then re-constructing arrangements in a form which might perform better in some respects, and situations.

83. Before considering any such reconstruction, though, it is important to understand more about the nature of the underlying reality, because this fundamentally determines what the price signals should be, what the risks are, and the extent to which "hedging" will be available to manage those risks. A great difficulty, in many discussions of this type, is that the proponents of particular propositions have in mind a particular situation, or constraint form, and, perhaps unconsciously, base their arguments on the assumption that this is the only kind of situation that will arise. It is all too easy to talk about assigning or selling hedging instruments, for example, using language that implicitly assumes they will have positive value, without recognising that, with different constraint coefficients, they will have negative value.

84. Thus this chapter explains some basic concepts which drive prices, focussing particularly on whether prices, rents, or rental shares will be positive or negative. This determines whether CRRs will be seen as assets conferring "rights" or liabilities implying "obligations", by particular participants. Thus it has fundamental implications for market processes `and psychology. Beyond that, we consider the implications of the various kinds of uncertainty which will affect prices, and the firmness of any hedging available. We defer consideration of any particular mechanism to assign CRRs, eg by CBR-style auctions or CSP/CSC–style allocations, until the next chapter

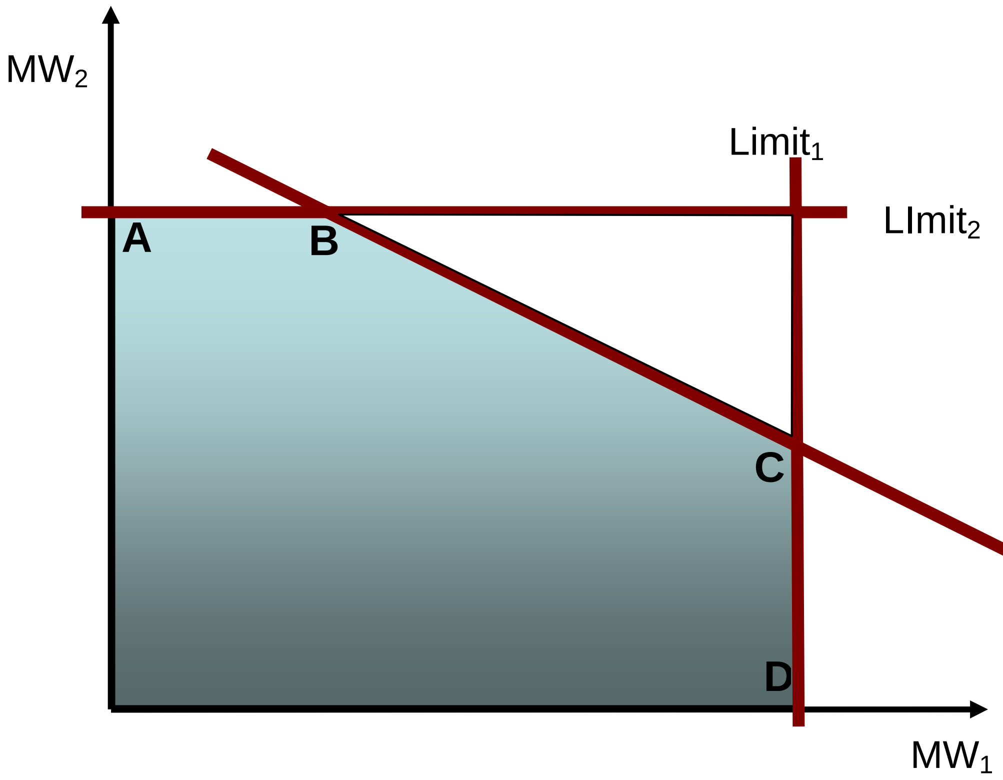
3.2 Hedging in Different Dispatch Situations

85. It will be useful to discuss some basic hedging concepts in relation to a simplified version of Figure 2.2 , in which the axes represent generation/flow variables, each of which is subject to a simple upper bound, and there is only one other constraint, which involves both of them, as in Figure 3.1. For the purposes of this figure, and all the discussion in this section, we will assume that only the variables represented on the two axes are under consideration for exposure to CP, and thus think of the RHS of this constraint as being the Protected RHS, after accounting for the impact of all other terms.

86. We will also follow the common practice of reducing all constraints to a "canonical form" so that they can be interpreted consistently. In this case we will express all

constraints are expressed in ≤ form, which means that, with a value maximising objective, they will always have positive CPs.[54]

Figure 3.1 Joint Resource Limit Constraint



3.2.1 Joint Resource Limits

87. The downward sloping line in Figure 3.1 represents a situation in which both generators, or interconnector flows, are competing for the same network resource, so that, if that resource constraint turns out to be binding (i.e. at any point between B and C), dispatch of one generator/interconnector can only be increased at the expense of reducing dispatch of the other. This is the most obvious way to draw a constraint, and probably the case implicitly assumed in most discussions on this topic. If both axes represent generation, this will be an intra-regional constraint, but more generally it will represent a trans-regional constraint.

[54] Mathematically, a constraint can always be manipulated into a form which will give either positive, or negative, prices, if desired. If a ≥ constraint is multiplied through by -1, it remains a valid constraint, but it becomes a ≤ constraint. The sign of the shadow price will be reversed, but then so are all the constraint coefficients, and the net effect, for our purpose, is the same. And an equality constraint may have a price of either sign, but can be re-expressed as a pair on inequalities, and manipulated to form two ≤ constraints, only one of which will have a positive CP. Thus these technicalities do not affect the basic intuition expressed above, which has important ramifications in what follows.

88. In either case, it is represented by a ≤ constraint in which both interconnector/ generation terms have positive coefficients. Such a constraint will always have a positive CP, if binding. Intuitively, the market will place a positive value on the RHS "resource" provided that RHS does actually represent a positive resource available to the market. The RHS "resource" could be increased through an increase in any of the involved constants on the RHS, and this would deliver a per-unit increase in value to the market measured by CP.

89. This constraint also has a positive Protected RHS[55]. Thus the net CRF available to exposed parties for hedging purposes is also positive, and so is the rent collected from each exposed party. The only way in which any party can end up with negative rent from such a constraint is if that party is somehow allocated a negative share of the CRF.

90. This may seem unlikely, because the constraint weights are positive for all parties. But it can happen if the exposed term itself becomes negative, and CRRs are implicitly allocated to match the dispatch, as in the status quo. This can not happen for a generator but, under the status quo, it will happen for an interconnector, if flow is in the reverse direction while the constraint binds.[56]

91. Exposing the interconnector to CP would reverse this implicit negative rental assignment, and replace it with an assignment based on whatever CRR quantity may be assigned, or purchased at auction. Under that regime, a negatively valued CRR assignment is still possible, because it corresponds to some party selling, rather than buying, a positively valued CRR. In a well designed regime, this should only happen because an obligation is intentionally bought by, or allocated to, some party. But there are very good reasons why some parties will want to sell, rather than buy, these CRRs. Indeed this already happens, implicitly, under the status quo.

92. Consider the situation of a party who wishes to trade in the opposite direction from a constrained flow. They would hedge their position by selling a "swap", to be bought by some party wishing to trade in the forward direction. If the constraint is binding, the net sum of all these backward and trades, physically, must add to (no more than) the RHS constraint capacity, and the same is true with respect to the expected capacity, in the forward swap market.

93. Thus it is perfectly reasonable to have, say, 900% of the CR pool sold in the forward direction, provided 800% is sold in the reverse direction. Equivalently, rather than selling CRRs in the reverse direction, we can think of the CR pool buying CRRs from traders wishing to sell swaps in the forward direction. [57] In the limit, an active swap market can exist, on this basis, even if the physical interconnector capacity is zero.

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55 This will generally be the case for this type of constraint.

56 This would correspond to a dispatch outside the positive quadrant shown in Figure 3.1 (or its mirror image, depending on which axis is reversed).

57 See discussion on inter-regional hedging markets in: PHB (1997a) "*Inter-Regional Hedging in the Australian National Electricity Market: Theoretical Framework*". Released by the National Electricity Market Management Company of Australia, PHB (1997b) "*Inter-Regional Hedging in the Australian National Electricity Market: Theory and Examples*". Report to the National Electricity Market Management Company, Australia

94. Although the focus here is not directly on swap markets, we will later argue that inter-regional price differences are actually driven by CPs[58], so that the IRSR actually consists of a bundle of CR components. Thus buying or selling an inter-regional swap, under the status quo, is entirely equivalent to buying or selling a bundle of CRRs. In this regard, it should be recognised that our discussion, at this point, relates only to trade in hedging instruments corresponding to a particular constraint which may potentially bind. Apart from any trans-regional constraints in which it may be involved, an interconnector will have two PILs, one in each direction, each of which would have its own CRF and CRRs. This can cause confusion when discussing "two-way" hedging, as discussed in *Box 1*.

95. Still, we may ask why any party would want to either buy or sell a CRR unless they were physically involved in the constraint, and wanted to hedge the risks associated with such involvement. But, where interconnector flows are involved, it should be recognised that these represent the net sum of all generation and load in all regions on the one side of the constraint. Thus there are a large number of generators implicitly "involved", via the interconnector flow variable, who may wish to trade with loads on the other side of the constraint. And there is no reason why they should not do so, provided there is enough trade in the reverse direction to keep flows within the constraint bounds, as discussed above.

96. The key point is that, in all of these discussions, we should not assume that the volume of CRRs assigned to any participant is necessarily positive, even if CRR values are positive, and there is a positive aggregate supply. Thus care does need to be taken in describing any proposal involving auctions, for example, because the desired market equilibrium may not be achievable without involving both buyers and sellers in a two-sided auction process. This might, perhaps, be better referred to as a two-sided auction/tender process.

97. Conversely, a regime which did not facilitate such sales could severely constrain the hedging market. If the primary auction process does not allow for both buying and selling, as above, it would be important to make sure that efficient secondary markets exist that either facilitate both buying and selling, or provide bundled products in which such buying and selling was implicit.

98. Essentially the same issues arise if CRRs are allocated, rather than auctioned. Then the issue becomes whether participants are prepared to accept CRR obligations which have negative value. But there is actually no reason why they should not, if they are part of a CRR bundle which has positive value overall, or if they are paid to take on the obligations, as part of a network support arrangement, for example. And note that many participants implicitly accept allocation of negatively valued CRRs under the status quo. So there is no reason, in principle, why they should not continue to do so, explicitly, as a condition of gaining CP exposure which delivers them positive value, overall.

[58] See discussion in Section 5.2

Box 1: Two-way Hedging vs Two-way Flows

Confusion often arises between the concepts of "two-way hedging instruments", "two-way" trading of hedging instruments, and "two-way" flows on an interconnectors

In this regard it is important to note that, as we have defined them, all CRRs relate to a single constraint, and will only have value when that constraint binds. But most physical limits will actually give rise to a pair of constraints, one limiting flows in one direction, and the other limiting flows in the opposite direction. For example, each interconnector will have a PIL for forward flows and a PIL for reverse flows. But when we talk about forward and reverse CRRs here we are NOT talking about CRRs related to these two PILs, which will only bind in very different situations. Rather we are talking about parties wishing to buy, or sell, CRRs which will have value in the same situation, that is when the line itself is constrained in a particular direction.

Participants will want to do this if, despite the net flow being in that direction, they still have a contract to deliver power to a party on the "upstream" side of the constraint, and wish to hedge the risk of a price differential arising when this constraint binds.

Of course, with flows in the reverse direction, the reverse PIL will bind, causing prices to fall in the region where they are contracted to deliver, and making it cheaper for the trader to meet their commitments by "buying in" power in the receiving region, rather than by "transporting" power generated in their own region. Thus the potential price differential which they would be hedging against would actually have positive value to them, and the hedge itself would have negative value. So one may ask why they would want to hold such a hedge.

But exactly the same situation arises in the energy market, or any other market employing two-way" hedges. All such hedges can be decomposed into a "call", which has positive value, and a "put" which has negative value, and it is the combination of the to which provides "firm" hedging, against price variations in either direction. Commercially, a party may well prefer to hold only the call, and so only be protected against adverse price swings. But that is true in the energy market too. The reason why such "one-way" options are not universally preferred is that they are considerably more expensive than the corresponding two-way option, and do not represent better value to a truly risk averse participant, who finds any price variation undesirable.

Thus participants who sell two-way contracts in the energy market should logically wish to purchase matching two way contracts for transmission. That would involve purchasing a positively valued CRR which applies when flows are constrained in the direction of trading. But it would also involve taking on a negatively valued CRR obligation when flows are constrained in the opposite direction. And this obligation can be taken up by selling a positively valued CRR in that direction, as discussed above. But a trading party will probably just want to buy a single "two-way" hedge in the desired direction, without worrying about the fact that it will have to be made up as a "bundle" of two directional CRRs, one bought and the other sold, as explained above. If such instruments are not available in the primary market, they will have to be provided by secondary markets.

99. But the existence of efficient secondary markets would probably be even more of an issue where the primary mechanism was one of CRR allocation, rather than auction. And this would be of concern in situations where hedging market liquidity was considered desirable. This is clearly the case with respect to inter-regional hedging. Accordingly, CRA's CSP/CSC approach involves allocation of CRRs to interconnectors, but it also proposes auctioning of the bundled IRSR thus formed, via the status quo SRA process. At the other extreme, it proposes that CRRs representing network support ancillary service obligations would be negotiated into place, and does not envisage active markets being established for trading such obligations. But it is far from clear that such trading would be considered desirable, or even acceptable. The situation with respect to intra-regional access is less clear cut, and will be addressed in Chapter 6 below.

3.2.2 Support or Blocking

100. Figure 3.2 represents another important dispatch situation, in which dispatch of one generator/ interconnector is "supported" by increasing dispatch of another.[59] Or we could equally say that holding the dispatch of 2 at some level "blocks" increasing dispatch of 1. In this case, for example, dispatch of generator/interconnector 1 can only be increased, after a certain point, if dispatch of generator/interconnector 2 also increases[60]. Mathematically, if this trans-regional constraint is expressed as a ≤ constraint, generator/interconnector 2 has a negative coefficient in the constraint equation, while generator/interconnector 1 has a positive coefficient.[61]

101. The CP on this constraint will also be positive since, when it binds, it restricts the market from moving the dispatch into an area where cost would be lower. But exposing these two parties to CP will have opposite effects, because their constraint coefficients have opposite signs:

- The party with the positive coefficient (1 in this case) will pay into the CRF, as above, because increasing dispatch of that party would make the congestion worse, forcing it against the constraint, the cost of which is measured by CP.
- But the party with the negative coefficient (2 in this case) will receive a payment from the CRF, because increasing dispatch of that party would make the congestion better, effectively relaxing the constraint, the value of which is measured by CP.

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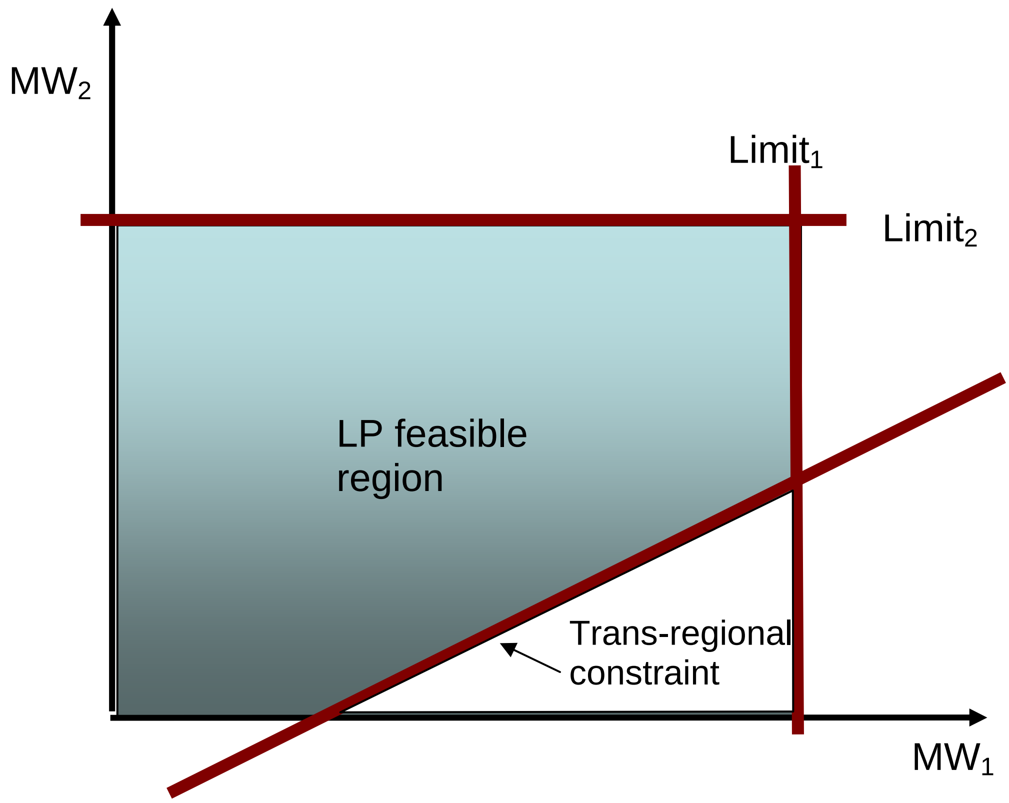
[59] The constraint drawn here actually has the opposite slope, but that is because it has been represented as a ≥ constraint, expressing the concept that dispatch of one variable "supports" the other. It must be multiplied through by -1 to transform it into the standard ≤ form assumed for all constraints throughout this discussion.

[60] An analogous situation could occur in which generator/interconnector 1 supports generator/ interconnector 2, but this case will be ignored since it is the mirror image of that illustrated here. Such a constraint would actually have coefficients of the same sign as that illustrated here, but it would be a ≤ constraint rather than a ≥ constraint, cutting off the top left hand corner of the feasible region.

[61] This would be typical of a constraint on a "tie-line", existing in a loop between two generator/ interconnectors. Injection at 1 can be increased until the tie-line flow reaches its limit, after which only a balanced increase in both 1 and 2 will avoid overloading that line.

Figure 3.2 Supporting/Blocking Dispatch Constraint



102. Ignoring any other transactions, the effect of this would be that the party requiring 'support" ends up facing a lower net price for their generation/flow because a premium has been extracted for "support". And, on the margin, that premium is paid to the party providing support, who thus receives a higher aggregate price for their output.

103. This logic extends to any number of parties, and is most likely to be useful when there are a larger number involved, so that something more than a bilateral arrangement is required. But note that there is already a third party involved here. The sum of all transactions to/from the CRF will not cancel out to zero, but will equal the CR matching the Protected RHS, as above. Thus we must ask who "owns" these rents.

104. Logically, the owner should be the owner of the resources represented by the Protected RHS. If all flow/generation terms are exposed, some combination of TNSPs supplying line capacity and ancillary service providers will be providing, or "supporting", network transfer capability, which will have a positive valuation. Load terms may also have a significant impact on the NEMDE RHS, but will quite likely play a negative role, reducing effective transmission capacity, which will have a negative valuation. The implications of actually exposing each of these elements to CP are discussed later, in the relevant chapters. But note that their combined contribution may be either positive or negative.

105. For the constraint shown in Figure 3.2, the Protected RHS is actually positive, when represented as a ≤ constraint. [62] This allows dispatch of 1 to be increased up to a certain level, without requiring any support from 2, and the value of that basic level of support is recognised once the constraint binds. That value can be expressed in terms of a CRR which may be either auctioned or allocated, but it is definitely positive, and 1 will need to buy a positive share of it if it wants a positive PRR to match a positive MW trading position.

106. The situation of participant 2 is a little different because it has a negative constraint coefficient. Matching a positive trading position with a positive PRR would require it to buy a negative CRR from the CRF. That is, effectively, it would want to sell a CRR, getting a positive price for it, representing the support it would be committing to provide. And every CRR it sells can then be bought by the other party. This corresponds to moving the trading position up, along the sloping constraint shown in Figure 3.2.

107. Thus, as discussed above, while the aggregate volume of hedging available to all exposed parties matches the Protected RHS, and is as firm as the Protected RHS, the volume which individual parties can buy can be much greater, provided this purchase is offset by sales made by other parties. Thus, once more, it should be stressed that a regime which did not allow for such sales could severely constrain the hedging market. If the primary allocation/auction mechanism does not allow for this, the existence of efficient secondary markets again becomes a critical consideration.

108. The situation would be a little different if the trans-regional constraint in Figure 3.2 was moved up so that it passed above the origin, as in Figure 3.3. In this case, the Protected RHS is actually negative[63], meaning that the network can not support the (positive) dispatch of 1 at all, without input from 2. In fact, unless 1 can be dispatched at negative levels, no feasible solution can be found unless 2 operates at a positive level.

109. From a financial perspective, Figure 3.3 represents a situation in which the Protected RHS represents a liability not an asset, and the hedging market can only clear if 2 is prepared to offer enough CRRs to match the Protected RHS, thus committing to operate at a level which allows a feasible dispatch to exist. It would need to be paid to take on this commitment, and some means must be found to fund that payment, since the market can not operate without it.[64] Beyond that point, essentially the

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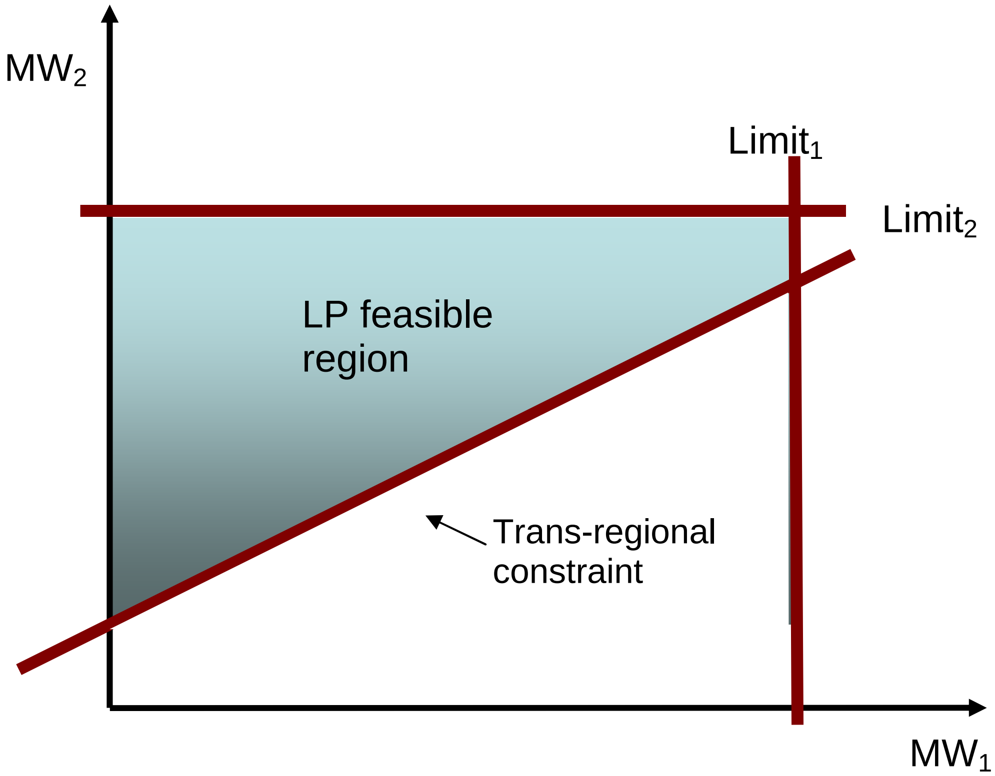
62 Again, the RHS appears to be negative in this figure, but that is because it has been represented as a ≥ constraint, and must be multiplied through by -1 to get it into the standard < form assumed throughout this discussion.

63 When represented as a ≤ constraint, as above.

64 This seems unlikely, globally, but can happen locally. For example, local loads in Northern NSW would have to be supplied by QLD generation via QNI in the event that flows from Central NSW were limited below the Northern NSW demand level.

same situation applies, with hedging/support only available to 1, to the extent that 2 is prepared to provide it.[65]

Figure 3.3 Trans-regional Constraint with a Negative Protected RHS



3.2.3 Joint Requirement

110. Finally, Figure 3.4 represents a situation in which two generator/interconnectors may have to be constrained on to meet some requirement, perhaps to support a load. In this case, after a certain point, dispatch of generator/interconnector 1 can only be reduced if dispatch of generator/interconnector 2 is increased to compensate. Mathematically, if this constraint is expressed as a ≤ constraint, both

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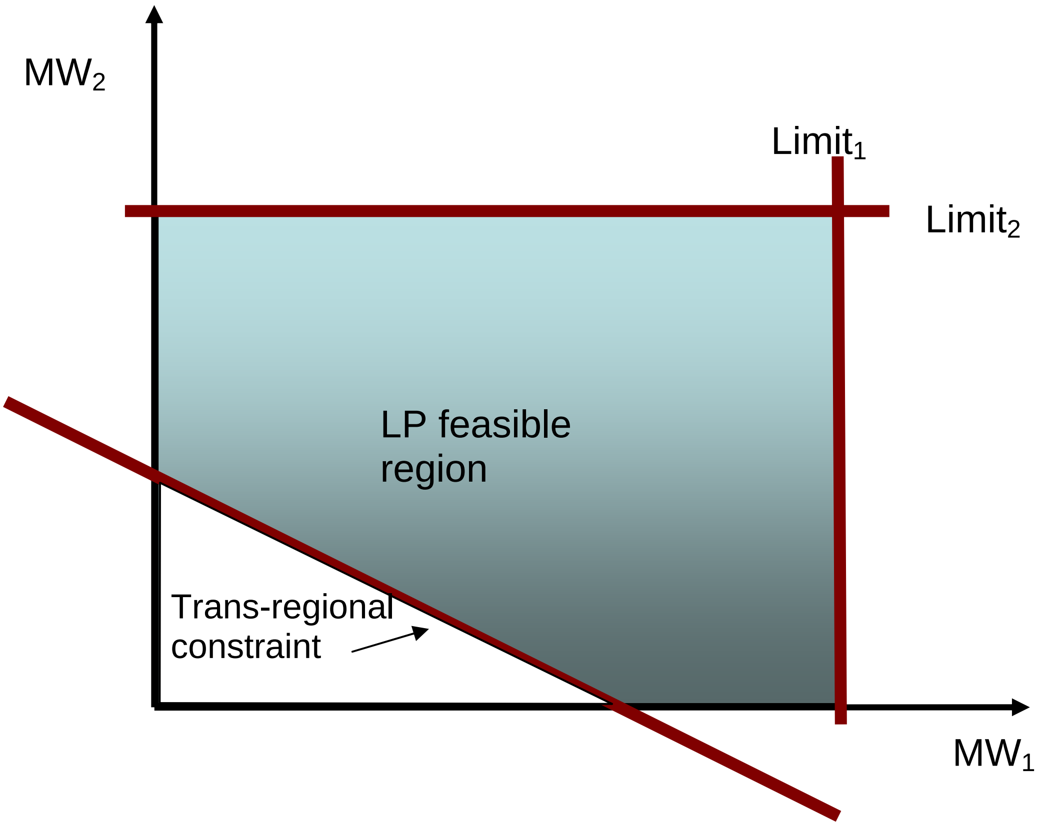
[65] These small examples highlight the issue of potential market power. The pricing mechanisms discussed here will all work best, in terms of market efficiency, if applied to constraints with a relatively large number of parties involved. But, if the number of parties involved in these situations really is small, market power will be a real issue under the status quo, too, and under any alternative regime. Thus consideration must be given to mechanisms to mitigate it, no matter what approach is adopted. And the number of participants involved may be an important criterion in deciding the situations to which some of these regimes might apply.

generator/interconnectors will have negative constraint coefficients, and the RHS will also be negative.[66]

111. As in all of these examples, the CP on this constraint will be positive since, when it binds, it restricts the market from moving the dispatch into an area where cost would be lower. But, since both parties now have negative coefficients in the constraint equation, exposing them to CP means that there will have to be payment out of the CR pool to each of them. They are, after all, "constrained on" by the constraint, and this additional payment merely raises the effective price they receive to a level which makes operation worthwhile, according to their offers.[67]

Figure 3.4 Joint Requirement Constraint



112. Similarly, arranging a positive PRR to match a positive trading position would mean taking up a liability, in the form of a negative CRR. While this would provide hedging to the Regional Reference Price, and thus has some value in reducing risk, we expect both parties would have to be paid to accept such a CRR. In other words, they would expect to sell CRRs to the CR pool, thus committing to meet the implied obligations to meet the constraint requirement.

66 The line shown in the figure actually has positive coefficients, and a positive RHS, but it is expressed as a ≥ constraint. It must be multiplied through by -1 to get a mathematically equivalent ≤ constraint.

67 LP optimisation ensures that CP is set to just this level, and no more.

113. Once more, the aggregate volume of hedging "available" to all exposed parties matches the Protected RHS, and is as firm as the Protected RHS, but this actually represents the need for the pool to buy in enough CRRs to cover the requirement implied by the Protected RHS, or face the prospect of those parties who are in a position to meet the requirement refusing to do so, or at least withholding capacity to force prices up, in real time. Thus an auction of rights in this CRF would really need to be thought of as a tender process for liabilities, rather than assets. And a hedging regime which did not allow for this would be unable to find a feasible solution at all.

3.2.4 Summary

114. All of the above results can be generalised to any number of dimensions, representing any number of parties interacting in any number of constraints. A simultaneous LP solution is required to determine which constraints are binding, and to determine CP. But once the simultaneous solution has been found, each binding constraint can then be considered independently, with their pricing/rental effects being additive.

115. If all constraints are expressed in a standard ≤ form, we conclude that:

- CP will always be positive; so
- CRRs for positive MW quantities will always have positive value; but
- PRRs matching positive dispatch positions will imply positive (and hence positively valued) CRRs for a party with a positive constraint coefficient, but negative (and hence negatively valued) CRRs for a party with a negative constraint coefficient; in other words
- parties with positive coefficients in a ≤ constraint will be looking to buy CRRs from the CR pool, but those with negative coefficients will be looking to sell; and
- there is no reason why the volume of sales can not greatly exceed the value of the pool, provided they are offset by enough purchases to match the aggregate CR, which must match the Protected RHS; so
- the aggregate CR will be positive or negative, depending on whether the Protected RHS is positive or negative; in other words
- the CR pool may represent a net store of "rights' to network resources, which can be sold or allocated to parties using those resources; or
- the CR pool may represent a net store of "obligations" to meet network requirements, which must be bought from parties able to meet those requirements.

116. This last situation is probably not very common, and the natural way to express it would generally employ a ≥ constraint. Of course a ≥ constraint is just a ≤ constraint multiplied through by -1[68]. So the results presented above can be translated into an equivalent set of results for ≥ constraints, naturally reversing many of the conclusions. But mixing conventions like this can be confusing, and we will not do it here. Instead we assume that all constraints are translated into a ≤ form. But we note that the CR pool for constraints which are naturally expressed in ≥ form will typically represent a net store of "obligations" to meet network requirements, which must be bought from parties able to meet those requirements.

3.3 Firmness

117. Although there is no stochastic analysis in the previous section, it talks about the availability of "hedging" which is an inherently stochastic concept. That is, hedging is all about managing risk arising out of fundamental uncertainties about the future state of the world. In this case, it is about managing the commercial implications of uncertainty about which network configuration will apply in any five minute dispatch interval, what the level and pattern of demand will be, and the pattern of generator dispatch.

118. Conversely, the hedging concept is quite irrelevant under deterministic assumptions. With perfect foresight, all parties can see, ex ante, how the world and the market will turn out, and will make the same assessment of the situation as they would ex post. In particular they will all place the same value on any "hedging instrument" which may be defined, and none will see any point in trading such instruments.

119. Of itself, then, simply identifying the existence of a positive Protected RHS, for example, does not constitute a stochastic analysis or proof. And we will not attempt one here. Still the statements made there, and in the remainder of this section are based on extensive analysis of, and experience with, analogous situations arising with respect to FTRs in nodal markets, for example. And we believe they are supported by CRA's original analyses, and also by Dr Biggar's more formal analysis, even though neither addresses all of the aspects of uncertainty discussed here. [69]

120. One basic concept, in discussing hedging, is "firmness". But this concept has proved controversial, with terminology being employed in various contexts which is complex, or at variance with common usage, or both.[70] To some extent this is

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68 This transformation has nothing to do with constraint orientation. Both forms of the constraint would be correctly oriented to the Regional Reference Node, with zero coefficients for generation at that node, and both forms would be perfectly acceptable in NEMDE. The convention described here is purely for ease of exposition. Practically, the only implication is that the settlements system needs to know whether the CP reported by NEMDE should be taken at face value (for a < constraint), or multiplied by -1 (for a ≥ constraint).

69 This is not to say that our interpretation of that analysis necessarily coincides with Dr Biggar's. Appendix A notes that CRA accepts the analysis, but disputes some points of interpretation.

70 To be exact, CRA considers that Dr Biggar's definition of "firm hedging" differs significantly from that understood by the industry, when he says that a hedge is firm if it matches the RHS of a constraint,

unavoidable, if the discussion is to properly reflect the underlying mathematical reality, which is not always simple.

121. In our view, though, a commonsense definition of "firmness" itself is really quite straightforward. A firm inter-locational hedge is one which fully hedges the risk on a MW quantity which is agreed in advance, against price risk arising between two locations[71]. So far as we are aware, this concept is well accepted in the sector, and the literature. Defined this way, a firm inter-regional hedge matches a firm energy hedge defined at a Regional Reference Node, thus allowing firm trading from one Regional Reference Node to another.

122. So the issue is, in our view, one of matching inter-locational trading positions in the energy contract market, ahead of time[72]. In our view, then it is obvious that the ability to provide firm hedging with respect to an energy trade being made at any time must be measured in terms of hedging instruments available at that time, at prevailing prices. We consider it to be virtually meaningless to say that "firm hedging" is available, if it would only be available at some later time, at prices which will reflect expectations prevailing at that time. That would mean that the transaction was not hedged with respect to changes in expectation over the intervening interval, and can not be "firmly hedged" at all.[73]

123. Later, as the trading situation evolves, some participants might wish to adjust their hedging position by buying more CRRs, but these would have to be bought off other participants, probably competitors, and the price would obviously reflect expected dispatch price differentials at the time of purchase. So these CRR prices will trend towards real time prices. In the end, a CRR purchased just before the dispatch interval would provide very little meaningful hedging at all, because the prices are already virtually certain, and will be reflected in the CRR price.

124. Greater difficult may be experienced in expressing the conditions under which firm hedging can be provided, or the "degree of firmness" provided by various regimes. Thus CRA, for example, has suggested that, under their proposed CSP/CSC arrangement, hedging "can be made as firm as the RHS" (of a NEMDE constraint). Some parties may have placed undue weight on this statement, and Biggar, for example, seems to treat it as if CRA were claiming that CSCs provide fully firm hedging.[74] But, on closer consideration, it seems clear that this is only a statement

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which may either vary, or be replaced by another constraint, in real time. (See later discussion of "capacity" and "configuration" risk). But CRA's discussion of hedging being "as firm as the RHS" may be regarded as complex, and may not match industry understandings either.

71 By way of contrast, Biggar(2006) effectively seems to define a firm hedge as one which matches an actual dispatch position, which can only be known ex post, but this is a key point in dispute between CRA and Dr Biggar, as noted in Appendix A.

72 Under the status quo, this means an inter-regional contract position. But if participants were exposed to CP then hedging to a Regional Reference Node would become an inter-locational issue, too.

73 This is not to say that such hedging is not of some value. Traders might wish to acquire long term inter-locational hedging positions in anticipation of likely future contract sales, or just to obtain access to a Regional Reference Price which is expected to be less volatile than their own PNP. Such hedging will not place the trader in a fully or firmly hedged position until matched with firm energy hedges at the same location. But it may still be called "firm", in itself, if the MW quantities are fixed.

74 This, also, is a point at issue between Dr Biggar and CRA.

about hedging with respect to a particular constraint, and not about "bundled CSCs" for example.

125. CRA's papers also make it clear that this degree of firmness can only be achieved, in a passive sense, if all LHS terms (of the NEMDE constraint) are involved in the CSP/CSC arrangement. But they also claim that hedging "can be made" firmer than the NEMDE RHS by actively entering into CSCs with various parties to "firm up the RHS"[75]. Thus their position might be better stated as saying that hedging "can be made as firm as the RHS can be made". [76] In the limit, they would claim that (revenue neutral) hedging can be made "fully firm" if, and only if, all parties with terms appearing on both the LHS and RHS of the NEMDE constraint equation , are involved in (commercially robust) CSP/CSC arrangements. That is, in our terminology, they must all be exposed to CP on this constraint[77].

126. Biggar (2006) employs language which appears to make rather stronger claims than this. But he employs a different definition of "firm hedging" from ours. In our view the mathematical analysis underlying his claims does not actually seem different from that in the CRA papers, with the caveat that he only considers passive, rather than active, constraint management. In other words he does not consider the possibility of 'firming up" the CRF.

127. While the underlying mathematical reality is no different, the notation developed here at least allows us to simplify some of these statements. Rather than saying that "hedging can be made as firm as the RHS (can be made)", which is effectively what CRA claims, we can now say that the hedging available to exposed participants is as firm as the Protected RHS (is). In aggregate, the hedging volume available is given exactly by the Net Constraint Rental (NCR) available after the implicit assignment of CRRs to protected terms, that is by:

$$NCR_k = CP_k * ProtectedRHS_k$$

128. But note that this is a statement about the aggregate hedging volume available, not about the firmness of hedging assigned to any particular party. So we must consider what it means to make hedging "available". One might infer from some discussion that the existence of mathematically desirable price relationships is, of itself, sufficient to indicate that hedging, or even "firm hedging", is available to participants.[78] But we consider that hedging is not available to participants, unless some positive volume of hedging can actually be purchased.

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75 See discussions in Chapters 7, 8 and 9, with respect to "active congestion management".

76 The wording here is our own, not that of the original CRA documents.

77 On its own, exposure of RHS parties shifts their terms from the Protected RHS to the Exposed LHS, and makes the total hedging pool firmer, by removing the effect of any variation in that term from the total hedging poll. CSC allocation then affects the volume of firm hedging assigned to the contracted party, and available to other parties. The practical issue here is not about "making hedging firm", but obtaining the desired volume of firm hedging.

78 Their interpretation may be disputed, but CRA points out that the analysis of "firm hedging" in Biggar (2006) appears not to consider volumes at all.

129. So the issue is, in our opinion, to identify the volume of hedging that can be purchased, and the degree of firmness of that hedging, once purchased. And we believe that, in many circumstances, there is a trade-off between these two characteristics. In various contexts we have suggested that it is "not possible" to provide hedging of various kinds and such statements need to be qualified.

130. Of course it is always "possible" to make hedging available, provided the mathematical relationships can be identified, and some party is prepared to underwrite it. But such hedging will not be "revenue neutral"[79] unless it can be supported by the rents arising from the market-clearing process: That is unless those rents are sufficient to (exactly) cover the payouts defined by the hedging instruments.

131. And it is, we think, well understood that it will always be possible to supply a volume of (acceptably) firm hedging with respect to a particular constraint, corresponding to a minimum constraint capacity level which is expected to be available with acceptably high probability. But, restricting the market to only deal with hedging provided on this basis would create two issues:

- First, it would considerably reduce the volume of hedging available, and make a significant part of the network's actual expected capacity unavailable to support the hedging market, and

- Second, the hedging market could not be "revenue neutral" because, on average, there would be excess rents generated by capacity that was normally available, in excess of the firm minimum limit.

132. Thus we consider that, having established the basic mathematical relationships, the real challenge of hedging market design is to make the aggregate hedging volumes naturally supplied by the network available to participants. That will require a portfolio of hedging instruments, of varying volumes, and firmness, to be provided to individual participants, within that overall aggregate supply.

133. Accordingly, we see little point in discussing whether the hedging provided to any individual participants is 'firm". It will always be possible to make some volume firm for some participant, if other participants are prepared to accept less firm hedging or, in the limit, to underwrite the firm hedge. Our discussions mainly focus on the volume and firmness of the aggregate hedging available. We note, though, that these discussions do relate directly to the situation which would be faced by participants if CRRs were defined in proportional terms, as proposed under CBR, because any lack of firmness with respect to the aggregate quantity would be reflected directly in a lack of firmness with respect to all proportional shares.

79 See below.

3.4 Impact of Contracting

134. In later chapters we will want to discuss situations in which the CSP/CSC regime proposes to use contracts with providers of what may be termed congestion management services (eg ancillary service providers) in order to make more and/or firmer hedging available to energy traders. CRA have previously referred to this as "firming up the RHS" of the constraint. But we have just claimed that the available hedging is "as firm as the Protected RHS". Since the "Protected RHS" is defined entirely by the choice of which parties are exposed to CP, without reference to any contracting, we must now ask exactly what impact contracting will have on the availability of firm hedging, and how this statement with respect to the Protected RHS aligns with CRA's earlier discussions.

135. The key is to note the distinction between the volume and firmness of hedging "available", in aggregate, to all exposed participants, and the volume_of firm hedging specifically available to energy traders. That is the volume of hedging available to parties represented either directly by generation terms or indirectly by interconnector flow terms, on the LHS of NEMDE constraint equations, as opposed to other parties such as TNSPs that could, potentially, be exposed to CP.

136. It is true that merely exposing ancillary service providers, for example, to CP, will increase the firmness of the aggregate CRF pool, by reducing variation in the residual Protected RHS. But it is also true that, unless firm contracts are somehow allocated to these ancillary service providers, they will be involved, along side energy traders, in buying and/or selling shares in CRF pool[80]. Thus neither can really say they have a specific volume of "firm" hedging, in aggregate, as a group.

137. Thus the volume of firm hedging available to energy traders is affected by contracting with non-trading parties, such as ancillary service providers. [81] But the interests of these two groups are not necessarily antithetical in this respect, because increasing firmness for the buyers of a service also increases firmness for suppliers of that service. Thus if firm contracts can be put in place with ancillary service providers, this also enables more firm hedging to be provided to energy traders. [82]

138. Such contracting is integral to the application of the CSP/CSC approach to ancillary service provision, for example. But we should examine how contracts "firm up" the RHS in a little more detail. If a CRC (that is a CRR with a fixed MW quantity) has been used to contract with party *i,* perhaps an ancillary service provider, we can conceptually break the constraint equation term representing the volume of the service actually provided by *i* (in participant MW terms), $PROV_i$, into two components:

- PRC_i, representing the CRC quantity re-expressed in participant MW terms; and

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[80] Given the likely coefficients, traders will generally have to buy hedging off exposed non-trading parties.

[81] We will frame this discussion in relation to contracting with non-traders, but the same principles apply with respect to firm CRC contracts entered into with any party.

[82] This will reduce their trading risk. Their overall risk may be increase, if they do not have a physically firm way of matching the contract in real time, but that is equally true for energy traders.

- VAR_i, representing (positive or negative) variations around that quantity.

139. In other words:

$$PROV_i = PRC_i + VAR_i$$

140. But PRC_i is a constant, and can be notionally transferred to the Protected RHS, where it represents the extra volume of firm hedging made available to energy traders as a result of the CRC with *i*. Noting that $weight_{ik}$ is negative for a participant "supporting" a constraint, we have:

$$\begin{aligned} &Hedging\ available\ to\ traders\ wrt\ constraint\ k \\ &= ProtectedRHS_k - \sum_{contracted\ non-traders} weight_{ik} * PRCV_{ik} \\ &= ProtectedRHS_k - \sum_{contracted\ non-traders} CRCV_{ik} \end{aligned}$$

141. In other words, the additional congestion rents created by contracting with non-traders providers can be sold to other market participants, thus increasing the volume of "firm hedges" available to traders. Thus we may think of these CRCs as 'augmenting' the Protected RHS capacity available to provide hedging to traders.

142. Since CRCV is a constant, hedging is still only "as firm as the Protected RHS", the variation in which is still the same as if the entire ancillary service term was thought of as remaining on the Exposed LHS. But this volume of firm hedging is now all available to traders[83]. Conversely, VAR may be thought of as a variable on the Exposed LHS of this constraint equation. When VAR is multiplied by CP (and its weight), it represents the net congestion rents which will be paid to/from the ancillary service provider to allow the residual CRF available to traders to be this firm for energy hedging purposes.

143. So, in summary, CRA previously talked loosely about involving various parties in CSP/CSC arrangements as "firming up" the hedging pool. But this is not quite correct. From the above discussion it can be seen that actually it is the exposure of the party to CP (or CSP in CRA's terminology) which increases firmness of the aggregate CRF. What CRC contracts with these parties do is to "augment" the volume of firm hedging actually available to traders.

144. The alternatives, for RHS parties such as TNSPs, loads or ancillary service providers would be:

- Not to expose them to CP, which means that they are implicitly protected by an IDMA allocation of CRRs, thus removing those CRRs from the aggregate

[83] That is; assuming non-trading participants, once contracted, do not subsequently get involved with buying or selling CRCs with respect to this CRF.

available for traders, and making the aggregate hedging pool significantly less firm than it could be[84]; or

- Exposing (some of) them to CP, but not contracting with them centrally via CRCs, so that energy traders can also trade CRRs with those parties in order to reach a hedging position which is, if this market operates perfectly, mutually satisfactory.[85]

145. But there is a whole other dimension to this issue because, irrespective of the reason they were entered into, financial contracts also motivate participants to act in certain ways which move their physical performance, eg dispatch position or capacity provision, toward the contract quantity. Indeed that is the whole point of contracting in many situations. Although referred to, technically, as "second-order effects" they can have a major impact on behaviour, as discussed in Box 2. Such contracting is relied on routinely in many markets to control market power, and could be used to contract for provision of ancillary services, as discussed in Chapter 7, for example,.

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84 This is; the status quo.

85 This is effectively what the CBR proposal, as described by Biggar(2006) seems to imply for the treatment of loads, as discussed in Chapter 9.

Box 2: How do Financial Contracts Motivate Participants?

The "hedges" discussed in this paper are all financial, not physical, contracts. For parties who have no physical influence over market situations, such contracts may be seen merely as hedging devices, and used to manage risks emanating from the market, over which they have no control. For parties physically involved in the market, the situation is very different, though. Basically, these contracts incentivise them to move their physical performance closer toward the contract quantity.

These incentives are referred to as "second order", because they modify the basic "first order" incentives provided by the price alone. Second order incentives would have no effect on a risk neutral perfect competitor, but can have a major influence on behaviour of real participants. There are two main effects:

Risk aversion: Any party who engages in hedging is presumably risk averse, and a risk averse generator will be trying to align their financial contracting position with their physical delivery capability, ie generation. If they can generate to match their contract position, they are perfectly hedged, and face no risk as a result of spot market price variations. But the further their generation moves from that point, the greater their net risk exposure becomes. Observation suggests that market traders are strongly motivated to match contract positions, even in competitive market situations.

Market Power: Market power is often described as a purely negative phenomenon, motivating participants who can influence the market price to withhold capacity that would be made available in a more competitive environment. But this is actually just a special case, arising in an environment where that participant has no prior obligation to supply: In other words, with a prior contract level of zero. Once (financial) contracts are in place, this situation changes to a more symmetrical one, where a participant has:

- Incentives to push production up towards its contract volume, thus pushing market prices down, because effectively it is paying those market prices to other parties to make up any deficit in its own supply, relative to the contract.

- Considerably reduced incentives to pull production down, towards its contract volume because, while this still pushes market prices up, the benefit of those market prices is largely passed on to the contract holders.

In effect, the contracted party's market position is defined by its net exposure, after accounting for the contract volume. Thus a supplier with a large market share may become a net supplier with a much smaller market share, or a net buyer, with very different motivations. We discuss the impact of these effects in many situations, and often rely upon them. But we also consider them much more important in some situations than in others. Market power, in particular, may have little influence at the NEM wide level, and perhaps with respect to trading of hedging on major interconnectors. But it will have a very major impact in localised situations, where there may be a monopoly supplier of "constraint support".

As a result, profit-maximising output volumes lie between the contract volume and the output volume that would be optimal under perfect competition. In the uncontracted case, the contract volume is zero, so second order incentives are always to reduce output. If the contract volume coincides with the perfectly competitive output volume, output is set at the perfectly competitive level.

3.5 Revenue Neutrality, Adequacy, and CRF Wholeness

146. If a constraint is not managed it will have no exposed terms, and both ProtectedRHS and NCR will be zero. This does not mean that there is no rent associated with the constraint, but merely that the rents generated by the valuation of the (NEMDE) RHS "resource" are all absorbed by the implicit allocation of CRRs to the (NEMDE) LHS terms, which also appear in the "protected" sum on the Protected RHS.

147. More generally, given that binding constraints hold with equality, NCR will also match the Exposed LHS, that is the weighted sum of exposed terms. That is, the hedging available to exposed parties, in aggregate, exactly matches their aggregate weighted dispatch positions. We will say that an explicit CRR allocation to exposed parties is "revenue neutral" if it exactly matches the NCR available, that is if:

$$\sum_{EXPOSED_k} CRRV_{ik} = ProtectedRHS_k$$

148. We will discuss such revenue neutral allocations, thus implicitly paralleling Dr Biggar's formal analysis, which is also implicit in the CRA work. But note that this analysis is essentially deterministic and relates to an ex post assessment of the rents which actually would be available to support hedges, and the result is that those rents will match the aggregate dispatch position of the exposed parties. As we see it though, the critical issue when discussing "firm" hedging is not the ability to match dispatch outcomes ex post, but rather the ability to match contract positions, ex ante.

149. Thus this result can be interpreted negatively, in that respect. Precisely because the rents match the aggregate dispatch position, they clearly do <u>not</u> cover any discrepancy between the aggregate dispatch position and the aggregate contract positions of the exposed parties. In other words, if revenue neutrality is to be preserved, all that can be achieved, ex ante, is to trade or allocate CRRs between the exposed parties, thus effectively partitioning the (as yet unknown) Protected RHS capacity between them, so as to match their contract trading positions as closely as possible.

150. With respect to firmness then, the first critical issue is to determine which parties are "exposed", because the ability of any individual market participant to obtain firm hedging is dependent on there being a sufficiently large, and diverse, group of exposed parties to allow an acceptable risk re-allocation to be found, whether by trading or by some other means. The set of "exposed" parties also determines the range of parties which can be involved in congestion management mechanisms via the regime.

151. Accordingly, the choice of which parties should be exposed to CP risk represents a critical factor defining a whole spectrum of available options, and that choice underlies the whole structure of our discussion. But there are also significant issues to be dealt with in relation to the characterisation and treatment of various kinds of uncertainty. And, strictly, we can not define the ex ante "firmness" of particularly hedging arrangements without giving proper consideration to such issues. Thus we suggest that the conclusions of deterministic discussions such as that in the previous section should really be expressed in terms of the 'wholeness" of CR pools, with the

understanding that ‘wholeness’ may be a pre-requisite for ‘firmness”, but by no means guarantees it.

152. Given the above definitions, the concept of ″wholeness″ is almost trivial. Thus we can say a particular regime creates a ″whole″ CRF for constraint *k* if that CRF contains all the rents collected from exposed parties. But this basically follows from the definition of “exposure” to constraint *k,* and brings the effective definition of “wholeness” back to a question about which parties are exposed, under a particular proposal.

153. Finally, FTR markets for congestion management in nodal markets usually relax the “revenue neutrality” requirement to one of “revenue adequacy”. Strict revenue adequacy would require rents collected on each constraint to more than cover the CRRs issued for that constraint, in each trading interval. But, in practice, a much looser approach is often taken, in which the requirement is imposed over all constraints, on average, and over a reasonably long timeframe, as discussed in Section 4.5.4.

3.6 Treatment of Uncertainty

154. Although uncertainty and risk have been mentioned above, the constraint representation in NEMDE, of itself, is still deterministic. We will not attempt a fully stochastic analysis here, but note that three kinds of uncertainty are important with respect to that representation:

- “Dispatch uncertainty” arises because participants can not know, in advance, how other participants will be dispatched, and hence, for example, what interconnector flows will be.
- “Capacity uncertainty” arises because participants can not know, in advance, what the RHS capacity each constraint will be, due to uncertainty about the status of lines or other network elements which affect the network’s ability to carry power, or about load levels, for example.
- “Configuration uncertainty” arises because participants can not know, in advance, what the precise configuration of network elements will be, due to outages etc. [86]

[86] There is a fourth kind of uncertainty here, namely each generator’s uncertainty about its own generation capacity. This is it is own risk, which only it can manage. It can not be covered by hedging in the CRR market, or in the energy market. In fact such hedging increases the participant’s risk in this regard, by establishing contract positions which it may be unable to match, physically. In terms of the generic diagrams used here, in which the participant’s own generation may be represented on one axis, this kind of uncertainty might be interpreted as a kind of “configuration uncertainty”, in that a “system element” has become unavailable. But this implication is not intended. Our definition of configuration uncertainty is intended to refer only to network elements. The interpretation of generation terms in these diagrams will be discussed further in relevant contexts.

3.6.1 Dispatch Uncertainty

155. “Dispatch uncertainty” will determine which constraints bind, and therefore have non-zero CPs, which obviously has critical implications for risk exposure, and hence for hedging. But the whole range of dispatch possibilities is represented by the set of points lying within a convex feasible region such as that shown in Figure 2.2[87]. And this is defined by a specific set of simultaneously applicable constraints forming a specific instance of the LP feasible region[88].

156. Provided the feasible region itself is known, strong results can be proved about the availability of hedging to cover this kind of risk. Basically, if all LHS (ie dispatched) terms are exposed, then hedging will be “as firm as the RHS”, no matter which constraints bind, or how many bind simultaneously. And, by assumption here, the RHS is known ex ante, so we can say that such a regime provides “firm hedging with respect to dispatch risk” for both generation and interconnector flows. [89]

157. More generally, in our terminology, whatever terms are exposed, hedging will be as firm as the residual Protected RHS. Thus if, for example, only interconnector terms are exposed, the Protected RHS would vary as a result of generator dispatch varying. In these circumstances, it would not be possible to provide firm revenue neutral hedging, in aggregate, to interconnector flows, even if the RHS used in NEMDE was firm. Similarly, if generator terms were exposed, and not interconnectors, the Protected RHS would vary as a result of interconnector dispatch varying. In these circumstances, then, it would not be possible to provide firm revenue neutral hedging, in aggregate, to generators even if the RHS used in NEMDE was firm.[90]

158. But note that this is only a statement about the feasibility of firm revenue neutral CRR allocation corresponding to a particular constraint, with a particular Protected RHS capacity. In other words, it is a statement about the volume and degree of hedging firmness which can be delivered with respect to dispatch uncertainty. It is not a statement about firmness with respect to hedging against capacity uncertainty. And nor is it a statement about the volume and degree of firmness with respect to hedging against configuration uncertainty, which not only relates to which

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87 That is a set in which a line joining any two feasible points also lies entirely within the region. This is an important property for optimisation of both dispatch and hedge allocations or, equivalently, for the existence of market equilibrium.

88 The constraint set can be different in each period, but what matters is that we know, in advance, what it is for each period.

89 We believe this is basically what CRA claimed originally, and note that CRA considers that claim to be confirmed by the underlying mathematical analysis of Biggar (2006),, although the latter’s analysis also included load as dispatch variables, and exposed them to CP risk. It corresponds to the basic “revenue adequacy” result applying to FTR markets, namely that a particular network configuration will always provide enough rent to support any proposed allocation of FTRs, if that allocation corresponds to a feasible dispatch for that network configuration.

90 But these statements apply to the total hedging pool, for which all exposed parties must compete. While simply exposing parties always makes the pool firmer, it also means those parties appear on the Exposed LHS, either buying or selling hedges. Thus the availability of firm hedging to any particular class of participants is not necessarily increased, or made more certain. To achieve that requires that there be contracts put in place with the newly exposed parties, as discussed in Section 3.4

constraints may bind, but which constraints will actually exist in the NEMDE real-time run.

159. Thus, statements about firmness of hedging provided by pure CRRs, with respect to particular constraints, should not be interpreted as making claims with respect to the degree of firmness which can be provided by any CRR "bundle", such as that implicit in the IRSR, or in the CSP/CSC proposal. Such bundled rights must be thought of as providing hedging with respect to the whole feasible region, as in Figure 3.5. Here we can interpret point *X* as defining financial, rather than physical rights (ie PRR_1 vs PRR_2) in the CRF for the trans-regional constraint to the parties represented on the two axes[91].

160. This MW assignment of capacity has been expressed in terms of quantities measured along the axes; that is in terms of "participant MW". As discussed earlier, if this is interpreted as defining a firm participant CRC (PRC), with volume PRCV, the corresponding allocation of Protected RHS capacity MW being given by[92]:

$$CRCV_{ik} = PRCV_{ik} * weight_{ik}$$

161. Note that, by construction, the sum of these two allocations equals the constraint capacity, and revenue neutrality is guaranteed. More generally:

$$\sum_i CRCV_{ik} = ProtectedRHS_k$$

162. This is a feasible PRC allocation because it corresponds to a feasible dispatch point, X[93]. Parties will seek to obtain PRCs corresponding to their planned (contractual) trading positions, and we might expect those to also align with their expected dispatch positions, at the time those contracts are entered into. As real time approaches, expectations about dispatch positions will change, perhaps drastically, for various reasons, but the holder of such a PRC is protected against what we have called dispatch uncertainty. That is, so long as the feasible region remains the same, they are protected against deviations from point X within that feasible region. [94]

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91 This figure has been labelled to represent two interconnector flows, in which case the parties represented on the axes are, implicitly, all the traders seeking inter-regional hedging on either interconnector. In reality, of course, the problem is of much higher dimension, and there are a very large number of constraints defining the feasible region. But, for the purposes of this section, it would not be appropriate to label one of the axes as "generation".
As noted above, the intention is not to provide hedging with respect to failure of the participant's own any generation unit. Hedging is provided with respect to the failure of any other unit, but that is just one of the factors creating "dispatch uncertainty". It does not affect the constraints defining network capabilities (the generator term still exists, but is just set to zero) and is represented by movement within the feasible region, rather than a change to the feasible region.

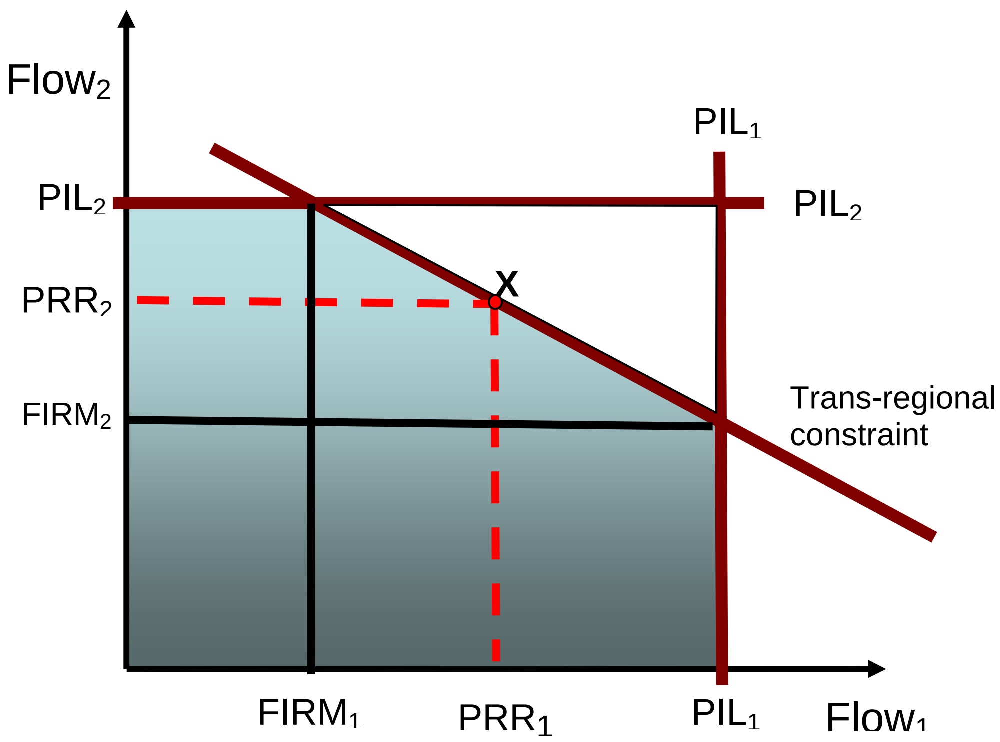
92 Note that the sum of these two allocations thus equals the constraint capacity, and revenue neutrality is guaranteed.

93 This is a well established result in the literature on nodal markets.

94 Actually, so long as both generators and interconnectors are exposed, a PRR expressed in proportional form will also be firm with respect to dispatch uncertainty, because the constraint RHS does not change.

163. Thus, so long as the PRC holder wishes to maintain that hedging position they may do so. If they wish to change it, though, they will have to do so by trading in the hedging market, at the prices then prevailing. Similarly, they may be induced to change, if some other party wishes to change, and offers an attractive price to either buy or sell some of this participant's hedges. Depending on how dispatch expectations have changed in the interim, they may make a gain, or suffer a loss, on these trades, relative to their original purchase price. And, when the dispatch market finally clears the hedges may well prove to be worthless, because the constraint did not bind. But the hedging volume will not change as a result of dispatch uncertainty.

Figure 3.5 Financial Contract Allocation



164. This logic applies to each individual CRR, and CRF pool. In the figure, it would apply to the trans-regional constraint CRF, and also to each PIL CRF, individually. But what happens if CRRs defined with respect to these CRFs are bundled, as suggested by the CSP/CSC proposal? As discussed in Section 2.6, the precise definition of CRR bundles is problematic.

165. In Figure 3.5 one possible approach to bundling can be represented by re-interpreting point X as implying acquisition of a CRR bundle, consisting of the PRC discussed above, with respect to the trans-regional CRF, but also a matching PRR, of the same volume, with respect to the interconnector PIL itself. If we interpret this as

corresponding to the "BRC" definition discussed in Section 2.6, then both of these CRR components is a PRC, with volume fixed, in participant MW terms.

166. This is possible, and it is also possible for this BRC to be firm, with respect to dispatch uncertainty, because the feasible region is assumed not to change. But notice that assigning BRCs to match point X leaves the network with unassigned hedging capability with respect to all constraints which are not expected to bind at that point; the two PILs in this case.[95] This is evident from the fact that the PRR volume implied by the agreed partitioning of the trans-regional constraint capacity (e.g. point X) is obviously less than that implicit in the individual interconnector/generator bounds.

167. But it is not possible to assign any more BRCs of this type, in aggregate, because it is not possible to fully dispatch both interconnectors simultaneously. Consequently, since the dispatch balance is not known in advance, it is not possible to guarantee full dispatch of either one of them, under all circumstances, or to sell firm hedging on that basis, even if the LP feasible region is known in advance.

168. This means that, even if all the constraints shown in Figure 3.5 are firm, the bundled inter-regional hedging instruments defined by the CSP/CSC proposal can not simultaneously be firm up to the full capacity of both interconnectors:

- Firm bundled hedging is definitely available with respect to interconnector 1, up to Firm1
- Firm bundled hedging is definitely available with respect to interconnector 2, up to Firm2
- Beyond those two points firm bundled hedging can only be obtained on one interconnector at the expense of denying firm bundled hedging to the other interconnector/generator.
- Firm bundled hedging can be provided, though, up to any feasible point, such as X, that might be agreed upon, or determined by trading in the hedging market.
- Having assigned firm bundled hedging in accordance with such a point, though, there is more hedging available from the network, but only in relation to that part of the PIL capacity not covered by the BRC assignment.
- This extra hedging capacity could be made available to the market, but not in the form of firm BRCs.

169. These observations have significant implications for the workings of both CBR and CSP/CSC mechanisms, and imply significant differences between them, as

95 It might be thought the hedging with respect to the PILs is irrelevant in this case because, if X is the expected dispatch point, they will not be binding. But this discussion is about hedging with respect to dispatch uncertainty which, by definition, involves consideration of the possibility that dispatch may differ from expectations, and from contract trading positions, and that other constraints may well be binding, even if the feasible region remains as expected.

discussed in Sections 4.3 and 4.4. But some general observations may be made here, with respect to the ways in which this situation may be addressed.

170. The CBR solution is simply not to bundle the CRRs, and allow each to be traded separately. As discussed in Section 4.3.2, this is the most flexible approach, and it does allow all of the hedging capacity to be assigned in a revenue neutral manner. But it may be considered more complex, and does not provide "firm hedging" in a conventional sense.

171. If the more flexible BRR definition discussed in Section 2.6 was adopted, BRRs could be created in which the entire PIL capacity was bundled with the trans-regional capacity assignment, in the ratio PIL:PIR. This would "use up" all the hedging capacity but, once such proportions have been fixed, trading of BRRs becomes an issue. The PRR component, on its own, could be traded to match any point on the trans-regional constraint between the two PILs. But the PIL:PRR ratio clearly changes as a result. Thus if a BRR were to be defined with a fixed PIL:PRR ratio, the PIL component of that BRR, which is only just feasible with respect to point X, would become infeasible, for one interconnector or the other, as soon as trading shifted away from point X.

172. In FTR markets, though, this issue is normally addressed by simply leaving some of the potential hedging capability of the network unassigned. All that is required is revenue adequacy, not revenue neutrality, and that is guaranteed for a feasible dispatch point such as X. Thus such a market would issue FTRs which are essentially bundled CRCs, corresponding to the BRC definition discussed here. And these would be firm, with respect to dispatch uncertainty. Any extra revenue which might arise as a result of the dispatch point shifting, so that the PIL constraints bound, for example, would be come a surplus in the overall FTR account, and most likely "shared" to offset deficits due to capacity/configuration uncertainty.

173. If a similar approach was taken here, the CRR bundle corresponding to point X could be interpreted as meaning PRR MW of firm hedging with respect to the constraints expected to bind at X, plus a matching amount of firm hedging with respect to the constraints on which spare capacity is expected[96]. This is, essentially, the more rigid BRC definition. With that definition, trading can actually occur freely across the feasible dispatch range, with varying consequences for the amount of excess hedging unassigned with respect to either PIL. The issue then becomes whether to:

- Attempt to sell that excess hedging capacity, which may not have much value because it relates to constraints which are probably not expected to bind, in the form of contingent hedging products; or

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[96] Although this discussion relates specifically to the PILs in Figure 3.5, where there is only trans-regional constraint, it applies also to the allocation of "unused' hedging capacity with respect to any trans-regional constraint expected to be non-binding at the current hedging position, as in Figure 2.2. if the BRC bundle is defined in terms of a fixed volume of participant MW (in this case interconnector flow) it can be taken as implicitly defining a MW share in each of the corresponding CRFs that will be only just feasible for those constraints expected to be binding, but more than feasible with respect to all others in the bundle.

- "Spread" any excess revenue which may eventually arise from that source, as in FTR markets.

174. The status quo creates a bundled CRR product via the IRSR/SRA process. As discussed in Section 2.6, the effective definition of that product matches that of a BRC, except that the common MW volume, applied across all CRFs but defined in interconnector flow terms, is only known ex post. Alternatively, this can be seen to represent the final solution that a perfect CRR trading regime might produce, if all participants kept trading to match their expected dispatch positions, right up to real time.[97]

3.6.2 Capacity Uncertainty

175. "Capacity uncertainty" is relatively easy to conceptualise. It involves shifting the constraints shown in Figure 2.2 up or down, without changing their slopes. This will obviously also impact on which constraints bind, and therefore have non-zero CPs. Thus it has critical implications for risk exposure, and hence hedging. But this raises an issue with respect to interpretation of statements about hedging being *"as firm as the RHS"*, for example.

176. The CRA discussion should be interpreted on the understanding that this situation is represented as it has been here; that is as a single constraint with a variable RHS. And Biggar (2006) should probably be interpreted similarly.[98] But NEMDE may actually characterise at least some of these variants as different constraints, even though it is only the RHS which varies. In that case, the RHS of each "constraint" is obviously firm, and firm hedging can be provided with respect to that constraint, if it occurs. So there would be no "capacity risk", as such. But then we are unsure as to which constraint form will occur, so exactly the same issues arise, except under the heading of "configuration risk".

177. Thus we will ignore the NEMDE convention and continue to describe this situation in terms of RHS variation on a single constraint, thus reducing the potential number of CRFs, and note that this means that the value of the CRF for each constraint will vary in direct proportion to the constraint RHS.

178. With that caveat, capacity risk has been basically covered by the analyses conducted previously by CRA, and by Biggar[99]. As CRA notes, the RHS of a NEMDE

[97] This does not mean that the status quo delivers equivalent incentives, or hedging value, though, because the value of hedging is measured, ex ante, by the conditional distribution of payouts expected at the time the hedge is acquired, irrespective of whether that value is realised by holding the hedging position through to real time, or selling it to some other participant in the interim.

[98] Alternatively, if Biggar's representation is interpreted as implying that a constraint with a different RHS is to be treated as a different constraint, there will be no "capacity risk" in this framework, but a very much increased degree of "configuration risk". Thus there would be no need to scale CRRs to match the RHS, or equivalently the CRF, so each CRR would be firm, with respect to its own constraint. But there would now be a separate CRF for each possible RHS capacity level, thus increasing the real degree of complexity without any real increase in firmness.

[99] In both cases, the conclusions with respect to this type of risk actually depend on an intuitive understanding of, and extrapolation from, an essentially deterministic analysis. But, as noted above,

constraint may include not only network capacity but load terms, which may exhibit considerable variation, and this will be reflected directly in the degree of firmness achievable, in aggregate, by CRF based hedging. More generally, if we now consider a wider of range of options, in which different parties may be exposed to CP, the degree of firmness achievable from each CRF is determined by the degree of variation in its Protected RHS. Thus, for example, exposing loads to CP obviously increases their risk, but greatly reduces the residual risk of the Protected RHS by removing load volatility from it, and consequently allows greater firmness in the aggregate hedging pool[100].

3.6.3 Configuration Uncertainty

179. "Configuration uncertainty" is more difficult to understand, or analyse. It involves uncertainty about both the slope and existence of the constraints shown in Figure 2.2. In other words the constraint may disappear, and may be replaced by a different "constraint form", with different coefficients, even though it may represent the same physical "limit". Such changes will occur as a result of any change to the underlying network configuration, and are probably both more common, and more significant, than is generally recognised.

180. "Lines" typically consist of two or more parallel "circuits", so that transmission can continue if one fails, or is taken out of service for maintenance. It is obvious that losing a circuit will reduce capacity on the line of which it forms a part, and that this should be reflected by changing the RHS of the relevant NEMDE constraint. Even if the basic network topology remains intact, though, removing a circuit will also alter the impedance of the line, and hence the impedance characteristics of any loop involving that line. This means that, while we may say we are still talking about the same "limit", the generic representation of that limit should really change to reflect this new network configuration. And that is equally true for the representation of all limits on all lines involved in all loops in which this circuit appears.[101]

181. In other cases, line outages can radically alter the network topology, particularly by breaking loops, thus producing radically different constraint representations for the same limit. In such situations many parties that were formerly involved in the constraint will no longer be involved at all, because power can no longer flow from them over the constrained line, while flows from those which are still involved will have a weight of 100%, because there is no longer an alternative path. Thus

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.such extrapolation seems reasonable given experience with analogous capacity right concepts in other markets.

100 Whether this translates into greater availability of firm hedging for generators, though, depends on that more contracts actually being made available by loads in that aggregate pool, as discussed in Section 3.4.

101 This re-expression would occur automatically in a nodal model linked to a database reflecting the impedances, but performing such a task manually would imply an unrealistic burden, especially in near real time, and imply an absolute overwhelming number of alternative constraint forms in NEMDE. Presumably, it is only done for the most significant changes to the most significant constraints, for network/market conditions under which they are likely to bind. And presumably, where possible, outages are timed to minimise the incidence of constraints binding. But that does not affect the principles under discussion here.

(ignoring losses) the finely graded set of coefficients typical of loop constraints will be replaced by coefficients of 0, 1, or -1, as in any unlooped network model.

182. These effects are illustrated in **Box** 3, for a simple 3 line circuit. It will be observed that 12 quite different constraint forms are generated for a single line limit, in this case the forward limit on the line from 1 to 0. There would be another 12 constraints for the reverse line limit. These would have the same form, but with the signs reversed, and would have their own distinct CRRs, thus creating a total of 24 CRFs for this one line limit.

183. Many of these correspond to situations in which the line can not possibly bind,[102] and some may have very low probability. In this case, there are only 4 distinct cases with N-0, or N-1 probability, although this increases to 10, if we consider N-1 contingencies with one circuit out for maintenance. Thus, if all such conditions need to be accounted for, we could have up to 20 CRFs for this one limit. With three lines in this example, that gives a total of 60 possible CRFs.[103]

184. Larger examples will obviously yield a very much greater number of potential CRFs. But this estimate considerably overstates the case, because many of these configurations are so unlikely, and/or the constraints in them so unlikely to bind, that they are not even represented in NEMDE, and so can not give rise to CRFs. Still, there are many thousands of constraint forms represented in NEMDE. But many bind very infrequently, so discretion could be exercised in deciding which would have CRFs calculated in the settlements system, and discretion definitely would be required with respect to which CRFs were made available for hedging purposes.

185. In terms of Figure 2.2 the point is that this configuration uncertainty can not be represented by adding in all the alternative constraint forms, because they do not exist simultaneously in the same future world. What we have, instead, is a great many alternative, and perhaps radically different, instances of the LP feasible region, (i.e. different forms of Figures Figure 3.1, Figure 3.2, and Figure 3.4, in any number of dimensions). And there is no simple way in which to characterise all those variations, or their impact on dispatch or pricing. Thus we should not expect to be able to prove strong results about the availability of "firm" revenue neutral hedging to cover this kind of risk.[104]

102 Reverse limits never bind in this example, because all load is at the Regional Reference Node.

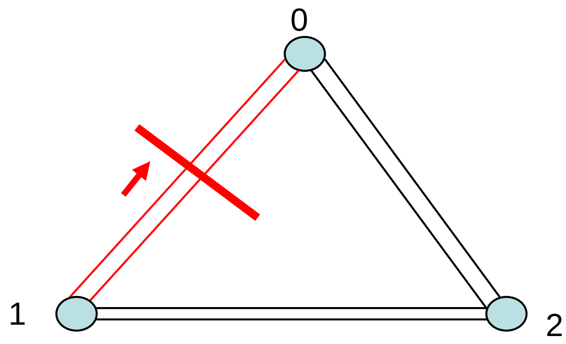
103 There are actually a great many more possible configurations for this simple 3 line circuit, but some of these configurations involve multiple contingencies which are very unlikely and/or imply the same constraint form as other configurations, for some lines.

104 In the limit, if all lines serving a generator are broken, there is no transmission capacity, and nothing in the CRF to support a hedge at all. Thus the only firm hedge that can be supported is one with zero MW volume. In our opinion, this is of no real value for hedging purposes, irrespective of any price relationships. Many generators will have more secure connections than this, and there will often be some positive volume of firm hedging that can be supported. Virtually by definition, though, the cases we are concerned about are those where there is not sufficient firm physical capacity to allow unconstrained generation, and it will not be possible to provide firm hedging up to the level desired by all participants.

186. In fact it should be evident that no revenue neutral CRF based hedging regime can be "firm" with respect to this kind of uncertainty, because it is entirely reliant on an ex ante assignment of rents to be generated from an unknown future network configuration, involving assets which may not even be connected in real time.

Box 3: Impact of Circuit Outage on Flow Constraints in a Loop

Consider a simple triangular loop, involving two generators and a load, and assume that all load is at node 0, the Regional Reference Node. So long as the loop remains intact both generators will be involved in any constraint representing a limit on any of the three lines, with coefficients determined by their relative impedances. But if any of the lines is broken the loop disappears, and there will either be a single line joining each generator to the load, or all flow will have to share a single line into the load, implying radically different constraint forms.



Ignoring de-ratings to achieve N-1 contingency cover, the constraint expressing the forward flow limit on line (1, 0) is:

If the loop remains intact:

0.67G1 + 0.33G2 < 2LIM if all lines intact
0.75G1 + 0.5 G2 < 2LIM if one (0,2) circuit out
0.75G1 + 0.25G2 < 2LIM if one (1,2) circuit out
0.5 G1 + 0.25G2 < LIM if one (0,1) circuit out
(plus 4 other cases with multiple circuit outages)

If the loop is broken:

G1 < 2LIM if two (1,2) circuits out
G1 + G2 < 2LIM if two (0,2) circuits out
Not required if two (0,1) circuits out
(plus 2 other distinct cases with multiple circuit outages)

187. Thus, at this point, the various claims which have been advanced with respect to hedging firmness need to be interpreted very carefully. For example, CRA's statements with respect to hedging being *"as firm as the RHS"* can only apply to changes in the RHS of a specific constraint form (that is with a fixed set of constraint

coefficients), not to situations in which the same "limit" is represented by a different constraint form.[105]

188. At this point, too, CRA's discussions about "bundled" CSCs become relevant, as does a significant body of literature about "revenue adequacy" in LMP/FTR markets. But that opens up a wide range of issues and options which are best left for consideration in the more specific context of discussions about particular congestion management mechanisms.

3.7 Treatment of Losses

189. In the interests of simplicity, a consistent treatment of losses has not been consistently worked through the analysis. Losses add significant complexity, not least because intra-regional and inter-regional losses are treated differently in the NEM, and because it is unclear to what extent loss effects may already have been accounted for in determining NEMDE constraint coefficients. But the difficulties this creates are more mathematical than conceptual, and can reasonably be ignored at this stage of the analysis.

190. The treatment of losses is discussed briefly in Section 3.7 of CRA(2004a), and Biggar (2006) has proposed an analysis. The matter deserves further investigation, but we note that a loss tranche limit on an interconnector is mathematically analogous to a PIL, and essentially the same analysis applies. Such "tranche PILs" will have shadow prices, just like the interconnector limits, and these produce rents which are implicit in the current IRSR, and would remain so under the CSP/CSC proposal, for example.

191. The difference is that, unlike the interconnector limit, each loss tranche has an associated coefficient, representing the actual losses due to interconnector flow utilising that tranche. This is a real cost to the system, and one which logically should be paid by traders using the interconnector. The tranche limit rents implicit in the IRSR can not, and so not, provide hedging for this cost component. What they represent, in aggregate, is the difference between this actual cost of losses, and the loss charges implicitly levied by the spot market, where inter-regional price differentials reflect marginal loss costs.

192. This net rental component is all that can be hedged from the IRSR, and this will not change no matter how the IRSR rents are re-assigned. For a pure quadratic loss function the loss rental component will be exactly half the margin loss component of the inter-regional price difference. And a pure quadratic gives a very good approximation for losses on any real line. But the NEM interconnectors are notional constructions, not real lines, and they need not have pure quadratic loss functions. The actual cost of losses effectively represents a purchase in the energy market, and the price risk, at least, may be hedgable by contracting in the energy market. But that is another matter.

105 And, while some parties have used terms such as "fully firm" hedging, such sweeping conclusions can not really be supported by analyses which do not consider this kind of uncertainty.

4 Generic Congestion Management Mechanisms

4.1 Introduction

193. Previous sections have introduced a general framework, described the status quo in terms of that framework, and explained some basic characteristics of the stochastic price structure which exists in the current market. That structure is a fundamental characteristic of the NEM engineering-economic system, and will always be reflected in the outcomes from an optimal dispatch process, no matter how it is constructed.

194. This section follows up on that description by explaining several approaches that have been proposed to rectify various problems identified with the status quo arrangements, particularly with respect to "interactions" between interconnectors involved in inter-regional constraints, between generators involved in intra-regional constraints, and between interconnectors and generators involved in trans-regional constraints.

195. We will ignore "physical " options involving the imposition of constraints to force generation, or interconnector flows, to particular values, and options involving "compensation" calculated according to some process or formula other than the CP. Thus we focus solely on CP based "financial" options, which can all be described exactly in terms of the conceptual framework developed here.

196. As previously, we can think of the dispatch point as moving around in the feasible region, but note that, as it does so, the CRR allocation is being implicitly adjusted, under the status quo. This does not matter so long as the constraint does not bind. But once it does, under the status quo, the share of the constraint resource "rights" which each generator/interconnector gets is determined entirely by their relative generator/interconnector dispatch level. The relative dispatch levels of generators and interconnectors are determined by the constraint coefficients applied to these generators and/or interconnectors, and by the offers of all generators involved, either directly, or indirectly through interconnector flows. Thus at least some of the problems identified with the status quo arise as a result of the fact that manipulating offers to secure particular dispatch outcomes ensures implicit allocation of CRRs which may have significant value in critically constrained situations.

197. Here we consider alternatives to this status quo allocation of CRRs. These alternative approaches allow the share of the constraint capacity assigned to each generator/interconnector to be determined by some ex ante process, such as negotiation between the relevant parties, or by an auction. The two broad regimes discussed in this chapter involve different ways of defining and dealing with such a notional partitioning of the constraint capacity.

198. These approaches employ financial, rather than physical, incentivisation mechanisms. This is, there would be no change to dispatch processes, or the NEMDE formulation, but only to settlements, and related contracting. These regimes are thus more directly analogous to the approach employed in the energy market, where spot prices provide the primary incentives for generation to meet

demand. In that context, financial contracts are used primarily to mange risk, but also significantly alter participant incentives, and can be used to manage market power, for example.[106]

199. These regimes both also involve a ”priced” approach to financial incentivisation, using the CP, rather than a “compensation” methodology based on assessment of costs, or market offers, for example. Thus all participants involved face the same “market-clearing prices”, reflecting the marginal system cost of both energy and congestion, although these may combine in different ways to give different signals to different participants.

200. Our initial discussion here is generic, but specific chapters then deal with the application of these generic mechanisms to interconnectors and generation, both of which appear on the LHS of NEMDE constraint equations, and then move on to deal with the ancillary service, TNSP, and load terms which make up the RHS.

201. It will become evident that there is, potentially a great deal of common ground between the CBR and CSP/CSC regimes, and that it would be possible to describe each as an adaptation, of the other. Specifically:

- CRA’s presentation of the CSP/CSC framework evolved over several papers, and left open a very wide number of options. Any participant of any type might be exposed, or protected, and CRRs could be firm or scaled, pure or bundled, and allocated or auctioned.

- By way of contrast, Dr Biggar’s description of CBR is quite narrowly focussed. As we read it he envisages exposing all generation, interconnector and load terms, but no others. And CRRs would be all pure, defined as proportional shares, and auctioned.

202. Arguably, the way in which it has been presented undersells the merits of the CBR approach, and we will take the liberty of suggesting some generalisations that might make it more practical, without compromising its essential nature too much. But we note that, as more and more such features are added to the proposal, it becomes progressively more like the CSP/CSC proposal and, in the limit, indistinguishable. Conversely, since the CSP/CSC framework was so broad, it is arguably possible to describe the CBR proposal as simply one of the many variants discussed by CRA[107].

203. In order to facilitate comparison of a broad range of distinct alternatives, though we have portrayed the CBR regime, primarily, as it was portrayed in the original proposal, but with some flexibility in the direction of generalisation. Conversely, we have focussed on a relatively narrow interpretation of the CSP/CSC regime, so as to keep it distinct from the CBR proposal. The concept of ”partitioning” CRFs

[106] Specifically, participants have “second order” (gaming) incentives to match their contract positions, as discussed in Box 2.

[107] With the possible exception that CRA tended to assume that participants would still see intra-regional and inter-regional hedging as distinct products, purchased from distinct pools. But CBR envisages participants purchasing both directly from CRFs. As discussed in Section 4.5.3, this relates closely to CRA’s assumption that the existing regional price structure would be retained for loads.

between intra-regional and inter-regional pools, for example, was not proposed in quite such definite terms by CRA.

4.2 Creation of CR pools

204. Both the CBR and CSP/CSC approaches, in all their variants, would start off by exposing generators and/or interconnectors to the CP prices of whatever constraints were to be managed. We will refer to the residual Protected RHS, formed as sum of all remaining protected terms, whether constant or variable, as $ProtectedRHS_{F}$, $ProtectedRHS_{G}$, $ProtectedRHS_{FG}$ etc. That is the Protected RHS applicable when only flow terms are exposed, or only generation terms, or both, and so on. [108]

205. Exposing the interconnector/generator terms means that rents (positive or negative) would be extracted from the IRSR pools, and/or from generators, and paid into CR pools, one for each managed constraint. Since the implications of this are different for generators and interconnectors, they are discussed later, in the relevant chapters. But note that, while these situations have been discussed with reference to simple two dimensional diagrams, in which corner points are defined by the intersection of only two constraints, the results generalise to any number of constraint intersections, and to any number of constraints intersecting at a point. [109]

206. As noted earlier, if the CRFs are not empty, they will most commonly contain only positive rents. A negative CRF is possible if, but only if, the constraint RHS is negative, with the constraint expressed in ≤ form[110]. A negative CRF represents an aggregate liability for the generator/interconnectors involved, such as a requirement to meet a cross-border load[111].

4.3 The CBR Approach

4.3.1 Auctioning CRRs

207. Having created these distinct CR pools, the basic CBR approach is simply to auction proportional shares of the rents in each pool separately, that is to sell unbundled proportional CRRs, then leave participants to sort out their own hedging

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[108] This notation is incomplete, because it does not specify precisely which terms are exposed in which managed constraints. Thus it may be taken to imply that, if a constraint is managed, then all terms of a particular type in that constraint will be exposed, which is not necessarily the case. Conversely, it is possible that a term which is exposed in one constraint may be protected in another. Thus our discussion applies, strictly, only if all generator/ interconnector terms are exposed in all constraints in which they appear. But it will suffice to establish the general principles.

[109] Optimal LP solutions always lie at a corner point of the LP feasible region. But that region is defined in a space of very high dimension, and has a great many corner points defined by the intersection of constraints other than the network constraints under discussion here. Still, solutions will involve intersecting network constraints rather more often than pure coincidence might suggest.

[110] Or equivalently, if the constraint RHS is positive, when expressed in ≥ form.

[111] See example in Section 6.4.

arrangements by re-combining these rents in combinations to match their trading requirements.

208. These CRRs would be neither bundled nor allocated, so the only central activity required would be to assign reservoirs to CRFs and run the auction process, thus extending the current SRA. And because the CRRs defined as shares are strictly proportional, strict revenue neutrality is maintained at all times.[112]

209. It might be thought that only exposed participants will want to trade in these pools. But, even if generators were still protected with respect to a constraint, they are still likely to want to arrange inter-regional hedging, by buying or selling the corresponding CRRs. Thus the volume of transactions in and out of each of these CR pools could be much larger than the pool itself, as discussed in Section 3.2.1.[113]

210. This means that institutional arrangements must somehow be provided to allow both buying and selling activity, if inter-regional hedging is to be made available to all requiring it. But it need not necessarily be provided in a centralised fashion. The current SRA regime only auctions shares in the net IRSR pools, and relies on secondary markets to arrange inter-regional hedging utilising these rents but also, presumably, matching swaps between traders wishing to trade in opposite directions. Thus the volume of hedging available in any particular direction should be significantly greater than that implicit in the IRSR alone, but that volume is only available in the secondary market, and then only if that market is effective.

211. Similarly, if CRFs are to be auctioned as in the existing SRA process, this presumably means that shares in the net CRF would be all either sold at auction, if positive, or bought in an equivalent tendering process, if negative. That is, there would be either an auction, or a tender, for each CRF. If so, while we may talk about "participants" being involved in these auctions, and quite apart from any transaction cost issues, there will be many participants who need hedging, but have no effective access to the auction. This is because the hedging they require can only be provided by selling, not buying, a positive valued CRR, or by buying a negative valued CRR, as discussed earlier. They would need to find another participant to trade with, who had the opposite hedging requirement, either directly, or indirectly through an agent, or secondary market. But a two-sided auction process may be more effective, as discussed in Section 4.5.5.

212. If Figure 3.1 in Chapter 3 represents two interacting interconnectors, this would imply replacing two "IRSR" pools with three CR pools in the SRA process (one for each constraint). This may be regarded as a modest variation on the market design, implying a moderate increase in complexity for participants. It can, in principle, provide hedging which is as firm as the network which turns out to be available at the time, and has the advantage of being revenue neutral by design. And it does

[112] Or, conversely, since Biggar claims strict revenue neutrality, we have interpreted his analysis as implying that CRRS are to be defined as "shares", and thus scaled in proportion to CRFs.

[113] Note that the "participants" directly represented in Figure 4.1 are interconnectors, but really it is the traders using those interconnectors who are ultimately responsible for managing risk exposure. Also note that if some participants are protected, any variation in their dispatch will be reflected as a variation in the Protected RHS, and hence the aggregate hedging available to exposed participants.

partition the rents into CR pools matching the underlying realities, thus making those pools whole, at least with respect to $ProtectedRHS_F$. But this example is deterministic, and we need to ask how this approach would deal with the three kinds of uncertainty identified previously.

4.3.2 Dealing with Dispatch Uncertainty via CBR

213. We have defined "dispatch uncertainty" as arising because participants can not know, in advance, how other participants will be dispatched. CBR should, in principle, allow "dispatch uncertainty" to be dealt with. Thus, if the "feasible region" shown in Figure 3.1[114] were known in advance, it should be possible for participants to trade so as to match their expected trading position.[115]

214. This does not necessarily mean that participants can hedge their desired dispatch position, though, because all participants' hedging positions must be simultaneously feasible. And all parties can not simultaneously obtain firm hedging with respect to all applicable constraints, up to the full capacity of any particular interconnector, for example, for the reasons discussed in Section 2.6. There simply will not be enough firm CRRs available to allow this, because there simply is not enough physical capacity in the network to support it.

215. The ideal hedge for most participants is likely to be one in which the same PRR volumes apply to all CRFs. In other words they would seek to purchase what is referred to in Section 2.6, and in the CSP/CSC discussion below, as a BRC. As noted there, though, if all traders acquired BRCs that would leave spare hedging capacity on some constraints. Thus a trader might cover more flow MW with PIL hedges, say, than with trans-regional hedges, just because the former are in excess supply and the latter are not. This would provide "more hedging", but of a less firm nature.

216. In any case, a trader will find it impossible to form a firm BRC from proportional hedges, because the underlying hedges are not firm themselves. But that lack of firmness relates to capacity and configuration uncertainty, not dispatch uncertainty.

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114 This will be the NEMDE LP feasible region if, but only if, all interconnectors and generation are exposed to CP, and no other parties. In other words, if the Protected RHS is also the NEMDE RHS. Otherwise there may be more hedging available (if RHS terms are exposed as discussed in other chapters), or less (if some interconnector or generation terms are protected).

115 As noted in Appendix A, CRA considers that the claims made by Dr Biggar are not entirely supported by his analysis. Thus we should distinguish what the CBR approach can actually deliver, and what it has been indisputably shown to deliver. As we understand it, the matematical analysis in Biggar (2006) appears to show only that this approach can provide "hedging" to match the actual real-time dispatch of participants. That line of proof seems inappropriate if, as we assume here, hedging is not about that matching dispatch positions, essentially ex post. (Note that the status quo already implicitly assigns CRRs which match dispatch outcomes.) But, even if the proof is incorrect, we believe that the CBR proposal actually will allow ex ante hedging to be improved, relative to the status quo, because the CR pools match the aggregate dispatch position of all participants. In other words, we consider the conclusion to be correct, in this regard, even if the analysis is debatable.

4.3.3 Dealing with Capacity Uncertainty via CBR

217. We have defined "capacity uncertainty" as arising because participants can not know, in advance, what the (Protected) RHS capacity of each constraint will be. The CBR methodology, as we understand it, deals with "capacity uncertainty" by scaling the CRRs purchased from each pool in proportion to the total rent available in that pool, that is, in proportion to $ProtectedRHS_F$ for that constraint.[116]

218. This scaling in the CBR approach preserves revenue neutrality, but means that hedging can not be "firm" in the conventional sense, as we understand and use that term. That is, a hedge which is scaled to match available capacity simply can not match a fixed MW energy trading position.[117] Also, the scaling applied to each constraint will be different, in any particular period, because each constraint's (Protected) RHS capacity varies (more or less) independently. So a revenue neutral bundle can not be defined in such a way as to scale consistently across all of the constraints which may bind, even under a given network configuration.[118]

4.3.4 Dealing with Configuration Uncertainty via CBR

219. We have defined "configuration uncertainty" as arising because participants can not know, in advance, what the precise configuration of network elements will be. The CBR proposal seems to ignore this type of uncertainty, and does not propose any specific mechanism to deal with "configuration uncertainty". We have already argued that revenue neutral hedging can not be truly firm with respect to this kind of uncertainty, but that is true for any revenue neutral approach, and should not be seen as a specific weakness of the CBR approach.

220. It should be recognised, though, that configuration uncertainty means that the number of CR pools will be very much greater than might at first be thought, from a deterministic analysis. As in Box 3, there is one CRF for every trans-regional constraint form which might arise over a potentially wide variety of network configurations. The CRFs corresponding to each alternative network configuration provide "contingent" hedging, only having value if that configuration actually occurs. But, to the extent that "firmness" can be achieved, the CBR approach requires that market participants somehow acquire portfolios of CRRs covering many uncertain contingent "states" of the world. Participants could perform their own analyses, and combine CRRs from different pools as best they could. Or they could rely on secondary market agents to do this for them.

116 As discussed earlier, we interpret this to be what Biggar (2006) actually means, when he says that a separate CRF would be established for each "constraint". The alternative interpretation would greatly increase the number of distinct CRFs, but ultimately not increase firmness.

117 Such instruments could emerge in a secondary market, but revenue neutral instruments can not deliver firmer hedging to one party without delivering less firm hedging to some other.

118 Again, such instruments could emerge in a secondary market, but they can not deliver firmer hedging to one party without delivering less firm hedging to some other.

4.3.5 Summary

221. It would be premature to attempt an assessment of the CBR approach at this point, and particularly before discussing how it might be applied to particular situations and participant classes. But it may be noted, at this stage, that it has certain appealing features:

- First, it is conceptually pure and simple;
- Second, it guarantees strict revenue neutrality at all times;
- Third, it minimises the requirement for any centralised process or institution to "bundle" or "allocate" rights; and
- Finally, it gives traders access to instruments representing the underlying economic structure of the market, and gives them flexibility to adjust trading positions to take advantage of that structure.

222. But the CBR approach also faces four significant limitations:

- First, the fact that it enforces strict revenue neutrality means that it can not provide firm hedging, as we understand that term;
- Second, it creates significant complexity that participants would have to deal with and/or places considerable reliance on the efficiency of secondary markets to deal with this complexity;
- Third, while the (relatively) short term CRR assignment achieved by regular auctions has advantages in terms of flexibility, it does not , of itself, provide firm long term instruments that can be used to guarantee long term market access, or control market power; and
- Finally, as presented, it is an essentially passive approach to congestion management, and does not attempt to provide a mechanism to contract for enhancements to network capacity.

223. Mechanisms may be proposed to overcome these limitations; by ignoring some CRFs and bundling others to reduce complexity, or by allocating longer term hedges, for example. This would also make CBR much more like the CSP/CSC proposals advanced earlier by CRA, though. So, in view of our intention to describe a range of alternatives, with distinctly different "flavours", we will stick with this relatively "pure" description of the CBR regime. This also preserves (we believe), something of the purity of the proposal actually advanced by Biggar (2006), which may be contrasted with the more eclectic and pragmatic nature of the various CSP/CSC proposals advanced by CRA.

4.4 The CSP/ CSC Approach

4.4.1 CSP/CSC vs CBR

224. CRA's CSP/CSC proposal, or more exactly its original proposals to NEMMCO[119], involves all the same mechanics as the CBR approach, except that:

(a) The primary definition of CRRs was conceived of in terms of fixed MW CSCs, which we are referring to here as CRCs, with the proviso that these would need to scaled somehow, if "revenue adequacy" conditions were not met;

(b) CRCs with various parties (eg TNSPs or NSCS providers[120]) could be used to contract for constraint "support" capacity, with the effect of "firming up" CR pools, as discussed in Section 3.3 ;

(c) CRCs would also be used to allocate some portion of the resultant (firmer) CR pools back to inter-regional hedging pools corresponding to the interconnectors, which would probably then be auctioned via the existing SRA process; and

(d) The remaining CP rent would be made available for intra-regional hedging purposes, by one of several methods discussed by CRA.

225. While the CSP/CSC approach involves the additional step of contracting, it may be argued that CSP/CSC actually involves a less radical change to the existing market design, inasmuch as it partitions intra-regional and inter-regional hedging in such a way as to specifically preserve its hub and spoke structure. An allocation of CRRs between intra-regional and inter-regional hedging pools was proposed to achieve this partitioning. More generally CRA discussed the possibility of various allocation mechanisms, and argue that allocation may be appropriate under some circumstances. But they also suggested that auctions may be appropriate under other circumstances. Thus it would not be true to say that CSP/CSC, as proposed by CRA, relied totally on "allocation" of CRRS, as opposed to the "auctioning" approach of the CBR proposals.

226. Rather, the difference is that the CSP/CSC approach allows for some of the CBR requirements to be relaxed, or additional mechanisms employed[121]. Specifically, it differs from the basic CBR proposal described by Biggar in that:

(a) The CSP/CSC approach envisaged flexibility with respect to which participant groups might be exposed to CP, whereas the CBR proposal, as presented,

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[119] A s summarised by CRA(2003b) and CRA(2004c).

[120] Network Support and Control Services (NSCS) are a combination of four contractual items: a) NCAS procured by NEMMCO via a tender process; b) NCAS sold to TNSPs in order for the TNSP to meet its basic secure network transfer requirements; c) Network Support Agreements entered into by TNSPs; and d) Reactive support obligations on generators that are part of their connection agreements with a TNSP.

[121] CBR could, in principle, be developed to include such allocation mechanisms. But, as noted earlier, for the purposes of this discussion there is little point in re-defining CBR in such a way as to effectively make it just another variation on the CSP/CSC proposal.

assumed exposure for generators, interconnectors, and load, but not for TNSPs or ancillary service providers;

(b) The CSP/CSC approach does not insist that strict revenue neutrality be maintained, with respect to each constraint in each trading interval, whereas the CBR proposal, as presented, did;

(c) The CSP/CSC approach allows for CRR "bundling", as discussed in Section 2.6, whereas the CBR proposal, as presented, did not;

(d) Whereas the CBR proposal, as presented, relied solely on auctioning, the CSP/CSC approach envisaged auctions being employed under some circumstances, but allowed for CRR allocation under other circumstances.In particular:

- The CSP/CSC approach allows for CRRs to be negotiated with TNSPs or NSCS providers, whereas the CBR proposal, as presented, did not; and
- The CSP/CSC approach employs a two tier mechanism, by which CRRs are first allocated to interconnectors, and the resultant inter-regional CRR "bundle" then auctioned, as above.

227. The CSP/CSC approach may thus be characterised as less "pure", conceptually, than CBR, and possibly more pragmatic. Since the various features of the CSP/CSC approach are not all relevant to all parties, they will be discussed as follows:

- The issue of which participant groups might be exposed to CP is discussed in a series of chapters dealing with those participant groups, while our broad discussions take a flexible attitude to the CBR proposal, exploring the possibility that it might be applied, or be not applied, to the same participants groups envisaged in the CSP/CSC proposal.
- The difference between strict revenue neutrality and "revenue adequacy", and its implications for CRR/CRC firmness will be discussed in the Section 4.5 below, dealing with pragmatic market issues;
- The potential value and performance of CRR "bundling" will be discussed in this section, inasmuch as it relates to the generic treatment of various kinds of uncertainty, but the concept is also discussed later, in specific contexts.
- The allocation of CRRs to particular participants will be discussed in the relevant chapters, later, but the generic concept of CRF partitioning will be discussed here, since it relates to the generic treatment of various kinds of uncertainty.
- The use of CRCs to contract for congestion management "services", will be discussed in the context of chapters dealing with the application of these concepts to TNSPs and ancillary service providers, in particular; and
- The use of CRRs, or CRCs, to allocate some portion of CR pool back to IRSR pools will be discussed in chapter dealing with interconnector issues.

4.4.2 Partitioning CRFs

228. At a generic level we note that, by identifying and dealing with the constituent CRF streams, and allocating each in accordance with an ex ante contractual agreement, we can obtain distinct intra-regional and inter-regional hedging pools which exactly match those ex ante agreements. In Figure 3.5, we can interpret point *X* as defining an assignment of financial, rather than physical, rights (ie PRR_1 vs PRR_2) to the interconnector/generators represented by the two axes.

229. This MW assignment of capacity has been expressed in terms of quantities measured along the axes; that is in terms of "participant MW". As discussed earlier, if this is interpreted as defining a CRR, this would be a participant CRR (PRR), with the corresponding allocation of Protected RHS capacity MW being given by[122]:

$$CRRV_{ik} = PRRV_{ik} * weight_{ik}$$

230. Note that, by construction, the sum of these two allocations equals the constraint capacity, and revenue neutrality is guaranteed. More generally:

$$\sum_i CRRV_{ik} = ProtectedRHS_k$$

231. Although the CSP/CSC proposal did not necessarily propose to partition the intra-regional hedging pool between participants in this way, it did propose to partition CRFs between inter-regional and intra-regional hedging pools, and between specific interconnectors. By partitioning the CRF in this way, the hedging funds available to each party, or group, become firmer. In the limit, if the Protected RHS of each constraint is firm, and the partitioning agreement is firm, then firm hedging should be available to participants up to the agreed volumes.

232. But it should be recognised that this firmness has been obtained at the expense of imposing limitations on the balance which can be achieved between inter-regional and intra-regional hedging, and between the inter-regional hedging available on particular interconnectors. Thus it may be seen as a financial, rather than physical, way of defining, and operationalising, a form of prioritisation, between various interconnector/generator flows.[123]

233. In reality, though, the underlying network is not firm, and we must ask how firm these contractual arrangements can be made, with respect to the three kinds of uncertainty identified previously.

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122 Note that the sum of these two allocations thus equals the constraint capacity, and revenue neutrality is guaranteed.

123 And this will ultimately have some impact on dispatch, because participants will have second order incentives to align dispatch volumes with ex ante trading positions. See discussion in Box 2, but note that competition will be much more effective, and hence second order incentives much less significant, in major regions, or over major interconnectors, than with respect to localised congestion problems.

4.4.3 Dealing with Dispatch Uncertainty via CSP/CSC

234. The CSP/CSC methodology allows participants to deal with "dispatch uncertainty" in much the same way as the CBR approach. That is, they must somehow obtain CP based hedges which match their planned trading position, ex ante. And the availability and firmness of such hedging is determined by the Protected RHS, via exactly the same mathematics as for CBR. The basic difference is that the available rents are partitioned into distinct intra-regional hedging pools (for each region) and inter-regional hedging pools (for each interconnector). And, at least in the latter case, they would be bundled.

235. The CSP/CSC proposal's ex ante partitioning of CRRs between separate intra-regional and inter-regional hedging pools, simplifies the hedging issue for participants, and makes each such pool firmer than under the status quo. The hedging pools are also "firmer" than under CBR, in the sense that the volume of inter-regional, and intra-regional hedging available is more certain. But this certainty has been achieved by partitioning the total hedging pool in, thus limiting the ability of participants to contract for intra-regional/inter-regional hedging to match desired (ex ante) trading patterns which deviate, in aggregate, from the agreed balance. [124]

236. More generally, under CSP/CSC the dimensionality of the hedging problem faced by traders has been reduced relative to CBR. The impact of this reduction in dimensionality has already been discussed in relation to Figure 3.1 in Section 3.6.1. If we now interpret "point X" in that figure as defining a partitioning of the trans-regional constraint capacity, we must consider what that might imply with respect to partitioning of the capacities of other constraints, including the PILs illustrated in that figure.

237. Several options are discussed in Section 3.6.1, but it concludes that it is, in fact, possible to define a fixed MW BRC that remains firm with respect to dispatch uncertainty. As noted there, though, that leaves excess hedging capacity with respect to all constraints which are not expected `to bind at the market solution corresponding to the BRC assignment[125]. Thus the issue becomes whether to attempt to sell that excess hedging capacity, which may not have much value because it relates to constraints which are probably not expected to bind, in the form of contingent hedging products, or to spread any excess revenue which may eventually arise from that source, as in FTR markets.

238. In other words, the issue becomes whether to offer less than fully firm hedging products, or to compromise on revenue neutrality. Exactly the same issue would be faced by any party attempting to construct firm inter-regional hedges based on the same CRFs, under any regime. In nodal markets, the same issues arise with respect to FTRs, which are essentially defined as equivalent to BRCs. Based on experience

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124 By way of comparison, under the status quo, participants can not obtain firm hedging for trading positions which deviate, in aggregate, from the actual dispatch, which is only known ex post. As noted in Box 5, the secondary market should theoretically be able to unbundle such bundled CRRs if it so desires.·

125 That is, just the PILs in this figure, but a great many more, in reality.

with such markets, the CSP/CSC proposal would opt to abandon revenue neutrality in favour of revenue adequacy standard[126], while recognising that firmness will be unachievable anyway, due to capacity and configuration uncertainty.

239. But note that these are all non-issues, inasmuch as they relate to inter-regional hedging products bought by traders, because this proposal assumes that the existing SRA process will continue, leaving secondary markets to sort out such details. The real implications of this discussion relate to the bundle of CRRs defining what comes into the IRH, and thus determining the characteristics of the bundles available in the SRA.

240. Figure 3.1 can be interpreted a defining a partitioning of CRF pools between interconnector hedging pools, or between interconnector and intra-regional hedging pools. The implication is that hedging provided to, and hence from, the IRH can be made firm, with respect to dispatch uncertainty, if CRR allocations to the IRH are all defined in terms of the same fixed MW interconnector flows. Thus this may be regarded as a useful guideline in the setting of any partitioning agreement.

241. But sticking with such a guideline would mean that rents collected in the IRSR when constraints which are not expected to bind at X actually do bind, would not be returned to the IRH, creating a net surplus in that case. On the other hand these surpluses will probably be more than offset by deficits arising when capacity and configuration uncertainty create situations in which the rents collected are lower than expected. In any case, there is no reason to expect that the logic of asset ownership, history, or politics will allow a CRF partitioning to be agreed upon which is uniform, in participant MW flow terms, across all potential constraints. Thus we expect that the aggregated CRF bundle accumulating in the IRH would not correspond to a precise definition of a BRC, although it should more closely approximate one than it does at present.

242. The partitioning discussed here does have another implication, though. CBR allows participants to build up inter-regional hedge, indirectly, by trading independently in each of the individual CRF pools, and that trading is not limited by partitioning of any of the CRF pools. When aggregated to the interconnector level, trading may result in BRC positions anywhere across the range of dispatch possibilities represented by the feasible region in the figure. But, if the CRFs are partitioned, and traders restricted to trade within each interconnector hedging pool, their trading will only be able to occur within the limits of the agreed partition.

243. Thus, while the partitioning of CRFs in the CSP/CSC proposal, “simplifies” the situation faced by traders, it also restricts the market’s ability to find an optimal balance between intra-regional and inter-regional hedging, or between hedging on particular interconnectors, in a more dynamic fashion. It may be argued that secondary market agents can readily “fix” this problem by unbundling and re-bundling the proceeds of IRH auctions[127]. But the restriction would undoubtedly have some negative impact. Within the CSP/CSC framework, this argues for a

126 See discussion in Section 4.5.4.

127 See discussion in Section 4.5.5.

refinement of the SRA process, at least, to allow the market to achieve a more dynamic balance, perhaps along the lines proposed in Section 4.5.10.

4.4.4 Dealing with Capacity Uncertainty via CSP/CSC

244. Just as for CBR, the CSP/CSC regime can not provide hedging which is both revenue neutral and "firm", in the conventional sense, in the face of "capacity uncertainty". While CRA did not make any firm recommendation, they suggested that this situation could be dealt with by scaling the CRRs purchased from each pool to match the total rent available in that pool, just as for the CBR proposal. But because the CSP/CSC proposal only required "revenue adequacy", not strict "revenue neutrality", this feature was not considered to be central to the proposal.

245. Even if it was considered necessary to preserve revenue neutrality, the scaling involved does not need to be proportional, and proportional scaling was not considered to be necessarily appropriate by CRA. But this perception relates to CRA's rather different view as to the processes by which participants might come to hold CRC's, as discussed in Box 4.

Box 4: Sharing Rules for Transmission Investment

Imagine a situation in which a new interconnector is being proposed. It would be reasonable to expect that, before committing such a project, consideration would be given to the way in which that interconnector might interact with incumbent interconnectors. And, under any kind of congestion management regime, it would be not unreasonable to expect a contractual agreement to be reached among the affected parties as to how capacity on the new and existing transmission elements, and their associated congestion rents, were to be apportioned. But it seems less likely that the incumbent would accept a pro-rata sharing of existing capacity, for example. Instead we might expect a typical agreement to preserve something like the access currently enjoyed by the incumbent, while granting incremental rights to any new capacity effectively created or unlocked by the newcomer, to that party.

Whether institutional arrangements exist to negotiate and effect such an agreement is not our current concern. The point is that a non-proportional CRR scaling rule could readily be devised to reflect such a situation, while preserving revenue neutrality. But this means that the scaling applied to each constraint may well be different, so a bundle can not be defined to consistently match the same MW energy trading position, across all of the constraints which may bind, even with a known network configuration.

4.4.5 Dealing with Configuration Uncertainty via CSP/CSC

246. Unlike CBR, the CSP/CSC approach provides a specific mechanism to deal with "configuration uncertainty", in the form of "bundling". Rather than rely on participants to perform their own analyses, and combine CRRs from different pools as best they could, CRA proposed that bundles be formed which might better match hedging, or contracting, requirements over a wide range of network configurations.

247. Thus CRA suggested that bundles could be constructed that related only to some limited range of network configurations, thus effectively forming contingent hedges.[128] It was envisaged that this would allow contracting, particularly for network support, to be tied to particular situations.[129] Thus this concept is considered further in Chapters 7 and 8, dealing with NSCS and TNSP contracting.

248. But CRA also proposed the bundling of CRRs to form inter-regional hedging pools analogous to the current IRSRs. With respect to trader hedging requirements, we have already argued that revenue neutral hedging can not be truly firm, in aggregate, with respect to configuration uncertainty, and this is just as true for the CSP/CSC approach as for the CBR approach. The potential advantage of bundling is just that it reduces the complexity faced by participants in relation to configuration uncertainty to what may be a more manageable level. On the other hand, bundling does create complexity for whoever must decide what the bundles should be, and assumes the existence of an institution in a position to perform that task, or at least oversee it.

4.4.6 Summary

249. Again, it would be premature to attempt an assessment of the CSP/CSC approach at this point, and particularly before discussing how it might be applied to particular situations and participant classes. But, by way of contrast with CBR, it has some obvious disadvantages:

- It is conceptually less pure, and more complex, in the sense that it attempts to provide more diverse mechanisms to deal with more diverse situations;
- It imposes a significant requirement for a centralised process, and institution to "bundle" and/or "allocate" rights;
- Its reliance on prior agreements with respect to allocation make it less flexible in terms of the level and variety of hedging that may theoretically be provided to participants;
- It does not guarantee strict revenue neutrality at all times; and
- It still can not provide fully firm hedging, in the conventional sense.

250. None of this desirable, if it can be avoided, but the proposal also has some potential advantages:

- One reason it is less pure, and more complex, is that it was intended to support both passive and active congestion management, by providing a mechanism to contract for enhancements to network capacity.

128 See Section 4.3 of CRA(2004a)_

129 See Slides 57-59 in CRA(2004d) for example.

- A related reason is that it was designed to enable long term contracts to be formed, and allocated to provide access and/or control market power over longer periods.

- One reason it is less flexible, and relies more on centralised arrangements, is because it has been designed to be simpler for participants to interact with, and to align more closely with the current market structure.

- A related reason is that this "inflexibility" translates into greater certainty with respect to the availability of hedging on any particular interconnector.

- It is also able to provide firmer hedging, in a pragmatic sense, than the CBR proposal because it does not enforce strict revenue neutrality.

4.5 Pragmatic Considerations

4.5.1 Introduction

251. It should be clear, from the summaries provided in previous sections, that both CBR and CSP/CSC proposals have their advantages and disadvantages. It would be premature to accept or dismiss either, at this point. But, although not highly mathematical, the above discussion is somewhat theoretical, focussing on relatively precise concepts, such as revenue neutrality, in an attempt to clarify basic principles, and establish a clear understanding, with respect to issues such as hedging firmness for example.

252. Market realities are seldom this precise, for all kinds of reasons. This is true of the existing NEM arrangements. But it is also true of arrangements in international markets which employ market-clearing, congestion management and inter-locational hedging arrangements that are, in principle, more mathematically precise and sophisticated than those in the NEM. Thus, before considering the application of the theoretical concepts developed here to particular participant groups, it seems appropriate to consider some rather basic pragmatic issues which would have to be considered in implementing any of these mechanisms, and may well be decisive in terms of any final evaluation.

4.5.2 Are the Proposed Mechanisms Actually Adding Value?

253. One fundamental point that should be borne in mind throughout this discussion is that there is no point in imposing institutions, or providing facilities, in which the market does not see sufficient value. This point obviously relates to the materiality of the underlying congestion problem, vs the potential cost of dealing with it.

254. In its previous work for the MCE, CRA concluded that a comprehensive change to the market design, such as a move to nodal pricing, was not justified. Thus they recommended a piecemeal application of congestion management mechanisms, but within a consistent overall framework. If that judgement is accepted, it would argue against widespread application of either the CBR or CSP/CSC approach, at this time.

255. Both of these proposals are designed to "fix" current problems with congestion management, and simply exposing participants to congestion prices would go some way towards that goal, without any further overlay. But it should also be recognised that, on its own, this actually makes hedging problems worse, so far as exposed participants are concerned. The difference between the proposals then lies in the range of participants for whom new hedging problems are created, and the mechanisms employed, or available, to "fix" the problems thus created.

256. At one extreme, Section 5.4 discusses a CSP/CSC option which would only affect interconnectors, and provide somewhat firmer inter-regional hedging, without affecting another party. But, at the other, universal application of either regime would expose all participants, both generation and load, to what is effectively a nodal market.[130] There is obviously much to be discussed between those two extremes, but that is the subject of the remaining chapters.

257. The point we wish to make here is a more subtle one; namely that the potential "advantages" of some of the mechanisms proposed to "fix" hedging problems will only be relevant in situations where particular participant groups are exposed to CP. Thus one should not just look at the advantages of the mechanisms themselves, but the overall advantages, and disadvantages of first exposing participants in this way, and then providing the new mechanism, vs retaining the existing IDMA mechanism.

258. This is not just a matter of whether a mechanism should be introduced, but of the extent to which it is pursued. This is inherent in the CSP/CSC approach, which was specifically designed to be applied only in limited situations, where it could be shown to deliver net value. By way of contrast, the CBR proposal, as presented, seems to envisage widespread (perhaps universal) exposure of generator, interconnector and load terms and probably, equally wholesale creation of CRFs.[131] But implementation could obviously be more limited, in either respect. In our view it would need to be, if the number of CRFs is to be realistic.

4.5.3 Is Generalised Hedging Useful?

259. To take a case in point, unless load is exposed to CP, it will want to contract to buy energy at a Regional Reference Node. Consequently traders would probably see no value in obtaining hedging which did not relate to access to, or between, Regional Reference Nodes. If so, the greater flexibility that CBR provides with respect to participants bundling their own CRRs may not offer much real advantage, unless loads are also exposed to CP, thus effectively facing nodal prices.

260. Conversely, the rigidity imposed by pre-aligning hedging instruments with the current NEM hub-spoke structure under the CSP/CSC approach does not necessarily place any restriction on the market other than that already implicit in the

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[130] The CSP/CSC proposal shied away from exposing load, but went further in other respects, by suggesting the possibility of exposing TNSPs and ancillary service providers.

[131] The notation does imply, that CRFs may only apply to a limited set of constraints

zonal structure applied to loads. [132] Thus limited application of CSP/CSC may be favoured on the grounds that it minimises disruption of the status quo. But the rigidity implied by pre-determining CRF shares under CSP/CSC is another matter. This motivates consideration of a more sophisticated hybrid proposal to remove that restriction, in Section 4.5.12

4.5.4 Is Revenue Neutrality Necessary?

261. Much of our theoretical discussion relates to what can, and can not, be done, while preserving strict revenue neutrality. Strict revenue neutrality requires payments into and out of each CRF to balance perfectly for each constraint, and in each trading interval. This condition was imposed in Dr Biggar's analysis, but CRA assumed that the very much weaker requirement of broad revenue adequacy would suffice, as it does for FTR auctions in nodal markets.

262. In other words, it is generally considered acceptable that net surpluses be allowed to remain in some rental pools, at some times, and that these surpluses may be used to fund shortfalls in other rental pools. Typically such markets will try to achieve revenue neutrality, but only on average, over the long term. Mechanisms to achieve revenue adequacy, typically include:.

- Simultaneous scaling of all FTRs to match the overall surplus available in an interval (ie risk spreading); and
- Accumulation of reserves that are rolled over to future periods, within some broad prudential envelope (ie risk smoothing).

263. These mechanisms can significantly improve the firmness of hedging available, effectively providing a form of "co-insurance", or risk sharing between participants. Such mechanisms are actually implicit in any regime which aggregates constraint rents from different periods and/or different constraints into a single bundle. In particular, they are implicit in the status quo SRA arrangements. [133]

264. Such mechanisms seem equally applicable to CR pools, and it is easy to see how they could be applied if the entire process of defining and allocating bundled CRRs were centralised in a manner analogous to the process applied to FTRs in a nodal market. Philosophically, risk spreading and smoothing are quite compatible with the CSP/CSC approach, and they were envisaged by CRA in proposing it.[134] The extent to which they should be pursued would be a matter of debate, though, and significant complexity could arise, as is normal in FTR markets elsewhere.

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132 Within this structure, the only alternative which might be worth considering would be to pursue a less comprehensive bundling approach with respect to network configuration, perhaps creating alternative inter-regional hedging pools, to apply under different network configurations.

133 And they are also explicit in some situations: For example, where negative residues must be allowed because a cross border load has to be met, and are subsequently rolled over to be offset against positive residues in later periods.

134 See discussion in Chapter 5 of CRA(2004a).

265. Of course, the CBR approach could also be modified by applying risk spreading or smoothing to the CR pools. But to do so requires re-defining CRRs in terms of a reference MW capacity, to be scaled as necessary, rather than simply as a proportional share. Otherwise, there is no obvious way to determine which are the "lucky" pools, or periods, from which excesses should be distributed to those less fortunate. But such a re-definition makes the CRRs equivalent to CRA's CSCs in this regard. Alternatively, perhaps the onus could be on participants purchasing CRF shares, or agents, to either absorb the short term risks involved, manage them within their own portfolios, or arrange some form of co-insurance in a secondary market.

266. But the critical message from these considerations is that the negative results cited above, about the theoretical impossibility of providing firm revenue neutral hedging under various circumstances, are much less significant than might at first appear. Throughout the world, FTR markets operate successfully without imposing such a stringent revenue neutrality requirement, and there is no obvious need to impose it in the NEM.

267. Thus a lack of revenue neutrality, in this strict sense, should not be seen as a barrier to implementation of any regime. And, if some form of co-insurance is considered desirable, the debate is not about the nature of the requirement, which is the same under CBR as under CSP/CSC, but about whether it is best to introduce some centralised mechanism to achieve it, or leave it all to market participants, or secondary market agents.

4.5.5 Will Decentralised Market Arrangements Actually Work?

268. According to our analysis, in order for any option based on "auctions" to work, it will be important that relevant participants be willing and able to sell CRRs into CRF pools in situations where others are dependent on such CRRs for hedging. Or, alternatively, efficient secondary markets must exist to allow this trading to occur away from the primary auction process.

269. In this respect, note that a participant who is exposed to a net price in excess of the Regional Reference Price (ie an upside benefit) may not think it beneficial to sell the corresponding CRR in order to reduce what they may see as potential upside.[135] The transaction costs of researching and participating in such markets will be a further deterrent. In theory, profit maximising participants will incur these costs if profit can be increased by doing so. But this is theoretically true already, with respect to the implicit assignment of CRRs available under the status quo. Although we are not in a position to comment whether any participants already participate as sellers of intra-regional hedging in secondary markets, that is an empirical question to consider when considering the extent to which they might participate, in future.

270. This may be of concern, because every CRR which is not sold by a participant who sees it as representing upside potential is a CRR which can not be bought by a participant who may well think it beneficial to buy that CRR in order to reduce

135 Or even an opportunity to exercise market power, by increasing CP.

what, for them, is downside risk[136]. This asymmetry of risks and benefits arising from CRRs could restrict the ability of participants to gain access to the RRP by trading CRRs among each other or by purchasing CRRs at auction. Thus, even if the SRA process were extended so as to allow symmetrical buying and selling, asymmetric risk attitudes are a significant issue to be considered in assessing whether the theoretical hedging properties attributed to these CR pools would actually be achieved in practice.

271. Whether or not the SRA process were to be extended in this way, significant reliance may also be placed on secondary markets to achieve efficient outcomes, particularly under the CBR proposal. The effectiveness of secondary markets in providing an integrated two-way hedging service, under the status quo, is an empirical issue, which lies beyond the present scope. Thus we can not comment on whether efficiency might be improved by allowing participants (or agents) to both buy and sell in the current IRSR auctions, for example.

272. To the extent that the CSP/CSC approach addresses the current mis-alignment between IRSR pools and inter-regional hedging requirements, it reduces the need to rely on the efficiency of secondary markets, relative to the status quo. But the efficiency of secondary markets would become more critical if the CBR approach were adopted, since even gaining access to a Regional Reference Node would then depend heavily on participants being able to both buy and sell CRRs.

136 Including the not insignificant risk that other parties, being unhedged, will take the opportunity to exercise market power by increasing CP.

Box 5: Will Secondary Markets Cure All?

Economists commonly state that secondary markets will emerge "if required". We would not want to disagree, or devalue the importance of secondary markets. But that comment does not, of itself, constitute a compelling argument for any particular option, because it is true, theoretically, for all options.

Thus, if we assume that secondary markets are efficient, any desirable hedging result which can theoretically be delivered by secondary markets under a CBR result could theoretically be achieved by re-combining rental streams implicit in bundled CSCs, too. In the limit, once hypothetical secondary market agents are involved, it should really be possible for an agent to construct any and all feasible hedging products from (a share of) the national NEM Settlement Surplus, even if it was all auctioned as one undifferentiated bundle, in combination with the CRRs implicitly allocated to participants by virtue of regional pricing.

In other words, even under the status quo, it should theoretically be possible for secondary market agents to re-combine IRSR streams in ways which reproduce many of the desirable characteristics claimed by CBR (or CSP/CSC). But clearly it is not. In reality, it seems very unlikely that a secondary agent could actually make realistic deals, under the status quo, with individual participants to unlock the hedging value inherent in their implicit CRRs in such a way as to make it available to other parties, who may value it more.

Thus, in assessing any proposal that relies heavily on secondary markets to achieve efficient outcomes, we should ask how efficient the secondary market currently is. Such an assessment lies outside the present scope. But it would not only have implications for the likely effectiveness of extending that regime, but also provides a counter-factual against which the incremental benefits of the alternatives discussed here could be assessed.

273. Box 5 discusses the common assertion that secondary markets will emerge "if required". The point is not to deny the potential role of secondary markets, but to note that, since the same total pool of rents is available under all options, including the status quo, the choice of options really comes down to issues of relative transaction costs, across both primary and secondary markets, and what this may imply for the market efficiency which is actually achieved.

274. And this means that the nature and likely performance of any secondary markets must be consistently and realistically assessed for all options, before any valid comparisons can be made. From this perspective, the potential advantage of the CBR approach is that it maximises market information and flexibility by breaking down the rental streams into their ultimate component parts. And this may make a secondary market more feasible, or more efficient. But that is, again, an empirical issue.

4.5.6 Is a Centralised Methodology Desirable

275. Having raised the empirical issue of the likely performance of secondary markets as an issue to be realistically assessed for all options, the same should apply equally to

assessment of the likely performance of centralised alternatives. It will ultimately prove fruitless to propose and pursue options that can only be implemented by centralised institutions if those institutions do not exist, or are not trusted by participants to implement this kind of development. And it may prove costly to proceed if centralised arrangements are inefficient or ineffective.

276. Where possible, we believe the market would, and should, prefer to rely on competitive arrangements rather than on centralised institutions and arrangements. Centralised institutions can be very expensive to establish and maintain, not least because of the need to gain, and maintain, the acceptance of such a large number of interested parties, a process which incurs considerable expense on both sides. And it is generally considered that centralised institutions, whether publicly owned or regulated, have a poor record of efficient or effective service delivery.

277. Earlier in NEM history, a similar argument was seen to favour the establishment of the current SRA process, with its reliance on secondary market mechanisms over a more centralised regime. Thus the same argument may be seen, now, to favour CBR over CSP/CSC, on the grounds that the latter places more ongoing reliance on centralised institutions to establish agreements with respect to partitioning CRFs, for example.[137]

278. Still, a variety of centralised institutions do play a very significant role in the electricity sector, both in Australia and elsewhere. Thus the judgement has been made, in each case, that the benefits of those arrangements outweigh the costs. And in many overseas markets the establishment and operation of a congestion management regime, using FTRs for example, would be considered an integral part of NEMMCO's role. Thus there is no prima facie reason to believe that this kind of arrangement would, or would not, be the best option for Australia. Again the issue is an empirical one, and needs to be carefully considered before valid comparisons can be made between options.

4.5.7 Would CRR Allocation be Acceptable?

279. Concerns have frequently been expressed about the difficulties of deciding on contract allocations under the CSP/CSC regime. Reaching agreement on such maters would clearly be contentious, and hence costly. Thus avoiding the need for such allocation must be considered one of the major advantages of the CBR proposal, as presented. Conversely, the CBR proposal could be adapted to allow for such allocation but, if it was, essentially the same issues would arise.

280. In reality, we suggest the issue is not really whether it is desirable to have a central body deciding on such matters, but whether significant progress can be made without it. Specifically, we suggest that some form of contract allocation and/or negotiation can only be avoided if each of the following questions can be answered in the negative:

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[137] Although it may also be said that centralised institutions would have to play a very major role in effecting the kind of radical change to market structure envisaged under CBR, which would have much more wide-reaching impact on participant wealth, for example, than any partitioning agreement.

- Is market power an issue?
- Is active congestion management desirable?
- Is long term access an issue?

4.5.8 Is Market Power an Issue?

281. Concerns have been raised with respect to the exertion of market power, under the status quo. In our framework, this may be seen to result from the fact that participants can obtain valuable CRRs by manipulating their dispatch positions. Market power would take a different form in a CP-based regime. But it would still be an issue, and perhaps a greater concern in some cases.

282. There would clearly be situations where only a few participants were involved in a constraint, and would have significant control over the congestion price for that constraint. Thus they would clearly have significant market power, in the spot market, if they were exposed to CP, without long term CSC assignment. ,

283. In that situation, the party who expects to benefit from a high CP will have incentives to push CP up, and may well be in a position to do so, by reducing the volume it offers and/or raising the price. By selling a CRR it effectively takes on an obligation to produce the specified volume , and considerably reduces its incentives to manipulate CP in this way. [138] But it can still extract the equivalent rent, with less risk, by setting a high price on the CRR it wishes to sell. And the parties who would be negatively affected by a high CP should theoretically be prepared to pay that price since, if they don't, they face the prospect of paying just as much, on average, because of a high CP, but with greater risk.

284. Thus, although the CRR can mitigate the exercise of market power in the dispatch process, essentially the same market power would be transferred to the auction process.[139] This is an issue for any CP-based regime relying solely on a spot market with CRR auction processes, just as it would be for a nodal market regime relying solely on a spot market with FTR auction processes. This seems particularly critical where some traders are relying on the availability of reasonably priced CRRS that can only be supplied by competing participants who may have significant market power.[140]

285. As presented, the CBR regime does not propose any specific measures to deal with such situations, but this was a major motivation of CRA's proposal that CRCs might have to be allocated, or negotiated into place in some instances, rather than simply relying on auction processes. Such negotiations may prove difficult, if conducted after participants have already been granted exposure to CP. But they do not seem so unrealistic if conducted prior to exposure, with agreement to such "vesting

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[138] See discussion in Box 2. It is not physically obliged to produce, but must compensate if it does not.

139 See Joskow,P.L and Tirole, J. (2000) "Transmission Rights and Market Power on Electric Power Networks" , RAND Journal of Economics, Vol. 31, No. 3, pp. 450-87 (Autumn 2000)

[140] Unless specifically barred, participants who were in a position to exercise market power would also be free to buy, or sell, rights in such a way as to actually enhance that market power.

contracts" being a pre-requisite for entering into a regime which will bring overall benefits to the affected participants. In order to be effective, though, such contracts would have to be of a fairly long term nature.

4.5.9 Is Long Term Access an Issue?

286. Obviously, reliance on a relatively short term auction process gives no long term guarantee with respect to access, or at least the cost of access, either intra-regional or inter-regional. If market power is not an issue, participants might rely on the creation of a competitive market to assure them that whatever access turns out to be physically available will be rationed in a competitive fashion, but participants planning long term capacity investment, are likely to seek more assurance. They do not expect to invest on the basis of short term leases of land, plant, or fuel, so it would be surprising if they did not see reliance on short term access to the transmission system as a negative risk factor when assessing investment options.[141]

287. The ability to provide long term access assurances is also likely to be a critical pre-condition to obtaining participant acceptance of the introduction of any CP-based regime, and/or in any boundary change situation. And the ability to "allocate" , long–term network support obligations may be critical to guaranteeing reasonable participant behaviour, by mitigating the exploitation of market power for example, which should also be a pre-condition for acceptance of the introduction of any CP-based regime, and perhaps also in some boundary change situations.

4.5.10 Is Active Congestion Management Desirable?

288. We have suggested that, as presented, CBR is an essentially passive approach to congestion management. That is, it aims to allow participants to manage their own relative share of exposure to the dispatch outcomes, as they turn out to be. It does not attempt to provide a mechanism to contract for enhancements to network capacity. By way of contrast, the CSP/CSC regime was originally envisaged as a mechanism for active congestion management, with "constraint support" contracts probably being negotiated into place. And it also envisaged that other parties, such as TNSPs or ancillary service providers, could be exposed to CP, and contracted in ways that would incentivise capacity enhancement.

289. This does not mean that the CBR regime would not provide useful signals and incentives for participants to behave in ways which would reduce congestion. It may be that these potential capacity providers would be prepared to offer CRRs corresponding to such capacity provision into CRF auctions. In that case, these auctions would effectively become a mechanism to tender for some kind of network support service, by some body purchasing CRRs from participants, as discussed in Section 4.5.5. But proportional CRRs seem an unlikely instrument for negotiating network support contracts.[142] Market power would also be an issue in some cases,

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[141] See discussion on investment incentives in Section 6.4.

[142] If the RHS halves due to failure of some party, the obligations of other parties would also scale to match, and a downward spiral would seem likely to ensure.

and it is not at all clear that parties such as TNSPs would be inclined to participate in an auction/tender process of the type envisaged under CBR.

290. In any case, we expect that those responsible for network security would only think it appropriate to set capacity limits in NEMDE on the basis of firm contractual arrangements, as discussed in Section 7.4.3, rather than just anticipated market responses. Thus the desirability of some kind of active congestion management seems evident, and the issue becomes whether a CP-based regime offers a better way to do it than other alternatives.

4.5.11 Is a CSP/CSC/CBR hybrid possible?

291. While there is room for debate about the relative merits of these proposals, it is also clear that the underlying mathematics is basically the same. Thus there is no real reason why they can not be combined so as to deal with particular constraints, parties, or issues, in the way to which each is best suited. In fact the original CRA proposal, can itself be regarded as a hybrid, in which:

- Relatively firm CRCs were proposed to resolve issues such as interconnector priority issues, and to incentivise capacity enhancement;
- These CRCs would also have the effect of "firming up" the inter-regional hedging pools, in particular;
- The resultant "bundled" pools would then auctioned, as proposed by Biggar (2006), or by Section 5.3.7 of CRA(2004a); and
- The CRCs purchased at those auctions would finally be scaled, as much as necessary to match the rents available, as proposed by Biggar (2006), and also in Chapter 5 of CRA(2004a).

292. Other hybrids could also be constructed, by mixing and matching elements of the two regimes in various ways. But perhaps the most promising approach would use an "Integrated Network-Based Auction", as discussed in the next section.

4.5.12 Is there a Better Integrated Regime?

293. Both CBR and CSP/CSC approaches involve auctioning some form of CRR, either in pure constraint-based form, or as a bundle assigned to a particular interconnector. Comment has been made that an auction of individual CRFs would create a significant burden for participants, in terms of dealing with the complexity of all the contingent hedging options implicit in the CR pools. But comment has also been made that auctioning off bundled constraint residues reduces the true dimensionality of the hedging available, and only creates firmness by pre-determining the balance between hedging available on each interconnector. Thus neither seems ideal.

294. No consideration has been given, though, to a third alternative, which would be to use an Integrated Network-Based Auction (INBA), of the type routinely employed in allocating FTRs for a nodal market. Such auctions essentially mirror the real-time

dispatch auction, using the same network model, and LP market-clearing process, but with the offers and bids being to buy and sell FTRs, rather than energy.

295. It can be shown that, if a feasible solution can be found to this auction, the corresponding FTR allocation will be feasible, in the sense that constraint rents will support any payout required, irrespective of the dispatch, provided the real-time network configuration/capacity matches that assumed in the auction. This condition is known as “revenue adequacy”, and is a central concern in the design and operation of FTR markets.

296. The applicability of this idea to CRR auctions in a zonal market requires further investigation but, at first sight, it should be possible, since the underlying mathematics is essentially the same as for FTRs in a nodal market. The fundamental difference would be that this concept would involve the simultaneous auctioning of all rights, in a single auction, rather than auctioning several rental pools separately, as in both the CBR and CSP/CSC approaches.

297. Participants (or their agents) would interact with the auction by bidding for their desired intra-regional and inter-regional requirements, as in CSP/CSC. But the market clearing algorithm would allow the pattern of participant hedging to be optimised directly, within a single auction, rather than requiring participants to attempt to combine hedging purchased in many separate auctions to match their requirements, as in CBR. A trade-off would be made, within the feasible region defined for the auction-clearing optimisation, between intra-regional and inter-regional hedging, and between hedging on the various interconnectors, thus eliminating the need for any restriction imposing a particular partitioning of available capacity between interconnector flows, as in the CSP/CSC approach.

298. In such an auction, a single LP run would still correspond to a particular network configuration, and set of line capacities, and would only establish revenue adequacy with respect to that possible future (i.e. a contingent network configuration). Obviously, market arrangements would have to be designed to ensure revenue adequacy over a reasonable range of network configurations, and capacity levels, as discussed above. But this problem is routinely dealt with in FTR markets, and the same basic mechanisms are probably applicable to CRR markets, too.

5 Dealing with Interconnector Interaction and the IRSR

5.1 Introduction

299. Previous sections have described the status quo in terms of our general framework and explained, in generic terms, how the problems identified there could be rectified. This section, and those which follow, discuss the application of those general ideas to specific groups of terms/participants. Thus each chapter deals, primarily, with a particular participant type, and can be regarded as considering a proposal that the mechanisms discussed be applied to that participant type alone. This is logically possible, but unlikely in practice.

300. Nor, by structuring the discussion in this way is it intended to imply that the options should be considered cumulatively, that is that consideration should first be given to exposing interconnectors, then to interconnectors plus generation, then to interconnectors, plus generation, plus ancillary services, and etc. A more realistic outcome is that some or all of the mechanisms discussed might be applied to some or all participants from each group, in some situations, for some periods of time.

301. Thus the mechanisms discussed have been designed and described in such a way as to allow considerable flexibility with respect to the way in which they might be combined and configured. Some such combinations are mentioned, but a wide variety of others are possible. Still, the participant types are considered roughly in order of the extent to which application of a CP approach to congestion management might be considered to alter the status quo approach, and/or to align with past proposals, experiments and discussions.

302. The interconnector situation is discussed first, even though it may be thought more complex than that of intra-regional constraints on generation, for example. This is because interconnector hedging is actually the one area in which some of these concepts already play a significant role in the market, and where it seems likely that they are widely misunderstood. Consequently, it is an area in which significant gains might be made, without any significant change to market design. The discussion in this section then serves as a template for discussion of the analogous situations that would arise if other parties were exposed to CP pricing.

303. Several proposals have been advanced, at various times, which would involve NEMMCO intervening to "clamp" or give "priority" to interconnector flows, in order to correct some dispatch situation which is thought to be inappropriate such as, for example, the occurrence of a negative IRSR. Forcing the market in this way obviously imposes economic costs, as measured by the market objective function, and we will focus, instead on financial market mechanisms which do not impose such constraints.

304. In discussing these concepts it will be useful to refer to the simple diagrams introduced in Section 3.2, interpreting both axes as representing interconnector flow variables, each of which is subject to a simple upper bound, with only one other constraint, which involves both of them. So, for the purposes of this discussion, we will assume that only the interconnector flow variables are under consideration for

exposure to CP, and thus can think of the RHS of this constraint as being the $ProtectedRHS_F$, which accounts for the impact of all protected terms. (I.e. in this case, load, generation, ancillary services, etc).

305. Such interconnector "interactions" could occur if interconnectors were allowed to form loops between regions in the NEM market structure illustrated by Figure 2.1. Even though the conceptual design has no loops, the network reality involves cross-border loops.143 But the NEM market design actually means that such interconnector interactions can occur even though the interconnectors do not physically interact at all. In fact we would expect this to be normal whenever a region contains intra-regional network loops, and has more than one interconnection.

5.2 Creation of CR pools

306. Both the CBR and CSP/CSC approaches would deal with the interconnector interaction issue, in the first instance, by exposing interconnectors to the CP prices of the trans-regional constraints in which they are involved. This means that rents (positive or negative) would be extracted from the IRSR pools and paid into CR pools for each managed constraint. Here, for simplicity, we will assume that only interconnector flows are exposed, leaving all other terms in $ProtectedRHS_{F.}$

307. This would not eliminate the current IRSR pools, but transform them into CR pools corresponding to the PILs in each direction that is, to the simple bounds on cross-border flow, which is conceptually what the IRSR might be thought to be, in the current market design. Ignoring losses[144], the net effect would be to leave the PIL/IRSR pools containing only the rents on the relevant interconnector bounds. Applying this process to all transregional constraints in which the interconnectors are involved would "unbundle" the total CR pool implicit in the IRSR for each interconnector into many separate pools – one relating to each PIL, and one for each constraint in which these interconnectors are involved.

308. We will largely confine our discussion to the simple generic example situations illustrated in Section 3.2, which involve interactions between only two parties. In examples with only one or two interconnectors, it is tempting to simplify the discussion by making the IRSR for one of the interconnectors also serve as a kind of "master CRF", with CR payments going in and out of that account. This does reduce the number of CRFs required by one, but creates conceptual confusion. This approach was taken in the original CRA work, where only one interconnector was involved, and also in the Snowy trial implementation. But here we follow the later CRA work (eg CRA(2004c)), which created a separate CRF for each constraint. Thus our analysis is readily generalised to as many parties as may be desired.

143 The Snowy constraint situation, relating to line flow limits between Murray and Tumut, provides a case in point, and is used to illustrate the concepts discussed here, in Gregan and Read (2008). Although the Dederang node lies outside the Snowy region, the analysis would be no different if it lay within the region. Other examples were examined by CRA (2004c).

144 See discussion in Section 3.7.

309. If both axes in Figure 3.1 represent interconnector flows, several cases may be differentiated, depending on where the dispatch point lies:

- A dispatch point strictly within the interior of the feasible region will not generate rents in any pool;
- A dispatch point lying on one of the interconnector bounds, ie strictly within line segments (A,B) or (C,D), will only generate rents in the relevant PIL CR pool;
- A dispatch point lying on the trans-regional constraint line, ie strictly within line segment (B,C), will only generate rents in the CR pool for that trans-regional constraint; but
- A dispatch point lying at the intersection of the trans-regional constraint and interconnector bound lines, ie at point B or point C, will simultaneously generate rents in the CR pool for the trans-regional constraint, and also for the relevant PIL CR pool.

310. In what follows, the PIL CRF will be treated just like any other CRF. So, if this regime applies to all constraints in which an interconnector is involved, the IRSR will be empty, and irrelevant, once rents have been allocated to CRFs. As discussed earlier, the rent on the PIL can not be negative, unless a positive lower bound is placed on flows in some direction, which seems unlikely.[145]

311. But negative CRFs will occur if there is a negative Protected RHS, perhaps reflecting a situation in which the interconnector(s) involved in a constraint had an obligation to support a locational load, as in Figure 3.4. 146 Participants will obviously have to be induced to accept negatively valued CRR assignments in such cases, and the mechanisms by which that might happen differ between CBR and CSP/CSC regimes. Participants may also be induced to accept CRR assignments that are negatively valued because they have negative volume, even though the CRF itself has positive value. See discussion in Section 4.5.5.

[145] Mathematically, a negative CP would arise if a lower bound were to be placed on net flows in the specified direction. But a lower bound on net flows in one direction is just an upper bound on net flows in the other direction. Normally this will correspond to a positive flow in that direction, and produce positive rents in the PIL rental pool for that direction. An exception could occur if, for some reason, flows were constrained to be above some positive limit in one direction. Such a constraint would have negative rents because it is not a "resource" available to the market, but a liability imposed upon it. As discussed earlier, this could occur if interconnector flow was necessary to meet a cross-border load. It could also arise artificially, from some form of physical management mechanism intended to give forced priority to flows in this direction. In this respect, we note that one reason for applying "clamping" only at a zero flow level is to avoid this issue. See CRA (2003a).

[146] This is unlikely where the constraints model interconnector interaction alone, but more likely where a joint constraint applies to generation and interconnector flows, as discussed in the next chapter.

5.3 Auctioning of CR pools via CBR

312. The CBR approach would auction proportional shares of the rents in each CR pool, separately, then leave participants to sort out their own hedging arrangements by re-combining these rents in combinations which match their trading requirements.

313. In each of the simple examples illustrated in Section 3.2, three CRFs would be created.[147] Inter-regional hedging would be available to both interconnectors, or more exactly to traders wishing to trade over those interconnectors:

- If the situation is a shown in Figure 3.1, traders wishing to use either interconnector would need to buy CRRs in both the trans-regional pool, and the relevant PIL pool. This would correspond to a situation in which two interconnectors were sharing a common network resource in one region or the other.

- If the situation is a shown in Figure 3.2, though, in traders wishing to trade over one of the interconnectors would have to sell CRRs into the trans-regional CRF, while buying CRRs from the relevant PIL CRF. Traders wishing to trade over the other interconnector would need to buy CRRs in the CRF for that interconnector, but also buy trans-regional CRRs, in part off those selling. This situation would be typical where two or more interconnectors feed into, or off, a loop in one region. [148]

- If the situation is a shown in Figure 3.4, traders wishing to trade over both interconnectors would have to sell, rather than buy, CRRs to achieve it, but they would both also buy CRRs from the relevant PIL CRF. This would be typical of a situation where flows on one or both interconnectors were required to meet loads in the receiving region.

314. This seems relatively straightforward, provided participants know that this constraint configuration will occur, and know the MW capacity available on each constraint, and hence in each CRF. In that case, they can scale their purchases, or sales, so as to achieve some exact level of MW cover. This may not be the MW level of cover they might desire, because firm MW hedging is simply not available up to the interconnector capacity, for the reasons discussed in Section 3.6. But participants should, in aggregate, be able to simultaneously partition the firm hedging that is available between the two interconnectors in some proportion, such as X, in Figure3.5. Less firm hedging, giving protection only against price differentials caused by binding limits on the interconnectors themselves, would be available up to PIL, on each interconnector separately.

315. Later, as their trading situations evolved, some participants might wish to adjust this hedging position by buying more CRRs. These would have to be bought off other participants who might be using either link, and the price would obviously

[147] For the Snowy example discussed by Gregan and Read (2008) three CRFs are created, one for each interconnector PIL, and a new one for the trans-regional constraint. But that example is highly simplified. There are actually over 100 alternative forms of this particular constraint, each of which would notionally have its own CR pool.

[148] The Snowy example discussed by Gregan and Read (2008) provides an example.

reflect expected dispatch price differentials at the time of purchase, as discussed in Section 3.3. But, if the constraint situation was still as it was assumed to be originally, this could be done within the feasible region, illustrated in Figure3.5, thus effectively shifting point X, anywhere between one extreme and the other, ie with all the hedging on one interconnector, or the other.

316. Although the value of the hedging available obviously falls as real time approaches, this regime does allow dispatch uncertainty to be dealt with.[149] In reality, though, participants who purchase cover on the expectation that MW capacity will be as shown, will actually end up with some different quantity of MW hedging, scaled to match the MW capacity actually available (ie capacity uncertainty), or no hedging at all, if these constraints are not the ones that apply in real time. (ie configuration uncertainty).

317. While it is not actually possible to provide firm revenue neutral hedging with respect to capacity and configuration uncertainty, the decentralised structuring of CR pools by traders (which is a key characteristic of the CBR approach) can, in principle, provide hedging which is as firm as the Protected RHS which turns out to be applicable at the time. But that Protected RHS illustrated in the figure, is not necessarily the NEMDE RHS.

318. As proposed by Biggar(2006), CBR does not just expose interconnectors. But if, hypothetically, only interconnectors were exposed to CP, the Protected RHS will vary as a result of variation in TNSP, ancillary service, load, and generation dispatch terms. This variation could obviously be considerable, particularly since protected participants are not disciplined by exposure to CP, and often have incentives to "grab" CRRs off exposed participants, by distorting the dispatch.

319. If only interconnector terms were to be exposed to CP, the CBR approach would mean that CRRs purchased from each pool would have to be scaled in proportion to $ProtectedRHS_F$. But this is really all that can be done under any regime, without either exposing other participants to CP, or compromising strict revenue neutrality.

320. Under CBR participants would also be left to deal with configuration uncertainty, by combining CRRs from different pools as best they could. The complexity of this approach thus depends on the degree of uncertainty about the exact network configuration that will apply in real time dispatch. Under conditions of certainty, it may imply only a moderate increase in complexity for participants. As discussed in Section 3.6.3, the real the situation may be much more complex because uncertainty can create a very large number of "state contingent" CR pools, each defined by the network configuration.

321. Under conditions of uncertainty, a trader wishing to establish a hedge that is as firm as the available network would (ex ante) have to purchase appropriate shares in every "state contingent" CR pool. And these would have to be structured, ex ante, so that once the "state of the world" is known (ex post), they deliver just the right combination of shares in the CR pools arising in the known "state of the world" so

[149] Although only inasmuch as it affects aggregate interconnector flows, assuming that only interconnectors are exposed, as in this chapter.

as to achieve a hedge that is as firm as possible under the realised network configuration and capacity levels. But the result clearly will not be firm.

322. In theory this means that a participant wishing to trade across any interconnector is obliged to understand, and trade, hedging instruments defined as shares in CR pools established for each of the constraints in which that interconnector is involved. More realistically, secondary market agents would need to understand this complexity, and create bundled instruments more suited to participant needs.

5.4 Allocation to Inter-regional Hedging Pools via CSP/CSC

323. CRA's CSP/CSC proposal was originally developed to deal with interactions between an interconnector and generation, and then subsequently to deal with interactions between several interconnectors.[150] The treatment of interconnectors in CRA's CSP/CSC proposal differs from their treatment under the CBR proposal, in that CRRs would be used to allocate all IRSR rents back to existing IRSR pools, which would then be auctioned via the existing SRA process.[151] We will refer to these re-constituted IRSR pools as Inter-Regional Hedging (IRH) pools, so as to make the distinction clear.

324. In order to create IRH pools, the CSP/CSC approach interprets a notional partitioning of the constraint capacity in terms of financial contracts as in Figure3.5. CRA's proposal was simply that, rather than accepting the "dispatch matching" assignment of CRRs to the IRSR implicit in the status quo, explicit CRRs (ie CSCs in CRA's terminology) should be introduced to allocate the rents, which were originally transferred to CRFs from IRSR pools[152] in proportion to flows in each trading interval, back to those IRSR pools, but in proportions to be agreed ex ante. [153]

325. Here we have expressed this slightly differently, by creating a new IRH pool distinct from the IRSR, but the mathematics is essentially the same, and can be expressed by saying that the IRH consists of the pool remaining after net payments to and from the CRFs for managed constraints have been accounted for. Rents relating to un-managed constraints would just be transferred from the IRSR to the IRH, or equivalently transferred from the IRSR to the relevant CRF (in proportion to flow), but then allocated to the IRH by IDMA (also in proportion to flow).

326. Several constraints may bind, but if interconnector *ij* is exposed in all constraints in which it is involved, the end result is that the total net rent accumulated in the IRH for that interconnector is:

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[150] See CRA(2004c) and summary discussion in Appendix D of CRA(2004a)

[151] Noting that, in this section, only interconnector flows are exposed to CP, so the only rents to be allocated are those in IRSR pools.

[152] In this chapter we are assuming no generator involvement.

[153] By way of contrast, CBR dispenses with the notion of interconnector hedging pools entirely, and allows the balances between hedging on the various interconnectors to be determined directly by the aggregate if individual participants' trades. And a different balance may result with respect to the allocation of rents from different constraints.

$$IRH_{ij} = IRSR_{ij} + \sum_k CP_k * (PRRV_{ijk} - FLOW_{ij})$$
$$= IRSR_{ij} + \sum_k CP_k * (Weight_{ijk} * CRRV_{ijk} - FLOW_{ij})$$

327. Recall that (ignoring losses) the IRSR can be determined by multiplying the interconnector flow by the relevant inter-regional price difference. That is:

$$IRSR_{ij} = FLOW_{ij} * (RRP_j - RRP_i)$$

328. But the inter-regional price difference is determined by the combined effect of all the trans-regional constraints in which $FLOW_{ij}$ is involved, including the PIL on that interconnector itself.[154] In fact, it can be shown that:

$$RRP_j - RRP_i = \sum_k CP_k * Weight_{ijk}$$

329. Substituting these expressions into the expression for IRH_{ij}, all the flow terms cancel out, and we get:

$$IRH_{ij} = \sum_k CP_k * PRRV_{ijk}$$

330. In other words, by identifying and dealing with the constituent CRF streams, and allocating each in accordance with an ex ante contractual agreement, we obtain an inter-regional hedging pool which exactly matches those ex ante agreements, and will be as firm as those agreements, and the underlying CRFs.[155]

331. Once such a CRR allocation is agreed, then the hedging available from the inter-regional hedging pools will be defined by the CRR allocation, not by the IRSR observed in the spot market. And the IRH will be positive, provided the CRF is positive, and the interconnector receives a positive CRR allocation[156]. If constraints are expressed in standard ≤ form, the CP will be positive, and so the CRF will also be positive provided the Protected RHS is positive: That is, if it represents a positive resource available to the market. In that case it will always be possible to create a positively valued IRH pool, if desired, for each interconnector. [157]

332. Having formed these IRH pools, the CSP/CSC proposal is not specific as to how they might be treated, but we will assume that they are simply auctioned via the current SRA process, and presumably therefore in proportional shares. Each such share would implicitly constitute a bundle of CRRs that were allocated to the IRH,

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[154] See Appendix D to CRA(2004a), noting that the effect of multiple constraints is additive.

[155] This is illustrated for the Snowy example discussed by Gregan and Read (2008).

[156] Or, if both are negative, which can occur.

[157] But see discussion below of a situation in which this may not be desirable and, in Section 6.4, of a situation where it may not be possible, because the Protected RHS is negative.

not necessarily all in the same proportions. [158] So, while this proposal does create a simpler situation for traders than the CBR approach, and relies less on effective secondary markets emerging, it ends up placing a similar degree of reliance on secondary markets to the status quo. Thus its chief claim, if applied only to interconnectors , would be that it makes each individual IRH pool firmer, and could eliminate the negative IRSR "problem" in many situations. But how firm is it?

333. Each CRF can still only be as firm as the Protected RHS of its own constraint. Thus, if only interconnector terms are exposed, each CRF will be as firm as $ProtectedRHS_F$. In other words, the Protected RHS will still reflect all variations due to generation, TNSP, ancillary service, and load terms. The only uncertainty which has been eliminated, by comparison with the status quo under which all terms are effectively on the Protected RHS, is the impact of aggregate dispatch uncertainty on the balance between inter-regional flows. [159]

334. We have already argued that revenue neutral hedging can not be truly firm, in aggregate, with respect to either capacity or configuration uncertainty, and this is just as true for this proposal as for the CBR proposal. As in the status quo, the IRH pools in CRA's CSP/CSC proposal represent CRR bundles. The difference is that under the CSP/CSC approach, the bundled rights to the IRH pools are assigned explicitly, rather than implicitly. This assignment should be firmer than under the status quo, because of the way in which the CRRs are allocated, ex ante.[160]

335. Still, even if the CRRs were fully firm the combined bundle can not provide truly firm hedging, in aggregate, because the participant MW capacity (PRR) of these CRRs can not all be identical, as discussed in Section 3.6.1. If a PIL binds, congestion rents corresponding to a MW flow (eg PIL_1) greater than that which can be hedged with respect to the trans-regional constraint (eg PRR_1) will be available to underpin hedges. If that rent is not assigned to the bundled CRR, there will be an excess rent in the IRH pool. But if a firm hedge were issued for any MW flow level above PRR_1, there would be a deficit whenever the trans-regional constraint bound. In other words inter-regional hedging still can not be both firm and revenue neutral, in aggregate, even if each of its component CRRs is firm and revenue neutral.

336. In our view, lack of revenue neutrality is not a critical shortcoming. As noted earlier, FTR markets operate successfully without imposing a strict revenue neutrality requirement, and there is no obvious need to impose it in the NEM. Unlike the status quo SRA arrangements, or the basic CBR approach, the CSP/CSC

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[158] Variants on this mechanism may be suggested, in which auctions might cover a wider range of hedging products, involving explicit CRR bundles, to provide configuration dependent hedging products, but that complexity will be ignored here.

[159] Partitioning the CRF pool, and hence implicitly the constraint capacity, in this way may be seen as conceptually equivalent to using CRCs with some parties to augment the firm hedging available to other parties, as discussed in Section 3.4 In this case, though, we are not contracting with non-traders to provide more firm hedging to traders. Rather, we are contracting with one interconnector to provide more firm hedging to another interconnector, and vice versa. Just as in that discussion, firm contracting with one party actually increases the firmness of hedging available to the other.

[160] The individual CRFs can also be made firmer, by contracting with other parties for various forms of network support, but that topic is discussed in Chapters 7 and 8.

approach allows for a variety of co-insurance mechanisms to both smooth and spread risks, as discussed in Section 4.5.4

337. But it should be recognised that, while the ex ante partitioning of CRRs between separate IRSR hedging pools under the CSP/CSC approach simplifies the hedging issue for participants, it limits the ability of participants to purchase and structure portfolios of CRRs so that they can match any desired (ex ante) trading patterns. This loss of trading flexibility matters because, in aggregate, the desired ex ante inter-regional trading patterns are likely to deviate from those assumed in the negotiated split of interconnector contributions to CRFs into IRH pools.

338. Thus, as real time approached, participants could still trade CRRs, as in the CBR approach but, in the primary market, they would only be able to trade bundled CRRs, and then only with other parties hedging across the same interconnector. This could lead to inefficiency in the hedging market, if the valuation of hedging on one interconnector implies a valuation of constraint rentals which is inconsistent with that implied by trading with respect to the other interconnector.[161] And it would ultimately lead to some dispatch inefficiency, as participants would have second order incentives to bias their dispatch positions toward whatever hedging position they have been able to establish.[162]

339. Further, the need for an ex ante agreement with respect to constraint partitioning implies the need for a process to form such agreements, and that implies the need for some party to be made responsible for obtaining agreement. That could be controversial and problematic, under the NEM institutional structure.

340. On the other hand, the possibility of a negotiated or allocated CRR assignment provides an alternative means of dealing with some situations which may be of considerable significance to the market, and to market efficiency. Thus the real question is whether it can ultimately be avoided:

- We have suggested (see Section 4.5.9) that there are situations in which participants will be seeking, and should reasonably be granted, long term rights of access. These can not be granted by any short or mid-term auction, and must inevitably involve some kind of negotiation or allocation process. It does not seem at all unreasonable that such long term agreements should be used in relation to the hedging/transportation value delivered by interconnectors, which are long-lived assets, providing both benefits and dis-benefits to more than one party.

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161 But note that secondary market trading should be able to eliminate any evident discrepancy between these two sub-markets, subject to the caveats expressed in Box 6.

162 See discussion in Box 2. Obviously, it is not "interconnectors", but participants trading over interconnectors who respond to such incentives. "Gaming" incentives will be minimal, if there is a reasonable degree of competition. Risk aversion will have an impact, although the primary (energy) contract opposition will generally be most influential in that regard.

- We have also suggested (see Section 4.5.8) that long term contracts may be needed to control market power is some situations, and that negotiation or allocation are really the only mechanisms applicable n such cases. [163]

341. And negotiated contracts are likely to be to be the most natural and effective means of implementing any form of active congestion management regime, which was the original intent of the CSP/CSC proposal.[164]

5.5 Summary

342. Overall we conclude that if a CSP/CSC style arrangement were applied only to interconnectors, it would involve minimal disruption to the status quo. Essentially, in situations where interconnectors interact in trans-regional constraints, the firmness of inter-regional hedging could be improved by partitioning the available constraint capacity between the interconnectors concerned. This would only require re-processing of the IRSR, in the settlements system to form firmer inter-regional hedging pools, which would then be auctioned via the current SRA process. This could be considered as a stand-alone proposal.

343. Applying a CBR style approach would involve slightly more change, because it would partition the rents in the current IRSR between a (possibly large) number of CRF pools, one for each constraint form which may apply, and the SRA process would have to be extended to include auctions for each such pool. The result would be more flexible than under the CSP/CSC scheme, but participants would face greater complexity, with the number of CRF pools probably being quite large. And each CRF auction might need to be constructed so as to allow both purchase and sale of CRRs by participants, who would have market power, in some cases.

344. Either regime seems preferable, theoretically, to proposals involving physical clamping, or prioritisation of one interconnector flow over another. In fact, this kind of financial approach seems capable of effectively removing the negative IRSR problem which has motivated such intervention in some of these cases. But note that, either way, a financial regime which deals only with interconnector interaction can not deal with the negative IRSR issue, or provide firm hedging, in situations where constraints are dominated by generator /generator, generator/interconnector, or generator/load interactions.

345. Neither regime seems ideal. But it does seems possible that a third, more flexible, regime could be developed for assigning CRRs, using the INBA concept, as implemented in FTR markets, and discussed in Section 4.5.12. The result would be to gain some of the advantages of the CBR regime, in terms of flexibility, while retaining most of the simplicity of the CSP/CSC regime, from a participant perspective.

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163 Such cases are most likely to involve specific generators, though, and will be discussed further in the next chapter.

164 Such cases are most likely to involve contracting with specific generators, ancillary service providers or TNSPS, and will be discussed further in the relevant chapters.

346. Specifically, in this context, the SRA would be modified so as deal with offers and bids for inter-regional hedges as in the CSP/CSC proposal. But those hedges would not be bundled, or apportioned between interconnectors in pre-determined ways. Rather, within the auction clearing model, they would be formed out of constituent CRRs, implicitly bought and sold with as much freedom as envisaged by CBR. The effect would be equivalent to a limited form of FTR auction, and could probably be implemented using that methodology, without explicit consideration of the constituent CRRs[165].

165 Since these are implicit in an FTR formulation for a nodal market.

6 Dealing with Generation

6.1 Introduction

347. This chapter explores how exposing generation to congestion prices in settlements can affect generator incentives, the efficiency of dispatch outcomes, and the firmness of hedging available to both to generation and to other parties.

348. Essentially the same analysis used to assess interactions between interconnector flows can be applied to assess interactions between generators, or between generators and interconnectors. There are significant differences, though, because generation and interconnector flows play distinctly different roles in the NEM design. Generation is, in the first instance, an intra-regional matter. A constraint which only involves generators is an intra-regional constraint, and the interaction between generators involved in such a constraint relates only to obtaining access to a Regional Reference Price.

349. Under the status quo, generators are not exposed to CP in any constraint. In other words the implicit allocation of dispatch-matching CRRs exactly matches their theoretical exposure to CP in each constraint, so that all generation is paid at the Regional Reference Price. Thus generation can effectively capture CRRs granting access to the Regional Reference Node by manipulating its dispatch position via its offers, and this has lead to counter-productive market behaviour in some instances.

350. But many constraints involving generation are trans-regional, also involving one or more interconnectors. When such a trans-regional constraint binds, the generators and interconnector(s) involved in the constraint interact. Intra-regional generators compete against each other, and against (traders using) the interconnector, to secure constraint capacity to be used for intra-regional access to the RRN. And (traders using) the interconnector compete with intra-regional generators for constraint capacity to provide inter-regional access.

351. The generators involved in the constraint seek to gain financial access to the RRP by their bidding behaviour. This bidding behaviour attempts to capture CRRs in the trans-regional constraint CRF pool, via IDMA under the status quo. In the limit, constrained-off generators may offer their desired volumes at the market floor price, safe in the knowledge that, as a result of this implicit CRR allocation, they will be settled at a RRP well above their offer price.

352. An interconnector involved in a trans-regional constraint also gain a volume of CRRs based on its dispatched flow, and these CRRs implicitly contribute to the IRSR, calculated as the difference between RRP across the interconnector. In this case it is not the bidding behaviour of the interconnector which affects the outcome, but the bidding behaviour of generators in both regions. The situation is not symmetric, though, because generation does not have implicit access to the RRP of another region, and must purchase it via the SRA process.

353. Thus, typically, intra-regional generators may tend to "crowd out" the allocation of the constraint limited volume of CRRs to the interconnector. This sort of bidding behaviour can also result in, or at least exacerbate, negative IRSRs, which has led

some to call for the "support" or "prioritisation" of interconnector flows over generation when there is a binding trans-regional constraint, in order to restrict the accumulation of negative residues.

354. As in the previous chapter, we do not consider approaches based on physical intervention and/or cost-based compensation, but focus on the exposure of generation to CP, in both intra-regional and trans-regional constraints, and the impact this will have on CRFs. Then we consider, in greater detail, the application of both CBR and CSP/CSC approaches to each of the following cases, in turn:

- First, exposure of generation terms, only in purely intra-regional constraints, that is constraints in which no interconnectors are involved, and in trans-regional constraints, in which interconnectors are involved, but not exposed; and

- Second, exposure of both generation and interconnector terms in trans-regional constraints, to provide an integrated regime for intra-regional and inter-regional hedging, as envisaged by both the CBR and CSP/CSC proposals.

355. Both cases may be discussed with reference to the simple 2-dimensional diagrams introduced in Chapter 3, with the axes re-labelled as appropriate. We believe that all of the 2-dimensional results discussed here will generalise to higher dimensional problems involving trade-offs between several parties, possibly of different types (e.g. generators and interconnectors), that are involved in more complex intra-regional or trans-regional constraints. We will also discuss the application of these concepts to a simple illustrative example.

356. For simplicity, discussion in this chapter, as in the previous chapter, refers to various participant groups, generically, as being exposed to CP, and involved in the mechanisms discussed. But it should again be stressed that the intention is NOT to imply that all interconnectors or generators must necessarily be involved in whatever regime(s) might ultimately be allowed for in the market design, or that these arrangements would necessarily apply with respect to all constraints in which any particular interconnector or generator was involved. The intention is merely to describe the characteristics of mechanisms which could be employed selectively to deal with situations in which they are deemed to be appropriate, for whatever period seems appropriate.

6.2 Exposing Generation in CR pools

357. The previous chapter discussed the possibility of dealing with interconnector interactions by exposing interconnectors to the CP prices of the trans-regional constraints in which they are involved. Here we are concerned with both generator/generator and generator/interconnector interactions, and consider the impact of exposing generation to CP in the constraints in which it is involved, with or without also exposing interconnector flows.

358. Note that this is a more radical change to the market design than that envisaged in the previous chapter. Exposing interconnectors to CP has no direct impact on any market participant. Inter-regional hedging would still be obtained via an auction process, either of inter-regional rents via the current SRA (under CSP/CSC), or via

an expanded auction of CRF pools, (under CBR). The real difference would be in the firmness, or at least wholeness, of those pools, as determined by calculations within the settlements system. Exposing generation, though, effectively creates a form of nodal pricing for the generators exposed, and significantly alters the implicit assignment of access rights under the status quo.

359. As before, if interconnectors are involved, rents (positive or negative) could be extracted from the IRSR pools and paid into CR pools for each managed constraint. But, whether or not interconnectors are exposed, congestion rents (positive or negative) would also now flow into these pools from/to any exposed generation terms. Specifically, if GEN_i represents generation from i, then, we have:

$$\text{rent collected from } i \text{ for } CRF_k = CP_k * weight_{ik} * GEN_i$$

360. The constraint weights applied to GEN_i in constraint k may be positive or negative. A generator involved in a constraint will pay or receive congestion rents from the CRF depending on the sign of the coefficient for that generator in the constraint equation. If a generator is constrained off by the constraint, as both parties are in Figure 3.1, its constraint coefficient will be positive, and this equation implies rents being paid from the generator to the CRF pool. If a generator is constrained on by the constraint, as both parties are in Figure 3.4, its constraint coefficient will be negative, and this equation implies rents being paid from the CRF pool to the generator.[166]

361. Either way, the implication of these rental flows is that an exposed generator effectively faces its "Adjusted-Nodal Price" (ANP), formed by adding the sum of CP terms on to the Regional Reference Price, rather than just its Regional Reference Price. Since constraint coefficients can be positive or negative, AP may be above or below the Regional Reference Price. If a generator is exposed in all constraints in which it is involved, it will actually face PNP, or equivalently its nodal price, as it would be calculated in a nodal market[167].

362. It should be noted that the interpretation of the rents implied by any of these figures is slightly different if one or both axes represent generation, rather than interconnector flow. The same mathematics applies but, in this case, the variable upper bound is not a PIL, but an upper bound on that generator's output. Thus it is not a bound on a common resource available to the market, but rather on a resource private to that generator. And this is recognised by the fact that, implicitly, the market settlement system assigns the rent on that constraint directly to the generator, rather than to any kind of CR pool.

[166] If both axes in Figure 3.2 represent generators, then one is being constrained on and the other constrained off.

[167] That is, unless the constraint coefficients account for non-NEO effects, as discussed in Section7.3. In this chapter, we assume that the constraint coefficients applied to generation only reflect NEO effects, so that generation can, conceptually, be treated as analogous to a negative load, or positive interconnector inflow. Consequently, when we discuss exposure of generation to the CP in this chapter, we mean that the generation appears on the exposed LHS of constraints in which it is involved, multiplied by the NEO portion of its constraint coefficient, representing the impact of its energy injection on the constraint. The non-NEO portion of its constraint coefficient, if any, should conceptually remain on the Protected RHS, unless involved in some form of ancillary service arrangement, as discussed in Chapter 7.

363. It can be shown that the shadow price on this constraint is, in fact, the difference between the generator's offer and PNP. But, under the status quo, the implicit assignment of CRRs means that the CP component of this price is cancelled out, leaving the generator to face the Regional Reference Price. The rent on this upper bound is just the generator "profit", over and above its offer cost, which is already implicit in the settlements system.[168] While this "profit element" is mathematically analogous to the PIL rent on an interconnector, it has already been assigned to the appropriate party, i.e. the owner of the limited resource, and need not concern us further here. Thus we focus solely on the CRFs for the network constraints in which generation is involved.[169]

364. For constraints of the form illustrated in Figure 3.1, rents will always be positive, indicating that a positive value would be added to the market if that constraint was relaxed, by making more of the constrained resource available. Negative rents are possible in other cases, though, where the constraint represents an obligation to be met, rather than a resource to be utilised, as in Figure 3.3. As discussed in Section 3.2, this negative rent would arise as the result of multiplying a negative CP by a positive RHS, if the constraint is represented in ≥ form, which seems most natural for thus is type of constraint. If the constraint is converted to the standard ≤ form assumed in most of our discussions, the price would also change sign, and the same negative rent would arise as the result of multiplying a positive CP by a negative RHS.

365. As discussed there, negative rents could also arise in other cases, depending on where the constraint line lies relative to the origin. But note that what is critical, for hedging purposes, is not the raw rent implicitly calculated in NEMDE by multiplying CP by the NEMDE RHS. The rent available for hedging is defined by multiplying CP by the Protected RHS. Thus, depending on which parties are exposed, the rent actually available for hedging may be negative when the NEMDE rent is positive, or vice versa. [170]

6.3 Intra-regional Access and Constraint Support

6.3.1 Introduction

366. The discussion in this section deals solely with intra-regional access and constraint support issues. With minor variations, it covers several cases:

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[168] We will ignore the detail that there will actually be several such bounds, representing offer tranche limits, but the same result apples to each of them.

[169] In other words, we are NOT considering or advocating the redistribution of rents arising from the fact that a particular generator is operating at its own maximum capacity. If there is a binding transmission constraint on the volume of aggregate generation at a location on the network, though, that would be a network capacity issue. The impact of this transmission constraint would have to be included in the CP-based regime if generators at that location are to receive appropriate incentives for generation and in order for an appropriate economic signal to be given to new entrants considering installing additional capacity at that location.

[170] As noted in Section3.4, the Protected RHS may be augmented by entering into firm, CRC contracts with various parties, thus increasing the net hedging pool available to other parties. In particular a negative CRF may be made positive by such means.

a) Purely intra-regional constraints;

b) Trans-regional constraints in which interconnector terms have not been exposed to CP; and

c) Trans-regional constraints in which interconnector terms have been exposed to CP, but constraint capacity has been partitioned, for hedging purposes, between intra-regional and inter-regional CRF pools, as proposed under the CSP/CSC approach.

367. The discussion in this section also covers both intra-regional "access", and "constraint support". Psychologically these may be considered very different concepts, and the practical arrangements required may differ significantly, too. Mathematically, though, the only difference between these two is the sign of the constraint coefficients involved:

- If the constraint coefficient (weight) is positive, a participant will think in terms of obtaining access to a Regional Reference Node, and place a positive value on that access.
- If the constraint coefficient (weight) is negative, a participant will probably not think in terms of obtaining access to a Regional Reference Node, which would have a negative value to them. But they may be induced, and expect to be paid, to provide "constraint support" to relieve congestion.

368. Mathematically, and in the context of this section, it really makes no difference why "support" is being sought from generators. In case (a) above, it would be to meet a strictly intra-regional constraint requirement. In the other two cases it could be to support an agreed level of interconnector flow, or just to provide greater interconnector flow capacity.

369. But it should be recognised that, generally, there will be generators on both sides of these arrangements. Typically, the more "support" some generators provide, the greater access some other generators are ale to obtain, not only inter-regionally (via increased interconnector flow), but intra-regionally. Thus these two topics are inextricably linked, and must be discussed together.

370. We first discuss a CBR-style approach to these issues, and then a CSP/CSC-style approach. In both cases we assume that purely intra-regional CRFs have been formed:

- In case (a) there will be no other CRF, and inter-regional hedging is irrelevant.
- In case (b) there will be no other CRF, as such, but the interconnector portion of any trans-regional constraint rent will be retained in its IRSR pool, which we assume to be auctioned via the SRA process as at present.
- In case (c) each CRF will have been formed from a combination of generator and interconnector CR payments/debits, but then partitioned between intra-regional and inter-regional hedging pools. The latter pools would be aggregated to form an IRH pool for each interconnector, and then auctioned via

the SRA process, as at present. The discussion in this section then relates to the treatment of the intra-regional portion of the CRF pool.

6.3.2 Managing Intra-regional Congestion via CBR

371. Having formed CRFs, as above, the CBR approach would auction proportional shares of the rents in each CR pool, separately, then leave participants to sort out their own hedging arrangements by re-combining these rents in combinations which match their trading requirements. In this case, though, it is intra-regional, rather than inter-regional access which must be purchased. [171]

372. In order to obtain access to the Regional Reference Price, a generator must purchase CRRs for all constraints in which it might be exposed, both intra-regional and trans-regional. Leaving aside any possibility of variation in $ProtectedRHS_G$ for any of these constraints, if it wanted to obtain access for the same fixed MW volume, $PRRV_i$ across all constraints, it would be looking to purchase a CRR in each constraint, k, with volume equal to[172]:

$$CRRV_{ik} = PRRV_i * weight_{ik}$$

373. Once purchased, these rental pool shares act just like the CSCs proposed by CRA. Thus, if a generator is exposed in a constraint, but also purchases a CRR from that constraint's CRF, it will receive a net payment of:

$$\begin{aligned} Nett\ payment\ to\ GEN_i &= GEN_i * (RRP - CP_{ik} * Weight_{ik}) + CRRV_{ik} * CP_k \\ &= GEN_i * RRP + CP_k * Weight_{ik} * (PRRV_{ik} - GEN_i) \end{aligned}$$

374. Thus the generator would be perfectly hedged with respect to this constraint, in the sense that it obtains access to the Regional Reference Price, if its generation matches the volume of its purchased CRR, as determined ex post.[173] Under the basic CBR proposal, though, CRRV varies in proportion to the Protected RHS of the constraint. So generators can not be firmly hedged for a fixed MW output level.

375. In effect, generators must remain un-hedged with respect to variation in those factors which are still included in the Protected RHS. If all flow and generation terms were exposed, the residual Protected RHS, $ProtectedRHS_{FG}$, will contain TNSP, ancillary service and load terms, so hedging will not be provided with respect to variation in these terms. This would clearly apply in case (a), where there are no interconnector terms, but:

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171 By assumption, inter-regional access would still be obtained via the SRA process, as above.

172 This expression actually applies to all constraints. If a generator is not involved in a constraint, its weight will be zero in that constraint, and it will not want to purchase any CRRs.

173 We focus on access to the Regional Reference Node, because that is what CRRs will naturally provide generators, in a regional market. Hedging to other points would be possible by buying and selling such CRRs, but probably not relevant unless load is also exposed to CP, as explained in Section 4.5.2

- In case (b), interconnector flows would not be exposed. So the residual Protected RHS, *ProtectedRHS*$_G$, would also reflect all variations in interconnector flows.

- In case (c), variability in the Protected RHS due to interconnector flows would be reduced, if not eliminated, by the partitioning agreement, which guarantees some volume of firm hedging available to generators, as discussed in Section 6.4.3.

376. Either way, then, the generators are competing to obtain access to, or provide support for, whatever intra-regional transmission capacity remains, after the (actual) protected or (contractual) agreed interconnector flows have been accounted for.[174] Once purchased, the CRRs would give firmer access, or at least more predictable, access to the Regional Reference Node than under the status quo, in that, while it will not guarantee access for any specific volume, the available capacity on any applicable constraints would effectively be partitioned in proportion to the CRRs held, rather than generators having to compete for implicit rights by manipulating their dispatch positions.

377. As for the interconnector case, the CBR approach may imply only a moderate increase in complexity for participants under deterministic assumptions.175 If each constraint pool was itself firm, this portfolio would give firm access to the Regional Reference Price. But there are three issues here:

- First, while it should be possible to hedge a feasible expected aggregate dispatch position firmly, there will still be further hedging available, which has value in hedging with respect to dispatch uncertainty, but which can not be firm, as discussed in Section 3.6.1.

- Second, we have argued that it is not actually possible to provide firm revenue neutral hedging, in aggregate, with respect to network capacity and configuration uncertainty. The situation then becomes much more complex, because uncertainty creates a very large number of potential CR pools — one for each constraint appearing in a possible state of network configuration. But CBR can, in principle, provide hedging which is as firm as the network which turns out to be available at the time.

- Third, for generators who may be constrained on, the CRRs which they would need to "purchase", would actually have negative value, and they would need to sell them in order to be hedged with respect to the Regional Reference Price, and in order for other parties to be able to purchase the access they require, as discussed in Section 4.5.5.

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[174] This regime may thus be interpreted as one operationalisation of the concept of "interconnector priority".

[175] Firm hedging can not be purchased up to the full capacity of any particular constraint, though, for all the same reasons as discussed in Section 3.6.1 with respect to interconnector limits.

Constraint Support

378. In this context, the concept of constraint "support" becomes relevant. There are two cases here:

- Either the CRF could be negative, representing an overall obligation (eg to support a load or agreed interconnector flow) that generators could be paid to accept a share in;
- Or the CRF could be positive, but their constraint coefficient negative, in which case they would need to be paid to "support" the constraint, so as to allow increased generation, or flow, from some other parties.

379. Section 4.5.5 discusses how this might be achieved by those participants selling CRRs in a tendering or two-sided auction process, and discusses the issues which may arise. In principle, such a market seems possible, although proportional (rather than fixed MW) CRRs, do not seem a good way of contracting for constraint support. The potential for market power to be exercised in situations where only a small number of generators can actually support a particular constraint is also an issue.

380. A situation of exactly this nature actually arises with respect to the Snowy constraint example considered earlier, and is illustrated in Gregan and Read (2008). That situation involves a trans-regional constraint but, with interconnectors protected, a trans-regional constraint would not really be treated any differently, than an intra-regional constraint.

381. If, the issue is one of interconnector support, we must also ask how this support would be funded. The logical answer is that, if generation is constrained on to support interconnector flows, that support should be funded by payments received from traders buying inter-regional hedging. And, logically, this might be achieved via a two-sided auction process in which both generators and interconnectors were exposed to CP, as envisaged in the full CBR proposal. If interconnector flows were protected, though, the nexus between payments received and payments made would be less direct, and would need to be negotiated somehow.

382. If this were a purely intra-regional constraint, though, the problem is somewhat different, because there is no interconnector support involved. In fact, such a constraint is most likely to result from a requirement for some kind of locational 'load support". Thus the logical parties to pay for this support would be the loads concerned, and this could be achieved by exposing them to CP, and requiring them to buy CRRs to protect their position.

383. This option seems to be implicit in the statement of the CBR proposal by Biggar (2006), and is discussed in Chapter 9. But that option is not available if all loads are to be protected, as has been assumed here. Thus the CRRs would have to be considered as a form of "network support" contract, and the CBR auction would effectively be a tender for such network support. Presumably, the costs of purchasing such network support would ultimately be met by loads, in aggregate.

384. More generally, load can be expected to be a major factor in many trans-regional constraints. Thus, if constraint support is being purchased, one must consider to

what extent it is really being purchased to support interconnector flows, and to what extent it is being purchased to support locational load requirements. In principle, our decomposition of the RHS allows that question to be answered precisely. The logical conclusion is that load should pay the same per MW rate as weighted interconnector flows. But translating that mathematical answer into a commercial arrangement is another matter.

385. Generalising further, an intra-regional or trans-regional constraint is likely to involve generators with both positive and negative constraint coefficients. Those with negative coefficients will be constrained on, and may be regarded as "supporting" the constraint, by relieving congestion, as above. But those with positive coefficients will be constrained off, and may be regarded as undermining that constraint "support", by increasing congestion. Thus, even if interconnectors are not involved, some generators would effectively be selling, and some buying, "support". Thus much the same issues arise, with respect to market power, for example.

Longer term issues

386. The advantage of auctioning off shares in a large number of individual, state contingent, CRFs (as advocated under the CBR approach) is that it leaves the market free to find an appropriate balance between intra-regional access and/or support for different participants, under different circumstances, as the trading situation evolves over time. But the political or commercial acceptability of a move from the current dispatch-matching allocation of CRRs to a process in which an auction was the sole means of assigning CRRs is an issue to be considered.

387. Quite apart from the complexity of the process, some generators would be required to purchase access to their own Regional Reference Node, in part from other generators who were simultaneously being relieved of any obligation to trade at that node. This would have to be regarded as raising concerns with respect to the economic transfers that would arise, and the potential commercial disruption and political action that would result. We find it hard to imagine that such a transition could be implemented without providing longer term guarantees of some kind, and that brings us straight back to the issue of allocating contracts to existing plant, just as for the CSP/CSC proposal.

388. But there are more than just transitional, or political, issues at stake here. Consideration needs to be given to the investment signals provided for potential entrants. Unless the auction horizon was very long, market participants (i.e. existing players and new entrants) would not be able to obtain effective access guarantees to the RRP for anything like the lifetime of their plant, and may consider themselves to be worse off than under the status quo, where they can gain implicit long term access to the RRP via the dispatch process.

389. Since access to settlement at the RRP affects investment incentives, it needs to be considered carefully. Firmer long term access to the settlement prices at major contract trading hubs (i.e. the RRNs), overall, should provide significant benefits to the market as a whole, because anything that reduces the risk faced by investors reduces their required rate of return, and hence the level of market prices needed to

make investment profitable. In other words lower investment risk translates into lower prices for consumers.

390. When it comes to locational decisions, though, it is not desirable that new plant should gain free access to the Regional Reference Price if it locates in a sub-region where generation is already being constrained off. Nor is it desirable that new plant should be forced to accept access to the Regional Reference Price if it locates in a sub-region where generation is already being constrained on. In both cases it is desirable that the new entrant should be required to "buy" access, rather than being assigned it for free, as happens under the status quo. Otherwise a major advantage of locational pricing for generation is being lost — i.e. the dynamic efficiencies arising from better investment decisions on the location and mix of generation plant.

391. In a constrained-off location the new generator would expect to be exposed to CPs, meaning that it would face an expected PNP below the Regional Reference Price, with some risk. It could either accept that risk, or deal with it by paying a positive price for access rights, in competition with incumbent generators, both local and distant (as represented by the demand for inter-regional hedges corresponding to interconnector flows).

392. In a constrained-on location, the new generator would also expect to be exposed to CPs, meaning that it would face an expected PNP (and probably ANP) above the Regional Reference Price, but with some risk. It could either accept that risk, or deal with it by paying a negative price for access rights, in competition with incumbent generators, both local and distant. That is it would need to be paid to accept the liability of contributing the rental payments which it would otherwise receive as a result of being exposed to CP, back into the corresponding CRFs.

393. In this regard the CBR process actually performs quite well, because it does force new plant to pay for access at whatever the going rate turns out to be at the time. But some means of obtaining longer term access guarantees seems desirable, although "allocation", for free, seems inappropriate for new generation capacity.

6.3.3 Intra-regional Congestion Management via CSP/CSC

394. CRA's CSP/CSC proposal was originally developed to deal with interactions between an interconnector and generation, and then between several interconnectors, in trans-regional constraints. But it was later generalised to deal with generator/generator interactions in intra-regional constraints too.[176] Those later proposals were less detailed, though, and CRA left a wide range of options open with respect to intra-regional hedging, which were not the main focus of its work.

395. The basic options discussed by CRA involved pure, rather than bundled, CSC rights (or CRCs in the current notation), and CRA envisaged that, if desired, they could be

[176] See Section 4.6 of CRA(2004a).

sold at auction or traded between participants, and they would probably have to be scaled , at least some times, to meet revenue adequacy requirements.

396. Described this way, the CSP/CSC proposal seems little different from the CBR proposal. Once they have been acquired, and any scalings applied, CSC rights really operate no differently from CRRs purchased in CBR auctions. But the general flavour of CRA's proposals did differ from CBR, particularly with respect to a number of additional features which were thought more likely to create a workable mechanism, in practice[177].

Bundling of Intra-regional Rights

397. One way in which CRA proposed to simplify intra-regional hedging for participants was by bundling CRRs. While the possibility of contingent contracts relating only to specific circumstances was seen as useful for network support contracting, CRA suggested that most participants probably only want to purchase, an intra-regional hedge, giving access to their Regional Reference Node no matter which constraints bind.

398. The difficulties of making such bundled products "firm" have been discussed in Section 3.6, and that discussion will not be repeated here. But those difficulties are fundamental to this situation, and apply equally to CBR, for example. It should be recognised, though, that a bundled intra-regional hedge suffers from the limitation that it is location specific. This does not diminish its value to a participant at that location, but means that its value to participants at other locations depends strongly on their (electrical) proximity to the location it is defined for.

399. Thus, unlike a bundled inter-regional hedge product, these intra-regional locational hedges are not interchangeable, and are not likely to be traded freely between participants. FTR auctions in nodal markets deal with this problem by allowing participants to offer their rights back into what we have called an (INBA) Network-Based Auction. Section 4.5.12, proposes investigation of a similar regime which could effectively synthesise CBR and CSP/CSC approaches. Implicitly, that mechanism would allow bundled rights to be unbundled into their component CRF parts, and then re-bundled to meet the requirements of other participants. Such a process sounds complex, but is implicit in the market-clearing algorithms used in all FTR markets.

400. Still, the potential need for such mechanisms should sound a note of caution with respect to the prospects of developing markets to trade bundled intra-regional rights. If such trading is considered essential, the more complex, but flexible, CBR model may be preferred to a fully bundled CSP/CSC model. In some parts of the NEM, sub-regional "trading hubs" might be employed. But Appendix B suggests an alternative model which combines allocated locational rights with a tradable bundled generic right between generator and load hubs.

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[177] Leaving aside CRA's proposed partitioning between intra-regional and inter-regional hedging pools, which becomes relevant in Section 6.4 below.

Firmness of Intra-Regional Rights

401. The CRA work also differed from the CBR proposal, in that it did not assume that rights would be defined, primarily, in terms of proportional shares. Instead CRA implicitly assumed a primary definition of CRRs (i.e. CSCs) in terms of either constraint RHS, or participant MW. In other words, the CSCs proposed by CRA were CRCs or PRCs, respectively, in the current terminology.

402. Fixed MW contracts were thought to be more appropriate if the purpose is to contract for interconnector support, for example. In that context concerns about "revenue neutrality", or "revenue adequacy" are reversed. The point of such contracting is to ensure that contracted parties make up, financially, the consequences of any physical shortfall they may be responsible for and/or reap the rewards if they exceed the agreed performance. Thus the volume of firm hedging available to other parties is increased, not reduced, by these contracts.

403. More broadly, though, the reason why the CSP/CSC regime treats scaling as an occasional, rather than universal, feature, is that it assumes risk spreading and smoothing between individual CRFs, subject to some broad revenue adequacy requirement.

404. It was recognised that individual constraint CRRs could only be "as firm as the RHS", or more precisely the Protected RHS, of its own constraint. Thus revenue neutral hedging can still not be firm with respect to either capacity or configuration uncertainty, and this is just as true for the CSP/CSC approach as for the CBR approach. The problem identified in Section 3.6 remains — namely that, even if the individual CRCs were fully firm, in the sense that $ProtectedRHS_{FG}$ was firm for each, the intra-regional bundles will probably not be fully firm, because the participant MW capacities (PRRs) implied by the individual, constraint specific, CRRs will probably not all be identical.

405. Accordingly, firm revenue neutral intra-regional hedging is still not possible when only generation is exposed to the CP, and this would seem to be a fundamental characteristic of the regional market design, driven by underlying physical factors. But strict revenue neutrality in each and every trading interval is a very strong requirement. As noted in Section 4.5.4, FTR markets operate successfully using the weaker requirement of "revenue adequacy" and there is no obvious need to impose a stricter requirement in the NEM.

406. As noted in that section the CSP/CSC approach allows for a variety of co-insurance mechanisms to both smooth and spread risks in a way which does not seem possible if CRRs are defined purely as proportional shares. In this context, we can think in terms of hedging instruments defined primarily in MW terms, while recognising that they may sometimes need to be scaled to meet some overall revenue long term neutrality requirement, as in FTR markets.

407. Some sort of revenue adequacy test must be applied in issuing such instruments. But such tests, while complex, are routinely applied in FTR markets, and can certainly be adapted for application to bundled inter-regional and intra-regional instruments in a centralised auction, or allocation process. By way of contrast the CBR approach, as presented, seems designed to avoid the need for such centralised

processes as bundling, smoothing or spreading. In that form it can not readily accommodate relaxation of the revenue neutrality requirement.

Allocating Intra-Regional Rights

408. CRA's original proposal to NEMMCO did not pay much attention to the allocation of intra-regional CRFs because a mechanism was being sought to actively "manage congestion", by incentivising "support" of a required interconnector flow. Thus it was assumed that the generators involved would most likely be exposed to CP in the context of negotiated contractual arrangements for interconnector support. While such contracts did hedge the risk of participants exposed to CP, and could be seen as implying access to the Regional Reference Price, this was not their primary purpose, or the primary focus of discussion. CRA's later work for the MCE did discuss several options for the allocation of intra-regional rights, but did not make any recommendation as to how rights in the intra-regional pool should be allocated.

409. One possibility would be to auction rights to each intra-regional CRF as proportional shares. In that case the CSP/CSC style approach would only differ from a CBR style approach in that it imposes a hub and spoke structure on the auction process. The advantages, and disadvantages, of partitioning the auction process in this way are discussed in Section 4.4.2. But note that, if only generation is exposed to CP, these two approaches would actually be identical, since both deal only with intra-regional hedging. Thus we focus here on the alternative allocation mechanisms discussed in the CSP/CSC papers, but not in the CBR proposal.

410. By introducing CSCs (or CRCs in the current notation) with a (potentially) longer term than the CRRs apparently envisaged in the CBR proposal, as presented, the CSP/CSC proposal enabled a wider range of allocation options to be considered. This flexibility in allocating CSCs is a strength of the CSP/CSC approach because it can be adapted to a variety of objectives, including transitional wealth protection, network support contracting, and mitigation of market power. But it also introduces a wide range of possible complications.

411. A distinction may be made between initial allocations, at the time when a particular CSP/CSC arrangement is introduced, and subsequent re-allocations, which might be achieved by bilateral trading, for example. Initial allocation options discussed by CRA included:

(a) allocation by formula based on current or historical dispatch;

(b) negotiation;

(c) decree; and

(d) grand-fathering;

412. With respect to option (a) note that, in the limit, CRR allocation based on historical dispatch comes down to allocating rights to match current dispatch. But, ignoring any ex ante partitioning of rights between intra-regional and inter-regional pools, this would be identical to the status quo IDMA allocation of assigning CRRs. That is, it would effectively undo the effect of CP exposure, and re-create the status quo,

with all of its issues. More generally, any formula which is partly based on ongoing dispatch outcomes will retain some characteristics of the status quo.

413. For example, a formula may be proposed by which participants would be automatically allocated CRRs corresponding to half their dispatched output level, leaving them to purchase the remainder of their hedging requirements from the residual CRFs. Such formulae have been proposed, and may be represented in the framework discussed here. In this case, the effect is partial (50%) exposure of generation, a concept discussed, for a different purpose, in Section 8.2. This halves, but does not eliminate the incentives participants currently have to capture CRRs via IDMA.

414. Basing future CRR allocations on current dispatch levels will have similar, although more diffuse, implications. Thus their properties will be intermediate between the status quo and the CSP/CSC proposal with full exposure of participants, and firm ex ante CRR allocation. Allocation formulae of this nature carry the implication that new entrant could acquire CRRs just by sitting at a position in the network, and operating there. This may seem "fair", but in our view this distorts locational invest incentives.

415. Option (b) has been, and will be, extensively discussed in this report, particularly in the context of contracting for network support. This is particularly applicable when contracting with ancillary service providers or TNSPs, as discussed in Chapters 7 and 8. But it is also applicable to contracting for network support from generation.

416. The critical point, here, is that such negotiations seem likely to be required prior to, and as a condition of, exposing generation to CP in the first place. If generation is constrained on, and will possess significant market power once exposed, it seems simply foolhardy to contemplate such exposure without first negotiating long term contractual arrangements which mitigate such market power. Conversely, if generation is constrained off, and will suffer significant losses as result of being exposed, it seems unlikely that it will be ready to accept such exposure without first negotiating long term contractual arrangements which protect its position.

417. Option (c) could cover a wide variety of allocation approaches, since virtually anything may be "decreed". It might, for example, involve allocation in accordance with a formula based on dispatch outcomes observed up to the time of the decree. But that would then constitute a distinctly different option to (a), if that CRR allocation was to be fixed from that time forward. It would also have distinctly different (and arguably superior) efficiency properties, because dispatch would no longer be distorted by participants trying to cover part of their hedging requirements by implicit allocation.

418. But a decree based on historical dispatch would effectively amount to "grandfathering", as in Option (d). This seems the most obvious approach to an initial allocation of intra-regional CRRs because it preserves the wealth distribution implicit in the status quo, and thus minimises market disruption. It also fosters dispatch stability, because participants will tend to prefer dispatch outcomes which do not deviate too far from their contract positions. Effectively the implicit rights which have been historically allocated to match dispatch under the status quo would be translated into explicit rights, and frozen, perhaps for a very long term.

419. In principle, this does not mean that the corresponding capacity would be "locked up", because the holder of such rights could be allowed to offer the rental streams derived from them back into any short term auction process. The rights themselves could also be tradable. But caution is appropriate with respect to the prospects for such trading, if these rights are expressed in terms of specific CRF pools, they are interchangeable with other CRRs for that CRF, and can be freely traded with other participants involved in that CRF. But if they are "bundled", and specific to a particular location, the prospects for trading them will be limited, as discussed above. And incumbents may not want to sell them to new entrants, for example.

420. For new entrants, the critical issue with grandfathering is not that they would have to pay for access rights. New entrants would have to pay for CRRs under CBR too, and we have argued that this is appropriate. Rather, the critical issue with grandfathering is whether incumbent holders of access rights would make the rights available to new entrants at a fair price, either directly or via the auction process, or be able to exercise market power to deter entry. The extent of such market power potential will depend on the number of participants involved in each CRF pool, and would probably be increased by bundling, if this makes rights more locationally specific, as above. This is a significant issue, and an argument against indefinite and indiscriminate grandfathering.

421. Grandfathering of rights does, however, offer an effective means of mitigating market power. As noted above, constrained on/off situations typically create market power of some kind, and exposing constrained on generation to CP may give a small group of generators the opportunity to exercise market power by forcing local (PNP) prices up. In this situation, access rights are actually obligations, and grandfathering will mitigate any abuse of such market power. If such "obligations" are not grandfathered, they may have to be negotiated into place thus giving generators the opportunity to exercise market power in the negotiating process.

6.4 Managing Generator/Interconnector Interactions

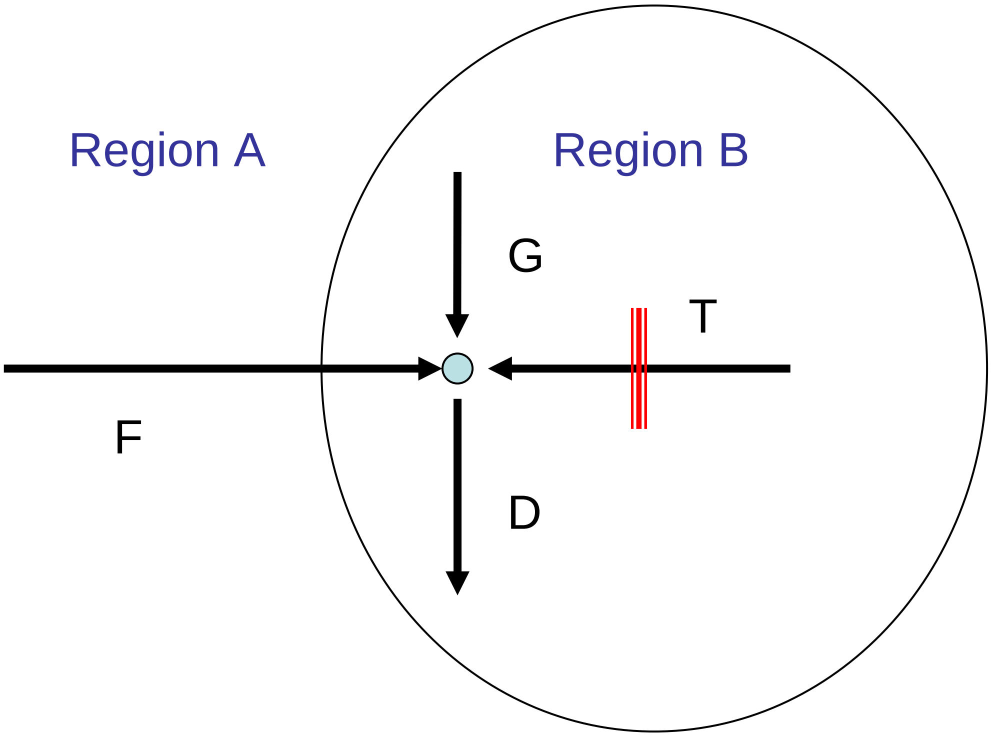
6.4.1 Introduction

422. The previous section has focussed, primarily, on analysis of situations in which generation, alone, is exposed to CP, either because a constraint was intra-regional, or because inter-regional flows were assumed to be protected. This was done in order to clarify issues relating to intra-regional hedging, and interconnector support contracting. But both the CBR and CSP/CSC proposals actually involved exposing both interconnector flows and generation terms to CP, and proposed mechanisms involving by which hedging could be provided for both intra-regional and inter-regional trading.

423. This situation is obviously a little more complex, but all of the elements required to deal with it have already been discussed. Here we simply focus on some further issues relating to the generator/interconnector interaction in this more general

environment. And we illustrate that discussion by reference to a very simple example, involving no loop flows, as shown in Figure6.1[178]

Figure 6.1 Simple Cross-border Load Example



424. Here a load, D, near the border of region B , must be met by some combination of local generation (G), cross-border flow (F) and intra-regional flow, limited by T. We will assume this latter limit is binding, and note that the natural form of this constraint equation would be:

$$F + G + T \geq D$$

425. This is also the correctly oriented form of the constraint if the Regional Reference Node lies on the other side of the transmission constraint from G and D. Re-arranging this constraint into a standard ≤ form leaves it correctly oriented, and placing constants on the RHS as in NEMDE, we get:

$$-F - G \leq T - D$$

[178] More complex examples are discussed by Gregan and Read (2008).

426. Since it is in ≤ form, this constraint will always have a positive CP. But note that, for this constraint to bind, the RHS must be negative. That is, D must be greater than T. Otherwise it would always be possible to meet the load using T alone. Thus this constraint represents an obligation, not a resource, to the system, and some combination of F and G must be constrained on to meet this requirement. [179]

427. Note, too, that the positive CP on this constraint means that the local PNP, applicable to D, G and F, will be higher than the Regional Reference Price for Region B. Thus generation in this sub-region is "constrained on". Assuming the cross-border flow to be unconstrained, PNP will also equal the Regional Reference Price for Region A. Thus F will represent a flow from a higher priced region to a lower priced region. In other words, we have a counter-price flow in a situation involving no loop constraints at all, and only one intra-regional line limit.[180]

428. The question is, then, how the various regimes discussed here might deal with this situation. And the critical issue is which parties are exposed to CP. In this section, we will assume that both F and G are exposed, while D and T are protected. Thus the Protected RHS of the constraint equation is just the NEMDE RHS, as above.

429. This means that both F and G get two settlement payments: i) a payment based on their own RRP for all generation; and ii) a payment based on the CP for this constraint. The net effect, before consideration of any CRR contracts, is that:

- G receives PNP per unit of output;
- F receives a CP payment which exactly cancels the negative IRSR that will arise with respect to its spot market transactions;
- but D is still protected by its implicit CRR allocation; so
- the CRF for this constraint is negative.

6.4.2 CBR for Generator/Interconnector Interaction

430. The CBR approach to integrated management of generator/interconnector interaction is essentially simple. Parties wishing to arrange either intra-regional or inter-regional hedging, or both, only need to work out the implications of their trading requirements in terms of exposure to each of the constraints in which they might be involved, and then either buy or sell appropriate shares in each of the corresponding CRFs, as discussed in Section 4.5.5.

431. If we ignore uncertainty, applying the CBR approach is very simple in the above example. Exposing the interconnector flow means that all rents will be paid out of that pool into relevant CRFs, so the IRSR will then be empty, and irrelevant. There is no binding PIL constraint at the regional boundary, so its CRF will be empty, too.

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[179] Note their negative constraint coefficients.

[180] But note that that the constraint involves F, which means it is trans-regional, even though the limit is intra-regional.

There is only one trans-regional CRF pool, and all parties have coefficients of +/-1 in the trans-regional constraint. Thus:

- If G wishes to hedge to its own Regional Reference Node, it must sell a CRR into the CRF, which effectively means it is committing to generate at the corresponding PRR level in order to meet some of the local load requirement.
- And generators in Region A can make similar commitments, also by selling a CRR into the CRF.
- If, jointly, they commit to meeting D-T, then the CRF will end up with a zero balance in the settlements system.
- Other generators in Region B may wish to hedge to the Regional Reference Node of Region A, which will have a higher price, and can do so by buying CRRs from the CRF. But there will only be CRRs for them to buy if the CRF has a positive balance, after accounting for contracts with G and generators in region A who wish to trade into region B via F: That is, if those parties jointly sell more than enough CRRs to cover (D-T) into the CRF.

432. The transactions referred to in this last bullet will all cancel out. This is effectively a swap market which could have existed even without any interconnector capacity. The big issue, though, is who will pay for the "load support" requirement represented by the constraint RHS of (D-T). The logical answer is that this should be the load, and that is what seems to be envisaged by the CBR proposal, as presented. If that is unacceptable, which we assume it is, then this situation must effectively be treated as requiring a network support arrangement.

433. Thus the CBR auction referred to above would effectively be a tender for network support. If F is unlikely to be constrained, this might be reasonably competitive, since all generation in Region A may be able to compete. But if F was also constrained, it would become extremely un-competitive, with G holding effective monopoly power.

434. Leaving that aside, though, if the problem is feasible, it should be possible to eliminate the negative IRSR by purchasing CRRs off both G and cross-border generation. This may not be possible if only either F, or G, is exposed, though, because the exposed parties may not be able to meet T-D on their own. In that case, the residue represents the cost of buying in uncontracted power on the spot market to meet the local load requirement. This would have to be financed somehow. In any case, funds would have to be found to pay for the CRRs purchased to top up the CRF, as above. If local load is not to cover these costs, then some other arrangement must be made, presumably to spread the cost over all loads, perhaps in some indirect form via TNSP charges, for example.

435. Conversely, if load really were exposed to CP it would actually face PNP for all of D, not just D-T. In order to hedge its position, load would not only need to purchase CRRs to cover (D-T), effectively from F and G, via the CRF, but also enough to cover T, corresponding to the Protected RHS of the constraint, also from the CRF. This latter purchase is effectively a kind of FTR, based on the rents generated on capacity supplied by the TNSP. And of course this CRR can be no firmer than the transmission capacity, T.

436. In principle, this lack of firmness could be addressed by exposing the TNSP to CP, and having it sell a CRR as discussed in Chapter 8. This would provide a complete CP-based solution to the problem, and allow firm revenue neutral hedging, in aggregate, since there would be no terms remaining on the Protected RHS. But, while CRA have discussed this kind of approach, the CBR proposal does not discuss TNSP contracting.

437. This example is very simple, but may be readily generalised. There could be any number of generators involved in buying and selling CRRs for this constraint and, with a more general constraint form, they may have a wide variety of constraint coefficients, both positive and negative. The application of the methodology to situations involving loop flows may be seen in Gregan and Read (2008), or CRA(2004c), and will not be developed here. But some generators will clearly need to be selling "support" which others are effectively buying, as discussed in earlier sections.

438. But notice that all of these generator transactions have been discussed in terms of PRRs which effectively grant generators access to their own Regional Reference Node. This is appropriate if that is where they want sell power, and it is implicit in the orientation of the constraint towards that Regional Reference Node, because this defines the constraint coefficients, or weights, used in the PRR formula. [181] But if G, for example, wishes to sell power in Region A, rather than its home region, it should acquire an intra-regional PRR to its own Regional Reference Node, and then an inter-regional PRR from that Regional Reference Node to that of Region A.

439. But, under the CBR regime, those two transactions can both be expressed in terms of transactions involving CRRs defined on the same CRF, and neted off one another. In the general case, a sale of *PRRV* MWs by generator *i* in region *r(i)* to load *j* at the Regional Reference Node of region *r(j)*, can be hedged with respect to congestion on constraint *k* by:

- Buying an intra-regional PRR with volume of PRRV MW, or equivalently, a CRR from CRFk of volume $CRRV = PRRV * weight_{ik}$ MW; and also

- Buying an inter-regional PRR with volume of PRRV MW, or equivalently, a CRR from CRFk of volume $CRRV = PRRV * weight_{r(i)r(j)k}$ MW.

440. The net effect of these two transactions may be expressed in terms of buying a CRR from CRF_k of volume[182]:

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[181] The Appendix discusses the implications of shifting the Regional Reference Node, in which case the PNPs do not change, and nor do the CRRs, because the constraints are still effectively the same. But the Regional Reference Price obviously does, and so do all the constraint coefficients (weights), and hence the PRRs which relate to the CRRs via the weights.

[182] Note that, since $weight_{ik}$ is expressed relative to *r(i)*, it could equally well be expressed as $weight_{ir(i)k}$. That is, it defines the congestion caused on constraint *k* by sending one unit of power from intra-regional location *i* to its Regional Reference Node, *r(i)*. So this expression might be re-stated as $Nett\_CRRV = PRRV * (weight_{ir(i)k} + weight_{r(i)r(j)k})$

$$Nett\_CRRV = PRRV * (\ weight_{ik} + weight_{r(i)r(j)k}\ ) \text{ MW}$$

441. In this case, if G *(=i)* wishes to sell power at the Regional Reference Node of Region A *(= r(j))* we have: [183]

$$weight_{ik} = +1$$

$$weight_{r(i)r(j)k} = -1$$

442. Thus these two transactions exactly cancel, which is as it should be, because G is physically on the same side of the binding trans-regional constraint as the Regional Reference Node of Region A, and exposing it to CP has already given it a PNP equal to the Regional Reference Price of Region A. Thus it does not need to hedge with respect to this constraint at all, if it wishes to sell in Region A.[184]

443. This discussion highlights another point, though. It may be argued that there is no need to contract with G at all. Since its exposure to CP, and hence effectively to the Regional Reference Price of Region A in this instance, means that it has incentives to generate to meet load D, with or without a contract.

444. That may be true, in theory, but it is equally true of any other generator, generating to meet any other load in the NEM. In theory no forward contracts are ever required, because the spot market will always induce sufficient generation if the price is high enough. But contracting is observed to happen, for reasons which relate to risk aversion and possibly in some cases control of market power. Both factors seem pertinent in this case, and it seems reasonable to assume that some kind of contract would actually be desirable. If the load, which is not exposed to CP, has inappropriate incentives, or inadequate understanding of the situation, it seems inevitable that some other body would be made responsible to do contract on its behalf.[185]

6.4.3 CSP/CSC for Generator/Interconnector Interaction

445. As described in Section 4.4, CRA's CSP/CSC proposal differs from the CBR proposal in that CRRs arising from the newly explicit CRFs would be used to

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183 Note that because flow has been defined as coming from region *j* (=B) into region *i* (=A), the weight on interconnector flow in the constraint is not $weight_{r(i)r(j)k}$, but its opposite $weight_{r(j)r(i)k} = +1$.

184 This does not mean that it does not need to hedge this transaction at all, but only that it need not hedge with respect to this particular constraint. It also needs to consider hedging with respect to any other constraint which may bind between its own location and the Regional Reference Node for A.

185 The discussion also highlights another point that may be puzzling. In all of our discussion we have treated interconnector and generator CRR transactions as being interchangeable. But generator injection and interconnector flow are quite different phenomena. One occurs at an intra-regional point, while the other occurs (notionally) between two Regional Reference Nodes. The answer is that their impacts on a constraint are equivalent, MW for MW, when expressed in weighted terms, and the corresponding CRRs are interchangeable. The PRRs are not interchangeable, because each is weighted to reflect the impact of a MW of flow/injection by a particular party. They can be compared and traded, though, when converted back into CRR equivalents, as above.

allocate some constraint rents back to IRSR (or IRH) pools. Thus, as noted earlier, the proposal envisages a two tier mechanism, aligned to the current NEM structure, in which:

- CRFs are first partitioned between intra-regional and inter-regional hedging pools; and
- The allocation of rights within each of those pools is then considered separately, with an SRA process most likely applied to the inter-regional pool, but a variety of alternative mechanisms available for consideration with respect to intra-regional CRR allocation.

446. Section 6.3.3 has already discussed the treatment of intra-regional CRRs under the CSP/CSC proposal. That discussion was focussed on generation, and covered the case where only generation was exposed to C in trans-regional constraints. As noted there, though, that same discussion remains essentially valid in the case where interconnectors are also exposed to CP under a CSP/CSC regime. This is because, once the CRF pools are partitioned into intra-regional and inter-regional pools, the allocation of intra-regional and inter-regional rights can be considered separately.

447. It may be observed that, in the original CRA work for NEMMCO, the "partitioning" of the CRF referred to here was not discussed in those terms, but was implicit in the assumption that a mechanism was being sought to "manage congestion", by "supporting" a required interconnector flow. That proposal:

- Applied CP (or CSP in that context) to price interconnector flow support services provided by generators (or ancillary service providers or other interconnectors); and
- Proposed the allocation of explicit CRRs (i.e. CSC contracts) so as to improve incentives for contracted participants to supply a defined support level and also ensure that the IRSR pool was made commercially firm, even if support deviated from that agreement.

448. While CP obviously measures the marginal system cost of supporting the required interconnector capacity, the issue of how the required level of "interconnector support" should be set, and how contracts to provide that level of support should be allocated, was not formally addressed by CRA's original work for NEMMCO, where the issue was seen to be resolved, most probably, by contractual negotiations with specific "support providers"[186].

449. In the above example, given that there is only one local generator able to support the local load requirement, CRA would probably have proposed that a network support agreement be negotiated with that generator, in the form of a CRC, under which it would pay into the CRF, thus reducing, if not eliminating, the negative IRSR. If more support was considered necessary, further negotiations could be

[186] That work was originally conceived of as a providing a contracting mechanism, and this terminology was used in various presentations and related materials. But the final report deliberately referred to "reference points" rather than "contract levels", so as to avoid precluding other allocation options.

undertaken with inter-regional generators, and if enough support was contracted the negative IRSR would be eliminated.

450. Conceptually, this does not really differ much from the CBR proposal discussed above, but there are some differences with respect to matters of detail:

- It substitutes negotiations for a tender process, but this seems like a choice which should be situation specific, particularly depending on the number of potential suppliers of support involved, and their market power etc.

- It perhaps assumes greater flexibility with respect to, for example, the term of the contracts involved, with longer term contracts most likely being appropriate in situations where market power is significant.

- And it would most likely define performance levels in absolute MW terms, rather than as proportional shares.

451. While this process would effectively "partition" the CRF between intra-regional and inter-regional participants, that partitioning was not explicit, and nor was it considered relevant, at that time. The concept became more relevant, though, when considering situations involving interacting interconnectors, which might support, block, or compete with one another. In that situation, contracting with individual participants seems less relevant than high level negotiations over policy, the results of which could reasonably be expressed in terms of partitioning available capacity, as in Section 5.4. The concept of partitioning capacity between intra-regional and inter-regional pools then subsequently seemed applicable when CRA's CSP/CSC proposal was generalised for the MCE.[187]

452. Under that proposal, both generators and interconnectors would be exposed to CP, so that all trans-regional CRFs would contain contributions from both the IRSR rents and the net rental contribution of` exposed generators. Having formed these CRFs the CBR approach leaves the balance between intra-regional and inter-regional hedging to be determined implicitly by the auction process. But, as proposed by CRA, the CSP/CSC approach would impose a previously agreed partitioning of the relevant CRFs between intra-regional and inter-regional hedging pools.

453. Notional partitioning of the constraint capacity between inter-regional and intra-regional components would be done via financial CRR contracts (ie CSCs in CRA's terminology), just as for the partitioning between interconnectors discussed in Section 5.4. Thus the situation can be represented as in Figure 3.5, but with one axis now representing an interconnector and the other aggregate generation within a region.

454. Such partitioning offers a financial alternative to physical intervention options, such as clamping or giving dispatch priority to an interconnector. The dispatch would be free to find its desired optimum, with no intervention to force it toward the desired balance point on the constraint line. But the financial contracts would work to

[187] See Appendix D to CRA(2004a), although "partitioning" was not described as rigidly as it has been here.

ensure that the ex ante desired balance is achieved in the settlements system, and also influence the dispatch toward that point, to some extent. [188]

455. Partitioning CRF auctions in this way has three advantages:

- First, it matches the hub and spoke nature of the NEM's conceptual market design.
- Second, it simplifies the task faced by participants in determining what access rights they actually require.
- Third, it allows both inter-regional and intra-regional to be "firmer", because the overall CRR allocation to each is firmer.

456. As discussed in Section 4.5.2, so long as loads only face a Regional Reference Price, it is difficult to see that traders would be interested in anything other than distinct intra-regional or inter-regional rights. Consequently, the greater generality of the CBR auction process may not offer much advantage with respect to meeting actual participant hedging requirements in this environment. There are two major issues with the CSP/CSC approach, though:

- First, achieving an optimal balance between the conflicting requirements of intra-regional and inter-regional traders is a central issue in congestion management. CRA did not say how such a balance would be determined, and that remains a major issue for this approach — just as it does for any physical intervention approach. Given the wide variety of situations likely to be considered, there is no obvious general rule, and essentially ad hoc negotiations seem most likely. This may be argued to be both a strength and a weakness.
- Second, Section 4.4.2 points out that there is an issue with a process that requires an ex ante decision to be made regarding the partitioning of each CR pool to achieve the desired balance between intra-regional and inter-regional hedging. The implication of having a "firm" pre-determined balance between intra- and inter-regional hedging is that this balance may differ from what the market would actually prefer, with respect to trading in any particular interval, thus artificially restricting hedging options, and ultimately distorting dispatch. In this respect, the CBR style approach of allowing intra-regional and inter-regional traders to compete directly in auctions for each individual CRF is more flexible, and could, at least theoretically, achieve a better result.

457. In the above example, where there is only one constraint binding, the CBR and CSP/CSC approaches are superficially very similar. The generator might obtain access to its Regional Reference Node by way of a "bundled CRR", but there is only one CRR in the bundle. And it might then obtain access from that Regional Reference Node to another by way of another "bundled CRR", but there is only one CRR in that bundle, too, or at most two if the PIL is included.

[188] See discussion in Box 2. As noted earlier, competition will be much more effective, and hence second order incentives much less significant, in major regions, or over major interconnectors, than with respect to localised congestion problems.

458. But, the implications of forcing a pre-determined split between the obligations placed on that generator, and those placed on inter-regional generators supplying via the interconnector may be quite serious, particularly when uncertainty is taken into account. Thus the generator would not be able to net off, or trade off, its intra-regional and inter-regional transactions. More seriously, we may be concerned that it could find itself able to obtain an excess of inter-regional hedging, but insufficient intra-regional hedging, for example.

459. This inflexibility may seem more severe where there is only one interconnector and one intra-regional resource capable of meeting the load requirement than it would in a more diversified trading environment with a larger pool of traders in both intra-regional and inter-regional market. And in fact, if it is believed that traders are informed enough to understand the CBR theory, and/or that secondary markets will be efficient, the problem is easily remedied by buying an appropriate mix of intra-regional and inter-regional hedge, and effectively re-combining them, just as one would do in a CBR market.[189]

460. Still the simplicity of the CSP/CSC proposal, from a user perspective, has clearly been bought at the cost of some loss of flexibility, relative to the CBR approach. As the number of potential constraints involved becomes larger, the restrictions implied by bundling CRRs together under CSP/CSC may be regarded as more severe, but the complexities involved in the CBR approach are clearly more severe, too. This brings us back to the suggestion that consideration be given to the possibility of retaining the concept of distinct intra-regional and inter-regional access rights, as in the CSP/CSC proposal, but combining intra-regional and inter-regional auctions into a single Integrated Network-Based Auction (INBA), as discussed in Section 4.5.12. This would allow the market to explicitly determine, via the auction process, its desired balance between intra-regional and inter-regional hedging, as would happen, implicitly, under the CBR approach.

6.5 Summary

461. Overall we conclude that either a CBR or CSP/CSC style arrangement could be applied to generators alone, in order to formalise intra-regional access arrangements, or the provision of constraint support. But it would seem more logical to also involve interconnectors in the regime, as discussed in the previous chapter.

462. In principle, applying a CBR style approach to both generators and interconnectors is little more complex than applying that approach to either alone. Either way, a separate CRF pool is created for each managed constraint, with no distinction between intra-regional and inter-regional hedging pools, thus offering greater flexibility than a CSP/CSC scheme. But participants would face significant complexity, with the number of CRF pools probably being quite large. And many of these CRF auctions would need to allow both purchase and sale of intra-regional CRRs by participants, with market power probably being a significant issue in many cases. Transition to a regime in which incumbents ware required to purchase access

[189] But see discussion in Section 4.5.5.

rights which they have traditionally enjoyed as of right may also be difficult, unless long term rights can be allocated as part of the transition agreement, as proposed by CRA.

463. A CSP/CSC style approach partitions the available constraint/hedging capacity between inter-regional and intra-regional pools, thus providing a financial analogue of "interconnector prioritisation". The inter-regional pools could be auctioned via the SRA process, while the intra-regional pools could either be auctioned, as proposed by CBR, or allocated. Partitioning simplifies the problem faced by participants, but the need for an ex ante agreement may be seen as a weakness of the approach, as may the implications in terms of reducing the flexibility of the market to find an optimal short term balance between intra-regional and inter-regional hedging.

464. The practicality of either regime may depend on the extent to which constraint-based CRRs can be bundled to form simpler intra-regional hedging instruments, as proposed by CRA. Bundling intra-regional access hedges greatly simplifies the situation faced by participants, but makes the hedges locationally specific, and not readily tradable.

465. One possible solution is the re-packaging of intra-regional CRRs into two types of product, one providing access from a specific location to an aggregated "Regional Generation Hub", and the other providing generic access from that hub to an aggregated "Regional Load Hub", as discussed in Appendix B.

466. The INBA approach discussed in Section 4.5.12 also seems promising, particularly in combination with the synthetic hub regime. In essence, it would allow participants to buy/sell simple intra-regional and inter-regional hedging instruments, without imposing any artificial restrictions on that trade.

467. Either regime, or some hybrid, seems capable of improving the status quo in some situations, but all are potentially complex, and probably only worth introducing in situations where congestion is a significant issue. Thus the original CRA proposal, of limited application of CSP/CSC to deal with a few specific situations, still seems worth considering.

7 Contracting for Ancillary Services

7.1 Introduction

468. This focus in this section is on what we refer to as "active" congestion management; that is activity designed primarily to increase the effective physical capacity of the network, as opposed to "passive" congestion management, focussed on providing hedging instruments to allow participants to manage their exposure to risk arising from whatever limitations may exist. In other words, it is about arranging for what we refer to as physical constraint "support".[190]

469. A binding constraint can be relieved in two ways: a) by adjusting the left hand side (LHS) variables in a constraint so that the limit no longer binds; or b) by increasing the limit on the right hand side (RHS) of the constraint. Both ways of relieving the constraint have equal marginal economic value, when measured by the reduction in the total cost of dispatch. This suggests that the financial exposure of RHS variables to congestion prices offers a range of additional options for managing congestion.

470. The LHS variables that are controlled by the NEM dispatch engine (NEMDE) in balancing energy demand and supply across the network include generation, interconnector flows, and dispatchable loads. The RHS limit comprises variables that NEMDE does not control, but instead takes as given parameter values: Non-dispatchable loads, ancillary services that support secure network flows, and the underlying physical capacity of the network. Ancillary services can increase the transfer capacity of the underlying physical network by enabling the full capacity of a network element to be used in a manner that maintains power system security in the event of an outage somewhere on the network.

471. This section deals with "ancillary services" as they may be broadly defined to cover any such service which might relieve congestion by supporting network capacity. The focus is on Network Support and Control Services (NSCS), which are: a) procured under tender by NEMMCO as NSCS; b) procured by TNSPs as Network Support Services; or c) provided by TNSPs through their network infrastructure and connection agreements. We will ignore FCAS, which is already traded in the spot market via an arrangement which may be seen to be analogous to the "priced" mechanisms discussed here[191]; and any possible interaction between FCAS and ancillary service provision required to support network capacity.

472. The issue of ancillary services contracting for network support can not be considered entirely separate from that of TNSP incentivisation, since TNSPs are likely agents to be involved in contracting for "network support" of various kinds. Thus any regime which exposed ancillary service terms to CP could also expose

[190] Although both aspects are complementary, and physical support also increases the Protected RHS, and provides financial support to an increased hedging capacity.

[191] Specifically, it is bought at a market FCAS price which is actually determined by the CP on the constraints in which it is involved. In other words FCAS is already exposed to the CP on those constraints. In principle, the arrangement could be extended to include contracting for FCAS, using CRCs, but this has not been done in the NEM.

TNSPs contracting for ancillary service provision. But the distinction between TNSP and NEMMCO procurement is conceptually irrelevant, at this level of abstraction, and will be ignored, here. The incentivisation of TNSPs to enhance network capacity in general, will be considered in Chapter 8.

473. Our specific concern here is with the provision of services other than "line capacity" that impact on the RHS, and may thus be seen as contributing to network support, or congestion management. And we are still assuming that the impact of these ancillary services can be represented by a distinct additive term on the RHS of a constraint equation.

474. As in earlier chapters, for simplicity, discussion in this chapter will refer to ancillary service providers, generically, as being exposed to CP, and involved in the various mechanisms discussed. But it should be stressed that the intention is NOT to imply that all ancillary service providers must necessarily be involved in whatever regime(s) might ultimately be allowed for in the market design, or that these arrangements would necessarily apply with respect to all constraints in which any particular ancillary service provider was involved. The intention is merely to describe the characteristics of mechanisms which could be employed selectively to deal with situations in which they are deemed to be appropriate, for whatever period seems appropriate.

475. But we should first ask which parties might be classified as ancillary service providers. Leaving aside the more obvious contenders, the situation of both load and generation is a little ambiguous in this regard.

7.2 Load as an Ancillary Service Provider?

476. The load term often plays a very significant role in determining the RHS of a constraint. Loads would appear as variables on the LHS of constraint equations in what might be considered their natural form.[192] But NEMDE shifts all non-dispatchable load to the RHS of its constraint equations, which means that any variation in load levels should really be reflected directly as a variation in the RHS quantity. And these load terms, in aggregate, of similar scale to the generation terms, and of roughly similar scale to the transmission line capacity terms, which define the basic RHS quantity. Normally they will vary much more, from interval to interval, than the line capacity and should, theoretically, be responsible for most of the "capacity uncertainty" discussed in earlier sections.

477. The full extent of this variation is not apparent in the NEMDE constraint set, though, because constraints are typically only specified for peak load conditions. This is quite sufficient, if constraints will only bind at such times. But variation in load levels, and patterns, is still significant across the range of intervals in which constraints may bind. Thus it is a significant factor affecting both the firmness of what appears in NEMDE to be physical network capacity and the volume of financial hedging available to other parties. Consequently, NEMMCO, or a TNSP, might well want to contract with a load to reduce the variation in network transfer

[192] They appear this way in many nodal market formulations.

capability caused by localised load fluctuations, and this could be classified as a "network support" arrangement. But should a TNSP contract with a load be considered an ancillary service, or merely a load contract (i.e. Demand Side Management (DSM))? Controlled reductions in load can be classed into two groups:

- Load limitation which is dispatchable, or arranged in advance and assumed in setting load levels for dispatch purposes (i.e. DSM) will be discussed in Chapter 9, where options for exposing loads to congestion prices are covered.; but

- Load reduction which is merely armed, to be triggered under some contingency condition can be regarded as an ancillary service as discussed in this chapter.

7.3 Generation as an Ancillary Service Provider?

478. Generation can affect congestion and also provide network support in three ways:

- by changing the net injections of energy at specific locations on the network;

- by creating or absorbing reactive power at specific locations on the network; or

- by providing inertia through being on-line.[193]

479. In effect, generation provides multiple products, each of which creates value in the dispatch process. Arguably, each of these three products can and should be priced and paid for in a manner consistent with the value it creates. A congestion management regime that does not recognise the multi-product nature of generation (and dispatchable load) is likely to overlook options for managing or relieving congestion that incentivise parties to provide network support and control services.

480. In this context, reactive support and unit inertia might impact on the calculation of the RHS, typically reflecting a form of network support function. And, if, there are effects which are proportional to generation, LHS constraint coefficients may be affected, too. Accordingly, CRA(2004) defined what it referred to as the "Network Energy Only" (NEO) effect of generation, just measuring the impact of its net energy injection, which is effectively a negative load, at a network location.

481. Two key points about the NEO effects of generation have important implications for any congestion pricing option, but particular importance for options that expose NSCS to congestion prices:

- First, (pseudo-) nodal prices should in principle be equally applicable to generation and load at the same point, and thus should only reflect NEO effects.

[193] Inertia assists in maintaining the stability of the power system and hence the secure operating bounds of the power system.

- Second, if any non-NEO effects were accounted for in determining constraint coefficients, they should really be separated out for the purposes of congestion price/rent calculations. [194]

482. The implication, is that when we talk about generation being exposed in a constraint, we should really distinguish between NEO and non-NEO effects. The impact of NEO effects should be reflected in any pricing regime relating to energy, whether generated or consumed, as discussed in Chapter 6. This would produce prices analogous to those in a nodal market. All of our discussions about the equivalence between nodal prices` and PNPs, and between CRCs and FTRs make that assumption.

483. But if non-NEO effects are deemed to relate to a form of implicit network support ancillary service, they could be accounted for separately. An extra set of generation terms, weighted to represent the non-NEO impact of any generation, whether constant or variable, should appear among the ancillary service terms, either on the Exposed LHS, or on the Protectec RHS of the constraint. The weight on the regular generation terms would be reduced to reflect only the NEO component of their impact. Any constant non-NEO effects, arising as a result of simply being on-line, for example, would also appear on the Protected RHS.

484. It may be said that none of this is necessary, and that if weights in any of the current NEMDE equations do include non-NEO impacts this will do no harm, because it only means that both components will be equally rewarded for their contribution. This is probably a reasonable position to take. Mathematically this re-arrangement would have no impact on the NEMDE solution, and the significance of this whole topic is unclear.[195] The distinction was introduced partly so that our discussion aligns properly with the theory of nodal pricing. Most discussions of nodal markets ignore such effects, which may be represented by adding additional security constraints, which will then have their own CPs, distinct from nodal prices.

485. But we should caution that, if such effects are implicit in NEMDE constraint coefficients, they will impact on all CPs, and affect both CBR and CSP/CSC proposals. Specifically:

- What may appear to be "nodal" prices will not really be quite what they seem, so that two generators connected at the same node could have different PNPs for reasons unrelated to their position in the network; and perhaps more

[194] Here we assume that non-NEO effects only relate to generation. If there are any such effects relating to load, or interconnector flows, the same principles would apply.

[195] Without knowing exactly how they were derived, it is not really possible to say whether the LHS coefficients applied to generation MW also reflect non-NEO effects. But some pre-NEMDE constraint forms included a considerable number of terms reflecting the benefits of having units "on-line", due to additional inertia or reactive support capability. While those terms were individually small, they were believed to have a measurable impact, in aggregate on RHS limit levels. Many such non-NEO effects have presumably been accounted for in determining the RHS value of NEMDE constraints, and may now be regarded as forming an inherent part of "line capacity". So far as we are aware, though, NEMMCO does not consciously and consistently distinguish between NEO and non-NEO effects in determining constraint coefficients, and there is no way of representing such a distinction in NEMDE. But the distinction could still be made, and applied, in the settlement system, which is what we are concerned with here.

importantly, generation and load at the same node would face different implied prices.

- What may appear to be "Inter-nodal price differentials" will not really be quite what they seem, either, and nor are the hedging products related to them. If the PNP prices faced by two generators differ partly because of differences in unit inertia, for example, then trading hedges related to those two prices somehow involves trading unit inertia, along with locational price differences. We have not attempted to investigate the theory of a market operating on this basis, but expect it would be different from the standard theory of nodal markets. This must impact on assessment of revenue adequacy etc. Thus we do suggest that, if NEMDE constraint coefficients implicitly include non-NEO effects, it would be best to give the matter some consideration, rather than, perhaps, create such a market inadvertently.

7.4 Financial Incentivisation of NSCS via CP Pricing

7.4.1 Introduction

486. Ultimately any consideration of incentivising provision of ancillary services for network support would have to consider:

- The implications of imposing mandatory standards on generators, to provide reactive support capabilities, for example;
- The nature and performance of traditional mechanisms for contracting with network support ancillary service providers; and
- The incentivisation of NEMMCO, and TNSPs to arrange for such services, under their respective regulatory regimes.

487. We will not attempt to address such a large and complex topic, and we will ignore the institutional issue of who might be responsible for contracting with ancillary service providers, or how they might be incentivised to do so[196]. We focus on explaining the basic concepts involved in exposing NSCS to CP and assigning CRRs to ancillary service providers, first under a CBR style arrangement, and then under a CSP/CSC style arrangement.

488. Under the status quo, ancillary service terms are not exposed to CP. Thus the market implicitly accepts whatever ancillary service contributions turn out to be available, and effectively grants ancillary service suppliers (negative valued) CRRs offsetting any payments which might otherwise be deemed to be due to them for the market value they add. If compensation is thought appropriate, it is provided through explicit ad hoc arrangements, which are negotiated between ancillary service providers and purchasers.

[196] But see discussion of TNSP incentivisation in the next chapter.

489. We suggest that adopting a CP-based mechanism, at least as a key component of such contracting, has the advantage that it directly measures, and rewards, the market value delivered by ancillary service contributions. Adopting a CP-based philosophy across the NEM would provide a consistent basis for negotiation and implementation of network support contracts, and for comparing the value of such contracts with other options, such as building more network capacity, or simply suffering some degree of congestion.

7.4.2 A CBR Style Approach

490. CBR has not been proposed as a mechanism for incentivising ancillary service provision, but the concept could be applied. In principle, all that would be required is for ancillary service providers to be:

- Exposed to CP prices; and
- Allowed to buy and/or sell CRRS in auctions.

491. If ancillary services were exposed to CP, without contracts, they would receive the rents corresponding to any ancillary services terms. In principle, if the ancillary services market were competitive, this should motivate them to provide ancillary services, thus increasing effective transfer capability. It would then be the ancillary service providers' prerogative to issue CRRs corresponding to the additional transfer capacity they provide, and create a market in such instruments, if there was sufficient demand to make this a profitable activity.

492. These CRRs would be basically the same as those discussed in relation to the CSP/CSC proposal below, or those issued on the basis of any other form of "network capacity". Implicitly, they provide a mechanism whereby a party that fails to provide contracted capacity, in this case an ancillary service provider, compensates participants who purchase hedges corresponding to that capacity for the loss in value to them, as measured by market prices.

493. It does not seem impossible to operate a decentralised market in such instruments, but CBR was not designed for this application, and does not seem well suited for it, at least in its pure form:

- The form of CRRs under CBR, as presented, means that ancillary service providers offering CRRs would be offering to make proportional contributions to enhancing the RHS of particular constraints or, if not, to compensate those they have issued CRRs to. But their contributions are not proportional, and may not be constraint specific.
- Concerns may be raised about the wisdom of relying on such a market process in situations where a single ancillary service provider may have a virtual monopoly with respect to dealing with a particular congestion situation.
- Nor is it obvious that this decentralised market approach would be regarded as an acceptable way of securing ancillary service provision, in practice.

494. With respect to the last point, there are two important differences between energy and ancillary services that are germane when considering how to create a market for ancillary services in a congestion management regime:

- First, unlike energy, ancillary services may not make any measurable contribution to the market unless they are accounted for by NEMMCO in setting the RHS of some network constraints.
- Second, NEMMCO can not simply rely on the hope that ancillary services will be provided in response to price signals. It can only adjust network capacity in NEMDE if it receives strong assurances that the ancillary service is actually armed, operational, and reliable.

495. Consequently, the process of ancillary service provision and compensation seems inherently, and inevitably, centralised. This probably precludes a pure CBR approach being applied to ancillary services, and no proposals have been made to do so. If it were to be done, a linkage would need to be provided between such commercial activity, the actual physical arming of ancillary service arrangements, and their recognition in NEMDE.

496. Even if a purely decentralised approach to purchasing ancillary services seems infeasible, though, consideration may still be given to a hybrid approach which uses the CSP/CSC style approach for contracting with ancillary service providers, but then auctions off the resultant enhanced CR pools to market participants, as in the CBR proposal.[197] Elements of a CBR-style approach could also appear in situations where several potential NSCS suppliers can compete in a tender to provide such services.

7.4.3 A CSP/CSC Style Mechanism

497. CRA's CSP/CSC proposal was simply that, even though ancillary service terms are implicit in the RHS of a constraint, they could be made explicit, and exposed to CP, just as for any other term. In the terminology introduced here, this means that the ancillary service terms that affect network transfer limits would be transferred from the Protected RHS to the Exposed LHS. But CRA also proposed that CSCs should be used to contract with ancillary service providers

498. The mechanism involved in such contracts would be essentially simple:

- First, agree on the circumstances under which the ancillary service is to be provided, the volume to be provided under those circumstances[198], and the amount the ancillary service provider is to be paid for entering into this contract.[199]

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[197] See discussion in Section 4.5.11

[198] Which may differ according to circumstance.

[199] This price for the contract is obviously critical, but it is technically a separate issue from the CP prices to be paid under the contract. The CP price is only applied to deviations from PRR. The payment made for

- Second express that agreement in terms of PRRs defining the desired provider performance when each of the constraints to be managed binds.[200]

- Third, expose the ancillary service provider to CP on the managed constraints.

- Finally perform settlements using the formula:

$$Nett\ payment\,to\ ASP_i = \sum_k CP_k * (\ AS\ Pr\,ovision_i - PRRV_{ik}\ )$$

499. CRA argued that this would have the twin advantages of:

- "firming up" the corresponding CR pool, financially; and

- incentivising ancillary service providers to provide firm physical capacity to meet CSC commitments.

Firming the CRF

500. If all flow, generation, and ancillary services terms are exposed, we are left with $ProtectedRHS_{FGA}$, which contains only terms relating to the "raw" network transfer capacity (i.e. line capacity excluding network support) and load terms. By itself, exposure of ancillary service providers to congestion prices would allow the aggregate hedging pool to be as firm as this new Protected RHS. But note that the total hedging defined by $ProtectedRHS_{FGA}$ is then available to all parties on the Exposed LHS, now including ancillary service providers, and they all must trade to meet their hedging requirements from that pool.

501. Specifically, this means that traders must buy hedging from ancillary service providers in that pool, as in the CBR-style mechanism discussed above. Thus the volume of firm hedging available to traders, is not guaranteed. But firm long term contracts c with ancillary service providers can guarantee that more firm hedging can be provided to energy traders, as discussed in Section 3.4.

502. If both load and "raw" network transfer capacity terms are still included in the Protected RHS, firm hedging can still not be provided with respect to variation in load levels, or network characteristics, including line capacity and configuration. However, firmness would be improved inasmuch as variation in ancillary service contributions may be a significant contributor to what might traditionally have been characterised as variation in line capacity.

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agreeing to the PRR target(s) might logically approximate the expected value of those prices. But, once agreed, it plays no role in the NEMDE optimisation, or in the operation of the CSP/CSC mechanism.

200 Again, this may differ according to circumstance, and there is actually no problem if the "desired" performance levels relating to differing constraints are in conflict when both bind. The implied incentives are then for the ancillary service provider to operate in the range between the two target levels, but biased toward the on e that is more critical (highest CP) at any time. See example on slide 58 of CRA(2004d).

Incentivisation of providers

503. Once contracted, ancillary service providers would have all the usual "second order" incentives to fulfil those contracts.[201] Specifically, ancillary service providers would be required to compensate the CRF pool, and hence indirectly participants who purchased hedges corresponding to the transfer capacity that was not delivered, for the loss in value to them, at market congestion prices.

504. Thus the market power of even a monopoly ancillary service provider would be strongly modified. Rather than having second order incentives to withhold its capacity, it would have second order incentives to keep its physical provision of the service close to the contract level. If ancillary service provision fell below the agreed level, and congestion occurs, CP would rise. But it would be the contracted ancillary service provider which is paying CP into the CRF, to compensate those participants adversely affected by its failure to provide.

505. The same would be true with respect to hedging contracts entered into under a CBR-style regime. Thus the major difference is that the CSC/CSC proposal envisaged some central party being responsible to actually secure contracted capacity, as is the case for physical network capacity, for example, and to deal with issues such as arranging physical delivery and market power up front. The capacity thus contracted would then be treated as a regular part of the RHS capacity available to traders for hedging purposes, under either a CBR or CSP/CSC regime.

506. Indeed this situation is implicitly assumed in any discussion on this topic,[202] which treats the RHS of NEMDE constraints as simply providing "network capacity", without enquiring as to whether that capacity is just physical line capacity, or includes contributions from ancillary service providers under some form of contract.

7.4.4 Treatment of Implicit Ancillary Service Provision

507. As discussed in Section 7.3, if we define "network support ancillary services" to include all non-energy contributions to network capacity, it seems likely that participants are already contributing such ancillary services without necessarily recognising that fact, or receiving any specific compensation for it.[203] So, if ancillary service provision were to be exposed to CP, we must consider the treatment of any such implicit ancillary service contributions.

508. Mathematically, if these contributions are reflected in constraint coefficients on the LHS of NEMDE constraints, then they will be automatically compensated if generation is exposed to CP, and the NEO vs non-NEO distinction ignored, as discussed in Section 7.3. If these contributions are reflected in constants on the RHS

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201 See discussion in Box 2, and note that second order incentives are much stronger with respect to localised congestion than with respect to trade over major interconnectors, or in major regions.

202 Including the CBR proposal document.

203 This discussion implicitly assumes that all such effects make a positive contribution. Logically, if this is not the case, some parties might need to pay compensation to the system, rather than vice versa.

of NEMDE constraints, though, they will not be compensated, unless specific arrangements are made.

509. It is debatable whether such arrangements are desirable, though. At present, these non-NEO contributions are presumably being made as a by-product of generation, and in the context of a complex set of network connection agreements etc, which apparently provide sufficient compensation, and incentivisation, for the current level of provision. Thus if the market value of that implicit service was to be rewarded under some CP-based congestion management regime, it would be reasonable to expect a corresponding change to other arrangements leaving participants, on average, in a similar financial position to the status quo. Returns to individual generators may vary, though, and if compensation incentivises greater ancillary service contributions, we would expect to see the resultant increase in system value reflected in a net increase in generator revenue.

7.4.5 Practicality

510. The regime discussed here could be employed to incentivise ancillary service provision, quite independently of any decisions with respect to exposure of other parties to CP. That is, exposing only network support ancillary services to congestion prices, while protecting all other terms (i.e. load, generators, interconnectors) from CP, would offer a means of increasing physical network capacity, and also the volume and firmness of CR pools (or IRSR pools), relative to the status quo. The cost of contracting for these ancillary services would also have to be accounted for, either by market charges for ancillary services, or by TNSP cost recovery arrangements. But the only direct impact it would have on other parties is via the market settlements system.

511. A critical issue may be whether NEMMCO, or TNSPs, believe they can rely on financial contracting alone to ensure the provision of an agreed level of ancillary service contribution. However, essentially the same issue arises with respect to FCAS provision, and the application of a priced market-clearing approach to compensation does not preclude the establishment and verification of physical arrangements fore ancillary service delivery.

512. What it does provide is a mechanism by which those participants impacted by non-performance, that is participants who purchased hedges corresponding to the transfer capacity that was not delivered, are compensated for the loss in value to them. If further penalties are believed to be necessary for physical non-performance, they could still be negotiated as part of a physical ancillary service contract.

513. When there is only one potential party that can provide NSCS, rather than setting up a CP based regime along the lines of CSP/CSC or CBR, it may be more cost effective to use the CP information as an input into the process of negotiating compensation for an ad hoc physical arrangement. This offers a practical means for NEMMCO, TNSPs and potential NSCS providers to come to an agreement on an appropriate payment for a network support ancillary service.

514. But there is also no reason why such a contract could not be cast in the form of a CSP/CSC arrangement, even if only one participant is involved. Since NEMDE

already calculates CP, the overheads do not seem any greater than for any other form of contracting, even if no other parties are exposed to CP. Where are many parties involved in the constraint, and those other parties are being exposed to CP, it seems logical to also expose network control ancillary service terms

7.5 Summary

515. Overall we conclude that CSP/CSC style arrangements could be applied to contract for NSCS provision, whether or not this approach is also applied to generators or interconnectors. This provides an alternative to current contractual mechanisms for active congestion management. It would have the advantage of aligning incentives with market values, and firming the hedging available from the CRF pools involved, including the IRSR pool under the status quo.

516. Like the re-computation of inter-regional hedging pools derived from the IRSR to account for interconnector interactions discussed in Section 5.4, this approach to NSCS contracting involves minimal disruption to the status quo. Thus it could be considered as a stand-alone proposal, or in conjunction with re-computation of inter-regional hedging pools, without implying any direct impact on the generality of market participants. It would also be compatible with adoption of a CBR style approach to the creating a market for hedging instruments based on the CR pools, "firmed up" by NSCS contracting in this form.

8 Incentivising TNSPs

8.1 Introduction

517. This focus in this section is again on what we refer to as ″active″ congestion management, designed primarily to increase the effective capacity of the network. Specifically, it is about incentivisation of TNSPs to enhance physical network capacity.

518. The issue of TNSP incentivisation can not be considered entirely separate from that of ancillary service contracting, since TNSPs are likely agents to be involved in contracting for "network support" of various kinds. Therefore any regime which exposed ancillary service terms to CP could also expose TNSPs contracting for ancillary service provision.

519. But ancillary service contracting has been discussed in the previous chapter, and our specific concern here is with the provision of "line capacity", which will typically be the basic term defining the constraint RHS, before adjustment for load, or ancillary services. As above, we will assume that the RHS can be expressed as a sum of these three components, but note that extension would probably be possible to deal with nonlinear RHS relationships.[204] The basic thrust of this chapter is to explore the implications of exposing the TNSPs responsible for this line capacity term to CP.

520. Under the status quo, TNSPs are incentivised to provide physical capacity by a wide variety of contractual and regulatory mechanisms. Consideration of such incentivisation is a large and complex topic, lying outside the present focus. But, if TNSPs were to be exposed to CP in any way, care would obviously be required to ensure that, for example:

- a TNSP is not doubly penalised (or rewarded) via regulatory regime and via exposure to pool;
- a TNSP does not have incentives to increase the level of congestion on the network to maximise the payments it gets form relieving that congestion;
- a TNSP does not have incentives to build new transmission capacity when purchase of NSCS would have been a more economically efficient option;
- a TNSP does have incentives to pursue NSCS contracts that create market benefits, but which are not required to meet reliability requirements alone.

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[204] Generalisation would be possible, providing the RHS is a convex function of these three components, but not all results will follow. In particular, statements made here about topics such as revenue neutrality and allocation rest on the assumption of additivity. A convex non-linear relationship would most likely produce a constraint rent component not directly attributable to any one component.

521. Arguably, these are all key issues to be considered under the heading of "congestion management", but may be more comprehensively considered in the context of the TNSP regulatory regime. Our focus will be solely on CP-based mechanisms.

522. Once more, the discussions in this chapter refer to TNSPs, in general, as being exposed to CP, and involved in the various mechanisms discussed. But it should be stressed that the intention is NOT to imply that all TNSPs must necessarily be involved in whatever regime(s) might ultimately be allowed for in the market design, and certainly not that these arrangements would necessarily apply with respect to all constraints in which any particular TNSP was involved. The intention is merely to describe the characteristics of mechanisms which could be employed selectively to deal with situations in which they are deemed to be appropriate, for whatever period seems appropriate.

8.2 Financial Incentivisation via Pricing

523. TNSPs, and specifically line capacity terms, are not exposed to CP, under the status quo. Thus the market implicitly accepts whatever line capacity turns out to be available, and effectively grants TNSPs CRRs offsetting any obligations they might otherwise be deemed to have had with respect to variations in line capacity. More exactly, since line capacity actually makes a positive contribution to the market, TNSPs are implicitly assigned negatively valued CRRs offsetting any payments which might otherwise be deemed to be due to them for the market value they add.

524. This reflects the fact that such payments are obviously inappropriate in a situation where the line capacity has already been paid for by other mechanisms under the regulatory regime. The critical issue, from a market participant's perspective, is that the TNSP faces no reduction in payments, and offers no compensation to participants, when line capacity falls below the expected level, which has already been paid for by these other mechanisms.

525. The CBR proposal does not discuss the issue of TNSP incentivisation, or propose their involvement in the CBR regime. But CRA have suggested that TNSPs could be exposed to CP, and also be assigned CSCs, and that this would have the twin advantages of:

- "firming up" the corresponding CR pool, financially; and
- incentivising TNSPs to provide firm physical capacity to meet CSC commitments.

526. First, if TNSPs were simply exposed to CP, without CRCs, they would actually receive the rents corresponding to the line capacity term[205]. In principle, if the transmission market were competitive, this should motivate TNSPs to supply line capacity. And it would then be the TNSPs prerogative to issue CRRs, and create a market in such instruments, if there was sufficient demand to make this a profitable activity.

[205] Mathematically, this is because the line capacity term would have a negative coefficient, when shifted to the Exposed LHS of the constraint equation.

527. Given the virtual monopoly status of TNSPs, this approach has not been thought acceptable, anywhere in the world, and is not likely to be an acceptable option for the NEM, either. This probably precludes a pure CBR approach being applied to TNSPs, and no proposals have been made to do so. But consideration may be given to a hybrid, using the CSP/CSC style approach outlined below for contracting with TNSPs, but then auctioning CR pools to market participants, as in the CBR proposal.[206]

528. In nodal markets, though, there has been extensive discussion of the merits of exposing TNSPs to (inter-nodal) price signals, with respect to deviation from agreed levels of capacity provision, as expressed by FTRs. In the NEM, the same basic concept would be expressed in terms of exposing TNSPs to CP signals, with CRC's in place. This could be part of the Service Target Incentive Scheme (STIS) for TNSPs, which is part of the transmission regulatory regime and is administered by the AER.

529. The net effect of exposing a TNSP to CP would be that the TNSP could profit from the market value added by providing capacity in excess of what had been contractually agreed. Conversely, the TNSP would effectively compensate the CRF, and hence CRR holders, for any reduction in market value as a result of capacity being less than what had been contractually agreed.

530. Importantly, though, this compensation would not just become another item in the regulatory accounts. Instead it would be paid out to those participants directly affected, that is to those holding CRR hedges corresponding to the agreed capacity. In other words, this arrangement would "firm up" the RHS, and the corresponding CRF, as claimed by CRA.

531. In the terminology introduced here, hedging is as firm as the Protected RHS. If the TNSP capacity term is shifted onto the Exposed LHS, variation in TNSP capacity will not appear on the Protected RHS. If, for example, all flow, generation, TNSP, and ancillary services terms are exposed, we are left with $ProtectedRHS_{FGAT}$, which contains only load terms. So the hedging pools associated with this constraint would then be firm with respect to all uncertainty, except for load variation. [207]

532. More exactly, if the same CRC is used in NEMDE constraints of the same form, but differing RHS, firm hedging would be provided with respect to capacity uncertainty due to variations in line capacity. Firm hedging would also be provided with respect to configuration uncertainty, if the same CRC is used for different constraint forms representing the same capacity limit.

533. On the other hand, this works both ways. Thus it would be TNSPs, rather than market participants, which gained the advantage from any upside potential with

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[206] Theoretically, consideration might also be given to allowing TNSPs to act as sellers in CRF auctions, but it is not clear what institutional structure would support this, or how it could be reconciled with the TNSP regulatory regime. And it would only seem appropriate for "incremental capacity" defined relative to some agreed base line, as discussed below.

[207] As noted in Section 3.4, the CRC quantity effectively adds a constant onto the hedging available to traders from the Protected RHS, with the CP mechanism working to ensure that the contracted party effectively supports the firmness of that capacity.

respect to line capacity.[208] The hedging available to participants would be firmer, but often at a lower level than under the status quo. Other things being equal, it would only be greater, on average, to the extent that TNSPs were motivated by CP-exposure to provide more capacity, on average, and found it profitable to sell hedging matching that extra capacity.

534. While similar regimes have been proposed elsewhere, in the context of nodal markets, they have often been rejected on the basis that TNSPs can not, will not, or possibly should not, accept the risks involved. It is important to note that this particular proposal involves a TNSP only taking responsibility for a much more specific, limited, and manageable risk than may be the case with respect to FTRs in a nodal market, for example.

535. Specifically, the TNSP would not be responsible for managing the risk arising from price differences between two points in the network, irrespective of cause, as it would be in guaranteeing an FTR. Nor would it be responsible for managing risk due to load variation or ancillary service provision, including the (possibly notional) ancillary services provided by non-NEO participant terms, which cause variations in the constraint RHS, as traditionally defined.

536. TNSPs would only be responsible for managing risk due to variation in the specific line capacity term in the RHS. Moreover, since CRCs are in principle specific to each constraint form, they can be customised to each network configuration. So the TNSP's responsibilities could be quite specifically tailored to match a reasonable expectation of what will be available, under different maintenance outage conditions, for example[209]. This is no different to the TNSPs having "state contingent" network support contracts, under the existing NEM arrangements, that is only called upon by the TNSP when an agreed set of circumstances arises (e.g. a network outage or pattern of generation and load that congests specific parts of the network).

537. While such a risk assignment may not be welcomed by TNSPs, it is difficult to argue that any other party is better placed to manage it, or could do so more appropriately. And contracted service levels can always be set so as to provide a net up-side, for TNSPs on average. The intent is to incentivise better network provision, thus enhancing value to the market. So there is no reason why TNSPS should not enjoy some share of any value thus created.

538. Still, if full TNSP exposure to such risks is deemed to be inappropriate, the intended goals of this proposal can still be at least partially achieved by introducing the concept of partial TNSP exposure to CP. This would not involve reducing the CRC, since that is intended to match some desired level of line capacity. Instead the TNSP's exposure to risk due to variation in actual line capacity would be reduced by moderating the payments required to/from the TNSP.

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[208] This also means that TNSPs, as monopoly suppliers of extra capacity, will not be perfectly motivated to supply as much as might theoretically be optimal, in a perfectly competitive environment. But, if nothing else changed in the regulatory environment, their commercial motivation to do so would still be much stronger than under the status quo.

[209] With obvious implications for the firmness of hedging available

539. If we let TEF_k be the TNSP's "exposure factor" for constraint k, and CAP_k be the actual capacity delivered, then assuming that the coefficient for line capacity in the RHS will be unity, the net payment from the TNSP into CRF_k would be:

$$TNSPpayment_k = TEF_k * CP_k * (CRC_k - CAP_k)$$

540. This allows any desired degree of incentivisation to be provided for the TNSP and ensures that incentivisation for provision of capacity to relieve any particular constraint, in any particular interval, is proportional to the impact which constraint capacity has on the market in that trading interval. If *TEF* is constant across all constraints, it also ensures that the TNSP is incentivised to provide capacity to relieve constraints in proportion to the impact which each has on the market. Thus *TEF* seem like a very reasonable parameter to be set as part of any TNSP regulatory regime.

541. Note that this regime could be employed for TNSP incentivisation, quite independently of any decisions with respect to exposure of other parties to CP. The only direct impact it would have on other parties is via the market settlements system, where the firmness of CR (or IRSR) pools would be enhanced, to a greater or lesser extent, depending on *TEF*.

8.3 Summary

542. Overall we conclude that CSP/CSC style arrangements could be applied to contract with TNSPs for provision of raw "line capacity".[210] More generally, the concept of partial exposure can be used to incentivise TNSP performance with respect to capacity provision.

543. This provides an alternative to current regulatory mechanisms, and would have the advantage of aligning incentives with market values, and firming the hedging available from the CRF pools involved, including the IRSR pool under the status quo. It could be considered as a stand-alone proposal, because it involves minimal disruption to the status quo market arrangements, and remains valid, whether or not a similar approach is also applied to generators or interconnectors.

[210] Or indirectly for NSCS, as discussed in the previous chapter.

9 Treatment of Loads

9.1 Introduction

544. In principle, all of the discussion in previous sections applies just as much to loads as it does to any other parties or terms. In principle, load may be treated symmetrically with generation, and it is treated that way in most nodal markets, for example.

545. In NEMDE, dispatchable load is treated symmetrically with generation, both being modelled using dispatch variables on the LHS of constraint equations. But almost all load is considered to be non-dispatchable, and modelled as constant, helping to determine the RHS. In the framework developed here, though, the traditional distinction between LHS and RHS terms is not really relevant. The question is whether the term is exposed to CP, and thus appears on the Exposed LHS, or protected, forming part of the Protected RHS, for a particular constraint.

546. In this framework, it may be seen that the NEM actually does treat load symmetrically with generation, at present. Although these terms appear on opposite sides of the NEMDE constraints, both are always protected, thus appearing on the Protected RHS of all constraint equations, in our representation. In other words the implicit allocation of dispatch-matching CRRs to loads exactly matches their theoretical exposure to CP in each constraint, so that both load and generation face the same Regional Reference Price.[211]

547. This means that load can also effectively capture CRRs granting access to the Regional Reference Node by "manipulating its dispatch position". As a non-dispatchable element, this behaviour is neither conscious, nor immediately recognisable. It does occur, though, and does distort the market equilibrium away from the optimal dispatch. But it is passively manifested as a non-response to the CP signals which are calculated by NEMDE, and used to dispatch generation, but have no impact on loads, and hence on load behaviour. That is, the use of RRP to settle loads insulates them from congestion prices, thereby eliminating incentives for load to provide location specific demand side responses that could reduce the economic impacts of congestion. This has non-trivial implications, because load variation is a significant factor affecting the RHS of NEMDE constraint equations.

548. As in previous chapters, we focus on options involving financial incentivisation of congestion management by loads. Once more, the discussion in this chapter is NOT meant to imply that all loads would necessarily be involved in whatever regime(s) might ultimately be allowed for in the market design, or that these arrangements would necessarily apply with respect to all constraints in which any particular load was involved. The intention is merely to describe the characteristics of mechanisms which could be employed selectively to deal with situations in which they are deemed to be appropriate, for whatever period seems appropriate.

[211] Here we are ignoring any adjustments for losses etc.

9.2 Exposing Load to Congestion Pricing

549. In principle, a complete and consistent implementation of either the CBR or CSP/CSC regimes would have all loads contributing to CP pools, just like generation. That is, they would effectively face nodal prices, and would logically have exactly the same hedging requirements as generation, and probably have access to the same hedging options.

550. This is, in fact, how the CBR proposal is presented by Biggar(2006). And, as presented by Biggar(2006), this regime seems intended to apply to all constraints, thus effectively exposing loads to nodal prices. In our terminology, this means that all constraints would be managed, with load being exposed, along with generation and flow, thus leaving only TNSP and ancillary service terms on the Protected RHS, which we may call $ProtectedRHS_{FGL}$.

551. As discussed previously, this means that CBR can deliver revenue neutral hedging which is as firm as $ProtectedRHS_{FGL}$. Configuration uncertainty is still as much an issue as ever, but capacity uncertainty would be very much reduced, since this version of the Protected RHS no longer has to reflect the impact of fluctuating load levels. On the other hand, loads would have to explicitly purchase access to their Regional Reference Nodes under that regime, rather than being assigned CRRs implicitly, at no cost, as occurs under the existing arrangements.

552. And it should be recognised that not all loads will want to do so, because the implicit nodal price they face under CBR would actually be lower than the Regional Reference Price. In principle, this is not a problem, because they could appear as net sellers of CRRs in the relevant CR pools. In practice, though, it is not clear that institutional arrangements would allow this to happen, or that loads would have sufficient understanding or motivation to see this as a profitable activity. If not, the firmness of hedging available to other parties would be compromised, as discussed in Section 3.4.

553. By way of contrast, although CRA discussed the possibility of exposing load to CP, this option was not considered politically acceptable because it introduces nodal settlement for loads, and therefore was not included in CRA's basic CSP/CSC proposal to the Ministerial Council on Energy (MCE). Thus CRA's CSP/CSC proposal to the MCE can not make the CRF hedging pools as firm as they would be under the full CBR proposal, as described by Biggar(2006), because the CSP/CSC proposal assumed that implicit hedging would have to be provided for all loads.

554. On the other hand, while exposing loads makes the total hedging pool much firmer, it means that loads would be competing with generation in both buying and selling hedging in the overall pool. Thus generators would need to buy hedging off loads in constrained-off regions, while loads would need to buy hedging off generation in constrained-on regions. Accordingly, the availability of firm hedging for "traders", as traditionally defined, is not necessarily greater.

555. This distinction is not actually fundamental to the respective CSP/CSC and CBR methodologies, though. There is no reason why CBR could not be applied with loads protected. It is just that the aggregate CR pools would be less firm, as was assumed in previous chapters. And there is no reason why loads could not be

exposed to CP, with CSCs allocated in some way so as to reserve access for, say, historic volumes, to their current Regional Reference Nodes, under the CSP/CSC regime.

556. Exposing the generality of loads to CP would be a major change to the market design, and may not seem attractive on a wholesale basis. But the concept is useful, and probably should not be precluded, because it may be applicable under some circumstances, including:

- Situations involving boundary changes, in which case load will lose its traditional access to a Regional Reference Node, making it potentially desirable to formalise the implicit intra-regional CRRs which gave it that access, and translate that into a new combination of explicit intra-regional and/or inter-regional CRRs, preserving that effective access under the new arrangement, perhaps for some part of the load over some limited period.

- Situations in which it may be necessary to ration network access between loads, which may thus be seen to provide a form of network support service.[212]

557. The first case was addressed by CRA (2004) and is discussed in Appendix B. The second case comes close to viewing "load reduction" as an ancillary service. But a distinction may be drawn between load reduction which is dispatchable, or arranged in advance and assumed in setting load levels for dispatch purposes, and load reduction as an ancillary service which is merely armed, to be triggered only under some contingency condition.

558. The latter situation is covered by the discussion on ancillary service contracting in the previous chapter. But there also seems no reason why loads should not be involved in contracting for some degree of "demand-side management", to be used as a congestion management mechanism. Since such demand-side management would contribute the same value, per unit, as any other congestion management measure, it would seem appropriate to pay for it at the same rate, ie CP.

559. This implies exposing "load reduction" to CP. But this is not quite the same thing as exposing "load" to CP. Simply exposing load to CP will give appropriate signals for load reduction in such situations, but it will do so by charging a high price to all load, which is not likely to be acceptable.

560. Under the status quo loads receive implicit rights which effectively mean that all load pays the Regional Reference Price. If the right to such access is regarded as a fundamental principle of the market design, loads which give up that right will expect to <u>receive</u> additional payments for <u>load reduction</u>, rather than <u>making</u> additional payments for <u>load</u>. We see no reason to think that load would

[212] This entire discussion relates to situations in which loads are situated in a region where the PNP is higher than their Regional Reference Price. In other words, generation and/or interconnector flows are being constrained on to meet local load requirements at some cost, and these costs could be reduced by reducing load. The reverse situation would be when generation and/or interconnector flows are being constrained off because local load is too low. This case has not been analysed. Analogous mechanisms could doubtless be employed, but the likely need for them, in practice, is not clear.

necessarily find the possibility of receiving such payments undesirable, or would wish to see them precluded as part of the market design.

561. Measuring "load reduction "is always a tricky issue, with the base-line against which it is measured likely to be controversial. In the framework discussed here, the baseline would effectively be a fixed CRC quantity, with load reduction below that level effectively being compensated at a rate of CP per unit, and failure to meet the CRC load reduction target effectively being penalised at a rate of CP per unit. This has the obvious advantage of providing a dynamic price signal to incentivise demand-side management to match the economic cost of congestion in each trading interval.

562. By way of contrast, while the CBR proposal assumes that loads will be exposed to CP, it does not explicitly discuss a mechanism to deal with such situations. In fact it seems to assume that all rights will have positive value, and be freely bought at auction. Section 4.5.5 discusses extending the concept to allow symmetric buy/sell participation in auctions, and the issues which this raises. The same mechanisms could possibly be adapted to a situation in which loads were not, in the first instance, exposed to CP. Thus they could, perhaps, participate in a tender process within which they offered to be exposed to CP, with specified CRR levels. But the mechanics of this option have not been thought through. And nor is it clear that proportional CRRs of the type proposed under CBR, would be acceptable for active congestion management of this type.

9.3 Summary

563. Overall we conclude that, in principle, fully firm hedging simply can not be achieved, for generators` or interconnectors, unless load is fully exposed to CP, along with TNSPs and NSCS providers. This would effectively imply nodal pricing for loads. Although the CBR proposal advanced by Biggar(2006) implicitly assumes that this will be the case, we do not believe this to be an acceptable option for the NEM, at this time.

564. There are situations, though, in which particular loads might be involved in supplying "network support" via negotiated CSP/CSC style arrangements. If these are viewed as being a form of NSCS provision, such arrangements could be considered quite independently of whether a similar regime was being applied to generators or interconnectors.

10 Overall Summary

565. We have tried to break down current proposals into their essential components, identify common elements, and develop a common terminology and framework within which a wide variety of options and approaches may be considered. We have applied that terminology to provide a "base-line" description of the status quo, then gone on to describe the application of those approaches to particular participant groups.

566. While there is a great deal of detail in each chapter, our broad conclusions are summarised by Table 1; which describes the implications of applying each concept to each type of participant, in turn. As noted in the introduction, there may be good reasons why somewhat different approaches might need to be taken to different participant groups or situations, within the same broad mathematical and philosophical framework. In each case, though, a Constraint Rental Fund (CRF) would be created for each constraint involved in a CP-based congestion management regime. The fundamental issues are then:

- Which constraints, if any, should be "managed" in this way?
- Which parties should be "exposed" to CP in those managed constraints?
- Should rights to the rentals in the associated CRFs be assigned:
  - Implicitly (ex post) to match dispatch, as at present;
  - By an "auction" process akin to the SRA, as proposed by Dr Biggar;
  - By an allocation or negotiation process, as proposed by CRA; or perhaps
  - By some hybrid methodology?

567. For simplicity, many discussions in this report have referred to various participant groups, generically, as being exposed to CP, and involved in the various mechanisms discussed. But we have stressed that the intention was NOT to imply that all parties of a particular style must necessarily be involved in whatever regime(s) might ultimately be allowed for in the market design. Nor was it meant to imply that these arrangements would necessarily apply with respect to all constraints in which any particular party was involved. The intention was merely to describe the characteristics of mechanisms which could be employed, selectively, to deal with situations in which they are deemed to be appropriate, for whatever period seems appropriate.

568. We have not attempted to assess the materiality of any of the effects discussed here, or the costs of implementing the various measures proposed to deal with them. Thus this report is not intended to make any overall recommendation with respect to acceptance of the CBR or CSP/CSC proposals, as a total package, or (more likely) of any particular hybrid.

569. CRA's earlier work for the MCE concluded that wholesale implementation of a comprehensive "solution" such as nodal pricing was not justified at that time, and

we see no reason to expect that the situation has changed greatly in the interim. Wholesale application of either the CBR or CSP/CSC regimes would effectively introduce nodal pricing for generators, at least, and would also represent a fairly radical innovation on the world stage[213]. Given the costs and market disruptions involved, we think it unlikely that wholesale application of either regime would be justified at this time.

570. But the CP-based framework developed here does seems appropriate for describing and assessing the impact of a wide variety of options, and we suggest that it may usefully be employed in framing the national debate on these topics, going forward. We also believe that it provides a consistent theoretical and philosophical framework within which mechanisms could be readily developed to deal with a particular congestion management issues and situations, as they arise.

571. Conversely, we see a danger that, without such a framework, mechanisms will be employed, in different parts of the NEM, to deal with particular aspects of congestion management in ways which are mutually inconsistent. Indeed, this may already be the case. Apart from the evident mis-alignment of participant incentives, at times, in parts of the NEM, there is no clear alignment between the various regimes currently applying to issues such as ancillary service provision for network support, or TNSP incentivisation, and the delivery of value to the market.

572. Thus we believe the framework advanced here could assist by at least providing guidance with respect to the directions in which such arrangements might be evolved, so as to move towards consistency over time. Further, we suggest that several possibilities have been identified which may deliver significant benefits in the more immediate future, and may be considered on a stand-alone basis. These include:

(a) Reform of the IRSR/SRA process, to the extent of adopting a CSP/CSC style mechanism to re-process the IRSRs, in the settlements system to form firmer inter-regional hedging (IRH) pools, which would then be auctioned via the current SRA process. This could be implemented without directly impacting on any participant, and using information already generated by NEMDE. It is thus less radical than the Snowy Trial, or any other proposal made in that regard. The only additional element required would be to reach agreement on the apportionment of rents between interconnectors.[214]

(b) Preparation, after appropriate consultation, of a standardised package, including generic market rules, draft contracts, and IT design, so as to be ready to implement CSP/CSC style arrangements, on a limited basis, to deal with particular congestion management situations as they arise[215]. This would

[213] Analogous concepts have been proposed, but not implemented, in the debate over "Flow Gate Rights" in the USA.

[214] This change, alone, seems likely to deal with most, if not all, negative IRSR situations, without requiring any "physical" intervention.

[215] In this regard we note that the ad hoc arrangements used to implement the Snowy Trial were not a "clean" implementation of the CSP/CSC concepts proposed by CRA, and would not serve as an adequate model for future implementations in other situations with different characteristics. (For example, all transactions effectively occurred in relation to the IRSR of one particular interconnector,

probably form a further development of the previous proposal, and in fact would require only a small extension of the IT application required for that proposal.

(c) Consideration of the CSP/CSC approach as a basic paradigm for assessing the value of, and/or contracting for, provision of network support ancillary services. This could improve consistency and probably open up new opportunities for cost effective enhancement of effective network capacity. It could be considered as a stand-alone proposal, and would align the economics of ancillary service provision with the value delivered to the market, irrespective of whether a CSP/CSC approach was also applied to generators or interconnectors.

(d) Consideration of the potential involvement of TNSPs, perhaps in conjunction with ancillary service providers or local market participants, in CSP/CSC type arrangements with respect to the performance of specific transmission elements and/or as a means of managing congestion arising from localised conditions. This may represent a cost effective short or longer term alternative to transmission capacity investment. This again, may be considered as a stand-alone proposal, delivering market benefits, irrespective of any other development.

(e) Consideration of "partial exposure" to CP as a component of the TNSP regulatory regime. This is another development which could be pursued independently, perhaps in a different context, and would help align TNSP incentives with market economics, thus hopefully firming network capacity at critical times, and improving the commercial firmness of hedging, too.

573. It will be also be evident that, since the CBR and CSP/CSC mechanisms are fundamentally compatible, a great number of more comprehensive hybrid proposals could be formed from the components discussed in this report, with all their variations. As noted, some of these components could actually be considered, and implemented on a stand-alone basis, thus forming "hybrid options", in conjunction with the status quo. For example one possible hybrid proposal could involve:

(a) Using CRCs, where appropriate, to contract with TNSPs, ancillary service providers, and possibly some generators or loads to provide active congestion management services, as originally proposed by CRA(2003b), thus also firming up the relevant constraint rental pools; and/or

(b) Using CRC/CRRs to resolve interconnector priority issues, and "firm up" the relevant IRSR pools, as originally proposed by CRA(2004c); then

(c) Auctioning the resultant Inter-Regional Hedging (IRH) pools, via the current SRA process, as assumed by CRA(2003b, 2004a, 2004c etc)

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rather than involving all parties symmetrically in specific CRFs established for each of the applicable constraint forms.)

(d) Auctioning the remaining constraint rental pools for intra-regional hedging, as proposed by Biggar(2006), or Section 5.3.7 of CRA(2004a), and

(e) Expecting the purchasers of such constraint rental steams to then package them into hedging products more suited to participant requirements which, in our opinion, are likely to take forms similar to FTRs or bundled CSCs, as in the existing SRA process.

574. More radically, there would also seem to be some merit in generalising the current SRA process, perhaps to allow simultaneous buy/sell trading with respect to inter-regional, and possibly intra-regional hedges. This could be achieved by adopting a CBR-style approach in which trading was conducted with respect to the underlying CRFs, rather than with respect to the current IRSRs, or the re-constituted IRH pools proposed by CRA.

575. But there seems to be potential in the idea of developing an "Integrated Network Based Auction" (INBA) similar to those used to trade FTRs in nodal markets elsewhere. This need not be any more complex for auction participants than the CSP/CSC approach, under which they would simply buy/sell inter-regional, and (locationally specific) intra-regional, hedges. But it could be as flexible as CBR, in that all of the complexities of dealing with constituent CRF pools would be dealt with internally, most likely using a variant of the NEMDE market-clearing software.

576. Finally, there may also be merit in re-defining the Regional Reference Price applying to loads to be a "Regional Load Hub' price, and possibly defining a similar "Regional Generation Hub" for generators, as discussed in Appendix B. At least conceptually, this allows the debate about intra-regional access to be simplified by separating the treatment of:

- Locational access for load;
- Locational access for generation; and
- Generic intra-regional or inter-regional hedging.

577. For example, it would seem possible to develop a regime in which:

(a) All load was covered by implicit dispatch matching CRR allocations, thus automatically paying the Regional Reference Price (now Regional Load Hub price), as in the status quo;

(b) All generation was allocated explicit, locationally specific, intra-regional CRCs giving access to the Regional Generation Hub, thus facing the Regional Generation Hub price on the specified CRC quantity, but facing local PNPs as a marginal signal for variations around that quantity;

(c) A competitive market was created for generic intra-regional hedging between the Regional Generation Hub and the Regional Load Hub; and probably

(d) The market for generic intra-regional hedges was integrated with that for inter-regional hedges, perhaps using the INBA approach discussed above.

A Unresolved Issues

A.1 Introduction

A1. This report draws on two distinct streams of work:

- First, a series of papers prepared by CRA for NEMMCO and the MCE, between 2002 and 2005, in which the CSP/CSC approach was developed; and

- Second, a paper prepared by Dr Biggar on the topic of *"Constraint-Based Residues"* (CBR), which was released by the AEMC in March 2007.

A2. In part, Dr Biggar's paper presents a critique of, and offers an alternative to, CRA's CSP/CSC proposal. Given the nature of some of Dr Biggar's statements about CRA's work, and the claims advanced for his own approach, the AEMC sought comment from CRA on those claims, and the supporting analysis.

A3. It would be fair to say that CRA believes that Dr Biggar's CBR proposal has merit and should be given due consideration, and that his basic analysis is mathematically sound. They also note that, although Dr Biggar interprets them differently, consideration of his examples has helped to develop their own understanding of some issues relating to CSC "bundling". But they consider the paper itself to contain a number of statements which are likely to lead to confusion and/or mis-understanding of key aspects of both the CSP/CSC and CBR frameworks.

A4. CRA understands that some confusion may have arisen as its proposals have evolved, and been presented, over several years in a number of reports. But it is concerned that Dr Biggar states that CRA did not consider various aspects of the problem which, it considers have been dealt with in public forums, and in papers and presentations which are publicly available, eg on the MCE website, but which Dr Biggar does not reference. As a result CRA considers that a number of claims made about innovations of the CBR approach are also features of the CSP/CSC framework.

A5. More importantly, CRA considers that the way Dr Biggar has analysed and presented both proposals confuses the similarities and differences between the CBR proposal and the CSP/CSC framework. In their view, he has also used common industry terminology in ways which are very different from the way in which CRA has used the same terminology, and the way in which it believes it is understood, both by the industry and the academic literature. In CRA's view, this confusion has lead Dr Biggar to present his conclusions about both approaches in ways which may be widely mis-understood.

A6. This situation is obviously concerning, since it is not really possible, and certainly unwise, to conduct a national debate in a situation where the relevant experts do not agree on such matters as the meaning of basic terminology, or the "plain English" interpretation of mathematical results which are, of themselves, not readily interpreted by many industry participants. Such a confused debate could easily lead to inappropriate decisions being made on the basis of incorrect understandings of what can be achieved with either approach.

A7. Accordingly, the AEMC commissioned the current paper with a view to promoting clearer debate on the underlying issues, using a new terminology which is not derived from any of the previous papers. The aim of the paper is to develop a common framework for any future discussion, and to allow rational consideration of alternative proposals which may draw on aspects of work done in the past, by various parties.

A8. The AEMC has subsequently decided that the relative immateriality of the underlying congestion problem does not justify further consideration of congestion management mechanisms at this time. So it is simply not necessary, at this time, to resolve all of the issues that may still be in dispute, and no attempt will be made to do so here. It would be unwise, though, not to place on record the fact that some of these matters are still in dispute, and will need to be resolved if, in future, it is determined that congestion is a sufficiently material problem to merit further consideration or development of any of the mechanisms discussed in this report. Otherwise, it may be falsely assumed that certain "facts' are established or accepted by the relevant experts when, in fact, they are not.

A9. In particular, it should be understood that, while Dr Biggar's has made his critique of CRA's work a matter of public record, and CRA has not responded publicly to that critique, CRA's silence should not be interpreted as implying that it accepts Dr Biggar's criticism of its work, or representation of his own work. What follows, then, is a summary of the main areas which CRA considers to be still in dispute, and which it believes would need to be openly addressed if a public debate on these matters were to be considered worthwhile, at some future debate.

A10. According to CRA, the main questions may be summarised under the following headings:

- What is "firm hedging"?
- Is the analysis appropriate?
- How do the proposals differ?

A.2 What is "firm hedging"?

A11. Dr Biggar's definition of "firm" is very different from CRA's understanding, and from what they believe most participants understand by that term and this is the most significant point of concern.

A12. Dr Biggar defines "firm hedging" as the ability of participants to purchase instruments, apparently irrespective of price or volume, the per unit value which will match their actual generation patterns, whatever those patterns may turn out to be. Although he does acknowledge that alternative definitions are possible.

A13. CRA considers that "firm hedging" relates to the ability of participants to purchase reasonably priced instruments, in sufficient volume, to cover the risks associated with forward trading between locations in the NEM ahead of time (and hence before actual generation patterns are known).

A14. CRA is concerned that that this difference in definitions means that Dr Biggar's paper may be widely mis-interpreted. To take an extreme example: Suppose a participant owns a 1,000MW generator and wishes to sell a forward contract for 1,000MW to a load, to which it is connected by a single transmission line. Then, under the CBR proposal, that participant could buy a hedge, in the form of a share of the rents on that line. But if, on the day, the transmission line failed, there would be no rents. So the participant would receive nothing, and would be forced to cover the cost of buying power from other sources to meet its contractual commitment to the load, or of compensating the load. But, as CRA understands it, this would still be classified as "firm hedging", under Dr Biggar's definition.

A15. CRA does not believe this corresponds to how the industry, or the literature, interprets the word "firm". CRA does not claim that the CSP/CSC proposal would deliver "firm hedging" in this case either. This is one area where the CSP/CSC proposal may have been mis-understood.. CRA notes that they only claimed that hedging via CSCs "could be made as firm as the RHS". That is, like CBR, it would only be naturally as firm as the nett constraint capacity, after accounting for network availability, load variations etc. (In the above example, the RHS reduces from 1000MW to zero, and the hedging is not at all firm.)

A16. But CRA also claims that, under their CSP/CSC proposal, hedging could be made firmer by using CSCs to form "network support contracts" with those parties responsible for elements creating capacity risk. That is, in the words of the current paper, that hedging "can be made as firm as the RHS can be made".

A.3 Is the analysis appropriate?

A17. CRA considers that Dr Biggar's mathematical presentation of their proposal does not entirely agree with that in the CRA documents And they note that he does not appear to have taken account of CRA's underlying papers and related presentations on the CSC/CSP proposal which directly address a number of the issues he has raised with respect to the CSC/CSP proposal.

A18. More importantly, CRA considers that, in comparing the proposals, Dr Biggar uses a deterministic framework that does not actually allow meaningful conclusions to be drawn directly about risk, or "hedging firmness", as they understand that term.

A19. In its view, "risk" relates to deviations from ex ante expectations, as determined ex post. Expectations of the future will inevitably be uncertain to some degree and hedging activity should take account of the range of possible outcomes.

A20. Thus it consider that the “availability” of “firm hedging” should be understood as relating to participants being able to purchase, ex ante, reasonably priced fixed MW hedging instruments in sufficient volume to match planned trades in an uncertain world. Since a deterministic analysis uses a single “known” outcome it can not distinguish ex ante from ex post, and thus CRA considers that it can not address this central issue of risk management.

A21. In its view, a stochastic analytical framework is needed to reflect the fact that in the real world hedging must be purchased ex ante to cover the risks associated with a wide variety of alternative constraint forms in many possible alternative future market-clearing models, representing different network states. As CRA read it, Dr Biggar's analysis seems to relate to a situation in which all of the constraints with respect to which hedging is purchased are thought of as applying simultaneously, in the same LP formulation.

A22. CRA considers that, in this respect and several others, the wording of Dr Biggar's paper does not fully or accurately reflect the implications of the underlying mathematics. Thus while CRA does accept the basic validity of the mathematical analysis, it considers that claims are then advanced using language (eg about “firm hedging”) which could easily be interpreted as saying something different from what they believe the analysis actually proves.

A23. Thus, for example, CRA points out that Biggar(2006) makes claims about “firm hedging” being “available” without apparently considering any analysis of either the volume available, or the ex ante price. In their view both volume and (ex ante) price are critical issues in determining “availability” of hedging, and can not be addressed by a deterministic (and hence implicitly ex post) analysis of mathematical price relationships alone. This is not to say that CRA necessarily disagrees with Dr Biggar's conclusions in that regard. But they do consider that those conclusions go beyond what can be supported by the type of analysis presented in this paper.

A24. CRA also considers that the examples analysed by Dr Biggar have been mis-interpreted. In its view, these examples do not prove that CSCs can not be formed corresponding to particular constraint forms, as claimed by Dr Biggar. CRA believes these examples illustrate points already made by CRA with respect to the difficulties inherent in forming “bundled” CSCs where there is uncertainty about network configuration. And it believes that, when properly analysed in a stochastic framework, the CBR proposal suffers from essentially the same limitations.

A25. But CRA also considers that all of this analysis may be taken as implying an unduly negative assessment of the difficulties involved in implementing either the CBR or CSP/CSC regime, because it assumes the regimes need to be “revenue neutral” for each constraint in each trading interval. CRA considers that all that should be required is “revenue adequacy” over the whole system, on average, over many trading intervals, as in FTR markets elsewhere.

A.4 How do the proposals differ?

A26. Dr Biggar's paper does not address a number of practical details which would need to be considered in implementing CBR. This makes it difficult for readers to be completely certain as to what the full CBR "proposal" might look like, in practice. For example, CBRC - the set of constraints to which the CBR regime is to apply, is defined without any discussion of whether this set should be quite small, as in the core CSP/CSC proposal, or perhaps cover all potentially binding constraints. By way of contrast the CRA papers do discuss many of these aspects, but often do not come to firm conclusions.

A27. Despite these differences and concerns CRA considers that the CBR and CSP/CSC proposals are actually very similar, and that the underlying mathematics is essentially the same. In its view the differences are basically differences of emphasis, and relate mainly to the differing motivations behind the proposals. As CRA see it, the CBR proposal is primarily focussed on "hedging", whereas the CSP/CSC proposal was originally intended to facilitate congestion management by incentivising, if not contracting for, "interconnector support". As a result, the CBR proposal does have a different flavour from the CSP/CSC proposal. But CRA noted that it did not make a firm recommendation with respect to any particular variant of the many options it discussed, but only that consideration be given to employing a congestion management mechanism developed from a broad framework of such options.

A28. As CRA understands the CBR proposal, from Dr Biggar's paper, it differs from the original CSP/CSC proposal in that it:

- Involves loads, thus introducing a form of nodal pricing for loads, an option which CRA discussed, but did not see as likely to be acceptable and thus did not recommend;
- Excludes consideration of payments to or from ancillary service providers and options for TNSP involvement;
- Appears to employ what CRA would call CSCs defined as proportional shares, rather than in fixed MW terms;
- Always auctions those CBR pool shares directly for hedging purposes, rather than perhaps forming bundled CSCs more directly aligned with likely hedging requirements; and
- Does not consider the possibility that some CSCs, at least, might be used as a means of contracting for firmer access and/or network support.

A29. These issues are clearly material and, in aggregate, create a proposal which would have different real-world characteristics from the original CSP/CSC proposal. Thus CRA considers that, while arguments can certainly be advanced for either package, and for many variants on either, they are not distinct and mutually exclusive alternatives. They are really only two out of a large number of equally valid, and perhaps equally promising, packages which can be defined by alternative combinations of the design options identified (in its opinion) by previous work.

A.5 Summary

A30. CRA's overall conclusion is that Dr Biggar's paper presents, compares and analyses the CSP/CSC and CBR proposals in ways which are likely to lead to misunderstandings. This is partly because his deterministic mathematical framework, while arguably more sophisticated than that used by CRA at the time, does not directly address some key issues relating to "risk", or hedge "availability". Hence, in their opinion, it can not support some of the claimed conclusions with respect to "availability of firm hedging", as CRA would understand that term. On the other hand, CRA is of the opinion that some of those conclusions are actually true, even if not proven by this particular analysis.

A31. All of this underlines a fundamental disagreement as to what the concept of "availability of firm hedging" actually means. Once the confusion is stripped away, the fundamental difference, in CRA's view, is a judgement about whether the CBR pools, once formed, should simply be auctioned so as to allow participants to work out their own hedging arrangements, or whether a (bundled) CSC mechanism could add value by creating instruments more directly aligned with market hedging/contracting requirements and/or to be employed to facilitate active "congestion management" by contracting for "constraint support", which was the original intention of CRA's work, particularly some of the initial work for NEMMCO.

A32. These are matters of legitimate debate, and that debate could be conducted by comparing Dr Biggar's proposal with (some variant of) CRA's, or by focussing on particular design choices out of the range of options previously identified. But CRA notes, and the AEMC agrees, that there is also no reason why aspects of the two proposals can not co-exist within a unified hybrid regime.

A33. What is absolutely essential that the debate be conducted using a common terminology, and that clarity be achieved with respect to what can, and can not, be inferred from the mathematical framework employed. Given CRA's comments, Dr Biggar's conclusions in this regard can not be accepted as having been firmly established. And, given Dr Biggar's critique of CRA's analyses, the same must apply in reverse. Thus this is a matter that would need to be re-visited, should it again become relevant to debate over real policy options.

B Variations on the Status Quo

B.1 Introduction

B1. The conceptual framework developed in this report has been used to describe the status quo, and a range of options that would modify the status quo by introducing some form of explicit congestion pricing. But that framework can also be used to describe other variations on the status quo, some of which are more radical, and some less, than those discussed in the body of the report.

B2. First we consider two possible changes to the market structure which are allowed for under the current market rules, but which can be usefully described in this framework, namely:

- Shifting a Regional Reference Node; and
- Shifting a Regional Boundary

B3. These are both important options, in this context, because they represent alternative responses to congestion. That is, rather than introduce an explicit congestion management mechanism, it may be decided to shift a Regional Reference Node, add or remove a region, or shift a regional boundary. Thus it is useful to be able to compare these options with more explicit congestion management mechanisms, using the same terminology and framework.

B4. Also, it will be seen that the framework we have developed here provides powerful tools, not only for understanding the implications of such changes, but also for effecting such changes, and for managing the transition, eg by maintaining traditional access rights for affected participants, if desired. These tools would also allow us to manage a transition from any of the CP-based regimes discussed here into, or through, a boundary change process for example, or a change of Regional Reference Node.

B5. Finally, we consider a more radical concept, namely the re-definition of the Regional Reference Price applying to loads to be a "Regional Load Hub" price, and the possibility of defining a similar "Regional Generation Hub" for generators. The point of such a development would be that, at least conceptually, it allows the debate about intra-regional access to be simplified by allowing each of the following to be treated separately:

- Locational access for load;
- Locational access for generation; and
- Generic intra-regional hedging, and
- Inter-regional hedging.

B6. We suggest that de-coupling these debates, and all of their attendant wealth transfer issues, could greatly simplify the policy debate, going forward. And we show that it could also allow development of a potentially attractive market trading structure.

B.2 Shifting a Regional Reference Node

B7. The choice of Regional Reference Node is obviously important under the status quo, since the Regional Reference Price represents the marginal cost of meeting load at that node. And we have argued that the status quo can be conceptualised in terms of an implicit allocation of CRRs giving participants access to the Regional Reference Node or, equivalently, to the Regional Reference Price. But what if a different Regional Reference Node were chosen?

B8. If a Regional Reference Node were to be shifted, the underlying engineering/ economic reality would not change, and nor would the corresponding price structure. It has been established that, in order to produce a Regional Reference Price corresponding to the marginal cost of meeting load at the Regional Reference Node, all constraints must be "re-oriented" to that node.[216] It might be thought that, since the "re-oriented" constraints are now different, the price structure would also be fundamentally different. But this is not the case.

B9. In fact, since constraint re-orientation does not change the physical reality represented by the constraints, it does not change CP either. What happens is that the constraint coefficients change so as to reflect the relative exposure of each term, by comparison with the Regional Reference Node.

B10. By construction, the Regional Reference Node has zero exposure, because it has a coefficient of zero in all constraints oriented to that node. But the CPs on managed constraints determine the (pseudo-) nodal price structure for all other nodes by defining the impact which each binding constraint has on the difference between the Pseudo-Nodal Price at each node, PNPi for node i, and the Regional Reference Price.[217] That is:

$$PNP_i = RRP - \sum_{AllConstra\,int\,s} weight_{ik} * CP_k$$

216See CRA (2003a).

217Note that we are using *PNP* in a more restrictive sense than CRA, here, having reserved this notation for the special case where all constraints are managed, so that the "Adjusted Nodal Price" *ANP* after accounting for CP on the managed constraint set, is effectively the (pseudo-nodal) nodal price that would be calculated in a nodal market (ignoring the possibility of non-NEO effects). If not all constraints are managed, *ANP* will change. The IDMA assignment of CRRs relative to the new Regional Reference Node will mean that participants will see the impact of any change in Regional Reference Node with respect to constraints in which they are not exposed to CP

B11. These PNPs do not change when the Regional Reference Node is shifted. We will use superscripts to distinguish between the Regional Reference Price, PNP etc applying when the Regional Reference Node is at, say Node 0 vs Node 1. The constraint "re-orientation" is achieved by changing the weights so that :

$$weight_{ik}^{1} = weight_{ik}^{0} - weight_{1k}^{0}$$

B12. And it can then be shown that[218] :

$$PNP_i = RRP^0 - \sum_{AllConstraints} weight_{ik}^{0} * CP_k = RRP^1 - \sum_{AllConstraints} weight_{ik}^{1} * CP_k$$

B13. What really changes when the Regional Reference Node is shifted is that all participants in the region effectively receive a new implicit CRR allocation, giving access to the new Regional Reference Node. Equivalently, they all now face a new Regional Reference Price, representing the marginal cost of supply to that node. If the new Regional Reference Price is higher, the CRRs assigned to loads are obviously less valuable than they were, but the CRRs assigned to generation are more valuable. With no imports or exports, these two changes would exactly offset each other.

B14. More generally, though, a higher Regional Reference Price in a region also raises the value of import CRRs, and lowers the value of export CRRs. The aggregate difference changes the balance in allocation of trans-regional constraint rents between the intra-regional and inter-regional hedging pools, and is evidenced by a change in the relevant IRSR accounts. This effect has already been observed and exploited in shifting the Snowy Regional Reference Node, under some circumstances.

B15. It may also be worth noting that the nett effect of de-allocating a CRR to/from the old Regional Reference Node, and then allocating one to/from the new Regional Reference Node is equivalent to allocating a transmission right (with respect to this particular constraint) from the old Regional Reference Node to the new Regional Reference Node. And the same would apply to any allocated CRR. Thus any transition of this nature can be characterised in such terms, and could actually be implemented that way, too. And the commercial position of any participant could, if desired, be protected for some period after any such change by allocating rights of this nature, thus effectively allowing CRRs to the old Regional Reference Node to remain effective for the agreed period.

B16. In fact the commercial position of a fully exposed generator, with no hedges in place, will stay exactly the same, irrespective of the change, because it will still be facing its PNP. And the value of CRRs, defined in terms of constraint RHS MW will not change either, since CP should not change. What would change, if rights defined with respect to the old Regional Reference Node were to be replaced with rights define with respect to the new Regional Reference Node,

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218 As a special case, , we also have: $RRP^1 = PNP_1^1 = PNP_1^0 = RRP^0 + \sum_{ALLConstraints} weight_{ik}^{0} * CP_k$

would be the weights, and hence the PRRs, defined in terms of participant MW. All that is required to retain access to the old Regional Reference Node, is to continue using PRRs defined using the old weights.[219]

B.3 Shifting a Regional Boundary

B17. If a regional boundary were shifted, any constraints would have to be re-expressed, too. This would not only involve re-orientation to a new Regional Reference Node, but introduction of new interconnector terms implicitly representing an aggregate of generator terms, and probably adjustments to existing interconnector terms, too.

B18. When a boundary change occurs, there is no change in the underlying physical reality. Assuming the same offers, optimal dispatch implies that the PNPs would not change, either.[220] They would just be formed by adding different CP components to different Regional Reference Prices. Under the status quo, a boundary change results in some participants implicitly receiving CRRs giving them financial (i.e. settlement) access to a different Regional Reference Nodes. The nett value is obviously different, but it is accounted for by the fact that the inter-regional price differential also changes. In other words, constraint rents are being re-allocated between these participants and an inter-regional hedging pool.

B19. The possibility of using CRRs to re-allocate congestion rents between market participants and inter-regional hedging pools means that, if desired, any agreed measure of access to the original Regional Reference Node could be maintained. [221] This would require identifying and explicitly allocating the constituent CR streams that were formerly allocated, implicitly, to those participants. The implication is that it would be possible to reduce, or even eliminate, the "shock" arising from changing region boundaries by allocating the affected participants explicit CRRs for various CR streams.[222]

B20. Of course, if 100% access was maintained for all affected participants, both generation and load, for all time, the regional boundary change would have no

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[219] There is a revenue adequacy issue here, though, because shifting the Regional Reference Node also changes the weights that should theoretically be used to calculate the weighted contribution of load terms to the RHS. Thus the RHS will change, and the CRF will, in reality, scale accordingly. CBR-style CRRs would scale proportionally with it. But fixed MW CRCs would not scale, so this will create a mis-match with the new RHS, and possibly a deficit, which must be funded somehow. This may make it commercially unrealistic to guarantee continued access. Simply re-expressing the implications of shifting the RRN in this way will not generate such funding, but it does enable us to see how it could be dome what would be required to fund it, and why; and perhaps why it can not be sustained.

[220] As above *ANP* will change, if not all constraints are managed. Participants will see the impact of any change in Regional Reference Node with respect to constraints in which they are not exposed.

[221] That is, if it can be funded. This may not be possible, for the reasons noted in the previous section. If loads, on average, receive lower prices as a result of the boundary change, it can not be possible for generation to keep on receiving the old prices (nett of any change in inter-regional hedging).

[222] Provided, of course, CRR allocation is allowed for under the congestion management regime.

effect. And it may not be desirable to shield participants from what, to them, may be negative implications of boundary change, indefinitely.[223] But the ability to understand, analyse, and allocate the constituent CR streams which effectively define such access seems particularly important in a context where congestion management schemes may be a prelude to, or substitute for, regional boundary change. This was one motivation for the "CSC" part of CRA's CSP/CSC proposal, developed in the context of a review of regional boundary issues.

B21. It becomes technically possible to translate access rights granted, implicitly or explicitly, under one guise, into equivalent rights, to be effective in the context of a different paradigm, or situation, once the following concepts are all defined and described in terms of CRR assignments:

(a) Being assigned to a region;

(b) Gaining access to a Regional Reference Node;

(c) Inter-regional hedging; and

(d) Being subject to a congestion management regime.

B.4 Using a Synthetic Trading "Hub" as Reference Node [224]

B22. The above analysis remains essentially valid even if the Regional Reference Node is not just shifted, but its definition is altered so as to represent a synthetic "hub price". CRA have previously argued the merits of a load weighted average "hub" price for loads over the current Regional Reference Node approach, mainly because it makes the load sector indifferent, on average, as to what the boundary or CSP/CSC arrangements are[225].

B23. Conceptually, it would actually be possible to "re-orient" constraints to such a synthetic "Regional Load Hub" (RLH), as discussed in CRA (2002).[226] But this is not necessary. As argued above, the PNPs do not depend on the Regional Reference Node employed in NEMDE, and this means that their load weighted average is also independent of the NEMDE Regional Reference Node. Thus the price corresponding to a synthetic RLH can be calculated in the settlements

[223] As noted above, this probably will not be possible, in reality, because it would require load, as well as generation, to be involved in an explicit CRR assignment regime.

[224] Some of the ideas in this section are drawn from Section 4.2 of Appendix D of CRA (2004a), and some are new. The conclusions should be considered tentative.

[225] See CRA (2002).

[226] Practically, though, this only seems workable if the load "weights" are treated as being constant from period to period.

system, ex post, irrespective of the Regional Reference Node assumed by NEMDE.[227]

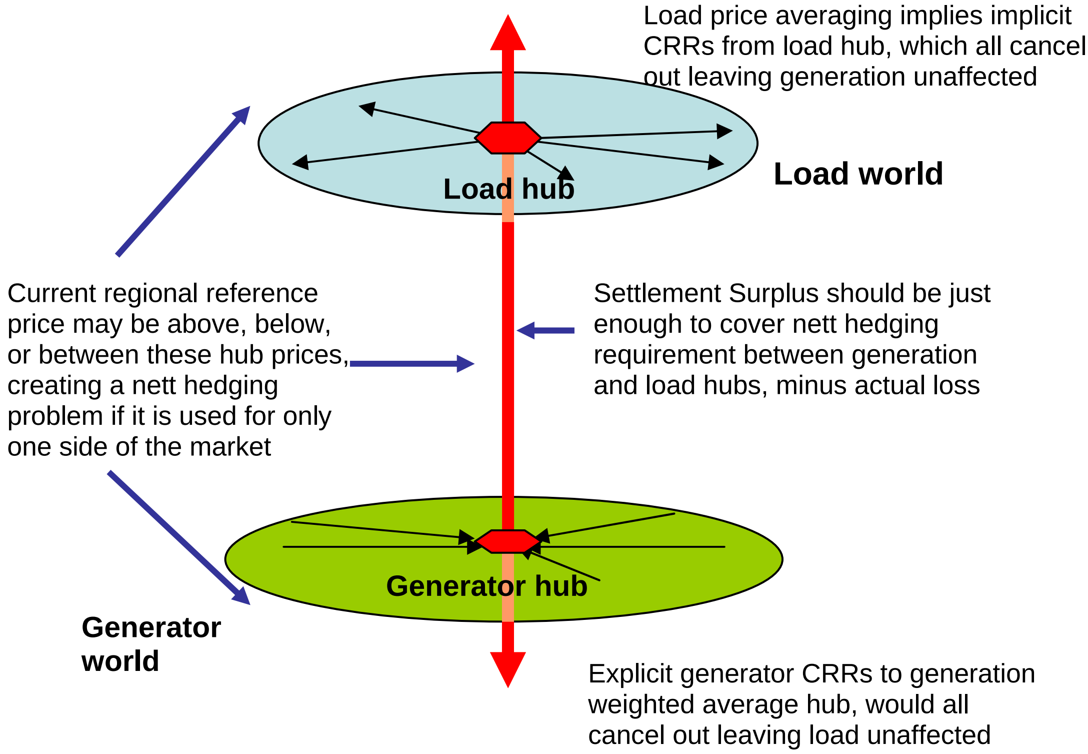
B24. This means that the total settlement surplus (TSS), representing the difference between the total amount which theoretically should be paid by loads, and the total amount which theoretically should be paid to generators, is also fundamental economic property of the NEMDE dispatch. The total settlement surplus is determined by the PNPs implicitly calculated by NEMDE, and hence by the CPs. Thus the TSS does not depend on the choice of Regional Reference Node, which is really an artefact of the settlements system. Consequently, we must ask how changing the Regional Reference Price faced by loads impacts on generators.

B25. If we ignore inter-regional trading, this TSS is just a Regional Settlements Surplus (RSS), and the intra-regional situation may be pictured as in Figure A.1, in which the market notionally buys power from generators at the RGH price, on average, but sells it to load at the RLH price, on average. Under this regime, loads would all be granted implicit CRRs to the RLH, just as they are to the RRP in the status quo. But all of these CRRs actually cancel out because the RLH price is just the load weighted average of load PNPs. In other words, the CRRs to the RLH just represent a re-arrangement of rents among loads.

[227] So, too, can the weights representing re-orientation of constraints to that synthetic hub, but that is probably not relevant unless generation also faces that load-weighted average price.

Figure B.1 Hedging to Regional Hubs

B26.



B26. Accordingly, the Regional Settlements Surplus (RSS) is all available to meet the hedging requirements of generators, which in this case will be purely intra-regional. But we should ask:

- How firm that hedging will be; and
- How it relates to the hedging available with a conventional NEM Regional Reference Price definition.

B27. The answer to this second question seems unclear, because there is no necessary relationship between the NEM Regional Reference Price and the RLH hub price. The situation seems clearer if we imagine, as a reference case, the generators all being paid a Regional Generation Hub (RGH) price, the generation weighted average PNP for generation. In that case the situation would be symmetrical with that for loads. Paying all generation the RGH price amounts to granting all generation implicit CRRs to the RGH. However, all of these CRRs also cancel out because the RGH price is just the (generation weighted) average of generation PNPs. In other words, they just represent a re-arrangement of rents among generation.

B28. Note that defining separate load and generation hubs in this way effectively creates separate load and generation price ”worlds”. And, within each world, it seems possible to re-structure and re-assign rents into different configurations and bundles, using CRRs defined in relation to their respective price hubs, without implying any nett surplus or subsidy. Revenue neutrality has been guaranteed, within each world, by changing to a different definition of the Regional Reference Price.

B29. Now consider a market in which: a) all generators are exposed to CPs, and thus effectively face their own local PNP; and b) loads are protected and effectively face the RLH price. In the limit, if all generation is exposed in all constraints, the effect is to create full nodal pricing for generation, with regional pricing applying only to loads, as in the Singapore market, for example.[228] In this environment we could auction explicit CRRs to the RGH.

B30. But, since the RGH price is just the average of generation PNPs, all of these CRRs actually cancel out, as above. And this means that approximately as many of them have negative value as positive. Clearly, we can not support the positively valued CRRs unless the negatively valued CRRs are taken up. Thus it may be more realistic to think of CRRs to the RGH as being allocated, rather than bought at auction.

B31. On the other hand, the fact that these CRRs to the RGH all cancel out means that they can be allocated to generation without requiring any nett contribution from the RSS at all. In fact the RSS now represents the price difference between the RGH and the RLH, minus the physical cost of losses, and is available for hedging between these two hubs. [229]

B32. This suggests a re-conceptualisation of the NEM market structure, which may have some merit. With this structure generators could, for example, be allocated location specific CRRs, some of which will have negative and some positive value, to hedge the difference between their PNPs and the RGH price, but then purchase generic regional CRRs, which will always have positive value, to provide hedging between RGH and RLH, in an auction which would be genuinely competitive.

B33. Although the above discussion has only referred to intra-regional hedging, the same concepts would still seem applicable when inter-regional issues are considered. As above, once the load and generation price "worlds" have been

[228] In that case the conceptual rationale for maintaining a hub and spoke structure within NEMDE is not obvious, and a NEM-wide FNM might equally well be employed. Similarly, generators could just be regarded as operating in a nodal market, with the hub and spoke structure just being applied to loads in the settlements system. But generators would still be selling to loads at hubs, and will probably still want to retain a hub and spoke structure, and be interested in hedging to, at, and between, regional hubs.

[229] This is analogous to the situation in other markets (such as the UK), where a variety of costs, including costs of constrained on/off compensation, are bundled into a single "uplift" charge. By charging this uplift to loads, a differential is created between the average load price and the average generation price, as above. If the uplift is thought of as comprising genuine costs, there is no rental pool available to provide hedging against it. In this case, though, the uplift consists entirely of rents, and the RSS is available to hedge it. But there is a quantity issue because the quantity bought off generators at the RGH includes losses, while that sold to load at RLH does not. We have not attempted to align this discussion with the current treatment of intra-regional losses for either generation or load, or to propose alternatives.

separated by creating separate load and generation hubs, it should be possible to re-structure those hubs in any way desired. Thus, as a limiting case, it would be possible to use a single national hub for loads, for example, while retaining the current NEM structure for generation. Or, the current NEM structure could be retained for both.

B34. In the latter case, we could imagine a NEM structure based primarily on the "generator price world", with the current NEM Regional Reference Prices being replaced by RGH prices. With that structure:

- IRSRs would arise as differences between RGH prices, and hedging could be arranged on that basis, as under the status quo, or using any variant of the CBR or CSP/CSC regimes discussed in this report. But this would all be achieved solely by nett re-arrangements of rents between generators.

- Intra-regional hedging would be provided by CRRs defined with respect to the LGH and RGH in each region, implicitly for loads and (probably) explicitly for generation; and

- Regional "inter-hub" (or "uplift") hedging would be provided from the RSS in each region, probably using auctioned CRRs.

B35. Mathematically, this should all be achievable. Once the NEMDE pricing solution is re-interpreted as a set of CPs, the prices, and hence the rents, can be re-constructed to match any hub structure that might be proposed. Although software would need to be developed to do this, averaging PNPs should not be hard. [230]

B36. Transition to such a regime would not be entirely painless, though. RGH prices would almost certainly be lower than current Regional Reference Prices, and LGH prices could possibly be higher.[231] Thus, if generators must buy all inter-hub hedging from the RSS pool then, just as in the CBR proposal, they would have to buy back access rights they have traditionally enjoyed, as of right, under the status quo. But, this transition could be managed by allocating, rather than auctioning, initial long term CSC style contracts.

B37. The difference would be that the CRRs required to preserve the overall aggregate position of generators, with respect to the status quo, would be generic CRRs, from the new RGH to the old Regional Reference Node. And

[230] But note that the mathematical equivalence of the particular structure outlined above to the status quo has not been checked, and no consideration has been given to issues such as what the IRSR arising in this situation might actually look like, for example. With so much of the rent allocated to the RSS pools, IRSRs may be significantly lower than under the status quo. That would be reasonable if many of the constraints currently impacting on IRSR actually involve significant intra-regional components. But further investigation is required before the mathematical properties of this regime could be stated with assurance.

[231] But see discussion above.

similar arrangements could be made for load, if desired[232]. Preservation of the relative positions of particular generators, who would now be facing locational prices either higher or lower than under the status quo, would be handled, if desired, by allocation of CRRs from their location to the RGH, as above.

B38. The implications of adopting this variation on the NEM zonal market design have not been followed through in the body of this paper. But, whether or not it is actually considered to be a realistic option for practical implementation, this conceptual market design offers a way of structuring and understanding the situation which promises to clarify, compartmentalise, and simplify, a number of issues which have, perhaps, been clouding and confusing consideration of congestion management issues, to date.

[232] Since the traditional Regional Reference Node corresponds to a major load centre in (almost) every region, its price is probably higher than the averaged RLH price, and certainly higher than the RGH price. So load may not actually want to "retain access".