VICTORIA – SOUTH AUSTRALIA INTERCONNECTOR CONTROL SCHEME FEASIBILITY STUDY

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Client	Australian Energy Market Operator

DOCUMENT CONTROL

Version	Date	Author	Change Reference
Draft 0.1	9-05-2012	David Strong and Michael Green	Draft Stage 1 report for client review
Draft 0.2	6-06-2011	David Strong and Michael Green	Draft report updated to include Stage 2 – for client review
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1.2	31-07-2012	David Strong	Further amendment to address SP AusNet feedback

EXECUTIVE SUMMARY

Introduction

The Australian Energy Market Operator (AEMO) and ElectraNet are carrying out studies for an upgrade of the Victoria – South Australia (V-SA) interconnector. A Project Specification Consultation Report was issued jointly by AEMO and ElectraNet in October 2011 and a public forum was held in Adelaide in November 2011.

Infigen owns wind generation in south east South Australia and made a submission proposing the use of a control scheme to increase the transfer capacity of the V-SA interconnector without installation of additional primary plant. As per the provisions in the RIT-T process, AEMO and ElectraNet decided to consider the feasibility of such a control scheme.

The Heywood RIT-T project engaged David Strong & Associates (DSA) as an independent expert to investigate the feasibility and provide information on the design and cost of such a scheme.

This report sets out a high level concept for the proposed control schemes, and discusses the issues that would need to be addressed in the development and implementation of the schemes.

The details of any control scheme that is implemented may vary from the concept in this report following detailed investigations and design.

Summary

It is technically feasible to implement control schemes to increase the thermal limits of the V-SA interconnector for power flow from South Australia to Victoria. A control scheme at Heywood Terminal Station (HYTS) will trip wind generation in South Australia if there is an outage of a HYTS transformer or HYTS-SESS 275 kV line at times of high South Australia to Victoria flow on the interconnector. A similar control scheme at South East Substation (SESS) will address the SESS transformer constraint by tripping wind generation in South Australia if there is an outage of a SESS transformer at a time of high South Australia to Victoria flow.

The control schemes will not increase the thermal limits for flow from Victoria to South Australia.

The control schemes will not increase the voltage or stability limits. There is a high percentage of dispatch intervals where the interconnector flow is limited to less than the thermal ratings. This indicates that action is also required to address the voltage and stability limits to obtain the full benefit from an increase in thermal limit.

If Lake Bonney is the only generation participating in a HYTS control scheme then at full Lake Bonney output of 278 MW the interconnector will be limited to 570 MW. If new wind generation is connected at Krongart and included in the HYTS control scheme the availability of 426 MW of wind generation for tripping would allow the transfer of 690 MW to Victoria based on the proposed constraint equation.

The SESS transformer constraint can be addressed by a separate control scheme to trip Lake Bonney generation.

Extensive power system studies are required by both AEMO and ElectraNet to assess the system security and other impacts under a range of foreseeable system operating conditions. This assessment will include impacts on other customers and stakeholders.

Commercial Issues

The majority of the assets to be protected by the HYTS control scheme are in Victoria. SP AusNet is therefore the logical developer and owner of the HYTS control scheme.

A control scheme to address the SESS transformer constraint should be developed and owned by ElectraNet.

It is recommended that AEMO as the provider of prescribed transmission services in Victoria contract with SP AusNet for the implementation and ownership of the HYTS control scheme.

The provision of the proposed control schemes requires that governance structures are established, commercial relationships are developed and the parties enter into supporting legal agreements. The following list provides an indication of the agreements required.

- HYTS control scheme implementation and ownership (AEMO-SP AusNet);
- Communication service provision; (SP AusNet – ElectraNet)
- HYTS Generator tripping services agreement (AEMO – Generators);
- HYTS Generator control scheme participation agreements (SP AusNet – Generators); and
- Site occupancy license or lease agreements (various).
- SESS Generator tripping services and participation agreement (ElectraNet – Generators);

Power System Review

Review of National Electricity Market (NEM) dispatch outcomes for 2011 showed that the V-SA interconnector flow was limited by a number of constraints. These included the SESS transformer thermal constraint, the HYTS transformer thermal constraint, and voltage and stability constraints. The proposed control schemes will address the thermal constraint for flows from South Australia to Victoria.

The power system associated with the interconnector and relevant to development of control schemes is shown in Figure 1.

Power system studies were carried out to provide an indication of the effectiveness of tripping generation in reducing loading on the interconnector following an outage of either a HYTS transformer or a HYTS-SESS 275 kV transmission line. There are two items that impact on the effectiveness of interconnector unloading.

- Tripping of generation will result in reduced transmission losses so 1 MW of generation tripped results in less than 1 MW of interconnector unloading. This is defined as the reduction ratio. Initial studies have indicated that 0.90 is a conservative reduction ratio for the HYTS scheme.
- Synchronous generation in South Australia may increase output in response to the frequency deviation caused by generation tripping. This response will increase the interconnector loading. A reloading ratio has been defined as the ratio of increase in loading on the relevant circuit to the total generation response in NEM. An initial review has determined a value 0.09 for the reloading ratio for the HYTS scheme.

The values for these ratios will need to be confirmed by more extensive power system studies during the design process.

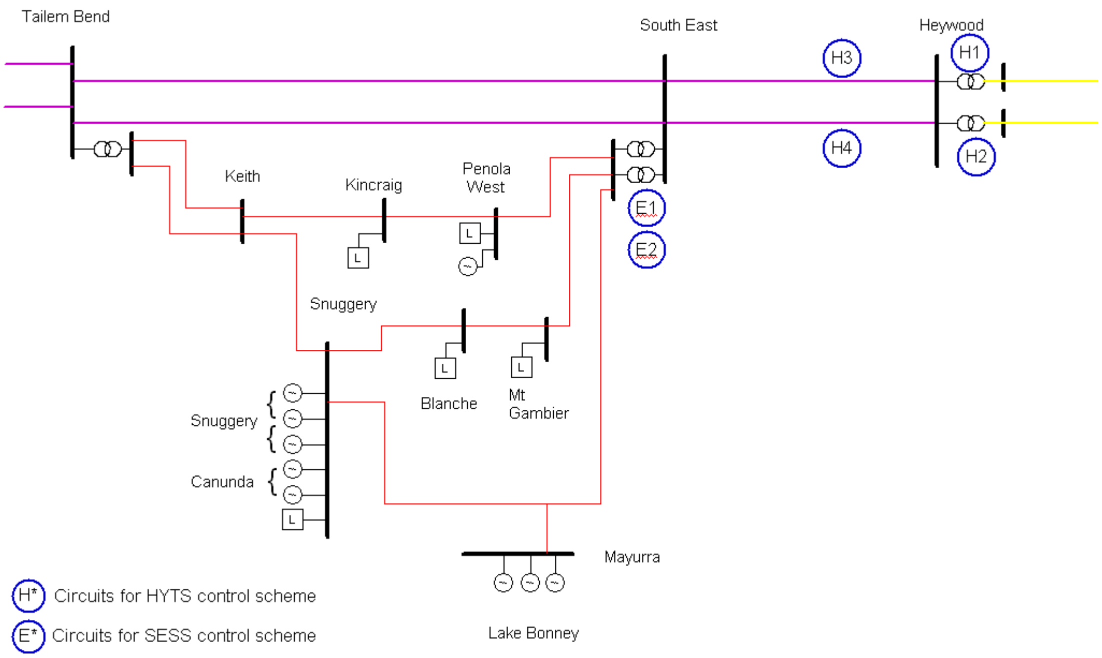

Figure 1 Power system for study consideration

The existing interconnector thermal limit is 460 MW based on the 30 minute rating of the HYTS transformers and allows for associated reactive power flow.

The interconnector thermal limit for flow from South Australia to Victoria can be formulated in terms of the generation available for tripping, the reduction ratio, the reloading ratio and a margin. The proposed V-SA interconnector limit for flow into Victoria can be calculated as set out below where the control scheme status is either 0 or 1 indicating whether the control scheme is unavailable or available.

Flow <= MAX(460,((MIN(Tx continuous rating (370) – Margin(25))*2,((Tx Continuous Rating + (GenAvailable * Reduction Ratio (0.90)) – (GenAvailable * Reloading Ratio (0.09)) – Margin) * control scheme status))))

A similar equation will be required for the SESS transformers.

Control Scheme Overview

A high level design for the proposed HYTS control scheme has been developed as shown in Figure 2. The control scheme will be a combination of supervisory control and data acquisition (SCADA) for collection of operational data and protection quality for the issue of trip signals to generation. The SESS control system will be similar.

The HYTS control scheme will consist of hardware and software installed at HYTS, hardware at SESS and hardware at the Generator site. The control scheme will collect operational data, run a calculation to determine the amount of generation to be tripped in the event of a relevant outage and select the clusters to be tripped. Control scheme action will be initiated by receipt of a circuit breaker open status from a relevant line or transformer when the interconnector loading is above the specified rating.

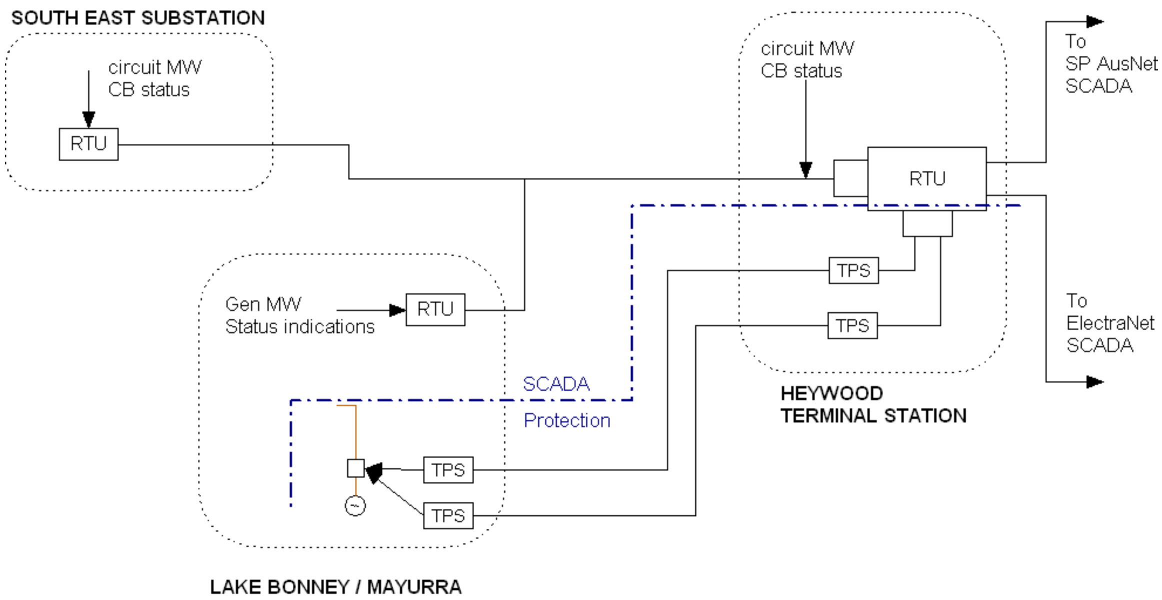

Figure 2 HYTS Control scheme design concept

The HYTS control scheme will allow the HYTS transformers and the HYTS-SESS 275 kV lines to be operated at close to full continuous rating and will utilise a short term capability to allow up to 1.5 seconds for transformers and 5 seconds for lines operating at close to twice continuous rating. In the event of an outage the loading on the remaining in service circuit will be reduced to below continuous rating within the required time.

The SESS control scheme will allow the SESS transformers to be each operated up to continuous rating.

The schemes require duplicate secure high speed communications between HYTS, SESS and Lake Bonney for the issue of trip signals to the generation. Communications is also required for operational data.

SP AusNet, ElectraNet and AEMO all require operational data from the control scheme.

A backup scheme is required so that for failure of the control scheme to reduce asset loading following an outage the backup scheme will operate to protect the asset.

Capital Cost and Schedule

The combined capital cost of both the proposed HYTS and SESS control schemes is estimated to be $10 million and take two years to implement. This includes the establishment of digital radio communications between HYTS and SESS.

Integration of new wind generation connected to Krongart into both schemes is estimated to cost an additional $830,000. This cost assumes that duplicate communications is installed as part of the generation project.

Operational Costs

The total operation and maintenance cost including hardware replacement up to 2040 is estimated to be $1.5 million for the HYTS scheme and $1.5 million for the SESS scheme.

CONTENTS

1 INTRODUCTION

The Australian Energy Market Operator (AEMO) and ElectraNet are carrying out studies for an upgrade of the Victoria – South Australia interconnector. A Project Specification Consultation Report was issued jointly by AEMO and ElectraNet in October 2011 and a public forum was held in Adelaide in November 2011.

Infigen owns wind generation in south east South Australia and made a submission proposing the use of control schemes to increase the transfer capacity of the V-SA interconnector without installation of additional primary plant. As per the provisions in the RIT-T process AEMO and ElectraNet decided to consider the feasibility of such control schemes.

The Heywood RIT-T project engaged David Strong & Associates (DSA) as an independent expert to investigate the feasibility and provide information on the design and cost of possible schemes.

DSA held meetings with AEMO, ElectraNet, SP AusNet and Infigen to obtain information relevant to the implementation and operation of control schemes and identify any potential issues that would prevent their implementation and operation.

The feasibility study identified a range of options for the scope of control schemes to address the South Australia to Victoria constraint and determined that the most appropriate option was two separate control schemes as follows.

- Scheme for managing HYTS transformer outage and HYTS-SESS line outage
- Scheme for managing SESS 275/132 kV transformer constraint.

This report sets out a high level concept for proposed HYTS and SESS control schemes, and discusses the issues that would need to be addressed in their development and implementation.

The details of any control scheme that is implemented may vary from the concept in this report following detailed investigations and design.

2 TRANSMISSION NETWORK SERVICE PROVIDER POLICIES

2.1 Equipment Ratings

ElectraNet and SP AusNet apply different ratings for their sections of the HYTS-SESS 275 kV transmission lines primarily due to different assumptions regarding wind speed.

The 15 minute circuit ratings of the Victorian section and the South Australian section of the SESS to HYTS 275 kV line are 514 to 728 MVA (LDSH rating) and 529 MVA respectively. These ratings compare with the 525 MVA 30 minute rating of a HYTS transformer.

2.1.1 Dynamic Transmission Line Ratings

Dynamic ratings can be used to increase the rating of transmission lines by using real time weather data to calculate the rating of the transmission line under the prevailing conditions. This dynamic rating is generally higher than a static rating which has to make conservative assumptions about weather conditions.

Dynamic ratings may not be required at this time for the HYTS-SESS transmission lines as the line rating is higher than the HYTS transformer rating so even with the HYTS control scheme the interconnector thermal capacity will be set by a HYTS transformer outage. The simplest scheme is to initiate trip within 10 seconds for all events. This avoids the requirement for dynamic line ratings and conductor temperature monitoring.

The benefit of dynamic or temperature based rating may be reviewed after the installation of a third transformer at HYTS. It is noted that SP AusNet does not consider that dynamic rating is prudent for the HYTS-SESS 275 kV lines.

2.1.2 Short Term Equipment Capability

ElectraNet and SP AusNet advised that they do not currently have short term ratings for equipment such as transmission lines and transformers. The implementation of control schemes would require both SP AusNet and ElectraNet to implement short term capability for equipment to be included in the control schemes.

All equipment must be rated for fault current. Therefore it is likely to have a short time capability based on an I^2t withstand. This short circuit withstand can be extrapolated to provide a ten second capability that would be required for the control schemes. In initial discussions with technical staff ElectraNet and SP AusNet recognised that this could be done and did not have any in principle objections.

The implementation of short term capabilities will require a project to review all relevant equipment such as Current Transformers, droppers, Line Traps and disconnectors. This may include specific tests and manufacturer consultation. There may be additional capital expenditure required above that assumed if the review identifies the need to upgrade any equipment.

2.2 Protection

The control schemes will require loading of equipment above its continuous rating for a short time. This will require a review of all relevant protection settings by both SP AusNet and ElectraNet and where necessary modification of protection settings to provide coordination with the control schemes.

2.3 Existing Control Schemes

Infigen has existing run rack schemes on the Lake Bonney wind farm to comply with the requirements under the NER and also to manage circuit loading. The proposed control scheme would have to take account of this control scheme and interaction between the two schemes would need to be co-ordinated.

At the time of potential implementation, there may be other existing and proposed control schemes in South Australia that would need to be taken into consideration.

SP AusNet has a number of control schemes. In particular there is a control scheme to protect the South Australian power system for loss of 500 kV supply from Victoria to the Portland smelter. This scheme is being modified due to the connection of new generation into the MLTS-HYTS 500 kV lines.

The proposed control scheme would have to take account of this control scheme and interaction between the two schemes would need some coordination and interfacing.

2.4 Response to Proposed Control Schemes

ElectraNet has not indicated any objections in principle to the proposed control schemes. However ElectraNet will need to carry out investigations to confirm the short term capability of its relevant plant and equipment.

SP AusNet raised concern about the capacity of the HYTS transformers to withstand twice rated current for 10 seconds. On this basis the proposed operating time for the control scheme in regard to a transformer outage has been reduced to 500 milliseconds and 1 second discrimination for the backup scheme making a maximum time of 1.5 seconds. The proposed maximum time for the control scheme in relation to the lines is 5 seconds.

SP AusNet advised that it would need to carry out investigation and testing to confirm the capability of the HYTS transformers to withstand twice load current for 1.5 seconds. Subject to a satisfactory outcome from its investigation and testing of transformer capability SP AusNet does not have any objection to the control scheme provided that the overload rating is carefully derived and all risks associated with the overloading mode are addressed.

3 CONTRACTUAL AND COMMERCIAL ISSUES

The provision of the control schemes will require that governance structures are established, commercial relationships are developed and the parties enter into supporting legal agreements.

The control schemes are assumed to be part of the prescribed transmission services in Victoria and South Australia.

The different transmission network service provider arrangements in Victoria and South Australia require differing jurisdictional governance arrangements. Hence, this section outlines possible arrangements for each of the HYTS and SESS control schemes. Note that this report presents the DSA-proposed outcomes of high-level discussion only. Detailed discussion between all relevant parties on the contractual arrangements was not within the scope of this study.

Various options for commercial arrangements are provided and a preferred arrangement is proposed for the HYTS control scheme. In the event that the control scheme is implemented it will be up to the parties to establish the arrangements that best suits their situations. A guiding principle that could be adopted in developing arrangements is that the party best able to manage the risks and technology should assume responsibility.

The arrangements considered cover:

- Jurisdictional transmission network service provider responsibility,
- Transmission asset owner responsibility,
- Communication service provision,
- Generation tripping service participation agreements that provide the legal basis for the control scheme tripping the generators, and
- Site occupancy licensing or leasing required by parties wishing to locate assets in third party facilities.

It is also assumed that the communications performance requirements covering control scheme SCADA and tripping are such that they can only be met by transmission network service provider communications.

It is assumed that Engineer, Procure and Construct (EPC) contracts would follow the normal practices of the parties and are not discussed.

Operational risks are discussed and comment is made on potential cross jurisdictional boundary regulatory issues.

3.1 HYTS Scheme

As the Victorian transmission network service provider AEMO has the responsibility for providing prescribed transmission services. Consequently AEMO will have responsibility for ensuring that the requisite arrangements are established for the HYTS control scheme.

Two governance options are considered:

1. AEMO contracts with service providers for each of the control scheme components, and
2. AEMO contracts with a single service provider.

3.1.1 AEMO Contracts Control Scheme Components

The agreements that AEMO would have to negotiate include:

- hardware and software at HYTS – SP AusNet,
- hardware at SESS – ElectraNet, SP AusNet
- communications between HYTS and SESS – SP AusNet and ElectraNet,
- communications between SESS and participant generators - ElectraNet,
- hardware required at the generator site – the generator, ElectraNet, SP AusNet, and
- generation tripping – the generator.

In addition to service provision agreements, licenses or leases will be required by parties wishing to locate and access assets in third party facilities; in particular, hardware at SESS, and communications terminal equipment and control scheme hardware at the generator site.

3.1.2 AEMO Contracts with Single Service Provider

AEMO traditionally acquires network services from a single service provider to meet its obligations as a Victorian transmission network service provider.

If SP AusNet is the service provider then it is assumed that SP AusNet would provide:

- hardware and software at HYTS,
- hardware at SESS,
- communications between HYTS and SESS, and
- hardware at the generator site.

If the service provider is not SP AusNet then that service provider would need to sub-contract for these requirements.

The service provider (whether or not SP AusNet) would enter into the following sub-contracts:

- communications between SESS and participant generators - ElectraNet, and
- generation tripping – the generator.

A subset of this option is AEMO entering into the generation tripping arrangements.

In addition to service provision agreements, licenses or leases will be required by parties wishing to locate and access assets in third party facilities; in particular, hardware at SESS, and communications terminal equipment and control scheme hardware at the generator site.

3.2 Proposed contractual arrangements

In developing a proposed contractual arrangement the following criteria were considered:

- respective jurisdictional roles,
- minimising cross entity liability issues,
- National Electricity Rules’ requirements, and
- generation tripping availability.

Jurisdictional roles lead to the conclusion that AEMO should enter into arrangements for the provision of the HYTS control scheme.

Due to the complexity of addressing asset related liability issues and National Electricity Rules’ registration requirements in relation to the implementation and ownership of a control scheme forming part of a transmission system it is proposed that AEMO enter into an agreement with SP AusNet for the implementation and ownership of the HYTS control scheme.

As there are existing communications arrangements between SP AusNet and ElectraNet it is proposed that the existing model be used for the provision of communications between HYTS and SESS and at the site of the generation tripping service provider.

Generation tripping arrangements may require two parallel agreements:

- one to provide tripping services; and
- the other to permit the control scheme to actually trip the generation.

The importance of generation tripping provision is such that it is proposed that AEMO has the responsibility to ensure these services are available to the scheme. These arrangements would be essentially commercial agreements.

In alignment with provision of assets at the generation tripping service provider site, it is proposed that SP AusNet enter into agreements to permit the control scheme to actually trip the generation.

As the regulatory test is a joint initiative between AEMO and ElectraNet any future requirement for reactive support in the South Australian transmission network would be reasonably met by ElectraNet under its prescribed services.

3.3 Control Scheme Risks

Risks associated with the control scheme are:

- implementation risks,
- operational risks, and
- ongoing generation tripping service availability.

3.3.1 Implementation Risks

The key risk with implementation of the scheme is associated with agreement to the governance structure and negotiation of the different agreements. Key issues include the allocation and limitation of liability as well as warranty provisions. These issues are routinely negotiated when establishing agreements associated with transmission services and the principle of allocation to the party in the best position to manage the issue should apply.

There is potentially a regulatory issue with the ability of entities in effect providing cross border transmission network services. In particular, it is a requirement in each jurisdiction to be licensed by the jurisdictional regulator to provide transmission services. Appropriate governance and contractual arrangements need to be implemented to avoid jurisdictional boundary issues. For instance, services can be provided to a transmission network service provider associated with the delivery of transmission services without the need for a transmission licence.

ElectraNet advised that it has proposed installation of digital radio communications from SESS to HYTS. This indicates that cross border issues are manageable.

The control scheme technology and interfaces with the power system are no different to those encountered through the normal provision of transmission services. Thus it is assumed that physical implementation risks associated with construction and commissioning of the control schemes would be managed by the use of good electricity industry practice and covered by normal risk management practices routinely employed by the industry.

3.3.2 Operational Risks

A key concern is the consequences of failure of the control scheme to operate correctly due to negligence and the liability arising from consequential damage to assets or broader impacts on the power system.

The risks can be characterised as being a subset of the risks of those already managed on a wider scale by network service providers. The control scheme is another source of exposure to the risks.

A particular concern is responsibility for protection of the assets of a third party. A tenet of power system protection is that in the final analysis all equipment should be self-protecting.

Connection agreements should also have provisions in relation to liability exposures.

The operational risks can be mitigated by:

- technology employed is widely used throughout industry,
- detailed design and specification,
- operational risk and consequence identification and mitigation,
- stringent protection grade performance requirements,
- duplication of key elements,
- real time operational monitoring and alarms,
- back-up scheme,
- ongoing continual performance monitoring and improvement, and
- operation and maintenance in accordance with good electricity industry practice.

It will be important to disclose the scheme during renewal of insurances. It is reasonable to expect that the insurer will view any additional risk exposure in the context of the overall company risk exposure and management practices. The consequences exposure should be similar to those routinely managed by network service providers and hence the impact on premiums whilst being the prerogative of the insurer can be expected to be small.

3.3.3 Ongoing Generation Tripping

The control schemes are aimed at increasing interconnector export capability from South Australia to Victoria. Thus scheme beneficiaries are:

- HYTS control scheme – all South Australian generators, and
- SESS control scheme – South Australian generators connected to the south eastern 132 kV network.

There is the potential for issues to arise associated with continued availability of generation to be tripped and “free riding”. As a consequence, consideration could be given to a requirement that all new South Australia large generator connection agreements have a requirement for the generator to participate in a control scheme if required by ElectraNet.

3.4 South East Substation Control Scheme

As the South Australian transmission network service provider ElectraNet has the responsibility for providing prescribed transmission services. Consequently ElectraNet would have responsibility for ensuring that the requisite arrangements are established for the SESS control scheme.

To fulfil its obligations efficiently ElectraNet would provide:

- hardware and software at SESS, and
- communications between SESS and participant generators.

The hardware at the generator site could be provided and owned by either ElectraNet or the generator under an agreement with ElectraNet.

ElectraNet would have to negotiate the generation tripping agreement with the generator.

In addition to service provision agreements, ElectraNet will require licenses or leases to locate and access assets in third party facilities; in particular, communications terminal equipment and control scheme hardware at the generator site if it owned the equipment.

4 POWER SYSTEM CONSIDERATIONS

4.1 V-SA Interconnector

The power system associated with the V-SA interconnector and relevant to development of control schemes is shown in Figure 3.

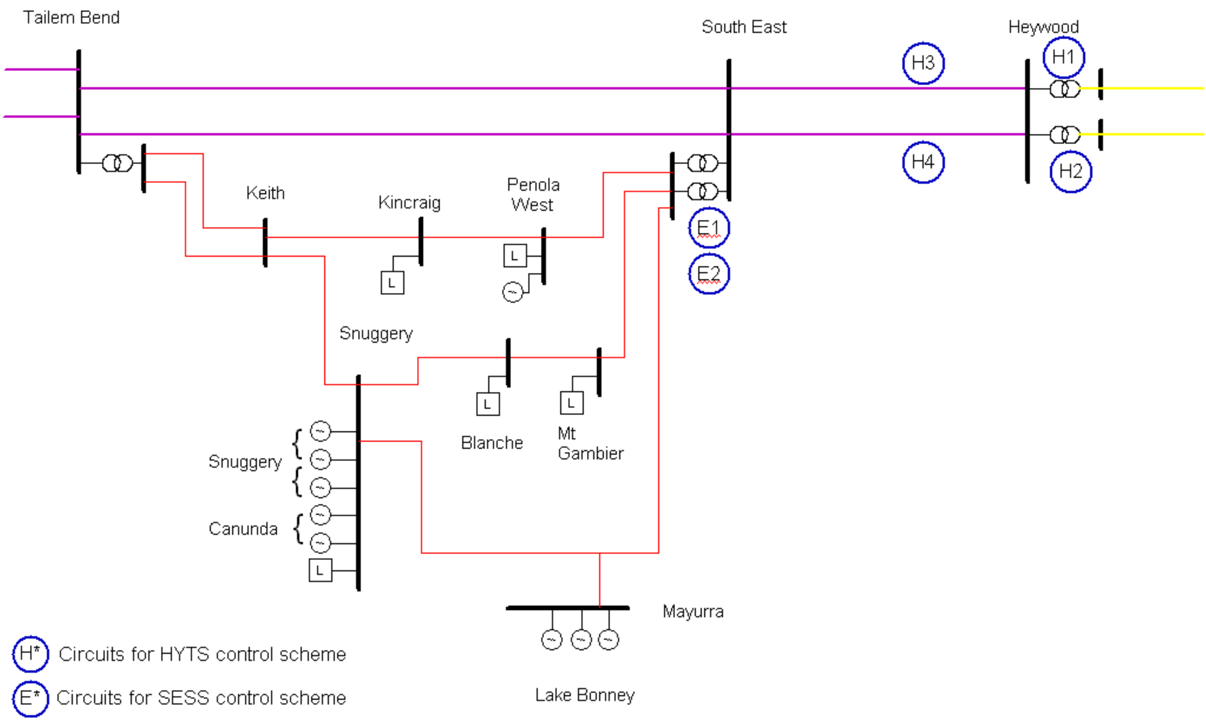

Figure 3 Power system for study consideration

4.2 Interconnector Operation

Review of NEM interconnector data for 2011 showed that the flow was from Victoria to South Australia for 74% of the time and from South Australia to Victoria for 26% of the time. The interconnector flow duration curve is shown in Figure 4.

The V-SA interconnector was binding on flow from South Australia to Victoria for 6,822 dispatch intervals in 2011. The SESS transformer constraint bound for 1,905 dispatch intervals and the HYTS limit was binding for 53 dispatch intervals in 2011. The balance of constrained dispatch intervals were primarily due to voltage and stability limits.

The V-SA interconnector was binding on flow from Victoria to South Australia for 32,807 dispatch intervals in 2011. A high percentage of the constrained intervals were due to either voltage or stability constraints. The HYTS transformer constraint bound for 182 dispatch intervals.

	SA to Vic	Vic to SA	Less than 1 MW	Total
Total DIs	26,673	78,039	408	105,120
DIs at limit	6,822	32,807		

Table 1 V-SA interconnector target summary for 2011[1]

1 Data sourced from www.aemo.com.au.

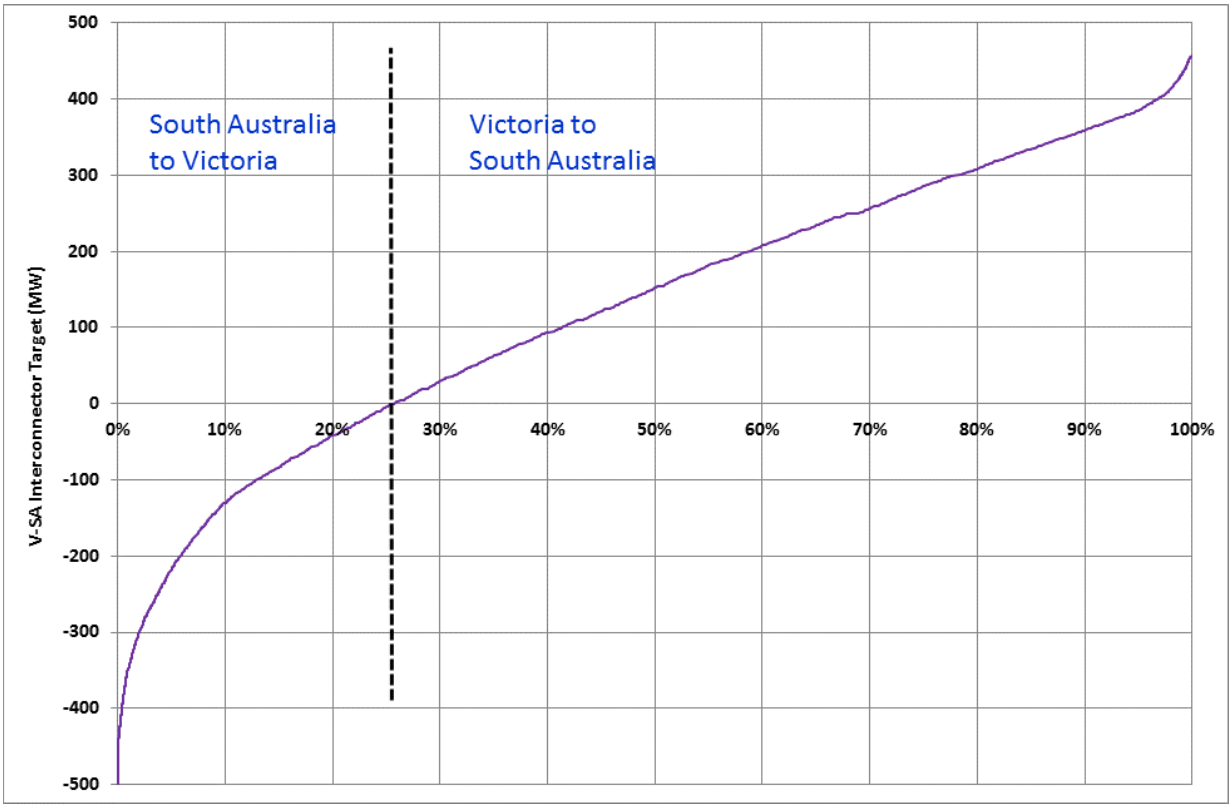

Figure 4 V-SA interconnector 2011 flow duration

4.3 Interconnector Constraints

Figure 5 is a schematic of the interconnector showing the three main thermal limiting elements. Table 2 shows the ratings of the three elements.

The constraint ID S>>V_NIL_SETX_SETX relates to the SESS 275/132 kV transformers. It constrains the amount of generation from Lake Bonney 2 and 3 and Ladbroke Grove depending on the flow on the interconnector. It has a significant impact on the Lake Bonney generation. This constraint can limit South Australia to Victoria flows to very low levels.

Installing a third transformer at SESS is one option to address this constraint. Another option is the implementation of a control scheme to manage an outage of a SESS transformer.

Constraint ID S>V_NIL_HYTX_HYTX relates to the HYTS 500/275 kV transformers. These transformers have 22 kV tertiary winding for local supply. The transformer continuous rating is 370/300/70 MVA or 370/370/0 MVA and a 30 minute rating of 525 MVA. The 30 minute rating is used to determine the Interconnector thermal limit of 460 MW and allows a margin for reactive power flows.

Installing a third transformer at HYTS is one option to address this constraint. Another option is the implementation of a control scheme to manage an outage of a HYTS transformer.

Installing a third transformer at HYTS would increase the transformer capacity but the interconnector thermal limit would then be the determined by the HYTS-SESS 275 kV transmission line rating. This rating depends on the time of day and season or ambient temperature.

Installation of a new 275 kV transmission line is one option to increase the interconnector thermal limit. Alternatively the HYTS-SESS transmission lines could be included in the HYTS control scheme.

With a 10 second capability of twice the continuous rating the transformer limit with the control scheme would be 740 MVA giving a limit to transfers of approximately 690 MW. This is above the rating of the of the HYTS-SESS 275 kV lines. Therefore to increase the interconnector capacity to 740 MVA the HYTS-SESS lines would need to be included in the scheme.

ID		Continuous Rating	Short Term Rating	Comment
A	HYTS transformers	370 MVA	525 MVA	sets 460 MW interconnector thermal limit
B(VIC)	HYTS-SESS 275 kV lines	442-644 MVA	514 -772 MVA	depends on temperature 5^0C to 45^0C
B(SA)	HYTS-SESS 275 kV lines	590/675 MVA		summer/winter
C	SESS transformers	160 MVA	NA	

Table 2 Interconnector thermal limiting elements[2]

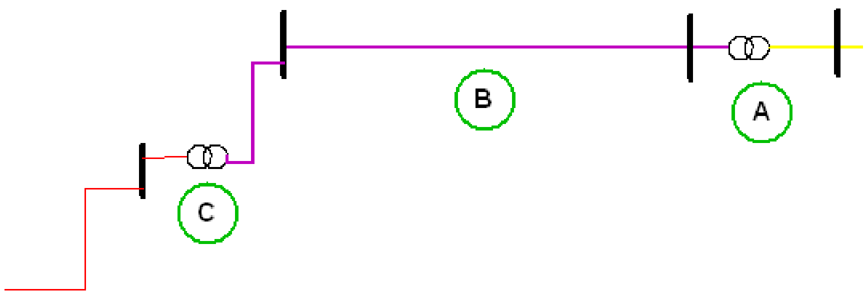

Figure 5 Interconnector asset ratings

4.4 Asset Re-loading

Control scheme action to reduce asset loadings following a contingency event on a parallel circuit is to reduce generation in South Australia behind the constraint.

For a HYTS transformer outage or loss of a SESS to HYTS 275 kV transmission line the generation could be located anywhere in South Australia. However tripping generation close to the constraint is more effective than generation remote from the constraint. This report considers the use of existing and future wind generation only in south east South Australia for inclusion in the scheme.

For a SESS 275 kV to 132 kV transformer outage the generation must be located in the south eastern South Australian 132 kV network in a position electrically close to SESS and electrically remote from Tailem Bend substation. This ensures that a majority of the reduced generation is reflected in reduced flow through the remaining in service SESS transformer.

For a SESS transformer outage and control scheme action re-loading should not be an issue unless significant new generation connection occurs on the South Australian south eastern 132 kV network electrically close to SESS.

For HYTS control scheme action following a transformer or transmission line outage re-loading can arise due to response from any South Australian generation.

[2] Ratings provided by asset owners.

The reduction in generation due to control scheme action will immediately initiate generation and load inertial responses to reducing system frequency and instigate governing action. These actions can potentially give rise to circuit re-loading.

Power system real and reactive power oscillations arising from dynamic effects of the clearance of the initiating fault and the power system returning to stable operation are of a transient nature and should not result in sustained asset re-loading.

Inertial response is determined by the rate of change of system frequency. So re-loading may occur during the initial fall in system frequency but as the frequency begins to recover the inertial response will in effect result in de-loading. In addition, South Australia would remain connected to the rest of the power system which is an order of magnitude higher inertia, hence South Australian contribution to inertial response would be very small.

The key considerations for asset re-loading are:

- enabled fast, slow, delayed, and regulating raise market ancillary services, and
- increases in generation due to governor action outside of enabled market ancillary service.

The re-loading due to market ancillary services can be managed through either:

- development of energy market and market ancillary service constraint equations that prevents re-loading due to the delivery of raise services by South Australian generation, or
- reduce generation by more than is necessary to permit raise service delivery by South Australian generation, or
- place operational margins on transfer limits.

This may not be a significant issue as the contribution to raise services by South Australian generation is generally small in relation to the total Frequency Control Ancillary Services (FCAS) requirement. For 2011 South Australia provided on average 1.2% of the 5 minute raise and 7.7 % of the 60 second raise. There were a relatively small number of dispatch intervals where the SA FCAS dispatch was higher up to 16% of 5 minute raise and 25% of 60 second raise.

Given that the maximum amount of generation to be reduced is less than the maximum mainland contingency the frequency deviation due to control scheme action will be small in comparison to permissible frequency excursions. Also, most of the raise service has to be sourced outside of South Australia, thus the re-loading from enabled FCAS is likely to be small.

Most thermal and hydro generators have governors and will respond to frequency disturbances irrespective of whether the generator is enabled for FCAS or not.

Re-loading due to increased generation outside of market ancillary service provision could be mitigated through either:

- reduce generation by more than is necessary to permit non-enabled raise service delivery by South Australian generation, or
- place operational margins on transfer limits.

The actual reloading depends on a range of power system conditions including the amount of synchronous generation on line, the amount of contingency FCAS raise service enabled, the droop setting of generating unit governors, and the generating unit governor status. A reloading ratio has been defined as the ratio of increase in loading on the relevant circuit (dues to upstream generation response) to the total generation response to the frequency deviation. The ratio of synchronous generation online upstream of the outage to the synchronous generation online in NEM provides an estimate of the reloading ratio for the HYTS scheme.

One dispatch interval in the early hours of the morning, which is the time at which high wind generation occurs, had a ratio of thermal generation on line in South Australia to total thermal generation of 0.0835. It is considered that a conservative estimate for the reloading ratio is 0.09. The actual worst case reloading ratio would need to be determined by power system dynamic studies and analysis of generation outage events.

For an SESS control scheme and in the absence of entry of significant generation connected to the south eastern South Australian 132 kV network, reloading would be a lesser issue as most of the increase in generation would flow across the 275 kV network and have limited impact on the 132 kV network. An initial study indicates that about 10% of the South Australian generation response to the frequency deviation would flow through the south eastern 132 kV network and therefore the remaining in service 275/132 kV transformer. The reloading ratio for the SESS control scheme is therefore 0.009. More detailed studies will be required to confirm this.

4.5 Interconnector Capacity

The HYTS control scheme will monitor flows in the HYTS transformers and HYTS-SESS 275 kV lines and will select generation to be tripped in the event of a transformer or transmission line outage.

The objective of the control scheme will be to reduce the circuit loading to below continuous rating (applicable at that time based on rating approach) following an outage of the parallel circuit. Continuous rating has been selected rather than a short term rating on the basis that both circuits had been operating close to continuous rating prior to control scheme action and therefore there is no thermal capacity available for a short term rating in the order of 30 minutes to provide AEMO with sufficient time to return the power system to a secure operating state.

The tripping of a specified amount of generation will result in a reduction in interconnector flow that is less than the amount of generation tripped. This occurs as the reduced loading on the south east South Australia network results in lower transmission losses. The ratio of the reduction in interconnector MW to the generation MW tripped is referred to as the reduction ratio.

The reduction ratio depends on power system conditions but in general will decrease as the network loading increases. Cases with a high network loading had a reduction ratio of about 0.92 with the reduction ratio increasing at lower loading. Generation connected at Krongart will have a higher reduction ratio than Lake Bonney generation. A reduction ratio of 0.90 is considered to be conservative for the HYTS control scheme action.

As discussed in section 4.4 synchronous generating units across the NEM will respond to the frequency deviation resulting from control scheme action. Some of the response will be from generating units in South Australia upstream from the circuit outage. This increase in output from synchronous generating units in South Australia will result in some increase in the interconnector flow above that immediately after the control scheme has tripped generation. The control scheme action must recognise this reloading of the interconnector following an event and trip sufficient generation to take account of the reloading. A reloading ratio of 0.09 has been applied.

The interconnector thermal limit is a function of the amount of generation that is available for tripping. The amount of interconnector transfer is also dependent on satisfactory pre and post contingency voltages. The cases studied did not require any additional reactive support. AEMO may also include an operational margin in the limit to allow for variation in reactive flows and under estimation of the reloading and reduction ratios. A margin of 25 MW is considered to be suitable.

If Lake Bonney is the only generation available for tripping at its full output of 278 MW the interconnector will be limited to 570 MW. With Lake Bonney and Canunda in the scheme at full wind generation output the interconnector will be limited to 609 MW. At lower levels of wind generation the South Australia to Victoria limit will be reduced accordingly. If new wind generation is connected at Krongart and included in the control scheme the availability of 426 MW of wind generation would allow the transfer of 690 MW to Victoria based on the proposed constraint equation. The stability impacts of tipping this amount of generation in South Australia will need to be investigated by power system studies and action may be required to increase the stability limits.

Case	SE wind gen. (MW)	outage	Gens tripped	MW tripped	Pre contingent HYTS TX (MW)	Pre contingent HYTS TX (MVA)	Post contingent HYTS Tx (MW)	Post contingent HYTS Tx (MVA)	reduction ratio
1	326	Tx	LB + Can	326	629	648	328	331	0.923
2	326	Tx	LB	278	580	592	324	327	0.921
3	253	Tx	LB	205	430	432	236	254	0.947
4	543	Tx	LB + New	505	699	721	226	232	0.937
5	326	Line	LB + Can	326	628	659	324	326	0.933
6	326	Line	LB	278	580	606	320	324	0.935
7	243	Line	LB	205	421	421	225	227	0.956
8	543	Line	LB + new	505	699	721	225	227	0.939
9	253	Tx	LB	205	516	518	323	325	0.939
10	503	Tx	LB + new	465	696	725	263	264	0.932
11	463	Tx	LB + new	425	693	732	299	300	0.927

Table 3 Power system studies

The control scheme provides an increase on the existing thermal of 460 MW based on the HYTS transformer 30 minute rating.

The interconnector flows set out in Table 3 are based on being able to get up to the full capacity of Lake Bonney dispatched. This requires the SESS control scheme to address the SESS transformer constraint.

4.5.1 Interconnector Thermal Limit

It is suggested that the limit equation be formulated as a function of the generation available for tripping, the reduction ratio and the reloading ratio and the control scheme status which is either 0 or 1 indicating whether the control scheme is unavailable or available.

Flow <= MAX(460,((MIN(Tx continuous rating (370)– Margin(25))*2,((Tx Continuous Rating + (GenAvailable * Reduction Ratio (0.90)) – (GenAvailable * Reloading Ratio (0.09)) – Margin) * control scheme status))))

4.6 SESS Control Scheme

The SESS control scheme to address the SESS transformer constraint could be similar to the HYTS control scheme. It should be designed to be expandable to cover the 275 kV lines north from SESS if new wind generation is established in south east South Australia.

5 CONTROL SCHEME HIGH LEVEL DESIGN

5.1 Scope of Control Scheme

The control schemes permit transmission corridor loading above its n-1 rating on the basis that a fast acting control scheme will reduce loading on remaining in service circuits in the event of a specified outage. The control schemes will trip generation to reduce loading on the relevant circuit to below the continuous rating fast enough to prevent any assets operating outside their design parameters, particularly operating temperature.

Power system equipment has thermal inertia and takes some time to reach steady state temperature after an increased load is applied.

A scheme in Tasmania allows each circuit in double circuit transmission line to be operated up to 95% of its continuous rating on the basis that in the event of an outage of a parallel circuit the loading on the remaining in service circuit is reduced to below the continuous rating before the conductor reaches its design temperature.

If all the assets were in the one jurisdiction and owned by the one party the solution would be a centralised control scheme to manage all constraints. However the transformers are owned by SP AusNet, the 275 kV line is primarily owned by SP AusNet and the SESS transformers and 132 kV lines are owned by ElectraNet.

The options considered for the control scheme were as follows.

- Implement a control scheme to address thermal limits in both Victoria and South Australia.
- Implement one control scheme to manage HYTS transformer and HYTS-SES 275 kV line thermal limits and a separate control scheme to manage the SESS transformer constraint and any other transmission line constraints in south east South Australia. These control schemes could be implemented in the relevant TNSP SCADA systems or be local schemes at HYTS and SESS.

Jurisdictional boundaries mean that the most practical approach is one control scheme for the HYTS constraint and one control scheme for the SESS constraint.

5.2 Control Scheme Concept

The control scheme would consist of software, hardware and communications. The software will obtain operations data from the relevant substations and run calculations on a regular basis to determine what action would be required in the event of a specified outage. The amount of generation available to the scheme will be an input to the NEMDE constraint equation.

The occurrence of a specified event would be identified by the receipt of a circuit breaker (CB) open status for a relevant circuit. This would initiate predetermined action which would be the opening of a circuit breaker to disconnect selected generation.

Figure 6 provides a high level concept for the HYTS control scheme. It involves a combination of SCADA equipment and protection equipment. SCADA data will be used to pre-calculate the required actions. The issuing of trip signals will be via high speed protection quality communications and hardware.

Figure 7 provides a high level concept for the SESS control scheme.

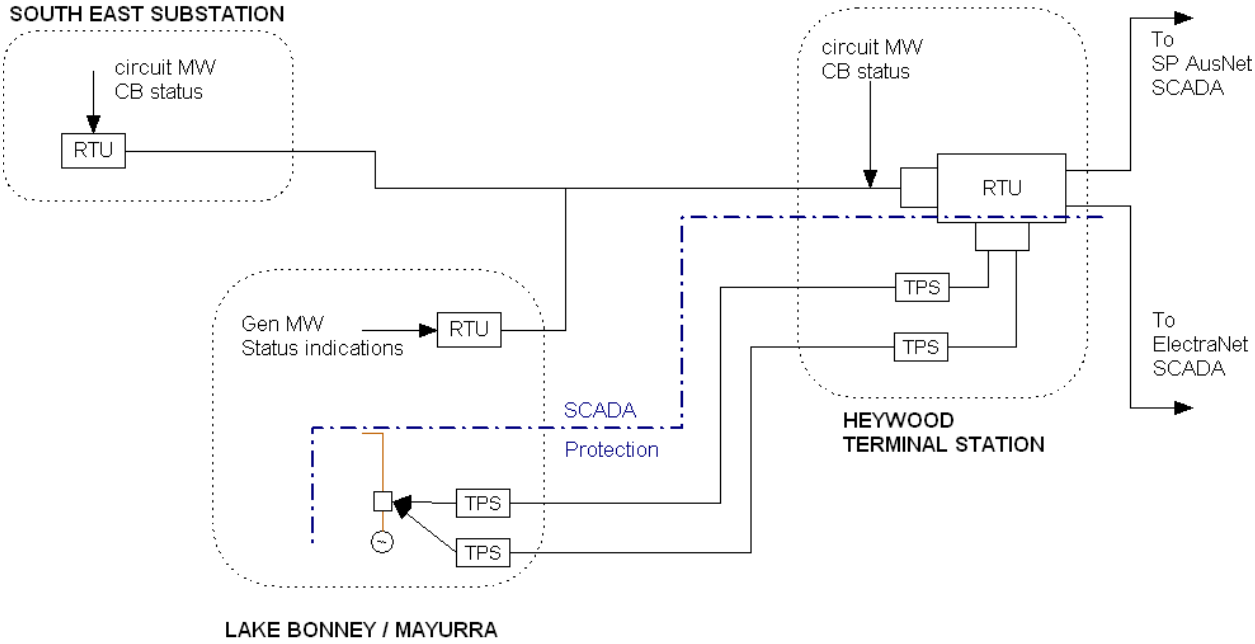

Figure 6 HYTS control scheme design concept

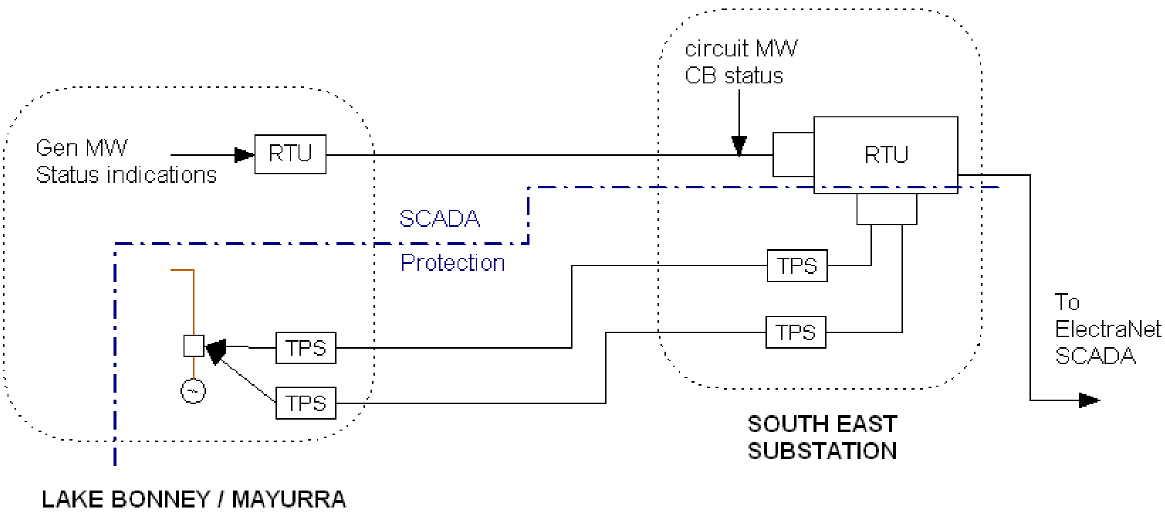

Figure 7 SESS control scheme design concept

5.4 Life of HYTS Scheme

The HYTS control scheme does not increase the thermal limit for flow from Victoria into South Australia. Therefore a third transformer is expected to be installed at HYTS in the longer term. However the installation of the third transformer does not make the control scheme redundant. Without the control scheme a third transformer would only increase the interconnector thermal limit up to the HYTS-SESS 275 kV line limit (514-772 MVA Victorian section and 590/675 MVA South Australian section). With the control scheme the interconnector thermal limit can be increased to 190% of the HYTS-SESS 275 kV continuous line rating (840-1224 MVA). This would be similar to the 1,100 MVA thermal capacity with a third HYTS transformer and HYTS control scheme, and is subject to addressing the voltage and stability issues associated with such large power transfers.

5.5 Design

The following provides a conceptual design framework. The actual design parameters will need to be developed as part of a detailed design process.

The control schemes will consist of hardware and software that will collect operational data and determine what action would be required in the event of specified contingencies. The software will run every eight seconds to calculate the required action.

The control schemes will need to receive CB status indications to trigger the issue of trip signals.

The control scheme action for the HYTS transformer should be completed in less than 500 milliseconds and control scheme action for the transmission lines completed in 3 seconds.

There will be a backup scheme to protect assets from overload in the event of failure of the control scheme to reduce asset loading. The backup scheme should operate at 1.5 seconds for the transformers and 5 seconds for the lines if the asset loading has not been reduced by that time.

5.5.1 Communications

Duplicate high speed communications circuits are required for sending trip signals from the control system hardware to the generator sites. Communications are also required for collecting and sending operational data.

ElectraNet has two high speed digital communications circuits into SESS and Mayurra. There is no existing high capacity communications between HYTS and SESS and several options to provide the HYTS control scheme communications between HYTS and SESS have been considered as follows.

- Duplicate OPGW
- Digital Radio and OPGW
- Digital Radio with route diversity
- Digital Radio using common towers
- Digital Radio and Power Line Carrier (PLC)

Option	Estimate Cost	Advantages	Disadvantages
Digital Radio and OPGW	\$7.5M	fully route diverse	High cost
Duplicate OPGW	\$7.0M	full duplication but not route diverse	High cost
Duplicate Digital Radio on separate towers and route	\$8.0M	fully route diverse	High cost
Duplicate Radio bearers on shared towers	\$4.5M	lower cost	All comms lost for loss of tower
Digital Radio and PLC	\$4M	lower cost	No capacity in existing PLC

Table 4 Control scheme communications options

The costs shown in Table 4 are indicative budget costs with accuracy of ±30%.

ElectraNet has investigated the installation of digital radio as an option to provide upgraded communications between HYTS and SESS. This project has been included in the ElectraNet submission for the next regulatory period with a budget cost of \$4 million.

The digital radio project could be expanded to include a second communications bearer on the same towers but with separate dishes and operating at a different frequency. This would provide duplicate communications circuits but not route diversity.

SP AusNet has considered installation of OPGW on the HYTS-SESS 275 kV line and has provided a budget estimate of $3.5 million.

Installation of OPGW requires extensive outages of the HYTS-SESS 275 kV line. There is a significant risk to the schedule due to the inability to obtain circuit outages. The installation is also subject to weather conditions. The reliance on a project to install OPGW is a significant risk to the project schedule. The OPGW will only provide a single communications circuit.

ElectraNet advised that it considered the communications should be digital radio and the second communications circuit OPGW to provide route diversity.

It is considered that an additional $3.5M to provide route diversity of communications circuits is not justified. If SP AusNet install OPGW between HYTS and SESS at a later stage it could provide one communications circuit but it should not be a requirement for or costed against the control scheme.

Two separate bearers using different frequencies, with separate dishes and power supplies, on the same towers is considered to be an acceptable option. The cost of providing such a second bearer is estimated to be $0.5 million.

The loss of a communications tower is an extremely low probability event. If a tower was lost AEMO would need to redispatch to reduce loading on the interconnector. This could take up to 10 minutes for the interconnector flow to be reduced to continuous ratings. The outage of a transformer in the ten minutes after loss of a radio tower is not a credible event. The power system will be in a satisfactory operating state if there is a loss of a radio tower. AEMO has 30 minutes to return the power system to a secure operating state. The backup scheme is intended to protect the power system if multiple events occur in a short time.

The digital radio should be designed to have two bearers on the same towers. The incremental cost to make this provision will be relatively low compared to the total cost. Issues to be considered will be tower height, wind loading and foundations.

5.6 Control Scheme Performance

5.6.1 Operating Time

The control schemes operating time is in the range of seconds. However each component of the scheme must operate in an appropriate time to ensure that the control scheme action meets overall time requirements. Table 5 sets out the proposed operating time for the control schemes.

Item	Maximum operating time for transformers	Maximum operating time for lines	Comment
site RTU obtains CB status	-	730 ms	hard wired input if necessary
central hardware obtains CB status	230 ms[3]	2.0 s	Transformer CB status hard wired
central hardware issues trip signals	20 ms	20 ms	
signal transfer to remote TPS units	50 ms	50 ms	
Trip relay and CB operation	200 ms	200 ms	
TOTAL TIME	**500 ms**	**3 s**	

Table 5 Control scheme operating time

5.6.2 Reliability

The control schemes require high reliability. Critical performance requirements are that the scheme must operate to trip generation when required in the specified time frame, and should not incorrectly trip generation. These requirements can be achieved through the control system design and equipment specification.

The control schemes will have protection grade equipment for trip signals with full duplication and route diversity of communications circuits to the extent practical. Trip circuit and communications supervision will be required.

There are a number of contingencies that could impact on the operation of the control scheme such as loss of operational data, loss of hardware, loss of trip circuit integrity. These need to be identified as part of the design process and rules developed for how the scheme will handle specific contingencies. Appendix 5 provides an initial risk analysis.

5.6.3 Availability

High availability is achieved through a combination of hardware reliability, control system design to provide redundancy, and maintenance outages.

The control scheme is required to be available when there is high flow from South Australia to Victoria. It is not required when the interconnector flow is from Victoria to South Australia. Times with interconnector flow into South Australia should provide sufficient opportunities for maintenance outages.

The level of redundancy will be determined during the design process but the requirements in Table 6 are suggested as a starting point. The use of duplicate hardware for the *central assets* or use of a warm standby should be reviewed during the specification process.

Spare units for critical components such as the *central assets* hardware and TPS units should be provided as part of the project to allow rapid replacement if there is a failure.

[3] This time is based on the central hardware being on the same site as the transformer, or the use of TPS units to transfer CB status from a remote site.

Item	Install	Spares	Target to repair / replace
central assets hardware		one spare on site	12 hours
TPs units	duplicate circuits	spares installed in cubicle at HYTS	12 hours
trip circuit communications	duplicate circuits	spare parts to be available	12 hours
RTU	single	in store	12 hours

Table 6 Redundancy and spares

5.7 Back up Scheme

In the event that a control scheme fails to operate to reduce loading on a circuit after an outage there needs to be a backup scheme to prevent damage to equipment from overloading. Three options have been considered for the HYTS backup scheme as shown in Figure 8 and summarised in Table 7. When new wind generation is installed at Krongart options 2 and 3 would require an expansion of the backup scheme.

An operation of the control scheme may only occur once every several years. The backup scheme would only operate if a transformer or circuit outage occurred at high interconnector flow to Victoria and both paths of the control scheme failed to trip generation. The occurrence of these events is very low probability and therefore option 1 is considered acceptable on the basis that the backup scheme being required to operate is very low.

The backup scheme for the SESS scheme must remove the Lake Bonney wind generation to reduce the flow in the 132 kV network. The options for this would be the same as options 2 and 3 for the HYTS scheme backup. Both these options rely on communications but with two route diverse communications paths any failure of the SESS control scheme is unlikely to be due to communications failure.

No	Detail	Advantages	Disadvantages
1	Trip parallel element	local scheme does not rely on communications	brute force, impacts on SA frequency, would require over frequency protection in SA to be co-ordinated
2	Trip Snuggery – SESS 132 kV line	could use SESS – Snuggery intertripping from SESS	relies on communications to SESS and Snuggery
3	Trip ElectraNet 132 kV CBs at Mayurra	Only trips wind generation, least system impact	relies on communications to Mayurra

Table 7 HYTS backup scheme options

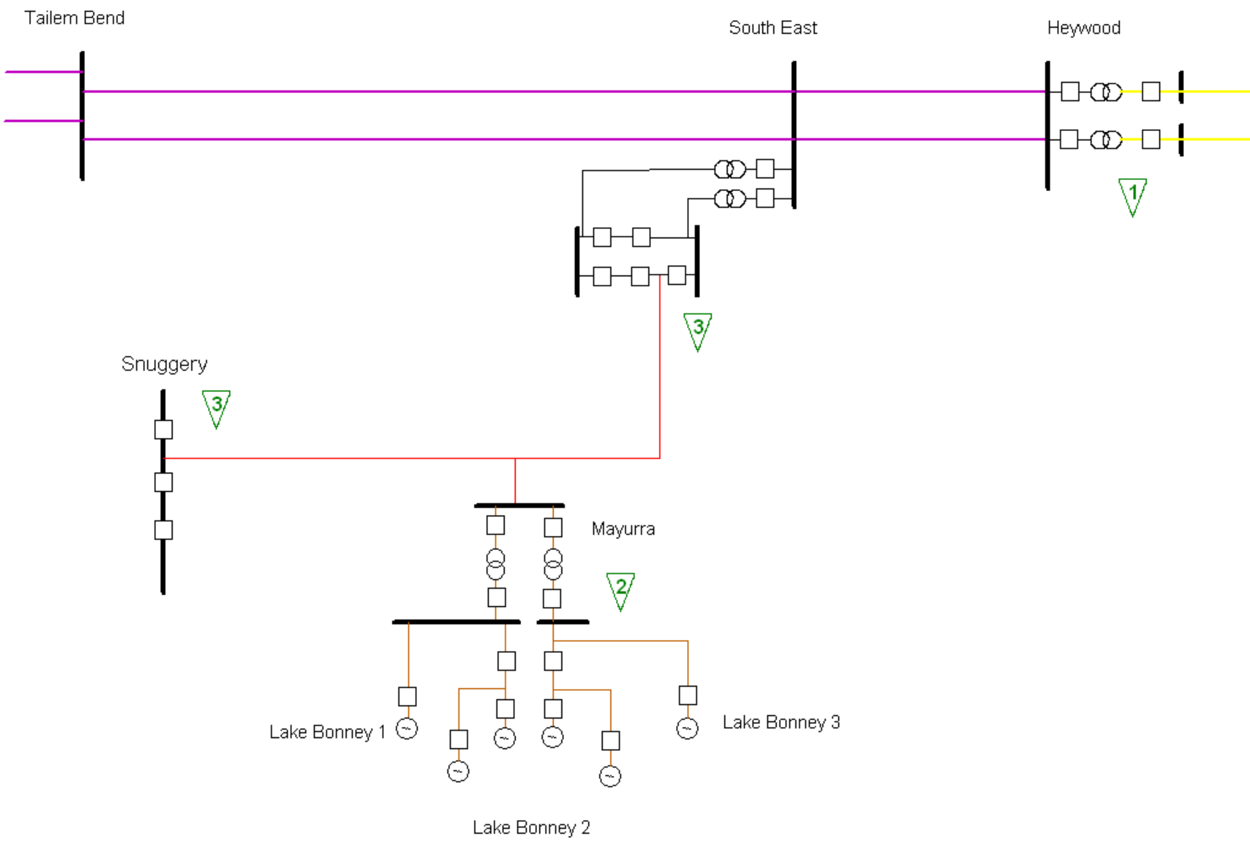

Figure 8 HYTS backup scheme options

5.8 Operating Arrangements

The control schemes will have a status indication that determines if it is in service or unavailable. This status will need to be available to both the relevant TNSP and AEMO. The detail of the status indication will be determined during the design process but it is could be a combination of a status calculated by the central assets hardware and a scan status of the central assets hardware from the TNSP SCADA.

The control scheme status will be used by AEMO in the relevant interconnector constraint equation.

5.9 Coordination with other Control Schemes

5.9.1 Loss of 500 kV to Heywood

There are existing control schemes covering the transmission network associated with the V-SA interconnector. In particular there is a control scheme to manage the loss of the 500 kV to HYTS. This scheme is designed to prevent South Australia having to supply the Portland aluminium smelter which would overload the South Australian power system.

If there was a loss of 500 kV supply to HYTS and that control scheme operated it should provide an output to the HYTS control scheme to inhibit its operation.

5.9.2 Transformer tap changers

The HYTS transformers have online tap changers with controls that act to manage voltages to within specified limits. An outage of a transformer or transmission line at high loading will have an immediate impact on voltages at HYTS and the tap changer control may initiate a tap change. A tap change operation at such high loading could result in tap changer failure.

The transformer tap changers may need an input from the HYTS control scheme to temporarily inhibit tap changing following an outage and consequent control scheme action.

The SESS transformers also have online tap changers and may also need an input from the SESS control scheme to inhibit tap change action following an outage and subsequent control scheme action.

5.9.3 SESS Control Scheme

The HYTS control scheme and the SESS control scheme will both have the same generation for tripping. This will not create any issues. If the some generation is tripped by one control scheme this action automatically reduces loading on the circuits protected by the other scheme. In this case if the other scheme operates shortly after the first scheme operates the amount of generation to be tripped by the second scheme will be less but the amount required to be tripped will also be less due to the loading reduction arising from operation of the first scheme.

6 ACCEPTANCE TESTS

The HYTS control scheme will consist of hardware and software at a number of geographically diverse locations. It is essential that not only the individual components of the system are tested but all the interfaces between the components.

The central assets time to receive circuit breaker status is a critical part of the scheme and a live test should be carried out, particularly opening of the HYTS-SESS line at SESS for the HYTS scheme.

Testing of the trip circuits should be carried out by initiating a live control scheme operation.

7 PROJECT SCHEDULE

The development and implementation of the control scheme involves a number of work streams. Several of these are relatively independent and can be progressed in parallel. Works will be required by AEMO, ElectraNet, SP AusNet and the generator. A project manager will be required to co-ordinate the work of the various parties.

The longest lead time is for installation of new communications between HYTS and SESS which is estimated to be two years. The main risks to the delivery schedule for the communications is obtaining sites and planning approval for two intermediate radio towers.

Negotiation of commercial arrangements can take a significant amount of time and work should start on these negotiations at a very early stage.

Extensive power system studies are required and could take up to 6 months. The development of a detailed specification should be progressed in parallel with the power system studies.

The control scheme requires a generator to participate in the control scheme. It may take some time to negotiate the participation agreement with a Generator, so an agreement in principle to participate in the control should be sought from the Generator as early as possible.

The control schemes central assets and remote assets could be delivered and installed in 18 months. These assets could be in place and soak testing for a few months while the HYTS control scheme communications are being completed.

The SESS control scheme could be in place in 18 months.

8 COST ESTIMATE

8.1 Capital Costs

The estimated combined capital cost for the HYTS and SESS control schemes is $10 million. This has an accuracy of ±30% and assumes that the full cost of the digital radio is allocated to the HYTS control scheme. The largest single cost item is the digital radio at $4.5 million. Table 8 provides a breakdown of the capital cost estimate[4].

Some of the work is common to both schemes and would be required for either scheme separately. Making an allocation of these common costs between the two schemes provides an indicative breakdown of costs between the two schemes. Implementing either scheme alone would result in higher costs for that scheme as the full cost of the common work would be allocated to a single scheme.

SP AusNet will provide a cost for the investigation and testing to confirm the HYTS transformer short term capability. This cost may be higher than amount included in this estimate. The AEMO and ElectraNet Project Team will incorporate any additional cost in the project evaluation.

Item	HYTS Scheme	SESS Scheme	Total Cost
Power System Studies	350,000	50,000	400,000
Functional Specification	200,000	100,000	300,000
Commercial Agreements	650,000	50,000	700,000
HYTS Control Scheme	580,000	0	580,000
HYTS back up scheme	230,000	0	230,000
SESS Control Scheme	0	500,000	500,000
SESS Back up Scheme	0	260,000	260,000
Digital Radio Communications	4,500,000	0	4,500,000
SP AusNet associated costs	580,000	0	580,000
ElectraNet associated costs	350,000	40,000	390,000
AEMO associated costs	320,000	45,000	365,000
Generator costs	15,000	5,000	20,000
Contingency	1,000,000	200,000	1,200,000
TOTAL	8,775,000	1,250,000	10,025,000

Table 8 Capital cost for control schemes

[4] Note that the SP AusNet associated costs (both in the table and throughout the report) were estimated by David Strong and Associates. They have not been derived or formally advised by SP AusNet.

8.1.1 Addition of Wind Generation at Krongart

The control schemes should be designed to be expandable to include additional wind generation. The initial scheme should include sufficient hardware at HYTS and SESS to connect an additional generator into both control schemes. The costs at the time of connecting the new wind generator will be the cost of installing equipment at the new generator site, reconfiguring the HYTS and SESS hardware and software, and modifications to SP AusNet, ElectraNet and AEMO SCADA systems, power system studies and commercial agreements. The estimated cost to add a new generator connected to Krongart into the both control schemes is $600,000. This assumes that duplicate communications to the generator site is installed as part of the generation project.

Work to include the Krongart-SESS 275 kV lines into the SESS control scheme would require a separate back up scheme at Krongart with an estimated cost of $230,000.

8.2 Operating Costs

The estimated total operation and maintenance cost for the HYTS control scheme from 2015 to 2040 is $1.5 million. This covers ongoing operation, annual inspections, 3 yearly testing and replacement of hardware every 10 years. A similar total operation and maintenance cost would apply for a SESS scheme.

This does not include any operation and maintenance cost for the communications as if the whole capital cost of the new communications is charged to the project then the project can effectively earn revenue by providing spare capacity for other ElectraNet and SP AusNet use.

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GLOSSARY

Definitions

central assets	The hardware and software that collects operational data, calculates actions and issues trip signals
control scheme communications	The communications required for the control scheme to collect operational data from relevant sites and issue trip signals to generators
control scheme status	A status indication to indicate the availability of the control scheme
operational data	Status indications, discrete values, analogue values and control commands
reduction ratio	The ratio of the MW reduction in loading on the circuit to the MW of generation tripped without the impact of reloading
reloading	An increase in circuit loading due to upstream generating unit responses to the frequency deviation arising from control system action
reloading ratio	The ratio of the increase in loading on the relevant circuit (due to generation response upstream of the circuit) to the total generation response in the NEM to the frequency deviation
remote assets	Hardware required for the control scheme that is located at a power station or substation other than the central assets location
upstream	The direction from which the power is flowing
wind turbine cluster	a group of wind turbines within a wind farm connected to the network by the same circuit breaker

Acronyms

AEMO	Australian Energy Market Operator Limited (ABN 94 072 010 327)
AI	Analogue Input
AO	Analogue Output
CB	Circuit Breaker
CCGT	Combined Cycle Gas Turbine
DI	Dispatch Interval (five minutes)
DI	Digital Input
DO	Digital Output
DSA	David Strong & Associates Pty Ltd (ABN 82 089 224 000)
EMS	Energy Management System
EPC	Engineer, Procure and Construct
FCAS	Frequency Control Ancillary Services
FCSPS	Frequency Control System Protection Scheme
HYTS	Heywood Terminal Station
ICCP	Inter-Control Centre Communications Protocol
NCSPS	(Basslink) Network Control System Protection Scheme
NEM	National Electricity Market
NEMDE	National Electricity Market Dispatch Engine (AEMO software)
NOCS	Network Operation and Control System
OPGW	Optical Fibre Ground Wire
PLC	Programmable Logic Controller
PLC	Power Line Carrier (communications)
RIT-T	Regulatory Investment Test for Transmission
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SESS	South East Substation
SPS	System Protection Scheme
TNSP	Transmission Network Service Provider
TPS	Tele-Protection Signalling (unit)
V-SA	Victoria – South Australia Interconnector

APPENDIX 1 SCOPE OF FEASIBILITY STUDY

The Consultancy Services shall consist of two stages, with Stage 2 being at AEMO's option.

STAGE 1

1. Liaise with SP AusNet, AEMO, ElectraNet, or other parties as required about:
    a. how they operate these assets,
    b. the policies currently in place regards to asset ratings and control schemes,
    c. the feasibility of the operation of a control scheme as proposed by Infigen within this framework, and
    d. the ownership of such a scheme and identification of risks arising from the ownership and operations of such a scheme.

    This investigation should take into account obligations in terms of safety, security, and reliability within the network (e.g. fully independent dual communication paths).

Additional information may need to be sought during Stage 1 to enable Stage 2 to progress.

STAGE 2

1. Undertake further liaison with stakeholders following on from stage 1 to enable the design to be progressed.
2. Based on information provided, detail the high level design required to enable market modeling. The design needs to be at a level of detail to enable future development of detailed specification. (if feasible). This should include:
    a. Network elements to be monitored and the conditions under which the scheme would need to be armed and to operate
    b. The timeframes in which the scheme would need to operate, as required by asset owners and system operator (AEMO)
    c. Redundancy and any backup scheme arrangements required
    d. Hardware requirements
    e. Operating arrangements, including coordination with AEMO NEMDE
    f. Telecommunications system requirements including redundancy
    g. Reliability and availability of operation
    h. Identification of potential issues in coordinating with other protection schemes.
3. Identify factors that would determine the maximum allowable loading to be considered as a function of generation available for tripping.
4. Determine the cost of such a control scheme, taking into account:
    a. Asset cost, including ongoing maintenance and operational costs
    b. Design, project management, and commissioning costs
    c. Identification of additional liability costs and estimation of legal (set-up) costs (including any assumptions in relation to participation costs)
    d. Any works required to implement in the NEM dispatch systems
    e. Identify any special terms and conditions that may be required from asset owners to provide this scheme.
    f. The modeling timeframe to 2040.

Advise on the time-scale which it could be implemented, taking into account required network studies, control scheme design, and equipment procurement, installation and commissioning.

APPENDIX 2 FEASIBILITY STUDY PROCESS

The project involved initial meetings with AEMO, ElectraNet, SP AusNet and Infigen. These meetings were aimed at obtaining the information required for the feasibility study and in particular identifying any issues that could prevent the implementation and operation of the proposed control scheme.

Table 9 provides a summary of issues discussed in these meetings.

Company	Issue	Comment	Status
ElectraNet	Planning	There is not much diversity between wind farm output	Noted
ElectraNet	Planning	The value of the SESS transformer constraint is low.	
ElectraNet	Planning	If was suggested that the control scheme did not meet the identified need. The control scheme does not address voltage or stability limits. Neither does a third HYTS transformer.	Noted
ElectraNet	Protection and Control	There would need to be a review of all relevant protection settings and where necessary modification of settings to ensure coordination with the control scheme.	Item for project
ElectraNet	Transmission lines	HYTS-SESS South Australian section rated at 590 MVA summer, 675 MVA winter	Noted
ElectraNet	Transmission lines	ElectraNet and SP AusNet use different wind speed for rating of HYTS-SESS line	Noted
ElectraNet	Transmission lines	Weather stations are required for dynamic line ratings. ElectraNet are working through issues with weather stations.	Noted
ElectraNet	Transmission lines	ElectraNet has carried out aerial survey of HYTS-SESS line. Work would be required to analyse data to identify critical spans if dynamic rating was to be introduced.	Noted
ElectraNet	SCADA	ElectraNet aim to keep the SCADA system as vanilla as possible to simplify upgrades. However the dynamic line rating application has been implemented on the SCADA platform.	Noted
ElectraNet	SCADA	ElectraNet would use a contractor for developing any application software for SCADA such as the proposed control scheme.	Noted
ElectraNet	SCADA	There would be a space problem if additional cubicles had to be installed at the ElectraNet Control Centres.	Noted
ElectraNet	SCADA	Operator like minimal alarms. There should only be an alarm when an operator is required to take action.	Noted
ElectraNet	Communications	ElectraNet has a proposal for digital radio communications between SESS and HYTS in the regulatory reset submission. This would require two repeater stations and cost about $4M.	

Company	Issue	Comment	Status
ElectraNet	Communications	There are duplicate communications to from Adelaide to SESS and Mayurra.	Noted
ElectraNet	CBs to trip	Wind farm 33 kV CBs	Design
ElectraNet	Legal	The implementation of the control scheme would require a number of legal agreements to be developed and executed.	Item for project
ElectraNet	Liability	Concern about ElectraNet liability is scheme fails to operate correctly. However this control scheme would be no different to any other control or protection scheme.	
ElectraNet	Insurance cost	This control scheme should not be treated any different to any other TNSP asset. It should have minimal impact on TNSP insurance costs.	
ElectraNet	Planning	Lake Bonney generation reduces interconnector capacity.	Noted
ElectraNet	Planning	Want to see if there are any roadblocks to this scheme before ElectraNet does any power system studies.	Noted
SP AusNet	Dynamic line ratings	SP AusNet does not use dynamic line ratings on HYTS-SESS lines but could implement if requested by AEMO.	Noted
SP AusNet	Terminal equipment short term rating	SP AusNet agreement on terminal equipment to be determined.	Item for project
SP AusNet	HYTS transformer short term rating	SP AusNet has agreed in principle to a short term rating for the transformer.	Formal response required
SP AusNet	Communications	SP AusNet could install OPGW on the HYTS-SESS lines. OPGW could be installed on the HYTS-SESS 275 kV line. The installation would be carried out with one line out of service. The work would have to be carried out at an appropriate time of year (autumn) and would be subject to obtaining line outages and to weather.	Noted
SP AusNet	Communications	SP AusNet suggested that PLC communications may be adequate for the control scheme	Consider
SP AusNet	Communications	The control scheme would require the use of both SP AusNet and ElectraNet communications and the interfaces would need to be negotiated	Item for project
SP AusNet	Existing control schemes	There is an existing pot line tripping scheme for an outage on the Victorian 500 kV system primarily to prevent SA from having to supply the Portland smelter for loss of the 500 kV from Melbourne.	Coordination required
SP AusNet / ElectraNet	Operational Data	The control scheme would require an ElectraNet RTU at HYTS to collect operational data. It was noted that modifications at HYTS resulted in loss on inputs to the existing ElectraNet RTU at HYTS.	Item for project
AEMO	SCADA impacts	AEMO would require operational data for the control scheme and a SCADA display. This is routine work and relatively low cost.	Item for project

Company	Issue	Comment	Status
AEMO	Constraint equations	Any upgrade requires work to modify constraint equations	Noted
AEMO	Contingency analyser	AEMO would require source code for any control scheme software so that the scheme could be modelled in the contingency analyser.	Noted
Infigen	Wind farm locations	Wind farm control room is beside Mayurra substation	Noted
Infigen	Wind farms to be included	Definitely Lake Bonney 2 and 3, Lake Bonney 1 could be included. International Power may be willing to include Canunda	Noted
Infigen	Reactive plant at wind farm	Reactive plant has been designed to operate in conjunction with wind generation. Would not provide voltage control on transmission network	Noted
Infigen	Space for hardware	There should be no issue with space for control system hardware	Noted

Table 9 Issues arising from initial meetings

Company	Issue	Comment	Status
SP AusNet	transformer capability – scheme operating time	Proposed operating time of scheme reduced from 10 seconds due to SP AusNet concern about HYTS transformer short term capability. The proposed time for a transformer outage is now 1.5 seconds with 0.5 seconds for the control scheme and another 1 second for the backup if the control scheme fails to reduce the overload.	Scheme design modified
SP AusNet	transformer capability	Investigation or testing will be required to confirm HYTS transformer short term capability. This will have a cost impact.	Noted

Table 10 Issues arising from further meeting with SP AusNet

APPENDIX 3 V-SA INTERCONNECTOR ANALYSIS

ImportGenConID	Dispatch Intervals
S>>V_NIL_SETX_SETX	1905
F_S++HYML_L60	946
V>>V_NIL_2B_R	835
V>>V_NIL_2A_R	610
S>>V_CGTB_TUTB_MOTB	535
F_S++HYSE_L60	474
F_S++HYML_L6	295
F_S++HYML_L5	258
S:V_420	153
S>NIL_CGTB_TUTB	115
S:V_580	78
F_S++HYSE_L6	78
SV_260	70
SV_300	61
#V-SA_RAMP_I_F	54
S>V_NIL_HYTX_HYTX	53
V>>V_TTSB1_SMTT_2A_R	25
F_S++HYSE_L5	23
V>>V_KTS_TX_A3_2B_R	21
S>>V_KNPW_SETX_SETX	21
CA_SPS_3D47601E_02	19
V>>V_ROTT_R_2B	17
V>>V_KTS_TX_A2_2B_R	13
V>>V_KTS_TX_A3_2A_R	12
V>>V_NIL_2_P	12

Table 11 Constraints binding on SA to Vic flow in 2011 for more than 10 dispatch intervals

ExportGenConID	Dispatch Intervals
V^^S_TBCP_NPS_SE_ON	4898
V^^S_TBCP_NPS_SE_OFF	3199
V::N_NILQE_BL_R	2632
V^^S_KHKN_MAXG_SEON	2185
V^^S_NIL_NPS_SE_OFF	2063
V::N_NILVE_BL_R	1933
V^^S_NIL_NPS_SE_ON	1861
V::N_NILVF_BL_R	1082
V::N_NILQF_BL_R	987
V^^S_KHKN_MAXG_SEOFF	985
VS_250	952
V^^S_PAVC_NPS_SEOFF	622
V::N_NILVB_BL_R	518
F_ESTN++HYML_L60	514

ExportGenConID	Dispatch Intervals
V^^S_PAVC_NPS_SEON	487
V>>S_HYML_2	483
V^^S_NIL_MAXG_AUTO	388
V>>S_HYML_1	374
V::N_NILQB_BL_R	355
V^^S_SEVC_NPS_SEOFF	344
F_ESTN++HYML_L5	318
V::N_NILVC_BL_R	304
V::S_NIL_NPS_SEON	292
F_QNV++HYML_L60	247
V::N_NILQC_BL_R	242
V^^S_SETX_NPS_SEON	220
V^^S_BNMT_NPS_SEON	213
V::S_PAAC	210
V>>S_NIL_SETB_KHTB	188
VS_HYTS_TX	182
V^^S_KNPW_NPS_SEOFF	160
V::N_BUDPQE_R	159
V::N_DDMSQE_R	156

Table 12 Constraints binding on Vic to SA flow in 2011 for more than 150 dispatch intervals

APPENDIX 4 EXAMPLES OF SIMILAR CONTROL SCHEMES

This appendix provides an outline of two control schemes that have been implemented in Tasmania. The design concept for the proposed HYTS control scheme is similar to these schemes.

A4.1 Basslink System Protection Scheme

Basslink is a monopole HVDC interconnection between Victoria and Tasmania. It has a continuous rating of 500 MW and a dynamic rating of 630 MW export from Tasmania. The Tasmanian power system has about 2800 MW of installed generation with a maximum demand of 1800 MW and an average demand about 1200 MW. Basslink is very large compared to the Tasmanian power system and loss of Basslink at high power transfer will have a significant impact on Tasmanian frequency.

A System Protection Scheme (SPS) was required as part of the Basslink project to allow the full capacity of Basslink to be utilised. The Basslink SPS consists of a Frequency Control SPS (FCSPS) and a Network Control SPS (NCSPS). It is owned and operated by Transend and is integrated with the Transend Network Operation and Control System (NOCS).

The FCSPS is designed to manage the frequency deviation in Tasmania following loss of Basslink by tripping generation if Tasmania is exporting or tripping load if Basslink is importing. It runs a calculation every four seconds to determine the amount of load or generation that would need to be tripped for a loss of Basslink, selects appropriate load blocks or generating units and sends controls to close relays on central trip boxes at two locations.

In the event of an outage of Basslink the Basslink converter station will issue a loss of link signal which is sent to the central trip boxes. This signal input to the central trip boxes initiates the issue of trip signals to the load blocks or generating units which had been armed by the SPS software.

The loss of link signal and trip signals use duplicate high speed communications. The loads or generating units will be disconnected from the network within 650 milliseconds of interruption to the Basslink flow.

The Tasmanian transmission network would not have been able to deliver 630 MW to the Basslink connection point when operating at n-1 without construction of new transmission lines and substantial cost.

The NCSPS allows transmission corridors to operate at up to 0.95 n capacity by tripping or running back generation in the event of a transmission circuit outage. The NCSPS monitors 18 circuits and will select generation to be tripped or run back for each circuit for an outage of an associated circuit, subject to specified conditions such as the network being intact, an associated circuit is out of service, or power flow is in a specific direction.

The NCSPS uses transmission line dynamic ratings and conductor temperature from the thermal rating calculator to determine the amount of time for a conductor to reach operating temperature. The NCSPS uses this time to determine if fast action (less than 10 seconds) is required, or slow action (minutes) is sufficient. If fast action is required generator circuit breakers are tripped. If slow action is required the governor solenoids are tripped and the generating units output ramps to zero while the generating unit remains on line and can assist with voltage control following the event.

CB status is collected by NOCS. The receipt of a CB open status for a relevant circuit will initiate the issue of trip or runback signals to the selected generating units. The NCSPS and FCSPS use the same high speed communications and Tele-Protection Signalling (TPS) units.

The Basslink SPS went into live operation on 15 December 2005.

A4.2 Tamar Valley Generator Contingency Scheme

A 208 MW combined cycle gas turbine was established at Tamar Valley Power Station in 2009. The AEMC Reliability Panel carried out a review of the Tasmanian Frequency Operating Standard in 2008 and determined that the maximum generator contingency in Tasmania be limited to 144 MW which is the size of the previous largest generating unit.

The determination required that the owner of the Tamar Valley Power Station develop a generator contingency scheme and contract with major industrial customers for interruptible load so that in the event of an disconnection of the CCGT when operating above 144 MW load would also be tripped such that FCAS would only need to be enabled to cover the loss of not more than 144 MW.

A generator contingency scheme was implemented. It consists of logic to determine when a loss of generator signal should be issued, software to calculate the amount of load to be tripped for loss of the generating unit and select load blocks to be armed, and communications for transferring trip signals to the load blocks in the event of a loss of the generating unit.

The Tamar Valley generator contingency scheme was commissioned in August 2009.

APPENDIX 5 RISK ANALYSIS AND MITIGATION

Table 13 sets out an initial risk analysis and mitigation. A more detailed analysis would be carried out as part of the project design.

Event	Impact	Mitigation / Action	Comment
Loss of analogue data from generator	Control scheme does not know how much generation available to trip	Remove wind turbine cluster from trip list. Reduce SA export limit to match with the reduction in Generation. Alarm for operator. Other clusters may be selected for tripping	
Analogue values outside reasonability limits	Data incorrect	Remove wind turbine cluster from trip list. Reduce SA export limit to match with the reduction in Generation Alarm for operator. Other clusters may be selected for tripping	
Loss of status indications from generator	Control scheme does not know health of trip circuit	Remove wind turbine cluster from trip list. Reduce SA export limit to match with the reduction in Generation Alarm for operator. Other clusters may be selected for tripping	
Loss of one trip circuit to generator	If outage occurs control scheme will be relying on one remaining in service trip circuit.	Alarm for operator. Allow cluster to remain in trip list for limited time (12 hours)	
Loss of both trip circuits to Generator	Generator can not be tripped if outage occurs prior to redispatch	Remove wind turbine cluster from trip list. Reduce SA export limit to match with the reduction in Generation NEMDE redispatch for next DI	Risk if outage occurs before generation is redispatched (maximum 10 minute window). Backup scheme would operate if outage occurred before redispatch
Trip circuit communications generates spurious trip signal	Generators tripped incorrectly	TPS and trip circuit communications designed to avoid spurious signals	Non credible.
Hardware incorrectly issues trip signal	wind turbine clusters tripped incorrectly	Frequency disturbance managed by contingency raise services	

Event	Impact	Mitigation / Action	Comment
Scheme does not receive CB status change from one end of circuit	CB status change from other end of circuit will initiate action		
Scheme does not receive CB status change from either end of circuit.	Scheme does not operate to reduce circuit loading	Backup scheme operates	
Line opens one end	Scheme operates if CB status received	Circuit loading reduced	
Failure of control system hardware	Scheme not able to trip generation in the event of a circuit outage	Alarm for operator. Reduce SA export limit to match with the reduction in Generation NEMDE to redispatch	Risk if outage occurs before generation is redispatched (maximum 10 minute window). Backup protection would operate is required.
Failure of control system software	Scheme not able to select generation for arming	Alarm for operator. Reduce SA export limit to match with the reduction in Generation NEMDE to redispatch	Risk if outage occurs before generation is redispatched (maximum 10 minute window). Backup protection would operate is required.

Table 13 Risk analysis and mitigation

APPENDIX 6 CONTROL SCHEME DESIGN

This appendix provides some more detail of the proposed design for the proposed control schemes.

A6.1 HYTS Control Scheme Central Assets

Central assets, in relation to this control scheme, refers to the hardware and software that collects operational data, calculates action, and issues trip signals. It is proposed that the central assets for the HYTS control scheme be installed at HYTS. Figure 9 provides an overview of the central assets hardware.

A RTU or similar device will be used to collect operational data from SESS and Generators participating in the scheme and run the software to determine the action required in the event of an outage. The trip outputs from the RTU will be hard wired to TPS unit inputs. The RTU will have an IRIG-B input for time synchronising.

The generation selected for tripping may be prearmed by closing relays, or the controls to the relays may be generated on receipt of a CB open status. The details will be finalised at the design stage.

There would be DNP3 communications from the RTU to both the SP AusNet and ElectraNet SCADA.

The software would provide status indications to the Generator to show when one or more wind turbine clusters were selected for tripping.

Time synchronising of the central assets hardware from a GPS clock is required. It is expected that there would be a suitable GPS clock at HYTS. If there is no existing GPS clock then a GPS clock will be included in the project.

The control scheme may need to issue a control to inhibit tap change operation in conjunction with the issue of trip commands. Operation of a transformer tap changer at the high loading following a transformer outage may damage the tap changer. The control should also inhibit tap change operation for control scheme action for a 275 kV line outage.

Receipt of a circuit breaker open status will initiate the issue of trip signals to any wind turbine clusters that were selected for tripping at that time.

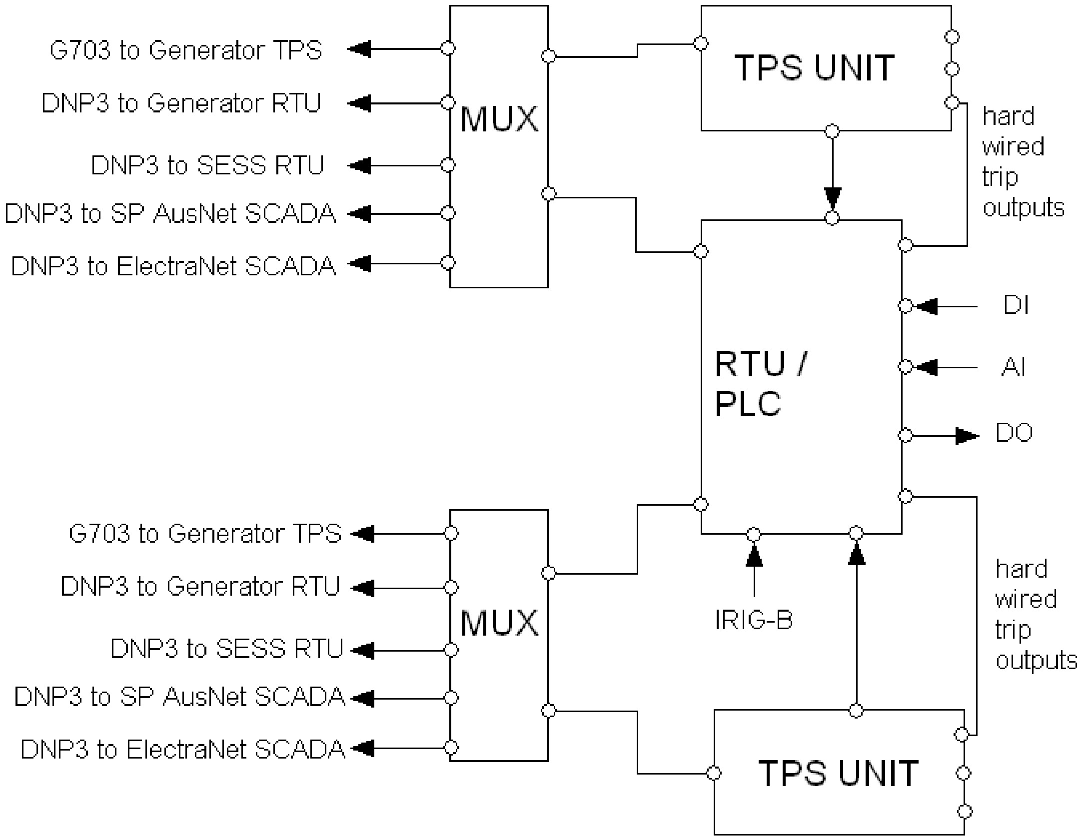

Figure 9 HYTS control system central assets hardware

A6.2 South East Substation

There will need to be an RTU or similar device at SESS to collect operational data for the HYTS control scheme. CB status indications from the relevant CBs at SESS would need to be collected. The design of the CB status inputs to the RTU must recognise that the required latency for the receipt of the CB status change is less than one second. The latency must be confirmed during the commissioning process. Analogue values such as line current or MVA would also be collected.

The SESS control scheme central assets are shown in Figure 10.

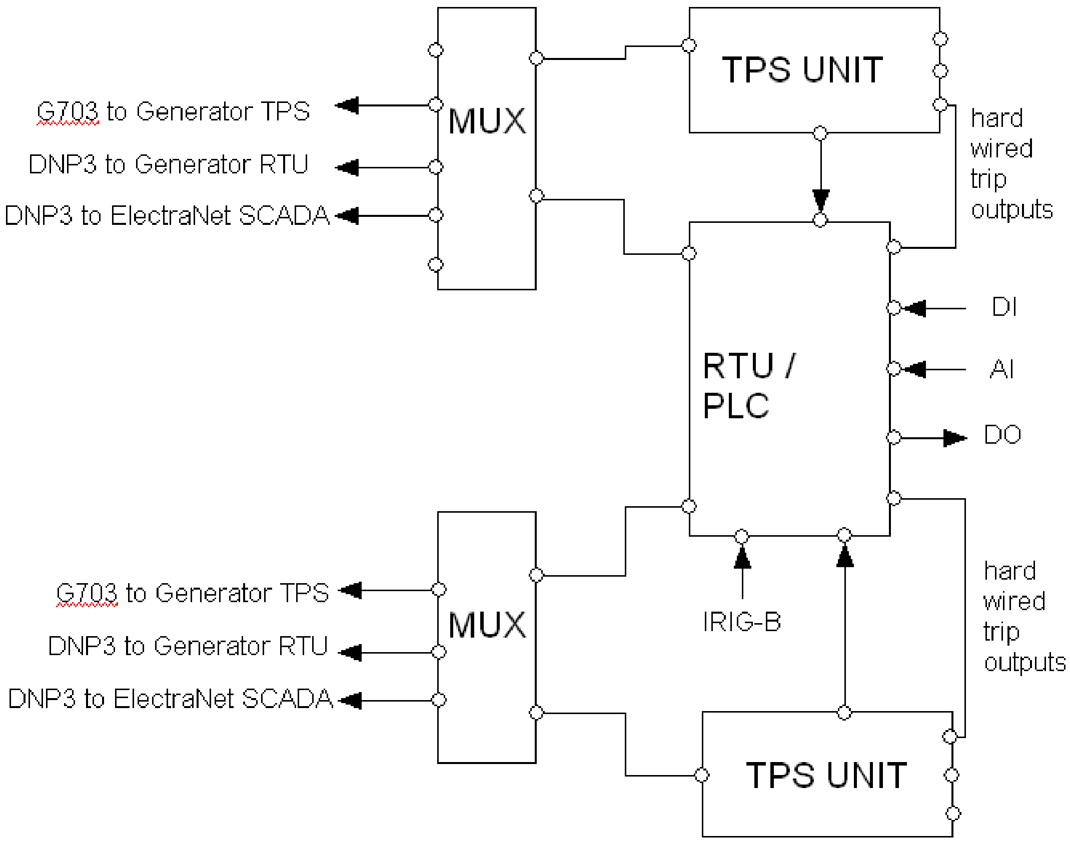

Figure 10 SESS control scheme central assets

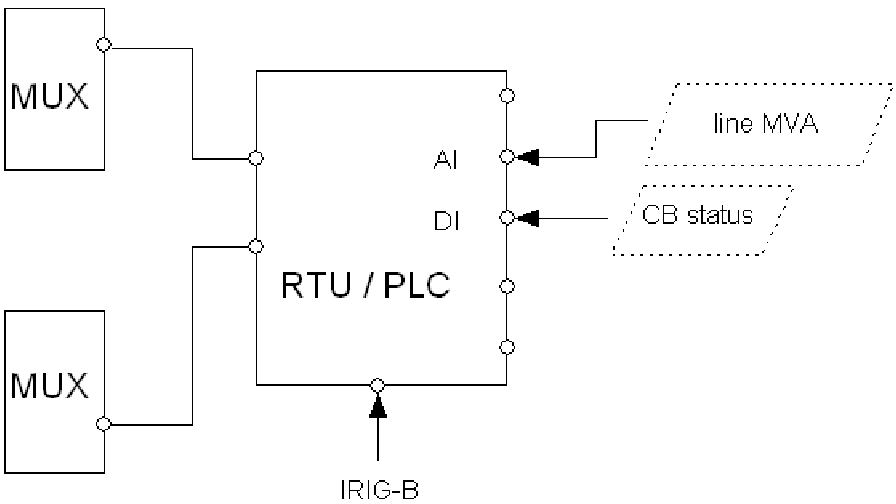

Figure 11 HYTS control scheme assets at SESS

A6.3 Generator

There will need to be an RTU at each Generator site to collect operational data from each relevant wind turbine cluster. The Generator site will also have two TPS units for receiving trip signals. The trip received output from the TPS units should be connected into the RTU. The RTU may also have some digital outputs to provide the Generator with indications when any of its wind turbine clusters are selected for tripping. Each TPS unit can provide for multiple trip signals.

At the initial stage Lake Bonney may be the only Generator participating in the control scheme. The Lake Bonney generation will be treated as four wind turbine clusters.

A TPS unit need to be located close to the trip circuit to which it is to be connected. The copper wire from the TPS output to the CB trip circuit is not monitored. Damage to this connection is not alarmed. This copper connection should be kept as short as possible by locating the TPS units close to the trip circuits.

The TPS units may need to be installed on the Lake Bonney site rather than Mayurra substation. This will require either a copper or fibre connection from the MUXs at Mayurra to the TPS units.

The assets for the HYTS and SESS control schemes may be installed in separate cubicles as shown in Figure 12. However it would be more cost effective for the two control schemes to share a cubical and RTU as shown in Figure 13.

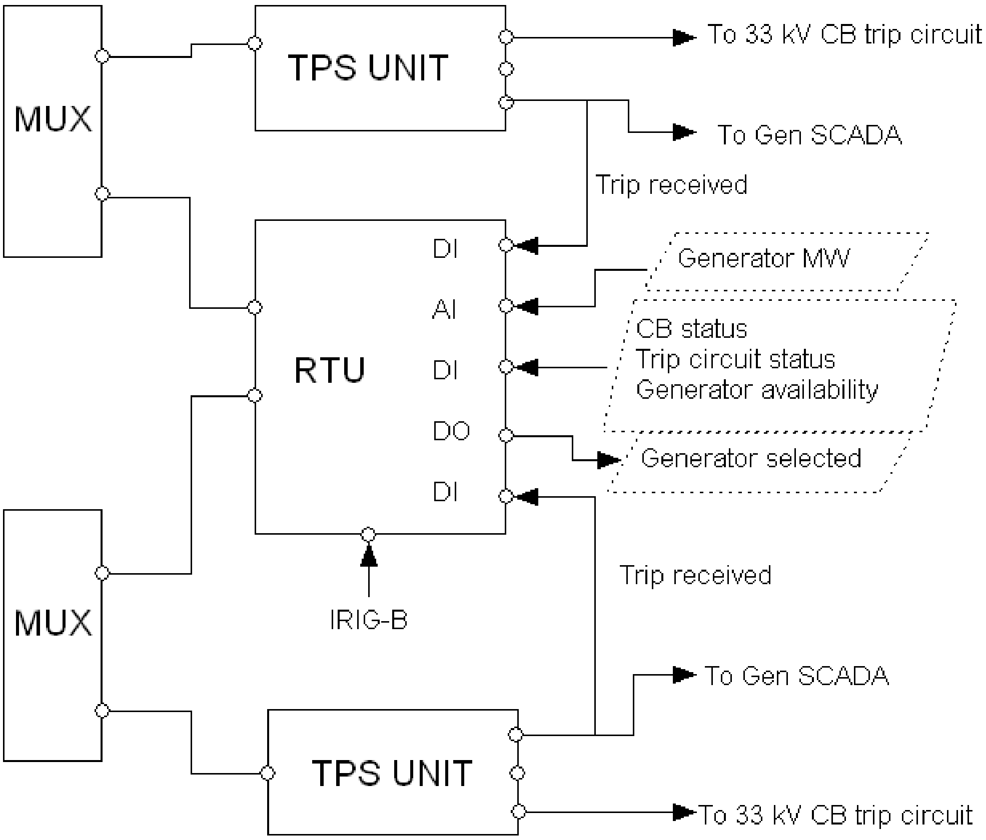

Figure 12 Installation at Generator – single scheme only

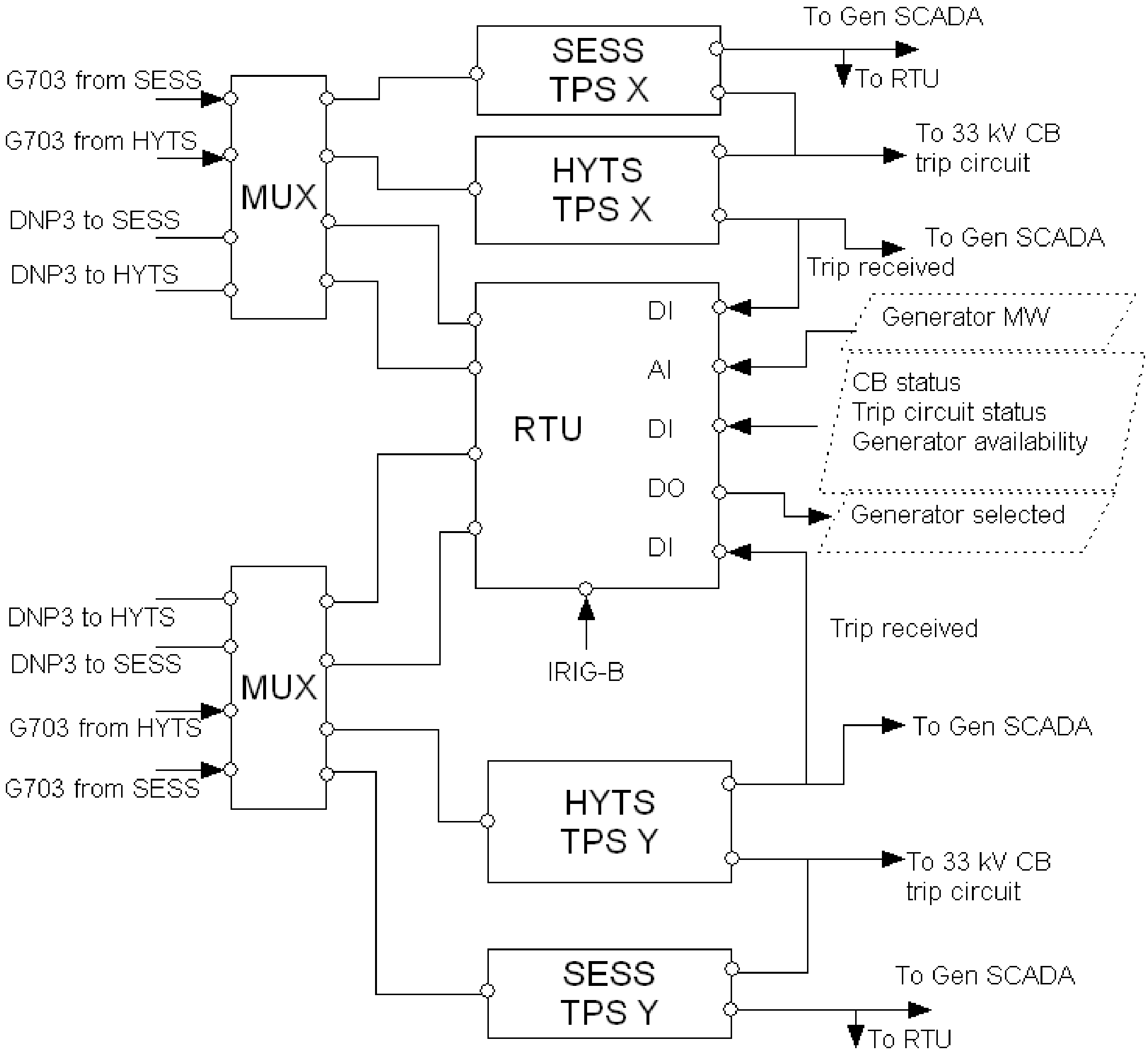

Figure 13 Installation at Generator – shared cubicle

A6.4 Software

Software is required to calculate the amount of generation that would need to be tripped in the event of a specified outage.

The software will collect operational data each eight seconds.

Quality checks should be carried out on the operational data to ensure that is within reasonability limits. Validation could include the comparison of values for the two circuits, and comparison of data from each end of a circuit. Rules will have to be developed for control scheme action when data fails validation.

Following successful validation the software will then determine if control scheme action would be required in the event of an outage, the amount of generation to be tripped, and which wind turbine clusters are selected for tripping.

Allowing 8 seconds between calculation cycles will allow control scheme action to be completed before the next calculation cycle in the event of an outage initiating control scheme action.

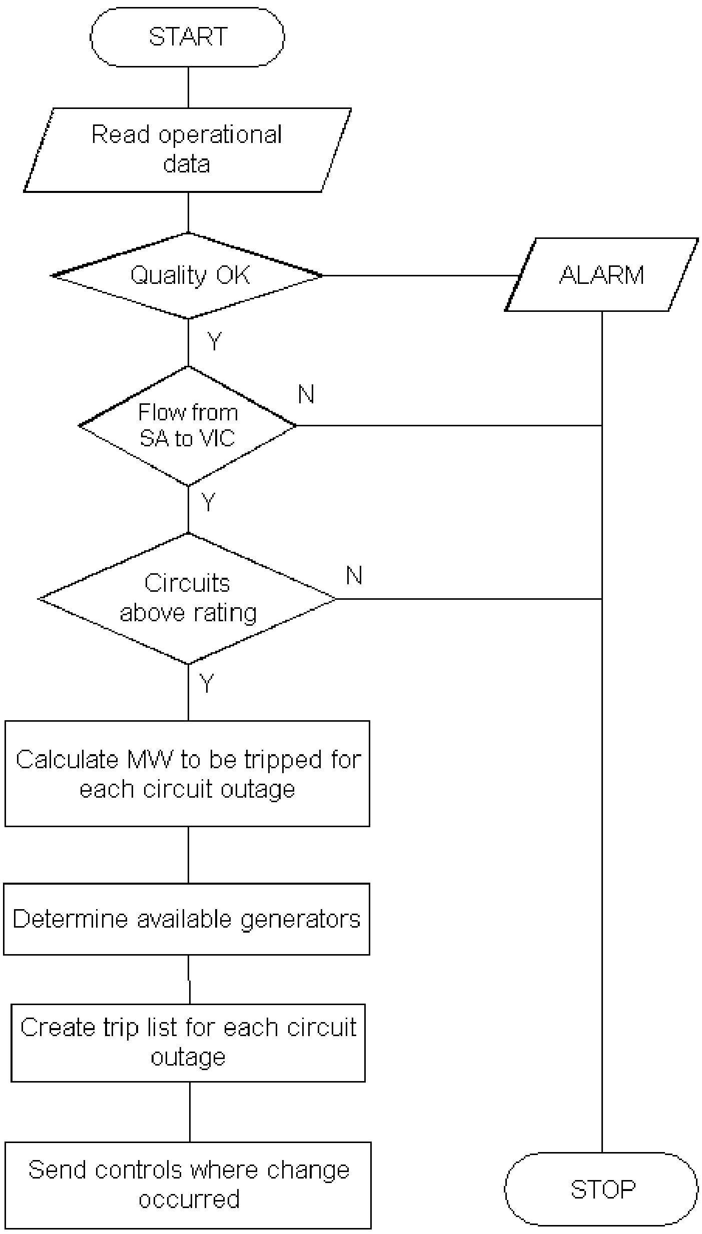

Figure 14 Logic for generator selection and arming

A6.5 Generation Tripping

A CB status change will initiate issue of trip signals to any generating units that are selected for tripping. The CB status change could initiate the issue of DNP3 controls to output relays in the RTU, or it could provide a wetting voltage for pre-armed relays. The details will need to be determined during the design stage. Figure 15 shows the Generator selected AND CB open status resulting in the issue of a trip signal.

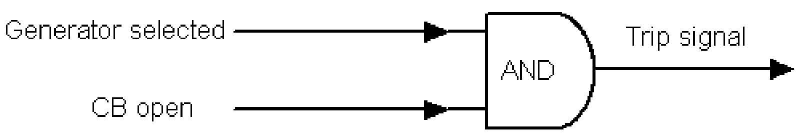

Figure 15 Generator tripping

A6.5 Operational Data

Operational data will be required for the assets being protected and the wind turbine clusters providing interruptibility services.

Operational data required from wind turbine clusters will be as follows.

- Generator MW
- CB status
- Trip circuit status
- Remote availability (if relevant)

A6.6 Hardware

The hardware to be used for the central assets and remote assets will be selected at the design stage. A number of manufacturers have suitable hardware and selection will depend on TNSP preferences.

A6.7 Backup Scheme

The backup scheme will be a last line of defence to protect the assets in the case of failure of the control scheme to reduce loading to below rating following an outage of a parallel element. It will be completely independent of the control scheme. The backup scheme will use a protection device to initial tripping if load is above short term rating for 9 seconds. Figure 16 shows the indicative logic for the backup scheme.

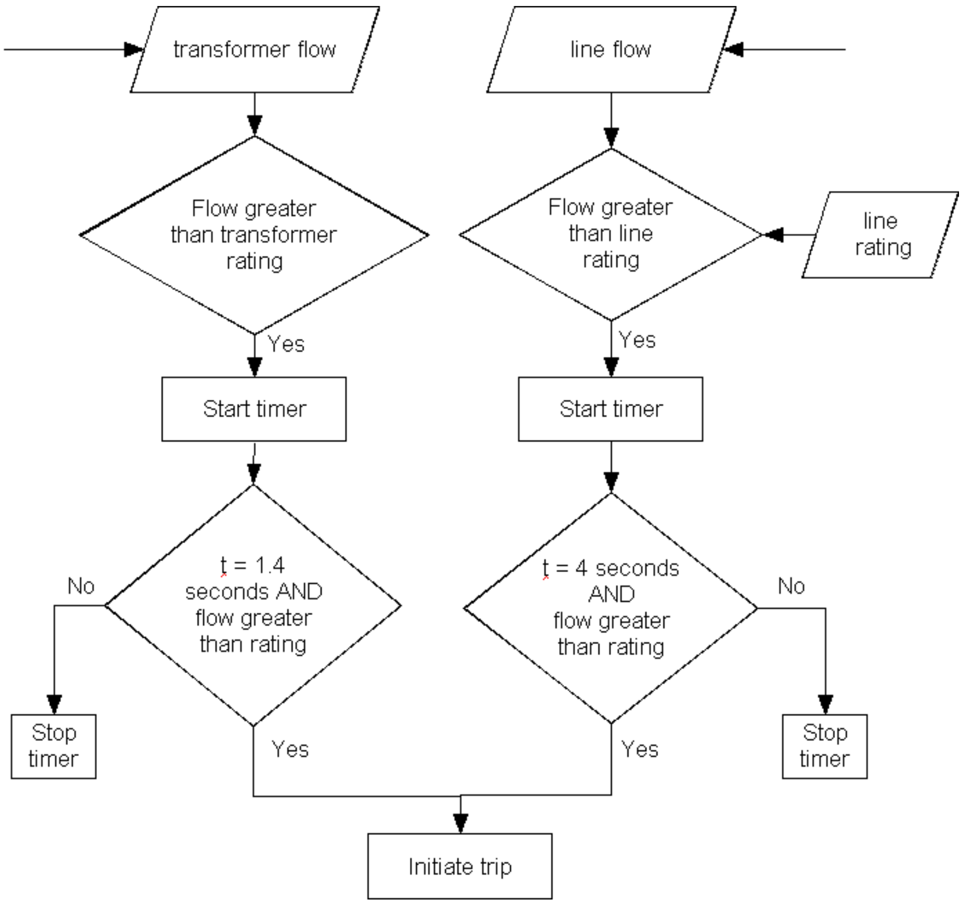

Figure 16 Backup scheme logic

APPENDIX 7 PROJECT SCHEDULE

Figure 17 shows an indicative schedule for implementation of the control scheme.

No	Item	Pre Requisite	Resp	Duration	Start	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25
1	Approval to proceed		AEMO																											
2	Generator Agreement in Principle			1																										
3	Power system studies	1, 2	AEMO	24	Wk1																									
4	Functional Specification	1, 2	AEMO	12	Wk1																									
5	Interruptibility Service Agreement		SP AusNet	24	Wk3																									
6	Lease Agreements			12																										
7	Connection Agreements			12																										
8	Communications Services Agreement		ElectraNet	24																										
9	Communications	1, 2	ElectraNet	104	Wk1																									
10	Protection Setting review		SP AusNet	4																										
11	Protection Setting modifications		SP AusNet	4																										
12	Transformer Short Term Rating		SP AusNet	6																										
13	Review terminal equipment		SP AusNet	12																										
14	Review HYTS-SESS critical spans		SP AusNet	20																										
15	SCADA points		SP AusNet	1																										
16	Operator display		SP AusNet	1																										
17	Thermal inspection		SP AusNet																											
18	Protection Setting review		ElectraNet	4																										
19	Protection Setting modifications		ElectraNet	4																										
20	Review terminal equipment		ElectraNet	6																										
21	Thermal inspection		ElectraNet																											
22	Review HYTS-SESS critical spans		ElectraNet	6																										
23	SCADA points		ElectraNet	1																										
24	Operator display		ElectraNet	1																										
25	Tender		SP AusNet	4																										
26	Let Contract		SP AusNet	2																										
27	Engineering Design		Contractor	3																										
28	Hardware Procurement		Contractor	16																										
29	Construct		Contractor	6																										
30	Software Development		Contractor	6																										
31	Factory Acceptance Testing		Contractor	2																										
32	Wiring for Generator installation		Generator	1																										
33	SCADA points		Generator	1																										
34	Operator display		Generator	1																										
35	Installation		Contractor	4																										
36	SCADA points		AEMO	1																										
37	Operator display		AEMO	1																										
38	Contingency Analyser Modifications		AEMO	12																										
39	Constraint Equations		AEMO	12																										
40	Soak testing		SP AusNet	32																										
41	Commissioning		SP AusNet	4																										
42	AEMO Operator Training		AEMO	8																										
43	SP AusNet Operator Training		SP AusNet	8																										
44	ElectraNet Operator Training		ElectraNet	8																										
45	Live Operation																													

Figure 17 Schedule for control scheme delivery