WA Independent Market Operator

Test and certification of the Wholesale Electricity Market Software

12 October 2007

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FOREWORD

This report sets out the results of the market audit by PA Consulting Group in carrying out its assessment of the compliance of the IMO's market software with the Western Australia Wholesale Electricity Market Rules.

This testing has been carried out under Market Rule 2.14.3.(c) which requires that;

> The IMO must ensure that the Market Auditor carries out the audits of such matters as the IMO considers appropriate, which must include:
>
> (a) the compliance of the IMO's internal procedures and business processes with the Market Rules
>
> (b) the IMO's compliance with the Market Rules and Market Procedures
>
> (c) the IMO's market software systems and processes for software management.

This report concludes that the market software systems comply.

TABLE OF CONTENTS

1. INTRODUCTION

The market software testing certification process assesses whether the mathematical formulations of the Western Australia wholesale electricity market systems have been correctly implemented by the software, 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).

The certification process, tests and results are documented in this report. This document is divided and sectioned 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 Reserve Capacity System Review* – provides the detail of the test scenarios used for the certification of the IMO's reserve capacity systems along with issues noted (if any)
- *Section 4 Details of Energy System Review* – as for Section 3 but covering the IMO's energy market systems
- *Section 5 Details of Settlement System Review* – as for Section 3 but covering the IMO's settlement systems

1.1 APPROACH TAKEN TO TESTING THE MARKET SOFTWARE

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 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.

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.

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.

[1] Version dated 1 July 2007

Where possible, we have tested the market software by using actual historical data from the WEMS.

Some features cannot be tested in this way because there is insufficient historical data available. These features have been tested individually using one or more simple test cases for each feature.

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.

In these tests, PA has not verified the accuracy of the meter data or other data collected and processed prior to the calculations performed by the software modules.

2. SUMMARY OF RESULTS

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 a couple of issues where identified during the course of the certification, all were satisfactorily addressed by the IMO and confirmed acceptable during retesting.

2.2 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 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, conditional status is given on the provision that the corrective action put forward is accepted and implemented within the proposed timeframes
  - AWAITING DATA, meaning we are still awaiting data from the IMO to confirm the result of this test

System	Subject		Conclusion
Market Systems	Reserve Capacity	Test RC1: Maximum Reserve Capacity Price	PASS
		Test RC2: Reserve Capacity Base Case	PASS
		Test RC3: Bilateral clearing, Auction Requirements	PASS
		Test RC4: Cascading between classes	PASS
		Test RC5: Auction Tie Break 1: First Criterion	PASS
		Test RC6: Auction Tie Break 2: Second Criterion	PASS
		Test RC7: Valid Exchange	PASS

System	Subject		Conclusion
		Test RC8: Auction Shortfall, no valid offers	PASS
		Test RC9: Max RCP Cap	PASS
Market Systems	STEM & Non-STEM	STEM ST1: Base Case	PASS
		STEM ST2: Under contracted	PASS
		STEM ST4: Over contracted	PASS
		STEM ST5: Bilateral position outside of Price Curve.	PASS
		STEM ST6: Multiple Optima Clearing Quantities	PASS
		STEM ST7: Multiple Optima Clearing Prices	PASS
		STEM ST8: Price set at Min-STEM price by default bid	PASS
		STEM ST9: Price set at Alt-Max-STEM price by default bid	PASS
		STEM ST10: Three Participants.	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
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 Verve Energy	PASS
		Test BS3: Unauthorised Deviation Settlement Amounts	PASS

System	Subject		Conclusion
		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

3. 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.

3.1.1 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.

Issues to be resolved: None.

3.1.2 Test RC2: Reserve Capacity Base Case

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

Conclusions: PASS. Results for this case were as expected, with the auction cleared at the price of the highest accepted offer.

Issues to be resolved: None.

3.1.3 Test RC3: Bilateral clearing, Auction Requirements

Purpose: Bilateral capacity is sufficient in Class 1 to cover lower availability classes.

Conclusions: PASS. The bilateral capacity accepted in Class 1 was large enough so that the excess could be cascaded to cover the requirements for Classes 2, 3 and part of 4. This worked as expected..

Issues to be resolved: None.

3.1.4 Test RC4: Cascading between classes

Purpose: Excess supply of certified capacity in Class 1, enough so that in the auction it will cascade through to cover the requirements of lower availability classes.

Conclusions: PASS. The last offer accepted in Class 1 was large enough so that the excess could be cascaded to cover the requirements for Classes 2, 3 and part of 4. This worked as expected.

Issues to be resolved: None.

3.1.5 Test RC5: Auction Tie Break 1: First Criterion

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.

Conclusions: PASS. 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). The registered facility was cleared. 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.

Issues to be resolved: None.

3.1.6 Test RC6: Auction Tie Break 2: Second Criterion

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.

Conclusions: PASS. A tie-break was set up between two facilities which were both offered at the same price. The first criterion did not resolve the tie-break (both were registered facilities), so the facility with the larger capacity was accepted first, on the second criterion. This was the intention of the test.

Issues to be resolved: None.

3.1.7 Test RC7: Valid Exchange

Purpose: Test of a valid exchange. These are performed manually after the auction.

Conclusions: PASS. An optimal manual exchange was performed. This was allowed as the excess capacity was greater than 100 MW. The excess was 119 MW and a 120 MW offer at $100 was exchanged for a 40 MW offer at $120, hence the total cost was reduced. The system relies on the exchange to be identified and performed manually by the Imo, which is acceptable under the rules.

Issues to be resolved: None. Note however, that it was revealed that if a valid but suboptimal exchange was made the software did not allow the suboptimal offer to then be exchanged out for a more desirable one. In this case there was a third offer of 110 MW at $105. A rerun of the auction was hence required, which was not a desirable situation. This has since been resolved by the IMO to allow for greater flexibility in the manual exchange process.

3.1.8 Test RC8: Auction Shortfall, no valid offers

Purpose: Test to see how the software handles the situation where an overall shortfall occurs due to insufficient bilateral capacity and no valid offers.

Conclusions: PASS. When there are no valid auction offers and we have a capacity shortfall, the auction gives a RCP of $0/MW. This does not contradict the market rules, however would result in a Monthly RCP of $0/MW, whereas if no auction was held we would get a Monthly RCP of 85% of the Maximum RCP.

Issues to be resolved: The software is in compliance as the rules are ambiguous on this point. However, we recommend that an addition be made to the Market Rules, requiring that the Reserve Capacity Auction will not be run when there are no valid auction offers. This recommendation has been logged with the IMO.

3.1.9 Test RC9: Maximum Reserve Capacity 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. The MPI software will not allow an offer to be submitted above the Maximum Reserve Capacity Price. This is in compliance.

Issues to be resolved: None.

4. 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.

4.1 STEM MARKET

4.1.1 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

	Correctly Implemented?	Comment
STEM bids and offers	Yes	STEM bid and offer curves are correctly built, with no bilateral positions these are equivalent to the demand and supply curves.
STEM Clearing Price	Yes	
STEM Clearing Quantity	Yes	Clearing Price, Clearing Quantity and Net Contract Positions were all calculated correctly.
Net Contract Position	Yes	

Issues to resolve: None

4.1.2 STEM ST2: Under contracted

Purpose: Test STEM auction deals with an under contracted situation correctly.

Conclusions: PASS

	Correctly Implemented?	Comment
STEM bids and offers	Yes	Bilateral Position results in participant being under contracted.
STEM Clearing Price	Yes	STEM bid and offer curves are correctly built, given the bilateral positions.
STEM Clearing Quantity	Yes	Clearing Price, Clearing Quantity and Net Contract Positions were all calculated correctly.
Net Contract Position	Yes	

Issues to resolve: None

4.1.3 STEM ST4: Over contracted

Purpose: Test STEM auction deals with an under contracted situation correctly.

Conclusions: PASS

	Correctly Implemented?	Comment
STEM bids and offers	Yes	Bilateral Position results in participant being over contracted.
STEM Clearing Price	Yes	STEM bid and offer curves are correctly built, given the bilateral positions.
STEM Clearing Quantity	Yes	Clearing Price, Clearing Quantity and Net Contract Positions were all calculated correctly.
Net Contract Position	Yes	

Issues to resolve: None

4.1.4 STEM ST5: Bilateral position outside of Price Curve.

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

Conclusions: PASS

	Correctly Implemented?	Comment
STEM bids and offers	Yes	Both the greater than the max quantity and less than the min quantity situations were tested.
STEM Clearing Price	Yes	The bid and offer curves were correctly built, including the extended portions at the Alt-Max STEM price or Min STEM Price.
STEM Clearing Quantity	Yes	Clearing Price, Clearing Quantity and Net Contract Positions were all calculated correctly.
Net Contract Position	Yes	

Issues to resolve: None

4.1.5 STEM ST6: Multiple Optima Clearing Quantities

Purpose: Tests STEM auction deals with the situation of multiple possible clearing quantities in accordance with the rules; by clearing the largest quantity.

Conclusions: PASS

	Correctly Implemented?	Comment
STEM bids and offers	Yes	The STEM Clearing Quantity is correctly taken as the maximum of the multiple optimal quantities available.
STEM Clearing Price	Yes	STEM bid and offer curves are correctly built, given the bilateral positions.
STEM Clearing Quantity	Yes	The Clearing Price and Net Contract Positions were calculated correctly.
Net Contract Position	Yes	

Issues to resolve: None

4.1.6 STEM ST7: Multiple Optima Clearing 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

	Correctly Implemented?	Comment
STEM bids and offers	Yes	The STEM Clearing Price is correctly taken as the minimum of the multiple optimal prices available.
STEM Clearing Price	Yes	STEM bid and offer curves are correctly built, given the bilateral positions.
STEM Clearing Quantity	Yes	The Clearing Quantity and Net Contract Positions were calculated correctly.
Net Contract Position	Yes	

Issues to resolve: None

4.1.7 STEM ST8: Price set at Min-STEM price by default bid

Purpose: Test where the STEM auction will clear at the Min-STEM price as a result of extending the bid curve down.

Conclusions: PASS

	Correctly Implemented?	Comment
STEM bids and offers	Yes	The Clearing Price was correctly set to the Min-STEM price by drawing an extension to the bid curve.
STEM Clearing Price	Yes	The Clearing Quantity and Net Contract Positions were calculated correctly.
STEM Clearing Quantity	Yes	
Net Contract Position	Yes	

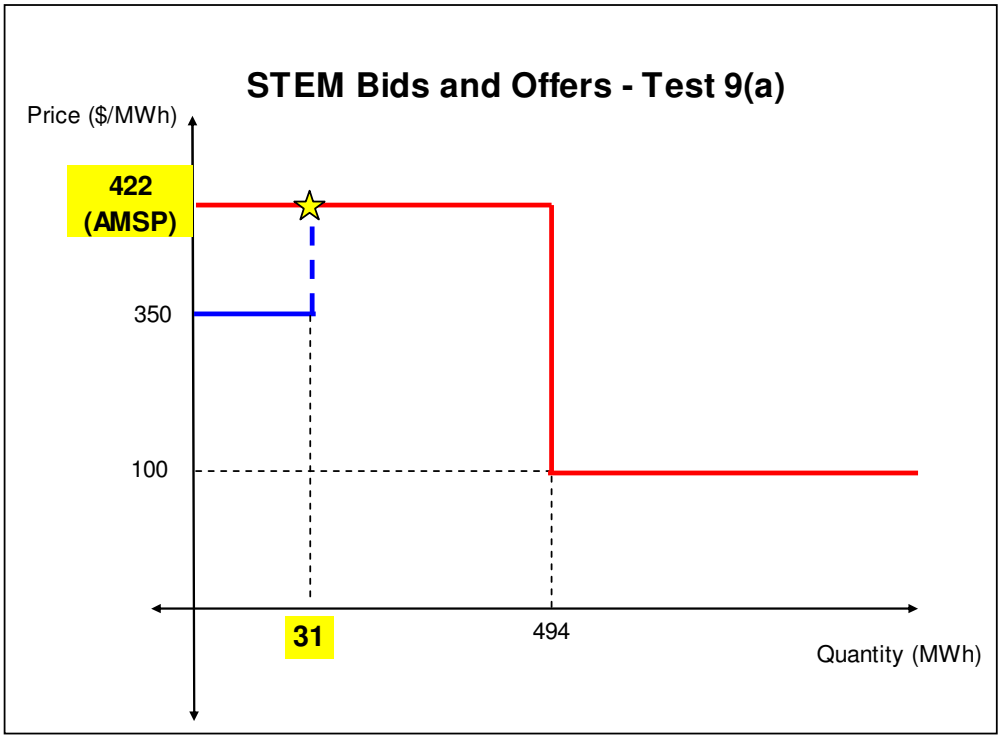
Issues to resolve: None

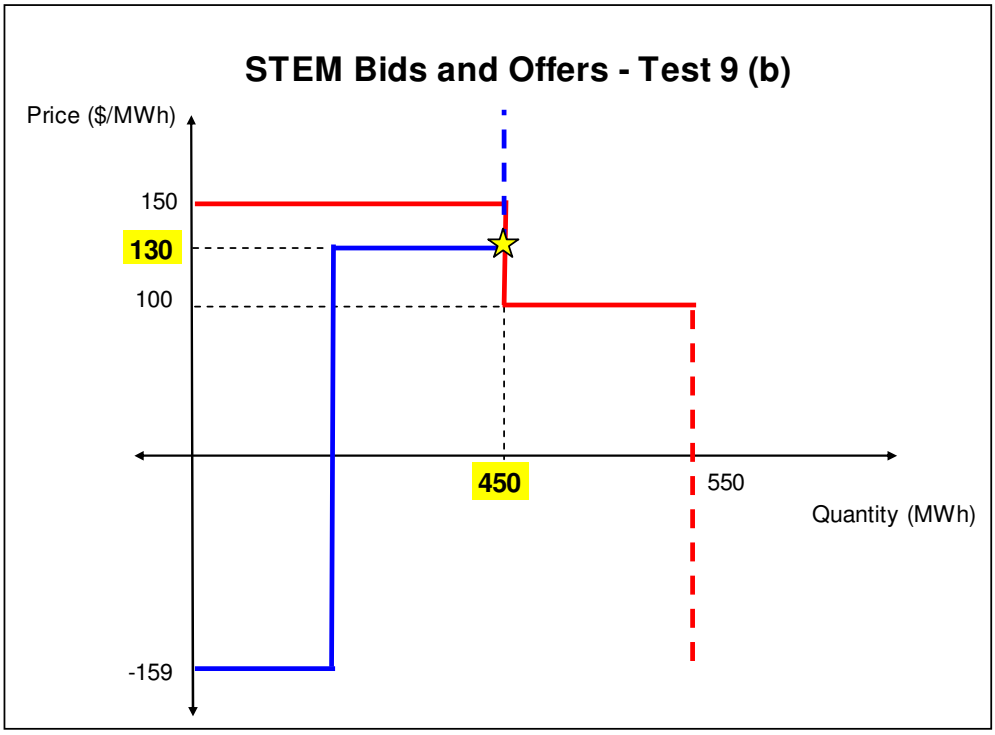
4.1.8 STEM ST9: Price set at Alt-Max-STEM price by default bid

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

Conclusions: PASS

	Correctly Implemented?	Comment
STEM bids and offers	Yes	Initially the STEM Clearing Price was taken at the offer price, not at the bid price as required under the rules (due to the extension on the offer curve up to the Alt-Max STEM Price).
STEM Clearing Price	Yes (after fix)	
STEM Clearing Quantity	Yes	This issue was resolved by a software fix by ABB.
Net Contract Position	Yes	It was verified that this error in the software had never affected results in actual production – as this situation had never occurred.





Issues to resolve: The software fix was tested with a variety of scenarios to demonstrate that the software now gives the correct STEM clearing price under this situation.

4.1.9 STEM ST10: Three Participants.

Purpose: Test STEM auction functions correctly with three participants.

Conclusions: PASS

	Correctly Implemented?	Comment
STEM bids and offers	Yes	Initially the STEM Clearing Price was taken at the offer price, not at the bid price as required under the rules (due to the extension on the offer curve up to the Alt-Max STEM Price).
STEM Clearing Price	Yes	
STEM Clearing Quantity	Yes	This issue was resolved by a software fix by ABB.
Net Contract Position	Yes	It was verified that this error in the software had never affected results in actual production – as this situation had never occurred.

Issues to resolve None

4.2 NON-STEM TESTS

4.2.1 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

4.2.2 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.

Issues to resolve: None.

4.2.3 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 recalculated correctly when the Relevant Quantity is not between 95% and 105% of the Scheduled Quantity.
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 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.

4.2.4 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 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.

4.2.5 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
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.
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.

Issues to resolve: None.

4.2.6 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.

Conclusions: PASS

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

Issues to resolve: None.

5. DETAILS OF SETTLEMENTS REVIEW

5.1 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.

5.1.1 Test AS1: USHARE and Reserve Share

Purpose: Test the accuracy of the Reserve Share algorithm.

Conclusions: PASS

	Correctly Implemented?	Comment
RBS	Yes	Used meter scheduled quantities to calculate the number of facilities each participant had in each capacity block. From this RBS, RGS and USHARE were calculated and results confirmed as correct.
RGS	Yes	
USHARE	Yes	
Reserve share	Yes	Participant and total values are calculated from USHARE.

Issues to resolve: None

5.1.2 Test AS2: Reserve Cost Share

Purpose: Test the calculation of Reserve Cost Share

Conclusions: PASS

	Correctly Implemented?	Comment.
Reserve Cost Share by participant	Yes	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 are correct.
Availability Cost	Yes	Availability costs are calculated as the monthly sum of the RCS over all participants. This was correctly calculated by the software.

Issues to resolve: None

5.1.3 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.

Issues to resolve: None

5.1.4 Test AS4: 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	Settlement values were calculated correctly.

Issues to resolve: None

5.2 STEM SETTLEMENT

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

5.2.1 Test SS1: Calculating STEM Settlement Amounts

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

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

	Correctly Implemented?	Comment
STEMSAS	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.
STEMSAD	Yes	

Issues to resolve: None

5.3 RESERVE CAPACITY SETTLEMENT

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

5.3.1 Test RCS1: Calculating Reserve Capacity Settlement Amounts

Purpose: Test the accuracy of the RCSA calculation for Supply and Demand.

Conclusion: PASS

	Correctly Implemented?	Comment
RCSAS **RCSAD**	Yes Yes	The application of "credits covered under special price arrangements" in the RCSAS formula was not tested as they have never been run in production. All settlement value results were correct.

Issues to resolve: The application of "credits covered under special price arrangements" in the RCSAS formula was not tested as they have never been run in production. This is acceptable so long as when/if they are ever implemented they are fully tested.

5.3.2 Test RCS3: Calculating Reserve Capacity Refund Settlement Amount

Purpose: Test the accuracy of RC Refund Settlements.

Conclusion: PASS

	Correctly Implemented?	Comment
Reserve Capacity Refund Settlement Amount (RCREFSAD)	Yes	The settlement value results were correctly calculated.

Issues to resolve: None

5.3.3 Test RCS3: 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	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

5.4 BALANCING SETTLEMENT

The equations for settlement of Balancing are found in Sections 9.8, with references back to Chapter 6. Balancing tests were run for various periods dependant on the availability of data to test all the components the balancing settlement amount.

5.4.1 Test BS1: Authorised Deviation Settlement Amounts

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

Conclusion: PASS

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

Issues to resolve: None

5.4.2 Test BS2: Authorised Deviation Settlement Amounts for Verve Energy

Purpose: Test the accuracy of the calculations of Authorised Deviation Settlement Amounts for Verve Energy.

Conclusion: PASS

	Correctly Implemented?	**Comment**
ADAWPD	Yes	Aggregations and final settlement values were correct. MCAP applied correctly as the price.
ADAWPS	Yes	

Issues to resolve: None

5.4.3 Test BS3: Unauthorised Deviation Settlement Amounts

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

Conclusion: PASS

	Correctly Implemented?	Comment
Upwards Unauthorised Deviation Amount (UUDAS)	Yes	Periods were chosen where there were deviations in DSQ from MSQ, in order to calculate unauthorised deviations, both upwards and downwards. 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

5.4.4 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	Periods were chosen where there were downwards deviations from the Resource Plan for a unit in order for a Resource Plan Deviation Amount (RPDAD) to be calculated. Aggregations and final settlement values were correct. DDAP was applied correctly as the price.

Issues to resolve: None

5.4.5 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	Aggregations and final settlement values were correct for DIPD and DIPS, with DIPP calculated and applied correctly as the price.

DIPNGD	Yes	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	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: None

5.5 OTHER SETTLEMENT CALCULATIONS

These are the equations in 9.10 to 9.15 of the rules. Previous IMO test results were checked and verified to ensure the software was implementing them correctly.

5.5.1 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

5.5.2 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 Verve Energy.

Issues to resolve: None

5.5.3 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

5.5.4 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

5.5.5 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.