WA Independent Market Operator

Audit and Certification of the WA Wholesale Electricity Market Systems

5 October 2006

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FOREWORD

The Wholesale Electricity Market Rules of Western Australia require that the Independent Market Operator (IMO) have an independent auditor certify the software systems used in operating the market. It has also been decided that System Management (SM) will also have an independent auditor certify the System Management Market Information Technology System, to be carried out in conjunction with the certification of IMO's market system. Both of these market systems are near complete and approaching readiness for market start.

PA Consulting were engaged to undertake these certifications and carried out the certification process between 28th May 2006 and 7th August 2006, with retesting and certification of failed items concluded prior to market commencement. This document represents the full report on the certification process and certification outcomes up to the commencement of the market on 21 September 2006. Two separate documents have been issued to IMO and SM providing respective system certification.

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1. INTRODUCTION

1.1 ABOUT THIS REPORT

The certification process assesses whether the mathematical formulations of the Western Australia wholesale electricity market systems has been correctly implemented so that the energy and reserve dispatch schedules and related prices and settlement values are correctly calculated with respect to the Wholesale Electricity Market Rules[1] (the Rules) and associated Market Procedures (the Procedures).

Within the certification process are those calculations codified in the Rules and incorporated within IMO's electricity market systems, referred to as the IMO Market Systems, as well those incorporate within SM Market Information Technology Systems, referred to as SMMITS.

The certification process, tests and results are documented in this report. This document is divided into a number of sections in the following manner:

- Section 1 Introduction – sets out the structure of this document and provides an overview of the approach adopted in conducting the certification
- Section 2 Overview – provides an overview of the key findings from the certification process and provides a summary of the certification tests and test outcomes
- Section 3 Details of SMMITS review – provides the detail of the test scenarios and cases used for the certification of the SMMITS systems along with the test results and issues noted (if any)
- Section 4 Details of Reserve Capacity system – as per Section 3 but covering IMOs reserve capacity systems
- Section 5 Details of Energy System Review – as per Section 3 but covering IMOs energy market systems including SMITS
- Section 6 Details of Settlement System Review – as per Section 3 but covering IMOs settlement systems
- Appendices – providing supporting documentation including details of reference documents and test data used.

1.2 APPROACH TAKEN TO TESTING THE MARKET SOFTWARE

Our principal approach to testing market software centres on testing one feature at a time using one or more simple test cases for each feature. We seek to isolate the specific feature being tested by disabling as many other features as possible and/or constructing the data so that a minimal set of features is active in each test. The software is then run to produce a set of results. Verification of the software results is generally conducted using one, or commonly both, of the following methods:

1. Directly comparing the results to our understanding of the formulation. This may involve answering questions such as: Are the appropriate constraints binding? Does the set of calculations change as we expect when input values are altered

[1] Version 2.5 (refer Appendix A for further details)

and the software is re-run? Does the software make optimal trade-offs between alternative resources, given their costs and associated constraints?

2. In many cases, we construct spreadsheet models of the specific case. The spreadsheet model may perform a set of calculations (such as pre-processing of data or quantity allocations, as defined by the formulation), or it may include an optimisation procedure designed to replicate a portion of the software's formulation.

If we are able to verify the software results in the cases being tested, then we can confirm that the software is performing according to its design.

In addition, to the tests using our test model, as needed and as appropriate, we also examined and verified the set of tests that had been conducted by IMO in their own software testing programme.

For the IMO software PA did not verify the accuracy of the meter data or other data collected and processed prior to the calculations performed by the software modules.

Although each test is designed to verify a specific model feature or attribute, other attributes or features are also verified simultaneously. This degree of crossover between tests enhances the audit coverage, and hence provides a higher level of confidence in the software. The software examined under this portion of the trial was ABB's Sable software market system and Navita's settlement system.

For the Market Systems software of IMO, the input data for every test case is stored so that each case can be reconstructed at a later time, if required.

For the SMMITS software of System Management (SM), we limited our tests to those obligations defined in the market Rules that relate directly to the conduct of the new energy market and hence have the potential to impact the fair and accurate operation of the market[2].

While many of SM's obligations have been incorporated within the newly developed SMMITS system, some important obligations include manual steps conducted outside SMMITS. As a result, for the purposes of this review we have extended our tests to incorporate those manual steps where these are part of an overall set of activities otherwise supported by SMMITS. For this reason we adopted a 'black box' test approach, were we drew a boundary around an identifiable set of business processes for each of the rules obligations, and structured our tests to confirm that any set of given inputs would produce outcomes consistent with our expectation, regardless of whether the arrangements used by SM to derive the outcome were fully or only partially supported by SMMITS. It should be noted that all references made in the balance of this document to 'SMMITS' is taken to mean both the new software system (known as SMMITS) as well as the set of manual steps conducted outside SMMITS but which are part of the solutions supported by SMMITS.

System Management performed all the SMMITS-related cases to test scenarios and scripts prepared by PA. Input data and test results were subsequently provided to PA for analysis.

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[2] The Rules place many obligations on SM that relate more specifically to the operation of the power system rather than the electricity market. Further, SM uses SMMITS and other systems to support both its market and system operation functions. This review only

2. EXECUTIVE SUMMARY

2.1 OVERVIEW

PA Consulting we contracted to conduct the independent certification of the systems used by the IMO and SM to support their respective roles in the operation of the new wholesale electricity market planned to go live in Q3 2006. This certification process was conducted between May and August 2006 using Version 2.5 of the Wholesale Electricity Market Rules and the then current releases of the respective software systems. Items that failed the initial certification process were retested and certified as fixes were released, with this report representing the position at the point of market commencement on 21 September 2006.

The focus of the certification was to confirm that the computations undertaken by the IMO and SM systems were conducted correctly and in accordance with a reasonable interpretation of the Rules. To conduct this certification PA devised a number of tests structured around each area of interest, and then compared the test results with an expected set of outcomes. Where differences were noted, these were investigated and recommendations put forward. Recommendations were at times to alter the Rules where the Rules were in error, and at other times to amend the software when, in our opinion and with the support of IMO, it breached the intent of the Rules.

Certification is then issued only on the basis that no software errors of material note are present at the time of issuing the certificate. In some cases a 'conditional' certification will be issued on the provision that defined corrective actions are implemented prior to market start (eg the amendment of Rules to remove an ambiguity).

2.2 CERTIFICATION RESULTS

The result of our certification process has concluded the following certification for the systems under review:

- ***Independent Market Operator Market Systems – Full Certification***
- ***System Management systems – Conditional Certification*** on the basis that the following issues are addressed prior to market start:
  - That the systems used to derive replacement settlement meter data (i.e. State Estimator and EGC meter data) are separately certified prior to their use in the live market

A summary of the tests and findings for these systems in provided in Sections 2.2.1 and 2.2.2.

2.2.1 Compliance of the IMO Market Systems

The software systems covered by this section of the review include:

- The Reserve Capacity system
- The Energy Market systems (including STEM)
- The Settlements systems

Our tests indicated that the IMO Market Systems generally produced answers consistent with the market Rules under operating conditions that could be reasonably expected to

occur over the life of the market. While several issues where identified during the course of the certification, all were satisfactorily addressed by the IMO and confirmed acceptable during retesting.

2.2.2 Compliance of SMMITS

Our tests indicated that the SMMITS system generally produced answers consistent with the market Rules under operating conditions that could be expected to occur over the next few years.

During the certification process we were unable to test two software systems due to their lack of readiness, and hence our certification does not currently extend to these areas. The two systems were:

- the State Estimator, as used to prepare replacement generation settlement data, and
- the EGC derived meter data system, as used to prepare replacement generation settlement data

Also, we observed a number of issues that resulted in the awarding of either a 'conditional' or 'Inconclusive' assessment on some of the tests. These tests produced result that were inconsistent with the market Rules but which in themselves were not considered sufficiently material in effect to justify a 'failed' status and hence redress prior to the commencement of the market (although we would recommend correction before market start where this can be done). A summary of these items is provided in the table in Section 2.3 with details provided in Chapters 3 along with recommended actions and timeframes.

Of the set of issues observed, the following are the most significant:

i. Application of Loss Factor adjustment ambiguous

The Rules define 'Loss Factor adjusted' as the multiplication of an energy quantity by any applicable loss factor. This is only correct when adjusting a quantity to the Reference Node. When adjusting away from the reference node to derive say a 'sent our quantity', the quantity must be divided by the loss factor. The rules are currently imprecise in this area and open to interpretation and potential misuse. This said, all instances of Loss Factor adjustment performed by SM were conducted correctly.

Recommendation: tighten up the definition of 'Loss Factor adjusted' in the Rules.

ii. Determination of Ancillary Services quantities calculated annually

SM use predetermined values and profiles calculated on an annual basis in determining the quantity of Load Following, Spinning Reserve and Load Rejection. While the Rules don't preclude such an arrangement being used, the Rules do presume that SM will be in a position to produce accurate ancillary service levels at all times. The current arrangements would not be able to assure this position. However, for the range of conditions the SM expects to encounter over the first year of the new market it is likely the current arrangements will produce a reasonably correct answer.

Recommendation: Consideration should be given by SM to bolstering the arrangements used to initiate the recalculation of ancillary service requirements (which may include

automating the calculation of ancillary service requirement to calculate on a more real time basis)

iii. Market Procedure for selecting between ancillary service providers during dispatch are not defined

Under the Rules SM is required for each Trading Day to prepare a list of facilities that it may call on to provide ancillary services. Neither the Rules nor the Power System Operations Procedures currently define how the facilities are to be selected and as such SM uses 'experience' to select between facilities. At market start the current arrangement may not be overly problematic as the only generation facilities participating in the ancillary service market are those of the EGC. Hence the SM is not open to unfairly distributing the burden or rewards of supply beyond the EGC. This situation will change when other market participants become ancillary service providers, at which time the criteria for selecting between providers will need to be more openly defined and fair in application.

Recommendation: Develop and document arrangements for the selection of facilities for ancillary service provision (which is arguably already an obligation on SM to document in the Power System Operations Procedures). This should be done prior to non-EGC generation providers offering their services to the Market.

2.3 SUMMARY OF TESTS CONDUCTED

This section provides a summary for the full set of tests conducted on the IMO and SM systems along with our conclusion of the tests. This detail is provided in tabular form and covers:

- The features of Market Systems and SMMITS software which have been tested
- The nature of the tests conducted
- A statement of conclusion, being either:
  - PASS, meaning the test returned the expected result (i.e. consistent with our interpretation of the Rules)
  - FAIL, meaning the test didn't return the expected result and that this unexpected result was likely to have a material effect on the market outcomes
  - CONDITIONAL, meaning the test didn't return the expected result but that the unexpected result was unlikely to have a material effect on the market outcomes. The conditional status is given on the provision that the corrective action put forward is accepted and implemented within the proposed timeframes
  - INCONCLUSIVE, meaning that either the test didn't produce an outcome (eg where the system in question was not yet functional), or where the Rules themselves are ambiguous and hence allow for multiple outcomes. In any case, further testing is recommended in these situations prior to the systems being used in the live market.

System	Subject		Conclusion	Comment
SMMITS	Load Forecasts	Test 1: Produce a morning load forecast	PASS	
		Test 2: Produce an afternoon Load Forecast; updated to reflect weather and actual demand conditions	PASS	
		Test 3: Estimate the MWh quantity of energy that can be called to meet Ancillary Service Requirements	PASS	
SMMITS	Settlement Data and Ancillary Service Requirements	Test 4: Operational System Load Estimate	PASS	
		Test 5: Quantity of non-compliance by the Electricity Generation Corporation (EGC)	PASS	
		Test 6: Energy dispatched under a Balancing Support Contract	PASS	
		Test 7: Schedule of energy output of a generating system. Verification and Cleansing of missing settlement data	CONDITIONAL	Subject to satisfactory testing of State Estimator and EGC meter data systems.
		Test 8: The estimated decrease in the output of each Non-Scheduled Generator	INCONCLUSIVE	Arrangements for calculating decrease not defined at time of audit.
		Test 9: The required decrease in consumption of each Curtailable Load	PASS	
SMMITS	PASA	Test 10: MT PASA Study	CONDITIONAL	Subject to satisfactory confirmation of Load Forecast methodology when published.
		Test 11: ST PASA Study	CONDITIONAL	As above.
Market Systems	Reserve Capacity	Test RC1: Maximum Reserve Capacity Price	PASS	
		Test RC2: Base case for testing the Reserve Capacity algorithm	PASS	
		Test RC3: Cascading Capacity through Availability Classes.	PASS	
		Test RC4: The most expensive offer not being needed.	PASS	
		Test RC5: Uncleared offer cascaded down to class 4	PASS	
		Test RC6: Tie-break on status	PASS	

		Test RC7: Tie break on Capacity	PASS	
		Test RC8: tie break 1 offer time	PASS	
		Test RC9: Valid Exchange	PASS	
		Test RC10: Exchange of existing	PASS	
		Test RC11: Maximum Price Cap	PASS	
		Test RC12: Overall shortfall	PASS	
		Test RC13 - zero clearing price:	PASS	
		Test RC14 mutually exclusive1	PASS	
		Test RC15- mutually exclusive2	PASS	
		Test RC16 - no auction	PASS	
		Test RC17 - bilateral tiebreak	PASS	
Market Systems	STEM & Non-STEM	STEM ST1: Base Case	PASS	
		STEM ST2: Under contracted	PASS	
		STEM ST3: Fully Contracted	PASS	
		STEM ST4: Undercontracted	PASS	
		STEM ST5; Price Curve Greater than / Less than Bilaterals.	PASS	
		STEM ST6: Multiple Clearing Quantities	PASS	
		STEM ST7: Multiple Optima Prices	PASS	
		STEM ST8: One Participant, Demand And Supply	PASS	
		STEM ST9: One Participant, Supply Only	PASS	
		STEM ST10: Base with Three Participants.	PASS	
		STEM ST11: Three Participants, (part II)	PASS	
		STEM ST12: Limit Tests	PASS	
		NST 1 Dispatch Merit Order	PASS	
		NST 2 Dispatch Instructions	PASS	
		NST 3 Administered Balancing Prices	PASS	
		NST 4 Reserve Capacity Obligation Quantities	PASS	
		NST 5: IRCR	PASS	

		NST 6: Loss Factors	PASS	
Settlement	Ancillary services Settlements	Test AS1: USHARE and Reserve Share	PASS	
		Test AS2: Reserve Cost Share	PASS	
		Test AS3 Availability Cost Spinning Reserve	PASS	
		Test AS4: Consumer Share	PASS	
		Test AS5: Load Following Share	PASS	
		Test AS6: Ancillary Services Settlement Amount	PASS	
Settlement	STEM Settlement	Test SS1: Calculating STEM Settlement Amounts	PASS	
Settlement	Reserve Capacity Settlement	Test RCS1: Calculating Reserve Capacity Settlement Amount for Supply	PASS	
		Test RCS2: Calculating Reserve Capacity Settlement Amount for Demand	PASS	
		Test RCS3: Calculating Reserve Capacity Refund Settlement Amount	PASS	
		Test RCS4: Calculating Reserve Capacity Rebates and Offsets	PASS	
Settlement	Balancing Settlement	Test BS1: Authorised Deviation Settlement Amounts	PASS	
		Test BS2: Authorised Deviation Settlement Amounts for Western Power	PASS	
		Test BS3: Unauthorised Deviation Settlement Amounts	PASS	
		Test BS4: Resource Plan Deviation Settlement Amount	PASS	
		Test BS5: Dispatch Instruction Settlement Amounts	PASS	
Settlement	Other Settlement	Test OS1: Commitment and Outage Settlement Amount	PASS	
		Test OS2: Non-Compliance Charge Settlement Amounts	PASS	
		Test OS3: Reconciliation Settlement Amount	PASS	
		Test OS4: Network Control Service Settlement Amount	PASS	
		Test OS5: Market Fee Settlement Amount	PASS	
		Test OS6: Intermittent Loads	PASS	

3. DETAILS OF SMMITS REVIEW

This section describes the tests that were performed on SM market information system (SMMITS).

While SM have developed the SMMITS system to support its role in the new electricity market, SMMITS itself does not perform all the necessary functions required of the market, with SM relying on a set of software applications (including SMMITS, METRIX, SEECOM, etc), electronic devices (eg SCADA), and manual processes to satisfy its obligations under the Rules.

The use of manual processes, while not explicitly problematic, can introduce variability to test results through the human operation. Our certification is focussed predominately on the ability of the 'system' to produce an expected outcome for a given set of inputs and over a limited set of test runs. By intent we only test each piece of software to the point where it produces the expected outcome. As such any variability in the result that may flow from the manual intervention will only be seen to the extent that the variability has resulted in an incorrect answer being produced. Where the correct answer is produced first time, we will have no visibility of the variability of the manual process. This point is made to highlight the purpose and limitation of the certification audit as it applies to the SM systems.

Further, while consideration was given to limiting the certification audit to only those functions codified in software, the reality is that much of the computational work required of the Rules involves manual steps, making any such tests rather meaningless. For this reason we chose to conduct what we refer to as a 'black box' test, where we developed test cases and test scenarios around the Rules requirements, and then had SM run these tests through their 'systems' to produce a set of outcomes. We separately verified these outcomes to confirm whether they were as expected.

For the purpose of convenience we divided the test program into the following three reasonably discrete process areas:

- Dispatch Load Forecasts & Ancillary Service Requirements
- Preparation of Settlement Data for IMO
- Preparation of Short Term & Medium Term PASA

The audit details for each of these process areas in provided in the following Sections.

3.1 LOAD FORECASTS AND ANCILLARY REQUIREMENTS

This section details the tests and test results used to confirm that load forecasts and ancillary service requirements produced by SM comply with Section 7.2 of the Rules. To test these requirements three sets of tests involving several different scenarios was prepared to produce the morning and afternoon load forecast and to determine Ancillary Service Requirements for Load Following and Spinning Reserve for a given Trading Day.

The three tests covered:

- Confirmation that the morning Load Forecast could be produced [Rules, Section 7.2.1(a)] – Test 1
- Confirmation that the afternoon Load Forecast could be produced taking into account changed weather, load and generation data [Rules, Section 7.2.1(b)] – Test 2

- Confirmation that the loss factor adjusted MWh of energy that could be called on to provide ancillary services could be calculated [Rules, Section 7.2.3A(a)] – Test 3
- Confirmation that a list of Facilities that SM might call on to provide ancillary services could be produced [Rules, Section 7.2.3A(b)] – Not tested[3].

For each test, test scenarios were devised and variables defined to achieve a set of test outcomes. These outcomes were then compared against independently derived outcomes to confirm the validity of test result.

By necessity, the test scenarios were largely structured around confirming the systems worked as expected rather than confirming the precision of the outcomes. This was necessary because the Rules in this area generally don't provide sufficient detailed methodology (in either the Rules or associated Power System Operations Procedures) to enable the accuracy of the values to be validated. As a result the aim of the tests was to simply observe that outputs such as the Load Forecasts behaved in a largely predictable manner when subjected to various input changes. Further, in the case of the requirements for Load Rejection, there was insufficient information in the Rules to prepare any meaningful tests for this requirement.

3.1.1 Test 1: Produce a morning load forecast

Purpose: To determine whether the Load Forecast represents Non-Dispatchable Load, Curtailable Load and Interruptible Load net of forecast Non-Scheduled Generation; predicts values for both MWh and MW total demand for each Trading Interval in the Trading Day; and be Loss Factor adjusted to the Reference Node.

Conclusions: PASS
The load forecast can be provided in the format specified in the Rules. The forecast is produced for the 48 Trading Intervals, is loss factor adjusted correctly, is supplied in both MW and MWh, and is produced with a reasonable (albeit unknown) level of accuracy.

Issues to resolve:

- The methodology for determining the Load Forecast is not included in the Rules or Power System Operations Procedures hence we could not independently confirm the validity of the forecast values
- System Management is providing a peak value of MW where an average or end of trading period figure was expected (the peak value being some 30MW greater than the average value). The Rules don't specify if this value is to be a peak, mean, min or max value of any trading period, although in the absence of any specific requirement it is reasonable to assume the figure represents an average or mean value.

3.1.2 Test 2: Produce an afternoon Load Forecast; updated to reflect weather and actual demand conditions

Purpose: To determine whether the afternoon Load Forecast can reflect any revised weather forecasts; higher or lower actual demand than predicted; and higher or lower Non-Scheduled Generation than predicted.

[3] The methodology for selecting facilities did not exist at the time of preparing this report. No tests could be undertaken as a result.

The tests required SM to prepare a morning load forecast which was used as the base case, and the to further prepare a number of afternoon forecasts based on the following changes in condition:

- setting the temperature 4 degrees higher and lower from a base case, to simulate the effect of temperature;
- setting the actual demand to be lower than predicted; and
- setting Non-Scheduled Generation to be lower than a base case.

Conclusions: PASS
There was an observed difference in the load forecast as a result of temperature changes. There was also an observed difference in the load forecast after it was adjusted to accommodate a decrease in actual load and verified that load forecast went up when Non-Scheduled generation was reduced.

Issues to resolve: None

We do note however that SM have interpreted the Rules to mean that the morning load forecast is not revised for the afternoon unless there has been a 'material' change in either the weather forecast, actual demand or non-scheduled generation. The definition of 'material' change is not documented and the decision to produce a revised forecast is largely a manual one left to the discretion of the operator on duty. As such we could expect some degree of variability in the accuracy of the afternoon Load Forecast as the result of a decision not to update, although just how significant this variability is has not be established.

3.1.3 Test 3: Estimate the MWh quantity of energy that can be called to meet Ancillary Service Requirements

Purpose: To test that the estimated MWh quantity of energy required for Ancillary Services is produced in accordance with the standards specified in 3.10 of the Market Rules.

Conclusions:

- Load Following: PASS
  - Verified that Load Following values submitted by SM meet the Ancillary Standards set by the Rules.
  - Verified that it is the greater of 30 MW and the capacity sufficient to cover 99.9% of the short term fluctuations in load and out of Non-Scheduled Generators and uninstructed output fluctuations from Scheduled Generators.
- Spinning Reserve: PASS
  - Verified that under normal operating conditions, SM calculates correct levels of spinning reserve
  - Verified that the MWh quantities are calculated correctly and loss factor adjusted

- Load Rejection: UNABLE TO TEST[4]

Issues to resolve:

- Load Following:
  - The 99.9% figure [Rules, Section 3.10.1(a)ii] is manually re-calculated by SM once a year. The Rules don't mandate a more frequent occurrence but it would be reasonable to expect SM to be able to recalculate the requirements whenever the underlying conditions change. Under the current market conditions the results produced were correct but under any other conditions the answer may be incorrect.
- Spinning Reserve:
  - The use of 'templates' for setting spinning reserve levels do not handle partial plant outages, which are accommodated by SM through the manual preparation of new profiles on an as-needs basis. Under normal system operating conditions SM is able to derive the correct answer, but under abnormal operating conditions the levels of spinning reserve requirement is likely to be less accurate. A review of a small sample of actual generation outputs from the two largest generation units showed that the 'actual' deviated from the 'template' quite significantly, particularly during the off peak period, providing anecdotal evidence that the templates are less than accurate.
  - Values for ramp rates are based on experience. In the absence of a documented procedure we were unable to validate the ramp rate.
  - The Rules [Section 3.10.2(a)] specify Spinning Reserve standards to be the greater of 70% of the total output and the maximum load ramp. The SM spreadsheet formula is currently MAX(E11,F11)*0.7 and should be MAX(E11*0.7, F11)
- Load Rejection:
  - Unable to verify that Load Rejection Reserve meets standards due to a lack of documented methodology.

3.2 SETTLEMENT DATA (PROVIDED BY SM)

System Management is required to provide the IMO with a range of settlement data. Five separate tests were developed to verify SMs calculations from the input data provided and to confirm that the settlement data can be produced in compliance with the Rules. These include checks on the application of Loss Factors and the conversion of units.

The five tests covered:

- Confirmation that the Operation System Load Estimate could be produced [Rules, Section 7.13.1(a)] – Test 4
- Confirmation that the quantity of non-compliance by EGC could be calculated [Rules, Section 7.13.1(cA)] – Test 5
- Confirmation that the energy dispatched under a Balancing Support Contract could be calculated [Rules, Section 7.13.1(dA)] – Test 6

[4] The requirement in the Rules is not sufficiently defined for any meaningful tests to be developed

- Confirmation that the MWh output of each generator could be calculated from SCADA system under a variety of conditions where SCADA data may be erroneous [Rules, Section 7.13.1(cC) & Power System Operating Procedure, Verification of Generation Facility MWh output data] – Test 7
- Confirmation that estimated decrease in MWh of the output of each Non-Scheduled Generator can be calculated [Rules, Section 7.13.1(eB)] – Test 8
- Confirmation that the required decrease in consumption in MWh of each Curtailable Load can be calculated [Rules, Section 7.13.1(eC)] – Test 9

3.2.1 Test 4: Operational System Load Estimate

Purpose: To test that the Operational System Load Estimate is the total Loss Factor adjusted MWh consumption supplied via the SWIS.

Conclusions: PASS
The operational load estimate included all generation points on the SWIS, was the 'sent out' energy value, was correctly Loss Factor adjusted, and provided in MWh for each of the 48 trading intervals.

Issues to resolve: None

3.2.2 Test 5: Quantity of non-compliance by the Electricity Generation Corporation (EGC)

Purpose: To determine whether non-compliance by an individual EGC facility is picked up only when it deviates from the System Management instruction by greater than 10MW. The test also validated that the unit conversion was applied correctly.

Conclusions: PASS
System Management was able to detect a deviation in excess of the allowable threshold of 10MW and correctly calculate a MWh quantity associated with that deviation.

Issues to resolve: The detection process was manual and required the on duty System Operator to log a deviation when it was observed. The reliability of this detection and logging process is, by definition, very dependant on the view, attitude and knowledge of the operator on duty at the time. Consideration should be given to making this process less dependent on manual intervention.

3.2.3 Test 6: Energy dispatched under a Balancing Support Contract

Purpose: To determine whether the MWh energy dispatched under a Balancing Support Contract is produced correctly for each Trading Interval in the Trading Day by Facility.

Conclusions: PASS
The total energy dispatched under Balancing Support Contracts can be calculated correctly from the sum of individual dispatch instructions for a Facility.

Issues to resolve: None

3.2.4 Test 7: Schedule of energy output of a generating system. Verification and Cleansing of missing settlement data

Purpose: To determine whether SM can prepare settlement ready data by energy output per Trading Interval per Generator. The test to confirm that raw SCADA data can be mapped correctly to a generating system, that any unit conversion is applied correctly, and that a suitable process for verifying and correcting missing data is applied.

To test the verification and cleansing of missing settlement data, different runs were performed for the same Trading Day to validate a number of scenarios:

- Base case – raw SCADA data received; data without missing or erroneous content
- Minor Deviation – raw SCADA data removed for part of a Trading Interval
- Major Deviation – SCADA data removed for 24 Trading Intervals; State Estimator used to supply replacement data
- Major Deviation – SCADA data removed for 24 Trading Intervals; EGC provided meter data used for replacement data

Conclusions: CONDITIONAL PASS
System Management was able to identify bad raw SCADA data – for both minor and major deviations – and override bad data as required to prepare a settlement ready file. A visual check was conducted to confirm that SMMITS database tables are populated with the corrected data.

This is a conditional pass pending the following concerns being addressed:

- The State Estimator and EGC meter data systems/process were not functional at the time of conducting this review. These systems need to be validated prior to market start.
- The Procedure titled 'Verification of Generation Facility MWh output data' was in early draft format with no formal version number or version control at the time of conducting this review. The full set of requirements imposed by this Procedure need to be further validated prior to market start.

Issues to resolve:

The draft version of the 'Verification of Generation Facility MWh output data' procedure imposes a requirement on SM to declare generation output data as 'provisional' where this data has been subjected by SM to 'substantial' changes. Two of our test scenarios should have triggered this declaration but failed to do so. It would appear this functionality is yet to be completed, probably due to the early and unofficial status of the draft procedure. We would recommend that once the procedure is finalized, that the requirements are further validated.

3.2.5 Test 8: The estimated decrease in the output of each Non-Scheduled Generators

Purpose: To test that SM can prepare a settlement statement of the MWh energy output per Non-Scheduled Generator, per Trading Interval as a result of Dispatch Instructions.

Conclusions: INCONCLUSIVE.
SMs systems can identify each instance when a Non-Scheduled generator has been instructed to reduce output, and it can log the instructed value of this decrease. However, the methodology for calculating the output that would have been produced in the absence of the dispatch instruction, which is set out in the Dispatch Procedure, is not in itself prescriptive, instead providing four alternatives for deriving a prescriptive methodology. At the time of conducting this review, none of the four alternatives had been defined in a prescriptive form, and as such none could be validated.

Issues to resolve: The expected frequency of a non-scheduled generator being instructed to reduce output is low (suggested to be less than once per year) hence the need for this functionality at market start is probably low. Further, when an occurrence does occur, it is likely that a suitable methodology could be agreed and the calculation conducted quite quickly. The need to have at least one methodology detailed prior to market start would be advantageous, although in our opinion not absolutely necessary.

3.2.6 Test 9: The required decrease in consumption of each Curtailable Load

Purpose: To test that SM can prepare a settlement statement of the MWh required decrease in consumption of Curtailable Load, in MWh, by Trading Interval as a result of Dispatch Instructions.

Conclusion: PASS
The calculation of the decrease in consumption of Curtailable load based on a dispatch instruction is correct.

Issues to resolve: None

3.3 PASA

System Management is obligated to produce a Short Term and Medium Term PASA study at defined intervals. Two sets of test were developed to validate these requirement, covering:

- Confirmation that load, generation and shortfall capacities for the short term PASA study could be calculated correctly [Rules, Section 3.16.9] – Test 10
- Confirmation that load, generation and shortfall capacities for the medium term PASA study could be calculated correctly [Rules, Section 3.17.9] – Test 11

SM prepares this information using a combination of SCADA data, off line study tools, spreadsheets and manual processes. At the time of conducting this review SM were unable to run the two set of test prepare by PA, so for the purpose of this review we have re-used the results of an earlier test conducted by SM. In this case, we have collected both the raw input data used by SM along with the resultant outputs, and then independently validated the two sets of data together.

3.3.1 Test 10: MT PASA Study

Purpose: To verify that the MT PASA study is complete, and where SMMITS is performing computations, confirm that they are calculated correctly. In particular to confirm that the:

- study includes the peak load forecasts for the following scenarios:
  - mean;

  - mean plus one standard deviation; and
  - mean plus two standard deviations.

- forecast total available generation capacity is calculated correctly
- forecast total available Demand Side Management capacity is calculated correctly given the input data
- calculation of the shortfall (as defined in 3.16.9(d)) is correct given the input data
- report identifies periods where there is an expected shortfall of capacity; that the Capacity Planning Margin for those weeks is negative.

The Rules/Procedures do not require the methodology for determining the Peak Load Forecast to be published until the release of the first PASA study after market start. At the time of conducting this review the methodology had not been finalised nor had the supporting systems been completed. As a result we were unable to independently confirm that the methodology is correctly supported by the systems under a range of possible scenarios. We did however confirm that the Load Forecast results produced for a single 'realistic' scenario were reasonable.'

Conclusions: CONDITIONAL PASS
Confirmed that Load Forecast appears reasonable given the input data. Confirmed that a mean, plus 1 and 2 standard deviations could be correctly calculated. Confirmed that available generation and Demand Side Management capacities could be correctly retrieved from standing data, and that shortfall margins could be correctly calculated.

Issues to resolve: A pass has been issued here on the condition that SM further validates that the Load Forecast is consistent with the final methodology to be published with the first PASA report under a range of reasonably expected network scenarios.

3.3.2 Test 11: ST PASA Study

Purpose: To verify that the ST PASA study is complete, and where SMMITS is performing computations, confirm that they are calculated correctly. In particular to confirm that the:

- study includes the peak load forecasts for the following scenarios:
  - mean;
  - mean plus one standard deviation; and
  - mean plus two standard deviations.
- forecast total available generation capacity is calculated correctly by six-hour period given the input data.
- forecast total available Demand Side Management capacity is calculated correctly by six-hour period given the input data
- calculation of the shortfall (as defined in 3.17.9(d)) is correct given the input data
- the report identifies six-hour periods where there is an expected shortfall of capacity; that the Capacity Planning Margin for those weeks is negative.

Conclusions: CONDITIONAL PASS
Verified that data is provided for each of the 6-hour intervals covering the 21 days of the ST PASA horizon. Verified that Unsecured Capacity Margin is correct based on the

calculation of expected shortfall defined in the Rules. Verified that the required information specified in the Rules are included in the spreadsheet.

Remainder of comments provided for MT PASA (above) apply to ST PASA.

Issues to resolve: A pass has been issued here on the condition that SM further validates that the Load Forecast is consistent with the final methodology to be published with the first PASA report under a range of reasonably expected network scenarios.

4. DETAILS OF RESERVE CAPACITY SYSTEMS REVIEW

This section describes the tests that were performed on Reserve Capacity Systems along with the test results and relevant commentary. A total of 16 tests, each comprising multiple test scenarios, were conducted on the system.

4.1.1 Test RC1: Maximum Reserve Capacity Price

Purpose: To verify that the software correctly calculates the Maximum Reserve Capacity Price

Conclusions: PASS
The calculations for this parameter are correct. See Appendix C1.

Issues to be resolved: The test of the formula found two minor wording errors in parts of the calculation not used in setting the value of the Maximum Reserve Capacity Price.

4.1.2 Test RC2: Base case for testing the Reserve Capacity algorithm

Purpose: To test for the case where there is sufficient supply of certified capacity for all classes to meet the requirement of that class.

Conclusions: PASS

RC2	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	All Bilateral Trades accepted, as expected.
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, no shortfalls.
Auction Requirements	Yes	Excesses cascaded through each availability class correctly
Auction Clearing	Yes	All offers accepted, as expected
Reserve Cap Price	Yes	Set by the highest price offer accepted
Exchange Offers	Yes	No exchanges possible

Issues to resolve: None

4.1.3 Test RC3: Cascading Capacity through Availability Classes.

Purpose: Excess supply of certified capacity in class 1, enough so that in the auction its last offer will cascade through to cover all other classes.

Conclusion: PASS

RC3	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	All Bilateral Trades accepted, as expected.
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, no shortfalls.
Auction Requirements	Yes	Extra 30 MW's cascaded through all availability classes, so that there was no requirement in classes 2,3 and 4. This was the intention of the test.

Auction Clearing	Yes	All the class 1 offers were accepted. None were accepted for 2,3,4. This is as expected.
Reserve Cap Price	Yes	Set by the highest price offer accepted.
Exchange Offers	Yes	No exchanges possible as all offers were accepted in class 1.

Issues to resolve: None

4.1.4 Test RC4: The most expensive offer not being needed.

Purpose: The data is the same as Test RC3, but is modified to test the solution with an increase in the capacity offered in class 1 resulting in the most expensive offer not being needed to meet the requirement.

Conclusion: PASS

RC4	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	All Bilateral Trades accepted, as expected.
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, no shortfalls.
Auction Requirements	Yes	Small excess from marginal unit cascaded correctly.
Auction Clearing	Yes	In Class 1 the most expensive offer was not accepted, due to the auction requirement being met with all other offers. Offers in 2,3,4 were cleared, but the most expensive remained uncleared as its offer price was higher than any of these offers.
Reserve Cap Price	Yes	Set by the highest price offer accepted
Exchange Offers	Yes	Exchange was not allowed as excess was less than 100 MW.

Issues to resolve: None

4.1.5 Test RC5: Uncleared offer cascaded down to class 4

Purpose: The data is the same as Test RC3, but is modified so that the uncleared offer from class 1 is accepted in class 4.

Conclusion: PASS

RC5	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	All Bilateral Trades accepted, as expected.
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, no shortfalls.
Auction Requirements	Yes	Small excess from marginal unit cascaded correctly.

Auction Clearing	Yes	In Class 1 the most expensive offer was not accepted, due to the auction requirement being met with all other offers. Offers in 2,3 were cleared, but plant remained uncleared as its offer price was higher than these offers. the expensive facility was then cleared in 4 as its offer price was lower than other facilities in that class. This was the intention of the test.
Reserve Cap Price	Yes	Set by marginal plant a class 1 offer but accepted in class 4
Exchange Offers	Yes	No exchanges allowed as excess was less than 100 MW.

Issues to resolve: None

4.1.6 Test RC6: Tie-break on status

Purpose: Tie break test - the purpose is to confirm that in a reserve capacity auction tie-break a facility with registered (existing) status is accepted before one with proposed (non-commenced) status.

Conclusion: PASS

RC6	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	All Bilateral Trades accepted, as expected.
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, no shortfalls.
Auction Requirements	Yes	Small excess the marginal unit after tie breaking, was cascaded correctly.
Auction Clearing	Yes	In Class 1 two facilities had the same offer price. Two tied facilities on the first criterion One was a registered (operating) facility and the other only a proposed facility (non-commenced). Had the tie-break been made on the next criterion (decreasing order of capacity) the proposed facility would have been accepted first. This was the intention of the test. The proposed facility was then correctly cleared ahead of a higher priced one in class 4.
Reserve Cap Price	Yes	Set by the highest priced offers accepted,
Exchange Offers	n/a	Not tested here. An exchange between two facilities looks to be feasible and desirable. See test RC8.

Issues to resolve: None

4.1.7 Test RC7: Tie break on Capacity

Purpose: Tie break test - the purpose is to confirm that in an reserve capacity auction tie-break a facilities with the same status are accepted in decreasing order of capacity.

Conclusion: PASS

RC7	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	All Bilateral Trades accepted, as expected.
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, no shortfalls.
Auction Requirements	Yes	Small excess was cascaded correctly.
Auction Clearing	Yes	A tie-break occurred in class 4 between two facilities who were both offered in at the same price. The first criterion did not resolve the tie-break (both were registered facilities), so one at 30 MW, was accepted ahead of one at 29 MW, on the second criterion - decreasing order of capacity. This was the intention of the test. It would appear to confirm that availability class does not play a role in the tie-break, as a class 4 was accepted ahead of a class 1, which is in accordance to the rules.
Reserve Cap Price	Yes	Set by the highest priced offer accepted
Exchange Offers	Yes	No exchanges allowed as excess was less than 100 MW.

Issues to resolve: None

4.1.8 Test RC8: tie break 1 offer time

Purpose: Tie break test - the purpose is to confirm that in a reserve capacity auction tie-break a facilities with the same status, capacity and expression of interest inclusion are accepted in order of the time of offers received, with the earlier offer being taken first.

Conclusion: PASS

RC8	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	All Bilateral Trades accepted, as expected.
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, no shortfalls.
Auction Requirements	Yes	Small excess was cascaded correctly.

Auction Clearing	Yes	In Class 1 a facility was not accepted as the requirement was met with lower price offers. A tie-break then occurred in class 4 between two facilities who were both offered in at the same price. The first criterion did not resolve the tie-break (both were registered facilities), the second criterion also did not resolve (both offered same MW) and the third criterion did not resolve (expression of interest). So the offers were cleared using the fourth criterion - in order of the time of offers received, with the earlier offer being taken first. The offer for the accepted facility was submitted first.
Reserve Cap Price	Yes	Set by the highest priced offer accepted
Exchange Offers	Yes	No exchanges allowed as excess was less than 100 MW.

Issues to resolve: None

4.1.9 Test RC9: Valid Exchange

Purpose: Test of a valid exchange. This is a repeat of test 5 but with the manual exchange performed after the auction.

Conclusions: PASS

RC9	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	See test 5
Auction Cap/Shortfall	Yes	See test 5
Auction Requirements	Yes	See test 5
Auction Clearing	Yes	See test 5
Reserve Cap Price	Yes	See test 5 - exchange did not effect this, despite a higher price offer being substituted in. This is as expected.
Exchange Offers	Yes	Manual exchange was performed, This was allowed as the excess capacity was greater than 100 MW. The total value was reduced (see below).
Total Value Before:		$117,442,800
Total Value After:		$102,610,800
Decrease in Total Value:		$ 14,832,000
Due to the decrease in total value the exchange is desirable		

Issues to resolve: None

4.1.10 Test RC10: Exchange of existing facilities

Purpose: Test of an exchange where a registered (existing) facility would be excluded. The rules state this is not allowed - but we are unclear whether this is their intention.

Conclusions: PASS

RC10	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	All Bilateral Trades accepted, as expected.
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, no shortfalls.
Auction Requirements	Yes	Small excess from marginal unit was cascaded correctly.
Auction Clearing	Yes	In Class 1 the facility is not required. It is accepted in class 4. This is as expected/intended.
Reserve Cap Price	Yes	Set by the highest priced offer accepted
Exchange Offers	Yes	An exchange between two facilities was attempted. Both these facilities are registered (existing). With excess capacity and a decrease in total value the exchange would be feasible and desirable with the exception of the criterion (last bullet in Appendix 3 of the rules - page 410) that "not result in an existing facility...being excluded". The exchange was rejected on this criterion (see below) which complies with the strictest interpretation of the rules. It is unclear, however, if this was the intention of the rules (see calculation below).
Error Message when exchange attempted:	Can not change the modified status to No when the FACILITY_STATUS is 'R' or 'C' and the APPROVED_STATUS is 'YES'	

If the exchange was enforced	
Total Cost Before Exchange	$117,346,200
Total Cost After Exchange	$102,514,200
Compensation to M	$ 9,000
Total saving from exchange	**$ 14,823,000**

Issues to resolve: The software performed according to a strict interpretation of the Rules. This case shows the benefit of an interpretation (or Rule modification) that allowed a large existing plant to be replaced by a smaller existing plant – without creating shortfall.

4.1.11 Test RC11: Maximum Price Cap

Purpose: Test to confirm that the max price cap is being correctly implemented, with the marginal facility to be accepted offering above the maximum price cap.

Conclusions: PASS

RC11	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	All Bilateral Trades accepted, as expected.
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, no shortfalls.

Auction Requirements	n/a	Auction not run, due to offers not being accepted in the MPI
Auction Clearing	n/a	Auction not run, due to offers not being accepted in the MPI
Reserve Cap Price	n/a	Auction not run, due to offers not being accepted in the MPI
Exchange Offers	n/a	Auction not run, due to offers not being accepted in the MPI
Inputs	Yes	Offers of greater than the Maximum Reserve Capacity Price would not be accepted in the MPI. It was the intention of the test to find out how the software dealt with offers above the MRCP, and the result confirms that software deals with this situation in an acceptable manner.

Issues to resolve: None

4.1.12 Test RC12: Overall shortfall

Purpose: Test to see how the software handles the situation where an overall shortfall occurs due to insufficient offers to cover the class 1 requirement.

Conclusions: PASS

RC12	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	All Bilateral Trades accepted, as expected.
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, no shortfalls.
Auction Requirements	Yes	There was not enough offered to meet the auction requirement for class 1. Hence a capacity shortfall resulted. This was the intention of the test.
Auction Clearing	Yes	All offers were cleared in their own availability class. This is as expected.
Reserve Cap Price	Yes	Set by the highest priced offer accepted. The rules are silent on how the reserve capacity price should be set in the case of a shortfall, so this result complies with the market rules' default rule for setting the price after the auction.
Exchange Offers	Yes	

Issues to resolve: None

4.1.13 Test RC13 - zero clearing price:

Purpose: Test to see how the software handles the situation where there is a zero clearing price in the auction - and also confirm that all zero priced offers are accepted, even if not needed to meet the capacity requirement.

Conclusions: PASS

RC13	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	All Bilateral Trades accepted, as expected.
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, no shortfalls.
Auction Requirements	Yes	Excesses cascaded through each availability class correctly
Auction Clearing	Yes	All offers cleared. RIHIA was not required but because its price was zero it was cleared. This is in compliance with the market rules and is as expected.
Reserve Cap Price	Yes	Set at zero by highest price offer, as expected.
Exchange Offers	Yes	None possible, all offers cleared.

Issues to resolve: None

4.1.14 Test RC14 mutually exclusive1

Purpose: Test that the software correctly handles the case of mutually exclusive facilities where both are making bilateral trade submissions. The facility that is rejected, in accordance with the rules, should also have its auction offers removed from the set of active offers.

Conclusions: PASS

RC14	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	Bilateral trades not accepted as it was mutually exclusive with another which was accepted first under the first criterion in the rules that "Facilities that are operational or are under construction will be accepted ahead of other Facilities"
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, a shortfall existed in class 1 due to a bilateral and auction offers not being accepted
Auction Requirements	Yes	Excesses cascaded through each availability class correctly
Auction Clearing	Yes	One offer was not cleared despite its price being lower than two others This is because it was removed from the list of active offers when its bilateral trade's were rejected on the grounds that it was mutually exclusive with another and had a lower facility status.

Reserve Cap Price	Yes	Set by the highest accepted offer as expected despite shortfall - see test 11
Exchange Offers	Yes	None possible, all available offers cleared.

Issues to resolve: None

4.1.15 Test RC15- mutually exclusive2

Purpose: Test that the software correctly handles the case of mutually exclusive facilities where neither is making bilateral trade submissions. The auction should be run for every possible combination to give the lowest shortfall or if there is no shortfall then the lowest total cost.

Conclusions: PASS

RC15	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	Two facilities made no bilateral submission. NOTE: Could not submit zeroes, otherwise a 0 MW was accepted while another 0 MW wasn't and its offer was rejected. This is acceptable.
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, no shortfall existed.
Auction Requirements	Yes	Excesses cascaded through each availability class correctly. In the solution a facility cascades to cover classes 2 and 3, while another (class 3 facility) is accepted into class 4. The alternative solution had a different facility having enough capacity to cascade and cover classes 2,3 and 4.
Auction Clearing	Yes	A facility offer was not cleared despite its price being lower. This is because it was removed from the list of active offers when its bilateral trade's were rejected on the grounds that it was mutually exclusive with another and had a lower facility status.
Reserve Cap Price	Yes	Set by highest accepted offer alternative solution would have had a lower price of but a higher total cost (see calculation below).
Exchange Offers	n/a	None considered.

Issues to resolve: none

4.1.16 Test RC16 - no auction

Purpose: Test that the software correctly handles the case where bilateral trade declarations are sufficient to meet the entire capacity and no auction is required. Also confirm that all bilateral trades are accepted for facilities that are existing or under construction - without considering whether they are needed to meet requirement.

Conclusions: PASS

RC16	Correctly Implemented?	Comment

Bilateral Trade Clearing	Yes	All bilateral trades were accepted. These were enough to cover the reserve capacity requirement in all classes. Some facilities were not needed to meet the requirement - as there was enough bilateral trade capacity accepted in class 1 to cover all classes. However, in accordance with the rules all bilateral trades for facilities that are existing or under-construction were accepted regardless of the requirement. This result is as expected.
Auction Cap/Shortfall	Yes	No auction required as bilateral declarations sufficient to cover reserve capacity requirement in all availability classes.
Auction Requirements	Yes	Auction requirements correctly set to zero in all classes.
Auction Clearing	Yes	No auction required.
Reserve Cap Price	Yes	Reserve capacity price set to zero - no auction was held.
Exchange Offers	n/a	Not possible with no auction.

Issues to resolve: None

4.1.17 Test RC17 - bilateral tiebreak

Purpose: Test that the software correctly handles the case where a tie-break exists in the bilateral trade declarations. Two facilities that are not existing or under construction must make declarations that will be enough to meet the reserve capacity requirement.

Conclusions: PASS

RC17	**Correctly Implemented?**	**Comment**
Bilateral Trade Clearing	Yes	All bilateral trades for facilities that are existing or under construction were accepted. Two others were both only 'proposed', Each had enough to meet the total remaining reserve requirement and both had the same level of availability, hence a tie-break situation existed. We would expect the larger one to have been accepted on the first criterion in the rules for a bilateral trade tie-break, that facilities will be accepted in decreasing order of capacity. The result was as expected.
Auction Cap/Shortfall	Yes	No auction required as bilateral declarations sufficient to cover reserve capacity requirement in all availability classes.

Auction Requirements	Yes	Auction requirements correctly set to zero in all classes.
Auction Clearing	Yes	No auction required.
Reserve Cap Price	Yes	Reserve capacity price set to zero - no auction was held.
Exchange Offers	n/a	Not possible with no auction.

Issues to resolve: Tie breaking criterion needs to be corrected in the software (tie-breaking events are expected to be rare so this fault is not considered sufficiently material to declare it a Fail).

5. DETAILS OF ENERGY SYSTEMS REVIEW

This section describes the tests that were performed on the energy markets systems, both STEM and non-STEM systems, along with test results and recommendations where appropriate.

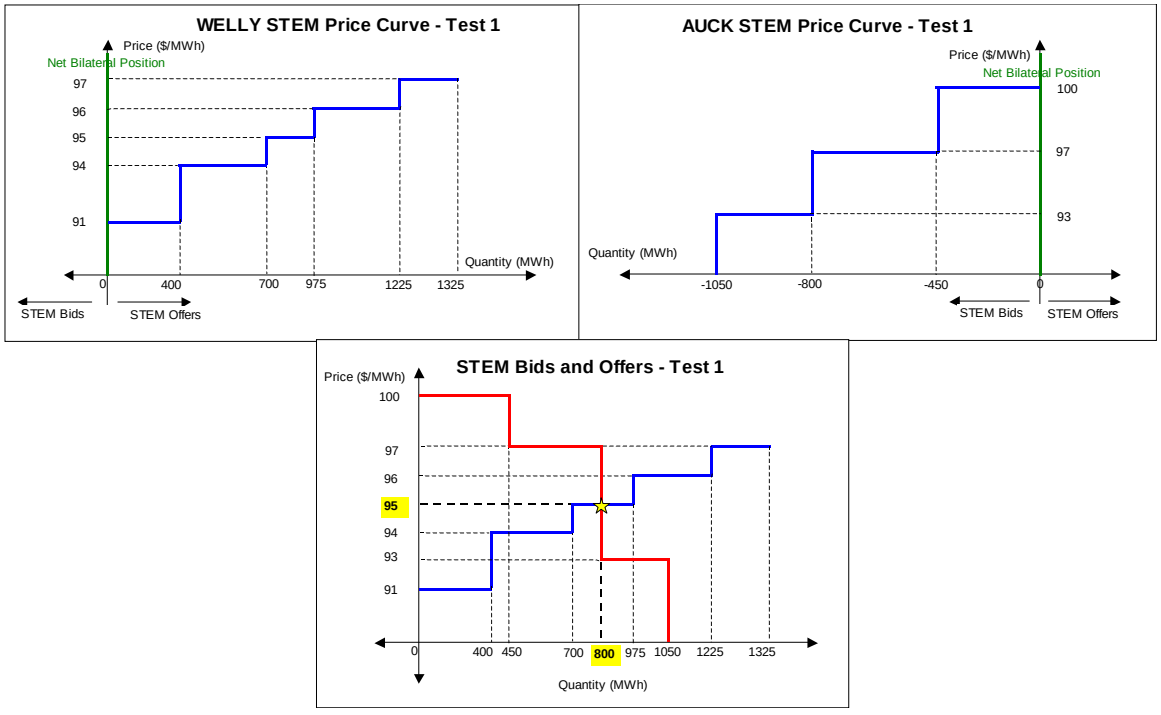
5.1 STEM MARKET

5.1.1 STEM ST1: Base Case

Purpose: Test STEM auction functions correctly with two participants - one with only supply and one with only demand. Neither participant has any bilateral contracts.

Conclusions: PASS

ST1	Correctly Implemented?	Comment
STEM bids and offers	Yes	All STEM bids are from customer AUCK, all STEM offers are from generator WELLY. They match supply and demand portfolio curves. As expected.
STEM Clearing Price	Yes	Clears at $95/MWh from where STEM offer and STEM bid curves intersect. As expected, and also where simple demand/supply intersect.
STEM Clearing Quantity	Yes	Clears at 800MWh from where STEM offer and STEM bid curves intersect. As expected, and also where simple demand/supply intersect.
Net Contract Position	Yes	AUCK increasing its consumption by 800/MWh giving net consumption of 800/MWh, WELLY increasing its suply by 800 MWh giving net generation of 800MWh. As expected.



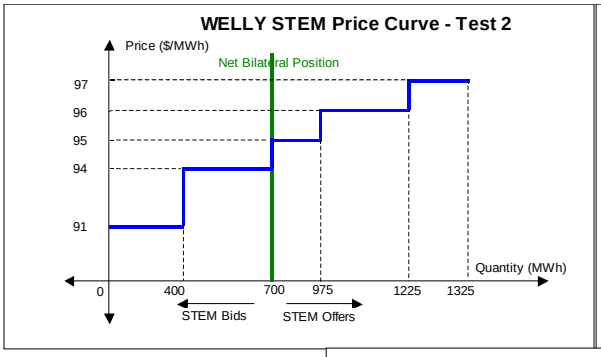
Issues to resolve: None

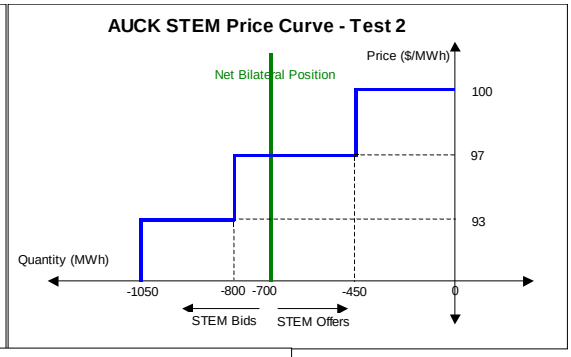
5.1.2 STEM ST2: Under contracted

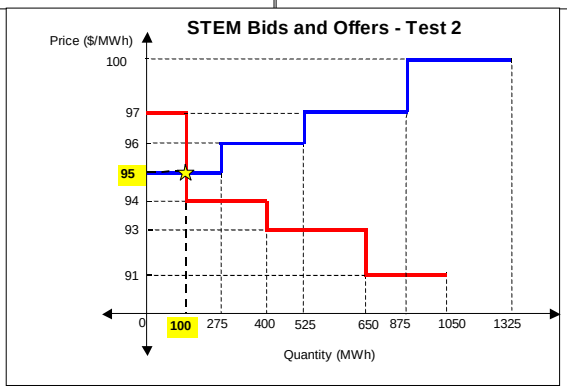
Purpose: Test STEM auction deals with an under contracted situation correctly. We have two participants - a generator and a customer with a bilateral contract between them. The generator is under contracted so seeks to sell additional quantity in the STEM. The customer is also under contracted so seeks to buy additional quantity in the STEM.

Conclusions

ST2	Correctly Implemented?	Comment
STEM bids and offers	Yes	The 700MW bilateral contract cuts the STEM price curves to determine the STEM bids and offers for each participant. For AUCK, all tranches below -700MWh on the STEM price curve become bids, and all above this become offers. For WELLY all tranches below 700MWh become bids, and above 700MWh become offers. As expected.
STEM Clearing Price	Yes	Clears at $95/MWh from where STEM offer and STEM bid curves intersect. As expected, and also where simple demand/supply intersect.
STEM Clearing Quantity	Yes	Clears at 100MWh from where STEM offer and STEM bid curves intersect. Also the difference between where simple demand/supply intersects (at 800MWh) and the contract position (at 700 MWh). As expected.
Net Contract Position	Yes	AUCK increasing its consumption by 100/MWh giving net consumption of 800/MWh, WELLY increasing its supply by 100 MWh giving net generation of 800MWh. Both participants were designed to be under contracted in this test, and they have traded in the STEM in order to compensate. As expected.







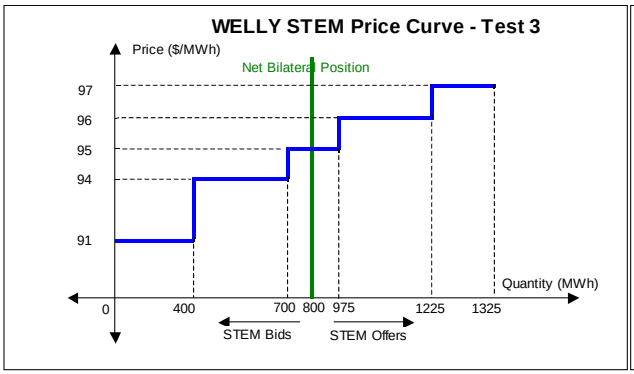
Issues to resolve: None

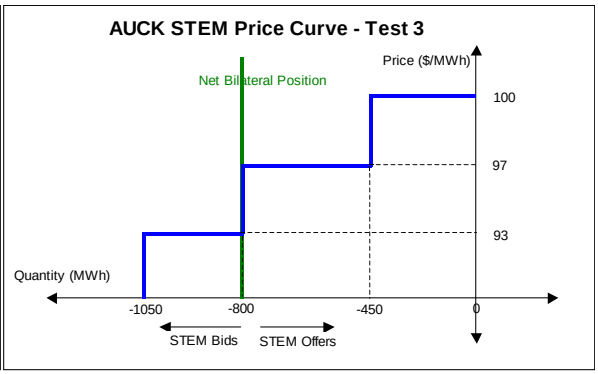
5.1.3 STEM ST3: Fully Contracted

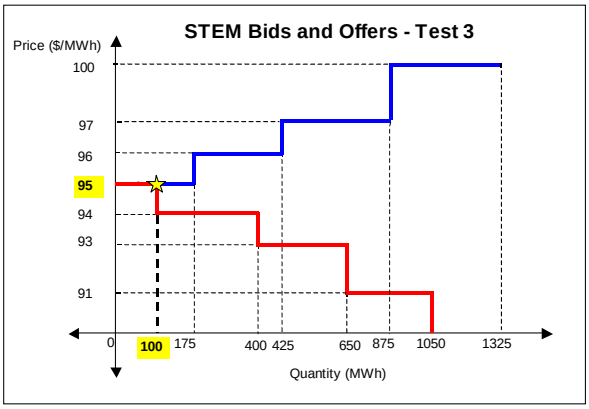
Purpose: Test STEM auction deals with an under contracted situation correctly. We have two participants - a generator and a customer with a bilateral contract between them. The generator and customer are both fully contracted so seek no trade in the STEM.

Conclusions: PASS

ST3	Correctly Implemented?	Comment
STEM bids and offers	Yes	The 800MW bilateral contract cuts the STEM price curves to determine the STEM bids and offers for each participant. For AUCK, all tranches below -800MWh on the STEM price curve become bids, and all above this become offers. For WELLY all tranches below 800MWh become bids, and above 800MWh become offers. As expected.
STEM Clearing Price	Yes	Clears at $95/MWh from where STEM offer and STEM bid curves intersect. As expected, and this is also where simple demand/supply intersect.
STEM Clearing Quantity	Yes	Clears at 100MWh from the max quantity where STEM offer and STEM bid curves intersect. The 100MWh value demonstrates a tie-break being performed in accordance with the rules - with the highest quantity being chosen. This 100 MWh trade is from WELLY to itself, so the net effect is zero for both participants. As expected.
Net Contract Position	Yes	No change in Net Contract position, as no energy traded between participants in the STEM. This was the intention of this test, where both participants are fully contracted. As expected.







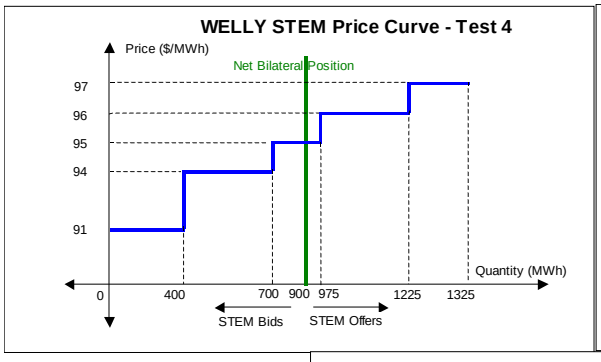
Issues to resolve: none

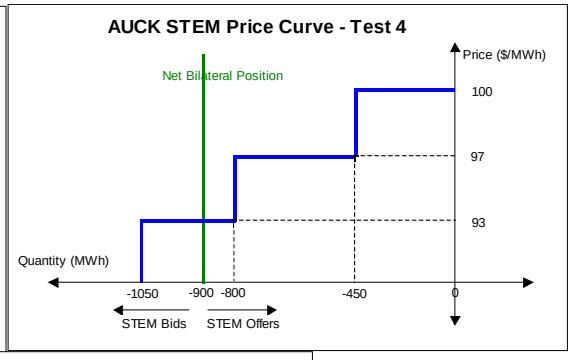
5.1.4 STEM ST4: Undercontracted

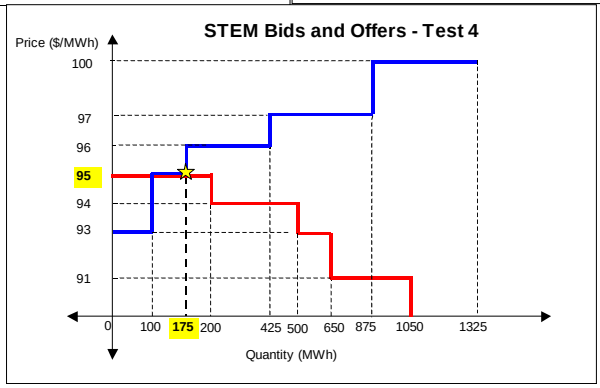
Purpose: Test STEM auction deals with an under contracted situation correctly. We have two participants - a generator and a customer with a bilateral contract between them. The generator is over contracted so seeks to buy quantity back in the STEM. The customer is also over contracted so seeks to sell quantity back in the STEM.

Conclusions: PASS

ST4	Correctly Implemented?	Comment
STEM bids and offers	Yes	The 900MW bilateral contract cuts the STEM price curves to determine the STEM bids and offers for each participant. For AUCK, all tranches below -900MWh on the STEM price curve become bids, and all above this become offers. For WELLY all tranches below 900MWh become bids, and above 900MWh become offers. As expected.
STEM Clearing Price	Yes	Clears at $95/MWh from where STEM offer and STEM bid curves intersect. As expected, and this is also where simple demand/supply intersect.
STEM Clearing Quantity	Yes	Clears 175MWh from the max quantity where STEM offer and STEM bid curves intersect. Tie-breaking has correctly chosen the max quantity. 75 MWh of this is a trade from WELLY to itself, so only 100 MWh is between participants - from AUCK to WELLY . As expected.
Net Contract Position	Yes	WELLY decreasing its generation by 100/MWh giving net generation of 800/MWh, AUCK decreasing its consumption by 100 MWh giving net consumption of -800MWh. Both participants were designed to be over contracted in this test, and they have traded in the STEM in order to compensate. As expected.







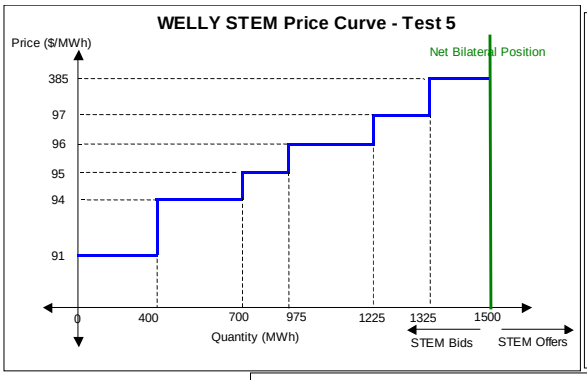
Issues to resolve: None

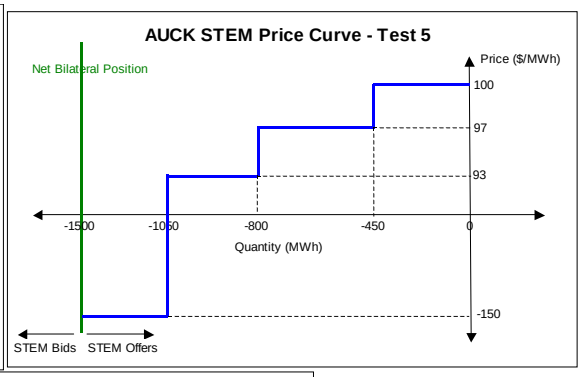
5.1.5 STEM ST5; Price Curve Greater than / Less than Bilaterals.

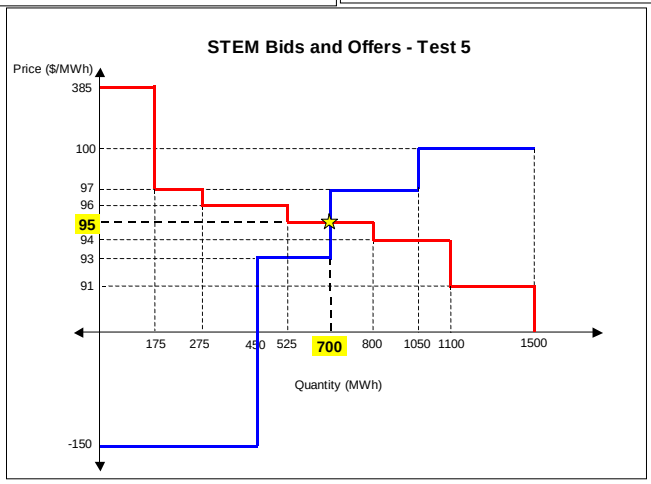
Purpose: Test that the software correctly extends the STEM price curves where the net bilateral position of the participant is less than its maximum quantity or greater than its maximum quantity.

Conclusions: PASS

ST5	Correctly Implemented?	Comment
STEM bids and offers	Yes	The 1500MW bilateral contract is greater than the max quantity on the demand curve or on the supply curve. For AUCK because all tranches of its STEM price curve are above -1500, an extra tranche is added at -$150 (the minimum price) to extend the AUCK price curve to -1500MWh. All tranches for AUCK become STEM offers. For WELLY all tranches on its STEM price curve are below 1500MWh so the price curve is extended to 1500MWh with an extra tranche added at the maximum price of $385. All tranches for WELLY become STEM bids. This was the intention of the test - to ensure that these extra tranches were added and implemented correctly. As expected.
STEM Clearing Price	Yes	Clears at $95/MWh from where STEM offer and STEM bid curves intersect. As expected, and this is also where simple demand/supply intersect.
STEM Clearing Quantity	Yes	Clears 700MWh, from where STEM offer and STEM bid curves intersect. As expected.
Net Contract Position	Yes	WELLY decreases its generation by 700/MWh giving net generation of 800/MWh, AUCK decreasing its consumption by 700 MWh giving net consumption of -800MWh. As expected.







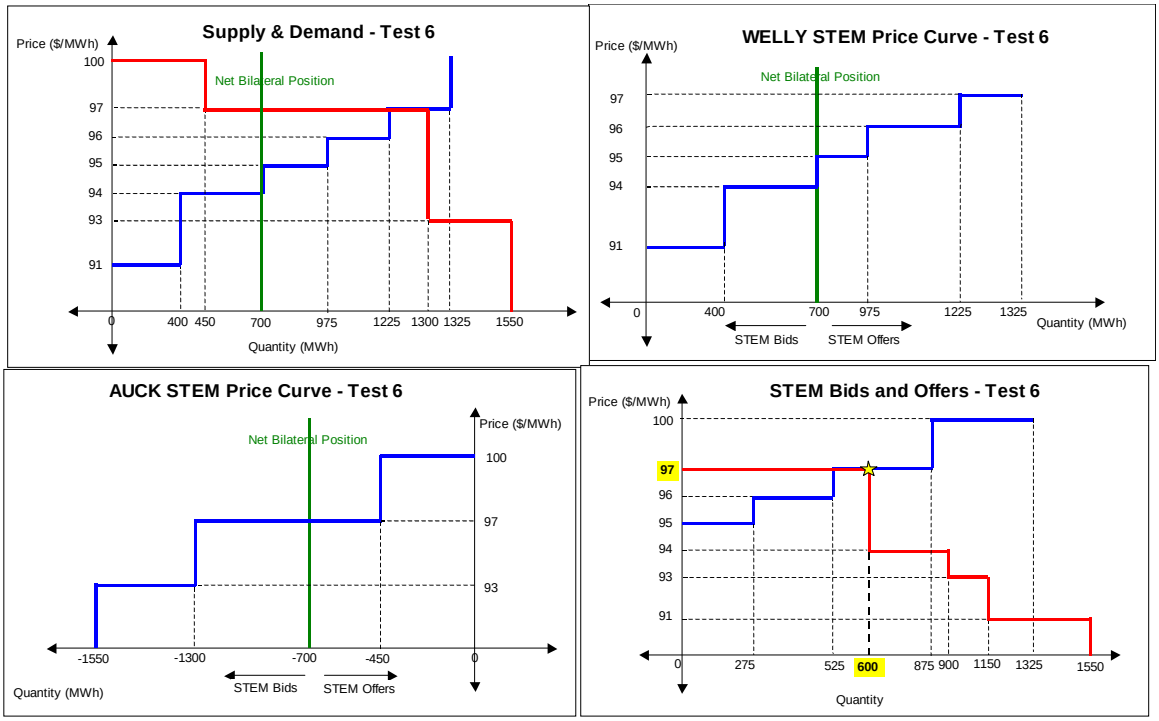
Issues to resolve: None

5.1.6 STEM ST6: Multiple Clearing Quantities

Purpose: Tests STEM auction deals with the situation of multiple possible clearing quantities in accordance with the rules - clearing the largest quantity. Also tests a situation of a proportional tie break on the last bid curve step during the STEM auction.

Conclusions: PASS

ST6	Correctly Implemented?	Comment
STEM bids and offers	Yes	The 700MW bilateral contract cuts the STEM price curves to determine the STEM bids and offers for each participant. For AUCK, all tranches below -700MWh on the STEM price curve become bids, and all above this become offers. For WELLY all tranches below 700MWh become bids, and above 700MWh become offers. As expected.
STEM Clearing Price	Yes	Clears at $95/MWh from where STEM offer and STEM bid curves intersect. As expected, and also where simple demand/supply intersect.
STEM Clearing Quantity	Yes	Clears at 600MWh from the maximum quantity where STEM offer and STEM bid curves intersect. Tie-breaking has been implemented correctly. Also the difference between where simple demand/supply intersects (at 1300MWh) and the contract position (at 700 MWh). However, of this 600 MWh, 525 MWh is clearly from WELLY to AUCK, while for the remaining, marginal, 75 MWh portion a tie break exists between two offers. One is a 100 MWh STEM offer from WELLY to AUCK, the other is a 250 MWh offer from AUCK to itself. This is done proportionally on the amount offered, so 75*100/(100+250) = 21.43 MWh from WELLY to AUCK and 75*250/(100+250) = 53.57 MWh from AUCK to itself. It should noted than in this case we get a result where a trade from a participant to itself (an effectively meaningless trade created by the STEM process) is taking away the ability for a participant to trade with another participant, due to the proportional allocation situation (6.9.10 of the rules). As this is in accordance with the rules as they are written.
Net Contract Position	Yes	AUCK increased its consumption by 546.43MWh (525 + 21.43) giving net consumption of 1246.43MWh, WELLY increased its supply by 546.43 (525 + 21.43) MWh giving net generation of 1246.43MWh. A net contract position of anywhere between 1225MWh and 1300MWh is feasible (from the original supply/demand intersect) so this result is feasible. It is also in accordance with the rules, which do not require that the maximum STEM quantity possible be taken for an individual participant.



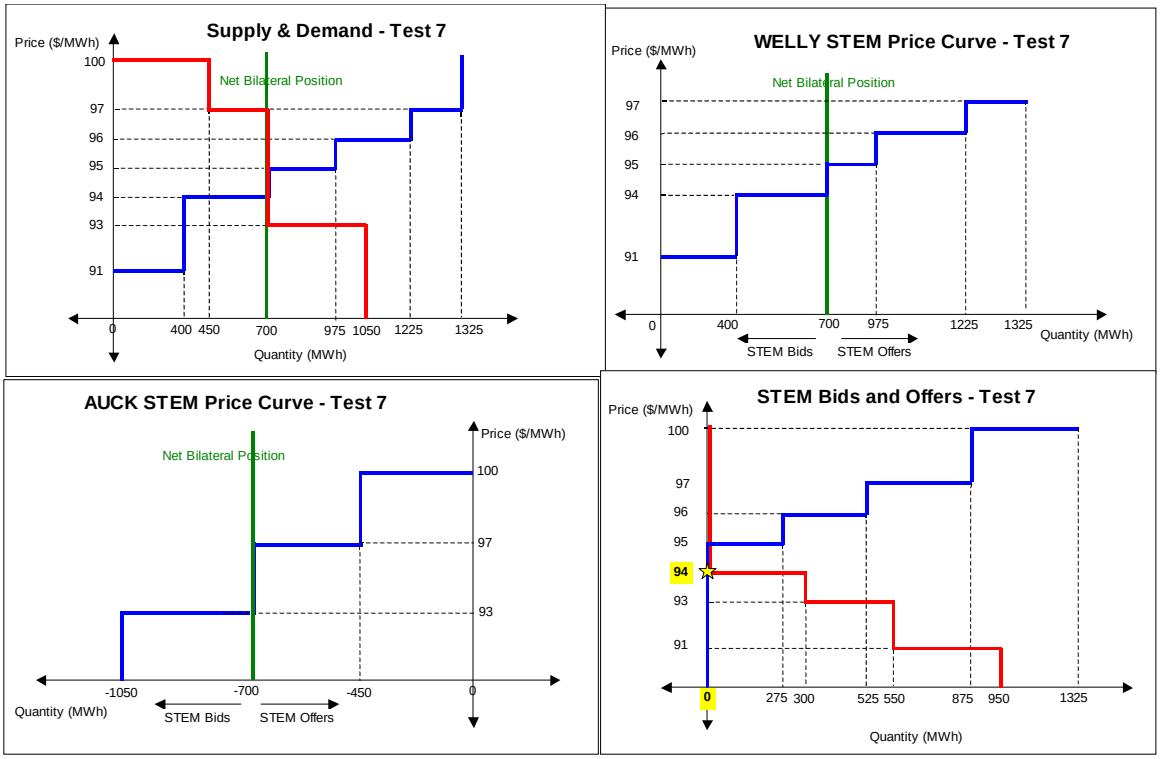
Issues to resolve: None

5.1.7 STEM ST7: Multiple Optima Prices

Purpose: Test STEM auction deals with the situation of multiple possible clearing prices in accordance with the rules - clearing the lowest price.

Conclusions: PASS

ST7	Correctly Implemented?	Comment
STEM bids and offers	Yes	The 700MW bilateral contract cuts the STEM price curves to determine the STEM bids and offers for each participant. For AUCK, all tranches below -700MWh on the STEM price curve become bids, and all above this become offers. For WELLY all tranches below 700MWh become bids, and above 700MWh become offers. As expected.
STEM Clearing Price	Yes	Clears at $94/MWh from the minimum price where STEM offer and STEM bid curves intersect. Multiple clearing price were available - anywhere between $94 and $95 - so this shows that the software correctly takes the minimum price. As expected.
STEM Clearing Quantity	Yes	Clears 0 MWh, from where STEM offer and STEM bid curves intersect. As expected.
Net Contract Position	Yes	No change in net contract positions, as clearing quantity was zero. As expected.



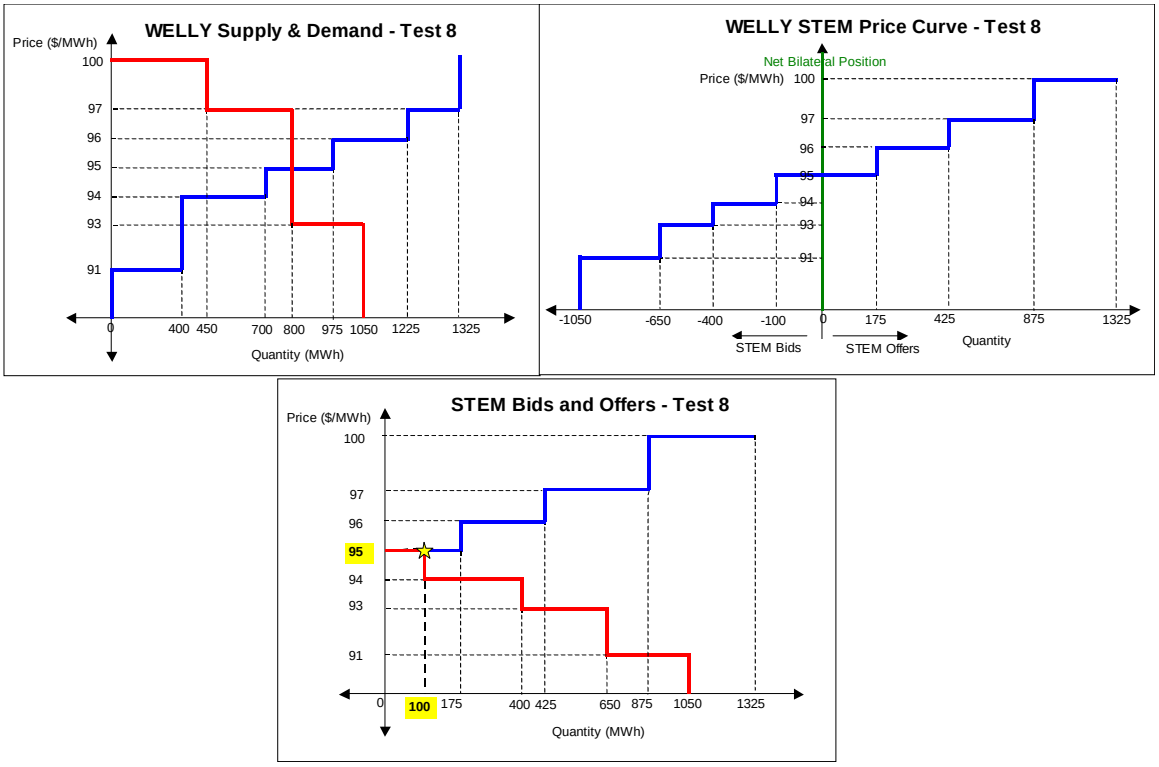
Issues to resolve: None

5.1.8 STEM ST8: One Participant, Demand And Supply

Purpose: Test STEM auction functions correctly with one participant - with both supply and demand.

Conclusions: PASS

ST8	Correctly Implemented?	Comment
STEM bids and offers	Yes	Zero net bilateral quantity, so tranches below 0 MWh on the STEM price curve become STEM bids, and all above 0 MWh this become STEM offers. As expected
STEM Clearing Price	Yes	Clears at $95/MWh from where STEM offer and STEM bid curves intersect. As expected, and also where simple demand/supply intersect.
STEM Clearing Quantity	Yes	Clears at 100MWh, the maximum quantity where STEM offer and STEM bid curves intersect. This 100 MWh is effectively meaningless as it is a trade from WELLY to itself. As expected.
Net Contract Position	Yes	No change in net contract position - remains at zero, as there is only the one participant. As expected.



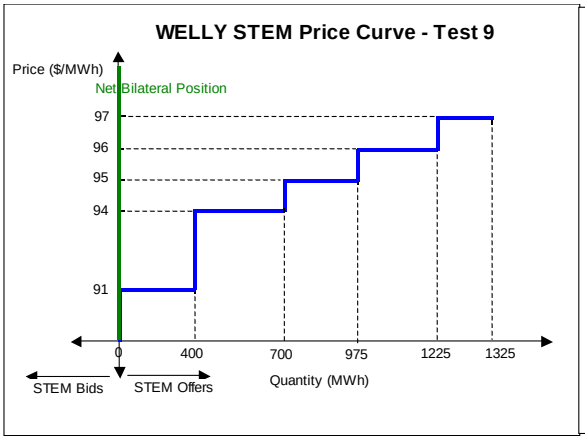
Issues to resolve: None

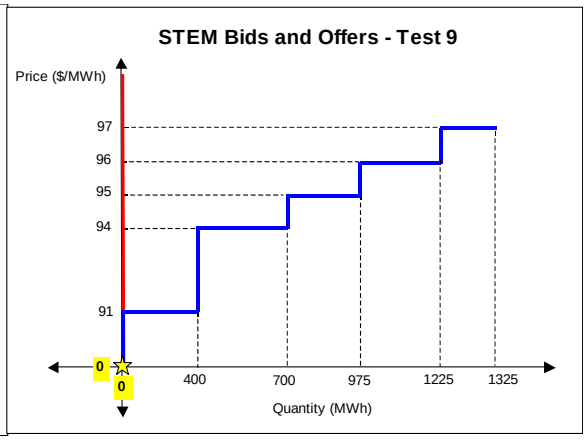
5.1.9 STEM ST9: One Participant, Supply Only

Purpose: Test STEM auction functions correctly with one participant - with supply but no demand

Conclusions: PASS

ST9	Correctly Implemented?	Comment
STEM bids and offers	Yes	Zero net bilateral quantity, and no demand curve, so the supply curve becomes the STEM offers. The only STEM bid is at (0,0). As expected.
STEM Clearing Price	Yes	Clears at $0/MWh from where STEM offer and STEM bid curves intersect. (STEM bid curve will extend up vertically at 0MWh from $0/MWh, so is taking the lowest price). As expected.
STEM Clearing Quantity	Yes	Clears at 0MWh, where STEM offer and STEM bid curves intersect. As expected.
Net Contract Position	Yes	No change in net contract position - remains at zero, as there is only the one participant. As expected.





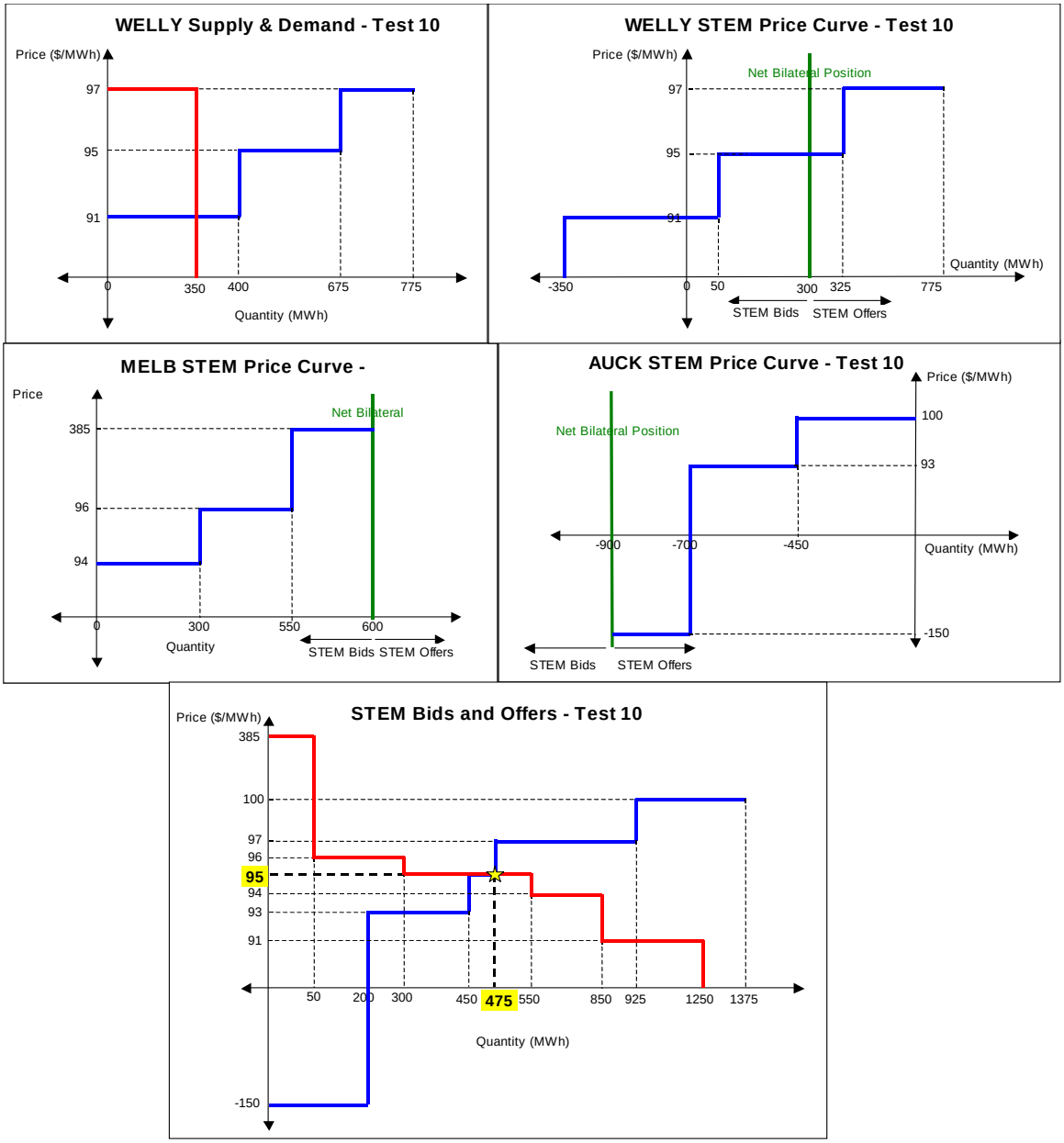
Issues to resolve: None

5.1.10 STEM ST10: Base with Three Participants.

Purpose: Test STEM auction functions correctly with three participants. One market generator, one market customer and one capable of both.

Conclusions: PASS

ST10	Correctly Implemented?	Comment
STEM bids and offers	Yes	Turns all tranches of each participant's STEM price curve that have a greater quantity than its net bilateral position into STEM offers and all tranches that have a lower quantity than its net bilateral position into STEM bids. Also correctly extends price curves to bilateral position - up at max price or down at min price. Refer to graphs. As expected.
STEM Clearing Price	Yes	Clears at $95/MWh from where the aggregate STEM offer and aggregate STEM bid curves intersect. As expected, and this is also where simple demand/supply intersect.
STEM Clearing Quantity	Yes	Clears at the maximum quantity where the STEM bid and STEM offer curves intersect (could be anywhere from 450 to 475). 25 MWh of this is effectively from WELLY to itself, while AUCK sells 450 MWh which is balanced by the 300MWh bought by MELB and 150 MWh (net) bought by WELLY.
Net Contract Position	Yes	All three participants were initially over contracted. AUCK decreases its consumption by selling 450 MWh in the STEM while MELB buys 300 MWH to decrease its generation and WELLY buys 150 MWh also to decrease its generation. As expected.



Issues to resolve None

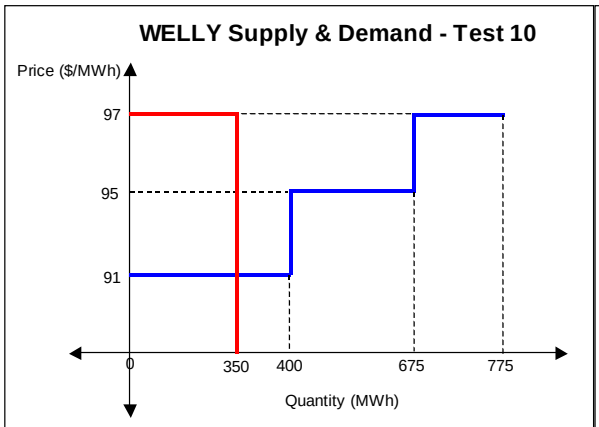
5.1.11 STEM ST11: Three Participants, (part II)

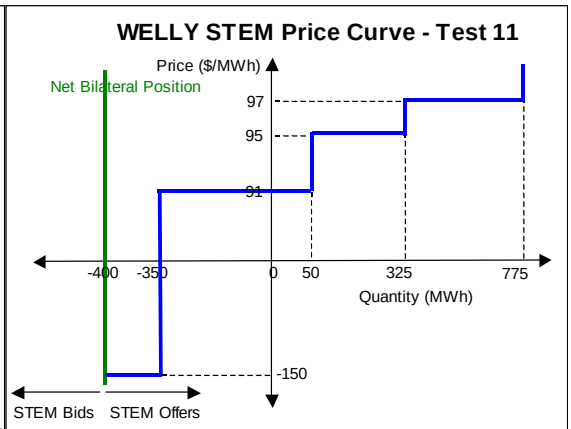
Purpose: Test STEM auction functions correctly with three participants. Only the one bilateral contract exists - so one participant has no bilateral contracts

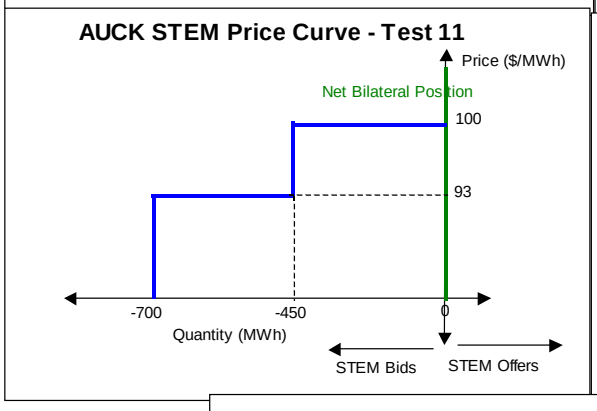
Conclusions: PASS

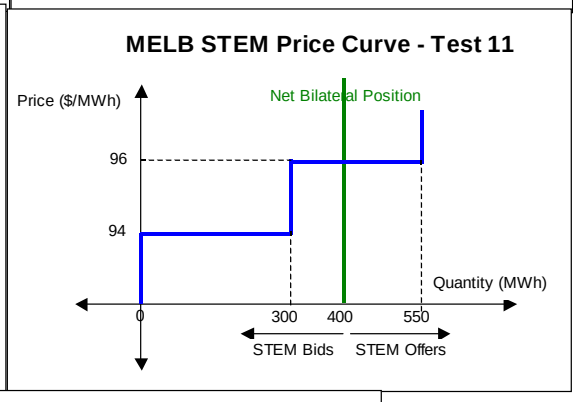
ST11	Correctly Implemented?	Comment
STEM bids and offers	Yes	Turns all tranches of each participant's STEM price curve that have a greater quantity than its net bilateral position into STEM offers and all tranches that have a lower quantity than its net bilateral position into STEM bids. Also correctly extends price curves to bilateral position - up at max price or down at min price. As expected.

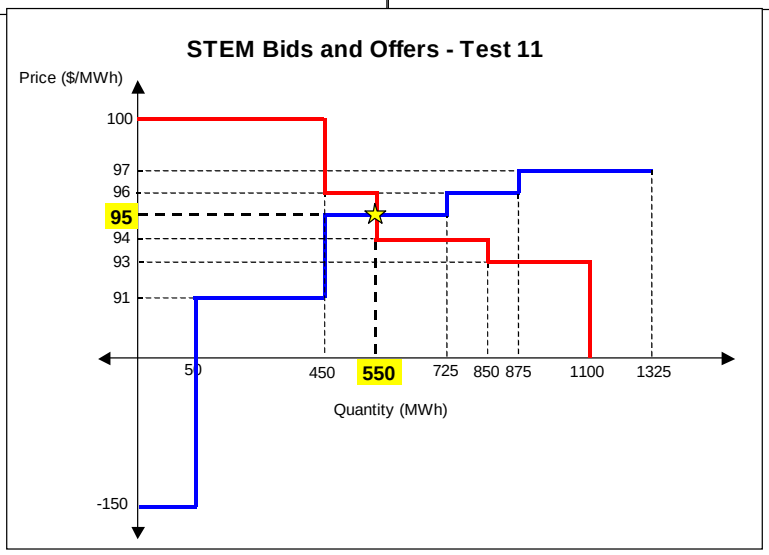
STEM Clearing Price	Yes	Clears at $95/MWh from where the aggregate STEM offer and aggregate STEM bid curves intersect. As expected, and this is also where simple demand/supply intersect.
STEM Clearing Quantity	Yes	Clears at the quantity where the STEM bid and STEM offer curves intersect. WELLY sells 550 MWh which is balanced by the 100MWh bought by MELB and 450 MWh bought by AUCK.
Net Contract Position	Yes	AUCK and WELL were initially under contracted (AUCK had no bilateral contracts), while MELB was over contracted. AUCK increased its consumption by buying 450 MWh in the STEM while MELB buys 300 MWH to decrease its generation and WELLY sells 150 MWh to increase its generation. As expected.











Issues to resolve None

5.1.12 STEM ST12: Limit Tests

Purpose: Test that STEM auction complies with the price and quantity limits

Conclusions: PASS

ST12	Correctly Implemented?	Comment
Maximum STEM Price	Yes	Will not allow the quantity of a participant's supply portfolio STEM submissions that are above the Max STEM Price ($150/MWh) to be greater than the max quantity of liquid supply capacity.
Alternative STEM Max Price	Yes	Will not allow any STEM submissions (demand or supply portfolio) above the Max Alternative STEM Price ($385/MWh)
Minimum STEM Price	Yes	Will not allow any STEM submissions (demand or supply portfolio) below the Minimum STEM Price (-$150/MWh)
Total Supply	Yes	Will not allow a participant's total STEM submissions (in their Supply Portfolio) to be greater than their Maximum Supply Capacity.
Total Demand	Yes	Will not allow a participant's total STEM submissions (in their Demand Portfolio) to be greater than their Maximum Demand Capacity.

Issues to resolve: none

5.2 NON-STEM TESTS

5.2.1 NST 1: Dispatch Merit Order

Purpose: Test that Dispatch Merit Orders are calculated in compliance with the rules.

Conclusions: PASS

	Correctly Implemented?	Comment
DOP/DP	Yes	Both implemented in increasing order of price, as expected. The two schedules are identical as they both use the decommitment price.
SIOP/SIP	Yes	Both implemented in increasing order of their respective increment prices, as expected.
SDOP/SDP	Yes	Both implemented in decreasing order of their respective decrement prices, as expected.
Tie break - DOP/DIP	Yes	Facilities of equal price are ordered in decreasing order of nameplate capacity, as expected.
Tie break - SIOP/SDOP/SIP/SDP	Yes	Facilities of equal price are ordered in decreasing order of sent-out capacity, as expected.

Issues to resolve: none

5.2.2 NST 2: Dispatch Instructions

Purpose: Test that Dispatch Instructions are scheduled correctly an in accordance with the rules.

Conclusions: PASS

	Correctly Implemented?	Comment
Scheduled time	Yes	Dispatch Instruction is scheduled at the Response Time specified, overriding the resource plan as required.
Scheduled quantity Ramp Rate	Yes	The software correctly implements dispatch instruction ramp rates.
Scheduled quantity calculation	Yes	The software correctly calculates the dispatch schedule quantity. An initial rules error in the Appendix 7 formula for Dispatch Schedule has been corrected.

Issues to resolve: None.

5.2.3 NST 3: Administered Balancing Prices

Purpose: Test that Balancing Prices are calculated correctly an in accordance with the rules.

Conclusions: PASS

	Correctly Implemented?	Comment
MCAP recalculation	Yes	MCAP is required to be recalculated only when the Relevant Quantity is 'not between 95% and 105%' of the Scheduled Quantity. Software recalculates when < 95%, >= 105%. This slight difference is considered immaterial and the results are acceptable.
MCAP values	Yes	The MCAP value is assigned correctly, to either the STEM price or the relevant intersection on the supply portfolio price curve. MCAP is also correctly assigned the alternative maximum STEM price ($385/MWh) when required.
UDAP, DDAP values	Yes	UDAP and DDAP are correctly calculated from MCAP, including correctly applying the difference for on-peak and off-peak.

Issues to resolve: None.

5.2.4 NST 4: Reserve Capacity Obligation Quantities

Purpose: Test that RCOQs are calculated correctly and in accordance with the rules.

Conclusions: PASS

	Correctly Implemented?	Comment
Obligation reduction due to high temperature	Yes	Capacity Obligation is correctly reduced to the facility's hot temperature (45c) obligation when the daily max temperature is above 41c.

Obligation reduction due to shortfall of capacity credits	Yes	Capacity obligation is reduced correctly when capacity credits held by the facility are less than that facility's certified capacity.
Obligation reduction due to outage	Yes	Capacity Obligation is correctly reduced due to a facility outage.
RCOQ values	Yes	RCOQ values are calculated correctly.

Issues to resolve: None.

5.2.5 NST 5: IRCR

Purpose: Test that IRCRs are calculated correctly and in accordance with the rules. Verified using IMO testing.

Conclusions: PASS

	Correctly Implemented?	**Comment**
12 peak trading intervals during hot season	Yes	Correctly identifies 3 peak periods from 4 'hottest' days
Notional Meter Calculations	Yes	Notional Meter Calculation performed correctly in accordance with the rules. Correctly includes all registered generators and participant loads.
NTDL values **TDL values**	Yes	Calculated correctly using median from 12 peak trading intervals.
Final IRCR calculation, **NTDLRCR** **TDLRCR**	Yes	Final IRCR value calculated correctly and in accordance with the rules including NTDLRCR, TDLRCR, ILIRCR and with new meters accounted for. Both non-temperature and temperature dependent RCR are calculated correctly, using the reserve requirement and interval metered values.
Intermittent Load IRCR Final Calculation	Yes	ILRCR calculated correctly in accordance with rules. Confirmed using WAPL_WORSLEY_IL1 and STHRNCRS SCE_IL where nominated max level is multiplied by the reserve margin

Issues to resolve: None.

5.2.6 NST 6: Loss Factors

Purpose: Test that Loss Factors are applied correctly and in accordance with the rules. Note that these tests also concern the use of Loss Factors in settlement. Verified using IMO-produced results.

Conclusions: PASS

	Correctly Implemented?	**Comment**
Loss adjustment calculation	Yes	The software multiplies the loss factors by non-loss adjusted amounts correctly

Loss factors for Capacity Shortfall variables correctly set to 1.0.	Yes	The inputs into the equation for SF (under 4.26 of rules), such as for CAPA, correctly use a loss factor 1.0 (as stated in 4.26.2A of rules).
Loss adjustment applied to correct variables	Yes	Variables requiring a loss-adjustment (RPQ, MSQ, DSQ) have had this applied correctly and in accordance with the rules. STEM quantities and Bilateral Positions have had loss-factors factored into their bids, while capacity credits, for example, are not adjusted at all.
Loss adjusted variables applied in settlement calculations	Yes	The correctly loss-adjusted variables are subsequently used in the settlement calculations as required.
RCOQ loss adjusted values	Yes	RCOQ is adjusted for losses only when the associated loss factor is < 1. This complies with the rules (4.26.2B).

Issues to resolve: None.

6. DETAILS OF SETTLEMENTS REVIEW

6.1 ANCILLARY SERVICES SETTLEMENT

The equations for settlement of ancillary services are largely found in Sections 9.9. These equations cover both the settlement of spinning reserve, load following and other ancillary services.

Unlike the other parts of the system, instead of performing our own analysis using our test model we have examined the settlement of ancillary services via the work previously performed by the IMO. So in this instance we are verifying the processes and results obtained by IMO.

6.1.1 Test AS1: USHARE and Reserve Share

Purpose: Test the accuracy of the Reserve Share algorithm.

Conclusions: PASS
Traced spreadsheet “”USHARE Test Harness OneInterval Tested”. The algorithm is working correctly for all cases tested by IMO and in agreement with Navita’s software. Note we had more difficulty following the working of some of the other spreadsheets, but are reassured by the correct working in the spreadsheet used.

	Correctly Implemented?	Comment
RBS	Yes	We went through the tests in IMO spreadsheets: It was tested in detail by tracing a single plant in one interval 18 may 2006. This module is used several times in the settlement equations for calculating reserve share.
RGS	Yes	
USHARE	Yes	
Reserve share	Yes	Participant and total values are calculated from USHARE.

Issues to resolve: None

6.1.2 Test AS2: Reserve Cost Share

Purpose: Test the calculation of Reserve Cost Share

Conclusions: PASS

	Correctly Implemented?	Comment.
Reserve Cost Share by participant	Yes	Traced through spreadsheet "Reserve Cost Share". The amounts include payment for spinning reserves and load following on an interval basis and also for AS contracts allocated by reserve share. The resultant calculations give the sum of peak and off-peak values for each half interval and for the monthly total per participant. The calculations by IMO match those from Navita.
Availability Cost	Yes	Availability costs are calculated as the monthly sum of the RCS over all participants. This was correctly calculated by Navita in spreadsheet.

Issues to resolve: None

6.1.3 Test AS3 Availability Cost Spinning Reserve

Purpose: Test the calculation of Availability Cost of Spinning Reserves

Conclusions: PASS

	Correctly Implemented?	Comment.
Spinning Reserves Availability Cost	Yes	Availability costs are calculated as the monthly sum of the RCS over all participants. This was correctly calculated by Navita.

Issues to resolve: None

6.1.4 Test AS4: Consumer Share

Purpose: Test the calculation of Consumer Share

Conclusions: PASS

	Correctly Implemented?	Comment.
Consumer share and Cost LRD (load rejection)	Yes	The IMO spreadsheets comply with the Rules as demonstrated with the June 2006 results.

Issues to resolve: None

6.1.5 Test AS5: Load Following Share

Purpose: Test the calculation of Load Following Share.

Conclusions: PASS

	Correctly Implemented?	**Comment.**
Load following share.	Yes	The calculation of load following was traced through spreadsheets: June_TPMLFCQ_Test.xls "VERIFICATION_AS_1069_20060630.xls".

Issues to resolve: None

6.1.6 Test AS6: Ancillary Services Settlement Amount

Purpose: To test the calculations of the final ancillary services settlement amount.

Conclusions: PASS

	Correctly Implemented?	**Comment.**
ASSA by participant	Yes	The calculation of load following was traced through spreadsheets. "VERIFICATION_AS_1069_20060630.xls".

Issues to resolve: None

6.2 STEM SETTLEMENT

The equations for settlement of STEM are found in Sections 9.6.

6.2.1 Test SS1: Calculating STEM Settlement Amounts

Purpose: Test the accuracy of the STEM settlement calculation for supplied quantities.

Conclusion: PASS
The algorithm is working correctly for all cases we tested and in agreement:

	Correctly Implemented?	**Comment**
STMINTP	Yes	The quantity sold and purchased in the STEM for each participant and relevant STEM price were applied correctly, and the STEMSAS and STEMSAD are calculated correctly.
STMINTSQ	Yes	
STMINTDQ	Yes	
STEMSAS	Yes	

STEMSAD	Yes	

Issues to resolve: None

6.3 RESERVE CAPACITY SETTLEMENT

The equations for settlement of Reserve Capacity are largely found in Section 9.7, with references back to Chapter 4.

6.3.1 Test RCS1: Calculating Reserve Capacity Settlement Amount for Supply

Purpose: Test the accuracy of the RCSA calculation on Supply side.

Conclusion: PASS

	Correctly Implemented?	**Comment**
Credits not covered by special price arrangements	Yes	Credits covered under special price arrangements (e.g. LTSPA) were matching the inputs in IMO, as were those not covered. MRCRP and the Monthly Special Price were both applied correctly – calculated using Yearly prices /12.
Credits covered by Special Price Arrangements	Yes	
RCSAS	Yes	Calculated correctly, this figure also includes the Supplementary Capacity Payment.

Issues to resolve: None

6.3.2 Test RCS2: Calculating Reserve Capacity Settlement Amount for Demand

Purpose: Test the accuracy of the RCSA calculation on Demand side.

Conclusion: PASS

	Correctly Implemented?	**Comment**
Shortfall Share	Yes	Some components of Shortfall Share and Capacity Share were entered as manual line items, as IRCR was not calculated. The calculation of IRCR is tested independently using IMO results. The Shortfall Share and Capacity Share were calculated correctly given these manual inputs.
Capacity Share	Yes	
RCSAD	Yes	This was calculated correctly.

Issues to resolve: None

6.3.3 Test RCS3: Calculating Reserve Capacity Refund Settlement Amount

Purpose: Test the accuracy of RC Refund Settlements.

Conclusion: PASS

	Correctly Implemented?	Comment
Capacity Cost Refund	Yes	Intermittent Load Refunds entered as manual line items to test functionality of final settlement only. Intermittent load calculations are tested independently using IMO results. The refund settlement amount was calculated correctly.
Intermittent Load Refund	Yes	
Reserve Capacity Refund Settlement Amount (RCREFSAD)	Yes	

Issues to resolve: None

6.3.4 Test RCS4: Calculating Reserve Capacity Rebates and Offsets

Purpose: Test the accuracy of the calculation of customer rebates and the RC Supplementary Security Offset.

Conclusion: PASS

	Correctly Implemented?	Comment
Reserve Capacity Supplementary Capacity Security Offset (RCSCOFF)	Yes	Some inputs entered as manual line items to enable all components to be tested in final settlement. All settlement values were calculated correctly.
Reserve Capacity Security Market Customer Rebate (RCSECCR)	Yes	
Reserve Capacity Refund Market Customer Rebate (RCREFCR)	Yes	
Reserve Capacity Load Following Requirement Market Customer Rebate (RCLFRCR)	Yes	

Issues to resolve: None

6.4 BALANCING SETTLEMENT

The equations for settlement of Balancing are found in Sections 9.8, with references back to Chapter 6. Balancing tests were run over a full day of results, with data designed to test all the components the balancing settlement amount. Selected interval results are shown in Appendix E.

6.4.1 Test BS1: Authorised Deviation Settlement Amounts

Purpose: Test the accuracy of the calculations of Authorised Settlement Amounts.

Conclusion: PASS

	Correctly Implemented?	Comment
TPNCON	Yes	Inputs flowing in from MOI correctly, aggregated correctly and final settlement amounts (ADAD for negative value, ADAS for positive) correct. MCAP applied correctly as the price.
TPDSQ	Yes	
ADAD	Yes	
ADAS	Yes	

Issues to resolve: None

6.4.2 Test BS2: Authorised Deviation Settlement Amounts for Western Power

Purpose: Test the accuracy of the calculations of Authorised Settlement Amounts for Western Power participants.

Conclusion: PASS

	Correctly Implemented?	Comment
ADAWPD	Yes	CERT_WELLY participant assigned as a proxy for Western Power. Hence it had calculated values for Western Power final settlement amounts (ADAWPD for negative, ADAWPS for positive) for CERT_WELLY. All inputs, aggregations and final settlement values were correct. MCAP applied correctly as the price.
ADAWPS	Yes	

Issues to resolve: None

6.4.3 Test BS3: Unauthorised Deviation Settlement Amounts

Purpose: Test the accuracy of the calculation of Unauthorised Settlement Amounts.

Conclusion: PASS

	Correctly Implemented?	Comment
Upwards Unauthorised Deviation Amount (UUDAS)	Yes	Facility data was set up to give deviations in DSQ from MSQ, in order to calculate unauthorised deviations, both upwards and downwards. All inputs, aggregations and final settlement values were correct. UDAP and DDAP were applied correctly as the respective prices.
Downwards Unauthorised Deviation Amount (DUDAD)	Yes	

Issues to resolve: None

6.4.4 Test BS4: Resource Plan Deviation Settlement Amount

Purpose: Test the accuracy of the calculation of Resource Plan Settlement Amounts.

Conclusion: PASS

	Correctly Implemented?	Comment
RPDAD	Yes	Facility data was set up in selected intervals to give downwards deviations from the Resource Plan for CERT_MELB - in order for a Resource Plan Deviation Amount (RPDAD) to be calculated. All inputs, aggregations and final settlement values were correct. DDAP was applied correctly as the price.

Issues to resolve: None

6.4.5 Test BS5: Dispatch Instruction Settlement Amounts

Purpose: Test the accuracy of the calculation of Dispatch Instruction Settlement Amounts.

Conclusion: PASS

	Correctly Implemented?	Comment
DIPD/DIPS	Yes	All inputs, aggregations and final settlement values were correct for DIPD and DIPS, with DIPP calculated and applied correctly as the price.

DIPNGD	Yes	All inputs, aggregations and final settlement values were correct for the Dispatch Instruction Payment Amount for Non Scheduled Generators (including Intermittent Generators), with DECP applied correctly as the price.
DIPCLS	Yes	All inputs, aggregations and final settlement values were correct for the Dispatch Instruction Payment Amount for Curtailable Loads (DIPCLS), with DECP applied correctly as the price.

Issues to resolve: Test results still to be collected from June results to verify these.

6.5 OTHER SETTLEMENT CALCULATIONS

These are the equations in 9.10 to 9.15 of the rules. Due to the relatively simple nature of these calculations, previous IMO test results were checked and verified to ensure the software was implementing them correctly.

6.5.1 Test OS1: Commitment and Outage Settlement Amount

Purpose: Test the accuracy of the calculation of Commitment and Outage Compensation Settlement Amounts.

Conclusion: PASS

	Correctly Implemented?	**Comment**
COCSA **COCDA**	Yes	The software correctly calculates the Commitment and Outage Compensation Settlement Amounts, including performing the correct aggregations of the inputs from MOI.

Issues to resolve: None

6.5.2 Test OS2: Non-Compliance Charge Settlement Amounts

Purpose: Test the accuracy of the calculation of Non-Compliance Charge Settlement Amounts.

Conclusion: PASS

	Correctly Implemented?	**Comment**
NCCSAWP	Yes	The software correctly calculates the Non-Compliance Charge Settlement Amount for Western Power.

Issues to resolve: None

6.5.3 Test OS3: Reconciliation Settlement Amount

Purpose: Test the accuracy of the calculation of Reconciliation Settlement Amounts.

Conclusion: PASS

	Correctly Implemented?	Comment
RSAS **RSAD**	Yes	The software correctly calculates the Reconciliation Settlement Amounts.

Issues to resolve: None

6.5.4 Test OS4: Network Control Service Settlement Amount

Purpose: Test the accuracy of the calculation of Market Participant Fee Settlement Amounts.

Conclusion: PASS

	Correctly Implemented?	Comment
Market Participant Network Control Settlement Payment (NCSMP)	Yes	The software correctly calculates the Network Control Service Settlement Payment Amount for a Market Participant.
Network Operator Control Service Settlement (NCSMO)	Yes	The software correctly calculates the Network Control Service Settlement Amount for the Network Operator.

Issues to resolve: None

6.5.5 Test OS5: Market Fee Settlement Amount

Purpose: Test the accuracy of the calculation of Market Participant Fee Settlement Amounts.

Conclusion: PASS

	Correctly Implemented?	Comment
MPMFSA **MPSOFSA** **MPRFSA**	Yes	The software correctly calculates the market fees settlement amounts for the IMO, System Operator and Regulator.

Issues to resolve: None.

6.5.6 Test OS6: Intermittent Loads

Purpose: Test that the calculations in producing the metered quantities for Intermittent Loads are being made correctly and are in accordance with the rules. Verified using IMO-produced results.

Conclusions: PASS

	Correctly Implemented?	**Comment**
NMQ	Yes	Net Metered Quantity is being calculated correctly – matching the sum of MSQ for the Intermittent Load, MSQ for any Associated Excess Generator and the effect of any metered load behind the IL.
MSQ **NLMQ**	Yes	Loss factor correctly applied in metered quantities.

Issues to resolve: None

APPENDIX A: LIST OF REFERENCE MATERIAL USED

This appendix provides details titles and versions of the key documents used in this review.

Ref No.	Title	Version No.
LEGAL INSTRUMENTS		
1	Wholesale Electricity Market Rules	Version 2.5
2	Power System Operation Procedure: Dispatch	(no version control)
3	Power System Operating Procedure: Verification of Generation Facility MWh output data	Draft
4	Power System Operating Procedure: MT PASA	V3
5	Power System Operating Procedure: ST PASA	V3b
6	Power System Operation Procedure: Ancillary Service Procurement	(no version control)
OTHER REFERENCE DOCUMENTS (SMMITS)		
7	SMMITS – Context Diagram [DMS#:2811800]	2
8	Phase 2 Requirements Specification, SM To IMO Interface Project, Business Processes/Requirements – Outage [DMS#:2716595]	1.1
9	Phase 2 Requirements Specification, SM To IMO Interface Project, Business Processes/Requirements – Dispatch [DMS#:2756480]	Draft (28/4/06)
10	Phase 2 Requirements Specification, SM To IMO Interface Project, Business Processes/Requirements – PASA [DMS#:2756619]	Draft (1/2/06)
11	Phase 2 Requirements Specification, SM To IMO Interface Project, Business Processes/Requirements – Ancillary Services [DMS#:2756736]	Draft (1/2/06)
12	Phase 2 Requirements Specification, SM To IMO Interface Project, Business Processes/Requirements – Settlement Data [DMS#:2757161]	1.0
OTHER REFERENCE DOCUMENTS (Electricity Market Systems)		
13	MA Functional Specifications [#WMSFS-808 20-007]	1.3 (30/1/06)

14	Design Description Settlements [WMS DD-80820-017]	1.3 (17/2/06)
15	Design Description MA Computational Module [WMS DD-80820-012]	1.3 (28/4/06]

APPENDIX B: SOFTWARE SYSTEMS

The test results contained in this document apply to the latest sets of software applicable at:

- 2nd September 2006 for those systems under IMO control
- 3rd August 2006 for those systems under System Management control

APPENDIX C: MAXIMUM RESERVE CAPACITY PRICE

C.1 CALCULATION OF MAXIMUM RESERVE CAPACITY PRICE

MAX RESERVE CAPACITY PRICE CHECK	Software Calculated	PA Calculated	Status
Capacity Year (t)	1/10/2006	1/10/2006	
Year difference (x)	1	1	
Year (t-x)	1/10/2005	1/10/2005	CORRECT
Commonwealth 10 Year Bond Rate	6.5	0.065	
Margin For Debt (%)	15	0.15	
Margin for Equity (%)	3	0.03	
US CPI (t-x)	100	100	
US CPI (t)	101	101	
US Inflation Rate (%)	1	1	CORRECT
Aust CPI (t-x)	100	100	
Aust CPI (t)	101	101	
Australian Inflation Rate (%)	1	1	CORRECT
Loan Period	15	15	
Debt Ratio (%)	60	0.6	
WACC Pre-Tax Rate (%)	16.7	0.167	CORRECT
Capital Costs			
Capacity - nominal (MW)	160	160	
SDF	1.18	1.18	
Capacity - summer (MW)	135.593	135.5932203	CORRECT
Losses	1	1	
Capacity - summer net of losses (MW)	135.593	135.5932203	CORRECT
Generator Price (US$/MW)	150,000.00	150,000.00	
Generator Price Scaling Factor	2	2	
Exchange Rate (US$/A$)	0.75	0.75	
Exchange Rate (A$/US$)	1.33333	1.333333333	CORRECT
Add Margin for NOx (%)	5	0.05	
Equipment Capital Cost (A$/kW)	420,000.00	420,000.00	CORRECT
On-Cost Margin (%)	15	0.15	
Total Cost (A$/MW)	483,000.00	483,000.00	CORRECT
Real Debt Rate (%)	21.5	0.215	CORRECT
IDC ($)*	22,634,689.83	22,634,689.83	
Total Cost of interest (A$M)**	77.28	77,280,000.00	
Transmission Cost (A$M)	15	15000000	
Fixed Fuel Cost (A$M)	3	3000000	
Fixed O&M Cost(A$/MW)	15,000.00	15,000.00	
Capital Cost Power Station (A$/MW)	424,200.00	424,200.00	CORRECT
Total Capital Cost (A$)	123,028,823.34	123,028,823.34	CORRECT
Annualised Capital Cost (A$)	22,793,571.42	22,793,571.42	CORRECT
Factor K	1	1	
Max Reserve Capacity Price (A$/MW)	**183,102.59**	**183,102.59**	CORRECT

Notes
* IDC = Interest during construction. It is part of the total capital cost formula.
** Label is wrong, should just read "Total Cost (A$M)".

Figure 1: Maximum Reserve Capacity Calculation

APPENDIX D: RESERVE CAPACITY BASIC MODEL

D.1 RESERVE CAPACITY BILATERAL TRADES AND AUCTION

Reserve Capacity Requirements

Capacity Year	Availability Class	Capacity Requirement
1/10/2006	1	3,960.00
1/10/2006	2	30.00
1/10/2006	3	30.00
1/10/2006	4	30.00

Market Participants and Facilities

Participant Name	Facility Name	Facility Type	Cap Block	Availability Class	Max Available Hrs/Yr
CERT_MELB	CERT_OLDEN	SG	BLOCK1	CLASS1	
CERT_MELB	CERT_ABINOJA	SG	BLOCK1	CLASS1	
CERT_WELLY	CERT_MATSON	SG	BLOCK1	CLASS1	
CERT_WELLY	CERT_GEORGE	IG	BLOCK1	CLASS1	
CERT_WELLY	CERT_THORNTON	SG	BLOCK1	CLASS1	
CERT_WELLY	CERT_RIHIA	SG	BLOCK1	CLASS1	
CERT_WELLY	CERT_ODONOGHUE	SG	BLOCK1	CLASS1	
CERT_AUCK	CERT_BOWMAKER	CL	BLOCK1	CLASS2	90
CERT_WELLY	CERT_TURNER	IL	BLOCK1	CLASS3	60
CERT_AUCK	CERT_MCSHANE	IL	BLOCK1	CLASS4	30

Figure 2: Base Data for Reserve Capacity Tests

Reserve Capacity Auction and Bilateral Trades

Test 1: Objective: **Sufficient supply of certified capacity for all classes to meet the requirement of that class.**

Inputs

Bilateral Trade Declarations and Auction Offers

Facility Name	Facility Type	Status	Availability Class	Max Capacity MW	Bilateral MW	Auction MW	Auction Offer Price
CERT_MATSON	SG	Registered	CLASS1	800	560	240	$ 91,000
CERT_OLDEN	SG	Registered	CLASS1	711	497.7	213.3	$ 92,000
CERT_ABINOJA	SG	Registered	CLASS1	600	420	180	$ 93,000
CERT_THORNTON	SG	Registered	CLASS1	600	420	180	$ 94,000
CERT_ODONOGHUE	SG	Registered	CLASS1	550	385	165	$ 95,000
CERT_RIHIA	SG	Registered	CLASS1	500	350	150	$ 96,000
CERT_GEORGE	IG	Registered	CLASS1	200	140	60	$ 97,000
CERT_BOWMAKER	CL	Registered	CLASS2	32	22.4	9.6	$ 85,000
CERT_TURNER	IL	Registered	CLASS3	31	21.7	9.3	$ 80,000
CERT_MCSHANE	IL	Registered	CLASS4	30	21	9	$ 75,000

Reserve Capacity Auction Requirement (calculated)

Availability Class	Bilateral	Requirement	Auction Capacity	Auction Offers
CLASS1	2772.70	3960.00	1187.30	1188.30
CLASS2	22.40	30.00	7.60	9.60
CLASS3	21.70	30.00	8.30	9.30
CLASS4	21.00	30.00	9.00	9.00

Outputs

Approved Bilateral Capacity

Facility Name	Facility Type	Status	Availability Class	Approved Class	Bilateral Capacity
CERT_GEORGE	Intmnt Gen	Registered	1	1	140
CERT_RIHIA	Sched Gen	Registered	1	1	350
CERT_ODONOGHUE	Sched Gen	Registered	1	1	385
CERT_THORNTON	Sched Gen	Registered	1	1	420
CERT_ABINOJA	Sched Gen	Registered	1	1	420
CERT_OLDEN	Sched Gen	Registered	1	1	497.7
CERT_MATSON	Sched Gen	Registered	1	1	560
CERT_BOWMAKER	Curt Load	Registered	2	2	22.4
CERT_TURNER	Intrpt Load	Registered	3	3	21.7
CERT_MCSHANE	Intrpt Load	Registered	4	4	21

IMO Accepted Reserve Capacity

Facility Name	Facility Type	Status	Availability Class	Approved Class	Approved	IMO Capacity
CERT_GEORGE	IMG	Registered	1	1	Yes	60
CERT_RIHIA	SG	Registered	1	1	Yes	150
CERT_ODONOGHUE	SG	Registered	1	1	Yes	165
CERT_THORNTON	SG	Registered	1	1	Yes	180
CERT_ABINOJA	SG	Registered	1	1	Yes	180
CERT_OLDEN	SG	Registered	1	1	Yes	213.3
CERT_MATSON	SG	Registered	1	1	Yes	240
CERT_BOWMAKER	CL	Registered	2	2	Yes	9.6
CERT_TURNER	IL	Registered	3	3	Yes	9.3
CERT_MCSHANE	IL	Registered	4	4	Yes	9

Reserve Capacity Auction Requirement (output)

Availability Class	Capacity Shortfall	Auction Requirem.
1	0	1,187.30
2	0	6.60
3	0	5.30
4	0	5.00

Reserve Capacity Price
Reserve Cap. Price
$ 97,000

Conclusions

	Correctly Implemented?	Comment
Bilateral Trade Clearing	Yes	All Bilateral Trades accepted, as expected.
Auction Cap/Shortfall	Yes	Auction Capacities set correctly, no shortfalls.
Auction Requirements	Yes	Excesses cascaded through each availability class correctly
Auction Clearing	Yes	All offers accepted, as expected
Reserve Cap Price	Yes	Set by GEORGE, the highest price offer accepted, at $97,000
Exchange Offers	Yes	No exchanges possible

Figure 3: Reserve Capacity Test 1 - Base Case

APPENDIX E: BALANCING SETTLEMENT RESULTS

Algorithms

	Quantity (MWh)	x Price ($/MWh)	by
ADAS	MAX((TPDSQ-(TPNCON+TPBSUPQ)),0)	MCAP	Participant
ADAD	MIN((TPDSQ-(TPNCON+TPBSUPQ)),0)	MCAP	Participant
ADAWPS	MAX((TPDSQ-(TPNCON+TPBSUPQ)+TTBSUPQ),0)	MCAP	Participant
ADAWPD	MIN((TPDSQ-(TPNCON+TPBSUPQ)+TTBSUPQ),0)	MCAP	Participant
UUDAS	IF(TESTFLAG=0,(MAX((MSQ-DSQ),0)),0)	UDAP	Facility
DUDAD	IF(TESTFLAG=0,(MIN((MSQ-DSQ),0)),0)	DDAP	Facility
RPDAD	(MIN(((TPNCON -RPSFQ) - (MIN(TPNCON,TPMSQ,TPDSQ))) , 0))	DDAP	Participant
DIPS	MAX(DIPQ,0)	DIPP	Facility
DIPD	MIN(DIPQ,0)	DIPP	Facility
DIPNGD	REDQ	DECP	Facility
DIPCLS	REDQ	DECP	Facility

where		Units	by
DIPQ	IF(DIPASDP>=MCAP,((MIN(MSQ,DSQ))-RPQ),((MAX(MSQ,DSQ))-(RPQ-BSUPQ)))	MWh	Facility
DIPP	IF(DSQ=(RPQ+BSUPQ),0,DIPASDP-MCAP)	$/MWh	Facility
TPNCON	NBLTPOS + STMINTSQ + STMINTDQ	MWh	

Inputs & Outputs

by participant

CERT_AUCK	Hour	*14*	*23*	Units
TPSDSQ	Interval 1	-5.214	-12.043	MWh
	Interval 2	-14.152	-5.553	MWh
TPNCON	Interval 1	-450	-800	MWh
	Interval 2	-450	-800	MWh
TBSUPQ		null	null	MWh
MCAP	Interval 1	385	94	$/MWh
	Interval 2	95	94	$/MWh
ADAS	Interval 1	171242.61	74067.958	$
	Interval 2	41405.56	74678.018	$

CERT_MELB	Hour	*17*	*19*	Units
TPSDSQ	Interval 1	293	246	MWh
	Interval 2	272.5	268.5	MWh
TPNCON	Interval 1	300	300	MWh
	Interval 2	300	300	MWh
TBSUPQ		null	null	MWh
MCAP	Interval 1	91	91	$/MWh
	Interval 2	91	91	$/MWh
ADAD	Interval 1	-637	-4914	$
	Interval 2	-2502.5	-2866.5	$

CERT_MELB	Hour	*4*		Units
TPNCON	Interval 1	475		MWh
	Interval 2	475		MWh
RPSFQ	Interval 1	150		MWh
	Interval 2	150		MWh
TPMSQ	Interval 1	472		MWh
	Interval 2	475		MWh
TPDSQ	Interval 1	342		MWh
	Interval 2	345		MWh
DDAP	Interval 1	385		$/MWh
	Interval 2	385		$/MWh
RPDAD	Interval 1	-6545		$
	Interval 2	-7700		$

CERT_WELLY	Hour	*12*	*13*	Units
TPSDSQ	Interval 1	226.628	390.515	MWh
	Interval 2	257.155	478.577	MWh
TPNCON	Interval 1	0	150	MWh
	Interval 2	0	150	MWh
TBSUPQ	Interval 1	30	50	MWh
	Interval 2	30	50	MWh
TTBSUPQ	Interval 1	80	100	MWh
	Interval 2	80	100	MWh
MCAP	Interval 1	95	385	$/MWh
	Interval 2	91	385	$/MWh
ADAWPS	Interval 1	26279.66	111848.275	$
	Interval 2	27951.105	145752.145	$

CERT_WELLY	Hour	*10*	*9*	Units
TPSDSQ	Interval 1	783.229	777.799	MWh
	Interval 2	798.018	793.494	MWh
TPNCON	Interval 1	800	800	MWh
	Interval 2	800	800	MWh
TBSUPQ		null	null	MWh
TTBSUPQ		null	null	MWh
MCAP	Interval 1	95	95	$/MWh
	Interval 2	97	95	$/MWh
ADAWPD	Interval 1	-1593.245	-2109.095	$
	Interval 2	-192.254	-618.07	$

Inputs & Outputs

by facility

CERT_OLDEN	Hour	18	19	Units
MSQ	Interval 1	250	250	MWh
	Interval 2	250	250	MWh
DSQ	Interval 1	200.278	200	MWh
	Interval 2	200	222.5	MWh
UDAP	Interval 1	45.5	45.5	$/MWh
	Interval 2	45.5	45.5	$/MWh
UUDAS	Interval 1	2262.351	2275	$
	Interval 2	2275	1251.25	$

CERT_OLDEN	Hour	16	18	19	Units
DSQ	Total	477.5	400.278	422.5	MWh
	Interval 1	250	200.278	200	MWh
	Interval 2	227.5	200	222.5	MWh
RPQ	Total	500	500	500	MWh
	Interval 1	250	250	250	MWh
	Interval 2	250	250	250	MWh
MSQ	Total	500	500	500	MWh
	Interval 1	250	250	250	MWh
	Interval 2	250	250	250	MWh
DIPASDP	Total	145	290	290	MWh
	Interval 1		145	145	MWh
	Interval 2	145	145	145	MWh
MCAP	Total	182	182	182	$/MWh
	Interval 1	91	91	91	$/MWh
	Interval 2	91	91	91	$/MWh
DIPP	Interval 1	0	54	54	MWh
	Interval 2	54	54	54	MWh
BSUPQ		0	0	0	MWh
MCAP	Interval 1	91	91	91	$/MWh
	Interval 2	91	91	91	$/MWh
DIPQ Qty	Interval 1	0	-49.722	-50	MWh
	Interval 2	-22.5	-50	-27.5	MWh
DIPS		0	-2684.988	-2700	$
		-1215	-2700	-1485	$

CERT_ABINOJA	Hour	3	Units
MSQ	Interval 1	150	MWh
	Interval 2	150	MWh
DSQ	Interval 1	190	MWh
	Interval 2	190	MWh
UDAP	Interval 1	106.7	$/MWh
	Interval 2	106.7	$/MWh
DUDAD	Interval 1	-4268	$
	Interval 2	-4268	$

CERT_MCSHANE	Hour	11	Units
DECP	Interval 1	139	$/MWh
REDQ	Interval 1	-1.5	MWh
DIPCLS	Interval 1	-208.5	$

CERT_BOWMAKER	Hour	11	Units
DECP	Interval 1	137	$/MWh
REDQ	Interval 1	-3	MWh
DIPCLS	Interval 1	-411	$

APPENDIX F: RESERVE CAPACITY SETTLEMENT RESULT

Algorithms

RCSAS	(MRCP * (CCNSPAP-CCANSPAS)) + (CCSPASA-CCASPASA) + SUPCAPP
RCSAD	(-1) * ((TRCC) * (TPMCAPSF/TTMCAPSF))+ ((SRCC) * (IRCR/TTIRCR))
RCSCSOFF	RCSSCCO * (TPMCAPSF/TTMCAPSF)
RCSECCR	RCSMCR * (IRCR/TTIRCR)
RCREFCR	(TTMCPREF+TTMILCPR) * (IRCR/TTIRCR)
RCLFRCR	(LFR*MRCP) * (IRCR/TTIRCR)
RCREFSAD	(CAPREF + ILCAPREF * 1AMT) * (-1)

Inputs

	CERT_WELLY	CERT_MELB	CERT_AUCK	ALL
MRCP				9,000
CCNSPAP	2,650	1,311	62	
CCANSPAS	100	71	-	
CCSPASA	473,118	-	-	
CCASPASA	50,000	-	-	
SUPCAPP	80,000	-	40,000	
TRCC				33,300,000
TPMCAPSF	1,900	350	1,450	
TTMCAPSF				3,700
SRCC				3,150,000
IRCR	200	50	100	
TTIRCR				350
RCSSCCO				550,000
RCSMCR				13,000,000
CAPREF	400,000	150,000	300,000	
TTMCPREF				850,000
ILCAPREF	6	8	10	-
TTMILCPR				24
LFR				20
1AMT				1

Outputs

	CERT_WELLY	CERT_MELB	CERT_AUCK
RCSAS	23,453,118	11,160,000	598,000
RCSAD	-18,900,000	-3,600,000	-13,950,000
RCSCSOFF	282,432	52,027	215,541
RCSECCR	7,428,571	1,857,143	3,714,286
RCREFCR	485,728	121,432	242,864
RCLFRCR	205,714	51,429	102,857
RCREFSAD	-400,006	-150,008	-300,010

SURPLUS	-25,226,677