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Report to

Southern Generators Coalition

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NATIONAL ELECTRICITY MARKET DEVELOPMENT

Analysis of the AEMC Draft Rule Determination to Abolish Snowy Region – Appendix A Modelling

3 April 2007

VERSION HISTORY

Version History		
Version Number	**Date**	**Description**
0.5	27-02-2007	Initial draft
1.0	02-03-2007	Initial Complete Report
1.1	14-03-2007	Update – Revised SHP cases due to error in VIC-NSW IRLF equation. Additional commentary.
1.2	22-03-2007	Update – Revised BAU case due to accuracy improvement in Clamping calculation.
1.5	03-04-2007	Final Report

3 April 2007

EXECUTIVE SUMMARY

The Southern Generators Coalition (SGC) has requested a review of the proposed Snowy Regional boundary change, which was recently the subject of a Draft Rule determination by the Australian Energy Market Commission (AEMC). ROAM Consulting (ROAM) has conducted a replication exercise of the modelling undertaken by the AEMC and its consultants, Frontier Economics (Frontier) in response to the requested review.

The configuration options assessed by the AEMC were:

1. The existing Business As Usual (BAU) regional boundaries including the Snowy region, excluding implementation of the CSP/CSC Trial and Southern Generators' Rule changes. Instead interconnector 'clamping' is implemented in the BAU case;
2. The Snowy Hydro Proposal (SHP), excluding clamping intervention to avoid negative settlement residues. In this case it is assumed that negative settlement residues are negligible following the abolishing of the Snowy region; and
3. The Split Region proposal with Dederang (SRD) included in the Murray region and set as the Murray regional reference node.

ROAM has replicated the above three options, together with two additional sensitivity cases. They are: an alternative BAU case representing the present situation in 2007 with the existing regional configuration and allowance for CSP/CSC and Southern Generators' Rule settlement adjustments; and, an alternate Snowy Hydro proposal, including clamping intervention to avoid negative settlement residues. They are labelled as follows:

- Business as usual with CSP/CSC and Southern Generators' Rule (BAU-CSP); and
- Snowy Hydro Proposal with clamping (SHP-CLAMP).

ROAM's modelling includes modelling of typical Snowy Hydro bidding and implementation of strategic bidding behaviour for the Snowy Hydro plant as described in the AEMC Draft Determination. A summary of outcomes from ROAM's modelling is presented and contrasted with the Frontier modelling documentation.

ROAM's ranking of the options (for typical Snowy Hydro bidding) in terms of decreasing annual NEM cost is:

Case	NEM Cost ($millions)
BAU	2,098.8
BAU-CSP	2,096.7
SHP	2,096.7
SHP-CLAMP	2,096.5
SRD	2,096.5

ROAM's ranking of the options (after Snowy Hydro strategic bid optimisation) in terms of decreasing annual NEM cost is:

Case	NEM Cost ($millions)
SRD	2,095.8
SHP-CLAMP	2,094.8
SHP	2,094.7
BAU	2,094.0
BAU-CSP	2,093.7

Here it can be seen that the relative ranking of the scenarios changes due to the different impacts of strategic bidding. The preferred alternative in terms of NEM efficiency is the BAU-CSP case, i.e. the present situation. The BAU case with clamping is the next most efficient, at around $0.34m/a higher cost. The Snowy Hydro proposal with clamping, which is the likely implementation option for the Snowy Hydro proposal, has an estimated $1.16m/a higher total NEM production cost than the present situation.

Frontier's modelling concluded that the BAU case is approximately $2.0m less efficient in terms of NEM dispatch costs than the SHP case. ROAM's modelling conflicts with this conclusion. ROAM's analysis concludes that the Business-As-Usual case provides a more efficient outcome than the Snowy Hydro Proposal by approximately $0.7million per annum.

Similarly, Frontier's conclusions were that the Split Region case (SRD) improved NEM efficiency by approximately $3.5m. ROAM does not support this conclusion, with a NEM efficiency loss of $1.8m under the SRD proposal.

ROAM's analysis of the two other cases not included in the Frontier work for the AEMC is significant. The BAU-CSP case shows the comparable NEM dispatch costs when clamping is not used to manage the accumulation of negative settlements. The current Tumut CSP / CSC rules instead have been calculated in order to model the current NEM dispatch scenario. NEM dispatch costs are lowest in this case of the five cases modelled, at approximately $2,093.7m per annum.

We consider the SHP-CLAMP case to be the most likely implementation of the Snowy Hydro Proposal, with NEMMCO implementing clamping to reduce the accumulation of negative settlements residues. ROAM has concluded that the SHP-CLAMP case has a total NEM cost of approximately $2,094.8m per annum, $0.8m less efficient than the BAU case (which also invokes clamping), and approximately $1.2m less efficient than the BAU-CSP case.

The Frontier analysis relied heavily on the results of a single demand point as far as the accumulation of efficiency benefits to either the SHP or SRD cases. 'Demand Point 29' (DP29) represented a period of relatively high NEM demand, particularly Victorian and South Australian demand. Across 17520 periods, the ROAM analysis has identified a reasonable number of periods which can be considered to approximately model the dispatch under Frontier's DP29. ROAM however has been unable to associate the efficiency benefits identified by Frontier to these periods. Loads close to Frontier's DP29 were periods of generally higher, or the same, NEM costs as compared with the NEM costs for the BAU case.

ROAM concludes that NEM loads around DP29 do not provide a significant benefit to Snowy Hydro for strategic withdrawal of capacity in the BAU case, nor strategic supply of higher capacity in the SHP case. We did however find that the benefits were accrued over a wider range of loads due to this general type of behaviour from the Snowy Hydro plant in the presence of clamping in the BAU case, but mainly during summer period high load conditions.

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1) INTRODUCTION

The Australian Energy Market Commission (AEMC) has recently published a Draft Rule Determination on the Snowy Hydro Limited proposal for a regional boundary change. Snowy Hydro has proposed that the Snowy region be abolished, and that the Tumut plant be included in the New South Wales Region, and the Murray and Guthega plant become a part of the Victorian Region. Frontier Economics (Frontier) undertook modelling work as consultants to the AEMC to compare the Snowy Hydro Proposal with the existing regional boundaries.

The AEMC concluded that the Snowy Hydro boundary change proposal is likely to promote stronger competition in the NEM, leading to more efficient dispatch of generators, lower and more cost-reflective pricing and enhanced opportunities and incentives for inter-regional trading. The Southern Generators Coalition (SGC) has requested ROAM Consulting (ROAM) to advise whether, if the assumptions are different, would the outcomes be different from those identified by the AEMC. The major benefit to the Rule change, according to the analysis completed as part of the Draft Rule Determination document, is the removal of interconnector 'clamping'. However if clamping is removed (with the application of CSP/CSC and also the Southern Generators rule), in SGC's view then there is no benefit.

2) SCOPE OF WORK

This assessment concentrates on one particular financial year, which has been selected to be 2008-09, which will provide an outlook which is representative of several future years ahead. It is also the middle year of Frontier's modelling. The 2-4-C market forecasting software[1] has been used to model the whole NEM on a half hourly basis to replicate, as far as possible in the limited time frame available, the description of the modelling undertaken by Frontier in support of the AEMC's draft determination.

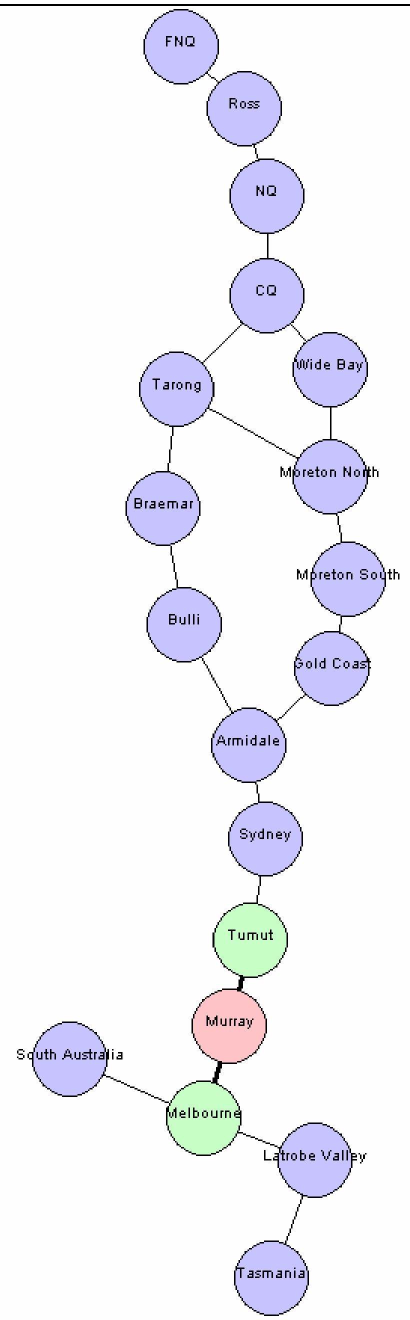
The purpose is to replicate and validate or otherwise the basis upon which the AEMC reached its draft decision to accept the Snowy Hydro proposal. The SGC's initial assessment of the determination has revealed several key issues warranting further investigation, involving the following steps:

- Repeat modelling with CSP/CSC trial system in place: The modelling appears to have also considered that where the Murray-Tumut constraint is binding, that the proposal will more efficiently price Tumut generation compared to a base case where Tumut is priced at the Murray node. However the present "interim" arrangements include a CSP/CSC trial system at Tumut which accurately prices Tumut, yet does not appear to have been considered as an alternative. ROAM has been asked to consider that had the "interim" arrangements been considered as the alternative, to what extent would this have altered the conclusion.
- Repeat modelling with "Southern Generators' Rule Change" in place: This should address the Inter-regional Settlement Residue (IRSR) "clamping" issue. ROAM has been asked to consider were this arrangement used as the base-case what difference to the conclusion would have been reached.

[1] This software has been used on behalf of NEMMCO to establish minimum reserve levels for all regions of the NEM since 2004.

- Determine whether physical constraints that exist between Tumut and Sydney and between Melbourne and Murray have been adequately assessed by the AEMC in light of the existing interim arrangements of the CSP/CSC trial.
- The Snowy Hydro Proposal requires using static loss factors for Murray (against VIC RRN) and for Tumut (against NSW RRN) which, due to the large distances and flow variances, should result in some mispricing (see Hydro Tasmania submission). In the existing, interim, Eraring and Macquarie generation proposals however dynamic loss factors are used. ROAM is asked to consider whether Frontier has satisfactorily included this matter in its modelling and if not, whether it would have influenced the conclusion by the AEMC.
- Examination of 'demand point 29' (DP29) in the Frontier modelling. This demand point is given a strong weighting in the calculation of the benefits associated with Business As Usual (BAU) cases as modelled by Frontier vs the Snowy Hydro Proposal. ROAM is asked to consider whether the AEMC has given appropriate weight to this matter, whether the results would be different under different assumptions and if so, whether it would have influenced the conclusion.

Figure 3.1 – 2-4-C Zonal Interconnected Model



3) 2-4-C SIMULATION MODEL AND GENERAL ASSUMPTIONS

3.1) 19 ZONE INTERCONNECTED MODEL OF THE NEM

For this project, ROAM has applied a 19 zone model of the NEM incorporating:

- 11 zones in QLD;
- 2 zones in NSW
- 2 zones in Snowy;
- 2 zones in VIC;
- 1 zone in SA; and
- 1 zone in Tas.

The underlying zonal structure and network topology of the NEM is maintained for all regional development options considered.

For alternative regional development proposals the zones have been re-allocated to the appropriate regions and the LP constraint equations have been modified according to the different constraint equation sets.

3.2) TRANSMISSION

All interconnector limit equations have been modelled in the market simulations as published in the 2005 Annual National Transmission Statement (ANTS) workbook. This is consistent with the description in the AEMC draft determination.

Transmission limit equations for the Snowy Hydro Proposal and the Split Region-Dederang Proposal have also been applied consistently with the description in the AEMC draft determination, using data obtained from the AEMC.

3.3) DYNAMIC INTER-REGIONAL AND STATIC MARGINAL LOSS FACTORS

All dynamic and static loss factors for the various regional development proposals have been modelled in the market simulations.

As the regional reference nodes for the Snowy Hydro generators change between the models, a different set of generator marginal loss factors is applied to the Snowy Hydro generators in each model.

The Inter-Regional Loss Factor (IRLF) equations and static Marginal Loss Factors (MLF) for the Business As Usual cases were taken directly from the 'List of Regional Boundaries and Marginal Loss Factors for the 2006/07 Financial Year' document from NEMMCO.

For the Snowy Hydro Proposal model and the Split Region-Dederang Proposal model we applied the alternate IRLFs and MLFs provided by the AEMC.

The differences in the IRLFs between the models also take into account the 'new' interconnectors. The Snowy Hydro Proposal model has a newly formulated IRLF applied to the Victoria to New South Wales interconnector, with the New South Wales reference node referred to the Victoria reference node. For the Split Region-Dederang Proposal model, the present IRLF for New South Wales to Snowy is applied to the 'new' New South Wales to Tumut interconnector. For the Dederang (Murray region) to Tumut interconnector a lossless model was applied. A new IRLF was formulated for the Victoria to Dederang interconnector, as provided by the AEMC.

3.4) DEMAND AND ENERGY FORECASTS

ROAM has developed half hourly load trace forecasts for the NEM corresponding with the 2006 NEMMCO SOO Medium economic growth, 50% Probability of Exceedence (M50) forecasts for regional energy and demand. The 2005-06 historic load trace has been used as the reference for developing the 2008-09 year forecast load traces.

3.5) GENERATOR BIDDING BEHAVIOUR

3.5.1) All NEM Plant excluding Murray and Tumut Power Stations

ROAM completed a detailed NEM reliability assessment on behalf of NEMMCO to establish regional minimum reserve levels in 2006 (2006 MRL studies). The data set applied in the 2006 MRL studies has been scrutinised and replicated by NEMMCO. The data set is detailed in the Assumptions Report for the 2006 MRL studies and is available from the NEMMCO website[2]. Given the time constraints for completing this study, and in the interest of transparency of data availability, ROAM has used the generator SRMC and LRMC data and bidding behaviour adopted for the MRL studies, including management of hydro and other energy limited plant throughout the NEM. The general bidding behaviour of NEM plant is described below.

All existing and assumed new entry thermal generators have been bid into the market as follows:

<u>Baseload plant</u>

Bid minimum generation level at $0.

Bid remainder of plant capacity at SRMC.

<u>Intermediate plant</u>

Bid full capacity at SRMC.

<u>Peaking plant</u>

Bid full capacity at LRMC.

It is noted that the bidding behaviour adopted here is a minor departure from the Frontier Economics (Frontier) studies undertaken for the AEMC which state that a bid price of five times SRMC has been applied for all peaking plant. However, this generally gives bidding prices in the same range as LRMC for those plants.

Energy limited plant including all NEM hydro plant has been bid into the market according to long term average operating profiles. To achieve this, energy limited plant is bid into the market at a very low price (between $0 to $5/MWh) for the capacity that would historically be dispatched within each half hour of the year. The remaining capacity is bid into the market at a high price, (around $500/MWh) and so remains available for reliability purposes, but generally is not called on to run, except for situations when interconnector and intra-connector constraints are binding, given the rest of the NEM plant is mainly bidding below $500/MWh.

[2] http://www.nemmco.com.au/powersystemops/240-0020.htm

3.5.2) Murray and Tumut Strategic Bidding

As described in the Frontier modelling documentation, 81 different strategic bidding strategies by Snowy Hydro for the Murray and Tumut power stations have been assessed to determine the optimum bidding strategy that will maximise Snowy Hydro revenue on a half hourly basis. The 81 different bidding scenarios are supplied in Appendix B.

The historic annual average capacity factor of Snowy Hydro's plant is approximately 15%, providing around 4900GWh/a generation on a long term average. This is the target Snowy Hydro energy production chosen by Frontier (section A.2.3.11). ROAM's analysis assesses the outcome of the 81 alternative strategic simulations against a 'typical' annual dispatch scenario (the 82nd case in Appendix B) to provide a revenue-optimised portfolio of bidding cases with approximately 14% annual capacity factor. This therefore allows strategic bidding to increase total annual generation, from approximately 4600GWh to the cap of 4900GWh.

For each regional boundary option (BAU, Snowy Hydro proposal, Split Region - Dederang proposal) ROAM has therefore modelled 82 separate case studies at the half hourly resolution for the 2008-09 year, based on the 81 strategic bidding alternatives used by Frontier and the additional 'typical' profile.

The methodology adopted to replicate Frontier's analysis, but on a half hourly basis, was:

- For each half hour we compared Snowy Hydro revenue per MWh for each of the 81 possible strategic bids against the 'typical' bid for the half hour;
- In each half hour, we chose the best strategic bidding strategy out of the 81, provided the Snowy Hydro production revenue (in $/MWh)[3] exceeded the 'typical' bid revenue (in $/MWh) by an adjustable margin. Additionally the outcome for the strategic bid must also increase Snowy Hydro gross revenue ($) for the half hour:
  - This meant that Snowy Hydro generation could increase or decrease in the half hour provided the half hourly revenue increased;
  - In many cases it was observed that a reduction in Snowy Hydro output would increase half hourly revenue through higher pool prices;
  - Snowy increases generation only when the resulting revenue (in $/MWh) is appropriately high, thereby ensuring that Snowy maximizes its revenue potential given its energy constraints; and
  - For more than 75 percent of half hours, the 'typical' bid was retained.

In this way dynamic bidding has been adopted consistently with the way that Frontier has modelled dynamic bidding.

The methodology delivers the best strategic outcome for Snowy Hydro for each regional configuration for the whole year, for each reconfiguration of the Snowy regional boundary.

[3] Since the Snowy revenue is affected by the CSP/CSC, Southern Generators Rule, 'clamping', location of regional reference nodes, and so forth, the Snowy revenue after all adjustments has been the criterion for determining the optimum bidding strategy.

The optimum revenue outcome for Snowy Hydro is calculated, subject to a maximum generation cap of 4900GWh per annum, and a minimum generation requirement of 4250GWh. In all cases the generation profile moved up to the cap.

The Snowy Hydro revenue per half hour has been calculated to account for the different regional boundary configurations and the application of CSP/CSC and the Southern Generators' Rule (where applicable).

Due to time constraints, strategic bidding was not implemented for generation other than Murray and Tumut generators. However, the introduction of random forced and planned outages goes some way towards replicating the behaviour of other NEM plant, which has been bid in mainly at SRMC as described in Section 3.5.1.

3.6) EXISTING AND NEW ENTRY GENERATION CAPACITIES

All existing NEM plant is included in the model as per the 2006 MRL studies. There are no scheduled retirements within the outlook period for this study.

We included new entry generation across the NEM based on committed or advanced proposals in order to meet the NEM regional minimum reserve level requirements. Table 3.1 shows the new entry generators assumed for the 2008-09 year study.

Table 3.1 – New Entry Generation Plant Installation Schedule

Year	Quarter	Region	Plant	Capacity (MW)
2007	**3**	**Queensland**	Kogan Creek	750MW
2008	**3**	**South Australia**	Hallett B	120MW
	3	**New South Wales**	Tallawarra	400MW

3.7) GENERATOR FORCED OUTAGE RATES

Generators throughout the NEM have forced and planned outages representative of those used for the NEMMCO 2006 Minimum Reserve Level studies. However, Snowy Hydro units have not been subject to forced or planned outages to avoid the interaction between strategic bidding and outage patterns of Snowy Hydro plant. This is justifiable for this project, based on the anticipated low forced outage rates for Snowy Hydro generators. Furthermore it is likely that Snowy Hydro capacity limitations due to planned outages will not significantly reduce Snowy Hydro capacity in the seasons where maximum generation from Snowy Hydro is likely to occur or be required.

The random forced and planned outage patterns for other NEM generators have been maintained identical for each of the regional boundary change options and therefore the simulation outcomes for the different regional configurations are directly comparable.

3.8) NEM PRODUCTION COSTING

To maintain consistency between generator dispatch and production costing, plant has been costed at the same price as it is bid. That is:

Baseload plant
Plant dispatch is costed at SRMC.

Intermediate plant
Plant dispatch is costed at SRMC.

Peaking plant
Plant dispatch is costed at LRMC.

Again, the SRMC and LRMC values applied are as published in the 2006 MRL studies Assumptions Report.

If load shedding occurs, due to generation shortfalls or inter- or intra-regional constraints isolating high loads from generation, regional pool prices will increase to the Value of Lost Load (VOLL) or $10,000/MWh. NEM production costs however are not adjusted for VOLL events.

3.9) SUMMARY OF MODELLING FEATURES

Table 3.2 – Summary of Modelling Features

Feature	Description
Model	19 Node Model incorporating NEM 6 region model, and alternative 5 region (Snowy region abolition) and 7 region (split Snowy region) configurations.
Bidding	Competitive bidding for Murray and Tumut only, and SRMC bidding for other plant, except peaking plant at LRMC
Load Forecast	Half-hourly M50 load trace forecast to meet NEMMCO SOO 2008-09 energy and demand targets for each individual region
Constraints	The full set of NEMMCO ANTS constraints, as well as alternate constraints for cases involving changed region boundaries (as used in Frontier modelling)

4) MODELLING METHODOLOGY

4.1) CASES AND KEY FEATURES

ROAM has developed five cases to replicate and analyse Frontier's findings and also to test the alternative conditions as requested by the SGC. The cases developed are described below.

4.1.1) Business-As-Usual Case (BAU) [As modelled by Frontier Economics]

This case maintains the region boundaries as they currently exist. In this case, it is assumed that NEMMCO manages the accumulation of negative settlement residues on the Victoria-Snowy and Snowy-NSW interconnectors by restricting ("clamping") power flows at times when negative settlement residues would otherwise accumulate.

NEMMCO's Operating Procedure – Dispatch (SO_OP3705) defines NEMMCO's procedure and trigger criteria for managing negative settlement residues. From December 2004, if the accumulation of negative residues over a period of counter price flows is forecast to reach $6,000 then NEMMCO would apply constraints to prevent the further accumulation, provided power system security could be maintained. These constraints would remain in place until they could be revoked without creating counter price flows. This trigger applies to all inter-regional constraints.

In general, interconnector limits may move at a rate no greater than that which applies for a planned outage. This ramping ceases at the point at which counter price flows are halted. From that point on, periodic adjustment of the level of the constraint might be necessary due to changing market conditions by either:

- Increasing the level of constraint if counter-price flows re-emerge; or
- Relaxing the level of constraint if significant positive inter-regional settlement accumulations indicate that the current level of constraint is excessive.

Clamping power flows in this way can undermine competitive pressure, distort the efficiency of dispatch and pricing outcomes, and reduce the effectiveness of Inter-Regional Settlement Residue (IRSR) units as an interregional price hedging instrument.

4.1.2) Business-As-Usual Case with CSP/CSC and the Southern Generators' Proposal (BAU-CSP)

This case features implementation of the current CSP/CSC trial payments as well as a mechanism for using positive NSW-Snowy residues to offset negative Snowy-Victoria residues through application of the Southern Generators Rule.

As of 1 November 2006, action to minimise negative residues on the Victoria-Snowy interconnector is not undertaken if a constraint in the Murray/Tumut constraint list is binding, or is forecast to bind, during the period of negative residue accumulation.

If negative residues accumulate, or are forecast to accumulate, on the Snowy to NSW directional interconnector (i.e. for flow from Snowy to NSW), action to minimise negative residues is not undertaken if a Snowy intra-regional constraint with a fully co-optimised type formulation is binding, or is forecast to bind, during the period of negative residue accumulation.

Instead, negative settlement residues are refunded through the eight separate trading amounts detailed in The Rules in Chapter 8A, Part 8, which ROAM has replicated in full, in order to determine revenues under the present arrangements, and assuming Snowy Hydro does not hold SRA units on the SN_NSW interconnector[4].

4.1.3) Snowy Hydro Proposal (SHP) [Abolish Snowy Region]

This proposal would abolish the Snowy region, and include Tumut in the New South Wales region. The Murray and Guthega plant would be located in the Victorian region. The existing Victoria-Snowy and Snowy-NSW interconnectors are replaced with a single Victoria-NSW interconnector.

In Frontier's modelling of this proposal, there is no clamping of flows on this new VIC-NSW interconnector to manage negative settlement residues under this proposal. The AEMC report states that negative settlement residues on this new interconnector were small enough to ignore.

4.1.4) Snowy Hydro Proposal with Clamping (SHP-CLAMP)

To test the sensitivity of clamping intervention on the Snowy Hydro Proposal the above case has been repeated with clamping activated on the new VIC-NSW interconnector.

4.1.5) Split Region-Dederang Proposal (SRD) [Split Snowy Region]

This proposal splits the Snowy Region so that Murray and Tumut become separate NEM regions. The new Murray region includes Dederang as the regional reference node (RRN). The existing Victoria-Snowy and Snowy-NSW interconnectors are replaced with three new interconnectors: Victoria-Murray, Murray-Tumut, and Tumut-NSW.

In Frontier's modelling of this proposal, clamping is not implemented to manage negative settlement residues.

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[4] In order to calculate the revenue impact to Snowy Hydro for TA7 and TA8, which adjusts the gross IRSR for the SN_NSW interconnector, an assumption of the % SRA Unit holding is required. An assumption of 0% SRA Unit holdings has been made. In any case this would not materially affect the way in which Snowy Hydro behaves as the VIC_SN negative IRSR is more generally due to loop flows rather than participant behaviour.

4.2) SUMMARY OF CASES

The following table illustrates the main features of each case evaluated by ROAM.

Table 4.1 – Scenarios and Features

	BAU	BAU-CSP	SHP	SHP-CLAMP	SRD
Regional Configuration	Current Snowy Boundary	Current Snowy Boundary	Snowy region abolished, Tumut in NSW, Murray and Guthega in Victoria	Snowy region abolished, Tumut in NSW, Murray and Guthega in Victoria	Separate regions for Tumut and for Murray and Guthega
Clamping on Victoria-Snowy	Present	No	N/A	N/A	N/A
Clamping on Snowy-NSW	Present	No	N/A	N/A	N/A
Clamping on VIC-NSW	N/A	N/A	No	Present	N/A
CSP/CSC	No	Present	No	No	N/A
Southern Generators Rule	No	Present	N/A	N/A	N/A

5) MODELLING OUTCOMES

5.1) BUSINESS-AS-USUAL CASE (BAU) [AS MODELLED BY FRONTIER ECONOMICS]

These tables summarise the initial outcome with 'typical' bidding of Snowy Hydro together with the outcome of strategic Snowy Hydro bidding to optimise Snowy Hydro revenue ($millions). The tables also show corresponding values of Snowy Hydro average revenue in $/MWh, Snowy Hydro energy production, NEM production costs and the Victorian pool price. The result of applying strategic bidding to Snowy Hydro is such that revenue is significantly increased and Snowy Hydro energy production increases to the cap of 4900GWh.

Table 5.1.1 – Market Summary of BAU Outcome

	SH Production (GWh)	SH Gross Revenue ($M)	SH Average Revenue ($/MWh)	NEM Production Cost ($M)	Victoria Annual Avg Pool Price ($/MWh)
Typical SH Operation	4,617.66	95.44	20.67	2,098.8	25.33
Strategic SH Operation	4,899.07	136.20	27.80	2,094.0	28.62
SH Optimisation Impact	281.41	40.76	7.13	-4.8	3.28

The above table shows that NEM efficiency improves with strategic bidding of Snowy Hydro, however this is primarily due to the increased utilisation of Snowy Hydro plant, with the optimisation allowing an increase of 300GWh from 4600GWh to 4900GWh. The additional generation at Snowy, costed at $1.00/MWh, displaces various other higher cost generation, thereby lowering overall production costs.

The next table shows the cumulative negative settlement residues on the interconnector(s) between NSW and VIC. This provides an indication of the severity of negative settlement residues for each of the cases. In the BAU case, interconnector clamping is implemented to manage negative residues if the dispatch is expected to cause a negative settlement residue greater than $1500 in any single trading interval. It may be seen here that strategic bidding of Snowy Hydro causes a higher incidence of negative settlement residues. The accumulation of any negative settlement residues in this case is caused by numerous insignificant NSRs, below the clamping threshold of $1500 per trading interval.

Table 5.1.2 – Transmission Summary of BAU Outcome

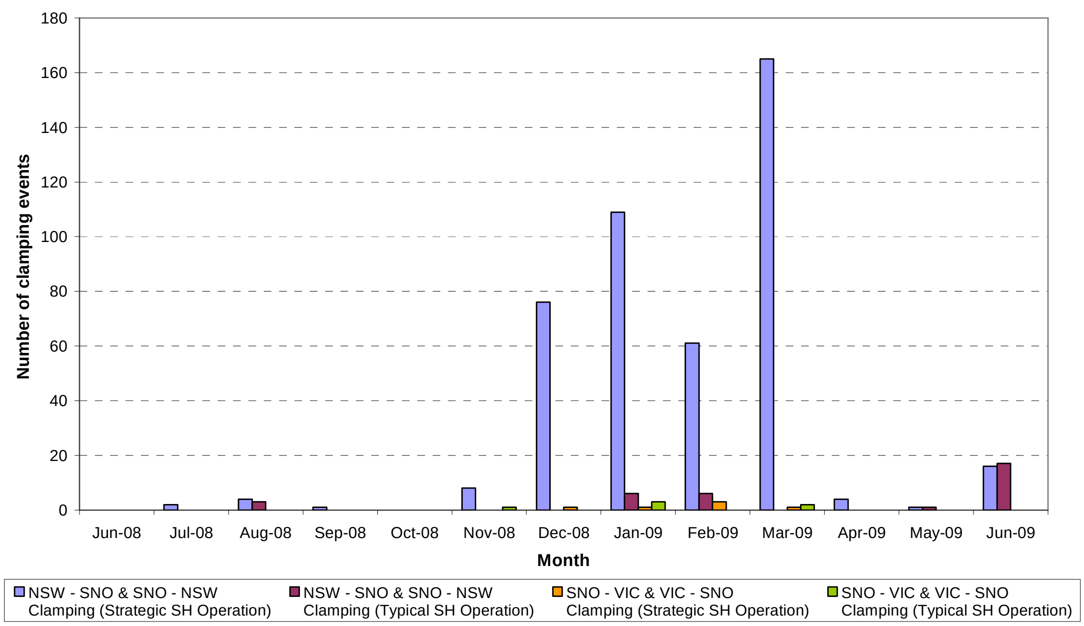
	Gross Negative Settlement Residue Accumulation ($M)				
	VIC_SN	**SN_VIC**	**SN_NSW**	**NSW_SN**	**Total NSR**
Typical SH Operation	0.00	0.05	0.39	0.00	0.44
Strategic SH Operation	0.00	0.12	0.43	0.00	0.55
SH Optimisation Impact	-0.00	0.07	0.04	-0.00	0.11

The frequency of 'strategic moves' from Snowy Hydro generators is presented in Appendix B.2. This illustrates the number of times that the Murray/Tumut generators alter their production level, from the 'typical' profile, in order to achieve a greater revenue return. In some cases this will be a withdrawal of capacity compared with the typical profile, in order to increase prices in the Snowy and/or adjoining regions. Conversely in some cases an increased level of production will not cause a significant reduction in pool price and therefore revenue will increase. Table B.2 shows that there is a wide variety of strategic moves in this BAU case which provides Snowy Hydro with increased overall revenue. A significant proportion of these are moves to low levels of Murray output with varying levels of Tumut output to best capture the effect described as 'importing the VIC pool price into Snowy'.

Under the current regional configuration, there is a reasonable incidence of events which invoke clamping conditions. There are a total of 447 periods, approximately 2.5% of all periods, which cause a clamping event on the NSW to Snowy interconnector and a total of 6 periods on the Snowy to Victoria interconnector when Snowy Hydro bids its plant strategically. Alternatively with Snowy Hydro using its typical bidding profile, there are only 40 periods throughout the year which invoke clamping. This included 33 half hours where the NSW to Snowy interconnector is clamped, and 6 half hours where the Snowy to Victoria interconnector is clamped.

Figure 5.1 below shows the frequency of these clamping periods. As the figure shows, the vast majority of clamping events on both interconnectors occur during the high load summer period.

Figure 5.1 - Frequency of Clamping Events in Business as Usual case



5.2) BUSINESS-AS-USUAL CASE WITH CSP/CSC AND THE SOUTHERN GENERATORS' PROPOSAL (BAU-CSP)

This case, which represents the present situation, provides a more efficient NEM dispatch with $0.34m/a reduced NEM costs for the optimised cases, and also a reduced capability for strategic operation from Snowy Hydro, when compared with the BAU case as described in Section 5.1.

While there are a significant number of strategic moves in the BAU-CSP case for Snowy Hydro, their influence on market outcomes is mitigated through the application of the market derogations and hence removal of the need to clamp interconnector flows. The CSP/CSC scheme removes the benefit of strategic operation of the Tumut generators to constrain the Snowy intra-regional connector. There is therefore decreased incentive to 'import the VIC price'. Furthermore, the removal of clamping provides a more efficient dispatch by not limiting flows from region to region.

When compared with the BAU case above, the BAU-CSP case decreases the forecast revenue for the Snowy Hydro generators after strategic bidding. This shows the reduced incentive and capability for Snowy Hydro to influence market outcomes. This coupled with removal of interconnector clamping leads to a more efficient dispatch of the NEM.

Table 5.2.1 – Market Summary of BAU-CSP Outcome					
	SH Production (GWh)	**SH Gross Revenue ($M)**	**SH Average Revenue ($/MWh)**	**NEM Production Cost ($M)**	**Victoria Annual Avg Pool Price ($/MWh)**
Typical SH Operation	4,617.71	98.07	21.24	2,096.7	24.86
Strategic SH Operation	4,900.56	126.31	25.77	2,093.7	28.85
SH Optimisation Impact	282.86	28.24	4.54	-3.0	3.99

Due to application of the CSP/CSC mechanism there is reduced incentive for Snowy Hydro to operate in a manner which causes the binding of the Snowy intra-regional constraint and exploits the capacity for the generation at Tumut to exploit market power in certain dispatch scenarios. In this case, the CSP/CSC mechanism and the Southern Generators Rule is used to manage negative settlement residues, therefore some accumulation of NSRs will occur during dispatch. However, the CSP/CSC trading amounts apply post-dispatch to offset these residues on the Snowy to NSW interconnector. Snowy Hydro Ltd in this case by definition will reimburse the Settlement Residue Auction pool (SRA) the amount of the negative settlement. Negative settlements on the SNO-VIC interconnector are managed by the Southern Generators rule, such that positive settlements on SNO-NSW in the same period are used to offset negative settlements on SNO-VIC.

Table 5.2.2 – Transmission Summary of BAU-CSP Outcome					
	Gross Negative Settlement Residue Accumulation ($M)				
	VIC_SN	**SN_VIC**	**SN_NSW**	**NSW_SN**	**Total NSR ($M)**
Typical SH Operation	0.00	0.26	0.46	0.00	0.73
Strategic SH Operation	0.00	2.03	0.78	0.00	2.81
SH Optimisation Impact	-0.00	1.76	0.32	-0.00	2.08

5.3) SNOWY HYDRO PROPOSAL (SHP) [ABOLISH SNOWY REGION]

Compared with the present situation (BAU-CSP), this case shows higher (less efficient) NEM costs by $1m/a and higher Snowy Hydro revenue. It also shows higher Victorian pool price outcomes, compared with the BAU-CSP case.

Analysis of Table B.4 in Appendix B shows that in this case Snowy Hydro has a significant incentive to operate strategically to maximize revenue, with a relatively large number of moves from the typical profile, compared with the BAU cases. The most frequent strategic move for Snowy Hydro is to withdraw Tumut output from the NEM at times of low NEM reserve margins and high southerly flows. This can cause the Sydney-Tumut constraint to bind (the existing NSW-Snowy interconnector). At times of high VIC pool price Murray can then operate up to an optimal level to achieve maximum returns. This is evident in the number of moves to strategic bids with zero Tumut output and varying Murray output (Bid IDs 10, 19, 28, 37, 46, 55). Snowy Hydro has almost twice as many bidding changes towards these profiles than the BAU-CSP case, and approximately six times more than the BAU case.

Table 5.3.1 – Market Summary of SHP Outcome					
	SH Production (GWh)	**SH Gross Revenue ($M)**	**SH Average Revenue ($/MWh)**	**NEM Production Cost ($M)**	**Victoria Annual Avg Pool Price ($/MWh)**
Typical SH Operation	4,616.94	108.53	23.51	2,096.7	24.84
Strategic SH Operation	4,898.83	144.35	29.47	2,094.7	29.88
SH Optimisation Impact	281.90	35.83	5.96	-2.0	5.04

In this case there are very few instances of negative residues on the new VIC to NSW interconnector, as concluded by the Frontier modelling. Small negative residues are predominantly due to IRLF effects at low transfers.

Table 5.3.2 – Transmission Summary of SHP Outcome			
	Gross Negative Settlement Residue Accumulation ($M)		
	VIC_NSW	**NSW_VIC**	**Total NSR ($M)**
Typical SH Operation	0.24	0.01	0.25
Strategic SH Operation	0.18	0.01	0.20
SH Optimisation Impact	-0.06	0.00	-0.06

5.4) SNOWY HYDRO PROPOSAL WITH CLAMPING (SHP-CLAMP)

The SHP-CLAMP case considers the effect of the Snowy Hydro Proposal with limited accumulation of negative settlement residues due to the application of clamping on the new VIC-NSW interconnector. ROAM considers that this is the likely implementation of the Snowy Hydro Proposal, as it eliminates the risk to NEMMCO of the accumulation of negative residues. With appropriate constraint and dynamic IRLF equations to manage flows across the new interconnector there are few instances where clamping is required. As such the outcomes for this case are very similar to the SHP case without clamping.

Table 5.4.1 – Market Summary of SHP-CLAMP Outcome					
	SH Production (GWh)	**SH Gross Revenue ($M)**	**SH Average Revenue ($/MWh)**	**NEM Production Cost ($M)**	**Victoria Annual Avg Pool Price ($/MWh)**
Typical SH Operation	4,617.62	110.09	23.84	2,096.5	24.75
Strategic SH Operation	4,899.26	148.08	30.23	2,094.8	29.88
Optimisation Impact	281.64	37.99	6.39	-1.7	5.13

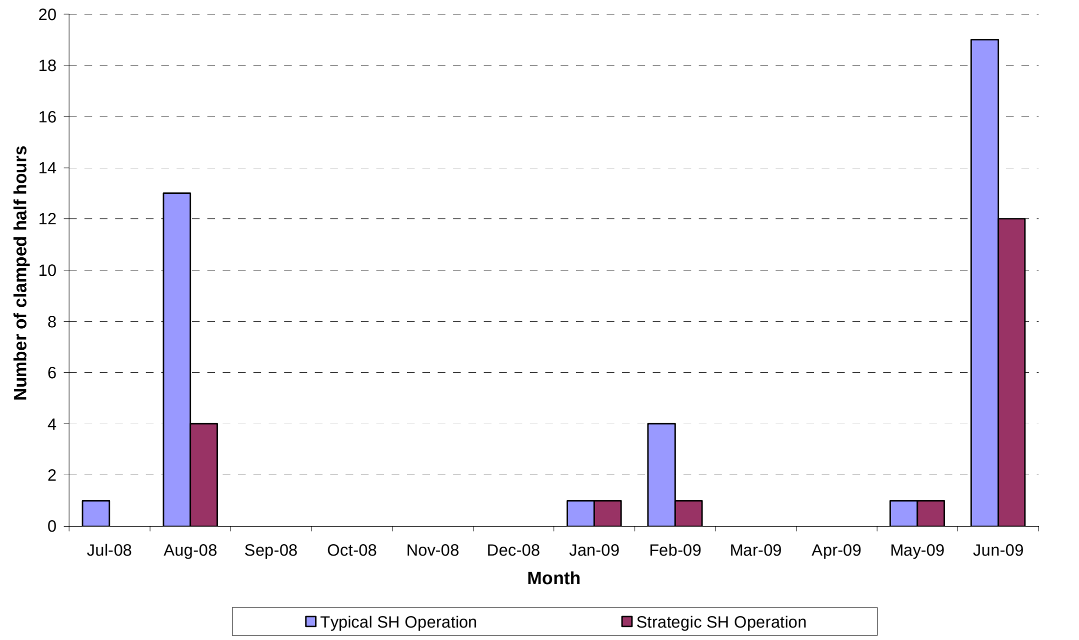
With clamping, there is a minor increase in strategic operation by the Snowy generators. Under the SHP-CLAMP case, Snowy Hydro has a greater incentive to withdraw Tumut generation and operate only at Murray (and Guthega). In approximately half of all clamping events (there are 39 periods in the optimised case) Snowy Hydro withdraws generation at Tumut and operates only at Murray.

Table 5.4.2 – Transmission Summary of SHP-CLAMP Outcome			
	Gross Negative Settlement Residue Accumulation ($M)		
	VIC_NSW	**NSW_VIC**	**Total NSR ($M)**
Typical SH Operation	0.13	0.01	0.14
Strategic SH Operation	0.13	0.01	0.14
SH Optimisation Impact	-0.00	0.00	-0.00

The effect of clamping, as is shown in the tables above is minimal. There are a total of 39 periods where clamping is invoked when Snowy Hydro bids strategically. There are a total of 19 periods under Snowy Hydro's typical bidding profile.

Figure 5.2 below shows the frequency of these clamping periods. As the figure shows, whilst some clamping periods occur during the summer months, the vast majority of clamping events occur during winter in this case.

Figure 5.2 – Frequency of Clamping Events in Snowy Hydro Proposal (Clamping)



5.5) SPLIT REGION-DEDERANG PROPOSAL (SRD)

The SRD case, where Tumut and Murray (with Dederang as the regional reference node) are reconfigured as individual regions, provides the most inefficient outcome for NEM dispatch costs. The case is approximately $2.1m higher in production costs than the BAU-CSP case, the most efficient option, and approximately $1m higher than the SHP-CLAMP case, the 4th most efficient option.

As the Murray and Tumut generators are located in their own pricing regions they are more frequently priced correctly. There is evidence that the existing benefit from importing the VIC price into the Murray node remains, however the revenue benefit is minimised as only the Murray (and Guthega) generators receive the high price and Tumut is priced correctly. The gross Snowy Hydro revenue is only marginally lower than that for the BAU-CSP case, indicating that this regional development proposal provides a similar outcome to the current market arrangements, as under the CSP/CSC trial Tumut is also priced correctly.

Table 5.5.1 – Market Summary of SRD Outcome					
	SH Production (GWh)	SH Gross Revenue ($M)	SH Average Revenue ($/MWh)	NEM Production Cost ($M)	Victoria Annual Avg Pool Price ($/MWh)
Typical SH Operation	4617	97.97	21.22	2,096.5	24.77
Strategic SH Operation	4900	122.39	24.98	2,095.8	29.61
Optimisation Impact	283	24.42	3.76	-0.7	4.84

Minor negative residues occur due to IRLF effects.

Table 5.5.2 – Transmission Summary of SRD Outcome							
	Gross Negative Settlement Residue Accumulation ($M)						
	VIC_MUR	MUR_VIC	MUR_TUM	TUM_MUR	TUM_NSW	NSW_TUM	Total NSR ($M)
Typical SH Operation	0.02	0.09	0.00	0.00	0.46	0.00	0.56
Strategic SH Operation	0.01	0.42	0.00	0.00	0.73	0.00	1.16
Optimisation Impact	-0.00	0.34	0.00	0.00	0.27	-0.00	0.60

5.6) SUMMARY OF MODELLING OUTCOMES

The following summary and option rankings are based on market outcomes following Snowy Hydro revenue optimisation.

With regard to the pool pricing outcomes described in this report two seemingly anomalous characteristics are apparent. Firstly, the average price outcomes for both NSW and Victoria which cluster around the $29/MWh and $20/MWh levels respectively appear to be low compared to current market beliefs of pool prices going forwards, this being particularly apparent in the NSW case. Secondly, at around $9/MWh the differential between NSW and Victorian prices appears to be unusually large and contrary to the perceived view of its direction. Both of these outcomes are a consequence of the bidding strategy deployed by ROAM for all NEM generators with the exception of that applied to Snowy Hydro.

In undertaking this assignment ROAM adopted a mixture of SRMC and LRMC bidding for plant based upon its load factor of operation as described in section 3.5.1. This decision was taken in order to as closely as reasonably practical mimic the approach adopted by Frontier but with recognition of the time constraints surrounding delivery of this report. Whilst Frontier also incorporated an element of strategic bidding on behalf of generators within all NEM regions ROAM has not replicated this part of their methodology as ROAM does not believe that it can be meaningfully implemented without extensive studies that go beyond the brief for this assignment. Furthermore, as the question of whether or not to implement the proposed boundary changes turns on issues of cost rather than on issues of market prices it does not believe that omitting strategic bidding on a large scale detracts from the validity of this report's findings. As a result of the mainly SRMC bidding approach taken by ROAM, pool prices are modelled as being significantly lower than would be expected using alternative bidding strategies but the integrity of generator dispatch levels is maintained.

Concerning the price differential between NSW and Victoria and its direction, this is consistent with the plant reserve margins expected to exist during the medium term. Whilst NSW has historically enjoyed higher prices than Victoria this can be argued to have been largely due to strategic bidding on behalf of the NSW generators. When the reserve levels in each state are examined it is clear that Victoria/South Australia will breach its minimum levels in 2007/8 whilst NSW will not reach this position until 2010/11. Whilst NSW native generation is lower as a proportion of regional demand than is the case for Victoria it may rely upon a greater capacity for inter state transfers from both the Snowy and the Queensland regions than Victoria where the level of interconnector support is much less. As a consequence ROAM considers that the relative pricing levels between each state in this study are reasonable, albeit somewhat counterintuitive when not considered in the light of the circumstances described here.

The highest NEM costs are delivered in the SRD option and the lowest in the BAU-CSP. The ranking of the options (after bid optimisation) in terms of decreasing NEM cost is:

Table 5.6.1 – Ranking of Options (in decreasing NEM cost)

Case	NEM Cost ($millions)
SRD	2095.8
SHP-CLAMP	2094.8
SHP	2094.7
BAU	2094.0
BAU-CSP	2093.7

The preferred alternative in terms of NEM efficiency is the BAU-CSP, i.e. the current regional configuration with the CSP/CSC trial and the Southern Generators rule used to manage inter-regional negative settlements.. BAU with clamping is the next most efficient, with higher dispatch costs of approximately $0.4m. The Snowy Hydro proposal with clamping, which is considered the likely implementation option for the Snowy Hydro proposal, and the Snowy Hydro proposal, are an estimated $1.16m higher in annual production costs than the present situation.

ROAM's findings are that the BAU case modelled by Frontier has a NEM Cost which is less than the SHP proposal as modelled by Frontier by about $0.7m. This does not agree with Frontier's modelling, which showed the SHP proposal as having lower NEM costs. This point is discussed further in Section 6. Clamping periods which would otherwise cause negative settlements under the Snowy Hydro Propsal (SHP-CLAMP) has a negligible impact on total NEM production costs. This supports Frontier's conclusion that negative settlements in the SHP case are minor.

Conversely, when the CSP/CSC and Southern Generators' Rule are used to manage inter-regional negative settlements in the current configuration (BAU-CSP), as opposed to clamping (BAU), the forecast NEM dispatch is the most efficient of all cases. This is due to the success of the CSP/CSC trial in pricing Tumut generation correctly, reducing the incentive to operate strategically and forcing intra-regional constraints in the Snowy region.

Based on the modelling outcomes, the SHP and SHP-CLAMP cases provide the most favourable revenue outcome to Snowy Hydro indicating the proposal does not lead to reduced capability for Snowy Hydro to operate strategically to influence market outcomes. The Victorian and New South Wales pool prices in the SHP case (and SHP-CLAMP case) remain in line with the pool prices returned in the BAU-CSP case. However the frequency of strategic bids under the SHP and SHP-CLAMP cases is increased significantly, from approximately 2500 periods to 3500 periods (of 17520 half hours of the year). The following table shows the gross pool revenue received by Snowy Hydro in each case (after bid optimisation):

Table 5.6.2 – Revenue received by Snowy Hydro for each case

Case	Snowy Hydro Revenue ($million)
SHP-CLAMP	148.1
SHP	144.4
BAU	136.2
BAU-CSP	126.3
SRD	122.4

The ranking of each case in terms of Victorian pool price (and therefore an indication of revenue to the Southern Generators) is:

Table 5.6.3 – Ranking of cases in terms of VIC pool price

Case	Victorian Pool Price (Melbourne node) ($/MWh)
SHP	29.88
SHP-CLAMP	29.88
SRD	29.61
BAU-CSP	28.55
BAU	28.18

The ranking of each case in terms of New South Wales pool price is:

Table 5.6.4 – Ranking of cases in terms of NSW pool price	
Case	**NSW Pool Price (Sydney node) ($/MWh)**
BAU	29.13
SHP-CLAMP	21.54
BAU-CSP	20.37
SRD	20.32
SHP	20.10

Compared with BAU-CSP, SHP increases prices slightly in Victoria. This is due to strategic bidding by Snowy to cause limits to bind more during southerly flows.

The figures below show the price duration curve for each of the five cases. Figure 5.3 shows that Victorian pool prices are much the same for all cases, as supported by Table 5.6.3 above, except for the BAU case, where a greater duration of prices are less than $35.00/MWh. We can see that the graph has the BAU curve (green) higher than the other curves between $20.00/MWh and $35.00/MWh, indicating that more often are prices between these points.

Figure 5.3 – Average Annual Victorian Pool Price Duration Curve

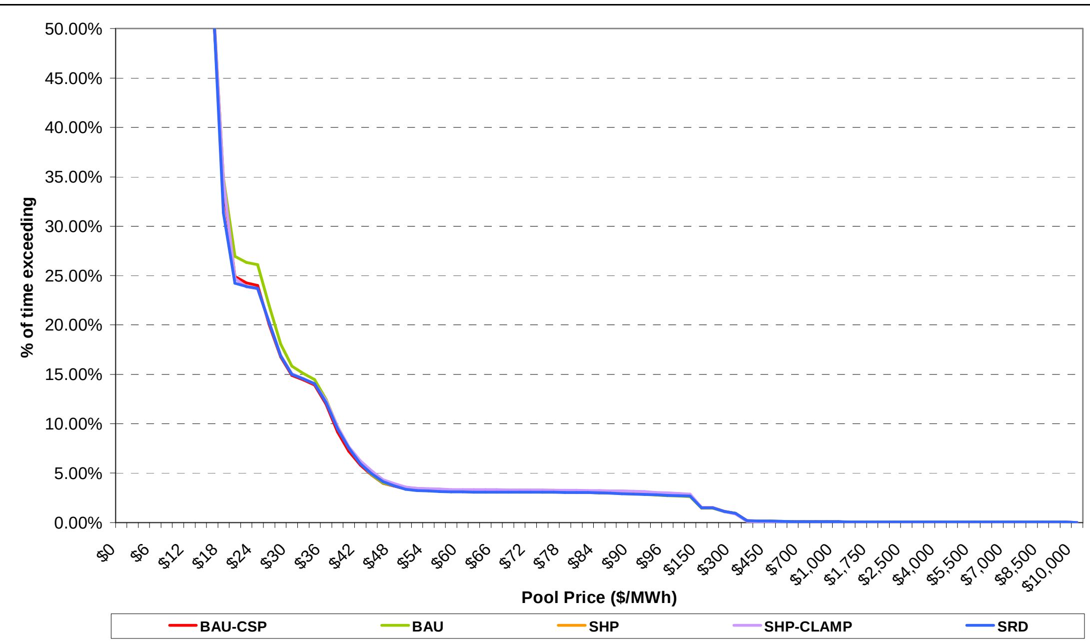
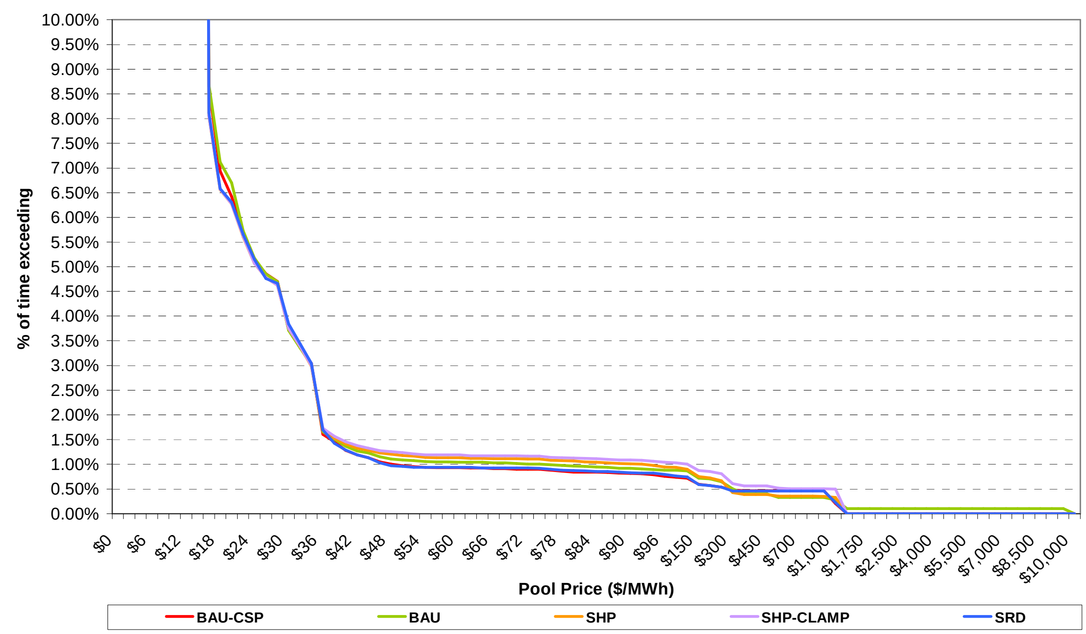


Figure 5.4 shows the impact that the regional configuration has on the forecast average annual pool price for New South Wales. As the figure shows, there is a slight difference in the duration at which prices persist above $40.00/MWh to $1000.00/MWh. The SHP-CLAMP case has a greater duration of higher priced periods, reflecting the marginally higher average annual pool price shown in Table 5.6.4..

Figure 5.4 – Average Annual New South Wales Pool Price Duration Curve



The BAU case provides significant uplift to NSW prices and a moderate downturn in Victorian prices. The high prices in the BAU case represent periods when clamping has reduced available capacity to NSW from Snowy, resulting in some VOLL events, coinciding with high loads in NSW and Queensland. This can be identified by the small percentage of prices above $1000/MWh in Figure 5.4. While the NSW pool price does not exceed $2,000/MWh at any time during all other cases, there are 18 periods of VOLL, where prices increase to $10,000/MWh and load is shed. This is causing the average annual pool price to increase by approximately $10.00/MWh compared to the remaining cases.

The SHP case results in higher Victorian pool prices and lower NSW pool prices. The BAU-CSP case provides for market outcomes in between these two extremes.

Lower prices in NSW compared with Victoria for all but the BAU case are mainly the result of a general shift towards southerly transfers which predominate in the SRMC bidding profiles. They do not necessarily reflect the outcomes from the adoption of more strategic bidding by NSW generators. They do however, reflect higher levels of capacity available from QLD and NSW, particularly after Kogan Creek 750MW unit is commissioned later in 2007.

6) DISCUSSION OF FINDINGS

6.1) BUSINESS AS USUAL REGIONAL CONFIGURATION

In the AEMC's Draft Determination, Frontier's modelling did not include the CSP/CSC trial and Southern Generators' Rule derogation. Instead the modelling re-introduces clamping intervention to manage negative settlement residues on both the VIC-Snowy and Snowy-NSW interconnectors. This effectively models the market arrangements prior to the introduction of the CSP/CSC trial in 2005.

It has been observed in the current market (with the CSP/CSC trial in place) that the CSP/CSC trial has been successful through application of 'pseudo nodal pricing' for the Tumut node in alleviating the incentive for Snowy Hydro to exercise market power. Since its implementation, binding constraints on the Murray-Tumut intra-regional interconnector have significantly reduced. Similarly negative settlement residues on the VIC-Snowy interconnector have been managed through the Southern Generators Rule amendment removing the need for NEMMCO intervention through clamping. This amendment offsets negative settlements on the VIC-Snowy interconnector with positive settlements on the Snowy-NSW interconnector for the same period.

ROAM's modelling includes full half hourly dispatch of the whole NEM for the current regional configuration for both scenarios:

1. With clamping on both VIC-Snowy and Snowy-NSW; and
2. No clamping on either interconnector, with negative residues on Snowy-NSW managed by the CSP/CSC trial and VIC-Snowy NSRs managed by the Southern Generators Rule.

Results have been analysed showing the difference in market efficiency and incentives for Snowy Hydro to exercise market power for each of these options. This analysis has shown that the current regional configuration, with continuation of CSP/CSC and the Southern Generators' Rule, is effective in delivering the highest achievable levels of efficiency to the NEM on an ongoing basis. NEM efficiency is also high, albeit less than with CSP/CSC in place, under clamping. This shows that the current regional configuration still remains a more competitive arrangement than any alternate regional configuration.

By analysing various individual half hours, ROAM has been successful in determining the difference between the SHP and BAU cases, and therefore the conclusions reached by us and by Frontier regarding the rankings of these two cases in terms of NEM efficiency. Due to ROAM's modelling of dynamic constraints, and the alternate constraint equations in the various cases, there may be differences between each case on a half-hourly basis on inter-regional transfer limits.

As an example, ROAM analysed the period with the greatest NEM cost difference between the BAU and SHP cases. During this period, the dynamic constraints differ on the VIC – SA limit, with increased generation required in Victoria with less export capability for South Australia in the BAU case. Due to this, the marginal generator becomes a higher cost station in Victoria, and pool prices across all regions are higher than in the SHP case using typical bidding. Due to this, there is decreased incentive for Snowy Hydro to operate strategically in the BAU case, as the pool price is sufficiently high to produce high returns on a 'normal' level of generation.

In the SHP case, which has a higher SA – VIC transfer capacity, pool prices are lower in the typical bidding case. This presents a greater benefit for Snowy Hydro by bidding strategically, and Snowy Hydro responds to this opportunity by withholding generation at Murray and lowering its output at Tumut. Pool prices across the regions increase accordingly, and NEM efficiency decreases.

As mentioned, it is unclear from Frontier's documentation whether the dynamic constraints have been fully applied for the BAU and SHP cases. However this may suggest the potential for differences between ROAM's and Frontier's conclusions regarding these two cases.

6.2) SNOWY HYDRO PROPOSAL

In this study it is assumed that the current inter-regional constraints between Tumut and the NSW RRN, and Murray and the VIC RRN, are shifted to intra-regional constraints within the NSW and VIC regions respectively. As the underlying transmission network is un-altered the same limitations on dispatch and transfers remain, and have been implemented accordingly into the constraint equations.

In the AEMC's Draft Determination, Frontier's modelling did not implement clamping on the new VIC-NSW interconnector to manage negative settlement residues. It is unclear why this is the case, as it is normal NEMMCO policy to manage negative settlement residues on any interconnector by implementing clamping.

ROAM's modelling of this regional configuration does however support the Frontier assessment which shows that there would likely be only very minor negative settlement residues on the new VIC-NSW interconnector and clamping has little effect in this case. ROAM's modelling however does not support the conclusions reached by Frontier that the SHP (without clamping) is more efficient than the BAU case (with clamping).

ROAM's modelling of the Snowy Hydro Proposal does however highlight the potential for Snowy Hydro to behave strategically to alter market outcomes due to the limitations on the transmission network which will remain following the regional boundary change, i.e. intra-regional constraints within NSW. The possibility of this outcome is not discussed in the Frontier modelling documentation. As discussed in Section 6.1, the modelling of dynamic constraints also offers increased opportunity for Snowy Hydro to exert market power and strategically withhold generation.

6.3) ASSESSMENT OF FRONTIER'S MODELLING OF CONSTRAINTS

Frontier appear to have used the appropriate set of ANTS constraints for their base case, however it is unclear in the Frontier documentation whether appropriate alternate dynamic constraints have been applied to the Snowy Hydro Proposal or Split Region Proposal models. The AEMC has provided alternative dynamic constraints workbooks for the key transmission flow paths for the alternative regional configurations and these are now available on request to interested parties.

6.4) ASSESSMENT OF FRONTIER'S MODELLING OF STATIC AND DYNAMIC LOSS FACTORS

The Frontier documentation does not state whether appropriate loss factors have been applied for the alternative region change proposals. From the data provided to us (which was also provided to Frontier) we believe that they would have used the appropriate dynamic and static loss factors for each case. This includes a 'lossless' interconnector between the Murray and Tumut regions for the Split Region proposal. As this case is of less interest at this stage the simplification is reasonable.

The type of bidding behaviour that both Frontier and ROAM have applied to Snowy Hydro results in part of the generating capacity being bid in at a very low price and the remainder bidding at a very high price. This modelling does not typically result in Snowy Hydro setting price in the market. Hence the relatively small shifts in dispatch of Snowy Hydro associated with a change from dynamic inter-regional loss factors to static intra-regional loss factors is not observable.

However, in the real market Snowy Hydro will at times wish to set price and will bid accordingly. In those circumstances the change from dynamic inter-regional loss factors to static intra-regional loss factors will create market inefficiencies that have not been estimated either by the Frontier modelling or by ROAM.

Converting to static intra-regional loss factors means that a single value of loss factor for each Snowy Hydro generator, calculated over the whole year, will replace the present range of dynamic loss factors which varies from approximately 0.85 to 1.2 between Snowy and NSW and Snowy and Victoria on a half hourly basis.

The outcome is likely to be an increase in transmission losses following removal of the Snowy region, since Snowy Hydro will have greater incentives to maximise production when prices in NSW and Victoria are high, regardless of the level of loading on the Snowy to NSW and Snowy to Victoria lines. Dynamic loss factors and the possibility of price separation presently mitigate these effects.

6.5) DEMAND POINT 29

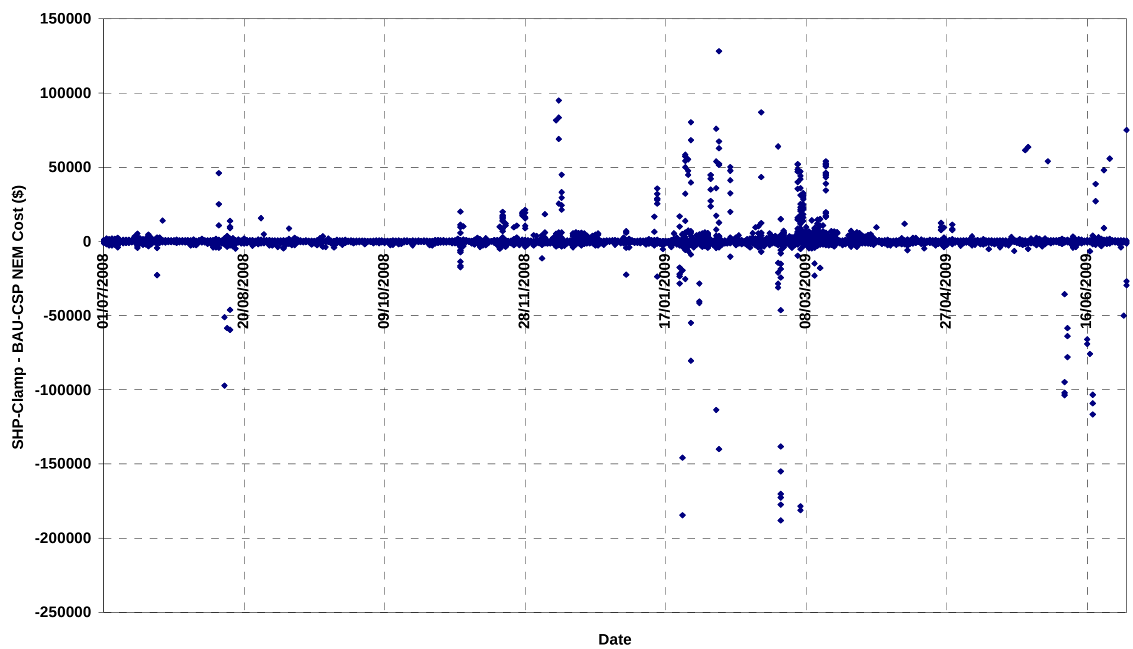
In the Frontier modelling used for the AEMC Draft Determination, the total benefits to the SHP case are due largely to the benefits accruing in demand point 29. These benefits are due primarily to a significantly increased level of production from the Snowy Hydro generators compared with the level of dispatch in the BAU case resulting in lower NEM production costs for the SHP case

As is shown in the following sections the ROAM modelling did not replicate this result.

6.5.1) SHP-CLAMP case relative to the BAU-CSP case

Figure 6.1 shows the forecast NEM production cost differential for each half hourly dispatch over the study period for the SHP-CLAMP case relative to the BAU-CSP case. The costs are more frequently significantly higher for the SHP-CLAMP case in summer, and the cost for the entire year is higher, as previously discussed.

Figure 6.1 - SHP-CLAMP cost differential against BAU-CSP costs ($) for Optimised Bids

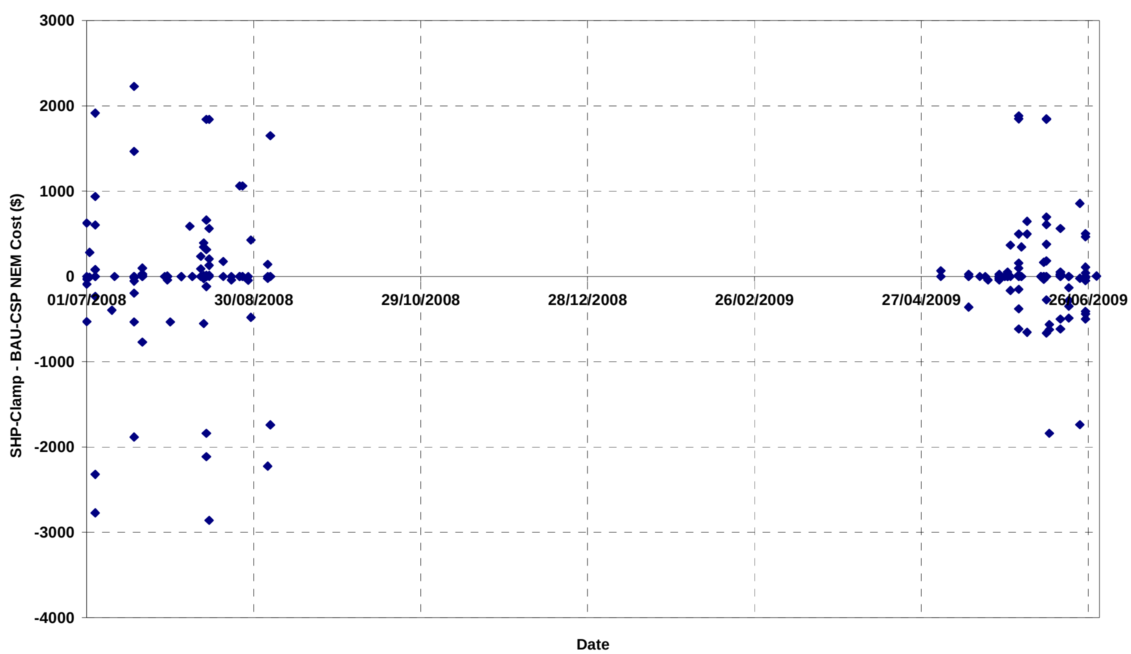


This figure illustrates that there are a substantial number of points in summer in which the BAU-CSP case delivers a lower NEM production cost than the SHP-CLAMP case. In these periods under the SHP-CLAMP case, analysis of the strategic bid moves (as shown in Appendix B) reveals that Snowy Hydro bids in a way which dispatches a small amount of Murray capacity, and very low to zero Tumut capacity. This causes higher priced generation to be dispatched elsewhere, especially gas fired plant in Victoria and South Australia. Under the BAU-CSP proposal, Snowy Hydro does not benefit from significant withdrawal of Tumut capacity, resulting in lower overall NEM production costs.

In the ROAM modelling the lower NEM production costs occur in the BAU-CSP case in the summer in high load periods.

Figure 6.2 shows the cost differential for periods throughout the year where all regional demands are within 6% of demand point 29[5]. As noted by Frontier in their modelling, demands close to demand point 29 tend to occur in the winter months.

Figure 6.2 - SHP-CLAMP cost differential against BAU-CSP costs for Demand Point 29 ($)



ROAM's modelling shows that on average the NEM production cost is higher for these points in the SHP-CLAMP case than for the BAU-CSP case.

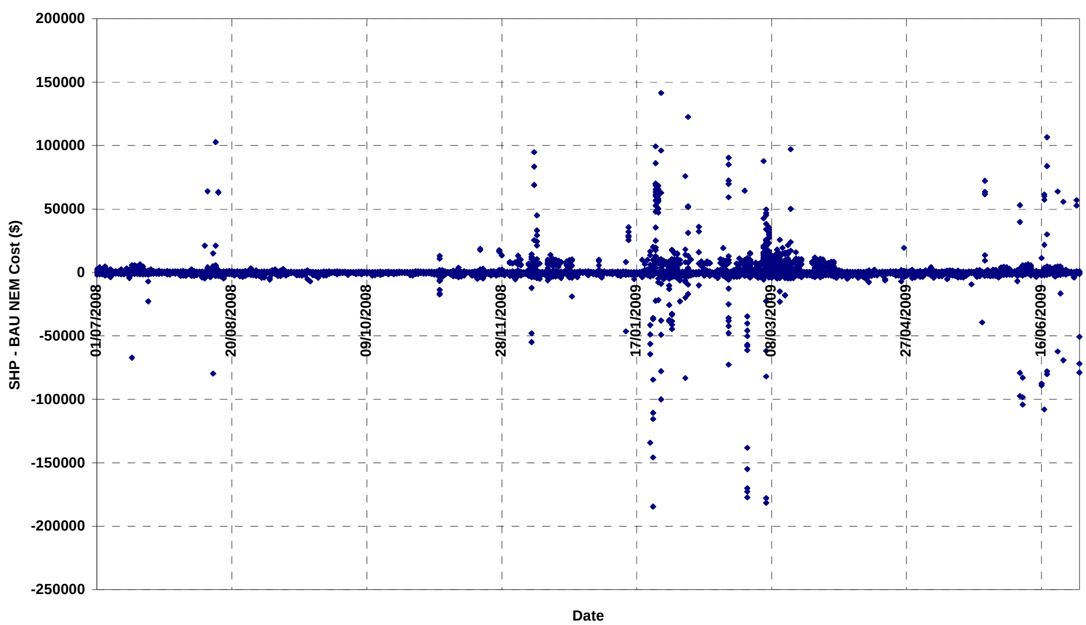
In the ROAM modelling the lower NEM production costs associated with demand point 29 occur in the BAU-CSP case in winter.

6.5.2) SHP case relative to the BAU case

For direct comparison with the Frontier modelling Figure 6.3 shows the NEM production cost differential over the entire study period for the SHP case relative to the BAU case,. In this case, no clamping is applied to the new VIC-NSW interconnector if negative settlements accumulate. As in the SHP-CLAMP case above , the costs are significantly higher for the SHP case in summer, and the cost for the entire year is higher, contradicting the findings of the Frontier report.

[5] The regional half hourly load traces have been analysed to find the periods throughout the year which best correlate with the set of regional demands presented in Demand Point 29. For each period, if each regional demand point in the load trace data was within ±6% of the level in Demand Point 29, then this half hour is included in the analysis.

Figure 6.3 - SHP cost differential against BAU costs ($) for Optimised Bids

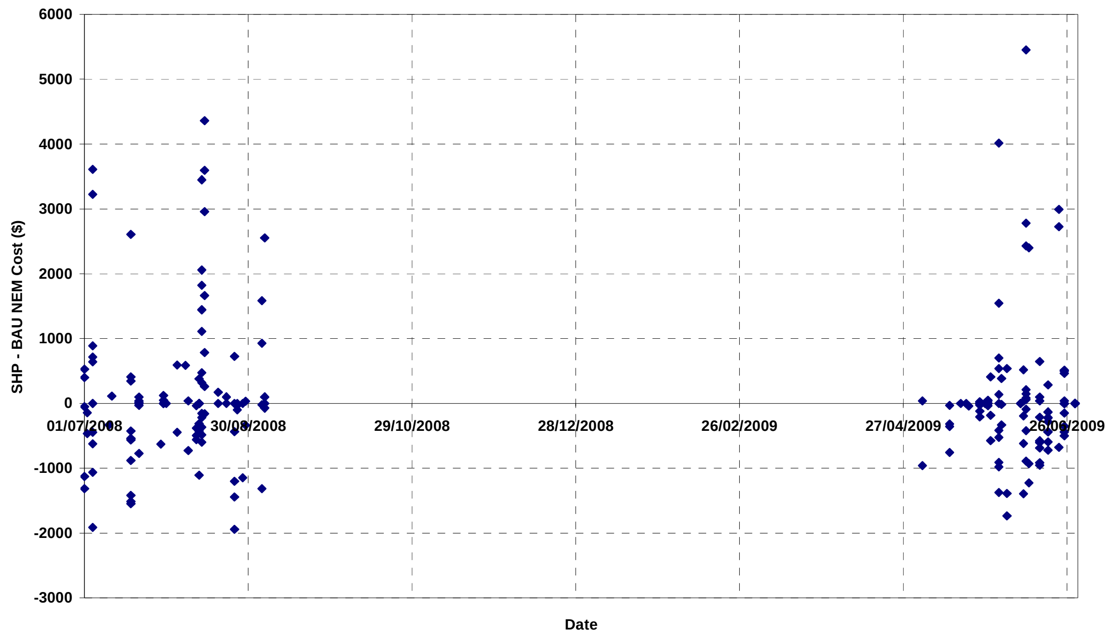


Although we found scattered periods near demand point 29 in which SHP was of lower cost than BAU, generally points near demand point 29 are less efficient, as shown in Figure 6.4. Furthermore, due to the large number of points in summer with very high Victorian demand inducing capacity withdrawal by Snowy Hydro in the SHP case, this case is also less efficient over the full year. Snowy Hydro has an incentive to withdraw capacity in this case so that the Murray and Guthega generators (located in the Victorian region) receive the high VIC price. This therefore forces the dispatch of more expensive generation in South Australia and Victoria, increasing overall NEM costs.

In the ROAM modelling the BAU case produces lower NEM production costs in the summer in high load periods than the SHP case.

Figure 6.4 shows the cost differential for periods throughout the year with all regional demands within 6% of demand point 29.

Figure 6.4 - SHP cost differential against BAU costs for Demand Point 29 ($)

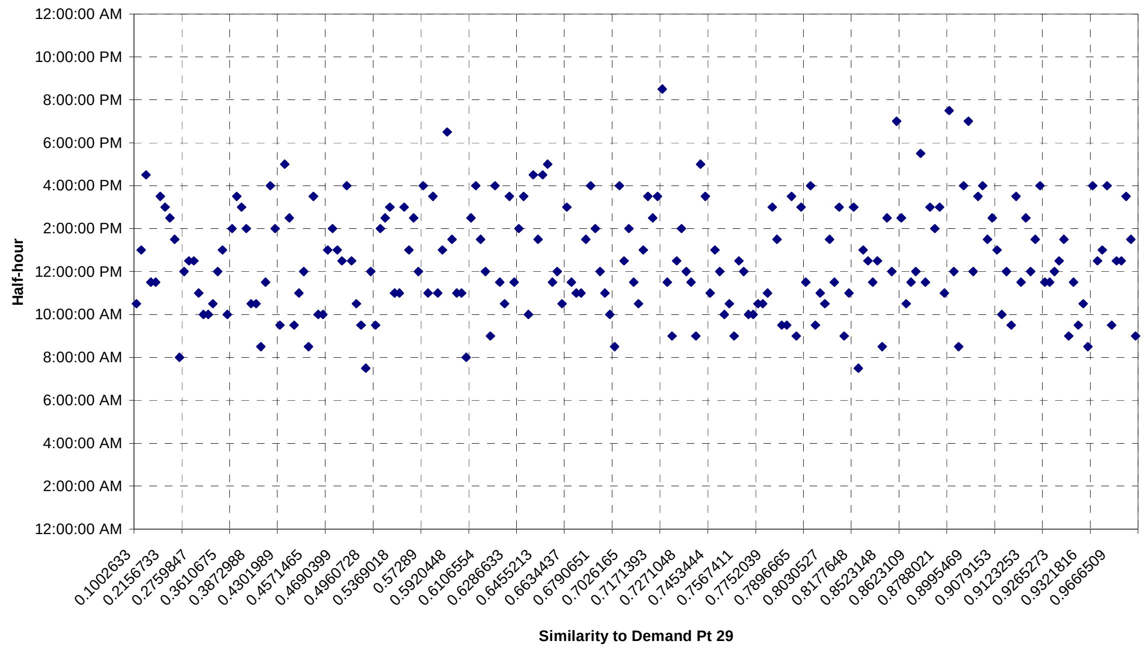


ROAM's modelling shows that on average the NEM production cost is higher for these points in the SHP case than for the BAU case.

In summary the above analysis shows that while the NEM costs are higher, on average, for periods considered within Frontier's demand point 29, Figure 6.1 and Figure 6.3 demonstrate that the most significant cause for reduced efficiency in the SHP and SHP-CLAMP cases are periods during summer, rather than the winter months. ROAM's conclusion therefore is that demand point 29 is not a significant period of interest, as suggested by Frontier, and that the strategic activity during summer is of greater interest. It is during these periods when higher NEM-wide loads persist and greater opportunities exist for Snowy Hydro to exert market power to cause binding constraints on the inter- and intra-regional connectors.

Figure 6.5 below illustrates the time of day in which the half-hour periods that are within 6% of demand point 29 occur in ROAM's half hourly load traces. The level of correlation diminishes with movement along the x-axis.. This analysis shows that demand point 29 is associated primarily with loads occurring during the winter peak hours, particularly between the hours of 8:00am to 4:00pm. It shows that these points occur mostly between 10am and 4pm, and as previously shown in Figure 6.2 predominantly in the winter period. However, Figures 6.1 to 6.4 indicates that there are substantial cost differentials between cases at other times, which are not covered by considering demand point 29 alone. The largest cost differentials occur in summer and winter periods, with smaller differentials in the shoulder seasons.

Figure 6.5 - Half-hour periods closest to Demand Point 29



6.6) RESULTS OF STRATEGIC BIDDING

Appendix B summarises the optimal bidding strategies for each case study as modelled by ROAM. As discussed in Section 3.6.2, the ROAM methodology was to compare the set of 81 strategic bidding options proposed by Frontier with an '82nd' bid profile representing typical bidding behaviour. In the bulk of half hours, for each case modelled, the optimal strategic bidding profile corresponded with the 'typical' bidding profile. In a relatively small percentage of half hours, a different strategic bidding scenario was found to be more advantageous to Snowy Hydro in terms of revenue generated in that half hour. The predominant outcome is that the Snowy Hydro Proposal favours strategic withdrawal of Tumut production in some half hours, and running Murray at low capacity. In the BAU-CSP case, Snowy Hydro has greater incentive to operate Tumut rather than Murray, despite the CSP/CSC trial 'correcting' the dispatch mispricing of the Tumut generation. The BAU case on the other hand has more uniform levels of Murray and Tumut production.

Table B.1 in Appendix B shows the 81 different strategic bidding options considered by Frontier, which have been replicated by ROAM on a half hourly basis to identify the strategic bidding patterns that will be most favourable to Snowy Hydro.

As can be seen from Table B.1, bidding patterns 1, 10, 19, 28, 37, 46, 55, 64, 73 correspond with increasing levels of generation from Murray but complete withdrawal of Tumut generation. These bidding patterns are heavily represented as the most beneficial generation arrangements to maximize Snowy Hydro revenue with the Snowy Hydro Proposal implemented. There are in fact almost twice as many occurrences of this type of bidding for the Snowy Hydro proposal (in either the SHP or SHP-CLAMP case) than the BAU-CSP case, and over six times more for the BAU case.

7) CONCLUSIONS

ROAM has replicated the Frontier modelling of the Snowy Hydro Proposal. The modelling conducted by Frontier has been reasonably detailed in terms of assumptions, modelling and discussion of outcomes. However, we have been unable to reproduce the results which led to Frontier's primary conclusions - that the Snowy Hydro proposal provides more efficient dispatch than the BAU with clamping case by approximately $2m/a. We found that the Snowy Hydro proposal provided higher NEM costs by $0.7m/a. We were also unable to demonstrate that demand point 29 was significant in terms of efficiency gains. Our analysis concluded that most efficiency differences can be found during the summer high load periods, whereas demand point 29 is associated more closely with peak winter periods.

At the request of the Southern Generators Coalition, we modelled a wider range of cases than modelled by Frontier, including the present situation, which includes the CSP/CSC trial and the Southern Generators' rule change, and the likely Snowy Hydro Proposal including clamping to avoid negative settlement residues. Comparing the Snowy Hydro Proposal with clamping on the new VIC-NSW interconnector, against the present situation with CSP/CSC trial and Southern Generators rule change, the latter was clearly superior in terms of efficiency of dispatch, resulting in a $1.16m/a reduction in NEM costs. Clamping on the new VIC-NSW interconnector however has had little impact on the efficiency of the Snowy Hydro Proposal, which is the same conclusion reached by Frontier.

Overall we have found that the Snowy Hydro proposal is inferior in terms of dispatch efficiency than a number of other cases, including the BAU with clamping case and the BAU with CSP/CSC and Southern Generators rule case (the present situation).

Appendix A) Glossary of Terms

Nodal modelling

This models individual nodes in a network.

Regional modelling

This aggregates nodes into a number of regions.

Radial network model

This is a network of nodes containing no loops. Constraint equations are easier to formulate.

Mesh network model

This consists of a non-linear network which includes loops.

Clamping

Clamping is a restriction of power flow from high to low price regions to prevent negative settlement residues from occurring. The flow is reduced until there are no counter-price flows. It has the effect of undermining inter-regional competitive pressure, which affects generator bidding behaviour. This distorts production and pricing decisions, and wastes resources.

Negative settlement residues

These occur in situations involving counter-price flows, in which customers would pay less for power than the generators are entitled to receive.[6]

Inter-Regional Settlement Residue (IRSR) Units

IRSR units are sold through Settlement Residue Auctions as a hedging mechanism for participants to manage the risk of entering inter-regional financial contracts. Counter-price flows can reduce the effectiveness of IRSRs.

Constraint Support Pricing / Constraint Support Contract Mechanism

The CSP/CSC mechanism includes an arrangement for distributing inter-regional settlement residues in the form of "constraint support contracts" (CSC)s. The Charles River Associates (CRA) proposal consists of two parts:

a) Locational marginal prices are set with reference to the regional reference price and the "cost" or "marginal" value of any binding constraints.
b) A mechanism for distributing rights to the newly created settlement residues, in the form of contracts known as "constraint support contracts".

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[6] A detailed explanation of the occurrence of counter price flows caused by the Snowy region is contained in the Commission's Final Rule Determination on the Management of Negative Settlement Residues in the Snowy Region, 14 September 2006, Section 2.3, p.7-8.

Each generator receives an entitlement to be dispatched by a certain amount, and receives a payment for this as a result. Generator profit is maximised when they are dispatched at a level of output where their marginal cost equals the nodal price. Thus (assuming adequate competition between generators) every generator has an incentive to bid in such a way as to truthfully reveal their marginal cost curve, whatever the level of entitlement. The amount of the entitlement is chosen to be equal to the dispatch the generator would obtain under the existing arrangements, which ensures that they are no worse off under the new arrangements.

The payment made to a generator is:

$$T = (p_{ref} - p_{pnp})(s_{entitlement} - s_{actual})$$

where p_{ref} is the reference node price, p_{pnp} is the pseudo-nodal price, $s_{entitlement}$ is the maximum generation allocation up to the level at which surrounding constraints allow that generator to exert market power, and s_{actual} is the actual nodal generation. In practise the pseudo-nodal price is a function of constraint coefficients and transmission loss factors with respect to the regional reference node, and the generation entitlement varies depending upon the inter-regional settlement values.[7]

Southern Generators Rule[8]

This introduces a new mechanism for managing negative settlement residues arising on the Victoria-to-Snowy interconnector. The rule requires positive settlement residues on the Snowy to NSW interconnector to be used to offset negative settlement residues accruing on the Victoria-to-Snowy interconnector (in both directions). This was intended to enhance the usefulness of Victoria to Snowy IRSRs, particularly for participants in Victoria seeking to hedge contracts referenced to the NSW RRN and to overcome the imperative for NEMMCO to intervene in dispatch or pricing.

This proposal aims to eliminate the risk of Victoria to Snowy IRSR units (in either direction) being in deficit, thereby eliminating the reason for NEMMCO to intervene in the operation of the market to impose clamping. Under this proposal, in the case of either northward or southward power flows, positive settlement residues accumulated on the interconnector between Snowy and NSW would be used to offset negative settlement residues accumulated on the interconnector between Victoria and Snowy.

[7] The actual trading amounts used are set out in chapter 8 of the Participant Derogations in version 9 of the NEMMCO National Electricity Rules.

[8] Australian Energy Market Commission, *Final Rule Determination – National Electricity Amendment (Management of Negative Settlement Residues in the Snowy Region) Rule 2006*

Appendix B) Optimisation Diversion Statistics

Table B.1 shows the percentage of capacity offered at SRMC by each generator for each possible bid:

Table B.1 – Bid Details

Bid_ID	Murray	Tumut	Bid_ID	Murray	Tumut
1	0.00%	0.00%	42	50.00%	62.50%
2	0.00%	12.50%	43	50.00%	75.00%
3	0.00%	25.00%	44	50.00%	87.50%
4	0.00%	37.50%	45	50.00%	100.00%
5	0.00%	50.00%	46	62.50%	0.00%
6	0.00%	62.50%	47	62.50%	12.50%
7	0.00%	75.00%	48	62.50%	25.00%
8	0.00%	87.50%	49	62.50%	37.50%
9	0.00%	100.00%	50	62.50%	50.00%
10	12.50%	0.00%	51	62.50%	62.50%
11	12.50%	12.50%	52	62.50%	75.00%
12	12.50%	25.00%	53	62.50%	87.50%
13	12.50%	37.50%	54	62.50%	100.00%
14	12.50%	50.00%	55	75.00%	0.00%
15	12.50%	62.50%	56	75.00%	12.50%
16	12.50%	75.00%	57	75.00%	25.00%
17	12.50%	87.50%	58	75.00%	37.50%
18	12.50%	100.00%	59	75.00%	50.00%
19	25.00%	0.00%	60	75.00%	62.50%
20	25.00%	12.50%	61	75.00%	75.00%
21	25.00%	25.00%	62	75.00%	87.50%
22	25.00%	37.50%	63	75.00%	100.00%
23	25.00%	50.00%	64	87.50%	0.00%
24	25.00%	62.50%	65	87.50%	12.50%
25	25.00%	75.00%	66	87.50%	25.00%
26	25.00%	87.50%	67	87.50%	37.50%
27	25.00%	100.00%	68	87.50%	50.00%
28	37.50%	0.00%	69	87.50%	62.50%
29	37.50%	12.50%	70	87.50%	75.00%
30	37.50%	25.00%	71	87.50%	87.50%
31	37.50%	37.50%	72	87.50%	100.00%
32	37.50%	50.00%	73	100.00%	0.00%
33	37.50%	62.50%	74	100.00%	12.50%
34	37.50%	75.00%	75	100.00%	25.00%
35	37.50%	87.50%	76	100.00%	37.50%
36	37.50%	100.00%	77	100.00%	50.00%
37	50.00%	0.00%	78	100.00%	62.50%
38	50.00%	12.50%	79	100.00%	75.00%
39	50.00%	25.00%	80	100.00%	87.50%
40	50.00%	37.50%	81	100.00%	100.00%
41	50.00%	50.00%	82	Typical	Typical

Table B.2 – BAU Case Half-Hourly Bid Frequencies											
Bid_ID	**Total**	**Offpeak**	**Peak**	**Summer**	**Winter**	**Bid_ID**	**Total**	**Offpeak**	**Peak**	**Summer**	**Winter**
1	53	45	8	48	5	**42**	-	-	-	-	-
2	69	40	29	48	21	**43**	-	-	-	-	-
3	30	15	15	30	-	**44**	-	-	-	-	-
4	30	15	15	30	-	**45**	-	-	-	-	-
5	45	18	27	45	-	**46**	4	4	-	4	-
6	41	25	16	41	-	**47**	-	-	-	-	-
7	55	33	22	53	2	**48**	-	-	-	-	-
8	113	63	50	112	1	**49**	-	-	-	-	-
9	175	100	75	168	7	**50**	-	-	-	-	-
10	528	319	209	375	153	**51**	-	-	-	-	-
11	9	3	6	8	1	**52**	-	-	-	-	-
12	5	2	3	4	1	**53**	-	-	-	-	-
13	4	2	2	4	-	**54**	-	-	-	-	-
14	4	-	4	4	-	**55**	-	-	-	-	-
15	6	3	3	6	-	**56**	-	-	-	-	-
16	9	5	4	9	-	**57**	-	-	-	-	-
17	11	5	6	11	-	**58**	-	-	-	-	-
18	16	12	4	16	-	**59**	-	-	-	-	-
19	8	8	-	6	2	**60**	-	-	-	-	-
20	2	2	-	-	2	**61**	-	-	-	-	-
21	-	-	-	-	-	**62**	-	-	-	-	-
22	-	-	-	-	-	**63**	-	-	-	-	-
23	-	-	-	-	-	**64**	-	-	-	-	-
24	1	-	1	1	-	**65**	-	-	-	-	-
25	-	-	-	-	-	**66**	-	-	-	-	-
26	-	-	-	-	-	**67**	-	-	-	-	-
27	2	1	1	2	-	**68**	-	-	-	-	-
28	-	-	-	-	-	**69**	-	-	-	-	-
29	1	1	-	1	-	**70**	-	-	-	-	-
30	-	-	-	-	-	**71**	-	-	-	-	-
31	-	-	-	-	-	**72**	-	-	-	-	-
32	-	-	-	-	-	**73**	-	-	-	-	-
33	-	-	-	-	-	**74**	-	-	-	-	-
34	-	-	-	-	-	**75**	-	-	-	-	-
35	-	-	-	-	-	**76**	-	-	-	-	-
36	-	-	-	-	-	**77**	-	-	-	-	-
37	2	-	2	-	2	**78**	-	-	-	-	-
38	-	-	-	-	-	**79**	-	-	-	-	-
39	-	-	-	-	-	**80**	-	-	-	-	-
40	-	-	-	-	-	**81**	-	-	-	-	-
41	-	-	-	-	-	**82**	16297	6039	10258	7710	8587
						Total Diversions	**1223**	**721**	**502**	**1026**	**197**

Table B.3 – BAU-CSP Case Half-Hourly Bid Frequencies

Bid_ID	Total	Offpeak	Peak	Summer	Winter	Bid_ID	Total	Offpeak	Peak	Summer	Winter
1	90	65	25	61	29	**42**	-	-	-	-	-
2	231	99	132	142	89	**43**	-	-	-	-	-
3	377	208	169	373	4	**44**	-	-	-	-	-
4	-	-	-	-	-	**45**	-	-	-	-	-
5	8	4	4	2	6	**46**	-	-	-	-	-
6	20	11	9	14	6	**47**	-	-	-	-	-
7	4	3	1	4	-	**48**	-	-	-	-	-
8	5	5	-	4	1	**49**	-	-	-	-	-
9	6	6	-	6	-	**50**	-	-	-	-	-
10	1725	921	804	1069	656	**51**	-	-	-	-	-
11	17	11	6	9	8	**52**	-	-	-	-	-
12	8	-	8	8	-	**53**	-	-	-	-	-
13	-	-	-	-	-	**54**	-	-	-	-	-
14	-	-	-	-	-	**55**	-	-	-	-	-
15	-	-	-	-	-	**56**	-	-	-	-	-
16	-	-	-	-	-	**57**	-	-	-	-	-
17	-	-	-	-	-	**58**	-	-	-	-	-
18	-	-	-	-	-	**59**	-	-	-	-	-
19	28	12	16	13	15	**60**	-	-	-	-	-
20	2	2	-	2	-	**61**	-	-	-	-	-
21	-	-	-	-	-	**62**	-	-	-	-	-
22	-	-	-	-	-	**63**	-	-	-	-	-
23	-	-	-	-	-	**64**	-	-	-	-	-
24	-	-	-	-	-	**65**	-	-	-	-	-
25	-	-	-	-	-	**66**	-	-	-	-	-
26	-	-	-	-	-	**67**	-	-	-	-	-
27	-	-	-	-	-	**68**	-	-	-	-	-
28	3	1	2	3	-	**69**	-	-	-	-	-
29	-	-	-	-	-	**70**	-	-	-	-	-
30	-	-	-	-	-	**71**	-	-	-	-	-
31	-	-	-	-	-	**72**	-	-	-	-	-
32	-	-	-	-	-	**73**	-	-	-	-	-
33	-	-	-	-	-	**74**	-	-	-	-	-
34	-	-	-	-	-	**75**	-	-	-	-	-
35	-	-	-	-	-	**76**	-	-	-	-	-
36	-	-	-	-	-	**77**	-	-	-	-	-
37	-	-	-	-	-	**78**	-	-	-	-	-
38	-	-	-	-	-	**79**	-	-	-	-	-
39	-	-	-	-	-	**80**	-	-	-	-	-
40	-	-	-	-	-	**81**	-	-	-	-	-
41	-	-	-	-	-	**82**	14996	5412	9584	7026	7970
						Total Diversions	**2524**	**1348**	**1176**	**1710**	**814**

Table B.4 – SHP Case Half-Hourly Bid Frequencies

Bid_ID	Total	Offpeak	Peak	Summer	Winter	Bid_ID	Total	Offpeak	Peak	Summer	Winter
1	52	37	15	34	18	**42**	-	-	-	-	-
2	53	27	26	43	10	**43**	-	-	-	-	-
3	13	9	4	9	4	**44**	-	-	-	-	-
4	-	-	-	-	-	**45**	-	-	-	-	-
5	-	-	-	-	-	**46**	1	1	-	-	1
6	-	-	-	-	-	**47**	-	-	-	-	-
7	-	-	-	-	-	**48**	-	-	-	-	-
8	-	-	-	-	-	**49**	-	-	-	-	-
9	-	-	-	-	-	**50**	-	-	-	-	-
10	3013	1571	1442	1986	1027	**51**	-	-	-	-	-
11	-	-	-	-	-	**52**	-	-	-	-	-
12	-	-	-	-	-	**53**	-	-	-	-	-
13	-	-	-	-	-	**54**	-	-	-	-	-
14	-	-	-	-	-	**55**	3	-	3	1	2
15	-	-	-	-	-	**56**	-	-	-	-	-
16	-	-	-	-	-	**57**	-	-	-	-	-
17	-	-	-	-	-	**58**	-	-	-	-	-
18	-	-	-	-	-	**59**	-	-	-	-	-
19	261	88	173	166	95	**60**	-	-	-	-	-
20	2	-	2	1	1	**61**	-	-	-	-	-
21	-	-	-	-	-	**62**	-	-	-	-	-
22	-	-	-	-	-	**63**	-	-	-	-	-
23	-	-	-	-	-	**64**	-	-	-	-	-
24	-	-	-	-	-	**65**	-	-	-	-	-
25	-	-	-	-	-	**66**	-	-	-	-	-
26	-	-	-	-	-	**67**	-	-	-	-	-
27	-	-	-	-	-	**68**	-	-	-	-	-
28	52	24	28	37	15	**69**	-	-	-	-	-
29	1	-	1	1	-	**70**	-	-	-	-	-
30	-	-	-	-	-	**71**	-	-	-	-	-
31	-	-	-	-	-	**72**	-	-	-	-	-
32	-	-	-	-	-	**73**	-	-	-	-	-
33	-	-	-	-	-	**74**	-	-	-	-	-
34	-	-	-	-	-	**75**	-	-	-	-	-
35	-	-	-	-	-	**76**	-	-	-	-	-
36	-	-	-	-	-	**77**	-	-	-	-	-
37	7	-	7	4	3	**78**	-	-	-	-	-
38	-	-	-	-	-	**79**	-	-	-	-	-
39	-	-	-	-	-	**80**	-	-	-	-	-
40	-	-	-	-	-	**81**	-	-	-	-	-
41	-	-	-	-	-	**82**	14062	5003	9059	6454	7608
						Total Diversions	**3458**	**1757**	**1701**	**2282**	**1176**

Table B.5 – SHP-CLAMP Case Half-Hourly Bid Frequencies

Bid_ID	Total	Offpeak	Peak	Summer	Winter	Bid_ID	Total	Offpeak	Peak	Summer	Winter
1	51	36	15	34	17	**42**	-	-	-	-	-
2	50	22	28	42	8	**43**	-	-	-	-	-
3	12	10	2	9	3	**44**	-	-	-	-	-
4	-	-	-	-	-	**45**	-	-	-	-	-
5	-	-	-	-	-	**46**	2	1	1	-	2
6	-	-	-	-	-	**47**	-	-	-	-	-
7	-	-	-	-	-	**48**	-	-	-	-	-
8	-	-	-	-	-	**49**	-	-	-	-	-
9	-	-	-	-	-	**50**	-	-	-	-	-
10	3090	1611	1479	2029	1061	**51**	-	-	-	-	-
11	3	2	1	1	2	**52**	-	-	-	-	-
12	1	1	-	-	1	**53**	-	-	-	-	-
13	-	-	-	-	-	**54**	-	-	-	-	-
14	-	-	-	-	-	**55**	3	-	3	1	2
15	-	-	-	-	-	**56**	-	-	-	-	-
16	-	-	-	-	-	**57**	-	-	-	-	-
17	-	-	-	-	-	**58**	-	-	-	-	-
18	-	-	-	-	-	**59**	-	-	-	-	-
19	266	89	177	167	99	**60**	-	-	-	-	-
20	4	-	4	1	3	**61**	-	-	-	-	-
21	1	-	1	-	1	**62**	-	-	-	-	-
22	-	-	-	-	-	**63**	-	-	-	-	-
23	-	-	-	-	-	**64**	-	-	-	-	-
24	-	-	-	-	-	**65**	-	-	-	-	-
25	-	-	-	-	-	**66**	-	-	-	-	-
26	-	-	-	-	-	**67**	-	-	-	-	-
27	-	-	-	-	-	**68**	-	-	-	-	-
28	58	28	30	39	19	**69**	-	-	-	-	-
29	5	3	2	3	2	**70**	-	-	-	-	-
30	1	-	1	-	1	**71**	-	-	-	-	-
31	-	-	-	-	-	**72**	-	-	-	-	-
32	-	-	-	-	-	**73**	-	-	-	-	-
33	-	-	-	-	-	**74**	-	-	-	-	-
34	-	-	-	-	-	**75**	-	-	-	-	-
35	-	-	-	-	-	**76**	-	-	-	-	-
36	-	-	-	-	-	**77**	-	-	-	-	-
37	8	1	7	4	4	**78**	-	-	-	-	-
38	-	-	-	-	-	**79**	-	-	-	-	-
39	-	-	-	-	-	**80**	-	-	-	-	-
40	-	-	-	-	-	**81**	-	-	-	-	-
41	-	-	-	-	-	**82**	13965	4956	9009	6406	7559
						Total Diversions	**3555**	**1804**	**1751**	**2330**	**1225**

Table B.6 – SRD Case Half-Hourly Bid Frequencies

Bid_ID	Total	Offpeak	Peak	Summer	Winter	Bid_ID	Total	Offpeak	Peak	Summer	Winter
1	115	77	38	73	42	42	-	-	-	-	-
2	422	188	234	266	156	43	-	-	-	-	-
3	9	5	4	7	2	44	-	-	-	-	-
4	-	-	-	-	-	45	-	-	-	-	-
5	-	-	-	-	-	46	-	-	-	-	-
6	-	-	-	-	-	47	-	-	-	-	-
7	-	-	-	-	-	48	-	-	-	-	-
8	-	-	-	-	-	49	-	-	-	-	-
9	-	-	-	-	-	50	-	-	-	-	-
10	2602	1397	1205	1675	927	51	-	-	-	-	-
11	27	11	16	14	13	52	-	-	-	-	-
12	1	-	1	1	-	53	-	-	-	-	-
13	2	1	1	2	-	54	-	-	-	-	-
14	-	-	-	-	-	55	-	-	-	-	-
15	-	-	-	-	-	56	-	-	-	-	-
16	-	-	-	-	-	57	-	-	-	-	-
17	-	-	-	-	-	58	-	-	-	-	-
18	-	-	-	-	-	59	-	-	-	-	-
19	74	31	43	44	30	60	-	-	-	-	-
20	-	-	-	-	-	61	-	-	-	-	-
21	-	-	-	-	-	62	-	-	-	-	-
22	-	-	-	-	-	63	-	-	-	-	-
23	-	-	-	-	-	64	-	-	-	-	-
24	-	-	-	-	-	65	-	-	-	-	-
25	-	-	-	-	-	66	-	-	-	-	-
26	-	-	-	-	-	67	-	-	-	-	-
27	-	-	-	-	-	68	-	-	-	-	-
28	7	2	5	3	4	69	-	-	-	-	-
29	1	1	-	1	-	70	-	-	-	-	-
30	-	-	-	-	-	71	-	-	-	-	-
31	-	-	-	-	-	72	-	-	-	-	-
32	-	-	-	-	-	73	-	-	-	-	-
33	-	-	-	-	-	74	-	-	-	-	-
34	-	-	-	-	-	75	-	-	-	-	-
35	-	-	-	-	-	76	-	-	-	-	-
36	-	-	-	-	-	77	-	-	-	-	-
37	3	-	3	1	2	78	-	-	-	-	-
38	-	-	-	-	-	79	-	-	-	-	-
39	-	-	-	-	-	80	-	-	-	-	-
40	-	-	-	-	-	81	-	-	-	-	-
41	-	-	-	-	-	82	14257	5047	9210	6649	7608
						Total Diversions	3263	1713	1550	2087	1176