Heywood Interconnector Augmentation

South East Control Scheme

February 2013

Version 2

ElectraNet Corporate Headquarters
52-55 East Terrace, Adelaide, South Australia 5000 • PO Box, 7096, Hutt Street Post Office, Adelaide, South Australia 5000
Tel: (08) 8404 7966 • Fax: (08) 8404 7104 • Toll Free: 1800 243 853

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Revision Record

Date	Version	Description	Author	Checked By	Approved By
30/11/12	1	Issue 1	Brad Harrison – Principal Energy Market Analyst	Hugo Klingenberg Senior Manager Network Development	
15/02/13	2	Minor editing changes, revision following improved certainty of demand changes in south east South Australia	Brad Harrison – Principal Energy Market Analyst	Vinod Dayal Principal Network Strategy Engineer Brad Parker Senior Planning Engineer	Hugo Klingenberg Senior Manager Network Development

Executive Summary

The Heywood interconnector upgrade RIT-T found that there was zero benefit realised from reducing congestion across the South East transformers. Whilst the model found approximately 180 hours of congestion per year across the transformers, the forgone generation was replaced by similar cost generation.

The RIT-T finding underestimated the level of congestion at the time, due to reducing demand in the South East of South Australia. The lower demand levels that became apparent at the time the conclusion was published and were largely the result of a single firm: Kimberly Clarke Australia (KCA).

The Heywood market modelling considered macro level assumptions rather than the decisions of individual firms. This was reasonable given the nature of the project was to explore an upgrade to a national flow path – and the relative size of KCA in the context of the market. The sensitivity of market benefit calculations for credible options to the decisions of individual firms was not well understood at the beginning of the project.

Additional modelling, taking into account the observed reductions in demand, indicates that actual congestion maybe five times higher than the levels found in the main market modelling undertaken in the Heywood interconnector upgrade RIT-T.

Despite the higher levels of congestion, an additional transformer is unlikely to be an efficient investment given the nature of congestion that is occurring, namely that of exports from the 132 kV network. A control scheme was explored that would allow greater utilisation of the existing south east transformers, whilst maintaining system security.

With the higher levels of congestion, the control scheme was found to be an economic investment, albeit a marginal one.

KCA is also planning to install a 20 MW generator. This will further exacerbate congestion across the transformers. This investment is expected to go ahead. Modelling indicates that with this generator in place, the control scheme delivers significant benefits.

On the basis that the KCA generator is progressing to committed status, ElectraNet plans to invest in the control scheme as part of the Heywood interconnector upgrade RIT-T.

Contents

1. Introduction

This paper explores the potential for a control scheme on the 275/132 kV transformers in the South East to allow greater exports of energy from the 132 kV network to the 275 kV network, at times of low load and high wind generation when Heywood Interconnector is exporting from SA to Victoria. ElectraNet is presently considering the possibility of applying a short term ratings to the South East transformers. While the benefits of these short term ratings are not modelled explicitly, they can be inferred from some of the analysis.

This paper examines the benefits of a South East transformer as already modelled by the Heywood interconnector upgrade RIT-T team in Prophet. It then sets up a second, reduced, network model which explores in more detail the potential for a control scheme given what is likely to be reducing demand in the South East region.

This paper concludes that under some future scenarios the benefits of the control scheme are sufficient to justify the costs of the control scheme.

The decision is sensitive to a number of uncertainties including the level of demand, annual operating costs and the value of constrained generation at the time of congestion.

2. Background

ElectraNet Pty Ltd (ElectraNet) is the principal electricity Transmission Network Service Provider (TNSP) in South Australia, operating as part of the National Electricity Market under National Electricity Rules. The company's revenue is set by the Australian Energy Regulator (AER).

ElectraNet's role is to own and manage the high-voltage transmission lines and substations that connect this State's electricity generation system to multiple customer connection points, including ETSA Utilities' lower-voltage distribution network. The role of ElectraNet in the electricity supply chain is shown in Figure 1:

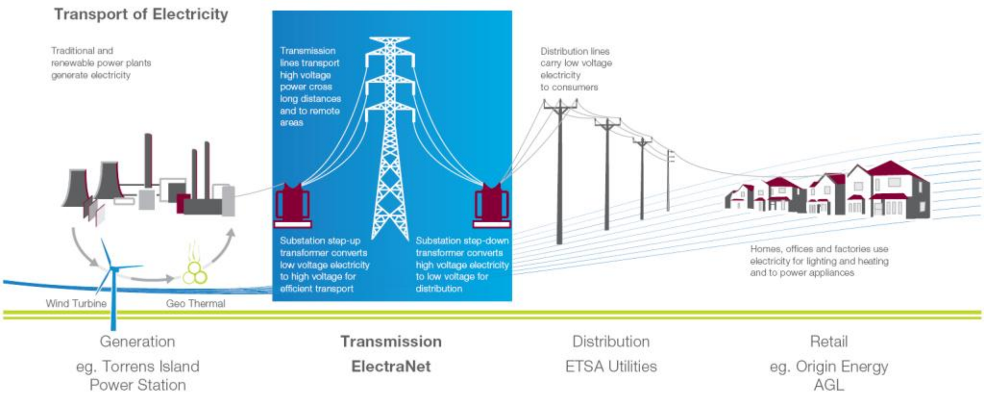


Figure 1: Role of ElectraNet in the electricity supply chain

ElectraNet's transmission network is one of the most extensive regional transmission systems in Australia, extending across some 200,000 square kilometres of the State. This network consists of transmission lines operating at 132,000 and 275,000 Volts, which are supported by both lattice towers and large stobie poles.

Following submissions on ElectraNet and AEMO's South Australia – Victoria (Heywood) Interconnector Upgrade Project Assessment Draft Report (PADR) the team committed to study in more detail the potential for a South East control scheme to allow a non-firm increase in the transformers capability to inject energy into the 275 kV network. It may be noted that there is an existing constraint due to the South East transformers during times of light load, high export and high wind generation in the South East region, which is expected to be exacerbated with reduction in demand from KCA and other demand in the region.

Previously, the team had studied in great detail the potential for a third transformer at the South East. This was shown not to be warranted, as benefits were not sufficient to cover the costs.

Since July 2012, congestion on the South East transformer has increased from historical levels. The limits on flows across the transformer have been reached for over 200 hours over the first four months of the 2012/13 financial year, specifically: 21 hours in July; 33 hours in August; 119 hours in September and 52 in October 2012. This is on par with annual levels over the preceding two years.

A reduction in demand in the South East of South Australia is leading to greater flows over the South East transformers. This reduction, caused by the decision of an individual firm, was not adequately explored in the Heywood modelling. Assumptions in the Heywood modelling considered broader scenarios – less likely to be impacted by the decisions of an individual firm – as is appropriate for assessing the national flow path.

The congestion that has recently occurred has been entirely on flows over the transformers injecting into the 275 kV network. A third transformer would deliver benefits in both directions. A control scheme could deliver benefits in only a single direction, at lower cost and hence is likely to be a more efficient solution to this congestion.

3. Prophet modelling

3.1 Third South East transformer benefits

The gross benefits of a third South East transformer were effectively zero[1] as calculated by the Prophet model. Given there could reasonably be expected to be some benefits, even if small, the benefits were also approximated for the alternative credible option of capacitor banks (option 2a and 2b). In this network option, the South East transformer delivered gross benefits of approximately $5.6 million. This remained insufficient to cover the costs of the transformer.

These benefits were calculated using cost and benefit values used in the PADR. Additional cost considerations have not been taken into account.

The zero value of congestion across the South East transformers in the prophet model is insufficient to warrant any investment, even at relatively small cost. Given the Prophet model omitted detail on south east SA demands (that have only recently become apparent), this result was somewhat inconclusive.

[1] The Present Value of the gross benefits was actually -$103,041. The fact that this was negative is put down to noise in the model.

It is clear from the Prophet modelling that under the preferred option, the impact to the market of the congestion significantly reduces from the current network configuration. This can be seen in the formulation of the constraints that manage this congestion, which have the interconnector co-efficient reduced from 22 per cent to 8.5[2] per cent.

Despite this formulation, and the zero value of congestion across the transformers, the transformers did impact on dispatch for an average of 180 hours per annum in the revised central scenario. This indicates that when the constraint has bound, it has replaced the spilt energy with energy of similar cost profile.

4. Reduced network model

A reduced network model has been developed to investigate the reduced loads in south east SA and the potential for increased congestion across the transformers.

4.1 Loads

Demand is taken from the medium forecasts in ElectraNet's 2012 APR. Demands at Snuggery Rural and Kincraig have been updated for the latest SA Power Network forecasts received in November 2012. Energy growth is based on AEMO's state-wide forecast of 0.9 per cent per annum. Baseline energy and demand traces are from calendar year 2011.

Canunda and Lake Bonney generation have been added back to demands. Lake Bonney generation has also been used as a proxy for Canunda's generation and has been scaled to suit this purpose.

Four different scenarios were applied to Snuggery Industrial.

Snuggery – Central: is based on the growth forecasts received in April 2012 with Snuggery Rural and Kincraig updated in November 2012. Energy consumption is based on the 2011-12 financial year (459 GWh).

Snuggery – Lower 10 per cent: is based on the Snuggery – Central. Initial annual energy is reduced by 10 per cent (45.9 GWh) based on a 10 per cent reduction in energy consumption at Snuggery. Demand growth is reduced by 10 per cent (5.22 MW) of 2011/12 forecast growth throughout the horizon.

Snuggery – Lower 20 per cent: is based on the Snuggery – Central. Initial annual energy is reduced by 20 per cent (91.9 GWh) based on a 10 per cent reduction in energy consumption at Snuggery. Demand growth is reduced by 20 per cent (10.44 MW) of 2011/12 forecast growth throughout the horizon.

Snuggery – Rural: is an extreme future with industrial loads reducing to zero. The scenario is based on the Snuggery – Central scenario, with energy reduced to 66 GWh.

[2] At 7 per cent, the terms are removed from the left hand side and the congestion would no longer be reflected on the interconnector at all if this occurred.

Scenario weightings are presented below. These weightings have been revised since the original report dated November 2012 due to greater certainty in future demand reduction in south east SA. A single sensitivity has been explored with the Rural scenario weighted at 100 per cent.

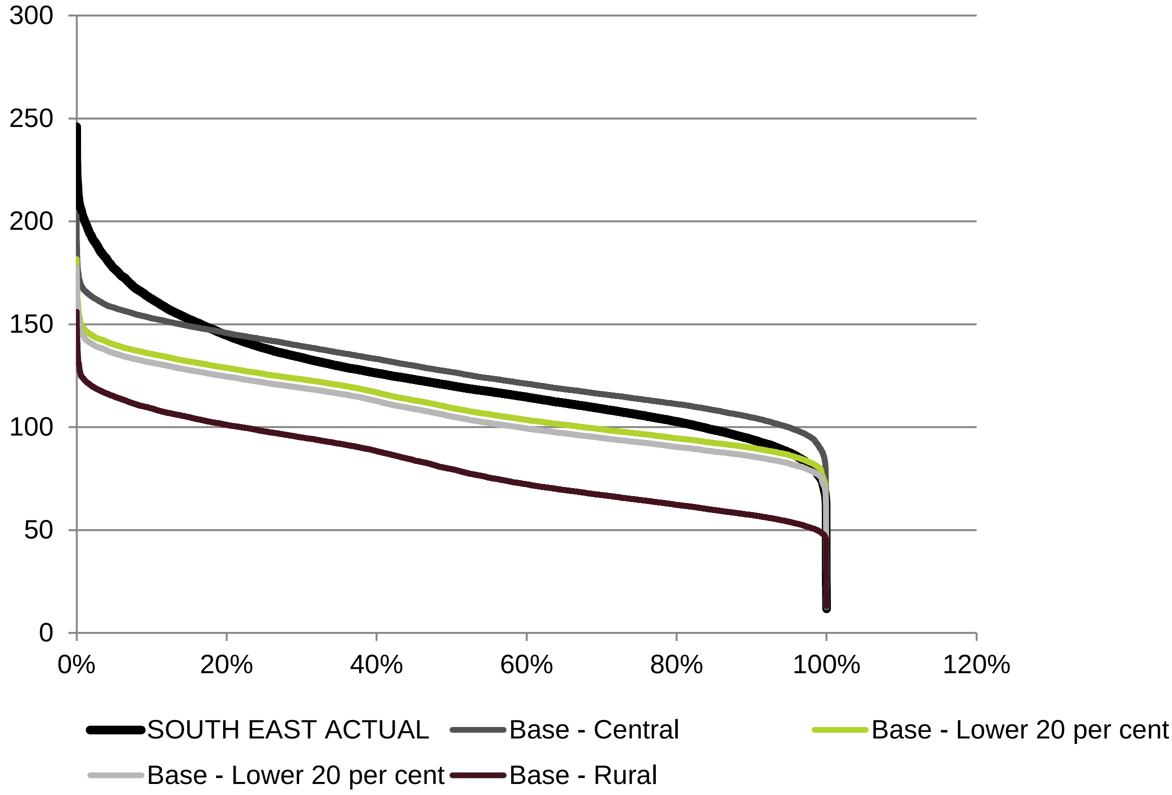
Figure 1: Scenario Weightings

Scenario	Weighting
Central	25 per cent
Lower 10 per cent	25 per cent
Lower 20 per cent	25 per cent
Rural	25 per cent

Whilst Central is given a weighting of 25 per cent it does represent a realistic upper estimate of demand over the next couple of years. Recently demands in the south east of SA have been observed to decline by 10 per cent year on year. It is possible that this will happen again and potentially be much higher. ElectraNet is currently working with SA Power Networks and Kimberly Clark Australia (KCA) on the connection of new embedded generation in the vicinity of the Snuggery connection point. This is expected to lead to lower future demand in south east SA and in effect make the Rural scenario more likely.

Figure 2 below shows load duration curves for 2014 in each scenario and includes the actual duration curve for 2011. There is a significant reduction in the amount of energy contained in the 10%, 20% and rural scenarios. The central scenario has less energy at the top end and more at the low end. It is at the low end of demand we expect to drive greater levels of congestion.

Figure 2: South East load duration curves, simulated and actual



4.2 Generators

The Snuggery peaking generators have not been modelled. It is assumed that when these expensive Open Cycle Gas Turbines operate, it is to meet peak South Australian demand. Under such conditions, power will flow through the South East transformers from the 275 kV to the 132 kV system, to meet the regional demand.

All Lake Bonney wind traces are based on the non-scheduled Lake Bonney 1 wind farm for calendar year 2011. This assumes 100 per cent coincidence of output across Lake Bonney 1, Lake Bonney 2 and Lake Bonney 3. Canunda has been derived from its own wind trace.

No random outages of units have been assumed. This is assumed to have been built into the wind traces.

Ladbroke Grove has a maximum annual capacity factor of 20 per cent applied. This is based on recent observation. Ladbroke Grove has operated as high as 35 per cent in 2006/07[3]. Increased operation of Ladbroke Grove would increase congestion.

[3] http://www.aemo.com.au/Electricity/Planning/Reports/South-Australian-Advisory-Functions/South-Australian-Historical-Market-Information?sc_camp=B9CC3A223249409C968499A7CDEFF314&ec_as=D7139EB82CA84CEBBE036EF60E974026

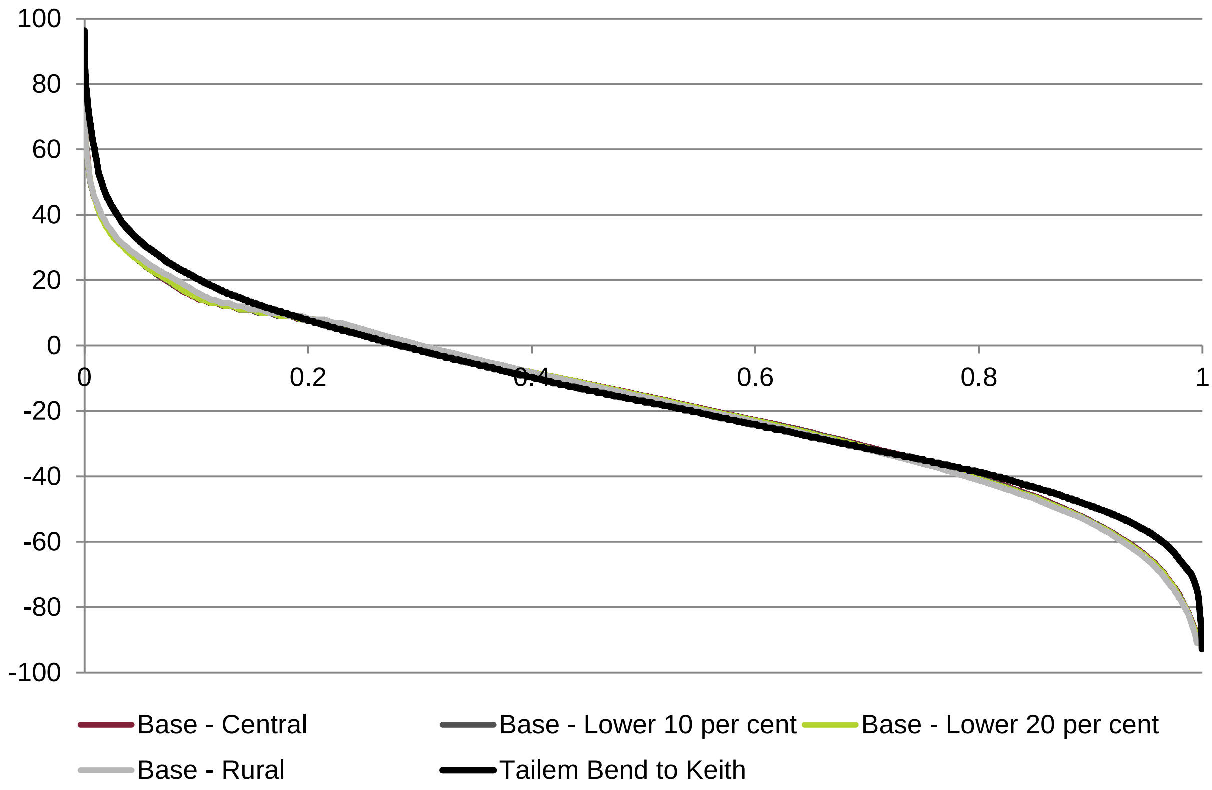
4.3 Markets

Plexos markets have been used to simulate energy flows into and out of the South East network and to prevent USE events when wind farms are not in operation. Three markets have been used: Eastern Hills, Tailem Bend and South East. These are presented in the network diagram (Figure 4) in RED with a bus and the letter M. The markets buy and sell energy to the network depending on the prevailing prices at the time.

The Tailem Bend and Eastern Hills markets have been used to simulate appropriate flows across the Keith to Tailem Bend line. Flows across the Tailem Bend transformer frequently flow north into the Eastern Hills. The model has not attempted to re-create these flows as they are not believed to impact on congestion across the South East transformers.

Flows across the remaining Keith to Tailem Bend line have been kept at the same levels as currently observed across the two Keith to Tailem Bend lines. This will over-estimate the flows south, which we expect to reduce with the proposed network augmentation, due to the higher impedance of the remaining single line in the 132 kV network and the reduced impedance of the 275 kV network due to the proposed series compensation. This is expected to increase the incidence of congestion over the 275/132 kV transformer in the South East during conditions of low demand and high wind generation in South Australia.

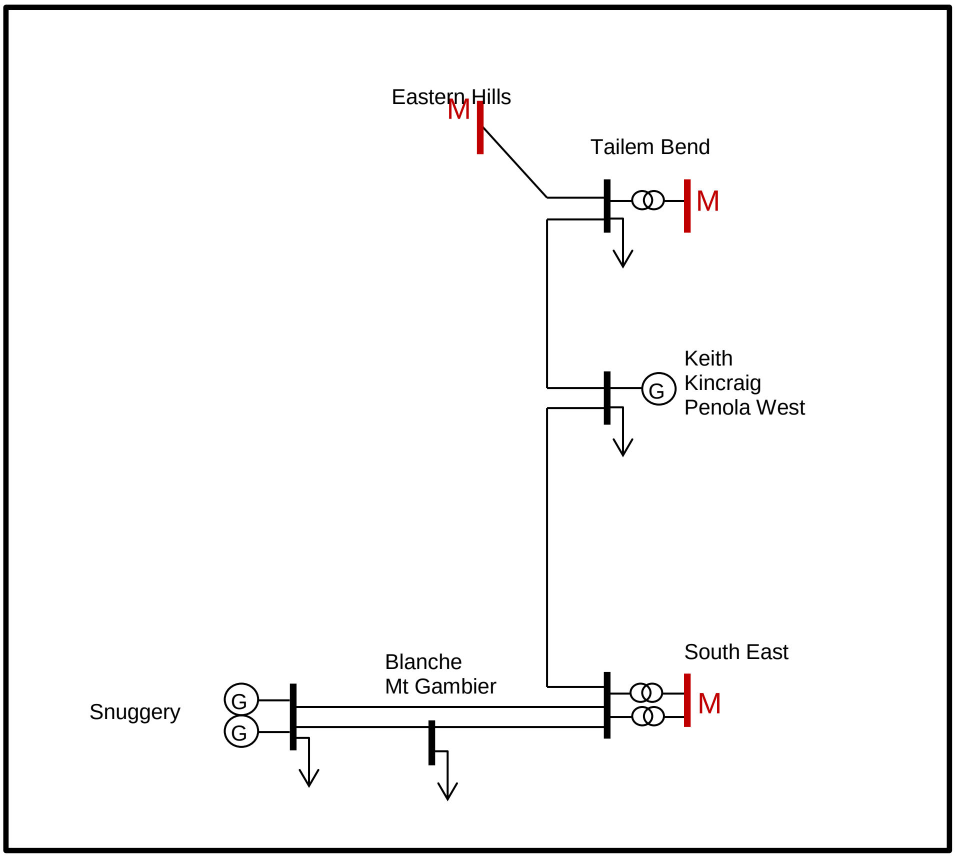
Figure 3: 2014 Tailem Bend to Keith flows, comparison with actual 2011 flows.



4.4 Network

The 132 kV network simulated has assumed decommissioning of the weaker Snuggery –Keith - Tailem Bend line. A graphical representation of the network is presented in figure 4. Static ratings, assuming winter conditions have been used.

Figure 4: graphical network representation.



4.5 South East Transformer Flows

Flows across the transformer without a control scheme are presented in Figure 5 below for all scenarios in year 2014. Actual flows for the calendar year 2011 have also been included. Figure 6 also shows the flow duration curves with the control scheme allowing the transformer to reach the full rating. Figure 7 shows the hours in each scenario the flows over the transformers were congested without the control scheme.

Figure 5: flows across the South East transformers with n-1 limit enforced

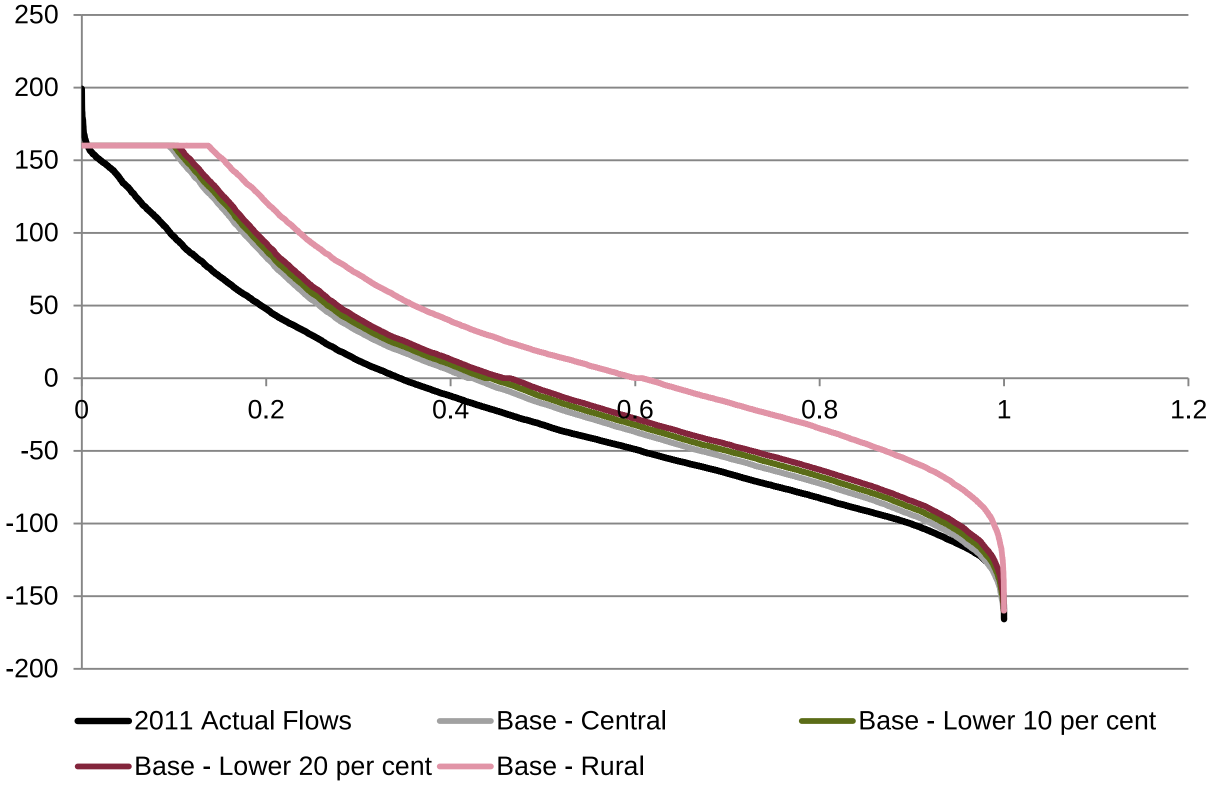


Figure 6: flows across the South East transformers with a control scheme

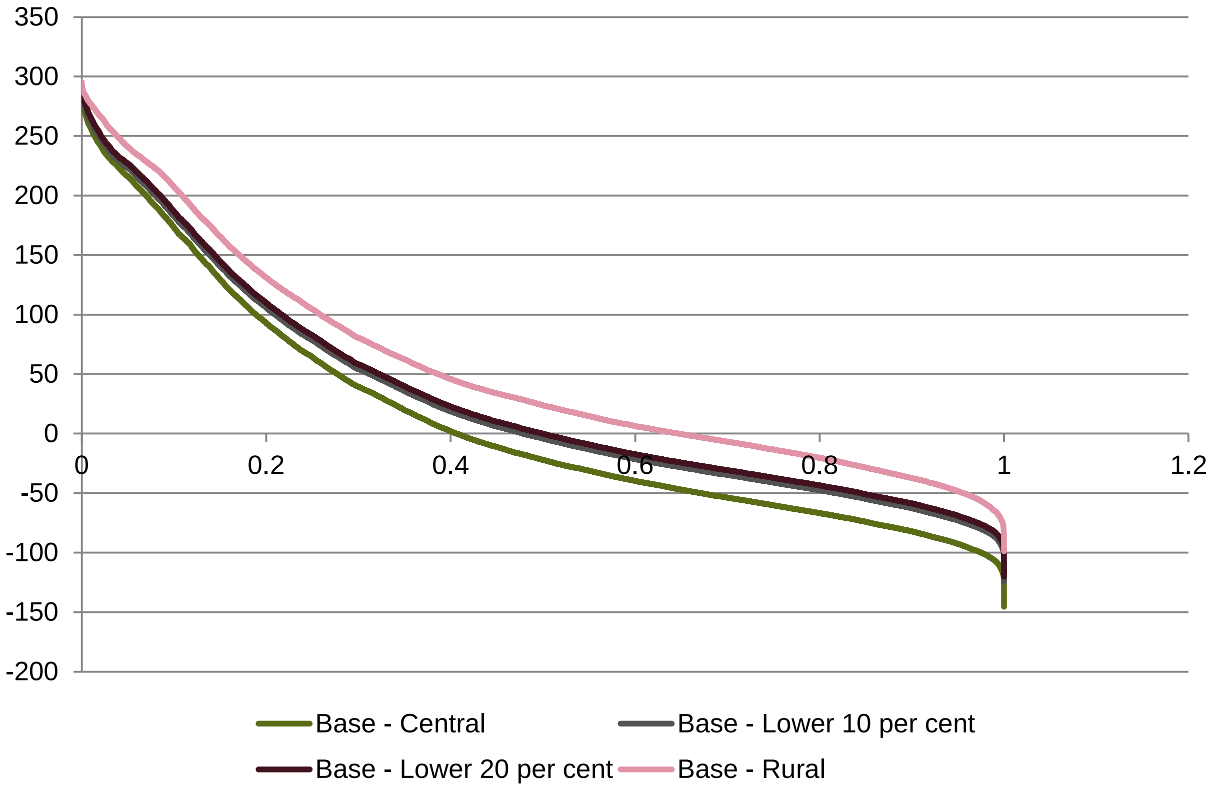
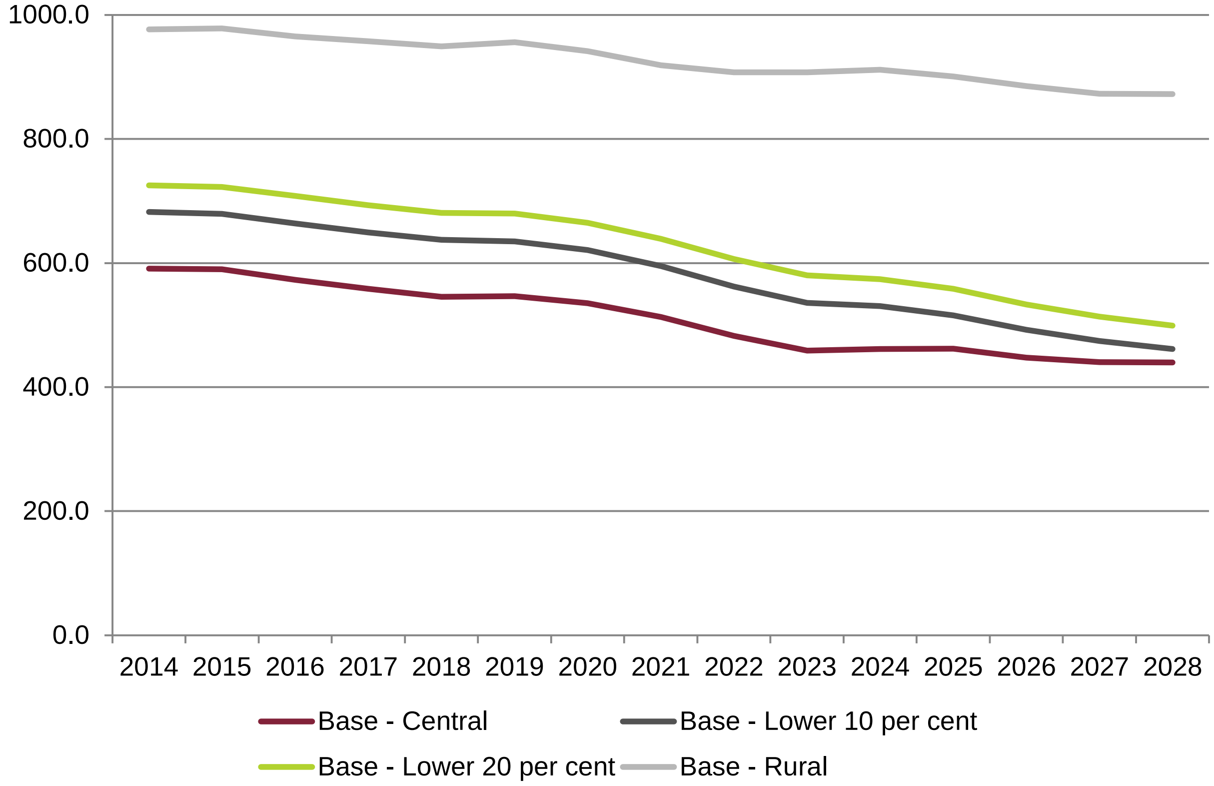


Figure 7: hours of congestion across South East transformers



Flows across the transformer with the control scheme in place show that flows actually get close under some circumstances to reaching the full rating of the transformers. They clearly exceed the 30 per cent increase in ratings that the short term ratings may deliver.

5. Costs

5.1 Capex

The control scheme has been assumed to have a 40 year life. This requires a detailed Opex budget that requires significant expenditure every five years. Given the declining rate of congestion, the control scheme is unlikely to have a 40 year life.

The discount rate applied is that proposed in the AER's draft decision of ElectraNet's 2013-18 revenue reset. This rate is 7.11 per cent.

5.2 Opex

The Opex spend has been determined so as to maximise the potential life of the control scheme. Figure 8 presents the 9 year cycle for Opex.

Figure 8: 9 Year Opex cycle

Year	1	2	3	4	5	6	7	8	9
Open	$22 k	$22 k	$72 k	$22 k	$22 k	$72 k	$22 k	$22 k	$360 k

6. Benefits

6.1 Replacement generation duration curve

The calculation of benefits is strongly influenced by assumptions regarding the generation source that is replaced by additional wind generation in the South East. Essentially a replacement generation duration curve is required. It is not well understood what this looks like. A few indicators are that in the preferred option under Prophet modelling, all of the congestion appears to coincide with other surplus wind generation. However, under the less preferred option, there are some benefits in a South East transformer so wind farms do replace more expensive generation. The following replacement cost duration curve will be explored.

Figure 9: replacement duration curve

Replacement price	Weighting
Zero	30 per cent
$23/MWh	30 per cent
$33/MWh	25 per cent
$43/MWh	10 per cent
$53/MWh	5 per cent

An additional sensitivity will be explored that shows a greater replacement of higher cost generation.

Figure 10: sensitivity to replacement of higher cost generation

Replacement price	Weighting
Zero	30 per cent
$23/MWh	20 per cent
$33/MWh	25 per cent
$43/MWh	15 per cent
$53/MWh	10 per cent

6.2 Benefits

Under the majority of the demand futures the control scheme delivers sufficient benefits to justify its development. Under the central scenario the control scheme is demonstrated to have small negative net market benefits.

In the Rural scenario, which is quite possible, the benefits of the control scheme are large.

The results of the base considerations and two sensitivities are as follows.

BASE	Replacement Fuel	$2	$25	$35	$45	$55	
	VOM	$2	$2	$2	$2	$2	
	Difference	$0	$23	$33	$43	$53	
	Simulated duration curve	30%	30%	25%	10%	5%	**Net Benefits**
Central	25%	-$1,182,163	-$327,457	$44,154	$415,765	$787,376	-$360,902
Lower 10 per cent	25%	-$1,182,163	-$18,872	$486,907	$992,685	$1,498,464	-$64,392
Lower 20 per cent	25%	-$1,182,163	$201,924	$803,701	$1,405,478	$2,007,255	$147,764
Rural	25%	-$1,182,163	$2,095,878	$3,521,113	$4,946,347	$6,371,582	$1,967,607
		-$1,182,163	$487,868	$1,213,969	$1,940,069	$2,666,169	$422,519

SCENARIO SENSTIVITY	Replacement Fuel	$2	$25	$35	$45	$55	
	VOM	$2	$2	$2	$2	$2	
	Difference	$0	$23	$33	$43	$53	
	Simulated duration curve	30%	30%	25%	10%	5%	**Net Benefits**
Central	0%	-$1,182,163	-$327,457	$44,154	$415,765	$787,376	-360,902
Lower 10 per cent	0%	-$1,182,163	-$18,872	$486,907	$992,685	$1,498,464	-64,392
Lower 20 per cent	0%	-$1,182,163	$201,924	$803,701	$1,405,478	$2,007,255	147,764
Rural	100%	-$1,182,163	$2,095,878	$3,521,113	$4,946,347	$6,371,582	$1,967,607
		-$1,182,163	$2,095,878	$3,521,113	$4,946,347	$6,371,582	$1,967,607

HIGHER COST REPLACEMENT GENERATION	Replacement Fuel		$2	$25	$35	$45	$55	
	VOM		$2	$2	$2	$2	$2	
	Difference		$0	$23	$33	$43	$53	
	Simulated duration curve		0.3	0.2	0.25	0.15	0.1	**Net Benefits**
Central		25%	-$1,182,163	-$327,457	$44,154	$415,765	$787,376	-$267,999
Lower 10 per cent		25%	-$1,182,163	-$18,872	$486,907	$992,685	$1,498,464	$62,053
Lower 20 per cent		25%	-$1,182,163	$201,924	$803,701	$1,405,478	$2,007,255	$298,208
Rural		25%	-$1,182,163	$2,095,878	$3,521,113	$4,946,347	$6,371,582	$2,323,915
			-$1,182,163	$487,868	$1,213,969	$1,940,069	$2,666,169	$604,044

7. Conclusion

ElectraNet is currently working with SA Power Networks and Kimberly-Clark Australia (KCA) on the connection of new embedded generation in the vicinity of the Snuggery connection point. This is expected to lead to lower future demand in south east SA and increase the cost of constraints.

There are sufficient benefits created by the South East control scheme to reasonably conclude that it is beneficial to the long term interests of the NEM should the load at south east South Australia fall.

Given the increased certainty of the KCA load reduction (which has emerged subsequent to finalising the analysis for the PACR) it is recommended the South East control scheme is added to the scope of the Heywood interconnector upgrade project. Under these conditions the PACR findings support a South East control scheme as part of the preferred option.