SNOWY REGION BOUNDARY CHANGE PROPOSALS:

FURTHER ASSESSMENT OF THE OPTIONS

Darryl Biggar

Draft 12 December 2006

1. This paper sets out a preliminary further assessment of Snowy Region Boundary change proposals before the Commission.

2. In my 1 December 2006 paper I set out a general methodology for obtaining an indication of the likely pricing, dispatch and hedging implications for any given region boundary change. That methodology allows us to compare the pricing, dispatch and hedging outcomes that will arise following a region boundary change with the pricing, dispatch and hedging outcomes in a hypothetical efficient market. That paper observed that there is no region boundary change in the Snowy region which will, under the current market arrangements, solve the pricing and hedging problems in the Snowy region.

3. A relevant question is whether a given proposal will yield a more preferred outcome than the status quo.

4. This paper extends the analysis of the earlier paper by attempting to compare the outcome that would arise under each proposal with the outcome that would arise under a "base case" or "status quo".

5. In this paper, consistent with the approach taken in the Frontier modelling, the "base case" or "status quo" option is not the current situation in the market (which includes the CSP/CSC trial and the Southern Generators' proposal for managing negative settlement residues). Instead, in the base case, any negative settlement residues are addressed through either clamping or reorientation.

6. This paper will focus on just four options, corresponding to options (A), (D), (F) and (G) in the previous paper. These options are as follows:

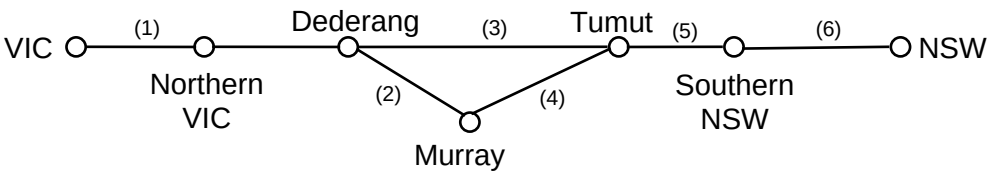
(a) The "base case" (as mentioned above) which involves the current definition of region boundaries, interconnectors and regional reference nodes, with clamping (and possibly reorientation) to limit negative settlement residues; (Option A in the previous paper)

(b) The "Snowy proposal" to abolish the Snowy region, to enlarge the existing VIC and NSW regions and to replace the VIC-Snowy and Snowy-NSW interconnectors with a single VIC-NSW interconnector; (Option D in the previous paper)

(c) The "Eraring submission option" to divide the Snowy region into two, replacing the Snowy region with two new regions (the "Murray" and "Tumut" regions) joined by a new Murray-Tumut interconnector; (Option F in the previous paper)

(d) The "Split Region option", which divides the Snowy region into two ("Murray" and "Tumut") regions, joined by a new Murray-Tumut interconnector, with Dederang included in the Murray region (and the regional reference node for that region).

7. As in the previous paper, this paper will illustrate the results using a particularly simple, stylized form of the network. Although it reflects the network loop in the Snowy region, the VIC and NSW regions are represented in a simple linear or radial manner. The location of the six physical network limits which are modelled are indicated below.



(n) = location of modelled network limits

8. The following table – extracted from the summary of the previous paper – summarises some of the key conclusions of the previous paper. This table sets out, for each option, the nodes that are mis-priced (leading to inefficient dispatch, inefficient location decisions, and negative residues) and the interconnectors which are not firm.

9. This table suggests a loose ranking of these options (roughly in the order set out below). For example, just focusing on the mis-pricing, we can see that the Eraring submission option results in the same or less mis-pricing than the status quo under all possible constraints, while the Snowy proposal results in the same or more mis-pricing than the status quo (with the exception that the Snowy proposal mis-prices the Murray node while the status quo mis-prices the Tumut node when the constraints around the D-M-T loop bind).

	Constraint 1		Constraints 2-4		Constraint 5		Constraint 6	
Option:	Nodes Mis-priced	I/Cs non-Firm	Nodes Mis-priced	I/Cs non-Firm	Nodes Mis-priced	I/Cs non-Firm	Nodes Mis-priced	I/Cs non-Firm
D (Snowy)	NV, D, M	VIC-NSW	M	VIC-NSW	T	VIC-NSW	T, SN	VIC-NSW
A (Base case)	NV, D	VIC-SNY	T	VIC-SNY, SNY-NSW	None	None	SN	SNY-NSW
G (Split Region Option)	NV	VIC-MUR	M	MUR-TMT	None	None	SN	TMT-NSW
F (Eraring sub option)	NV, D	VIC-MUR	None	VIC-MUR, MUR-TMT	None	None	SN	TMT-NSW

10. However, to compare each of these proposals with the base case requires more in-depth analysis, as set out below.

11. As we will see, whether or not a given proposal is preferred over the base case depends on which constraints are binding (and in which direction). It may be that a given proposal is better when certain constraints are binding and worse when other constraints are binding. To

make an overall assessment we need to forecast which constraints will be binding under each of the proposals.

12. Examination of the constraints in Frontier's modelling carried out for the AEMC suggests that the following constraints are important:[1]

Constraint ID	Corresponding constraint in the simple network above	Binding in the following scenarios:
VH>V3NIL	1 (V-NV) Northerly	Base case and Snowy proposal
H>>H-64_K	4 (M-T)	Base case
N:H_LTUT	6 (SN-N) Southerly	Base case
HV_1900	1 (V-NV) Southerly	Eraring submission option and Snowy proposal

Constraint 1: Constraints within VIC

13. The formulation of the constraint equations to represent constraint labeled 1 (the intra-regional constraints in VIC) in the simple network above, are set out below. We can see that the formulation of the base case and the Eraring submission option are identical. Therefore, we would expect that the outcomes in these two cases would be identical. Furthermore, since there is (in practice) no generation at the Dederang node, these constraint equations are identical to the constraint equation for the Split Region option case:

Option	Formulation of V-NV limit constraint equation (northerly)
(1) Base case	$-z_{NV} - z_D + F_{VIC \to SNY} \leq K_1$
(2) Snowy proposal	$-z_{NV} - z_D + -z_M + F_{VIC' \to NSW'} \leq K_1$
(3) Eraring sub option	$-z_{NV} - z_D + F_{VIC \to MUR} \leq K_1$
(4) Split Region option	$-z_{NV} + F_{VIC \to MUR} \leq K_1$

14. As noted earlier, the constraint "VH>V3NIL", which is binding for a material number of hours in the Frontier model in the base case and the Snowy proposal, takes this form.

15. In all four cases, generators in northern VIC are paid the VIC price but are dispatched according to a (higher) local price – that is, they are constrained on. They have an incentive to prevent themselves being dispatched for an amount above the amount they are willing to be dispatched at the (lower) VIC RRP.

16. Under the Snowy proposal, Murray generation is also constrained on. If Murray is successful in preventing itself from being dispatched for more than the amount it wishes to be

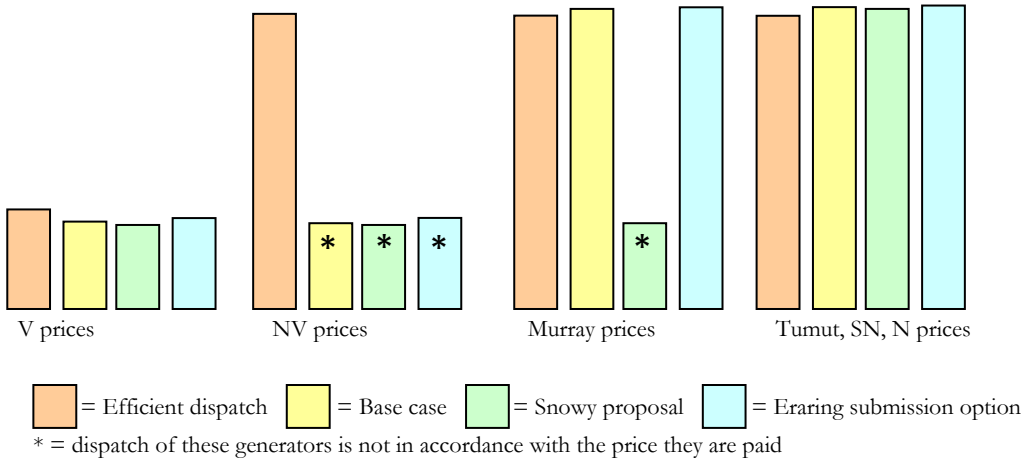
[1] There are other constraints which are more significant in the Frontier modelling, but these constraints do not affect generators in or around the Snowy region.

dispatched at the VIC RRP, the output of Murray will be lower in this case than in the base case, Eraring submission option, or Split Region option. Conversely, the output of generators north of Murray and in northern VIC will be somewhat higher.

17. If the lower output at Murray is offset by higher generation at Tumut and in the northern part of the NEM, this is inefficient, since the marginal cost of the additional generation at Tumut and the northern part of the NEM must be higher than the marginal cost of the Murray generation which is foregone. On the other hand, if the lower output at Murray is offset by higher generation in northern VIC, the relative efficiency depends on the level of the variable cost at Murray and at northern VIC.

18. The generators in northern VIC are predominantly small hydro generators. If we assumed that these generators have, on average a higher opportunity cost than Murray generation, it would follow that the Snowy proposal, by reducing the output of plant with lower opportunity cost, increases the overall dispatch cost (i.e., reduces efficiency).

Indicative price outcomes when constraint 1 (V-NV network limit) binds in the northerly direction



19. When the constraint binds in the southerly direction, generators in northern VIC are constrained off in all four cases. In the Snowy case, Murray generation is also constrained off. If Murray generation is successful at being dispatched to the amount it is willing to be dispatched at the higher VIC price, we would expect, therefore, that the Murray output would be higher than under the other three cases.

20. As before, if the higher output at Murray is offset by lower generation at Tumut and in the northern part of the NEM, dispatch efficiency is reduced for the reasons given earlier. On the other hand, if the higher output at Murray is offset by lower generation in northern VIC, the efficiency consequences depends on the relative level of the variable cost at Murray and at northern VIC.

21. As before, if we assume that the northern VIC generators have, on average a higher opportunity cost than Murray generation, it follows that the Snowy proposal, by increasing the output of plant with lower opportunity cost, increases efficiency.

22. As noted earlier, the constraint "HV_1900" is binding in the Frontier modelling for a material number of hours in the Split Region option and Snowy proposal. This constraint is similar to the southerly form of the equations set out above, except it does not include terms involving generators in northern VIC. When this constraint binds, higher output at Murray (in

the Snowy proposal) must be offset by lower generation at Tumut and in the northern part of the NEM, reducing overall dispatch efficiency.

23. Therefore, in both the cases of the "VH>V3NIL" and "HV_1900" the analysis suggests that the dispatch outcome in the Eraring submission option will be the same as the base case and in both cases the Snowy proposal will result is lower dispatch efficiency.

Constraint 4: Murray-Tumut constraint

24. The correctly-formulated constraint equations for the Murray-Tumut constraint (northerly direction) in the simple network above are set out below.

Option	Formulation of M-T limit constraint equation (northerly)
(1) Base case	$-\frac{2}{3}z_G - \frac{2}{3}z_{UT} - \frac{2}{3}z_{LT} - \frac{1}{3}F_{VIC\to SNY} + \frac{2}{3}F_{SNY\to NSW} \le K_4$
(2) Snowy proposal	$\frac{1}{3}z_M + \frac{1}{3}F_{VIC'\to NSW'} \le K_4$
(3) Eraring sub option	$-\frac{2}{3}z_G - \frac{1}{3}F_{VIC\to MUR} + \frac{2}{3}F_{MUR\to TMT} \le K_4$
(4) Split Region option	$\frac{1}{3}z_M - \frac{1}{3}z_G + \frac{1}{3}F_{MUR\to TMT} \le K_4$

25. As noted in the previous paper, when this constraint binds and flows are in the northerly direction on both the VIC-Snowy and Snowy-NSW interconnectors (or the VIC-Murray and Murray-Tumut interconnectors in the case of the Eraring submission option), negative settlement residues will automatically arise (on the VIC-Snowy or VIC-Murray interconnector, respectively). As mentioned earlier, I will assume that this results in clamping on the relevant interconnector. In particular, I will assume that this clamping occurs to the point and only to the point where the Murray-Tumut constraint no longer binds.

26. As noted earlier, various equations of this form are binding in the base case in Frontier's modelling and give rise to clamping. (As an aside, note that Frontier's modelling assumes that when clamping occurs, the interconnector flow is set to zero. The analysis here allows for a flow greater than zero, but sufficient to alleviate the constraint).

27. It is worth noting that, (ignoring Guthega output) in the base case and the Eraring submission case, the Murray-Tumut constraint can be written as:

$$\frac{2}{3}z_M + \frac{1}{3}F_{VIC\to SNY} \le K_4$$

28. So, (ignoring Guthega output) the impact of the clamping is to, in effect, change the relevant constraint equations to the following:

Option	Formulation of M-T limit constraint equation (northerly)
(1) Base case	$F_{VIC \to SNY} \leq 3K_4 - 2z_M$
(2) Snowy proposal	$\frac{1}{3} z_M + \frac{1}{3} F_{VIC' \to NSW'} \leq K_4$
(3) Eraring sub option	$F_{VIC \to MUR} \leq 3K_4 - 2z_M$
(4) Split Region option	$\frac{1}{3} z_M + \frac{1}{3} F_{MUR \to TMT} \leq K_4$

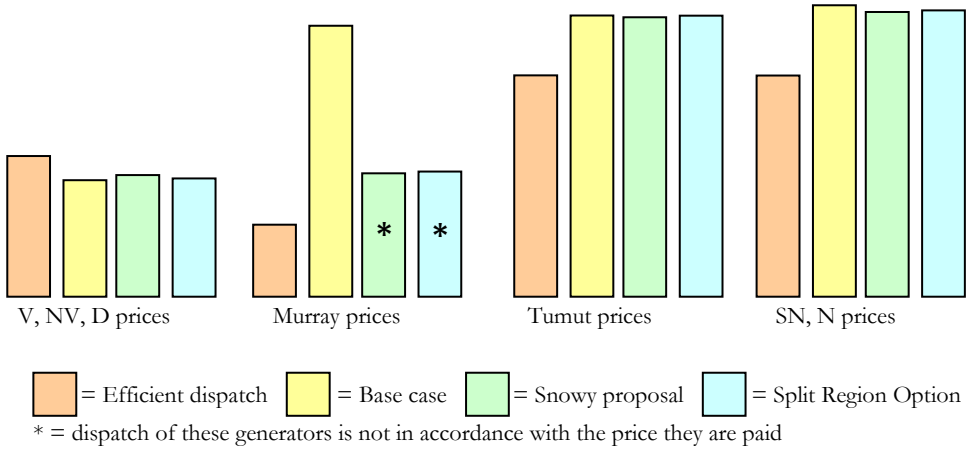
29. Since the VIC-Snowy (base case) and VIC-Murray (Eraring submission option) interconnectors represent the same notional set of generators, the outcomes under the base case and the Eraring submission option are identical. In both cases, Snowy Hydro can, by increasing its output at Murray, force the dispatch engine to reduce the exports from the southern part of the NEM and increase the increase the output in the northern part of the NEM. Since the Murray and Tumut prices are linked to the prices in the northern part of the NEM, we would expect that under these options, as long as the price in the northern part of the NEM is above the opportunity cost of Murray and Tumut plant, Snowy Hydro would have an incentive to increase the output at Murray to its maximum, in order to induce the M-T constraint to bind and in order to maximise the price it receives when the constraint does bind.

30. Similarly, since the VIC-NSW (Snowy) and Murray-Tumut (Split Region option) interconnectors represent the same division in the notional set of generators, the outcomes in the Snowy proposal and the Split Region option are identical. Under these Murray generation is paid a price corresponding to the price in the southern part of the NEM, but is dispatched at a level corresponding to its (lower) local price.

31. Since Murray is therefore "constrained off", Snowy Hydro would like to increase the output at Murray up to the level it would like to be dispatched at the southern NEM price. As with the base case, Eraring submission option, and Split Region option, Snowy Hydro has an incentive to increase the dispatch at Murray. However the extent to which Snowy Hydro would like to increase the dispatch at Murray depends, to an extent, on the southern NEM price. If the southern NEM price is low enough, Snowy Hydro may prefer not to increase the output of Murray. Under this circumstance it appears that the overall dispatch would be more efficient than the base case or the Eraring submission option.

32. Overall, this analysis suggests that when the Murray-Tumut constraint is binding in the northerly direction and NEMMCO responds with clamping on the VIC-Snowy (or VIC-Murray) interconnector, the Snowy proposal and the Split Region option will either have the same efficiency outcome as the base case/Eraring submission option or, in some circumstances, may be more efficient than the other options.

Indicative price outcomes when constraint 4 (M-T network limit) binds in the northerly direction



33. In the case where the Murray-Tumut constraint is binding in the southerly direction, negative settlement residues again arise on the VIC-Snowy (base case) or VIC-Murray (Eraring submission option) interconnector. In this case, I will assume that the response of NEMMCO is to reorient the constraint equations to Dederang. In this case, therefore, the constraint equations are as follows:

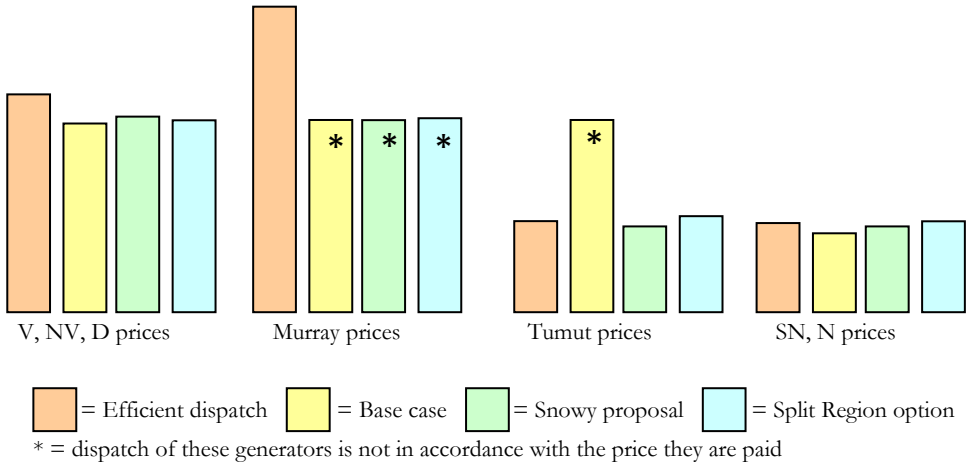
Option	Formulation of M-T limit constraint equation (southerly)
(1) Base case	$-\frac{1}{3}z_M + \frac{1}{3}z_G + \frac{1}{3}z_{UT} + \frac{1}{3}z_{LT} - \frac{1}{3}F_{SNY'\rightarrow NSW} \leq K_4$
(2) Snowy proposal	$-\frac{1}{3}z_M - \frac{1}{3}F_{VIC'\rightarrow NSW'} \leq K_4$
(3) Eraring sub option	$-\frac{1}{3}z_M + \frac{1}{3}z_G - \frac{1}{3}F_{MUR\rightarrow TMT} \leq K_4$
(4) Split Region option	$\frac{1}{3}z_M - \frac{1}{3}z_G + \frac{1}{3}F_{MUR\rightarrow TMT} \leq K_4$

34. As before, ignoring Guthega output, the outcomes under the Snowy proposal, Eraring submission option and Split Region option are the same; the question is whether these outcomes are more or less efficient than the base case. In the base case there is also mis-pricing at Tumut. In fact, Tumut generation is constrained off – it is paid the price that prevails in the southern part of the NEM but is dispatched to a level consistent with its lower local price. If Tumut generation is successful at increasing its dispatch up to the level it would like to be dispatched at the price it receives, the output of some other generation must be reduced.

35. The other generation whose output is reduced is either the generation at Murray, in the southern part of the NEM, or in NSW. If the generation whose output is reduced is in NSW or the southern part of the NEM, there is a reduction in efficiency, for the reasons discussed above. If the generation whose output is reduced is at Murray, there is substitution of Tumut for Murray generation. If we assume that Tumut and Murray generation has a similar opportunity cost, it follows that there is no loss in efficiency of dispatch.

36. Overall, therefore, when the Murray-Tumut constraint binds in the southerly direction, and NEMMCO responds with reorientation, it appears that the efficiency of dispatch under the Eraring submission option and Split Region option is the same as the Snowy proposal and both are either as efficient or less efficient than the base case.

Indicative price outcomes when constraint 4 (M-T network limit) binds in the southerly direction



Constraint 5: Limits between Tumut and NSW

37. Under the base case, Split Region option and Eraring submission option, the limits between Tumut and NSW are efficiently represented in the dispatch engine – that is, they do not lead to any mis-pricing at any generator connection points and the settlement residues are firm. However, under the Snowy proposal, as noted in the previous paper, (and as can be seen from the constraint equation below) when these constraints bind in the northerly direction, Tumut generation is constrained off and the VIC-NSW residues are not firm.

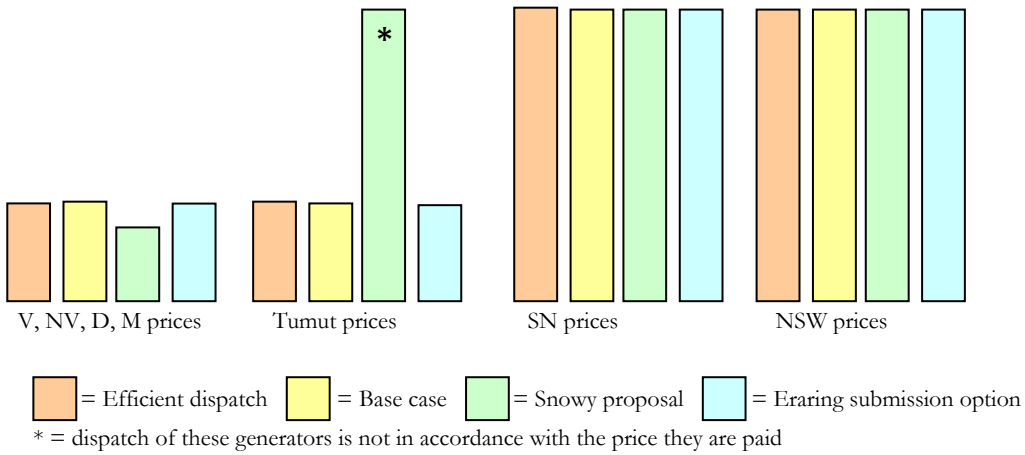
Option	Formulation of T-SN limit constraint equation (northerly)
(1) Base case	$F_{SNY \to NSW} \leq K_5$
(2) Snowy proposal	$z_G + z_{UT} + z_{LT} + F_{VIC' \to NSW'} \leq K_5$
(3) Eraring sub option	$F_{TMT \to NSW} \leq K_5$
(4) Split Region option	$F_{TMT \to NSW} \leq K_5$

38. Under the Snowy proposal, when this constraint binds in the northerly direction, Tumut generation has an incentive to try to increase its output up to a level consistent with the level it would like to be dispatched at the NSW RRP. If it is successful at achieving this, the dispatch engine must respond by reducing the output of generators in the southern part of the NEM.

39. The result is that under the Snowy proposal, additional Tumut generation displaces generation in the lower part of the NEM. This is always inefficient for the reasons given above

(the marginal cost of the additional Tumut output exceeds the marginal cost of the generation foregone in the southern NEM). We can conclude that when these limits bind in the northerly direction, the Snowy proposal yields a less efficient dispatch than the base case, Split Region option or the Eraring submission option.

Indicative price outcomes when constraint 5 (T-SN network limit) binds in the northerly direction



40. Conversely, when this limit binds in the southerly direction, Tumut generation is constrained on under the Snowy proposal. This causes Tumut generation to try to reduce its output to a level consistent with the price it receives (the NSW RRP). If Tumut is successful at doing so, this reduction in output must be met by an increase in output in the lower part of the NEM. For the reasons given above, this always reduces the efficiency of dispatch.

41. Overall, the Snowy proposal yields less efficient dispatch than the base case, Split Region option or the Eraring submission option when this constraint binds in the northerly or the southerly direction.

42. Does this conclusion change when we consider the possibility that generators in NSW might have market power? Under the simple network above, when constraints between Tumut and NSW bind, it is not possible for any increase in flow into NSW. Therefore, even though Tumut is constrained off in the Snowy proposal and bids $-1000, this has absolutely no impact on the NSW price. In other words, even if the baseload generators in NSW have market power, under the Snowy proposal it is not the case that this market power could be mitigated by increased output at Tumut.

43. However, as noted before, the simple network above does not accurately reflect the complexities of the physical network in the NSW region. In particular, the NSW region features a large loop (the "western ring") rather than a simple linear network as in the network above. One of the implications of this is that under the Snowy proposal, when the generators in NSW exercise market power, it may be that when Tumut generation offers its output at $-1000, the dispatch engine is able to increase the flow from Tumut to the NSW regional reference node. This would have the effect of moderating the extent to which the generators in NSW could exercise market power.

Constraint 6: Constraints within NSW

44. The constraint labeled constraint 6 in the simple network model of the earlier paper reflects a hypothetical network limit within the NSW region. The correctly-oriented form of this network limit for the northerly direction is set out below.

Option	Formulation of SN-N limit constraint equation (northerly)
(1) Base case	$F_{SNY \to NSW} + z_{SN} \leq K_6$
(2) Snowy proposal	$z_G + z_{UT} + z_{LT} + F_{VIC' \to NSW'} + z_{SN} \leq K_6$
(3) Eraring sub option	$F_{TMT \to NSW} + z_{SN} \leq K_6$
(4) Split Region option	$F_{TMT \to NSW} + z_{SN} \leq K_6$

45. We can see that the formulation of constraint 6 is the same under the base case, the Eraring submission option, and the Split Region option so these three options yield the same pricing, dispatch and hedging implications when this constraint binds. The question for us is whether or not these outcomes will be more or less efficient than the outcomes under the Snowy proposal.

46. When this constraint binds it is efficient for generation located close to the NSW RRP to be dispatched (even if that generation is more expensive), increasing the NSW RRP, while NSW generation located on the wrong side of the constraint, and all other generation in the rest of the southern part of the NEM to be dispatched to a level consistent with a lower price. The pricing outcomes are illustrated in the diagram below.

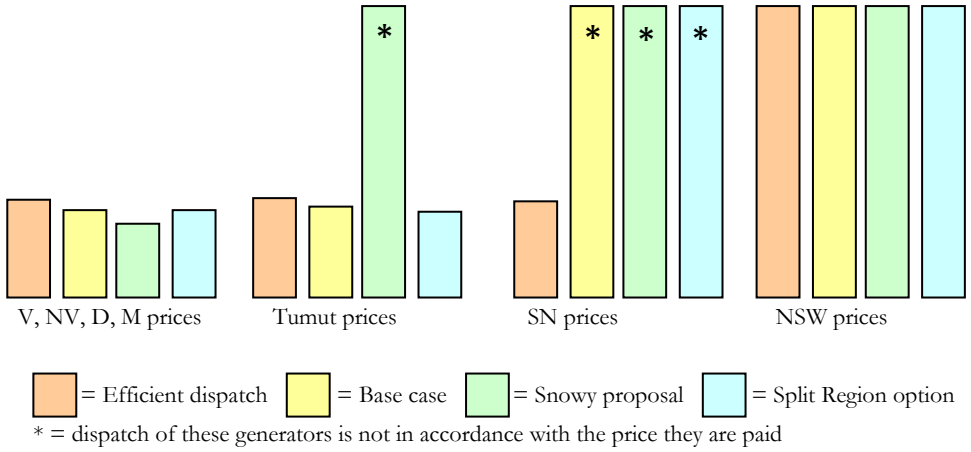
47. Under the base case, Split Region option and the Eraring submission option, the remote intra-regional generators in NSW are "constrained off" – that is, they are paid the NSW RRP, but are dispatched to a level consistent with a lower price. These generators therefore have an incentive to bid inflexible, reduce their ramp rates or to offer their output at $-1000/MWh. If these generators, by distorting their bids in this way, are successful at increasing their dispatch to a level consistent with the NSW RRP, the constraint equations above show that the dispatch engine must respond by reducing the flow on the Snowy-NSW (base case) or Tumut-NSW (Eraring sub/Split Region options) interconnector. The dispatch engine can do this by reducing the price paid to generation in the Snowy region and the southerly part of the NEM below the efficient level.

48. In effect, under the base case, Split Region option and the Eraring submission option, when this constraint binds, the output of remote intra-regional generation in NSW is increased while the output of generators in Snowy and the southern part of the NEM is decreased relative to the efficient level. This reduces the overall dispatch efficiency (since the marginal cost of generators whose output is increased is higher than the marginal cost of generators whose output is decreased; since higher-marginal-cost generation is displacing lower-marginal-cost generation, this is inefficient relative to a hypothetical efficient dispatch outcome).

49. It is theoretically possible that the remote intra-regional generators in NSW are able, by distorting their bids, to increase their output to the point where the flow on the Snowy-NSW (base case) or Tumut-NSW (Eraring sub/Split Region options) interconnector is reversed, giving rise to negative settlement residues. At this point NEMMCO would be forced to intervene by

clamping the flow on the Snowy-NSW or Tumut-NSW interconnector. This intervention would limit the magnitude of the inefficiency in dispatch that could result from this mis-pricing.

Indicative price outcomes when constraint 6 (SN-N network limit) binds in the northerly direction



50. Now consider the implications of the Snowy proposal. Under this proposal, (as we can see from the constraint equation above) when this limit binds, not only remote intra-regional generation in NSW but also Tumut generation is constrained off. Therefore, in addition, Tumut generation has an incentive to distort its bid in order to increase its dispatch up to a level consistent with the NSW RRP. As Tumut increases its output, the output of the other remote-intra-regional generators in NSW, and the output of generators at Murray and the remainder of the southern part of the NEM, must reduce.

51. There are therefore two effects of moving from the base case/Eraring submission option to the Snowy proposal. Such a move would (a) increase the output at Tumut, (b) offset by a reduction in either or both (i) the output of generators at Murray and in the Southern part of the NEM; or (ii) the other mis-priced remote intra-regional generators in NSW.

52. To the extent that the increased output at Tumut is offset by a reduction in output in the southern part of the NEM, this directly reduces dispatch efficiency relative to the base case or the Eraring submission case (since, as we have already seen, the extra output occurs at a marginal cost greater than the efficient southern-NEM price, while the reduction in output occurs at a marginal cost lower than the efficient southern-NEM price).

53. To the extent that the increased output at Tumut is offset by a reduction in output by the remote intra-regional generators in NSW, this may or may not reduce overall dispatch efficiency. Dispatch efficiency will be reduced if and only if the variable cost of Tumut generation is larger than the variable cost of the displaced remote intra-regional generation in NSW.

54. It is plausible that the opportunity cost of Tumut generation is higher than the average variable cost of the generators in NSW (which are predominantly base-load coal-fired power stations). If we assume that the Tumut variable cost is higher than the variable cost of the generation it displaces in NSW it follows that the Snowy proposal is less efficient than either the base case, Split Region or Eraring submission options in terms of short-term dispatch efficiency.

55. Furthermore, to the extent that the mis-pricing at Tumut that arises under the Snowy proposal inefficiently induces a generator (including Snowy Hydro) to locate or expand its output in the Tumut region, relative to a location in the southern part of the NEM, the dynamic efficiency of the NEM is also reduced relative to the base case, Split Region option or the Eraring submission options. The overall conclusion is that when this constraint binds in the northerly direction, the base case and the Eraring submission option will likely yield a more efficient outcome than the Snowy proposal.

56. When the same constraint is binding in the southerly direction we find that, under the Snowy proposal, Tumut generation is paid the lower NSW price, but is dispatched according to the higher VIC price – that is, Tumut generation is constrained on. If Tumut is successful at reducing its generation to the level it is willing to produce at the NSW price, the corresponding reduction in output must be offset by an increase in output either in the southern part of the NEM or by a remote intra-regional generator in NSW.

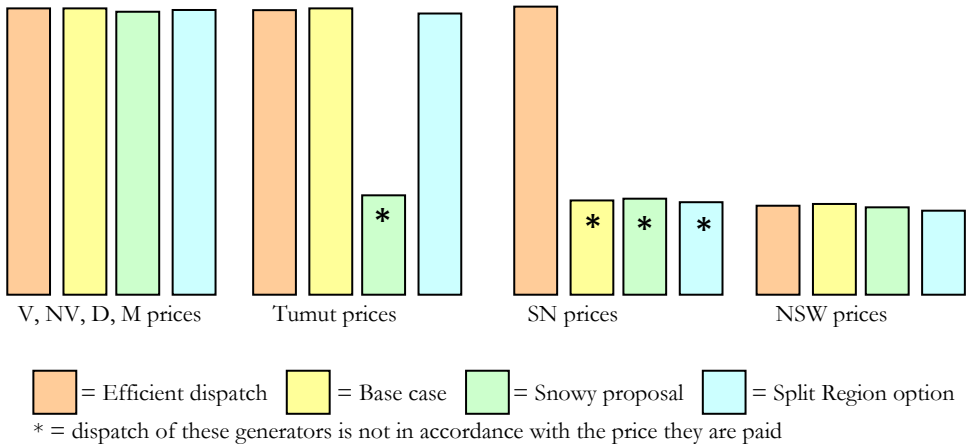
57. As before, to the extent that Tumut's reduction in output is offset by increased output in the southern part of the NEM, overall dispatch efficiency is reduced. On the other hand, if Tumut's reduction in output is offset by remote intra-regional generation in NSW, dispatch efficiency increases (assuming, as before, that Tumut's variable cost is higher than the remote-intra-regional baseload generation in NSW).

58. Again, there are also longer term dynamic efficiency effects due to location signals. To the extent that a generator is deterred from locating at Tumut relative to Murray, this is less efficient than the base case/Eraring submission option.

59. Earlier we noted that the equation "N:H_LTUT" (which is binding for a material number of hours in the base case in the Frontier modelling) takes the form of this constraint 6 for the southerly direction. However inspection of this constraint shows that the other generators that are constrained are not the baseload generators in NSW but generators such as the Hunter Valley GT, Shoalhaven, Blowering and Hume (NSW). In this case it may well be that these generators are higher cost than Tumut generation.

60. Overall, the analysis suggests that when constraint 6 binds, the outcome in the base case proposal, Split Region option and the Eraring submission option will be the same. In comparison, the Snowy proposal will lead to higher output at Tumut in the northerly direction, and lower output at Tumut in the southerly direction. If we assume that Tumut variable cost is lower than the variable cost of the displaced generation in NSW, this increases dispatch efficiency in the northerly case, and lower dispatch efficiency in the case of southerly flows.

Indicative price outcomes when constraint 6 (SN-N network limit) binds in the southerly direction



Conclusion

61. The following table summarises the results above. The table indicates whether, on the basis of the analysis carried out here, it is possible to state whether the given proposal is an improvement on the base case (represented by a +), likely to be worse than the base case (represented by a -) or the same as the base case (represented by 0).

	Northerly			Southerly		
Constraint	**Snowy**	**Eraring Sub**	**Split Region**	**Snowy**	**Eraring Sub**	**Split Region**
1. V-NV	- **	0	0	+**	0	0
4 M-T	+	0	+	+	+	+
5 T-SN	-***	0	0	-	0	0
6. SN-N	+ *	0	0	-*	0	0

* depends on assumption about Tumut cost relative to NSW cost
** depends on assumptions about Murray cost relative to northern VIC
*** if generators in NSW exercise market power it is theoretically possible that their market power could be mitigated by increased output from Tumut in this case.

62. In the light of the constraints identified by the Frontier modelling, it would appear that in the case of the constraints VH>V3NIL, N:H_LTUT, and HV_1900. The Split Region option should yield the same outcomes as the base case and the Snowy proposal should yield outcomes worse than the base case. In the case of the Murray-Tumut constraint, however, both the Snowy proposal and the Split Region option should yield outcomes better than the base case, due to the elimination of clamping in the northerly direction.

63. If the elimination of clamping yielded large enough dispatch efficiency benefits it would follow that these proposals could be ranked with the Snowy proposal better than the base case and the Split Region better than the Snowy proposal. This analysis is therefore potentially

consistent with the Frontier analysis, which roughly shows that the Split Region Option is preferred over the Snowy proposal, which is preferred over the base case.

64. It is important to recognise that none of these options are necessarily better than the current market arrangements. As already noted, the current market arrangements (including the CSP/CSC trial and the southern generators' proposal for managing negative settlement residues) were not considered under any of the options above. It is possible that these arrangements would emerge as preferred over any of the options above. Similarly, these options are not necessarily better than the Macquarie Generation proposal which has not been analysed here.

65. Finally, as emphasised in the earlier paper, there are other options available which solve both the pricing and hedging problems under all constraint scenarios and therefore would emerge as preferred to any of the options mentioned above. These options have not been described or analysed here.

Appendix: Constraint 2: Dederang-Murray constraint

66. The correctly-formulated constraint equations for the Dederang-Murray constraints (northerly direction) are set out below.

Option	Formulation of D-M limit constraint equation (northerly)
(1) Base case	$\frac{1}{3}z_G + \frac{1}{3}z_{UT} + \frac{1}{3}z_{LT} + \frac{2}{3}F_{VIC\to SNY} - \frac{1}{3}F_{SNY\to NSW} \le K_2$
(2) Snowy proposal	$-\frac{2}{3}z_M + \frac{1}{3}F_{VIC'\to NSW'} \le K_2$
(3) Eraring submission option	$\frac{1}{3}z_G + \frac{2}{3}F_{VIC\to MUR} - \frac{1}{3}F_{MUR\to TMT} \le K_2$
(4) Split Region option	$\frac{1}{3}z_G - \frac{2}{3}z_M + \frac{1}{3}F_{MUR\to TMT} \le K_2$

67. From the above constraint equations we can see that, when this constraint binds and flows are in the northerly direction on both the VIC-Snowy and Snowy-NSW interconnectors (or the VIC-Murray and Murray-Tumut interconnectors in the case of the Eraring sub option), negative settlement residues will automatically arise on the Snowy-NSW (base case) or Murray-Tumut (Eraring sub/Split Region options) interconnector. As in the discussion of the Murray-Tumut constraint, I will assume that this results in clamping on the relevant interconnector. As before, I will assume that this clamping occurs to the point (and only to the point) where the Dederang-Murray constraint no longer binds.

68. As before, in the base case and the Eraring submission option, the Dederang-Murray constraint for the northerly direction can be written as:

$$-\frac{2}{3}z_M + \frac{1}{3}F_{SNY\to NSW} \le K_2$$

69. So, ignoring Guthega output, the impact of the clamping is to, in effect, change the relevant constraint equations to the following:

Option	Formulation of D-M limit constraint equation (northerly)
(1) Base case	$F_{SNY\to NSW} \le 3K_2 + 2z_M$
(2) Snowy proposal	$-\frac{2}{3}z_M + \frac{1}{3}F_{VIC'\to NSW'} \le K_2$
(3) Eraring sub option	$F_{MUR\to TMT} \le 3K_2 + 2z_M$
(4) Split Region option	$-\frac{2}{3}z_M + \frac{1}{3}F_{MUR\to TMT} \le K_2$

70. By inspection of these constraint equations we can predict that, for a given level of output at Murray, the outcomes under the Snowy proposal, Split Region option and the Eraring submission option will be the same. For a given level of output at Murray, both proposals will result in exactly the same dispatch and pricing outcomes at all the locations in the NEM. In the base case, however, Tumut generation will receive the same price as Murray and the southern

part of the NEM. Therefore, for a given level of output at Murray, the primary difference between the outcomes is that in the base case, the Tumut price will be lower, leading to lower output at Tumut, and slightly higher prices and output in the northern part of the NEM.

71. This reduction in Tumut output and increase in output in the northern part of the NEM reduces the overall efficiency of dispatch (since the reduction in output at Tumut reduces the output of generation with a marginal cost below the efficient level and replaces it with generation with a marginal cost above the efficient level).

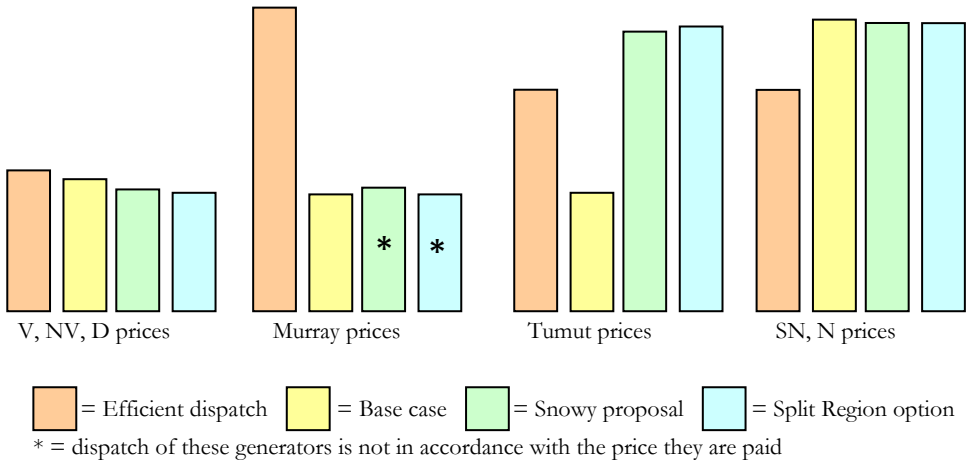
72. In summary, for a given level of output at Murray, the base case results in a lower efficiency than either the Snowy proposal, Split Region option or Eraring submission option.

73. But will the same level of output at Murray arise under the three options? Under the base case, a reduction in output at Murray allows for increased flow from Snowy to NSW, increasing price at Murray and Tumut. Therefore, under the base case we would expect that Snowy Hydro would have an incentive to keep the output at Murray low, to prevent the constraint binding in the northerly direction and to keep the price at Murray and Tumut price high in the event the constraint does bind.

74. The situation for the Snowy proposal, Split Region option and Eraring submission option is a little more complicated. In both cases, a reduction in the output at Murray allows for more flow from the region from Murray south to the region from Tumut north. This would be likely to raise the price at Murray and reduce the price at Tumut. Whether or not Snowy Hydro benefits from such a move depends on its relative output at Murray and Tumut.

75. Overall, the efficiency consequences are difficult to judge. We would expect that the base case would result in lower dispatch at Tumut than the other cases, but it is not clear whether lower dispatch at Tumut is more or less efficient. The inappropriate representation of the underlying network limit (which applies in all of the cases, due to clamping or the design of the region boundaries) yields a dispatch at Tumut which is inefficiently high and a dispatch at Murray which is inefficiently low. It may be that a reduction in the dispatch at Tumut and an increase in the dispatch at Murray would improve overall dispatch efficiency.

Indicative price outcomes when constraint 2 (D-M network limit) binds in the northerly direction



76. Let's now look at the case where the Dederang-Murray constraint binds in the southerly direction. As before, when this constraint binds in the southerly direction, negative settlement residues arise on the Snowy-NSW (base case) and Murray-Tumut (Eraring sub option)

interconnectors. Let's assume that NEMMCO responds by clamping these interconnectors. The constraint equations are now:

Option	Formulation of D-M limit constraint equation (southerly)
(1) Base case	$-F_{SNY \to NSW} \le 3K_2 - 2z_M$
(2) Snowy proposal	$\frac{2}{3} z_M - \frac{1}{3} F_{VIC' \to NSW'} \le K_2$
(3) Eraring sub option	$-F_{MUR \to TMT} \le 3K_2 - 2z_M$
(4) Split Region option	$\frac{2}{3} z_M - \frac{1}{3} F_{MUR \to TMT} \le K_2$

77. As before, for a given level of output at Murray, all four cases will result in the same dispatch outcomes, with the exception of the base case, which yields a price for Tumut output which is inefficiently high. Unfortunately, as before, it is not clear that reducing the price for Tumut output will result in more efficient dispatch.

Indicative price outcomes when constraint 2 (D-M network limit) binds in the southerly direction