24 July 2008

Alinta
Alinta Energy (Tamar Valley)
Pty Ltd
ABN 29 123 391 613
Alinta Plaza
12 - 14 The Esplanade
Perth WA 6000
GPO Box W2030
Perth WA 6846
Telephone +61 8 6213 7000
Facsimile +61 8 6213 7092
www.alinta.net.au

Mr Ian Woodward
Chairman, Reliability Panel
Australian Energy Market Commission
Level 5, 201 Elizabeth Street
Sydney NSW 2000

Dear Mr Woodward

Review of Frequency Operating Standards for Tasmania
Response to NEMMCO Advice Dated 23 May 2008

Alinta's initial submission in this review process was provided in our letter of 24 April 2008 and the enclosed Frequency Standard Development Report. Following that submission, NEMMCO has provided its 23 May 2008 advice to the Reliability Panel which raised issues about the assumptions made in our initial submission, and indicated the need for additional studies.

Alinta and Hill Michael have discussed these matters with NEMMCO staff and believe that all issues have now been satisfactorily addressed.

Alinta is pleased to provide the following additional information to the Reliability Panel. All responses are referenced to item numbers in NEMMCO's 23 May advice.

1 ASSUMPTIONS

1(a) Multiple Contingency Events

NEMMCO advised that simulations be expanded to cover the loss of 540 MW (60% of 900 MW of system demand) caused by multiple contingency events under Tasmanian light load conditions. NEMMCO advised that its previous work had concluded that "narrowing the band to less than 1.5 Hz may present significant challenges" for design of the UFFLS.

An additional case to cover these issues has now been modelled. The system details for this case are given in Table 1.

Case No	8
Load - MW	903.8
Inertia - MWsec	4170
Basslink Import (sending end) - MW	440.0
Generation	
Total	510.0
Hydro (JB, TU, CL, MB, GO, TR, PO)	236.3
Thermal (CCGT)	135.0
Wind	138.7
Largest generating unit Scheduled – MW (CCGT)	135
Reserve Required for largest unit tripping - MW	110.6
Estimated FCAS 6s Raise	
Total	115.1
Hydro	74.1
Thermal	50.6
Basslink	55.0
Fault Level (GT converter) – MVA	
Note: • Risdon capacitor bank switched in to improve voltage • Burnie capacitor bank switched in and Farrell 220/110 kV transformer set to voltage control to improve voltage on the West Coast	

Table 1: System Details for Case 8

The simulation of loss of 60% of generation is represented by tripping of Basslink and wind farm generation (total output 564 MW) when the system inertia is as low as 4170 MWsec. This level of inertia is 10% lower than that identified by NEMMCO (4500 MWsec) at 900 MW load. The resulting frequency envelope is presented in Figure 1.

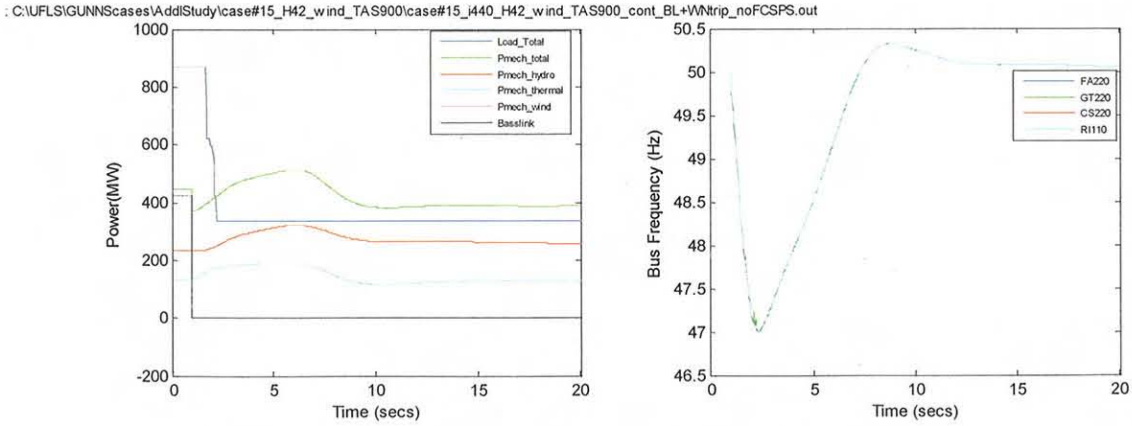


Figure 1 – Frequency and Pmech for loss of 60% of generation – Case 8

Observations from the simulation study are:

- Minimum frequency reached is 47 Hz at 1.3 seconds after tripping of Basslink
- All 7 blocks of load are shed by UFLSS: total load shed is 534 MW.
- Enough load is available under UFLSS to manage loss of 60% of generation
- Total loss of generation is 564 MW (60% of generation.
- Rate of change of frequency is very high 2.8 Hz/sec because of very high loss of generation. As a consequence UFLSS operates well before any FCAS is available to reduce the load shed.
- The system remains stable after load is shed
- Frequency recovers after load shedding: maximum frequency reached is 50.3 Hz.

It is concluded that it is feasible to design UFLSS to cover such a severe event.

1(b) Assumptions about Light Load Conditions

NEMMCO advised that simulations should be conducted for system light load of 900 MW, rather than the 1080 MW used in the report to test robustness of the proposed standard. NEMMCO advised that 440 MW of Basslink import should be assumed at the same time.

Essentially NEMMCO wanted simulations to be conducted with 900 MW load conditions with 440 MW of Basslink import and assess the ability for frequency to be maintained above 48HZ for loss of single credible contingency.

Simulations have now been carried out for:

- loss of CCGT
- loss of Basslink

Results for the CCGT trip are shown in Table 2 and Figure 2.

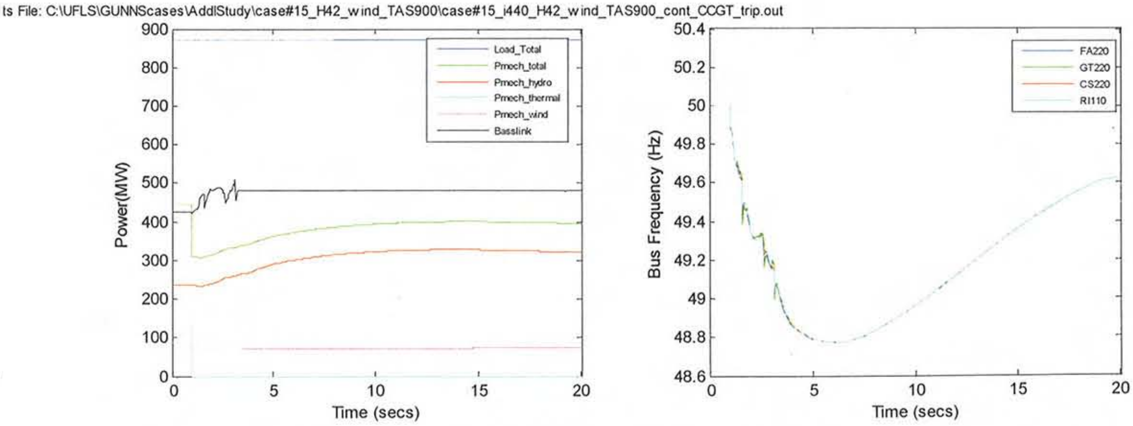


Figure 2 – Frequency and Pmech for CCGT trip – Case 8

case	Min. Freq		Max. Freq		Load she		MW				Inc. in Bassli
#	Hz	Time- s	Hz	Time-se	MW	Item	Hydro	Thermal	wind	Total	MW
8	48.77	5.28	49.62	19	0	Increase- Pmech at min Freq	66.5	0	-2.5	63.9	55.9
						Increase - Pmech at 6sec	72.2	0	-2.6	69.6	-55.9
						FCAS at 6sec	72.4	0	-2.8	69.6	

Table 2: Minimum Frequency and FCAS for CCGT trip

Observations for the CCGT trip are:

- Minimum frequency reached is 48.77 Hz which is well above 48 Hz, indicating that FCAS provided is adequate.
- Frequency stays well above 48 Hz because adequate FCAS is scheduled, and also because of Basslink's fast response to increase the and slow down rate of change of frequency decay. This provides sufficient time for FCAS from hydro to pick up and enable faster frequency recovery.
- FCAS scheduled is higher than that required for local unit loss to cover contingency of Basslink. (Such a high level Basslink transfer at such low load conditions requires higher FCAS than that would be set by the largest unit of 135 MW of CCGT used in this case).

Results for the Basslink trip and correct FCSPS operation are shown in Table 3 and Figure 3.

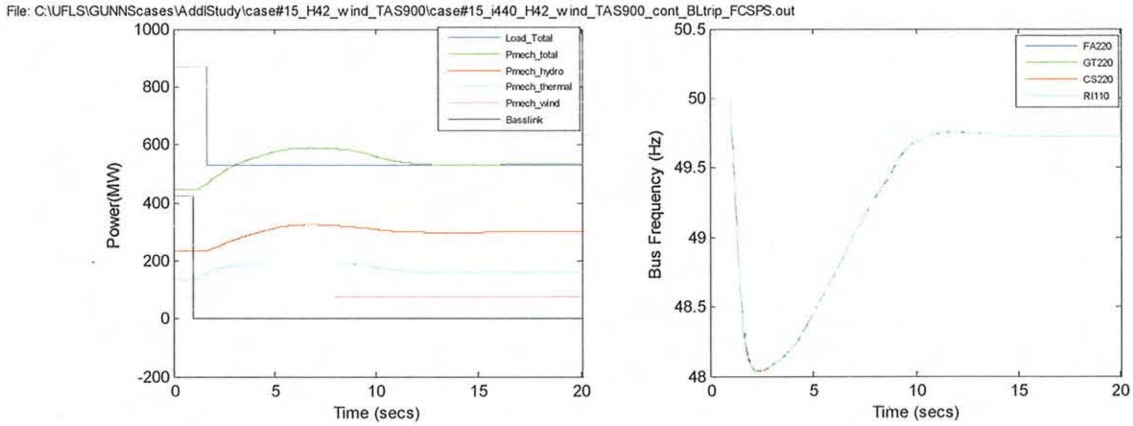


Figure 3 – Frequency and Pmech for Basslink trip – Case 8

case	Min. Freq		Max. Freq		Load she		MW				Inc. in Bassli
#	Hz	Time- s	Hz	Time-se	MW	Item	Hydro	Thermal	wind	Total	MW
8	48.03	1.35	49.76	10.85	338	Increase- Pmech at min Freq	16.4	38.7	0.1	55.2	0
						Increase – Pmech at 6sec	88.9	55.1	0.1	144.1	0
						FCAS at 6sec	102.2	89.7	0.1	192	

Table 3: Minimum Frequency and FCAS for Basslink Trip with FCSPS operating

Observations for the Basslink trip are:

- Minimum frequency reached is 48.03Hz
- Minimum frequency occurs at 1.35 seconds
- Alinta generator delivers all FCAS raise service in less than 3 seconds
- UFLSS does not pick up even with this very high rate of change of frequency, indicating that discrimination between FCSPS and UFLSS can be achieved with the proposed UFLSS settings

1(c) Assumption about Future Generation Developments

NEMMCO advised that additional windfarm generation should be considered for testing the frequency standard.

Additional simulations with a case similar to case 8 used in 1(b) above have been provided. Additional wind generation assumed to be at Musselroe and total wind generation output is increased from 138 MW to 160 MW. System details for this case are given in Table 4.

Case Number	10
Load (including GUNNS) – MW	903.4
Inertia – Mwsec	4430
Basslink Import (sending end) – MW	440.0
Generation	
Total	504.7
Hydro (JB, TU, CL, MB, GO, TR, PO)	209.7
Thermal (CCGT)	135.0
Wind (SB, BP)	160.0
Largest generating unit Scheduled – MW (CCGT)	135.0
Reserve Required for largest unit tripping - MW	110.6
Estimated FCAS 6s Raise	
Total (Hydro + Thermal)	132.8
Hydro	82.2
Thermal	50.6
Basslink	55.0
Fault Level (GT converter) – MVA	
Note: • Risdon Cap Bank switched in • Burnie cap bank switched in • Farrell 220/110 kV transformer set to voltage control to improve voltage in West Coast	

Table 4: System Details for Case 10

Results of studies with wind farm tripping and Basslink trip with FCSPS failing to operate are shown in Table 5 and Figure 4. Wind farms are assumed to trip 1 sec after the Basslink trip

case	Min. Freq		Max. Freq		Load she		MW				Inc. in Basslin
#	Hz	Time- s	Hz	Time-se	MW	Item	Hydro	Thermal	wind	Total	MW
10	46.98	1.34	50.11	8.78	533.1	Increase- Pmech at min Freq	19.0	39.3	0.0	58.3	0.0
						Increase - Pmech at 6sec	91.9	55.0	0.0	147.0	0.0
						FCAS at 6sec	115.4	90.4	0.0	205.8	

Table 5: Minimum Frequency and FCAS for Basslink trip with FCSPS failing to operate and wind farm trip – Case 10

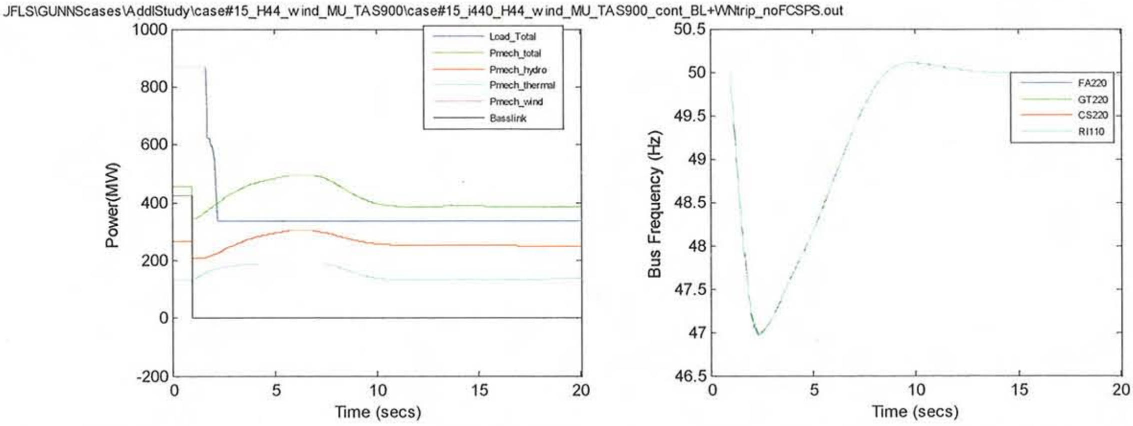


Figure 4: Frequency and Pmech for Basslink trip with FCSPS failing to operate and wind farm trip – Case 10

Observations from studies are:

- Minimum frequency reached is 47 Hz at 1.34 seconds after tripping of Basslink
- All 7 blocks of load are shed by UFLSS: total load shed is 533 MW.
- Total loss of generation is 585 MW (63% of generation.
- Initial rate of change of frequency is very high (2.9 Hz/sec) because of the very high loss of generation. As a consequence UFLSS operates well before any FCAS is available to reduce amount of load shed.
- Frequency recovers after load shedding: maximum frequency reached is 50.1 Hz.
- System remains stable after load is shed
- Load available under UFLSS is adequate to cover loss of 63% of generation at light load

1(d) Management of Load Events

NEMMCO advised that fast lower service procurement has proved to be difficult to procure in Tasmania, and that satisfactory operation to the new frequency standard will only be possible if there is an increased supply of such services.

Alinta has confirmed that it intends to offer lower FCAS services when dispatched.

NEMMCO also noted that operating to new standard when the Alinta or Gunns plant is out of service will make this situation worse.

Alinta generation is base-loaded and its unavailability will be very low, due only to forced outage or maintenance periods expected to be 3 weeks in a year. Alinta's view is that coincident outage of the Alinta and Gunns plants is likely to be rare.

1(e) Management of Over Frequency due to Multiple Contingency Events

The first issue raised here is whether Alinta plans to offer its plant for inclusion on OFGSS scheme.

Alinta confirms that it offers and expects its plant to be included in the OFGSS scheme. Alinta expects that the significant FCAS (L6) capability provided will permit an OFGSS trip to be delayed enough to allow FCAS to operate. Alinta expects that only if frequency were to reach 52 Hz would the CCGT be tripped.

The CCGT protection over-frequency trip will be initiated within 10 ms of reaching 52 Hz, and the generator circuit breaker will open within 100 ms. No additional time delay is offered at this time.

2 FURTHER WORK

2(a) Ability to Procure Required FCAS

Alinta has commissioned detailed market simulation studies to forecast FCAS requirements. This report will be forwarded under separate cover.

2(b) Discrimination between FCSPS and UFLSS

Studies carried out to date on all scenarios, including those identified in the NEMMCO document, indicate that there are no issues with FCSPS and UFLSS discrimination. The studies shows that, even under extreme low load conditions and lower inertia that that identified by NEMMCO, appropriate discrimination is achieved.

2(c) Generator Performance Standards

Alinta confirms that the CCGT will ride through frequency change of -2.8 Hz/sec identified in the analysis as theoretically possible for a multiple contingency event on a lightly loaded system (900 MW) with low inertia (4100 MWsec).

Alinta confirms that there is no known reason for the plant to trip for this rate of change of frequency reduction, and protection trips are not provided to deliberately trip the plant in such a circumstance.

Summary

Alinta has conducted additional studies to simulate the assumptions, conditions and scenarios nominated by NEMMCO. The study results do not indicate any technical issues which invalidate operation of the proposed plant in conformance with the proposed standard.

Please contact Allan Coleman or Les Green if you have any queries on these matters.

Yours Sincerely

Allan Coleman
Project Director
Tamar Valley Power Station Project

cc Mr Michael Lyons
NEMMCO

29 July 2008

Alinta
Alinta Energy (Tamar Valley) Pty Ltd
ABN 29 123 391 613
Alinta Plaza
12 - 14 The Esplanade
Perth WA 6000
GPO Box W2030
Perth WA 6846
Telephone +61 8 6213 7000
Facsimile +61 8 6213 7092
www.alinta.net.au

Mr Ian Woodward
Chairman, Reliability Panel
Australian Energy Market Commission
Level 5, 201 Elizabeth Street
Sydney NSW 2000

Dear Mr Woodward

Review of Frequency Operating Standards for Tasmania
Summary of Technical and Market Simulation Studies

Alinta Energy (Tamar Valley) Pty Ltd (Alinta) has provided its response to technical issues as part of this review process in our Initial Submission letter dated 24 April 2008, with the Frequency Standard Development Report enclosed, and in our response dated 24 July 2008 to additional issues raised by NEMMCO. We believe that all technical issues have been satisfactorily addressed.

This submission provides an overview of the results of market simulation studies conducted by ROAM Consulting. Alinta will submit the full ROAM report and presentation slides later today for the panel deliberations on Wednesday. References are also made to the related technical studies.

1 Background

Alinta seeks to connect a 210 MW combined cycle gas turbine (CCGT) generating unit into the Tasmanian electricity network. AEMC has identified that the current Frequency Operating Standard (FOS) for Tasmania is derogation on the NER (mainland) standard and is a barrier to entry for gas turbine or steam turbine technology in Tasmania. NEMMCO and AEMC acknowledged this limitation in establishing the current Tasmanian FOS in 2005 to facilitate the connection of Basslink. AEMC has directed this formal review of the Tasmanian FOS after appropriate system operating experience with Basslink.

In formulating its response to these technical and market issues, Alinta has been guided by NER Clause 3.1.4 Market Design Principles which is "intended to give effect to the following market design principles:

(1) minimisation of NEMMCO decision-making to allow Market Participants the greatest amount of commercial freedom to decide how they will operate in the market;

(2) maximum level of market transparency in the interests of achieving a very high degree of market efficiency;

(3) avoidance of any special treatment in respect of different technologies used by Market Participants;"

2 Derogated FOS for Tasmania

The existing Tasmanian FOS derogation allows:

☐ the frequency excursion for multiple generation contingencies to fall to 46.0 Hz compared to the NER standard of 47.0 Hz; and

☐ the frequency excursion for single contingencies to fall to 47.5 Hz compared to the NER standard of 49.0 Hz.

The existing Tasmanian FOS blocks entry of the CCGT technology which has dominated new plant developments in the remainder of the NEM.

Alinta has proposed tightening of the FOS to more closely match the NER standard to permit connection of larger and more efficient CCGT generation technology without resort to further derogations on a unit-by-unit basis.

3 Impact of Proposed Changes to Tasmanian FOS

Extensive market modelling by ROAM Consulting demonstrates that the current Tasmanian FOS unnecessarily limits the generation technologies that can be connected to the Tasmanian system without derogation. The modelling clearly shows that the market is not disadvantaged by altering the FOS to allow connection of CCGT plants up to 160 MW, compared with current largest unit of 144 MW in Tasmania. Narrowing of the frequency range to that proposed does not limit effective operation of larger units.

It is acknowledged that the appropriate FOS changes will require modification and further coordination of existing controls schemes such as FCSPS, UFLSS and OFGSS to ensure that load shedding does not occur for a single generator or network event. Detailed technical studies have demonstrated that it is feasible to redesign the existing control schemes to implement the proposed FOS and enhance the NEM security objective. Alinta has committed to incorporation of the CCGT in these schemes.

4 Increasing the Size of the Largest Tasmanian Unit

The ROAM modelling has identified that if the machine size is above 160 MW the cost of FCAS and the limitations on Basslink flow would need to be managed to ensure efficient market outcomes. Operating commitments would be required of proponents of generation larger than 160 MW. These arrangements could be similar to the commercial commitments given by Basslink to protect the Tasmanian market from Basslink's market power and could be incorporated into an MNSPS.

Alinta is willing to consider such arrangements for the CCGT plant.

As more CCGT units are introduced into Tasmania the greater will be the competition benefits, the lower the probability of FCAS cost increases, the more the flexibility for management of water resources in Tasmania, the greater the protection for Tasmania from cost impacts of ETS on Victorian-based energy prices, and the greater the options for both energy and FCAS services.

Alinta proposes to connect a single CCGT with an output of 210 MW early in 2009 and Gunns has proposed a plant with similar generation technology. These connections cannot be made under the existing FOS.

5 Conclusion

The ROAM consulting modelling demonstrates the beneficial impact of changing the Tasmanian FOS to closely match the NER standard.

The Hill Michael modelling shows that it is technically sound to move to the proposed FOS to allow CCGT connection.

Alinta's submission to the Reliability Panel details that the objectives of the National Electricity Law are enhanced by moving to the proposed FOS, and that the proposed FOS would permit expansion and improved performance using generation developed in accordance with international practice.

Alinta acknowledges that there are potential negative impacts from larger generating units, but that this is a separate issue to the FOS change and can in any case be managed to protect the market. The principle of such commercial arrangements is demonstrated in the existing arrangements to manage the negative impacts of Basslink's market power.

Please contact Allan Coleman or Les Green if you have any queries on these matters.

Yours sincerely

Allan Coleman
Project Director
Tamar Valley Power Station Project

ALINTA ENERGY (TAMAR VALLEY) PTY LTD (AETV)

AETV PRESENTATION TO THE RELIABILITY PANEL

Paul Simshauser (BB Power)
Simon Himson (AETV)
John O'Brien (Hill Michael)
Chandra Kumble (Hill Michael)
Ian Rose (ROAM Consulting)
Ben Vanderwaal (ROAM Consulting)
30 July 2008

Reliability Panel Presentation

Context

- 2005 – Tasmania joins the NEM
- FOS standard established in accordance with historic Tasmanian standards as derogation to NER
- AEMC and NEMMCO acknowledged that Tasmanian FOS standard is barrier to entry for thermal and CCGT units
- AEMC requested review after experience with Basslink

Reliability Panel Presentation

Context

- AETV is committed to build a 210 MW CCGT plant with the expectation of operating in the NEM in 2009
- AETV cannot register plant for operation in Tasmania (Although it could be registered on mainland as it fully complies with mainland standard)
- AETV supports altering the Tasmanian FOS to align more closely with NER – allow connection of industrial thermal units
- FCAS total costs are typically less than 1% of total NEM market costs (~2% in Tasmania)

Reliability Panel Presentation
Standard Change Impacts

- Industrial thermal units will be able to connect
- Connection for units larger than current 144MW (AETV 210 MW) will be sought
- More competition in energy and Frequency Controlled Ancillary Services (FCAS) market
- Greater flexibility in water management for Hydro
- Greater capacity to compete with Victoria in Emission Trading Scheme (ETS) in future

Reliability Panel Presentation

Technical Issues of FOS change

- All Issues are resolvable as demonstrated in the Frequency Standard Development Final Report prepared by Transend and Hill Michael and additional modelling requested by NEMMCO

Reliability Panel Presentation

Technical Issues with Larger Machine Size

- The impact on Tasmanian frequency if the AETV CCGT trips
- The impact on Tasmanian frequency with the AETV CCGT in service if any other generator in Tasmania trips or Basslink trips
- Reserve requirements - Increased Reserve requirement due to larger machine

Reliability Panel Presentation

Analysis

- Technical analysis to identify if it is feasible to coordinate all control schemes to allow NEMMCO maintain system security
- Market impact of increased unit size for Tasmania
    - Energy price impact
    - Reserve price impact
- Basslink flows and settlements
- Economic implications

Reliability Panel Presentation

Technical Analysis

- Extreme contingency scenarios identified by NEMMCO have been modelled and they show discrimination can be maintained between FCSPS & UFLSS schemes
- UFLSS could be accommodated within the proposed compressed frequency band
- No other technical issues identified
- Standard is technically feasible and present level of system security could be maintained

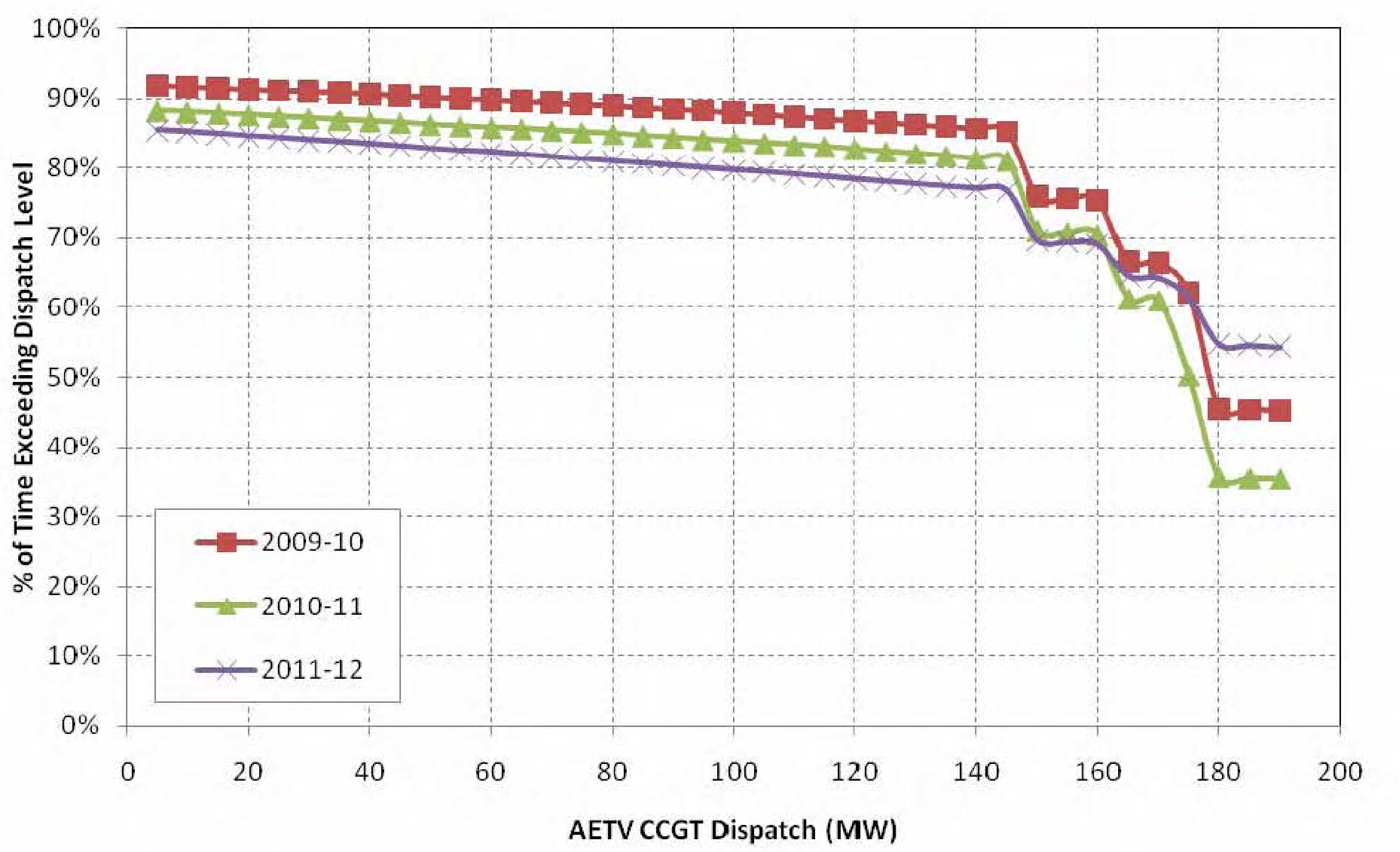
Reliability Panel Presentation

Market Analysis of Standard Change

- Co-optimised market impact of increased unit size
- Projected requirement without standard change (No new entry base loaded generation in Tasmania)
  - Energy Price
  - Reserve Quantity
  - Reserve Price
- Projected requirements with Standard change (New entry CCGT & Gunns)
  - Energy Price
  - Reserve Quantity
  - Reserve Price

Reliability Panel Presentation

Market Impact of Increased Unit Size

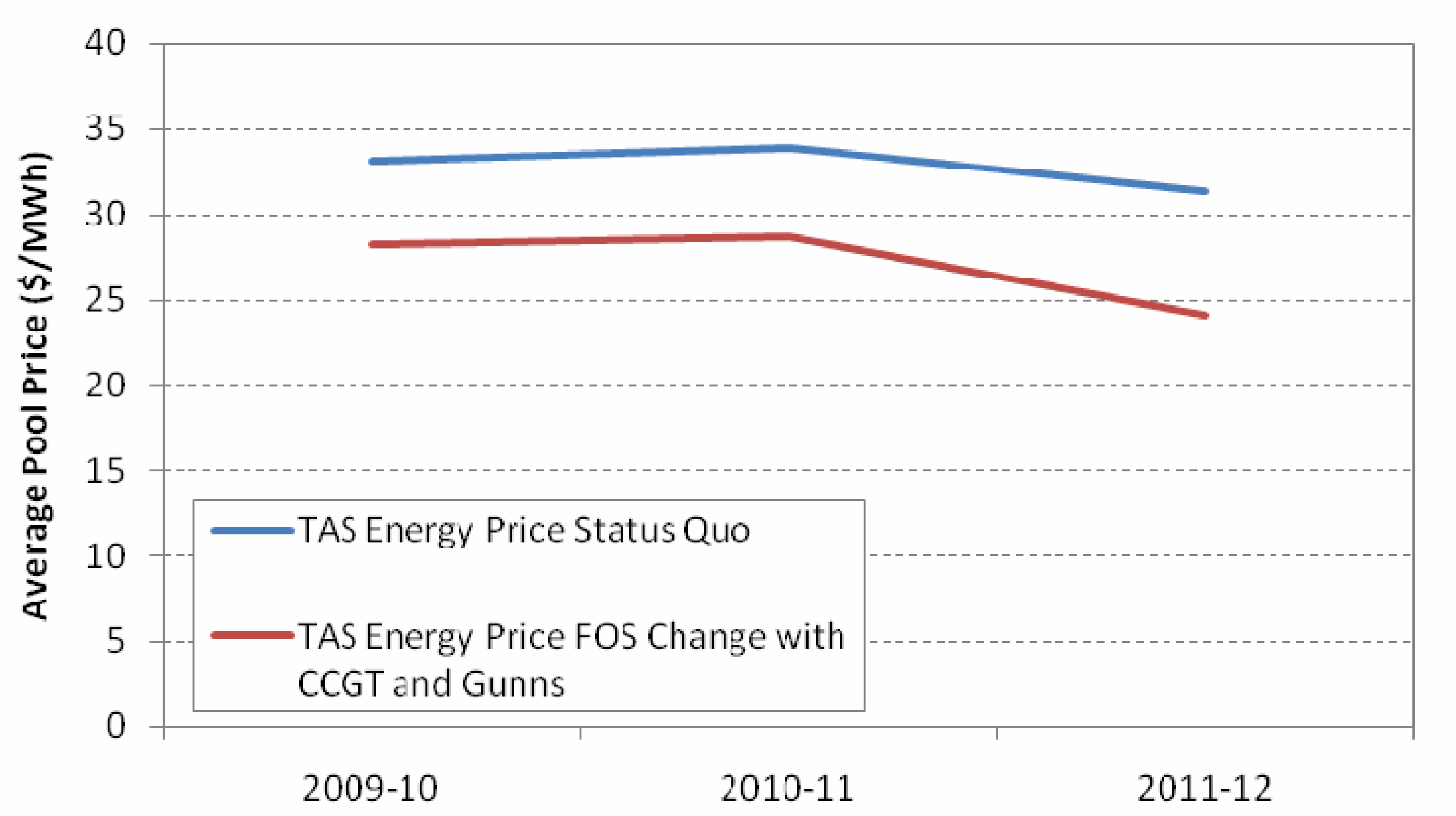


The modelling indicates:

1. 160MW could occur for up to 70% of time
2. 180MW or higher could occur 35-55% of time
3. Additional thermal plant in 2011 significantly increases dispatch

Reliability Panel Presentation

Energy Pool Price Projection

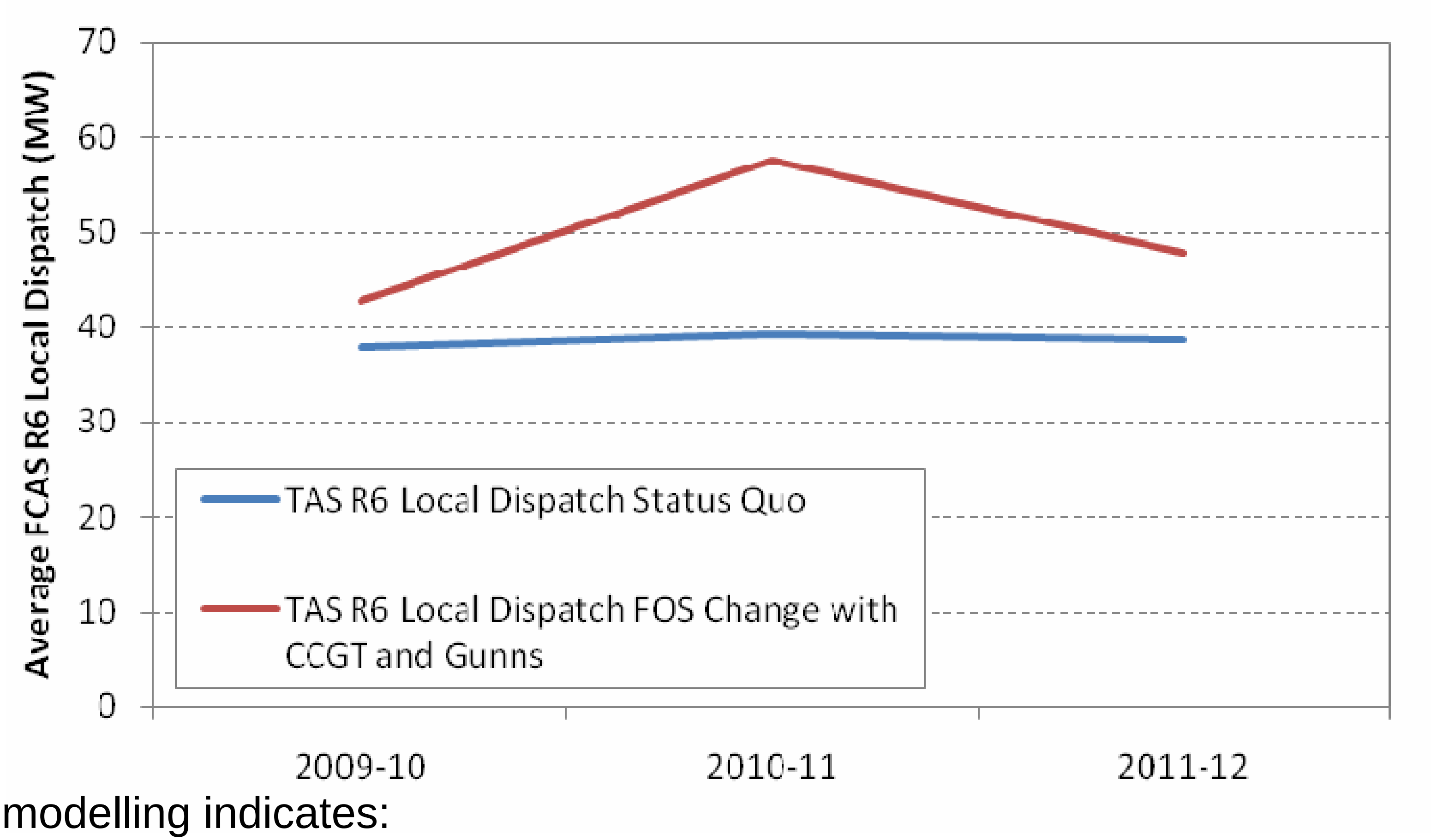


The modelling indicates:

1. The Tasmania annual average energy price with new base load generation decreases by 15%
2. Further reduction in 2011 due to new entry of additional thermal plant

Reliability Panel Presentation

FCAS R6 Local Dispatch Projection

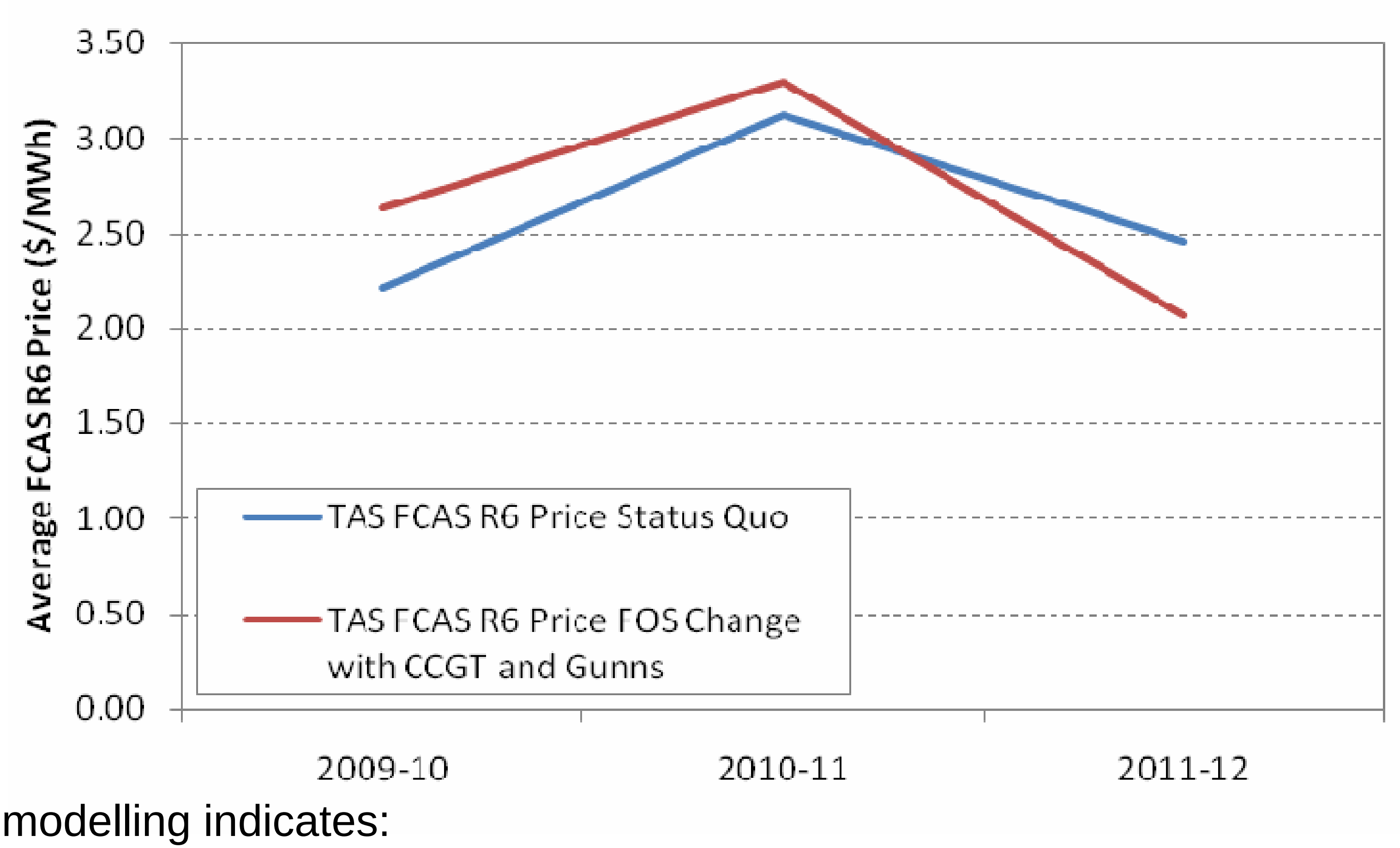


The modelling indicates:

1. FCAS local requirement is higher due to FOS change; however
2. Local FCAS supplies will increase substantially following subsequent new entry of thermal plant in Tasmania

Reliability Panel Presentation

FCAS R6 Price Projection



The modelling indicates:

1. FCAS prices are marginally higher while only a single large generator in service
2. Once again significant reduction in 2011 due to subsequent new entry

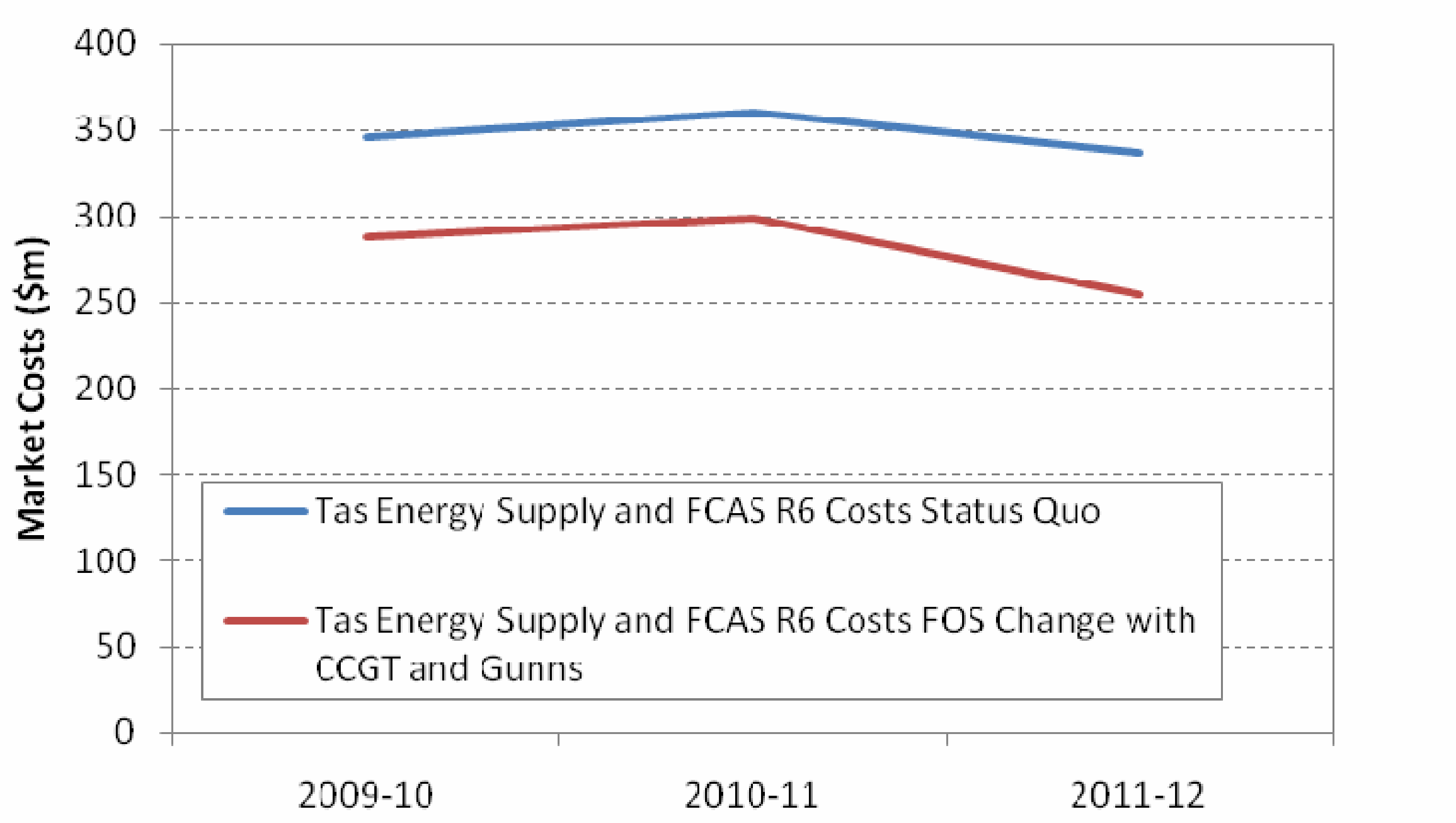
Reliability Panel Presentation

Market Impacts of Standard Change

- Eliminates Barrier to entry for new base load plants
- Larger generator can be optimally dispatched to eliminate issues regarding unit size
- Reduces:
  - Reliance on Basslink import, Tasmania Hydro has more freedom with building up storages
  - Incidence of Basslink importing at the limit reduces from ~15% to ~3% mitigating market power
  - Positive settlement residues across Basslink
- The standard change has positive economic impact compared to do nothing scenario

Reliability Panel Presentation

Energy and FCAS R6 Market Costs



The modelling indicates:

1. FCAS cost plus energy costs in the Tasmania region are reduced
2. FOS change provides a net benefit in terms of total energy supply cost in Tasmania

Reliability Panel Presentation

Summary View

- Do nothing is not an option
- In AETV's view the FOS change:
  - Is essential for entry of all future Baseload Thermal/Gas plants in Tasmania
  - Provides open access to all class of generators as per NEM objective
  - Proposed Standard is technically feasible
  - Proposed standard brings efficiency gains in total energy supply costs
  - Facilitates secure supply to Tasmania:
    - Builds storage levels
    - Covers Basslink cable failure
    - Reduces impact of Emission Trading Scheme (ETS)
    - Provides Market Competition

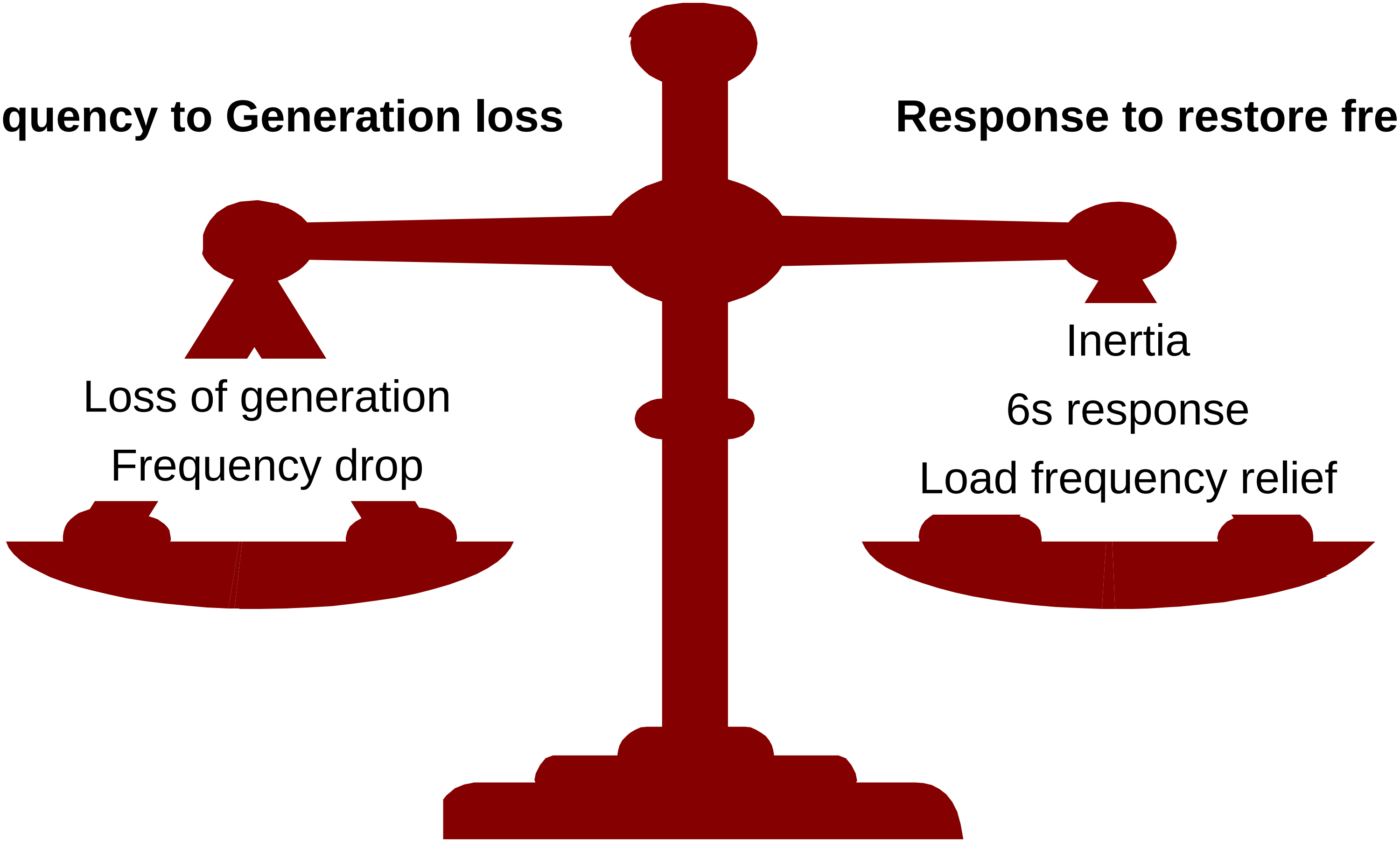
Reliability Panel Presentation

Thermal Plant Consideration

- Existing Bell Bay station effectively a 240MW generating unit – larger than 144MW size currently considered
- Installation is not in compliance with existing Tasmanian FOS
- Long history of operation with existing UFLSS, etc
- Inferior performance under system disturbance conditions than CCGT
- Requires separate consideration for system reliability if continued operation contemplated

Reliability Panel Presentation

FCAS Tasmania-6s Response Issue



Frequency to Generation loss

Loss of generation

Frequency drop

Response to restore frequency

Inertia

6s response

Load frequency relief

Balance avoids load shedding on first contingency

ROAM
CONSULTING
ENERGY MODELLING EXPERTISE

ROAM Consulting Pty Ltd
A.B.N. 54 091 533 621

Report (Hma00017) to

HILL MICHAEL
STRATEGIC ENGINEERING

NATIONAL ELECTRICITY MARKET FORECASTING

Tasmania Frequency Reserve Market Impact Study Stage 1 – Back-Cast Simulation

25 July 2008

VERSION HISTORY

Version History				
Revision	**Date Issued**	**Prepared By**	**Approved By**	**Revision Type**
1.0	2008-07-08	David Yeowart Jason Merefield Ben Vanderwaal	Ben Vanderwaal	Initial draft for discussion
1.1	2008-07-25	David Yeowart	Ben Vanderwaal	Final

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1) BACKGROUND

ROAM Consulting is undertaking modelling studies of the Tasmania electricity network on behalf of Alinta Energy (Tamar Valley) Pty Ltd in relation to the present 'Review of Frequency Operating Standards for Tasmania'. In doing this ROAM is applying the 2-4-C simulation model with the 2007 ANTS Constraint equations for the energy market and FCAS constraints for co-optimised dispatch of the energy and ancillary services market.

To provide confidence in the model ROAM is undertaking a back-casting exercise to verify and calibrate the 2-4-C dispatch model and constraint equations set. In order to provide a high quality back-cast ROAM has completed a 5-minute dispatch back-cast for the 1-week period 03-12-2007 to 10-12-2007.

2) IMPLEMENTING FCAS CO-OPTIMISATION

To assess the impacts of any proposed frequency standard change, ROAM Consulting has extended the 2-4-C market simulation package to include the dispatch and co-optimisation of frequency control ancillary services (FCAS). This methodology was then verified against history through a 'back-cast', simulating past periods with historical demand and bid offers to compare 2-4-C's results to NEMDE.

Modelling the contingency FCAS markets requires calculating the amount of FCAS required to be enabled to cover a 'credible single contingency' (typically loss of the largest generation unit or load). This calculation is of the form:

Contingency requirement = largest single load/generation unit at risk – load relief

Regulation FCAS is not related to any specific contingency and is calculated differently.

2.1) LOAD RELIEF

Load relief represents the response of an AC system to a change in system frequency. Many devices are sensitive to power system frequency and their power consumption is proportional to it. For example, the rotational speed of a synchronous motor is linked to system frequency; a synchronous motor will slow down when system frequency falls and thus consume less power. The opposite is also true, when the system frequency rises synchronous motors will speed up and consume more power.

This effect will always oppose any change in system conditions, reducing FCAS requirements. Load relief is represented as a percentage change in load per percentage change in frequency ratio. It has been determined to be approximately 1.5% for mainland regions, and 1.0% for Tasmania[1].

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[1] As determined by NEMMCO, 'Operating procedure: Frequency control ancillary services'

The reduction in FCAS requirements due to load relief is defined as the allowable change in frequency due to the disturbance * the load relief factor * the present load.

For example, the mainland frequency standard states that the allowable frequency band for six seconds after the loss of the largest generator is 49.5-50.5Hz. The load relief for a frequency drop then becomes, 1%[2] * 1.5% * the current mainland load.

Load relief varies with respect to both the timeframe of the FCAS service considered and the type of contingency event, but will always reduce the FCAS service requirement.

2.2) FCAS BID OFFERS

FCAS bid offers are similar to energy bid offers in that they consist of 10 price/quantity pairs and a maximum quantity available that define a generator's willingness to provide a service. FCAS bid offers also include an 'FCAS trapezoid' that defines the generator's capabilities to provide FCAS based on their energy dispatch.

An FCAS trapezoid features five points that define the relationship between energy dispatch and available FCAS:

1. Enablement low, which defines the lowest energy dispatch at which an FCAS service may be provided;
2. Low breakpoint, which defines the lowest energy dispatch at which the maximum quantity of FCAS bid may be provided;
3. High breakpoint, which defines the highest energy dispatch at which the maximum quantity of FCAS bid may be provided; and
4. Enablement high, which defines the maximum energy dispatch at which an FCAS service may be provided.
5. Maximum available, which defines the maximum FCAS dispatch between the low and high breakpoints.

The FCAS trapezoid is pictured in graphical form in Figure 2.1 below.

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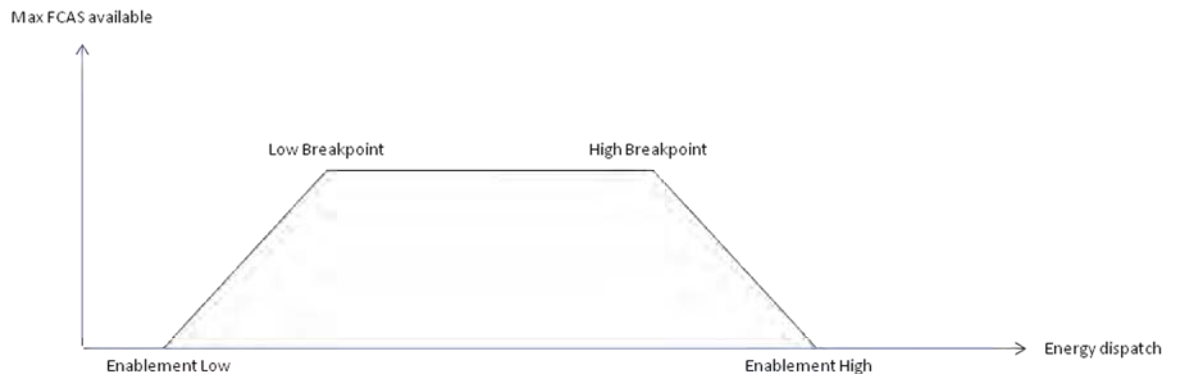
[2] 1% is the percentage change in frequency, (0.5/50).

Figure 2.1 – FCAS Trapezoid



FCAS trapezoids link FCAS and energy offers through the design and implementation of the NEMDE linear program formulation. The formulation shares common elements in the parallel energy and FCAS markets (such as generation units) and is referred to as co-optimisation.

2.2.1) Modelling FCAS Trapezoids

FCAS trapezoids are nonlinear, and cannot be directly implemented in a linear programming optimisation. 2-4-C determines whether a generator is enabled to provide FCAS based on the outcome of the previous dispatch period.

A linear model approximating the FCAS trapezoids has been developed that is equivalent within the range of enablement low to enablement high. Outside these limits, the model is not valid and leads to distorted outcomes, thus a methodology to address this is required. ROAM's solution is that if a unit was within its enablement limits in the previous period and has a nonzero maximum FCAS availability, its energy target is restricted to be within the enablement limits in the current dispatch interval, the FCAS trapezoid model is applied for that unit and the unit may provide FCAS. If a unit does not meet these conditions, its output is not restricted to the enablement range and it is not eligible to provide the FCAS service in question.

This can lead to suboptimal outcomes as units enabled for FCAS can only be dispatched within their trapezoid in the energy market regardless of the FCAS market outcomes (NEMMCO refers to this outcome as being 'trapped' by the FCAS bid). ROAM understands however, that NEMDE has similar limitations and this difficulty is not avoidable in a linear program.

As units enabled for FCAS service provision can be 'trapped' between their enablement limits in the energy market, a mechanism is needed to allow units to 'escape', otherwise units will always be constrained on to at least their enablement low. ROAM allows units to escape their trapezoid by only enabling a unit for an FCAS market if the previous energy target was *above* the enablement low (if the enablement low is nonzero). NEMMCO requires participants to rebid to escape trapezoids. ROAM believes the approach chosen is consistent with NEMDE, and observes that NEMDE is documented to share many of the same limitations.

2.3) BASSLINK

Each interconnector in the NEM has a nominated flow direction convention. The convention is generally for positive flow values to be towards the north and west. Basslink operates typically between approximately 600MW towards the mainland and 480MW towards Tasmania. Its operating range as defined by NEMMCO is -478MW to 594MW.

Basslink has several unique properties that make it pivotal in both the mainland and Tasmania NEM FCAS markets. Although a DC link and therefore asynchronous, Basslink has the capability to rapidly vary its power transfer in response to changes in frequency. This allows limited transfer of FCAS between the mainland and Tasmania, restricted by the ‘headroom’ remaining on Basslink.

2.3.1) Headroom

AC interconnector transfer capacity in NEMDE is primarily limited by ‘N-1’ contingency requirements (the requirement for no network element to exceed a firm limit after any single credible contingency), and thus they are rarely operated to their physical limits. In practice this means that they may be treated as able to transfer FCAS without limitation.

Basslink, due to being both a controllable network element and the unique arrangements for loss of link (FCSPS, NCSPS) is able to be dispatched at close to the firm capacity of the link in the energy market. This leads to a limit on the amount of FCAS that may be transferred across Basslink. The minimum power transfer characteristic of Basslink also limits FCAS transfer with the mainland NEM regions.

Headroom is the difference between Basslink’s energy dispatch target and the minimum/maximum flows possible. For example, with a dispatch target of 200MW, the headroom available for Tasmania to import raise FCAS is 150MW (current flow – lowest possible flow [50MW in exporting zone]).

The need to maintain headroom to permit FCAS transfer can ‘trap’ Basslink in periods of FCAS scarcity into a specific flow direction, which may result in counter-price flows in the energy market.

2.3.2) FCSPS

Due to the magnitude of Basslink transfers in relation to the size of the Tasmanian AC system, a dedicated protection scheme was required to avoid requiring operation of the Tasmanian load shedding schemes on loss of link. The frequency control system protection scheme (FCSPS) involves contracted loads and generation armed for immediate tripping in response to a loss of Basslink. FCSPS is designed to limit the contingency FCAS requirement to avoid placing unrealistic demands on the Tasmanian system following the tripping of Basslink.

When inadequate load or generation is armed for FCSPS action to maintain full dispatch, Basslink energy transfer is restricted to limit the ‘effective’ contingency.

2.3.3) Deadzone

Due to technical characteristics of materials used in its design, Basslink has a minimum sustainable transfer level of approximately 50MW. NEMMCO models this by dividing Basslink flow into three operating 'zones' (as observed 'in Tasmania') as follows:

1. The importing zone is Basslink flow < -50, in this zone the link may be dispatched to any point <= -50.
2. The exporting zone is Basslink flow > 50, in this zone the link may be dispatched to any point >= 50.
3. The 'deadzone' is -50 <= Basslink flow <= 50, in this zone Basslink may be dispatched at any point >= -125 and <= 125. FCAS transfer capability is not available in the dead zone.

During transitions between zones, Basslink becomes unavailable for FCAS transfer. This is consistent with the Basslink model used in NEMDE, as summarised in Table 2.1 below.

Table 2.1 – Basslink Operating Zones

Initial Flow	Valid Targets	FCAS transfer available?
Basslink < -50MW	<= -50MW	Yes
Basslink > 50MW	>= 50MW	Yes
-50MW <= Basslink <= 50MW	-125MW <= Basslink <= 125MW	No

2.4) REGULATION FCAS

Regulation FCAS is enabled to control variations in frequency resulting from small supply-demand imbalances such as demand forecast errors. As this is not in response to any particular contingency, there is no analytical approach available to calculate the required amount of regulation FCAS and NEMMCO's approach historically has been based on empirical observation.

3) SPECIFIC BACK-CAST CONSIDERATIONS

3.1) INPUT DATA

Historical demand and generation offers for both the energy and FCAS markets are publicly available from NEMMCO for all scheduled market participants on both a half hourly and five minute basis. NEMMCO also provides a set of constraint equations (as part of the ANTS process) intended to provide an accurate representation of the NEM using only 'high level' entities, such as interconnectors and generating units. FCAS requirements are calculated as per information publicly available from NEMMCO[3]. These form the main inputs to a back-cast.

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[3] Basslink Energy and FCAS Equations, NEMMCO 2006

3.2) NETWORK OUTAGE CONDITIONS

The ANTS constraints provide an accurate representation of system normal conditions, however network conditions invariably deviate from this in practice. The back-cast, which applies only system normal constraints, cannot replicate history during periods in which non-system normal constraints have been invoked.

3.3) HISTORIC NON-CONFORMANCE

Similar to network outage conditions, 2-4-C does not model the possibility of non-conformance of dispatch targets. As such, when a generation unit has been non-conforming in history, the back-cast will deviate from historic market outcomes.

3.4) AGGREGATED UNITS

Aggregation of generating units into a single logical unit is common practice in the NEM. Hydro stations in particular, are often aggregated to a single logical unit for NEMDE, and their FCAS offers (including enablement and breakpoints) are provided on this basis.

2-4-C traditionally models all generation units individually, as the ANTS constraints feature many terms which depend on numbers of units online (NEMDE has access to SCADA data to avoid this complication). This raises issues with either disaggregating these offers into a per unit basis, or identifying units online in a number of ANTS constraints.

For the purposes of this back-cast, Tasmanian Hydro units were aggregated as per NEMDE bid offers and Tasmanian regional ANTS constraints were modified to account for this. Mainland FCAS and energy bids were however decomposed into a per physical unit basis to avoid modifying the much larger constraint set.

Where possible, ROAM prefers to disaggregate FCAS bids to avoid altering constraint equations as this approach is highly subjective. Due to the structure of the Tasmanian Hydro FCAS bids and that in practice Basslink is mostly restricted by FCSPS availability and FCAS outcomes rather than the energy constraints identified by the ANTS studies, aggregation and constraint modification was determined to be a closer approximation to NEMDE for the Tasmanian region.

3.5) REGULATION FCAS REQUIREMENTS

NEMMCO's approach to determining regulation FCAS requirements has been revised regularly. For the purposes of the back-cast, regulation FCAS requirements were set in accordance with Appendix D of Frequency & Time Deviation Monitoring in the NEM, January 2008[4]. This is consistent with the regulation FCAS requirements historically applied for the week modelled in this back-cast.

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[4] Frequency & Time Deviation Monitoring in the NEM, January 2008, NEMMCO

Although ROAM understands that NEMMCO have recently trialled and implemented regulation FCAS requirements calculated from observed time error, the back-cast period predates this and applies the fixed time sculpted requirements as documented.

3.6) TASMANIA CONTINGENCY FCAS REQUIREMENTS

The Tasmanian contingency FCAS requirements are not calculated in the same way as the mainland requirements. The Tasmanian contingency requirements are noted by NEMMCO to be calculated to consider system inertia, and are observably different from the basic contingency – load relief calculation in historic market data.

Several assumptions have been made with respect to calculation of Tasmania FCAS requirements to enable the back-cast to be completed, as follows.

3.6.1) FCSPS

The load enabled for FCSPS is not public information and thus the limit imposed on Basslink transfer cannot be accurately determined. For the purposes of the back-cast, ROAM assumes that sufficient load or generation is available and armed for FCSPS action to allow Basslink to be dispatched to approximately 422MW import (the average import limit historically imposed by FCSPS in the back-cast timeframe), and full export. This is known to be inconsistent with history, and as such the back-cast will tend to slightly misstate Tasmanian energy prices.

The alternative is to assume Basslink flow is unrestricted by FCSPS load availability. This approach results in large errors in Tasmanian regulation raise FCAS prices as less Basslink ‘headroom’ is available than was historically, and as such Basslink flow is restricted in the *energy* market to meet the Tasmanian regulation requirement.

3.6.2) Contingency Requirements

NEMMCO has provided the basis on which the Tasmanian contingency FCAS requirements are calculated for the purposes of completing this study and ROAM has adapted this to dynamically calculate the contingency response required for Tasmania in the 2-4-C simulation.

ROAM understands the reason for the differing calculation approach to be that the rate of change of frequency in Tasmania can be rapid enough under low load conditions to breach the frequency standard before the timeframe in which the respective FCAS services are defined to operate in. NEMMCO must assume a certain relationship between the amount of FCAS a unit is enabled for, and the amount of contingency response able to be provided in a shorter timeframe, and adjust the contingency FCAS requirement accordingly. This leads to the non-intuitive outcome that under certain extreme scenarios the amount of enabled contingency FCAS can be significantly more than the contingency itself.

Similarly, Tasmanian generators specify their fast lower capabilities in response to a 1Hz maximum frequency excursion load event, yet the maximum allowable frequency excursion for a network event is 3Hz. NEMMCO has calculated a ‘discount’ factor to be applied to fast lower requirements for network events to account for this difference, which is assessed at .4.

System inertia for the back-cast modelling is calculated through actual machine inertia values provided by HMAC for each generator in the Tasmanian region. These calculations will not align exactly with history due to aggregated units requiring assumptions about how many physical units are online, but are observed to be very good approximations.

4) IDENTIFIED FCAS DOCUMENTATION ERRORS

4.1) FCAS RAMP RATE CONSTRAINTS

A NEMMCO document[5] describing software with regards to FCAS dispatch identifies two enhancements to NEMDE, the first relating to FCAS dispatch and available ramping capacity. As described by the document, ramp rate capacity is in reality shared between energy and regulation FCAS – a dispatch outcome that enables for example, 10MW of regulation raise on a unit already ramping up at the maximum available rate is not physically realizable. The goal of the software changes was to remove this possibility by ensuring that ramp rate capacity was shared between regulation FCAS and the energy market in NEMDE.

This appears to not be applied in practice, as historic market outcomes are not consistent with this principle. Below are several examples obtained from published market dispatch outcomes.

SETTLEMENTDATE	DUID	INITIALMW	TOTALCLEARED	RAMPUPRATE	RAISEREG
2007-12-14 06:20:00	BW01	524.665	520	240	10
2007-12-14 06:25:00	BW01	524.665	540.56	240	10
2007-12-14 21:00:00	BW01	475.59	480	240	9
2007-12-14 21:05:00	BW01	481.732	501.73	240	5.89

Bayswater unit 1 is clearly able to be dispatched to provide regulation FCAS in excess of the ‘spare’ ramping capability, using both initial measurements and the previous dispatch target as the starting point. ROAM’s conclusion is that this change was not applied and that FCAS offers are not limited by ramp rates, but rather the trapezium exclusively.

5) BACK-CAST OUTCOMES

5.1) ENERGY MARKET OUTCOMES

The back-cast is generally very consistent with historical energy price outcomes. The following figures illustrate the performance of the 2-4-C back-cast simulation versus historically observed prices. Notable differences are primarily observed during periods that historically featured significant network outages.

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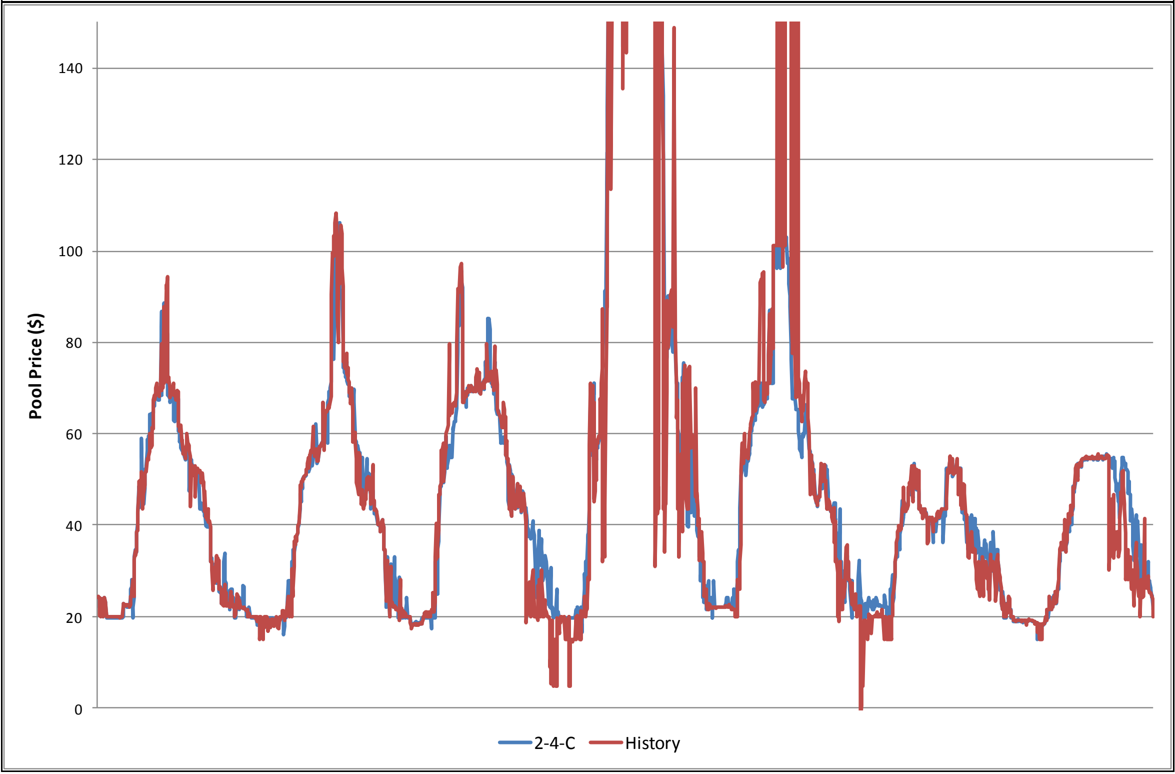
[5] Unit Energy and FCAS Ramping & Capacity Constraints Business Specification, NEMMCO 2005

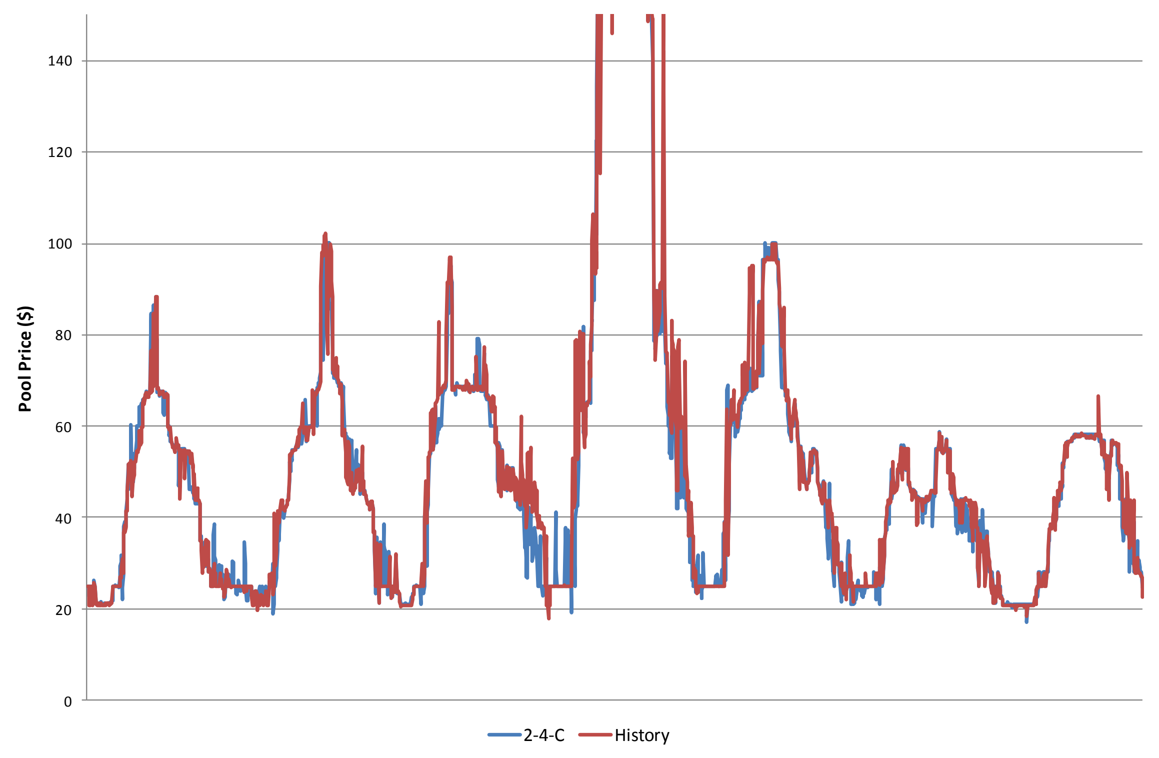
Despite multiple non system normal conditions, the back-cast pool price outcome for Queensland compares extremely well with history, deviating slightly due to partial QNI and Terranora outages not replicated in 2-4-C.

Figure 5.1 – Queensland Energy Price



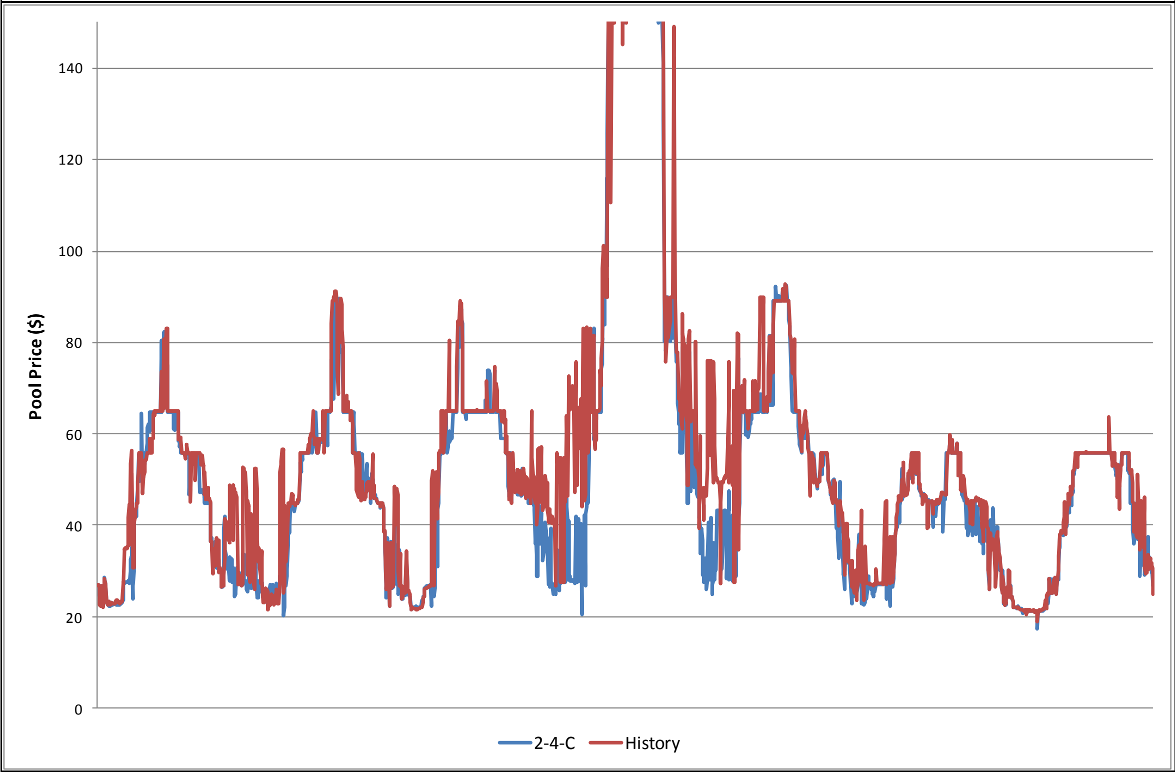
Similar to Queensland, the NSW pool price outcomes compare extremely well with history, only diverging due to network outages.

Figure 5.2 – New South Wales Energy Price



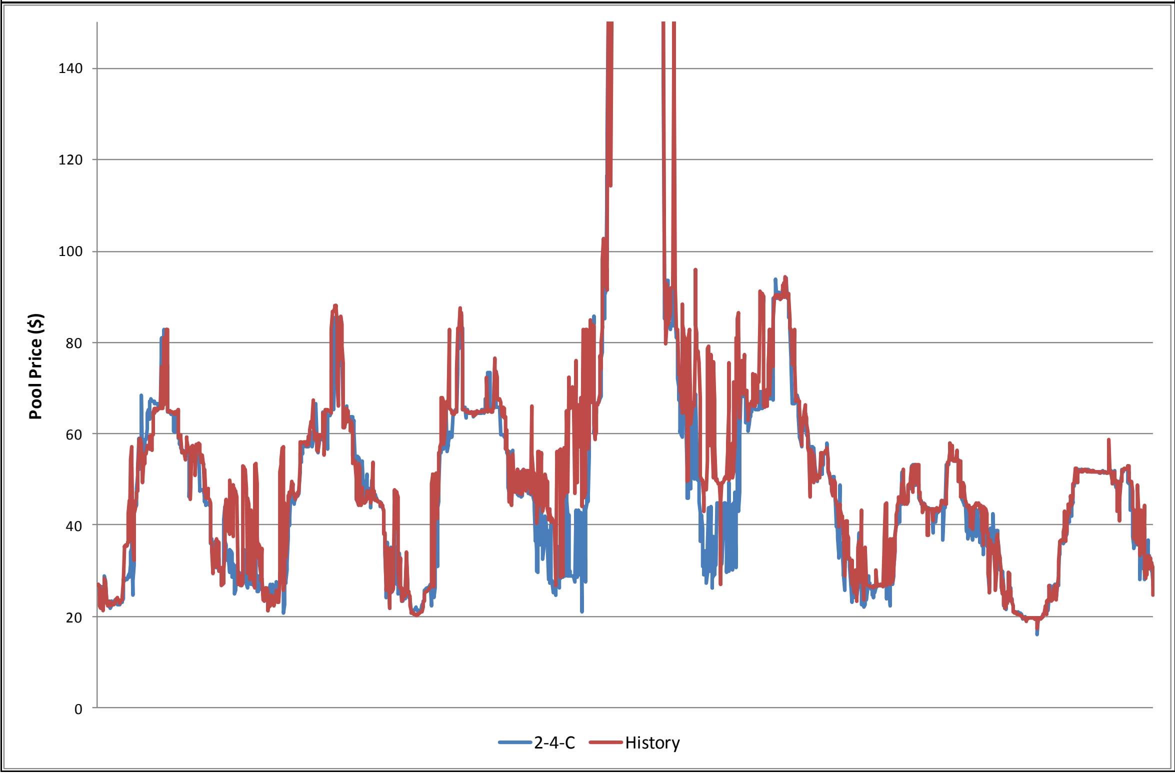
Snowy pool price outcomes are affected by both the NSW->QLD outages and the outage of a Kemp's Creek SVC on the fourth day of the back-cast, and differ significantly during low load periods on this day. ROAM considers this unavoidable due to the nature of the modelling as only system normal conditions are considered. Material differences with multiple key network elements and significant non-conformance are not the focus of this exercise.

Figure 5.3 – Snowy Energy Price



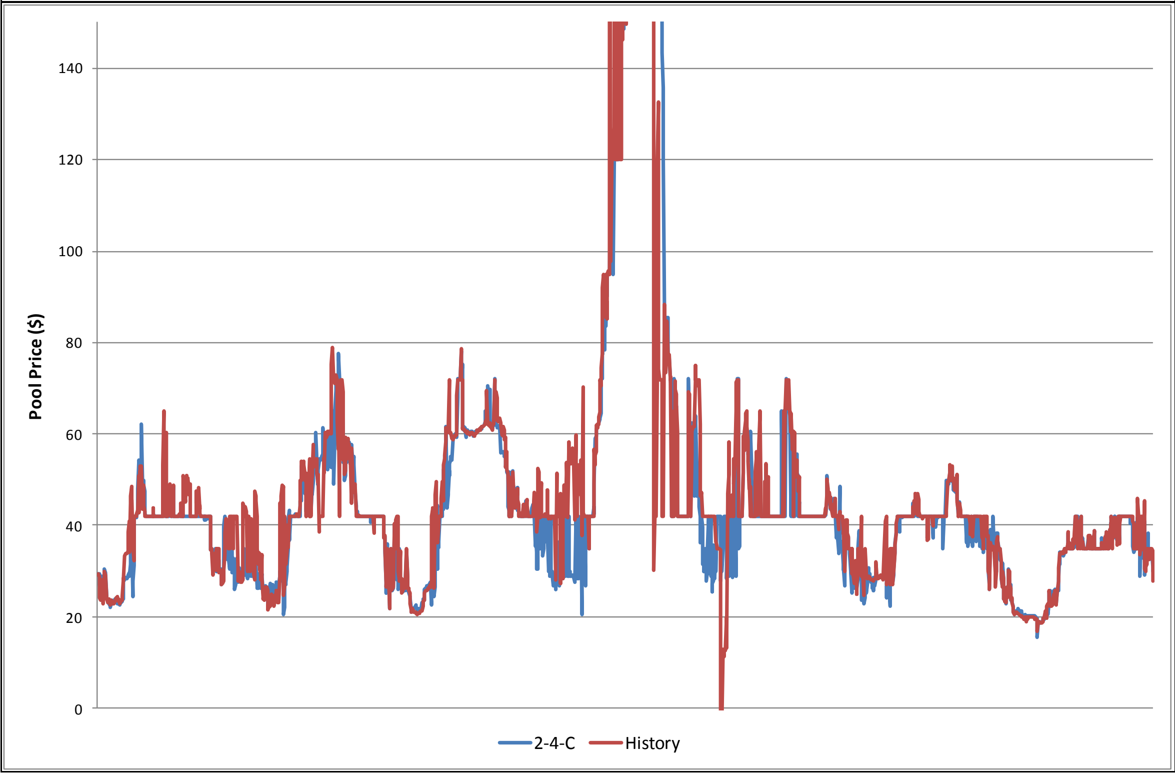
Much the same as Snowy, Victorian pool price outcomes are generally very consistent with history, but differ in the low load periods of the fourth day due to significant network elements being restricted below normal operating limits. Yallourn unit one is also observed to exhibit significant non-conformance throughout the back-cast period.

Figure 5.4 – Victorian Energy Price



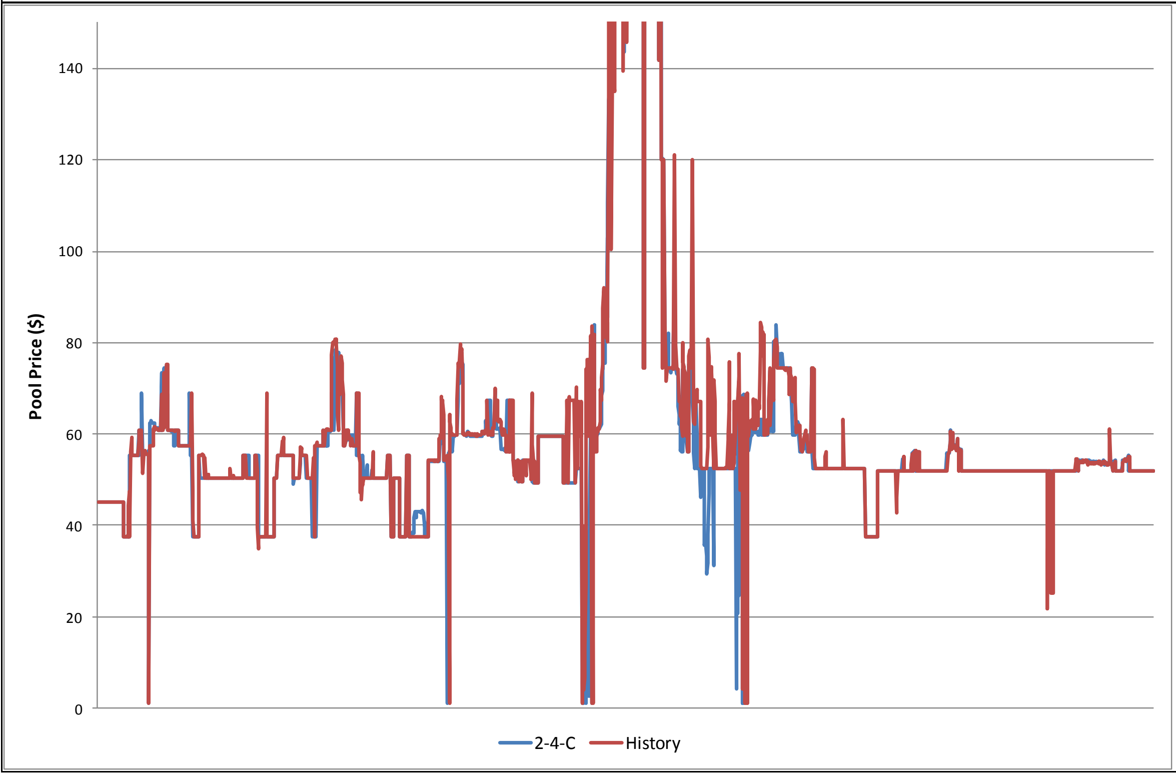
South Australian pool price outcomes compare well with history, but are also affected by a number of outage condition constraints in history which are not replicated in the back-cast.

Figure 5.5 – South Australian Energy Price



Although influenced by the assumptions about FCSPS availability, the Tasmanian energy price correlates very well with history.

Figure 5.6 – Tasmanian Energy Price



5.2) MAINLAND FCAS MARKET OUTCOMES

The accuracy of FCAS market pricing outcomes are limited by several main factors.

System outage conditions have a larger effect on the FCAS pricing outcomes than energy, as they are sensitive to very small changes in system conditions.

Historically, one of the AC lines that make up the QNI interconnector was not available for part of the back-cast. As such, the Queensland region became 'islanded' with respect to the FCAS markets. Mainland thus refers to the mainland regions excluding Queensland, as the back-cast does not replicate this network outage condition.

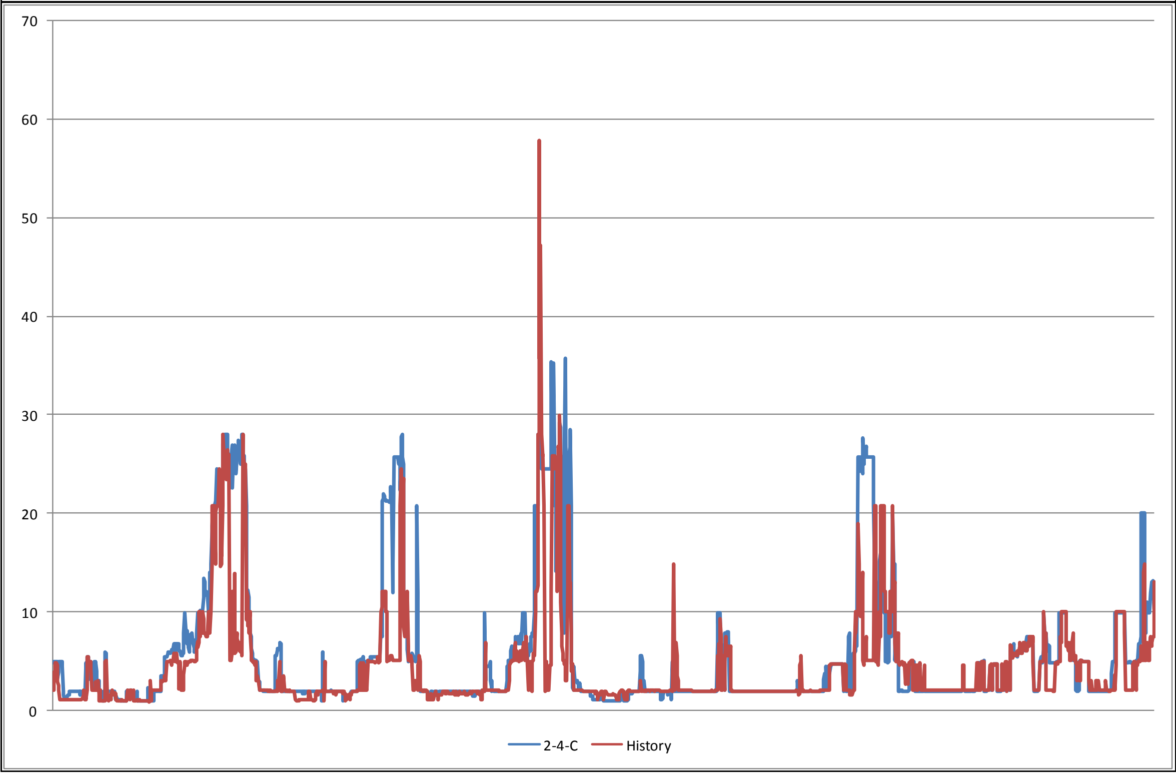
The assumption that there is a static amount of load available for FCSPS action is known to be inconsistent with history, and may affect pricing outcomes.

Basslink flow has a large impact on FCAS prices and is the result of complex interactions between bids and previous system conditions and as such very small energy market outcome differences can compound into significant FCAS price spikes, as Basslink may reverse direction a period too early or too late in the back-cast, relative to history.

Even so, the back-cast is able to consistently replicate historical mainland ancillary services price outcomes. Note that the graphing scale varies significantly between each ancillary service and the energy market outcomes.

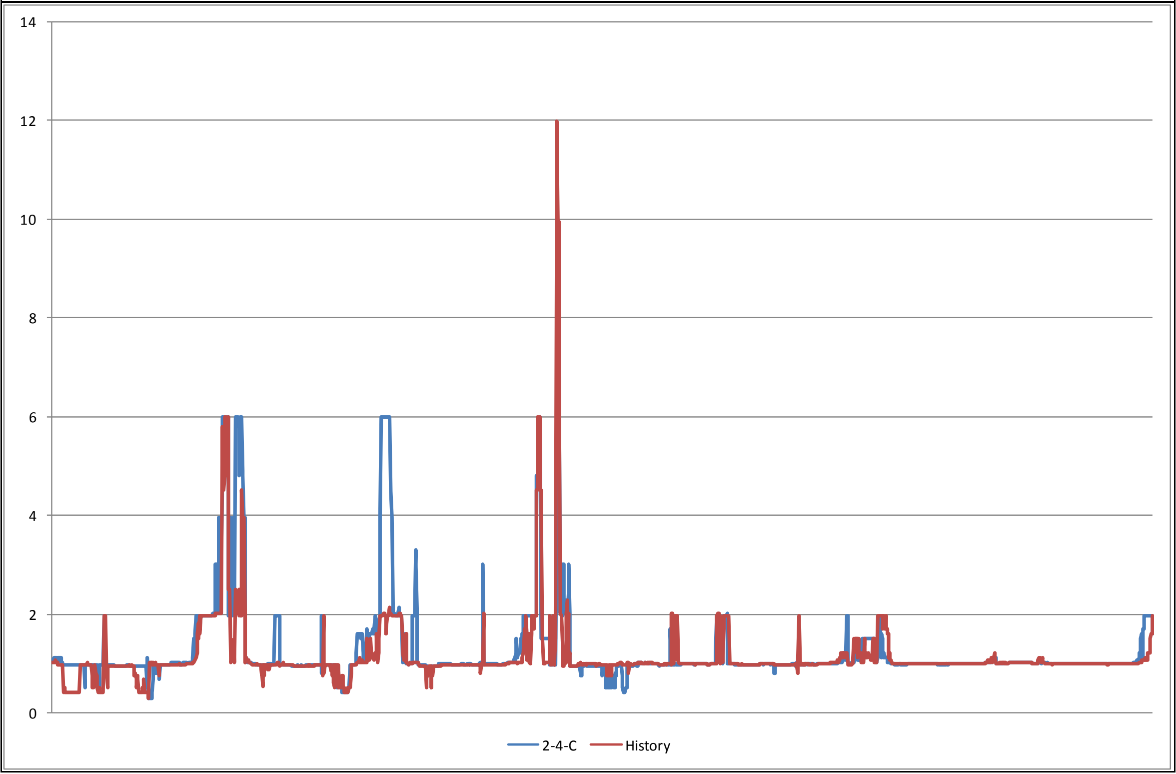
The mainland R6 price tracks well with history – small differences are observable due to network conditions, such as the islanding of Queensland in the FCAS markets.

Figure 5.7 – Mainland R6 FCAS Price



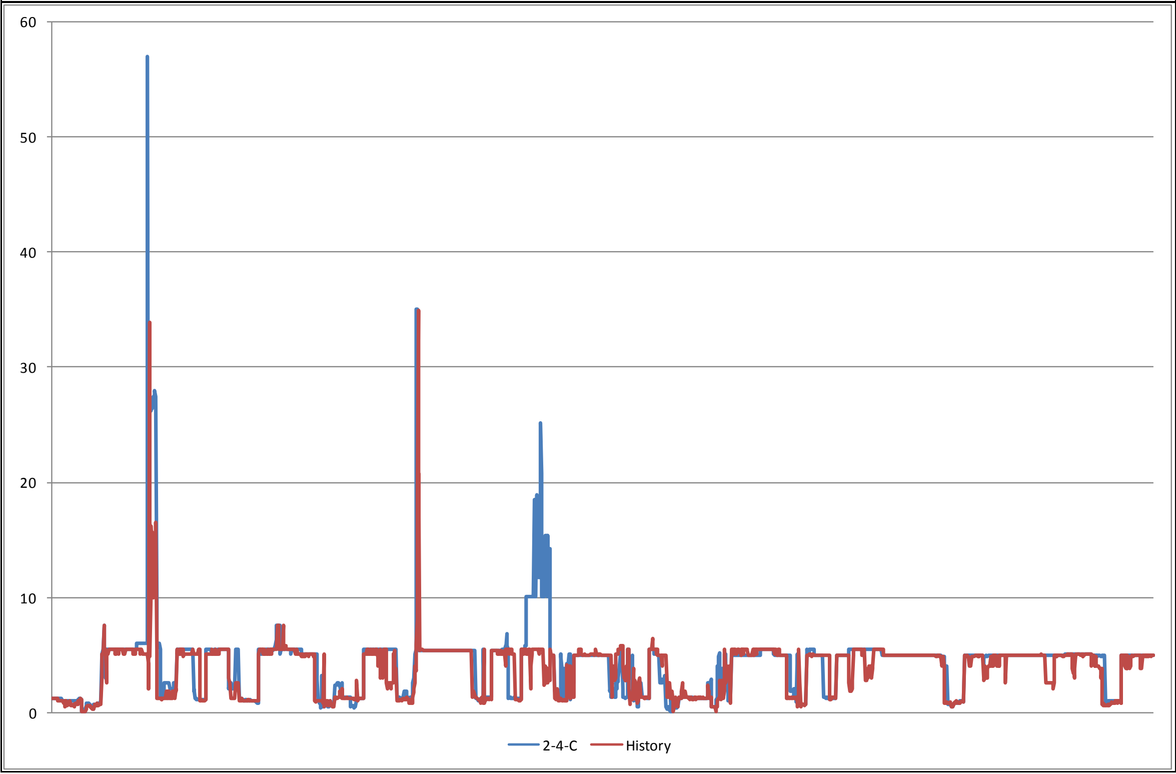
The mainland R60 price is generally very stable, both in history and the back-cast. Again, small differences will be observed due to network outage conditions.

Figure 5.8 – Mainland R60 FCAS Price



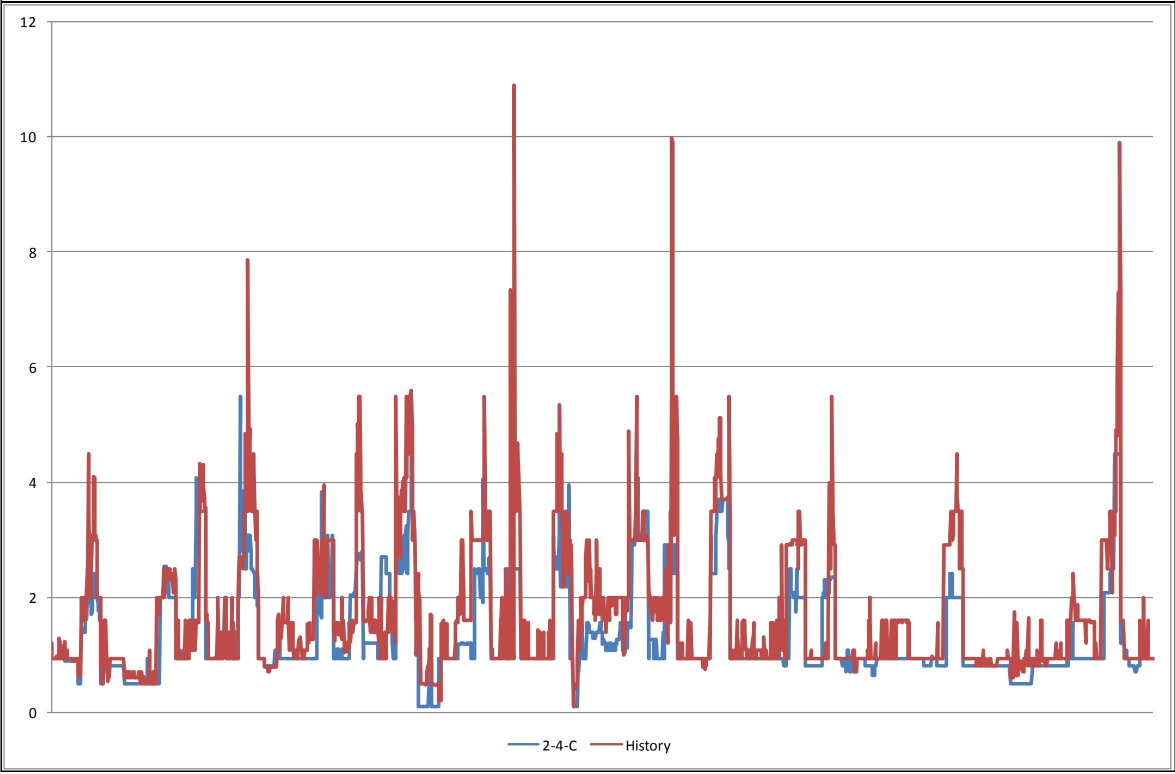
The mainland R5 pricing outcomes are very consistent with history. The difference observed on the third day is the result of network outages.

Figure 5.9 – Mainland R5 FCAS Price



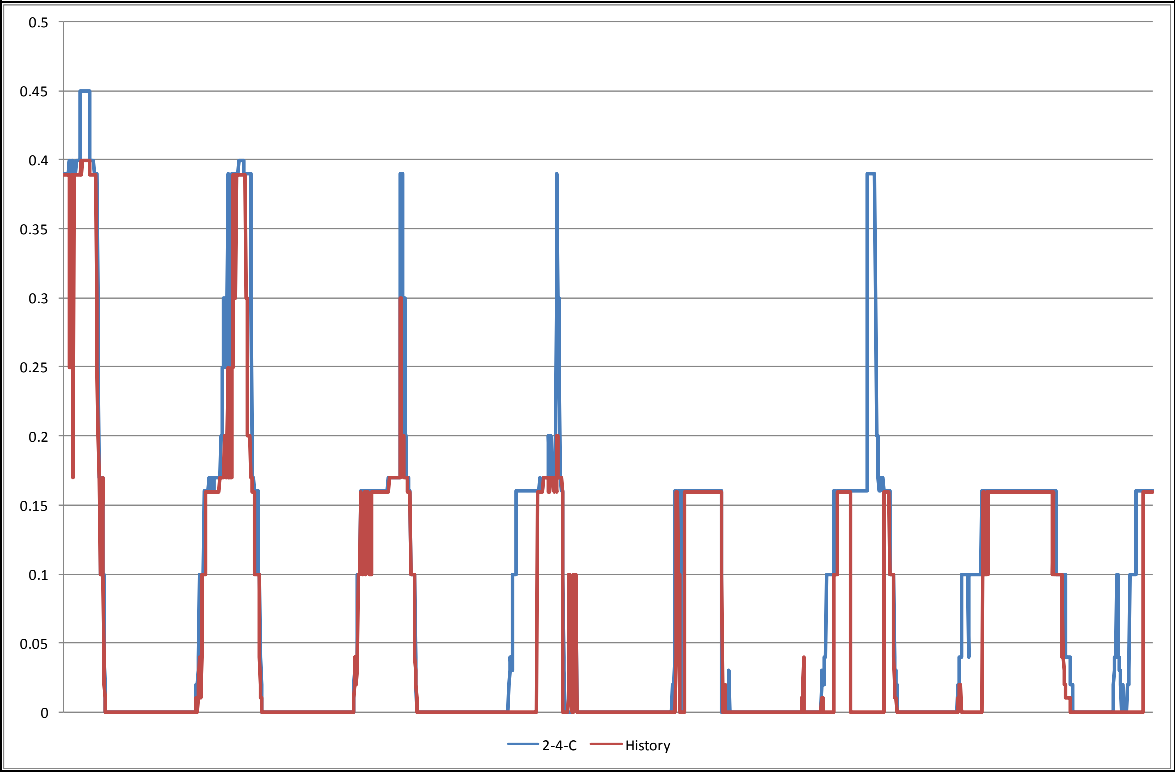
Mainland regulation price outcomes differ somewhat from history due to historical non-conformance and network outage conditions. ROAM considers this unavoidable and the back-cast output is otherwise clearly consistent with history.

Figure 5.10 – Mainland RReg FCAS Price



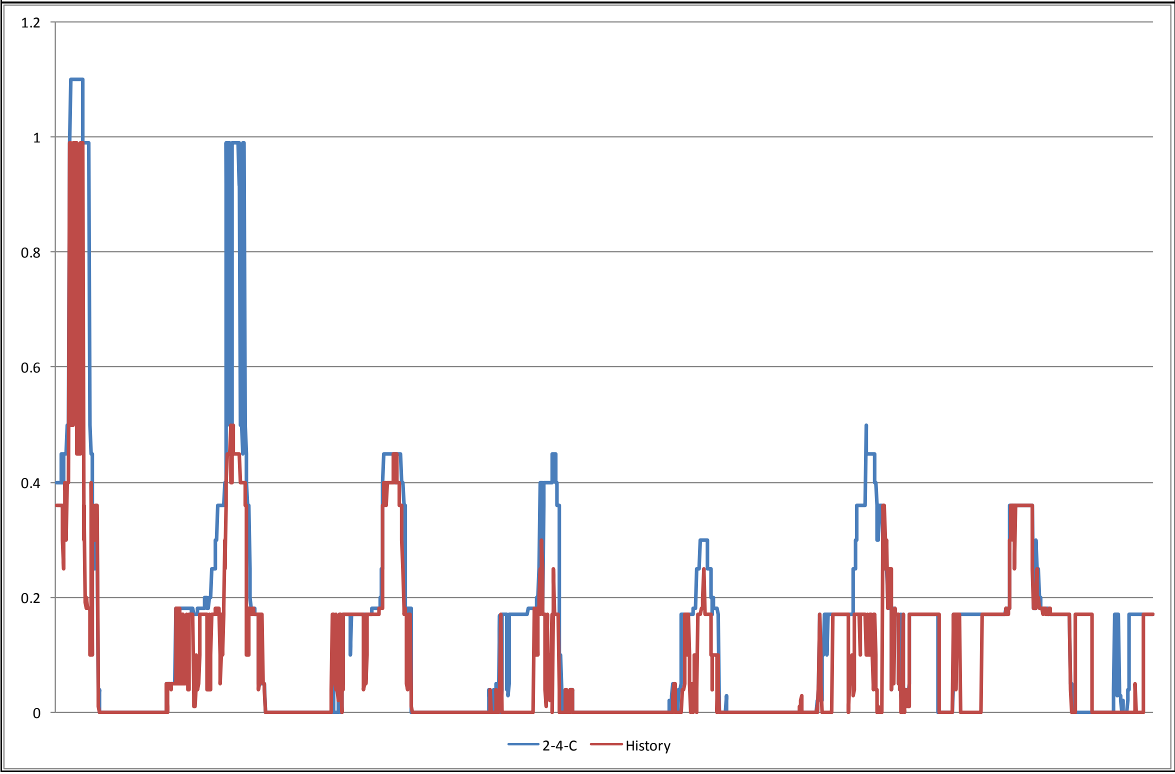
The mainland L6 Pricing outcomes compare well to history.

Figure 5.11 – Mainland L6 FCAS Price



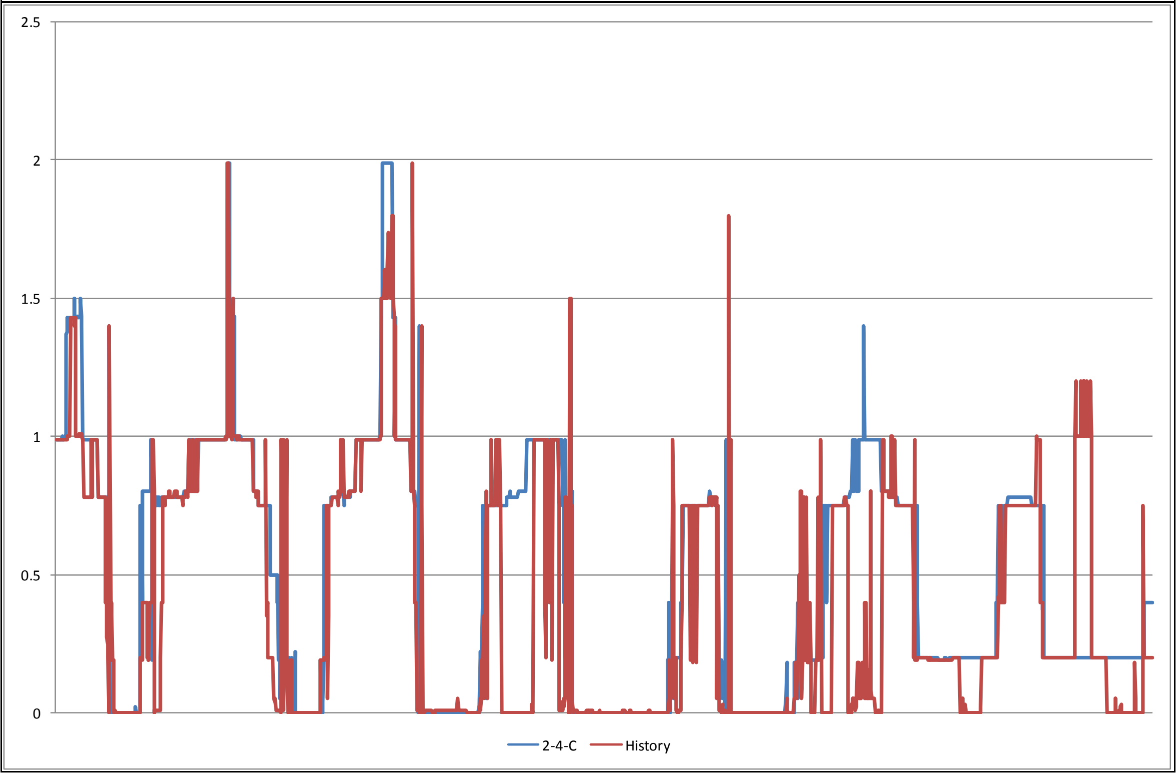
The mainland L60 pricing outcomes also compare well with history.

Figure 5.12 – Mainland L60 FCAS Price



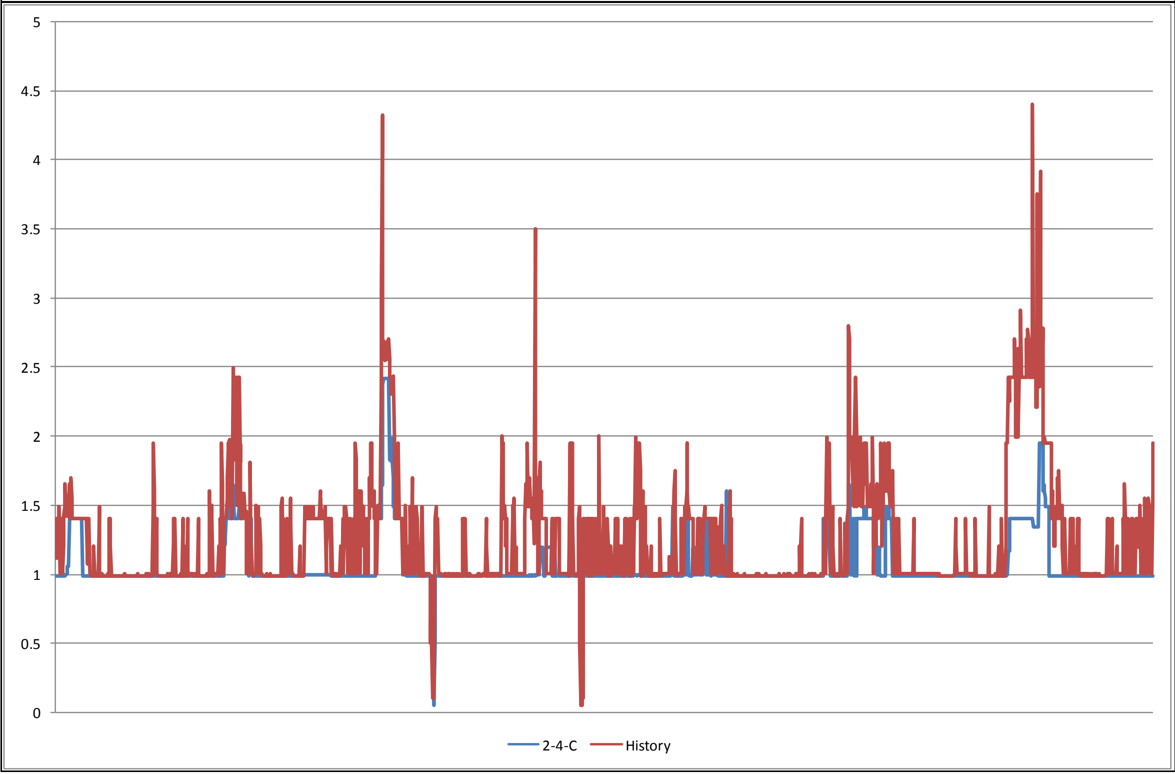
Mainland L5 pricing outcomes correlate well with history, and differ only due to network outage conditions towards the end of the back-cast week.

Figure 5.13 – Mainland L5 FCAS Price



Mainland lower regulation service price outcomes are influenced by minor variations in unit dispatch when compared to history and network outage conditions such as the islanding of Queensland in the FCAS markets.

Figure 5.14 – Mainland LReg FCAS Price



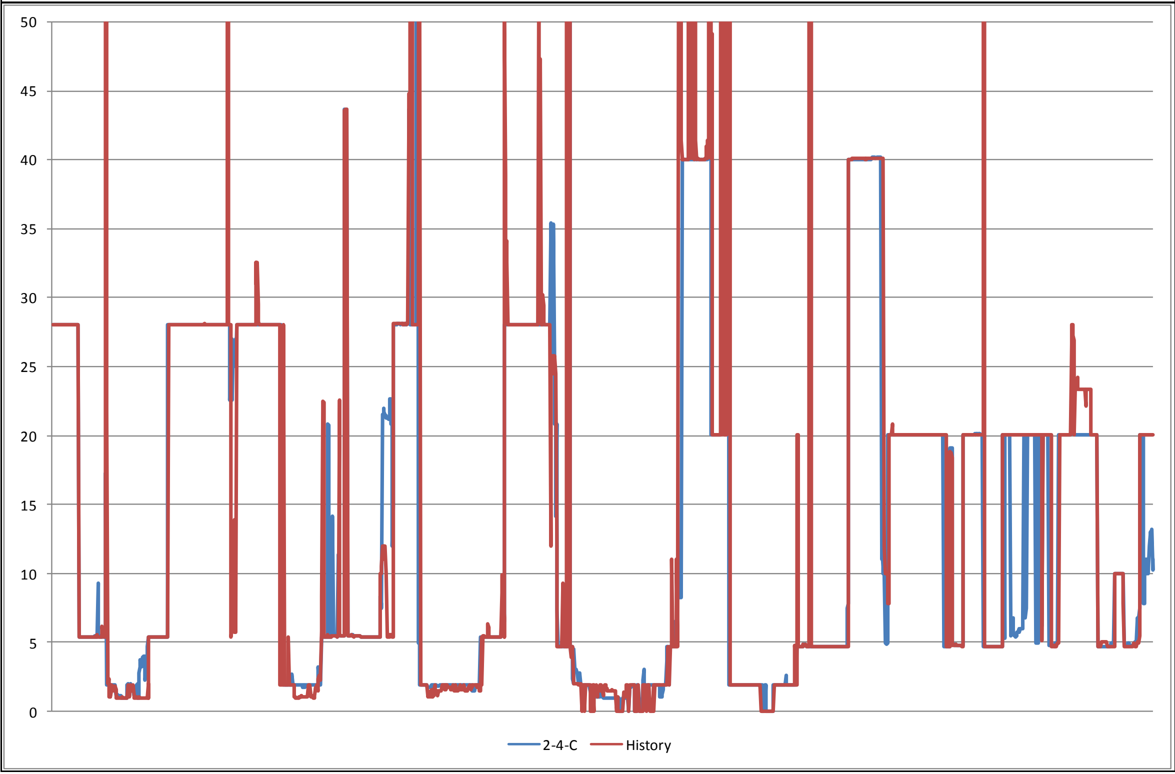
5.3) TASMANIAN FCAS MARKET OUTCOMES

The Tasmanian FCAS market is influenced strongly by the assumptions made about FCSPS load availability. These are known to be inconsistent with NEMDE, and thus the Tasmanian FCAS market outcomes were not expected to perfectly align with history.

Regardless, Tasmanian FCAS outcomes are highly comparable to historical data, providing confidence in the 2-4-C implementation of the FCAS markets.

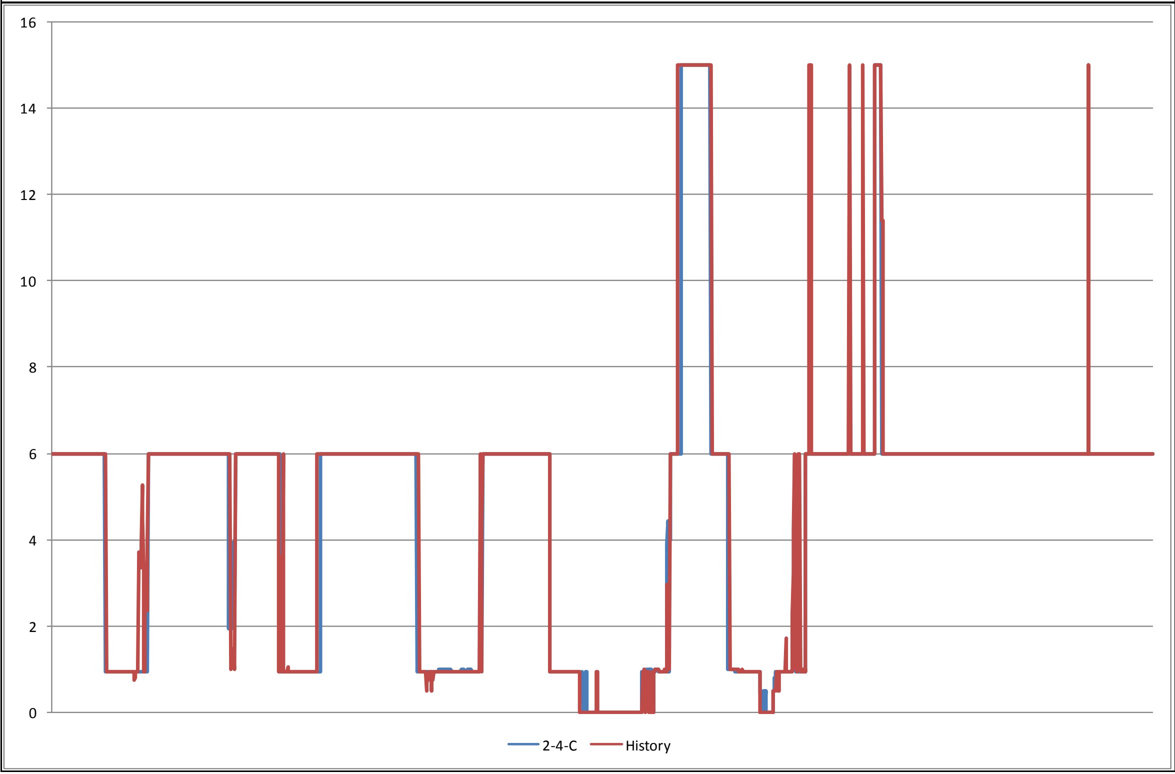
The Tasmanian R6 pricing outcomes compare well with history, with small variations due to differences in Basslink flow and reversal times.

Figure 5.15 – Tasmanian R6 FCAS Price



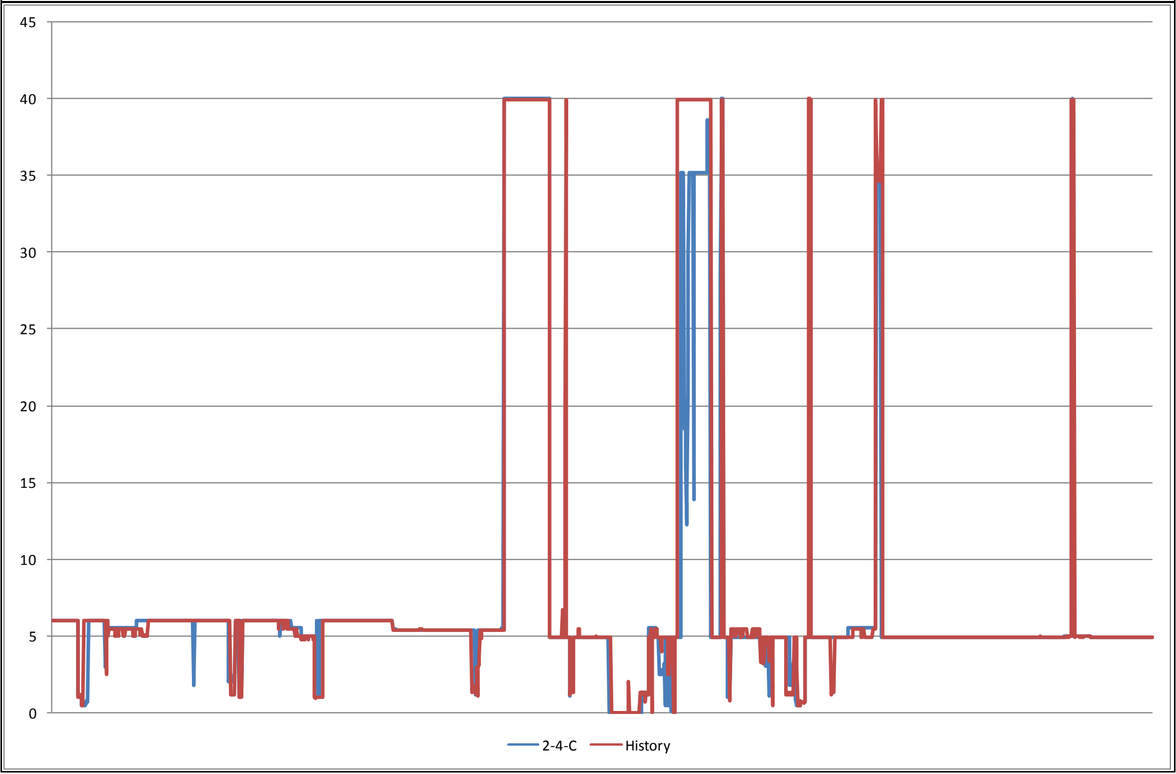
The Tasmanian R60 pricing outcomes are almost identical to history.

Figure 5.16 – Tasmanian R60 FCAS Price



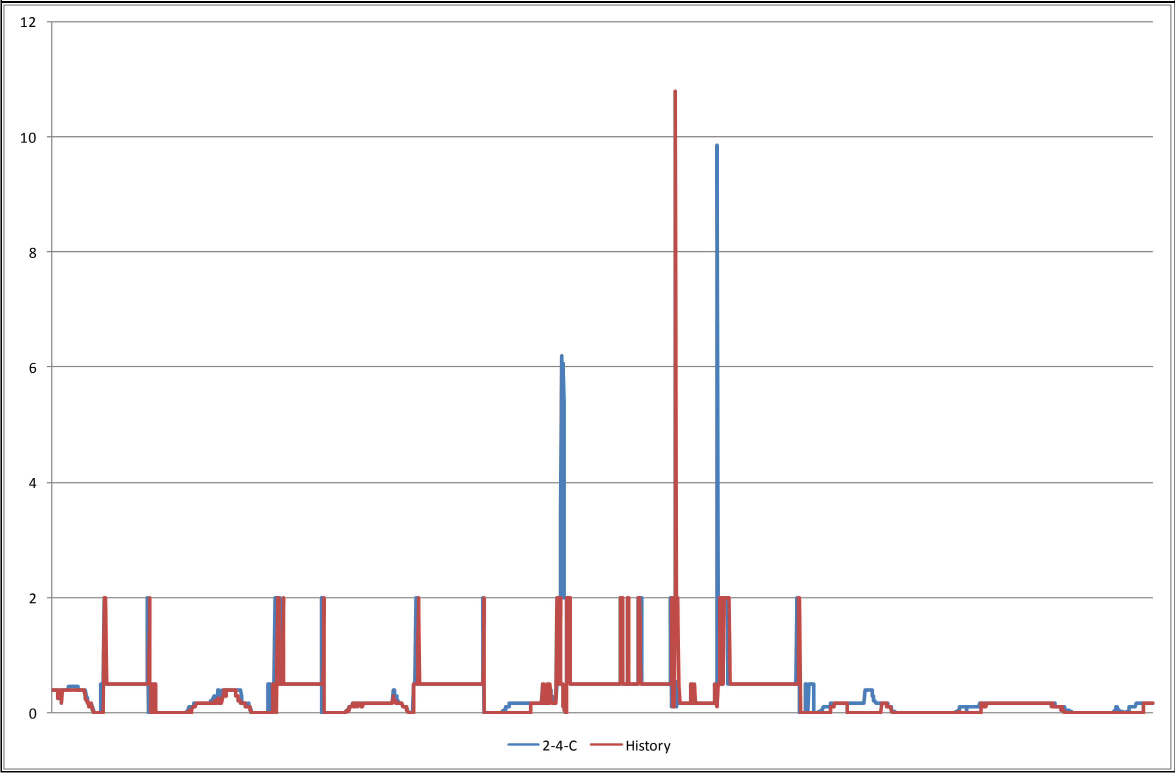
Tasmanian R5 pricing outcomes also compare very well with history, differing due to small differences in Basslink flow.

Figure 5.17 – Tasmanian R5 FCAS Price



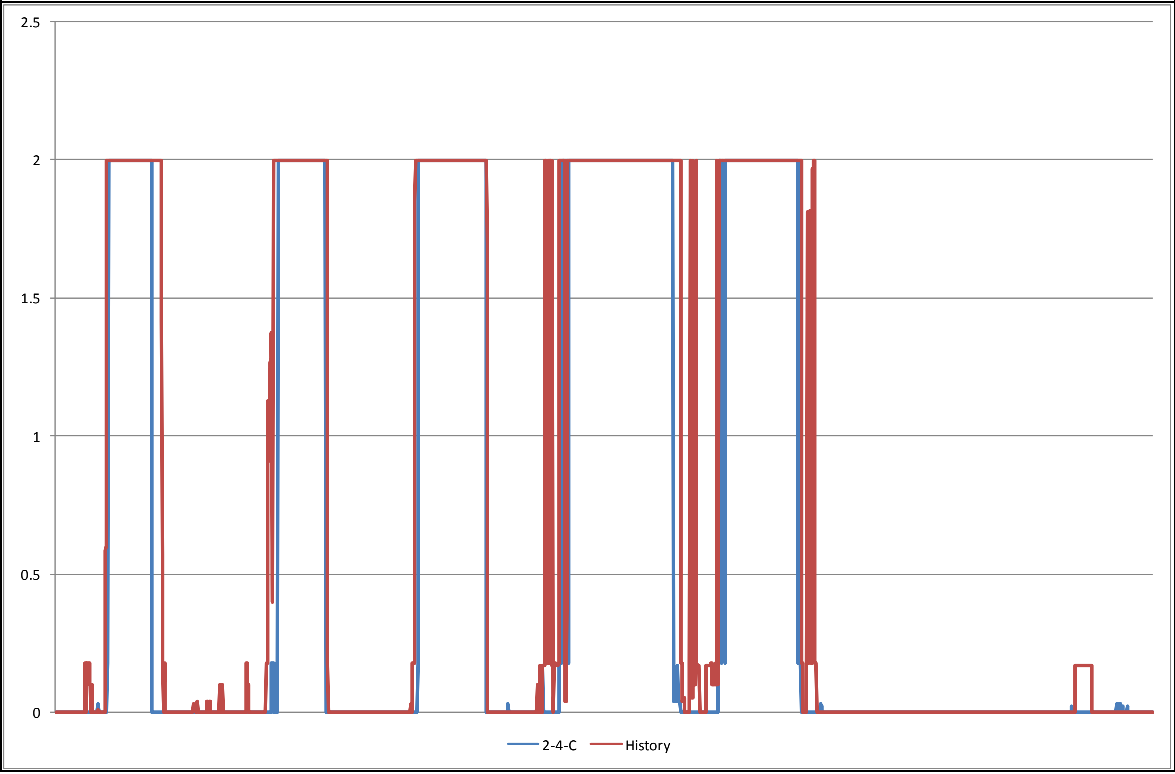
The Tasmanian R6 pricing outcomes compare well with history, with small variations due to differences in Basslink flow and reversal times.

Figure 5.18 – Tasmanian L6 FCAS Price



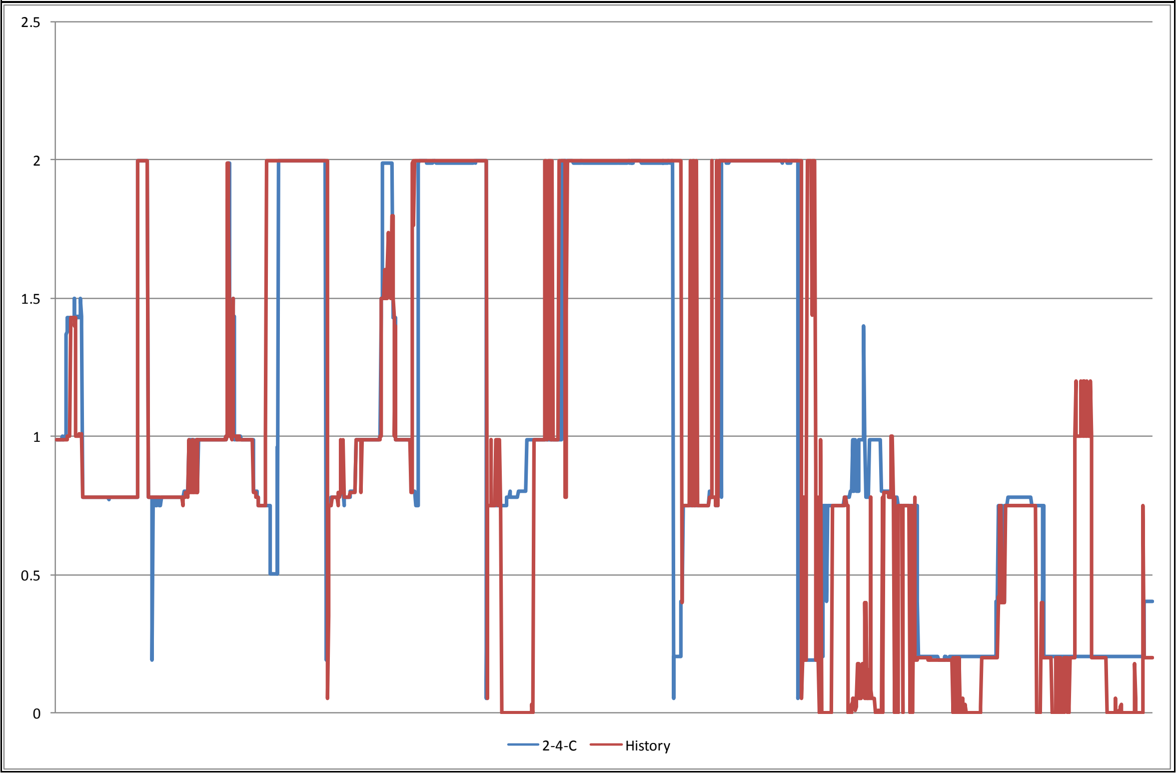
The Tasmanian R60 pricing outcomes are almost identical to history.

Figure 5.19 – Tasmanian L60 FCAS Price



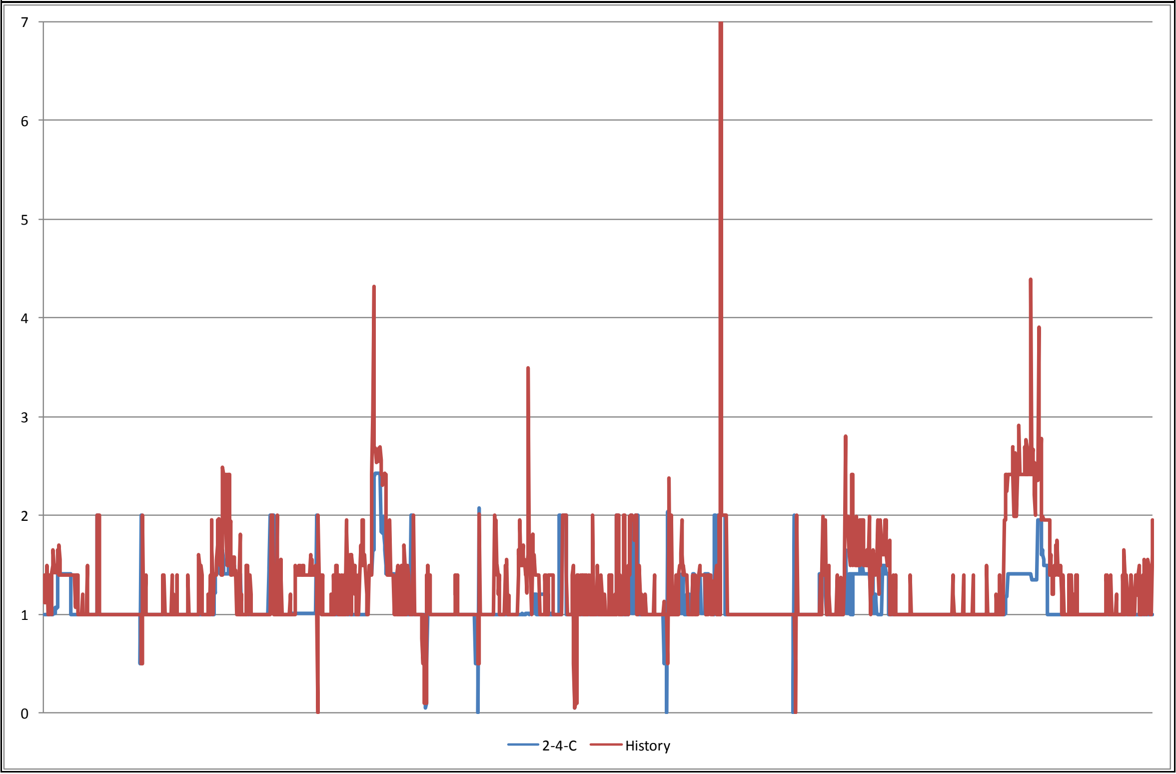
The Tasmanian R6 pricing outcomes compare well with history, with variations due to minor differences in Basslink flow and reversal times.

Figure 5.20 – Tasmanian L5 FCAS Price



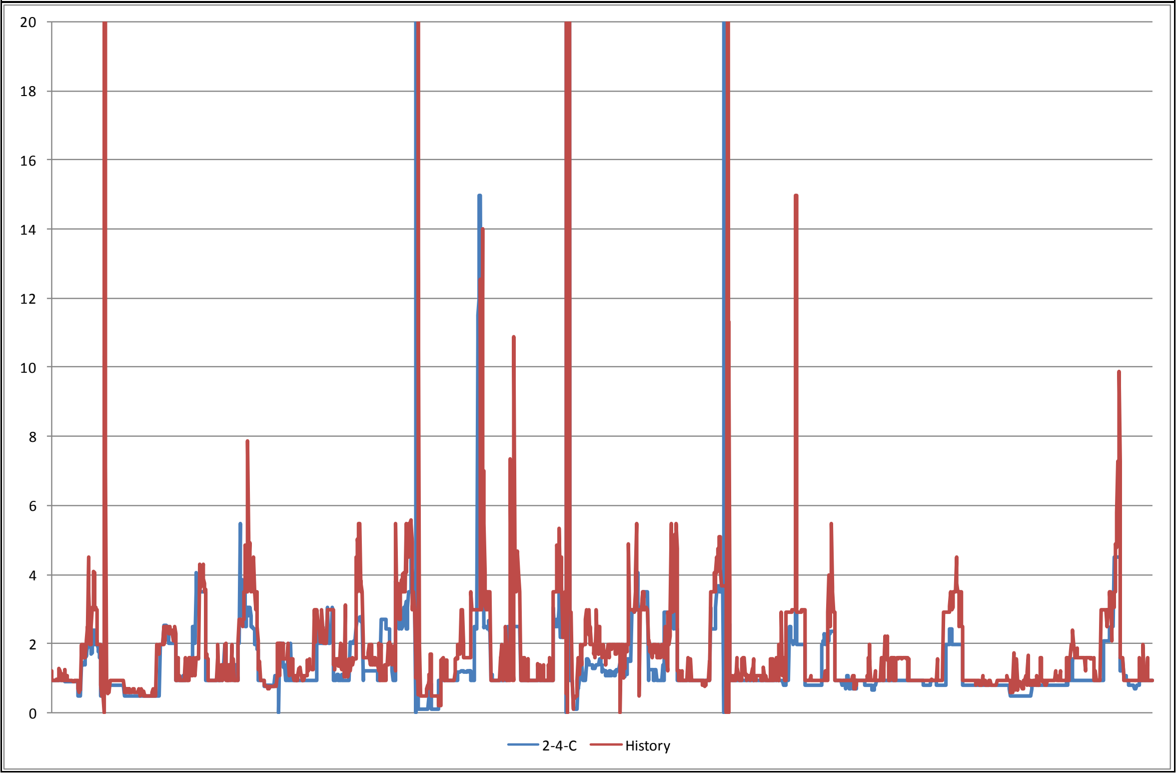
Similar to mainland regulation services, Tasmanian lower regulation pricing outcomes differ mildly from history.

Figure 5.21 – Tasmanian LReg FCAS Price



Similar to mainland regulation services, Tasmanian raise regulation pricing outcomes differ mildly from history.

Figure 5.22 – Tasmanian RReg FCAS Price



6) CONCLUSIONS

The 2-4-C dispatch model has been developed to enable the co-optimisation of the energy and FCAS markets in a similar way to actual dispatch of the NEM in the NEMDE. The 2-4-C dispatch model has been verified through application of a detailed back-casting process. The back-cast process applies initial conditions for market elements along with all relevant market data including the prevailing demand, generator offers for energy and FCAS, technical generator and load limitations and energy and FCAS constraints.

The outcomes comparing the 2-4-C dispatch model with historic market outcomes show that the 2-4-C model provides an accurate representation of the actual dispatch of the NEM under normal operating conditions. Significant difference in market dispatch and resulting energy and FCAS prices were observed only when the NEM system deviated from system normal conditions.

Although FCAS pricing is highly sensitive to very small variations in system conditions, 2-4-C was able to replicate NEMDE outcomes down to individual dispatch periods with a high degree of accuracy for contingency FCAS requirements. As regulation FCAS is often sourced in small quantities from a large number of units, minor variations in dispatch with respect to history resulted in minor price variations compared with the back-cast.

ROAM CONSULTING
ENERGY MODELLING EXPERTISE
ROAM Consulting Pty Ltd
A.B.N. 54 091 533 621

Report (Hma00017) to

HILL MICHAEL
STRATEGIC ENGINEERING

NATIONAL ELECTRICITY MARKET FORECASTING

Tasmania Frequency Reserve Market Impact Study Stage 2 – Market Simulations to Develop Energy & Reserve Price

29 July 2008

VERSION HISTORY

Version History				
Revision	**Date Issued**	**Prepared By**	**Approved By**	**Revision Type**
0.5	2008-07-08	ROAM Consulting	Ben Vanderwaal	Pre-release draft for discussion
1.0	2008-07-25	ROAM Consulting	Ben Vanderwaal	Complete draft
1.1	2008-07-29	ROAM Consulting	Ben Vanderwaal	Additional commentary Final draft

EXECUTIVE SUMMARY

This assessment is designed to assist *Alinta Energy (Tamar Valley) Pty Ltd* (hereafter referred to as Alinta) to determine the reserve implications of dispatching a 210MW[1] unit in the Tasmanian system based on proposed new frequency standards developed for the Tasmania network. Market simulation is conducted to determine the impact on required reserves[2] and associated price due to the proposed frequency standard in relation to do nothing option of retaining the present standard. Further the simulation studies also assess the economic dispatch of the 210MW unit following the implementation of the new standard.

MODELLING SUMMARY

Generally, the proposed frequency operating standard change and introduction of the initial large thermal generator in the Tasmania region is a short term transient problem. Implementation of the frequency standard change will facilitate entry of future thermal generators which will provide diversity in the Tasmania energy supply, fully mitigating the short term implications. Assumed new entry of the Gunns cogeneration facility (or any other significant thermal generation development) will provide supporting FCAS raise and lower services, in addition to lowering the contingency requirement due to the significant provision of inertia.

The results show that the market cost of implementing the frequency operating standard change is small. This results in some uplift to the FCAS R6 prices at times of scarcity, but otherwise does not have a large impact on market costs in general, nor does it create any significant problems with Basslink being trapped in FCAS provision.

Dispatching a larger single generator of up to 210MW causes significant market distortion, increasing FCAS R6 average price and costs by a factor of up to thirty. Dispatch of a larger single generation unit however can be managed in the Tasmania system through controlled dispatch at times of low demand or shortages of FCAS raise services provision. For the period preceding new entry of a second significant thermal generation development, the analysis shows that the Alinta plant may provide the least cost of energy supply for the market at dispatch up to full load at times. Dispatch of up to 190MW is achievable without any self provision of FCAS in excess of 30% of the time. Such a base loaded generation will facilitate local firm supply under critical water shortages, allow building up of storages and also cover possible extreme events such as loss of Basslink for long periods of time.

FREQUENCY STANDARD CHANGE

The modelling results indicate that the proposed frequency standard poses no major issues with regards to market dispatch. The cost of provision of FCAS increases considerably, albeit remaining very small compared with the market as a whole. Basslink is not significantly constrained and the increase in negative settlement residues is only minor.

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[1] It is to be noted that Alinta's proposed generator is 208.9MW and for the purpose of ease 210 MW unit is modelled.

[2] ROAM model has incorporated the NEMMCO FCAS calculator to determine the reserve quantity.

Although the frequency standard change results in a net increase in FCAS requirements, the benefits of the system inertia provided by the new thermal entry mitigate this considerably and the negative impacts on the Tasmanian system is likely outweighed by the additional capacity the Alinta CCGT and Gunns cogeneration facility will provide.

210MW CONTINGENCY

The modelling results indicate that full dispatch of the CCGT prior to entry of a second large new entry generator has dramatic effects on the Tasmanian market, leading to severe negative settlement residues on Basslink and very large increases in the Tasmanian energy and fast raise ancillary service market costs.

Co-optimization of the CCGT's energy dispatch target with the R6 FCAS requirement was ineffective in mitigating this outcome. A system mechanism outside the market dispatch engine would appear to be initially required to limit the largest unit online to an 'optimal' dispatch level at times. Future new entry, particularly the Gunns development is likely to significantly reduce the requirement for such a mechanism however.

One of the reasons co-optimisation is ineffectual is that there is no cost associated with transferring FCAS across Basslink. Extending MNSP transport offers to the FCAS markets may provide a tool to mitigate the Tasmanian R6 requirement.

CONCLUSIONS

The Alinta generator will provide overall benefits to Tasmania provided the FCAS issue associated with increasing the maximum generator contingency above 144MW is managed. There are several ways to do this, including voluntary co-optimising of energy and reserve markets. This is an established technique previously applied when Queensland was an isolated network.

Changing the existing FOS to 47.0Hz (for a multiple contingency event, bringing it into line with the NEM mainland) and 48.0Hz (for a single contingency) is a positive step and would logically follow from the additional energy and inertia provided by the Alinta generator.

The Alinta generator would be indifferent to the frequency excursion if it tripped, which is the most likely event that could cause a severe frequency drop towards 47.5Hz for a single contingency. Therefore a change to the FOS to accommodate an Alinta generator trip is unnecessary. However, if subsequent thermal generation such as the Gunns cogeneration facility enters the Tasmanian network, the tightened FOS would need to be implemented.

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Report to:

HILL MICHAEL
STRATEGIC ENGINEERING

NEM FORECASTING

Tasmania Frequency Reserve Market Impact Study Stage 2 – Market Simulations to Develop Energy & Reserve Price

Hma00017

29 July 2008

1) BACKGROUND

ROAM Consulting is undertaking modelling studies of the Tasmania electricity network on behalf of *Alinta Energy (Tamar Valley) Pty Ltd* (hereafter referred to as Alinta) in relation to the AEMC Reliability Panels present 'Review of Frequency Operating Standards for Tasmania'. In doing this ROAM is applying the 2-4-C simulation model with the 2007 ANTS Constraint equations for the energy market and FCAS constraints for co-optimised dispatch of the energy and ancillary services market.

To provide confidence in the model ROAM has completed a back-casting exercise to verify and calibrate the 2-4-C dispatch model and constraint equations set. The back-cast outcomes and issues identified during the back-casting exercise are outlined in the report "*Tasmania Frequency Reserve Market Impact Study, Stage 1 – Back-Cast Simulation*, ROAM Consulting, July 2008".

This second phase of work involves conducting market simulation forecasts for a number of scenarios, to determine the energy and FCAS prices for alternative Tasmania Frequency Standards and new entry generator development to assess the relative impact of the standard change on the FCAS and energy price.

2) INTRODUCTION

This Stage 2 assessment is designed to assist Alinta to determine the reserve implications of dispatching a 210MW[3] unit in the Tasmanian system based on proposed new frequency standards developed for the Tasmania network. Market simulation is conducted to determine the impact on required reserves[4] and associated price due to the proposed frequency standard in relation to do nothing option of retaining the present standard. Further the simulation studies also assess the economic dispatch of the 210MW unit following the implementation of the new standard.

3) SCOPE OF WORK

3.1) STATUS QUO SCENARIOS

The status quo scenarios assess the market assuming there will be no significant thermal generation development in the Tasmania region within the next five years[5]. In this case neither the Alinta CCGT nor Gunns cogeneration facility is assumed to enter the Tasmania market. This provides a baseline energy and FCAS price outlook both prior to and following implementation of the proposed frequency operating standard.

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[3] It is to be noted that Alinta's proposed generator is 208.9MW and for the purpose of ease 210 MW unit is modelled.

[4] ROAM model has incorporated the NEMMCO FCAS calculator to determine the reserve quantity.

[5] On the basis that the present standard is a barrier to entry for efficient thermal/CCGT gas units.

Table 3.1 – Status Quo Modelled Scenarios

Scenario	Description
0A	Present frequency standard (47.5-53 Hz) Present largest unit (Max 144MW) Only Musselroe and Bell Bay GT #4 60MW OCGT No Alinta GGCT or Gunns plant
0B	Proposed frequency standard (48-52 Hz) Present largest unit (Max 144MW) Only Musselroe and Bell Bay GT #4 60MW OCGT No Alinta GGCT or Gunns plant

3.2) REFERENCE SCENARIOS

This phase of work involves conducting market simulations for a number of scenarios over the simulation period from 01-07-2009 to 30-06-2012, to determine the volume and price for energy and FCAS services in the Tasmania region. The purpose of this simulation is to determine the energy and reserve price and its impact on the generation output from the Alinta CCGT. Market simulation will be conducted for the following scenarios:

Table 3.2 – Reference Scenarios

Scenario	Description
1A	Present frequency standard (47.5-53 Hz) Present largest unit (Max 144MW)
1B	Proposed frequency standard (48-52 Hz) Present largest unit (Max 144MW)
2A	Present frequency standard (47.5-53 Hz) Proposed largest unit (Max 210MW)
2B	Proposed frequency standard (48-52 Hz) Proposed largest unit (Max 210MW)

In this case, Scenarios 1A and 1B include 3x70MW generators in place of the single 210MW unit. This hypothetical situation will maintain a similar supply demand balance in terms of energy and capacity between the scenarios and provide an alternative assessment of the cost of the proposed frequency standard.

3.3) CCGT DISPATCH OPTIMISATION

The larger single CCGT generator will be able to operate for periods of time where there is sufficient FCAS contingency services and/or Basslink can optimally provide FCAS services in place of energy imports (as energy will be provided by the CCGT). In order to determine the likely optimal dispatch behaviour of the larger single generation unit, four scenarios have been assessed in which the larger single unit is constrained to a lower maximum output. Additionally, the CCGT is restricted from providing the R6 FCAS service to avoid self provision[6]. The four cases considered are as follows:

Table 3.3 – CCGT Dispatch Optimisation Scenarios

Scenario	Description
2B_145	Proposed frequency standard (48-52 Hz) Proposed maximum dispatch unit (Max 145MW)
2B_160	Proposed frequency standard (48-52 Hz) Proposed maximum dispatch unit (Max 160MW)
2B_175	Proposed frequency standard (48-52 Hz) Proposed maximum dispatch unit (Max 175MW)
2B_190	Proposed frequency standard (48-52 Hz) Proposed maximum dispatch unit (Max 190MW)

A co-optimisation process within the linear programming optimisation that directly relates the R6 requirement to the CCGT dispatch was trialled and determined to have minimal effect. For further information on this option refer to co-optimisation of FCAS requirements in Appendix B).

4) GENERAL ASSUMPTIONS

This assessment is designed to determine the impacts on market dispatch of implementing a change to the present Tasmania frequency standard. General assumptions applied in the modelling are summarized as follows:

1. Demand and Energy forecasts are based on the 2007 NEMMCO SOO corresponding with the Medium economic growth and 50% Probability of Exceedence demand (M50) for all regions of the NEM. Forecast load traces are developed based on the 2006-07 reference year.
2. Transmission limitations across the interconnected NEM are modelled through application of the 2007 NEMMCO ANTS[7] constraint equation set. The 2007 ANTS constraints include all NEM system normal transmission constraints in a similar form to those applied in the real-time NEMDE. These constraints have been found to provide a faithful representation of NEMMCO's dispatch under typical conditions.

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[6] NER presently permits self reserve dispatch, but in this analysis it is assumed that there is no such provision from Alinta. Therefore summary findings on the maximum output may be enhanced if the present rules are applied.

[7] ANTS: The Annual National Transmission Statement, prepared by NEMMCO and released annually with the Statement of Opportunities (SOO). The 2007 ANTS Constraints have been modified in accordance with information published by NEMMCO (*Converting Constraints for the Snowy Region Abolition*', NEMMCO, Jan 2008) to reflect the committed abolition of the Showy Region of the NEM.

3. All existing and committed NEM generation is included in the dispatch model with trading behaviour in both the energy and FCAS markets based on analysis of recent history:
    a. Thermal plant has been modelled based on recent historic market behaviour. Thermal plant which has been impacted by ongoing drought conditions are modelled according to the latest NEMMCO Drought Scenario Investigation[8].
    b. Committed new entry plant has been based on the best publicly available information including media releases, NEMMCO SOO updates and the latest NEMMCO Drought Scenario Investigation.
    c. Energy limited generators such as hydro plant have been modelled based on recent information releases for this medium term outlook. Specifically, the market simulations assume an energy availability of around 8500GWh from the Tasmania Hydro generators.
4. NEMMCO FCAS calculator has been used in the simulation to determine the reserve quantity.

The assumed committed new entry generation and retirements in the Tasmania region are of key importance to this assessment. Assumed generation development in the Tasmanian region is summarised in Table 4.1 below. In both the status quo and reference scenarios it is assumed that the existing 2 x 120MW Bell Bay gas fired steam turbines have been retired prior to the beginning of the study.

Table 4.1 – Tasmania Region Generation Development

Station Name	Alinta OCGTs (CCGT alt.)	Alinta CCGT	Gunns Pulp Mill	Alinta Bell Bay GT #4	Musselroe Wind Farm
Start Date	01-07-2009	01-07-2009	01-07-2011[9]	01-07-2009	01-07-2009
Scenarios	1A, 1B	2A, 2B, 2B_xxx	1A, 1B, 2A, 2B, 2B_xxx	0A, 0B, 1A, 1B, 2A, 2B, 2B_xxx	0A, 0B, 1A, 1B, 2A, 2B, 2B_xxx
Unit config	3 x 70	1 x 210	1 x 60	1 x 60	1 x 120
Raise 5	Nil	Nil	50	Nil	Nil
Raise 60	30	30	50	Nil	Nil
Raise 6	30	30	50	Nil	Nil
Raise Reg	30	30	Nil	Nil	Nil
Lower 5	Nil	Nil	130	Nil	Nil
Lower 60	30	30	130	Nil	Nil
Lower 6	30	30	130	Nil	Nil
Lower Reg	30	30	Nil	Nil	Nil
Outages	Yes	Yes	Yes	Yes	Nil
Type Gen	Baseload OCGT	Baseload CCGT	Baseload Cogen	Peaking OCGT	Intermittent Wind

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[8] Drought Scenario Investigation, June 2008 Update, NEMMCO.

[9] Gunns advice indicates a commissioning date of March 2011. This has been set at July 2011 to simplify the analysis on a financial year basis.

4.1) ISSUES AND KEY ASSUMPTIONS

The following key assumptions will have a significant impact on market outcomes, particularly for the FCAS market, which is the main focus of this study:

1. Calculation or assumption for:
    a. Load enabled for FCSPS under Basslink import conditions;
    b. Generation enabled for FCSPS under Basslink export conditions.
2. Calculation or assumption for Tasmania system inertia:
    a. Calculation of system inertia for existing Tasmania generation portfolio based on actual dispatch;
    b. Impact of generation development on system inertia calculation including development of further wind generation, the Alinta 210MW CCGT and/or Gunns 188MW cogeneration facility;
3. Calculation of Tasmania FCAS requirement based on system conditions. FCAS requirement must be able to be calculated taking into account:
    a. Tasmania load;
    b. System inertia;
    c. FCSPS enablement.

These key assumptions have been carefully considered to develop this assessment of the Alinta development proposal.

4.1.1) FCSPS Load and Generation Enablement

The Tasmanian FCSPS (frequency control system protection scheme) is designed to allow Basslink to operate at transfers beyond what would normally be considered secure by arming interruptible loads and generation for rapid tripping in response to the loss of Basslink. This reduces the contingency requirement imposed by Basslink to a level manageable in the Tasmanian market and is an essential mechanism for Basslink operation.

When the load or generation available to the FCSPS scheme is below the design criteria, the energy target of Basslink is restricted to maintain a similar required contingency response. Historically there is often insufficient load enablement to allow maximum import on the Basslink interconnector. It is understood that this is due to an agreement between Basslink and the load enablement participants, which allows loads a six month leave from enablement if they have been activated.

For the purpose of this forecast it is assumed that there will always be sufficient load and generation enablement to allow the Basslink interconnector to operate up to the prevailing energy limits at all times. As the load available to the FCSPS scheme is dependent on commercially sensitive contracts and is not publicly available, this is the most reasonable assumption. Generation available is determined by which generators Hydro Tasmania chooses to make available for FCSPS action, and is unlikely to limit maximum Basslink export.

4.1.2) Calculation of Tasmania System Inertia

As the rate of change of frequency in the Tasmanian system can be extreme relative to the mainland, special considerations must be taken to determine the appropriate FCAS contingency levels – under light load/inertia conditions the excursion band of the frequency standard may be breeched before fast FCAS services are assumed to fully operate.

Thus, the Tasmanian FCAS contingency requirements depend on system inertia to determine the time in which any frequency excursion must be controlled and thus the appropriate contribution from contingency FCAS. Machine inertia values for each individual generator in the Tasmania region have been applied. Inertia values are included for all existing generators and also the proposed Gunns plant, Alinta CCGT and Alinta OCGT alternative plants.

4.1.3) Calculation of the Tasmania FCAS Requirement

As part of the back-casting exercise ROAM found that the FCAS requirements calculated as per information publicly available from NEMMCO[10] did not provide a sufficiently accurate representation of the observed operation of the market. This was found to be due mainly to the significant relationship between the Tasmania system inertia and the FCAS contingency requirements. Furthermore, the formulae provided in the public document have the assumed present frequency operating standard 'built in' to the coefficients in the loss of Basslink equations.

To overcome this limitation NEMMCO provided the calculations necessary to replicate the operation of the NEM to ROAM under confidentiality agreement for the purpose of this modelling. These calculations were found to provide a very good representation of the system in the back-cast, and have thus been applied in the forecasting studies completed. The calculations include terms for both Tasmania system inertia and the maximum frequency excursion allowed. This allows the same set of equations to be used for modelling both the existing and proposed frequency operating standards.

Although nonlinear, these equations also proved suitable to co-optimise the energy target of the Alinta CCGT with fast raise FCAS costs by dynamically constructing a piecewise linear approximation to the relationship between energy dispatch and fast raise FCAS requirements based on demand and previous system inertia.

4.1.4) Discounting of the Tasmanian L6 Network Event

Tasmanian generators specify their fast lower capabilities in response to a 1Hz maximum frequency excursion load event, yet the maximum allowable frequency excursion for a network event is 3Hz, which allows considerably more time for generators to provide an FCAS response. NEMMCO has calculated a 'discount' factor to be applied to fast lower requirements for network events to account for this difference, which is assessed at 0.4.

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[10] Basslink Energy and FCAS Equations, NEMMCO 2006.

This was not revised for the cases assessing the proposed frequency operating standard, as the methodology for this process was not publicly available and fast lower requirements are not the focus of the study. Furthermore, procurement of lower services are unlikely to be problematic with new entry thermal generation providing significant fast lower service. The result of this assumption is that the effect of the proposed frequency standard on the fast lower FCAS market may be understated.

4.1.5) Self Provision of Contingency FCAS

NEMDE currently does not prevent units from providing FCAS services to cover for their own failure. Although this is a known deficiency in the dispatch engine, in practice this has not been sufficiently problematic for NEMMCO to justify resources to address, as mainland raise requirements are regularly sourced from a wide variety of units and the current largest Tasmanian units are aggregated (Gordon power station).

The Alinta CCGT development will however clearly be the largest single contingency in the Tasmania region whilst operating at levels above 144MW. This is likely to require NEMMCO to address the issue of self provision of FCAS as the issue will be far more prevalent and the effects more severe in this case compared with the NEM as a whole. For this reason modelling of the “CCGT Dispatch Optimisation” scenarios have included the impact of not allowing self provision of FCAS for the specific Alinta CCGT. It is to be noted that application of self provision will allow for a moderate increase in the optimal dispatch of the Alinta CCGT in the energy market in proportion to the value of available self bid FCAS. Therefore the study findings from this scenario provide a conservative but realistic estimate of dispatch.

4.2) KEY GENERATOR ASSUMPTIONS

4.2.1) Gunns Pulp Mill

The Gunns Pulp Mill development is a cogeneration facility made up of an 188MW steam generator coupled with a 128MW equivalent load, providing a baseload 60MW power injection into the Tasmania grid at Georgetown. The Gunns development is represented as a 60MW generator in the modelling.

The facility is assumed to trip the pulp mill load on loss of the cogeneration facility to limit the net FCAS enablement required to levels well below the current largest unit. It is noted that the Gunns cogeneration facility can provide FCAS and/or FCSPS services, although the commercial implications of providing these services are unclear. Information provided by Gunns[11] suggests that the facility may provide 170MW of FCAS Lower services, as this will be readily achievable through controlled generation reduction. FCAS Raise services may also be provided through reduction in internal load of up to 65MW. (Note that 130MW Lower and 50MW Raise service offers have been included in the modelling following consultation with Gunns Limited)

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[11] Gunns presentation to the Stakeholder Forum, Friday 6th June 2008. Available from: http://www.aemc.gov.au/electricity.php?r=20080424.133954

The Gunns project also serves to significantly increase system inertia and thus reduces the requirements for all contingency FCAS services in Tasmania, particularly in low load periods. The contribution that the Gunns facility provides to system inertia has been included in the FCAS contingency requirements calculations based on data provided by HMAC.

4.2.2) Alinta CCGT

The Alinta CCGT development is modelled as a 210MW single generation unit. The CCGT's capacity is made up of approximately 1/3 steam turbine (ST), fed by excess heat from 2/3 gas turbine (GT), in terms of equivalent capacity. For the purpose of modelling this is assumed to be 140MW GT and 70MW ST.

As the Alinta plant is a CCGT, FCAS enablement and offer prices have been constructed such that technical requirements are adhered to, such as minimum load for steam generator operation. The Alinta CCGT FCAS provision has been modelled based on information from the developer and calibrated against the Swanbank E generator which is of similar technology. The Alinta CCGT has been configured to provide around 30MW of raise and lower services into all but the five minute FCAS market.

The Alinta CCGT also significantly increases system inertia, and thus reduces the requirements for all contingency FCAS services in Tasmania when operational.

4.2.3) Alinta OCGT Alternative

The Alinta OCGT alternative plant has been configured for the purpose of modelling to allow for similar provision of energy, whilst maintaining the largest single unit in the Tasmania system consistent with the present 144MW. This has been established by offering 3x70MW generators into the energy and FCAS markets at the same bid offer prices as the Alinta CCGT.

5) MARKET SIMULATION OUTCOMES

5.1) STATUS QUO SCENARIOS

The status quo scenarios provide an outlook of the Tasmania energy and FCAS markets assuming no new baseload generation developments in the region. Tasmania Hydro energy production is around 8300GWh per annum, with the remaining energy requirement being provided through sustained high levels of import on Basslink.

Implementation of the proposed frequency operating standard (FOS) results in a marginal increase in the incidence of Basslink being 'trapped' in FCAS provision when flowing in the northerly direction. The marginally higher requirement in FCAS contingency services are able to be provided for marginal increase in price and reduction in Basslink energy provision at times. The assessment shows that the incidence of Basslink negative settlement residues increases by 100 to 200 trading intervals per annum, due to implementation of the proposed FOS.

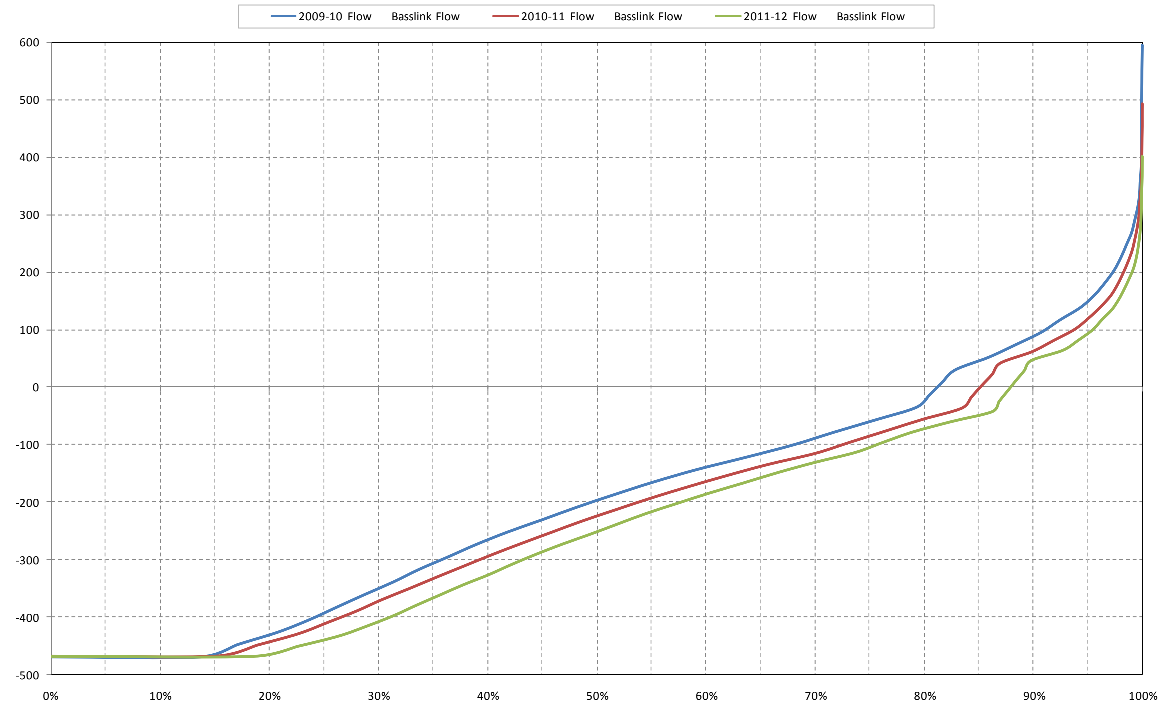
A summary of these outcomes is provided below:

Table 5.1 – Summary of Modelling Outcomes (Status Quo Scenarios)

	$/MW	MW	$/MWh	MW	$	$	# T.I.'s
	R6 Price	TAS R6 Local Dispatch	TAS PP	BLINK Avg Flow	BLINK PSR	BLINK NSR	# NSR
0A	Present FOS (47.5-53Hz), 144MW Contingency						
2008-09	$2.44	38.72	$37.88	-199.01	$21,386,683	-$1,200,120	5,778
2009-10	$2.21	37.77	$33.17	-198.54	$16,160,257	-$1,240,971	5,873
2010-11	$3.12	39.21	$33.94	-222.02	$18,620,832	-$1,464,676	5,626
2011-12	$2.46	38.60	$31.39	-243.97	$23,115,132	-$1,221,900	5,072
0B	Proposed FOS (48-52Hz), 144MW Contingency						
2008-09	$4.03	43.05	$38.42	-197.84	$21,592,813	-$1,481,619	5,866
2009-10	$4.64	42.20	$34.37	-196.70	$16,467,519	-$1,953,225	5,998
2010-11	$7.45	43.46	$37.21	-216.33	$18,972,694	-$3,988,075	5,872
2011-12	$4.57	42.93	$32.13	-242.89	$23,518,074	-$1,531,384	5,132

The Basslink flow duration curves for 2009-10, 2010-11 and 2011-12 are presented in Figure 5.1 below. As may be seen, reliance on Basslink for imports and the amount of time that Basslink is constrained importing into Tasmania increases due energy growth in the region. Further analysis of negative settlement residue evens shows that around 80% of the NSR periods occur whilst Basslink is flowing in the southerly direction. In these cases FCAS dispatch on Basslink is preventing Basslink from changing direction from southerly into northerly flows.

Figure 5.1 – Basslink Flow Duration (Status Quo Scenario 0A)



5.2) REFERENCE SCENARIOS

The reference Scenarios 1A and 1B provide a hypothetical comparison case to the Status Quo outcomes in which there is 210MW of equivalent new entry baseload generation in Tasmania, whilst maintaining the contingency within the present 144MW standard. These scenarios also show a relatively minor impact on market outcomes due to the implementation of the frequency standard change alone. Comparing Scenario 1A and 1B with the Status Quo scenarios, it is clear that the additional 210MW of baseload capacity significantly reduces the reliance of Basslink to supply the Tasmania energy requirement, reducing the average annual import to below 100MW. A significant result of the reduced reliance on Basslink is the reduction in the accumulated positive settlement residues by a factor of more than two, whilst also reducing the total cost of negative settlement residues.

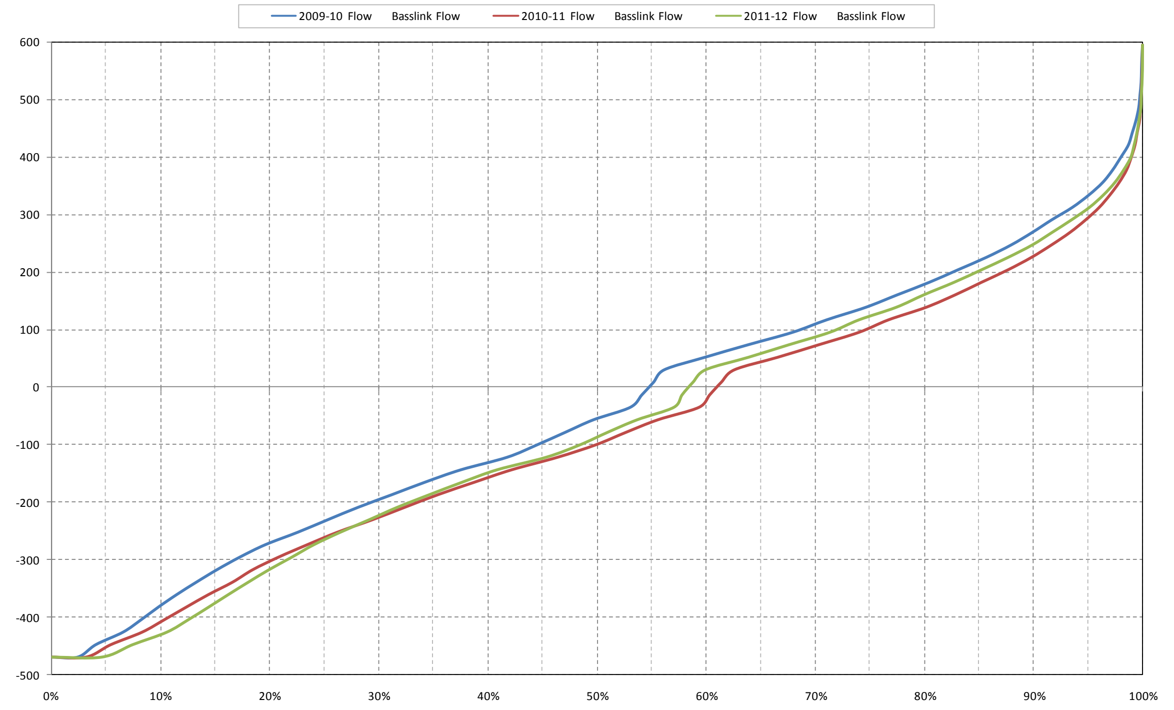
A summary of these modelling outcomes is presented in Table 5.2 below.

Table 5.2 – Summary of Modelling Outcomes (Reference Scenarios, 144MW Contingency)

	$/MW	MW	$/MWh	MW	$	$	# T.I.'s
	R6 Price	TAS R6 Local Dispatch	TAS PP	BLINK Avg Flow	BLINK PSR	BLINK NSR	# NSR
1A	**Present FOS (47.5-53Hz), 144MW Contingency**						
2009-10	$1.37	30.84	$27.26	-45.39	$7,675,626	-$926,377	5,748
2010-11	$1.67	33.13	$27.23	-81.99	$6,335,391	-$1,111,363	6,027
2011-12	$1.31	30.41	$23.97	-73.89	$7,371,215	-$1,103,539	5,822
1B	**Proposed FOS (48-52Hz), 144MW Contingency**						
2009-10	$1.66	34.62	$27.31	-44.79	$7,685,670	-$940,820	5,836
2010-11	$2.26	36.95	$27.52	-80.61	$6,331,462	-$1,250,685	6,115
2011-12	$1.47	34.00	$24.02	-73.23	$7,373,945	-$1,104,978	5,878

The flow duration for Basslink shows the significant reduction in the reliance on Basslink flows for energy supply in Tasmania, allowing more free flowing trade between Tasmania and the mainland NEM and reducing the incidence of constrained import into the Tasmania region.

Figure 5.2 – Basslink Flow Duration (Reference Scenario 1A)



Introduction of the single 210MW generation unit into the Tasmania system, without any controlled reduction during times of FCAS supply scarcity significantly increases the incidence of Basslink being trapped whilst flowing in the northerly direction. This in turn requires increased energy dispatch from the Tasmania Hydro generators to support the Basslink flow, resulting in significant increases in the Tasmania energy price. This is clearly a sub-optimal outcome contravening the NEM objective. This may however be resolved through an ideal dispatch regime from the larger CCGT generator. Furthermore, the issues are substantially minimised with introduction of a second large generator in the Gunns cogenerator facility.

Table 5.3 – Summary of Modelling Outcomes (Reference Scenarios, 210MW Contingency)

	$/MW	MW	$/MWh	MW	$	$	# T.I.'s
	R6 Price	TAS R6 Local Dispatch	TAS PP	BLINK Avg Flow	BLINK PSR	BLINK NSR	# NSR
1A	**Present FOS (47.5-53Hz), 210MW Contingency**						
2009-10	$37.67	56.27	$62.10	38.12	$6,865,880	-$32,438,737	9,761
2010-11	$38.90	56.80	$62.42	-3.57	$6,323,695	-$33,129,883	9,635
2011-12	$6.24	45.67	$28.22	-53.96	$7,443,233	-$4,836,305	7,192
1B	**Proposed FOS (48-52Hz), 210MW Contingency**						
2009-10	$54.81	63.46	$78.61	77.87	$6,373,088	-$53,899,732	11,064
2010-11	$58.64	64.11	$81.91	39.22	$5,685,281	-$57,930,162	11,209
2011-12	$8.58	51.31	$30.27	-47.69	$7,433,119	-$6,907,286	7,525

Figure 5.3 below shows the impact on Basslink dispatch for the 2009-10 year, due to FCAS requirements forcing Basslink to remain flowing in the positive direction. In this case, the CCGT does not voluntarily reduce dispatch in order to allow Basslink to change direction resulting in significant blocking.

Figure 5.3 – Basslink and Alinta CCGT Duration (Reference Scenario 1B and 2B, 2009-10)

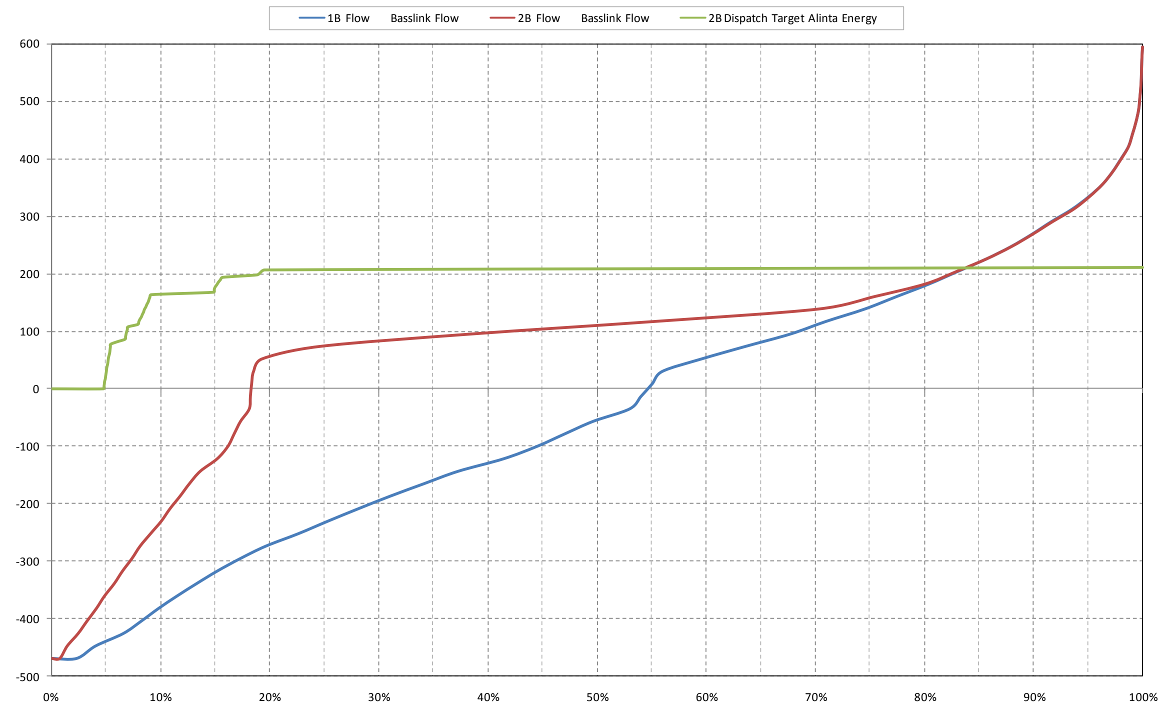


Figure 5.4 below shows that new entry of a second significant thermal generator through introduction of the Gunns cogeneration facility provides for a significant reduction in FCAS contingency requirements, whilst providing 50MW of raise service. This provides significant support to the Tasmania system, blocking Basslink reversal in far fewer instances.

Figure 5.4 – Basslink and Alinta CCGT Duration (Reference Scenario 1B and 2B, 2011-12)

5.3) OPTIMAL CCGT DISPATCH

It is clear that increasing dispatch of the single generator results in increasing levels of FCAS requirements. This leads to increasing intervals of Basslink FCAS entrapment whilst flowing towards the north and as a result, increased negative settlement residues, higher FCAS prices and higher energy prices.

Four scenarios in which the largest single generation unit is dispatched at 145MW through to 190MW have been completed. ROAM has assessed the outcomes from these four dispatch scenarios to develop an optimal dispatch pattern. The optimal dispatch is selected based on minimising the cost of Tasmania energy supply based on an assessment of the energy price and demand, Basslink interchange and FCAS R6 service price and requirement[12]. The resulting dispatch generation duration curve is presented in Figure 5.5 below. Figure 5.6 further presents the optimal dispatch outcome along with Basslink duration curve for the 2009-10 year.

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[12] Calculated for each trading interval as:

(TAS R6 Price * TAS R6 Local Dispatch) +

If (BL Flow < 0)

- BL Flow * VIC Pool Price + [(TAS Demand + BL Flow) * TAS Pool Price)]

Else

[(TAS Demand - BL Flow) * TAS Pool Price)]

Table 5.4 – Summary of Modelling Outcomes (Optimal CCGT Scenarios)

	$/MW	MW	$/MWh	MW	$	$	# T.I.'s
	R6 Price	**TAS R6 Local Dispatch**	**TAS PP**	**BLINK Avg Flow**	**BLINK PSR**	**BLINK NSR**	**# NSR**
2B_145	**Proposed FOS (48-52Hz), 145MW Contingency**						
2009-10	$2.85	41.50	$29.27	-93.07	$8,147,050	-$1,396,638	6,296
2010-11	$3.66	43.30	$29.71	-123.78	$8,062,688	-$1,809,939	6,460
2011-12	$1.90	40.23	$25.12	-110.15	$7,844,516	-$1,161,600	6,145
2B_160	**Proposed FOS (48-52Hz), 160MW Contingency**						
2009-10	$5.01	44.43	$30.69	-76.48	$8,078,128	-$2,490,256	6,655
2010-11	$5.92	46.18	$31.22	-109.02	$7,796,694	-$3,088,990	6,829
2011-12	$2.34	42.56	$25.06	-97.84	$7,725,046	-$1,242,417	6,353
2B_175	**Proposed FOS (48-52Hz), 175MW Contingency**						
2009-10	$15.63	48.63	$37.45	-49.65	$7,858,629	-$7,880,344	7,416
2010-11	$15.97	49.96	$38.55	-82.99	$7,182,643	-$9,260,044	7,535
2011-12	$3.60	44.94	$25.31	-85.91	$7,697,801	-$1,554,709	6,637
2B_190	**Proposed FOS (48-52Hz), 190MW Contingency**						
2009-10	$45.18	57.26	$62.25	16.70	$6,738,516	-$30,851,800	9,547
2010-11	$44.25	57.63	$61.02	-25.37	$6,480,172	-$30,108,526	9,374
2011-12	$5.26	47.80	$26.36	-72.19	$7,667,982	-$2,659,623	6,940
2B_Opt	**Proposed FOS (48-52Hz), Optimal Alinta Dispatch**						
2009-10	$2.63	42.79	$28.21	-70.68	$8,272,625	-$1,587,838	4,648
2010-11	$3.30	57.63	$28.66	-104.86	$7,819,635	-$2,245,901	5,001
2011-12	$2.07	47.80	$24.07	-88.36	$7,756,285	-$1,278,976	4,606

Figure 5.5 – Optimal Dispatch Generation Duration Curve

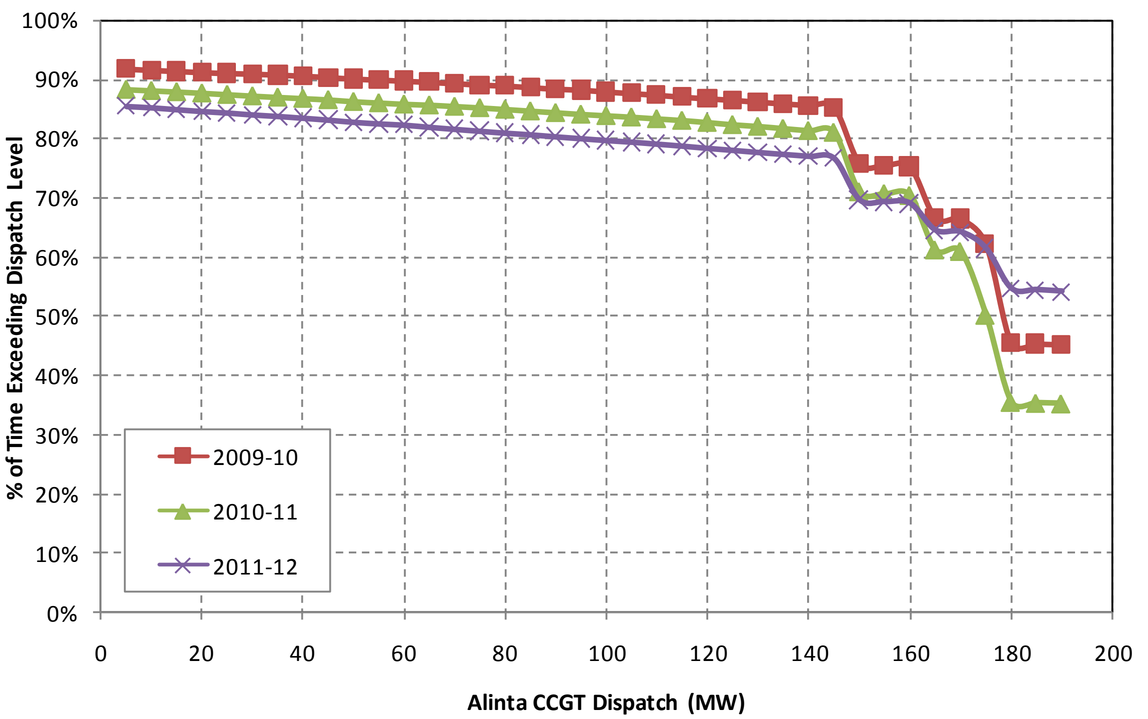
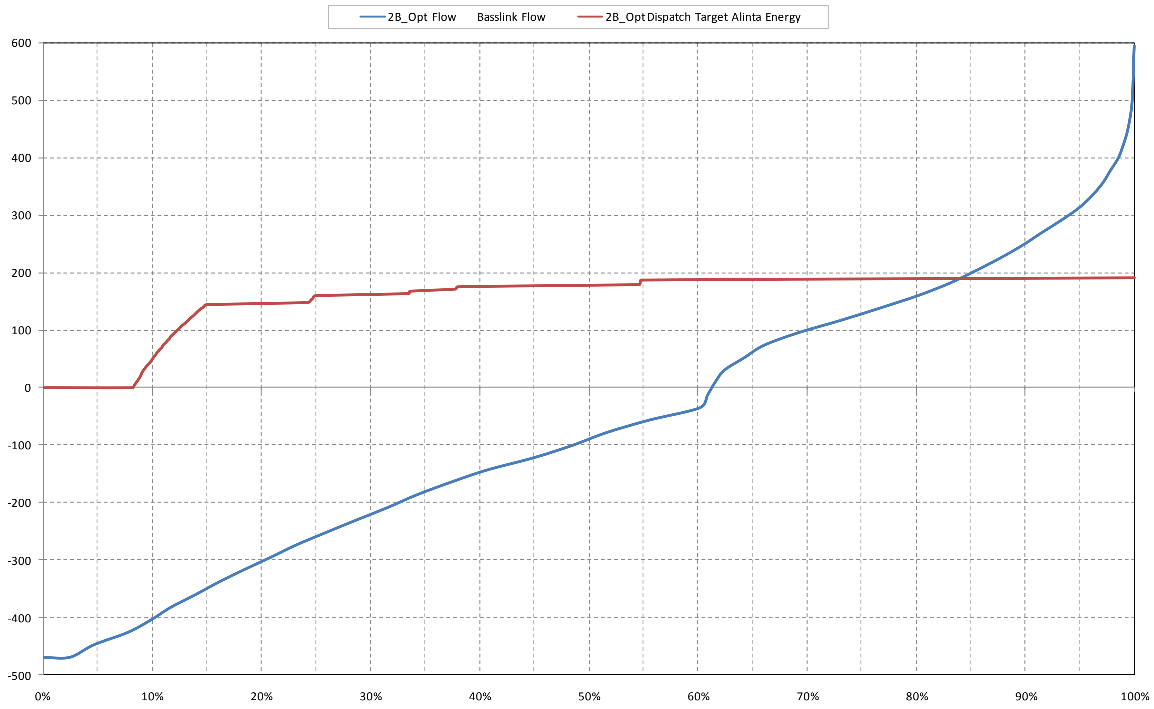


Figure 5.6 – Basslink and Alinta CCGT Duration (Optimal CCGT Dispatch, 2009-10)



6) CONCLUSIONS

6.1) GENERAL OVERVIEW

Generally, the proposed frequency operating standard change and introduction of the initial large thermal generator in the Tasmania region is a short term transient problem. Implementation of the frequency standard change will facilitate entry of future thermal generators which will provide diversity in the Tasmania energy supply, fully mitigating the short term implications. Assumed new entry of the Gunns cogeneration facility (or any other significant thermal generation development) will provide supporting FCAS raise and lower services, in addition to lowering the contingency requirement due to the significant provision of inertia.

The results show that the market cost of implementing the frequency operating standard change is small, (Status Quo Scenario 1A to 1B). This results in some uplift to the FCAS R6 prices at times of scarcity, but otherwise does not have a large impact on market costs in general, nor does it create any significant problems with Basslink being trapped in FCAS provision.

Dispatching a larger single generator of up to 210MW causes significant market distortion, increasing FCAS R6 average price and costs by a factor of up to 30. The significantly increased FCAS contingency requirement causes Basslink to be trapped exporting at high levels to enable R6 import into Tasmania. This in turn leads to very high NSR's on Basslink and furthermore the higher energy production required from Tasmania generators to support the Basslink export raises Energy prices by 2 to 3 times.

Dispatch of a larger single generation unit however can be managed in the Tasmania system through controlled dispatch at times of low demand or shortages of FCAS raise services provision. For the period preceding new entry of a second significant thermal generation development, the analysis shows that the Alinta plant may provide the least cost of energy supply for the market at dispatch up to full load at times. Dispatch of up to 190MW is achievable without any self provision of FCAS in excess of 30% of the time. Such a base loaded generation will facilitate local firm supply under critical water shortages, allow building up of storages and also cover possible extreme events such as loss of Basslink for long periods of time.

6.2) FREQUENCY STANDARD CHANGE

The modelling results indicate that the proposed frequency standard poses no major issues with regards to market dispatch. The cost of provision of FCAS increases considerably, albeit remaining very small compared with the market as a whole. Basslink is not significantly constrained and the increase in negative settlement residues is only minor.

Although the frequency standard change results in a net increase in FCAS requirements, the benefits of the system inertia provided by the new thermal entry mitigate this considerably and the negative impacts on the Tasmanian system is likely outweighed by the additional capacity the Alinta CCGT and Gunns cogeneration facility will provide.

6.3) 210MW CONTINGENCY

The modelling results indicate that full dispatch of the CCGT prior to entry of a second large new entry generator has dramatic effects on the Tasmanian market, leading to severe negative settlement residues on Basslink and very large increases in the Tasmanian energy and fast raise ancillary service market costs.

Co-optimization of the CCGT's energy dispatch target with the R6 FCAS requirement was ineffective in mitigating this outcome. A system mechanism outside the market dispatch engine would appear to be initially required to limit the largest unit online to an 'optimal' dispatch level at times. Future new entry, particularly the Gunns development is likely to significantly reduce the requirement for such a mechanism however.

One of the reasons co-optimisation is ineffectual is that there is no cost associated with transferring FCAS across Basslink. Extending MNSP transport offers to the FCAS markets may provide a tool to mitigate the Tasmanian R6 requirement.

Appendix A) General Observations of the Frequency Standard Change Issue

Table A.1 below provides a summary of the total cost of the NEM energy and eight FCAS markets for the 2007 calendar year. The analysis shows that in 2007 the total energy supply cost was in the order of 200 times to total cost of all FCAS markets. With the total FCAS market equating to 0.5% to 1% of the energy market, the possible impact on energy prices due to implementing (or more importantly *not* implementing) changes to the Tasmania Frequency Standard may be significantly higher than costs associated with the FCAS markets.

Table A.1 – 2007 Energy and FCAS Market Cost, Calendar 2007 ($)[13]

REGION	NSW1	QLD1	SA1	SNOWY1	TAS1	VIC1	Total
Lower 5	152,947	3,665,680	715,996	7,474	1,213,183	1,558,379	7,313,657
Lower 60	33,139	2,322,707	8,899	340	1,299,603	26,200	3,690,887
Lower 6	7,510	3,841,597	4,474	0	1,527,690	8,755	5,390,025
Raise 5	2,569,009	2,238,029	1,264,686	2,273,556	2,880,471	5,595,558	16,821,308
Raise 60	633,879	313,403	1,768,984	69,682	1,266,376	2,417,858	6,470,181
Raise 6	2,368,252	2,233,487	2,365,050	505,424	4,325,255	4,612,507	16,409,974
Lower Reg	668,550	464,372	411,276	59	398,159	239,984	2,182,398
Raise Reg	1,685,712	1,507,558	1,314,447	303,101	1,123,640	635,879	6,570,336
FCAS Total ($)	**8,118,996**	**16,586,831**	**7,853,810**	**3,159,633**	**14,034,375**	**15,095,119**	**64,848,763**
Energy ($m)	**5,956**	**3,750**	**866**	**26**	**600**	**3,607**	**14,805**

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[13] Based on a calculation of public dispatch records, volume times price for each service.

Appendix B) Co-optimisation of FCAS Requirements

Co-optimisation was evaluated as a proposed solution to relating the dispatch of the CCGT and the fast raise requirement imposed on the Tasmanian system. Although nonlinear, the Tasmanian FCAS requirements for loss of the CCGT given a specific demand and inertia may be represented as a piecewise linear function. In practice, co-optimisation is observed to have a minimal effect in managing Basslink negative settlement residue and FCAS market costs.

Although counterintuitive, this outcome is the result of limitations in the co-optimisation of the energy and FCAS markets in a system which pays the marginal cost of supply to all suppliers. In essence, minimising the objective function is *not* the same as minimising actual system costs.

A typical case in which co-optimisation may be expected to improve the solution is when Basslink is trapped exporting counter-price due to a high Tasmanian R6 requirement. Consider the incremental system change to a reduction in dispatch from the largest Tasmanian unit. Although the local Tasmanian FCAS requirement would decrease, the actual FCAS dispatch is unlikely to change at all. Indeed, the LP objective function cost will increase, as the mainland generator replacing the Alinta CCGT generation must have a higher marginal cost (or it would have already been at full dispatch). Why does this outcome occur?

The global R6 requirement is typically at least 400MW. Given that in this situation Basslink is constrained to import FCAS, much of this R6 capacity is dispatched in the mainland regions. MNSPs have no ability to bid for FCAS transfer, and thus the only cost to using the already enabled mainland R6 FCAS is to dispatch enough Tasmanian generation to force the counter-price flow.

As such, decreasing the Alinta CCGT output only decreases the Tasmanian R6 *requirement*, not the R6 *dispatch*. As the requirement is met by Basslink importing already dispatched mainland R6 service, there is no FCAS saving associated with the reducing the CCGT output.

To demonstrate this effect, assume a Tasmanian pool price of $100/MWh, a mainland spot price of $50/MWh, the CCGT bidding 210MW at $15/MWh, Basslink flowing north and the R6 requirement being equal to the dispatch of the CCGT, with 160MW of R6 service available in Tasmania. With or without co-optimisation, Basslink will be constrained to at least 100MW northward to support the Tasmanian R6 requirement.

Any reduction in the CCGT's output will be met with an increase in mainland generation; in settlement this is generally desirable so long as the mainland spot price does not increase, as the Tasmanian spot price is much higher. Assuming no change in spot prices, the saving is $100 - $50 + cost saving in decreasing Basslink losses, or settlement costs reduce by ~$50 per MW CCGT generation is scaled back.

The objective function of a linear program is representative of a 'pay-as-bid' system however, and cannot contain spot prices or settlement costs. The linear program optimisation sees the saving associated with reducing the CCGT's output as the CCGT bid price less the cost of replacement generation, or $15 - $50 + cost saving in decreasing Basslink losses ~= -$35. As reducing the CCGT output clearly does not improve the objective function, the co-optimisation process will have no effect on dispatch in this case.

Note that co-optimisation may however change the marginal cost (and thus the spot price) of the R6 FCAS. Without the co-optimisation the marginal cost of the Tasmanian R6 requirement is the cost of forcing more counter-price flows. i.e. the cost of increasing the output of the marginal Tasmanian generator and decreasing the output of the marginal mainland generator, or $100 - $50 + increased Basslink losses ~= $50. The R6 FCAS price in this situation is set by energy bids.

In the co-optimisation case, the increased requirement may also be met by decreasing CCGT generation and increasing the output of the marginal Tasmanian generator. As the reduction in FCAS requirement may be significantly larger than the reduction in CCGT output – especially in low load periods, this can act to reduce R6 pricing.

Appendix C) Key Forecasting Outcomes

	$/MW	$/MW	$/MW	MW	$	$/MWh	MW	$	$	# T.I.'s	# T.I.'s	# T.I.'s	GWh	$m	$/MW
	R5	R60	R6	TAS R6 Local Dispatch	R6 Cost	TAS PP	BLINK Avg Flow	BLINK PSR	BLINK NSR	# NSR	#PF NSR	#NF NSR	Alinta Energy	Alinta Pool Rev. ($m)	Total Tas Costs
0A	**Present FOS (47.5-53Hz), 144MW Contingency (No new entry)**														
2009-10	$0.62	$0.52	$2.21	37.77	$961,815	$33.17	-198.54	$16,160,257	-$1,240,971	5,873	984	4,889	0	0	$345,653,344
2010-11	$0.63	$0.53	$3.12	39.21	$1,445,188	$33.94	-222.02	$18,620,832	-$1,464,676	5,626	837	4,789	0	0	$359,739,556
2011-12	$0.66	$0.53	$2.46	38.60	$1,005,836	$31.39	-243.97	$23,115,132	-$1,221,900	5,072	773	4,299	0	0	$336,322,124
0B	**Proposed FOS (48-52Hz), 144MW Contingency (No new entry)**														
2009-10	$0.62	$0.53	$4.64	42.20	$2,783,362	$34.37	-196.70	$16,467,519	-$1,953,225	5,998	1,182	4,816	0	0	$358,837,475
2010-11	$0.64	$0.53	$7.45	43.46	$3,734,569	$37.21	-216.33	$18,972,694	-$3,988,075	5,872	1,163	4,709	0	0	$390,940,196
2011-12	$0.66	$0.54	$4.57	42.93	$2,757,713	$32.13	-242.89	$23,518,074	-$1,531,384	5,132	884	4,248	0	0	$345,297,672
1A	**Present FOS (47.5-53Hz), 144MW Contingency (210MW baseload capacity)**														
2009-10	$0.62	$0.48	$1.37	30.84	$530,106	$27.26	-45.39	$7,675,626	-$926,377	5,748	1,586	4,162	1,632	47	$275,748,494
2010-11	$0.63	$0.50	$1.67	33.13	$681,486	$27.23	-81.99	$6,335,391	-$1,111,363	6,027	1,530	4,497	1,544	45	$283,952,196
2011-12	$0.64	$0.48	$1.31	30.41	$476,228	$23.97	-73.89	$7,371,215	-$1,103,539	5,822	1,753	4,069	1,431	38	$252,114,027
1B	**Proposed FOS (48-52Hz), 144MW Contingency (210MW baseload capacity)**														
2009-10	$0.62	$0.49	$1.66	34.62	$774,008	$27.31	-44.79	$7,685,670	-$940,820	5,836	1,717	4,119	1,634	47	$276,528,547
2010-11	$0.63	$0.50	$2.26	36.95	$1,159,849	$27.52	-80.61	$6,331,462	-$1,250,685	6,115	1,669	4,446	1,547	46	$287,074,327
2011-12	$0.64	$0.49	$1.47	34.00	$603,032	$24.02	-73.23	$7,373,945	-$1,104,978	5,878	1,855	4,023	1,432	38	$252,723,563
2A	**Present FOS (47.5-53Hz), 210MW Contingency**														
2009-10	$0.72	$0.51	$37.67	56.27	$25,904,908	$62.10	38.12	$6,865,880	-$32,438,737	9,761	7,785	1,976	1,654	110	$641,894,389
2010-11	$0.73	$0.53	$38.90	56.80	$26,806,015	$62.42	-3.57	$6,323,695	-$33,129,883	9,635	6,976	2,659	1,543	109	$653,937,106
2011-12	$0.71	$0.51	$6.24	45.67	$4,286,593	$28.22	-53.96	$7,443,233	-$4,836,305	7,192	3,465	3,727	1,502	47	$297,546,459

	$/MW	$/MW	$/MW	MW	$	$/MWh	MW	$	$	# T.I.'s	# T.I.'s	# T.I.'s	GWh	$m	$/MW
	R5	**R60**	**R6**	**TAS R6 Local Dispatch**	**R6 Cost**	**TAS PP**	**BLINK Avg Flow**	**BLINK PSR**	**BLINK NSR**	**# NSR**	**#PF NSR**	**#NF NSR**	**Alinta Energy**	**Alinta Pool Rev. ($m)**	**Total Tas Costs**
2B	**Proposed FOS (48-52Hz), 210MW Contingency**														
2009-10	$0.72	$0.53	$54.81	63.46	$37,633,000	$78.61	77.87	$6,373,088	-$53,899,732	11,064	9,855	1,209	1,680	140	$810,372,432
2010-11	$0.74	$0.55	$58.64	64.11	$38,680,488	$81.91	39.22	$5,685,281	-$57,930,162	11,209	9,381	1,828	1,570	141	$863,564,069
2011-12	$0.71	$0.52	$8.58	51.31	$6,655,400	$30.27	-47.69	$7,433,119	-$6,907,286	7,525	3,922	3,603	1,509	51	$319,940,897
2B_145	**Proposed FOS (48-52Hz), 145MW Contingency**														
2009-10	$0.64	$0.51	$2.85	41.50	$1,717,444	$29.27	-93.07	$8,147,050	-$1,396,638	6,296	2,101	4,195	1,127	35	$302,612,722
2010-11	$0.65	$0.52	$3.66	43.30	$2,198,316	$29.71	-123.78	$8,062,688	-$1,809,939	6,460	1,863	4,597	1,077	34	$313,824,690
2011-12	$0.67	$0.51	$1.90	40.23	$958,621	$25.12	-110.15	$7,844,516	-$1,161,600	6,145	2,042	4,103	1,030	29	$268,570,002
2B_160	**Proposed FOS (48-52Hz), 160MW Contingency**														
2009-10	$0.66	$0.51	$5.01	44.43	$3,444,480	$30.69	-76.48	$8,078,128	-$2,490,256	6,655	2,657	3,998	1,245	40	$316,058,596
2010-11	$0.66	$0.52	$5.92	46.18	$3,978,719	$31.22	-109.02	$7,796,694	-$3,088,990	6,829	2,406	4,423	1,186	40	$328,129,774
2011-12	$0.68	$0.51	$2.34	42.56	$1,385,833	$25.06	-97.84	$7,725,046	-$1,242,417	6,353	2,412	3,941	1,140	32	$267,345,800
2B_175	**Proposed FOS (48-52Hz), 175MW Contingency**														
2009-10	$0.67	$0.51	$15.63	48.63	$13,428,606	$37.45	-49.65	$7,858,629	-$7,880,344	7,416	3,806	3,610	1,362	54	$391,891,019
2010-11	$0.68	$0.52	$15.97	49.96	$12,373,852	$38.55	-82.99	$7,182,643	-$9,260,044	7,535	3,463	4,072	1,293	55	$410,141,272
2011-12	$0.69	$0.51	$3.60	44.94	$2,791,674	$25.31	-85.91	$7,697,801	-$1,554,709	6,637	2,782	3,855	1,244	35	$270,135,107
2B_190	**Proposed FOS (48-52Hz), 190MW Contingency**														
2009-10	$0.70	$0.53	$45.18	57.26	$36,910,164	$62.25	16.70	$6,738,516	-$30,851,800	9,547	7,111	2,436	1,490	99	$661,955,081
2010-11	$0.71	$0.54	$44.25	57.63	$35,557,746	$61.02	-25.37	$6,480,172	-$30,108,526	9,374	6,354	3,020	1,400	95	$654,273,708
2011-12	$0.70	$0.52	$5.26	47.80	$4,604,458	$26.36	-72.19	$7,667,982	-$2,659,623	6,940	3,234	3,706	1,346	40	$281,446,115

	$/MW	$/MW	$/MW	MW	$	$/MWh	MW	$	$	# T.I.'s	# T.I.'s	# T.I.'s	GWh	$m	$/MW
	R5	R60	R6	TAS R6 Local Dispatch	R6 Cost	TAS PP	BLINK Avg Flow	BLINK PSR	BLINK NSR	# NSR	#PF NSR	#NF NSR	Alinta Energy	Alinta Pool Rev. ($m)	Total Tas Costs
2B_Opt	**Proposed FOS (48-52Hz), Optimal Alinta Dispatch**														
2009-10	$0.65	$0.51	$2.63	42.79	$1,560,416	$28.21	-70.68	$8,272,625	-$1,587,838	4,648	2,126	4,648	1,371	41	$287,626,860
2010-11	$0.66	$0.52	$3.30	57.63	$1,882,675	$28.66	-104.86	$7,819,635	-$2,245,901	5,001	1,897	5,001	1,290	40	$298,867,864
2011-12	$0.68	$0.51	$2.07	47.80	$1,176,729	$24.07	-88.36	$7,756,285	-$1,278,976	4,606	2,061	4,606	1,278	34	$254,693,979