

UNDERSTANDING CONSTRAINT SUPPORT PRICING / CONSTRAINT SUPPORT CONTRACTS

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1. In a paper prepared for the Ministerial Council on Energy¹, Charles River Associates recommend an interim process for managing intra-regional constraints which they refer to as “Constraint Support Pricing / Constraint Support Contracts” or CSP/CSCs. This note attempts to describe this proposal and its strengths and weaknesses.
2. The main points of this note are as follows:
 - As in any public policy problem, it is important to be clear about the problem we are trying to solve. It is widely accepted that under the existing arrangements, intra-regional congestion in the NEM is poorly managed. Under the existing arrangements, generators which are constrained on or off do not have an incentive to truthfully reveal their costs, even in the presence of competition from other generators. This problem leads to inefficient dispatch, distorted prices and negative settlement residues. Any solution to this problem must involve improving the price signals for constrained generators. In particular, any solution to this problem must involve a move towards nodal pricing for generators.
 - The CSP/CSC proposal is not, to my knowledge, fully set out in one place in any of the CRA papers. I have attempted to reconstruct the mathematics in a way which reflects what I believe CRA intend with the CSP/CSC proposal. This model is set out in the appendix to this paper.
 - When fully implemented, the CSP/CSC proposal is, in my view, no different from other proposals for full nodal pricing for generators, combined with a system for allocating rights to the “settlement residues” thereby created. It therefore shares many of the same strengths and weaknesses of other nodal pricing proposals. Like other proposals, the CSP/CSC proposal ensures that generators face the correct nodal price at the margin. CSP/CSCs therefore, in principle, eliminate the current incentive that exists for constrained generators to artificially manipulate their bids and thereby enhance the efficiency of dispatch.
 - In addition, like any move towards full nodal pricing, the CSP/CSC approach would also allow the system operator to eliminate negative settlement residues and, more generally, improve the “firmness” of inter-regional settlement residues as a hedging instrument (up to the degree of firmness on the underlying physical interconnector).
 - In addition, as with any move towards nodal pricing, the “constraint support prices” could, in principle be affected by the behaviour of generators with market power, in the same way that the RRP can be influenced by generator behaviour in the NEM at

¹ CRA, “NEM – Transmission Region Boundary Structure”, September 2004. This note has benefited from comments by E. Grant Read which are gratefully acknowledged.

present. But the problem of market power is not made worse by a move to nodal pricing.²

- Any move towards nodal pricing will lead to new intra-regional settlement residues accruing to NEMMCO. The CSP/CSC proposal includes an arrangement for distributing some or all of these revenues in the form of “constraint support contracts” (CSCs). CRA deliberately do not specify precisely how rights to these CSCs should be allocated or why. Free distribution of rights is not necessary to achieve any of the efficiency benefits of the proposal. In my view, the allocation of rights does not affect the ultimate dispatch of generators at all. Therefore, the decision as to whether or not to freely distribute rights to the residues is purely a distributional question – affecting whether the extent existing market participants will be made better off or worse off from a change to a nodal pricing regime.
- For much of this note I explore the implications of one particular allocation of rights to the intra-regional settlement residues. Specifically I assume that these are allocated in such a way that each generator is made no worse off by a move to the CSP/CSC approach. This can be achieved if each generator is required to accept an entitlement based on its current level of dispatch under the existing arrangements. If this is done accurately, no generator is made worse off by the change and therefore no generator has an incentive to oppose the change (although some generators may try to refuse to accept their grandfathered entitlements).
- However, attempting to define the entitlements in this way would, in practice, be extremely difficult. The dispatch of a generator under the existing arrangements will vary for a myriad of reasons, such as changes in demand, transmission outages, outages of other generators and so on. The on-going determination of such rights would be highly contentious and a source of on-going dispute with every major network development (such as new entry, network changes, demand changes, etc.). If the rights to the intra-regional settlement residues are not defined in this way there is no guarantee that generators will be made better off by the proposal, and no guarantee that the proposal will lead to a positive overall level of residues.
- In summary, the “CSP” part of the CRA proposal sets the price signals for generators correctly. This part of the proposal should therefore be welcomed. However, in my view, any free distribution of rights should be avoided. Instead, (a) the intra-regional settlement residues should be auctioned in a manner which facilitates the use of these residues as risk-management instruments; and (b) the proceeds from those auctions should then be returned to market participants in a manner which does not impose risk or distort their decisions in any way (for example, by reducing TUOS charges).

Introduction

3. It is widely recognised that under the existing arrangements, the NEM does a poor job of managing intra-regional constraints. This problem arises because intra-regional constraints are not explicitly priced in the NEM – each generator in a region is paid the same price – the regional reference price (RRP) - no matter what constraints exist within the region.

² This statement is true for network congestion but not necessarily for losses. At present intra-regional losses in the NEM are modelled using static marginal loss factors. This leads to a dispatch which is less efficient than if dynamic loss factors were modelled, but at the same time, may enhance competition. Therefore a move to full nodal pricing might conceivably enhance market power arising from transmission losses.

4. In the absence of any intra-regional constraints, competition between generators forces each generator to submit an offer curve which approximates its true marginal cost curve (at least in the price-quantity region which the generator expects to see realised). When an intra-regional constraint arises, however, some generators must increase their output, and others must decrease. Under the current arrangements, those generators which are “constrained on”³ are not paid any more than the RRP. These generators therefore have an incentive to bid very high, to pretend to be unavailable or to bid “inflexible”⁴ in an attempt to not have their output increased.

5. Conversely, generators which are “constrained off” are still paid the RRP for their output. These generators have an incentive to bid very low, or to bid “inflexible” in an attempt to prevent having their output decreased. These practices destroy the information content of the bids of generators, leading to inefficient dispatch and, in the worst cases threatening system security. These practices can also distort the price in neighbouring regions and/or give rise to negative settlement residues which, under the present system, are deemed to be undesirable (primarily due to the effect of negative settlement residues on the usefulness of the inter-regional settlement residues as a hedging instrument).⁵

6. The basic problem can therefore be stated as follows – under the existing arrangements the NEM does not correctly price intra-regional constraints which leads remote intra-regional generators to distort their bids in various ways, reducing the efficiency of dispatch, potentially distorting price signals in neighbouring regions and increasing the likelihood of negative settlement residues.

7. Any solution to this problem will almost certainly involve explicit pricing of intra-regional transmission constraints⁶ – in other words, any solution to the problem will involve some form of “locational marginal pricing” or “nodal pricing”.

8. In particular, there must be a consistency between pricing and dispatch. This means that if a generator faces a given price, it should be dispatched for the corresponding quantity on its offer curve. Conversely, if a generator is dispatched for a given quantity, it should be compensated at a rate given by the corresponding price on its offer curve. Under present arrangements this “consistency” between pricing and dispatch is broken in the presence of intra-regional constraints – a generator which is constrained off will receive a price corresponding to the RRP, but may be dispatched for a quantity much less than the quantity on its offer curve corresponding to the RRP. Conversely, a generator which is constrained on

³ Here I am using the terms “constrained on” and “constrained off” to refer to generators which are dispatched for an amount which is larger (or smaller) than the amount which they signalled they would be willing to produce in their offer curve at the prevailing regional reference price (adjusted for the generator’s marginal loss factor).

⁴ A generator can bid “inflexible” by submitting a “fixedload” bid, by reducing its possible ramp rate to zero, or by manipulating its ancillary services bids so that the dispatch engine ensures that its output remains at the same level (so as to be able to use this generator to provide ancillary services when required).

⁵ In addition, since in a voluntary auction system, participants will not pay for a right which will involve a net obligation to make payments on average, NEMMCO could not sell settlement residues which are negative on average, so this revenue needs to be made up from elsewhere.

⁶ The only exception to this rule which I can see is where there is only a single constrained-on or constrained-off generator at the end of a radial link. In this case, the output of this generator is determined by the constraint so the bidding behaviour of the generator is, up to a point, irrelevant. Such a generator could still bid unavailable and so may need to be compensated to be constrained on (perhaps through a “network support contract”) but, in any case, there is no necessary role for nodal prices in this context. Put another way, rather than use prices to clear the market in this context it may be simpler to adjust the quantity of the affected generator.

may be dispatched for a quantity much higher than the quantity it is willing to be dispatched at the RRP.

9. As already noted, any solution to this problem will involve compensating generators different amounts for their marginal output at different locations. In other words, any solution to this problem will involve some form of move to full nodal pricing for generators. The different solutions to the intra-regional congestion management problem – whether that solution is “constraint support prices”, “pay-as-bid”, or “locational marginal prices” – all involve some form of nodal pricing for generation.

10. But any move towards locational marginal pricing for generators inevitably gives rise to new “residues” which we might call “intra-regional settlement residues” (which are, of course, closely analogous to existing “inter-regional settlement residues”). The different solutions to the intra-regional congestion management problem differ only in how they propose to dispose of these revenues – and, in particular, whether and how these revenues are allocated to existing generators.

The CSP/CSC Proposal

11. In their paper on region boundary issues, Charles River Associates propose a mechanism for improving the handling of intra-regional constraints in the NEM. They anticipate that this mechanism will not be permanently applied but, rather, will only apply for intra-regional constraints which are “significant but not persistent”. Charles River calls their proposal the “Constraint Support Pricing / Constraint Support Contracts” (CSP/CSCs) proposal.

12. It is my understanding that the precise details of the CSP/CSC proposal have not, to my knowledge, been set out fully in any one place. The MCE paper does contain a few worked examples of the CSP/CSC approach but these worked examples are puzzling in that the examples illustrate no efficiency gain from the use of CSP/CSCs – yet that is presumably the only reason for their existence?

13. In order to make progress in analysing the CSP/CSC approach we need a clearly specified model. This paper attempts to fill that gap by specifying in detail a model which matches my understanding of the details of the CSP/CSC that have been revealed by CRA. This model is set out in the appendix.

14. The CRA proposal consists of two parts:

- (a) A mechanism for setting locational marginal prices within a region by reference to (i) the regional reference price and (ii) the “cost” or “marginal value” of any binding constraints. These prices are referred to by CRA as “constraint support prices”. This approach is fully consistent with nodal pricing. Indeed, CRA claim that the approach is a generalisation of nodal pricing in that it allows for pricing not just of energy at each location but non-energy services (such as reactive support).
- (b) An unspecified mechanism for distributing rights to the newly created settlement residues, in the form of contracts known as “constraint support contracts”.

15. The nodal pricing arrangement under the CSP/CSC approach can be expressed mathematically as follows. Suppose we have a number of generators at different nodes labelled i . Suppose that there is a single binding intra-regional constraint. Let’s suppose that

the coefficient of generator i in the constraint equation is α_i . Let's suppose that the regional reference price for generator i is RRP_A . The "Constraint Support Price" or CSP is the "marginal value" of the constraint calculated by the dispatch engine. In a simple network model (known as the DC lossless flow model), the correct nodal price for generator i (called the "pseudo-nodal price" by CRA) in this example (PNP_i) is:

$$PNP_i = RRP_A - \alpha_i * CSP$$

16. The entitlements or rights of a generator under the CSP/CSC approach can be expressed as follows: Suppose that the entitlement of generator i is labelled $CGEN_i$ and the dispatch of this generator under the CSP/CSC proposal is $MWGEN_i$. The payment from the system operator to the generator under the "constraint support contract" is:

$$\begin{aligned} CSC_i &= \alpha_i * CSP * (CGEN_i - MWGEN_i) \\ &= (RRP_A - PNP_i) * (CGEN_i - MWGEN_i) \end{aligned}$$

17. In principle, under the CSP/CSC approach the system operator could decide which binding constraints will be handled by this mechanism and which will be ignored.

18. If the system operator chooses to reflect all material binding constraints in this mechanism, each generator will face a nodal price which is the same as it would face under full nodal pricing.⁷ In other words, the CSP/CSC approach, like any solution to the intra-regional congestion problem, is a move in the direction of full nodal pricing for generators.⁸

19. But, as already noted, a move in the direction of full nodal pricing will result in new settlement residues which will accrue to NEMMCO (just like the existing inter-regional settlement residues). The CSP/CSC approach includes a mechanism for distributing these residues in the form of constraint support contracts – but how is the entitlement of each generator to CSCs to be defined? And does it matter?

20. CRA have deliberately⁹ not specified in detail how the entitlements will be allocated. In this regard there are several points which are worth making:

- (a) First, although economic theory is largely silent on how rights to the settlement residues should be distributed, it is very clear from theory that the market participants should have access to these residues in some form for the purposes of managing risk. In my view, the allocation of the settlement residues does not matter as long as all of the settlement residues are made available to the market in a manner which allows individual market participants to enter into contracts for allocating market risk to those prepared to bear it.¹⁰ It does no good to allocate the settlement residues in a way

⁷ Ignoring, for a moment, the non-energy constraints.

⁸ The close link between the CSP/CSC proposal and a regime of full nodal pricing plus FTRs is recognised by CRA: "The CSP/CSC regime is conceptually similar to the existing settlement residue process in the NEM and also has parallels with Financial Transmission Right (FTR) regimes. CSP/CSCs create incentives for performance to manage the effects of network congestion, whereas FTRs are primarily risk instruments". (page 54).

⁹ I understand that CRA considered that it is not their role to come to a definitive judgement with respect to the desirability of any allocation approach in the NEM context, but to determine the limits and implications of what is possible.

¹⁰ For more on this see my paper Biggar, Darryl, "Firm Financial Transmission Rights in the NEM – They already exist", August 2004.

which makes more difficult the process of financial contracting to allocate risk. In particular, for example, the settlement residues should not simply be “smeared” over existing market participants.

- (b) Second, economic efficiency requires that any free allocation or distribution of rights to the settlement residues should be independent of the actions of generators – otherwise those actions will be distorted in an attempt to increase the allocation of valuable rights. In particular, if, say, the allocation of rights depends on a generator’s average dispatch in the previous period, generators will have an incentive to attempt to be dispatched in order to increase the size of their entitlement. Like the intra-regional congestion management problem discussed above, this induces generators to inefficiently distort their bidding and is undesirable.¹¹ I will assume in what follows that any distribution or allocation of rights is independent of the (future) actions of generators. (This implies, in particular, that new entrant generators – with projects that are not already “committed” - must inevitably be treated differently from existing generators).
- (c) Third, it is widely recognised that the incentive on generators to exercise market power depends very closely on the structure and level of any hedge cover by generators. It is very important that before any change is made to the structure of prices in the NEM, policymakers are sure that the change will not lead to an overall reduction in the level of hedge cover by generators.

Having said that, it is not clear that (in the absence of any additional controls) the allocation of rights will affect generator market power or dispatch in equilibrium. It is true, of course, that entitlements such as CSCs have a similar effect to a change in the level of hedging of a generator – that is, acquiring an entitlement could increase or decrease the incentive on a generator to exercise market power. However generators can, through trade between themselves and retailers, adjust their hedging to the optimum level which they desire. Any change in the initial allocation of rights need not have any impact on the final level of hedging of each generator once trading between market participants has been allowed. In other words, the initial allocation of rights need not have any impact on the market outcome even in a market with significant market power.¹²

21. So if “constraint support contracts” do not affect the outcome, what are they for? As noted earlier, the decision as to whether or not to grandfather certain rights is purely a distributional question – that is, it makes some generators better off (and possibly some worse off). Why then would we seek to grandfather certain rights?

22. As I will argue below, I believe there are likely to be on-going problems with any “free” distribution of entitlements or rights. Nevertheless, it is worthwhile considering the arguments in favour of such a distribution. In my view, the strongest argument is that doing so may be necessary in order to obtain the consensus from generators needed for a move to a system of enhanced nodal pricing. Let’s assume, for the moment, therefore that we seek to grandfather rights in such a way that every generator is no worse off under the new arrangements than they would be under the existing arrangements.

¹¹ At present, generators which locate at a node which is periodically constrained off receive (for free) an implicit right to be dispatched at the RRP. This free allocation may potentially distort the location decisions of generators.

¹² As a contrary argument we could point to the vesting contracts – is it not the case that the vesting contracts changed the behaviour of generators? This might have been due to other factors, such as the immaturity of the hedge market at that time. In any case, this issue needs to be explored further.

23. This can be achieved by allocating the rights to each generator equal to the amount that the generator would have been dispatched under the existing arrangements. In other words, the entitlement $CGEN$ is the equation above is set equal to the level of dispatch under the existing arrangements (which we might call, say, $MWGEN_OLD$). (Recall that the level of dispatch under the existing arrangements is likely to be inefficient as a result of the NEM's poor handling of intra-regional constraints).

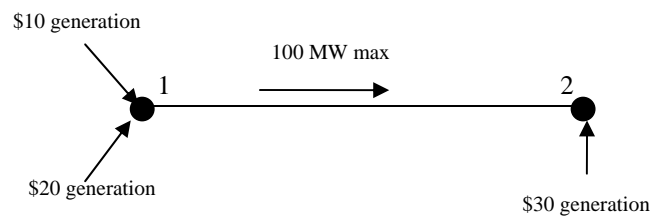
24. In the examples which follow I will make the assumption that the entitlements are set in this way.

Examples

25. The following examples illustrate some of the properties of this approach. It is unfortunately not possible to use the examples proposed by CRA in their paper (Appendix B, page 58). In those examples the dispatch is exactly the same with and without the CSP/CSC mechanism – in other words there is precisely no efficiency gain from the move to the CSP/CSC approach, which seems to defeat the purpose of the examples in the first place.

26. The following sequence of examples is intended to illustrate different features of the CSP/CSC approach.

27. The first example has a very simple network with a single region. The single transmission line in this network has a capacity of 100 MW. There are two remote generators located at node 1 who are competing to be dispatched with a variable cost of \$10 and \$20 respectively. There is also generation at node 2 with a variable cost of \$30 which sets the RRP of \$30.



28. Under the existing arrangements each generator at node 1 would compete to be dispatched by bidding \$-1000. Since these generators would then appear to have exactly the same cost to the dispatch engine, the dispatch engine, say, would dispatch them both for an equal amount - 50 MW and they would both receive the RRP of \$30.

29. Under the CSP/CSC proposal as set out in this document, the price would drop at node 1 to \$10. The \$10 generation would be dispatched for 100 MW and the \$20 generation would not be dispatched at all. These outcomes are summarised in the following table:

Generator		Existing arrangement		CSP/CSC proposal		
Number	Variable Cost	Price	Dispatch	Entitlement	Price	Dispatch
1	\$10	\$30	50	50	\$10	100
2	\$20	\$30	50	50	\$10	0
3	\$30	\$30	100	100	\$30	100

30. Note that, as the following table illustrates, each generator is no worse off under the CSP/CSC proposal and some of the remote intra-regional generation is strictly better off.¹³

¹³ In the absence of the grandfathered rights the intra-regional generation would be strictly worse off.

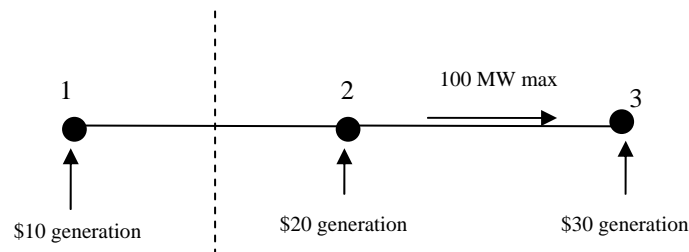
Notice that the total profit of the generation industry has increased due to the enhanced efficiency of dispatch.

Generator	Existing arrangements		CSP/CSC proposal			
	Revenue from sales at RRP	Profit	Revenue from sales at RRP	Grandfathered right	Total revenue	Profit
1	\$1500	\$1000	\$3000	\$-1000	\$2000	\$1000
2	\$1500	\$500	\$0	\$1000	\$1000	\$1000
3	\$3000	\$0	\$3000	\$0	\$3000	\$0
Total	\$6000	\$1500	\$6000	\$0	\$6000	\$2000

31. The table below shows the balance sheet of the system operator. In this simple example the total output of generators does not change and the RRP does not change so there is no increase or decrease in net revenue of the system operator. The payment obligations on the rights sum to zero.

System operator balance	Existing arrangements	CSP/CSC proposal
Purchases from generators	\$-6000	\$-6000
Sales to end-users	\$6000	\$6000
Net settlement residue	\$0	\$0
Payments on grandfathered rights	\$0	\$0
Net position of system operator	\$0	\$0

32. The second example features two regions so that we can explore the effect of the proposal on inter-regional settlement residues. In this example there is demand of 200 at node 3 and demand of 100 at node 1. Under the existing arrangements node 2 generation is constrained off and therefore has an incentive to bid low in an attempt to get dispatched. In this case I have assumed that the node 2 generation bids as low as \$10, thereby displacing generation in the neighbouring region and reversing the “normal” flow on the interconnector.



33. As before, the price and output of each generator before and after the implementation of the proposal is set out below. Note that under the existing arrangements the generator at node 2 is producing sufficient output to meet demand at node 1, leading to negative settlement residues of 100 times \$20 = \$-2000.

Generator		Existing arrangements		CSP/CSC proposal		
Number	Variable Cost	Price	Dispatch	Entitlement	Price	Dispatch
1	\$10	\$10	0	0	\$10	200
2	\$20	\$30	200	200	\$10	0
3	\$30	\$30	100	100	\$30	100

34. In this example the generator at node 2 receives an entitlement corresponding to its original dispatch of 200 MW. This entitlement is worth \$4000. Therefore the remote intra-

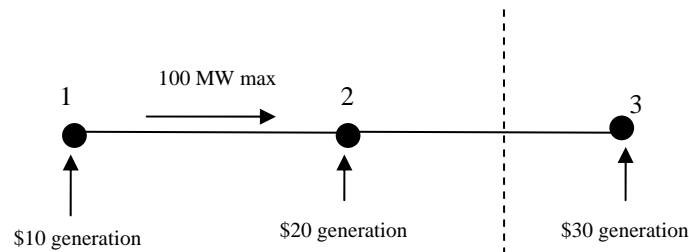
regional generation is made significantly better off in this example. The total profit of the industry has increased due to the enhanced efficiency of dispatch.¹⁴

Generator	Existing arrangements		CSP/CSC proposal			
	Revenue from sales at RRP	Profit	Revenue from sales at RRP	Grandfathered right	Total revenue	Profit
1	\$0	\$0	\$2000	\$0	\$2000	\$0
2	\$6000	\$2000	\$0	\$4000	\$4000	\$4000
3	\$3000	\$0	\$3000	\$0	\$3000	\$0
Total	\$9000	\$2000	\$5000	\$4000	\$9000	\$4000

35. Under the existing arrangements the system operator is out-of-pocket by \$2000. Under the CSP/CSC proposal the system operator is still out-of-pocket by \$2000, but the settlement residue is positive (and the flow is in the correct direction) – i.e., introducing the correct nodal price signals has both enhanced the efficiency and improved the firmness of inter-regional settlement residues.

System operator balance	Existing arrangements	CSP/CSC proposal
Purchases from generators	\$-9000	\$-5000
Sales to end-users	\$7000	\$7000
Net settlement residue	\$-2000	\$2000
Payments on grandfathered rights	\$0	\$-4000
Net position of system operator	\$-2000	\$-2000

36. The third example illustrates the case of a generator which is constrained on. As in the second example there are two regions. There is demand of 200 at node 3 and demand of 100 at node 1 and the link between node 1 and 2 is limited to 100 MW.



37. Under the existing arrangements node 2 generation is constrained on and therefore has an incentive to bid high in an attempt to avoid being dispatched. Let's assume that node 2 generation is successful, so the remainder of the demand at node 3 has to be made entirely by node 3 generation. As before, the price and output of each generator before and after the implementation of the CSP/CSC proposal is set out below.

Generator		Existing arrangements		CSP/CSC proposal		
Number	Variable Cost	Price	Dispatch	Entitlement	Price	Dispatch
1	\$10	\$10	200	200	\$10	200
2	\$20	\$10	0	0	\$20	100
3	\$30	\$30	100	100	\$20	0

¹⁴ As in the previous example, in the absence of the grandfathered rights the remote intra-regional generation would be worse off.

38. In this case the constrained generation is no better from the move to CSP/CSC – instead it is the generation in the neighbouring region which is made better off. Again, total industry profit has increased.

Generator	Existing arrangements		CSP/CSC proposal			
	Revenue from sales at RRP	Profit	Revenue from sales at RRP	Grandfathered right	Total revenue	Profit
1	\$2,000	\$0	\$2,000	\$0	\$2,000	\$0
2	\$0	\$0	\$1,000	\$1,000	\$2,000	\$0
3	\$3,000	\$0	\$0	\$1,000	\$1,000	\$1,000
Total	\$5,000	\$0	\$3,000	\$2,000	\$5,000	\$1,000

39. Because the settlement residues are positive in this example, the system operator earns a positive revenue of \$2000 (normally this revenue would be returned to the market in the form of the settlement-residue auctions). This is the same under the existing arrangements or under the CSP/CSC proposal.

System operator balance	Existing arrangements	CSP/CSC proposal
Purchases from generators	-\$5,000	-\$3,000
Sales to end-users	\$7,000	\$7,000
Net settlement residue	\$2,000	\$4,000
Payments on grandfathered rights	\$0	-\$2,000
Net position of system operator	\$2,000	\$2,000

Discussion

40. As these examples show, the CSP/CSC approach (like all nodal pricing approaches) correctly solves the problems arising from inefficient dispatch. At the same time, this approach to grandfathering existing dispatch rights ensures that each generator is no worse off under the CSP/CSC approach than it would be under the existing arrangements¹⁵. In addition, the system operator is no worse off under this proposal than under the existing arrangements.

41. In fact, it is possible to show that these are generic results of the CSP/CSC approach when the grandfathered rights are set in this way – each generator has an incentive to bid truthfully (i.e., not to distort its bids). Furthermore, provided that the entitlements are set equal to the amount the generator would be dispatched under the existing arrangements, each generator is no worse off and the system operator is no worse off under the CSP/CSC proposal. These results are demonstrated in the appendix.

42. These are important strengths of this particular approach. But they are critically dependent on being able to set the entitlement correctly – equal to the quantity for which the generator would have been dispatched under the existing arrangements.

43. Unfortunately, however, this is likely to be an impossible task. The dispatch of a generator under the existing arrangements depends on a number of factors, such as:

¹⁵ However, a generator may be worse off than it would be under the alternative of full nodal pricing with no grandfathered rights.

- the level of demand
- the number and identity of outages on this generator or other generators in the market
- the number and identity of outages on the transmission network
- changes in the number or composition of generators
- changes to the network configuration
- changes in the cost of input fuels
- changes in the level of market power.

44. It is impossible to construct an entitlement that accurately predicts the dispatch of every generator under each of these different scenarios. Recall that it is not just the constrained generators which must receive an entitlement of CSCs – other generators could be made better or worse off from the inefficiencies in the dispatch of the constrained generators and therefore must also accept an entitlement to CSCs. In principle, even if there is just one constraint in the NEM, every generator in the NEM might need to be compensated through some form of CSC.

45. In practice, the actual entitlement which is built in to any such CSP/CSC scheme would inevitably be an approximation – reflecting perhaps the “average” dispatch of the generator under a variety of possible conditions. But the desirable properties of the particular entitlement proposed above no longer hold in this context.

46. To see this, consider again the first example above, but this time let’s suppose that the entitlement is for a transmission line with a capacity of 100 MW but for some reason the line actually drops in capacity to 50 MW. Under the existing arrangements each generator at node 1 would be dispatched for 25 MW and they would both receive the RRP of \$30. Under the CSP/CSC proposal as set out in this document, the price would drop at node 1 to \$10. The \$10 generation would be dispatched for 50 MW and the \$20 generation would not be dispatched at all. These outcomes are summarised in the following tables:

Generator		Existing arrangements		CSP/CSC proposal		
Number	Variable Cost	Price	Dispatch	Entitlement	Price	Dispatch
1	\$10	\$30	25	50	\$10	50
2	\$20	\$30	25	50	\$10	0
3	\$30	\$30	150	100	\$30	150

47. Now the entitlement leaves each generator significantly better off than before, but the system operator has a net obligation under the entitlements.

Generator	Existing arrangements		CSP/CSC proposal			
	Revenue from sales at RRP	Profit	Revenue from sales at RRP	Grandfathered right	Total revenue	Profit
1	\$750	\$500	\$1,500	\$0	\$1,500	\$1,000
2	\$750	\$250	\$0	\$1,000	\$1,000	\$1,000
3	\$4,500	\$0	\$4,500	\$0	\$4,500	\$0
Total	\$6,000	\$750	\$6,000	\$1,000	\$7,000	\$2,000

48. As a result the system operator can no longer balance its budget:

System operator balance	Existing arrangements	CSP/CSC proposal
Purchases from generators	-\$6,000	-\$6,000
Sales to end-users	\$6,000	\$6,000
Net settlement residue	\$0	\$0
Payments on grandfathered rights	\$0	-\$1,000
Net position of system operator	\$0	-\$1,000

49. Alternatively, consider again the second example, but this time let's assume that the constrained line drops in capacity to 50 MW, while retaining the entitlement for a 100 MW line. The outcome is summarised in the following tables:

Generator		Existing arrangements		CSP/CSC proposal		
Number	Variable Cost	Price	Dispatch	Entitlement	Price	Dispatch
1	\$10	\$10	0	0	\$10	150
2	\$20	\$30	150	200	\$10	0
3	\$30	\$30	150	100	\$30	150

Generator	Existing arrangements		CSP/CSC proposal			
	Revenue from sales at RRP	Profit	Revenue from sales at RRP	Grandfathered right	Total revenue	Profit
1	\$0	\$0	\$1,500	\$0	\$1,500	\$0
2	\$4,500	\$1,500	\$0	\$4,000	\$4,000	\$4,000
3	\$4,500	\$0	\$4,500	\$0	\$4,500	\$0
Total	\$9,000	\$1,500	\$6,000	\$4,000	\$10,000	\$4,000

50. The budget balance of the system operator is even worse than before:

System operator balance	Existing arrangements	CSP/CSC proposal
Purchases from generators	-\$9,000	-\$6,000
Sales to end-users	\$7,000	\$7,000
Net settlement residue	-\$2,000	\$1,000
Payments on grandfathered rights	\$0	-\$4,000
Net position of system operator	-\$2,000	-\$3,000

51. CRA appear to be aware of the major difficulties of defining the appropriate level of the entitlement. They describe this as a drawback of the "full nodal pricing for generators" approach. Specifically, CRA write:

"Allocation ... of FTRs to protect the financial position of (existing) participants following the introduction of nodal pricing would theoretically be possible, but difficult to implement. We are aware that this is of vital concern to incumbent generators in particular and is seen as a matter of significant regulatory risk.

If FTR allocations are to be designed to cover the positions of incumbents adversely affected by the introduction of nodal pricing they can be financially self-contained only if they are held by market participants would have fallen as well as those who would have seen a rise in price. This ... forces consideration of a [obligatory] central allocation to incumbents if they are to be indifferent. ...

The methodology for initial allocation of FTRs would ... be contentious, as would any subsequent transition following major changes in the network configuration. We have concluded that, even had there been a case on economic grounds for a nodal ... market design, it would have been unsafe to recommend such a change until the matters of policy raised here had been resolved".

52. CRA do not address how the entitlements would be defined under the CSP/CSC proposal. They merely note: “Assignment of contracts and thus level of participation in the regime will be a key matter to be established and highlights the similarity between CSP/CSC and FTR regimes discussed in this report”. (page 55). In my view the issue of determination of the entitlement level is a critical issue to be addressed by any proposal for a change in the structure of prices in the NEM.

53. In my view, any free distribution of rights should be avoided on the grounds that it creates new rights and entitlements which will be controversial and a source of on-going dispute. CRA consider that the decision to *not* distribute rights to the settlement residues is simply a decision to distribute the residues in some other way. This is strictly correct since, as long as the system operator is a non-profit entity, any revenue it receives must be returned to the market somehow. CRA conclude that our choice is not between distributing rights for free or not but between different ways of distributing rights.

54. However, this line of argument is misleading. It suggests that it is not possible to both (a) ensure that the settlement residues are fully used for risk management purposes and (b) avoid creating new controversial rights and entitlements. In contrast, it *is* possible to distribute the settlement residues to the market in a way which both ensures that the risk-management properties are fully exploited and no new rights and entitlements are created. Specifically – the settlement residues can be packaged and auctioned in a manner which maximises their usefulness as a risk management tool. At the same time the proceeds from the auction can be distributed in a way which does not distort the incentives of market participants (for example, they could be used to reduce TUOS charges).

55. In other words, we have the choice as to which residues will be distributed for free and which will be auctioned. In my view we should avoid creating new rights and entitlements which could be controversial and a source of on-going dispute.

Conclusion

56. The problems arising from inefficient dispatch in the presence of intra-regional congestion can only be effectively resolved by correct pricing of electricity at constrained on or constrained off nodes. Therefore, all proposals for addressing the existing problems with the NEM involve some move towards full nodal pricing for generators. The only difference in these proposals can therefore be in the nature of any grandfathered rights that might be allocated to the incumbent generators.

57. In my view, the CRA CSP/CSC proposal is best viewed in this light. The CRA proposal is a form of nodal pricing for generators, coupled with some yet-to-be-determined allocation rights to the resulting settlement residues.

58. I have demonstrated that if the grandfathered rights are set in a particular way – specifically, equal to the dispatch of the generator under the existing arrangements, the resulting outcome has desirable properties in that it ensures that neither any generator nor the system operator is left worse off as a result of the change.

59. However, in my view, any attempt to define a set of grandfathered rights will be difficult and contentious. Instead, generators should expect to purchase any rights to the intra-regional settlement residues in the same manner as currently occurs for inter-regional settlement residues.

Appendix: The theory of the CSP/CSC approach:¹⁶

60. Suppose that we have a network with a set of nodes labelled i . Let's suppose that there is a nodal price defined at each of these nodes p_i . Suppose that these nodes are grouped into regions with a single regional reference node in each region. Let's suppose that the regional reference node for the region in which node i is located is node $k(i)$. The regional reference price is equal to the nodal price at the regional reference node, so the RRP for node i is $p_{k(i)}$.

61. Let's suppose the output of a generator at node i is s_i and the cost of producing that output is $c_i(s_i)$.

62. Under the existing arrangements, a generator at node i which is dispatched the amount s_i earns the RRP $p_{k(i)}$ on each unit of output and incurs costs $c_i(s_i)$ for a total profit of:

$$\pi_i(s_i) = p_{k(i)}s_i - c_i(s_i)$$

63. Under the CSP/CSC proposal, each generator receives an entitlement to be dispatched an amount \bar{s}_i . If the generator is dispatched s_i the amount paid to the generator by the system operator is:

$$T_i(s_i) = (p_{k(i)} - p_i)(\bar{s}_i - s_i)$$

64. The profit of each generator under the CSP/CSC proposal is therefore:

$$\begin{aligned}\pi_i(s_i) &= p_{k(i)}s_i - c_i(s_i) + T_i(s_i) \\ &= p_i s_i - c_i(s_i) + (p_{k(i)} - p_i)\bar{s}_i\end{aligned}$$

65. Immediately we can see that this is maximised when the generator is dispatched at the level of output at which its marginal cost is equal to the nodal price. Therefore (assuming adequate competition between generators) every generator has an incentive to bid in such a way as to truthfully reveal its marginal cost curve, whatever the level of the entitlement \bar{s}_i . In other words, this approach solves the problem of inefficient bidding in the presence of intra-regional constraints.

66. Now suppose that the entitlement \bar{s}_i is chosen to be equal to the dispatch the generator would obtain under the existing arrangements. Under the new arrangements if the generator bids in such a way as to maintain this dispatch its profit is:

$$\pi_i(s_i) = p_i \bar{s}_i - c_i(\bar{s}_i) + (p_{k(i)} - p_i)\bar{s}_i = p_{k(i)}\bar{s}_i - c_i(\bar{s}_i)$$

¹⁶ This appendix builds on the theory set out in my paper Biggar, Darryl, "Managing Intra-Regional Congestion in the Australian NEM", April 2003.

which is the same profit the firm would obtain under the existing arrangements. In other words, the firm can always do at least as well as it did under the existing arrangements (and will often be able to do better).

67. Now consider the balance sheet of the system operator. Let the demand at node i be d_i . The system operator earns revenue $p_{k(i)}d_i$ from customers at this node and must pay out $p_{k(i)}s_i$ in payments to generators at this node. Under the existing arrangements, therefore, the system operator's net balance is:

$$TSR = \sum_i p_{k(i)}(d_i - s_i)$$

68. Under the new arrangements, the system operator also has the obligation to service the new entitlements which are $T_i(s_i) = (p_{k(i)} - p_i)(\bar{s}_i - s_i)$ at each node, so the operator's net balance is now:

$$\begin{aligned} TSR &= \sum_i p_{k(i)}(d_i - s_i) - \sum_i T_i(s_i) = \sum_i p_{k(i)}(d_i - s_i) - (p_{k(i)} - p_i)(\bar{s}_i - s_i) \\ &= \sum_i p_{k(i)}(d_i - \bar{s}_i) + p_i(\bar{s}_i - s_i) \end{aligned}$$

69. Now, if we assume that the entitlement \bar{s}_i is set equal to the dispatch under the existing arrangements and if we assume that the nodal prices do not change with the change to the new CSP/CSC approach, the first term in the expression above is just the system operator's balance under the existing arrangements. So the question whether or not the system operator is better off depends on the sign of the second term.

70. But since s and \bar{s} are both feasible dispatches (i.e., they satisfy the constraints on the transmission network) we know that the total cost of the optimal dispatch s must be less than or equal to the total cost of the dispatch \bar{s} . Let $C(s)$ be the total cost of a dispatch s . Consider a small move away from s in the direction of \bar{s} , say $s_\varepsilon = s + \varepsilon(\bar{s} - s)$. Then $C(s_\varepsilon) \approx C(s) + \varepsilon(\bar{s} - s) \cdot \nabla C(s) = C(s) + \varepsilon \sum_i p_i(\bar{s}_i - s_i)$. Since $C(s_\varepsilon) \geq C(s)$ it follows that $\sum_i p_i(\bar{s}_i - s_i) \geq 0$ which proves that the system operator is better off under the CSP/CSC scheme.

71. Finally, it is worth noting that under a nodal pricing scheme, if λ_l is the marginal value of the constraint and H_{li} is the matrix of distribution factors (i.e., the "coefficients" in the constraint equations), under nodal pricing, the nodal prices exhibit the following relationship: $p_N - p_i = \sum_l \lambda_l H_{li}$. Hence it is possible to write the optimal nodal price at any node as follows:

$$p_i = p_{k(i)} + \sum_l CSP_l * Coeff_{li}$$

where CSP_l is the marginal value of the constraint associated with line l and $Coeff_{li}$ is the coefficient of node i in the constraint equation for line l (formulated with reference to the regional reference node) $Coeff_{li} = H_{lk(i)} - H_{li}$.