

Independent Market Operator

Compliance of the IMO's market software
systems and processes for software
management

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Executive summary

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 market audit 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:

- other than a small number of non-material exceptions, the IMO's market software systems comply with the Market Rules; and
- the IMO's processes for software management comply with the Market Rules.

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1 Introduction

This document sets out the results of the market audit by PA Consulting Group in carrying out its assessment of the IMO's market software systems and processes for software management.

1.1 Scope of the market audit

This market audit has been carried out under Market Rule 2.14.3 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:

- d. *the compliance of the IMO's internal procedures and business processes with the Market Rules*
- e. *the IMO's compliance with the Market Rules and Market Procedures*
- f. *the IMO's market software systems and processes for software management.*

This document covers our audit under sub-paragraph (c).

1.2 Audit period

The period covered by the audit is 13 August 2011 to 10 August 2012.

1.3 Market audit process

We have approached the audit in two components, respectively examining:

1. IMO's software management processes and controls; and
2. Changes to the software itself.

With respect to the software management processes and controls we have:

- Examined the documented processes for software management;
- Compared them to actual operational practices; and
- Reviewed the compliance of operational practices with the Market Rules.

With respect to the software changes, we have:

- Reviewed all system changes implemented since the last audit;
- Assessed whether those changes have potential for material effect on prices and quantities;
- Reviewed whether or not those changes have been certified as required under the Rules;
- Reviewed all rule changes commencing since the last audit;
- Assessed whether a rule change requires a change to the systems; and
- Identified where those changes have not been implemented.

1.4 Structure of this report

The report is in two parts:

- Chapter 2 *Compliance of the IMO's software management processes and controls* reports on the compliance of the market software management processes;

- Chapter 3 *Compliance of the IMO software* reports on the compliance of the market software with the Market Rules.

2 Compliance of the IMO's software management processes and controls

Appropriate management of the market software by the IMO is essential given the nature of the business risk to both the IMO and the Western Australia Electricity Market.

Although there are no relevant Market Procedures relating to this subject, there are three relevant Internal Procedures:

- Internal Procedure: Change Management Procedure;
- Internal Procedure: IT Support Pack; and
- Internal Procedure: WEMS Software Configuration Management Plan.

2.1 Market Rules

The Market Rules set out certain obligations with respect to the IMO's software management systems and controls. In the period since the last audit, the Rules have changed to explicitly include the new balancing and load following markets.

The requirements set out in Market Rule 2.36.1 are:

Where the IMO uses software systems to determine Balancing Prices, to determine Non-Balancing Facility Dispatch Instruction Payments, to determine LFAS Prices, in the Reserve Capacity Auction, STEM Auction or settlement processes, it must:

- maintain a record of which version of software was used in producing each set of results, and maintain records of the details of the differences between each version and the reasons for the changes between versions;*
- maintain each version of the software in a state where results produced with that version can be reproduced for a period of at least 1 year from the release date of the last results produced with that version;*
- ensure that appropriate testing of new software versions is conducted;*
- ensure that any versions of the software used by the IMO have been certified as being in compliance with the Market Rules by an independent auditor; and*
- require vendors of software audited in accordance with clause 2.36.1(d) to make available to Rule Participants explicit documentation of the functionality of the software adequate for the purpose of audit.*

2.2 Changes to software management processes and controls

In the period since the last audit the IMO's IT processes and practices have continued to develop. We noted last year that the IMO intended to effect a step change in the maturity of its IT practices. The evidence shows that this step change is occurring, but that there are still areas for improvement.

None of the internal procedure documentation explicitly references the Market Rule obligations as is the practice in other IMO internal procedures.

2.2.1 Changes to documentation, frameworks and tools

We noted last year that the IMO was working on an IT Policy framework to fill out the internal documentation set. To that end, the IMO has introduced a new internal procedure, the WEMS Software Configuration Management Plan (SCMP), which captures policies and processes used to manage software through the development and releases cycle.

Some of the material in the WEMS SCMP supersedes that in the pre-existing Change Management Procedure; work remains to bring the two documents into alignment. This would be assisted by defining a clear structure showing how the various IT processes relate, which could be achieved by adopting some sort of process framework, such as ITIL.

The JIRA tool is now well embedded in IT processes, functioning as a tool for:

- Change management;
- Incident management;
- Knowledge capture; and
- Reporting.

2.2.2 Changes to practice

The IMO now has an effective environment management process, ensuring that system changes are staged through the various environments as specified in the WEMS SCMP.

Testing practices for WEMS have matured significantly since the last audit, with test plans, scripts, and detailed results now created, used and stored for each individual release. These form an excellent audit trail of the testing performed by the IMO for each software release.

Testing practices for the settlements system remain less advanced. This is partly due to the different nature of the software: WEMS is effectively developed in house, with unit testing performed by dedicated testers, and user acceptance testing performed by IMO staff, while settlements is developed by an external provider, with the IMO only performing user acceptance testing. This means that the WEMS systems routinely benefit from the attention of professional testers, while settlements tests are planned and executed solely by operational staff. Settlements testing would benefit from additional application of professional testing disciplines as seen in planning and execution of tests on other systems.

The IMO has also made a number of changes to change and release practices to ensure that software changes are certified prior to release. This includes a final check shortly before release, and a discussion with the auditor where the requirement for certification is unclear. In past years, settlement releases were treated differently, but have now been brought into the standard process, which is working well.

2.3 IMO Compliance with the Market Rules

The IMO's software management processes remain sufficient to comply with the market rules:

- With respect to 2.36.1(a), the IMO continues to maintain a record of all versions of market software used together with their dates in service, details of the differences between each version and the reasons for the changes between versions. These take the form of release notes and JIRA records;
- With respect to 2.36.1(b), the IMO maintains the ability to roll back versions of the market software by restoring previous database versions and re-installing previous versions of the software;

- With respect to 2.36.1(c), the IMO tests all new releases of the market software prior to their being placed in service, and in the last year has strengthened the controls around testing of the WEMS software;
- With respect to 2.36.1(d), four software release were not independently certified prior to implementation;
- With respect to 2.36.1(e), the IMO provides documentation on the functionality of the market software and the IMO is also provided with copies of the release notes provided by the vendors. Given the degree of confidentiality over the software imposed by the vendors, PA accepts that the degree to which the IMO provides documentation is sufficient for compliance with this Market Rule.

2.3.1 Non-compliance with 2.36.1(d)

We have observed four instances where the IMO has implemented software changes without independent certification of their correctness. The specific cases are covered in Chapter 3.

In two cases, certification was considered prior to implementation, and consciously decided against. The other two cases are related to settlement releases, and occurred prior to the tightening of the settlements release process discussed above. All settlement releases since September 2011 have followed the process correctly.

We have also noted one instance where a rule change requires an update to IMO software, and this change has not been implemented at rule commencement, again by conscious decision.

2.3.2 Tools external to the core market systems

The IMO has identified a number of tools which are external to the core market systems, but still used in calculations with potential for material impact on market outcomes.

For the purposes of compliance with the Market Rules, it is unclear whether these tools - many in spreadsheet form - are covered under the 'software' referred to in clause 2.36.1. Nonetheless, the IMO has determined that as part of prudent operation of the market, these tools should also be subject to certification where they meet the criteria in the Internal Procedure: Market Audits.

These tools are not subject to the same rigour of change and release management as the core market software. It is therefore difficult to determine when a version change occurs, and build in appropriate controls. Nevertheless, several of these tools have been certified since the last audit, as noted in chapter 3.

2.4 Opinion

The software management processes employed by the IMO comply with the requirements of the Market Rules.

3 Compliance of the IMO software

The market software testing and certification process assesses whether the mathematical formulations specified in the Market Rules, Market Procedures, and vendor documentation have been correctly implemented by the software.

The software systems covered by this section of the review are the core market systems:

- The Reserve Capacity system;
- The Energy Market systems (including the Short Term Energy Market, the Balancing Market and the Load Following Ancillary Service Market); and
- The Settlements systems.

Where a tool outside of the core market systems has been tested and certified, that certification is also covered.

3.1 Approach taken to reviewing the market software

3.1.1 Initial software testing

Verification of the market software results is generally conducted using one or both of the following methods:

- Constructing independent models of the specific case. The 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.
- Directly comparing the software 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?

In testing the IMO's market software, we use both approaches.

Because much of the software tested is embedded in the market systems, the tests to be performed have generally been specified by PA and then conducted by IMO staff. PA has then reviewed the test results to determine whether the results are in accordance with the requirements of the Market Rules.

3.1.2 Repeat software testing

Once software has been tested and shown to be compliant, it is not necessary to retest the software unless:

- Changes have been known to be made to the software which render the previous testing no longer valid; or
- It is believed that unapproved changes have been made to the software.

The first circumstance is readily picked up where there is a rigorous software change control procedure. The second exists where such a change control procedure is lacking.

As part of the 2006-7 and 2007-8 annual audit of the IMO’s market software systems we carried out full regression tests to verify that the market software systems comply with the requirements of the Market Rules. Since the 2008-9 year, we have determined the status of the market software by:

- Examining the market software change procedures to ensure that they are robust;
- Examining the changes made to the market systems software to determine whether the changes required independent testing and certification; and
- Carrying out such testing and certification on those software changes as required.

Under this regime, should there be no changes made to the software since the last time it was certified, we may deduce that the software continues to comply with the Market Rules.

This is in line with the approach we use when verifying software compliance in other jurisdictions.

3.2 Market software certification prior to the 2011-12 audit period

This section provides a summary for the full set of tests conducted on the core IMO market systems previously along with the results of those tests.

This detail is provided in tabular form below and covers:

- The features of Market Systems software which have been tested;
- The nature of the tests conducted; and
- 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; or
 - CONDITIONAL, meaning that the test returned an unexpected result, but can be accepted on the provision that the proposed corrective action is accepted and implemented within the proposed timeframes.

Table 1: Summary of previous tests conducted

| System | Subject | Test | Result | Year |
|-----------------------|-----------------|--|--------|------|
| Market Systems | STEM & Non-STEM | STEM ST1: Two Participants | PASS | 2008 |
| | | STEM ST2: Multiple Optima Clearing Quantities | PASS | 2008 |
| | | STEM ST3: Multiple Optima Clearing Prices | PASS | 2008 |
| | | STEM ST4: Price set at Min-STEM price by default bid | PASS | 2008 |
| | | STEM ST5: Price set at Alt-Max-STEM price by default bid | PASS | 2008 |
| | | STEM ST6: Bilateral position outside of Price Curve | PASS | 2008 |
| | | STEM ST7: Three Participants | PASS | 2008 |
| | | NST 1 Dispatch Merit Order | PASS | 2008 |
| | | NST 2 Dispatch Instructions | PASS | 2008 |
| | | NST 3 Administered Balancing Prices | PASS | 2008 |

| System | Subject | Test | Result | Year |
|-------------------|--------------------------------|--|--------|------|
| | | NST 4 Reserve Capacity Obligation Quantities | | |
| Settlement | Ancillary services Settlements | Test AS1: USHARE and Reserve Share | PASS | 2008 |
| | | | PASS | 2008 |
| | | Test AS2: Reserve Cost Share | PASS | 2008 |
| | | Test AS3 Availability Cost Spinning Reserve | PASS | 2008 |
| | | Test AS4: Consumer Share | PASS | 2008 |
| | | Test AS5: Load Following Share | PASS | 2008 |
| | | Test AS6: Ancillary Services Settlement Amount | | |
| Settlement | STEM Settlement | Test SS1: Calculating STEM Settlement Amounts | PASS | 2008 |
| Settlement | Reserve Capacity Settlement | Test RCS1: Calculating Reserve Capacity Settlement Amount for Supply | PASS | 2008 |
| | | | PASS | 2008 |
| | | Test RCS2: Calculating Reserve Capacity Settlement Amount for Demand | PASS | 2008 |
| | | Test RCS3: Calculating Reserve Capacity Refund Settlement Amount | PASS | 2008 |
| | | Test RCS4: Calculating Reserve Capacity Rebates and Offsets | | |
| Settlement | Balancing Settlement | Test BS1: Authorised Deviation Settlement Amounts | PASS | 2008 |
| | | Test BS2: Authorised Deviation Settlement Amounts for Verve Energy | PASS | 2008 |
| | | | PASS | 2008 |
| | | Test BS3: Unauthorised Deviation Settlement Amounts | PASS | 2008 |
| | | Test BS4: Resource Plan Deviation Settlement Amount | PASS | 2008 |
| | | Test BS5: Dispatch Instruction Settlement Amounts | | |
| Settlement | Other Settlement | Test OS1: Reconciliation Settlement Amount | PASS | 2008 |
| | | | PASS | 2008 |
| | | Test OS2: Market Fee Settlement Amount | PASS | 2007 |
| | | Test OS3: NCS, CO and NCC Settlement Amounts | | |
| Settlement | Other Settlement | Test OS1: Reconciliation Settlement Amount | PASS | 2008 |
| | | | PASS | 2008 |
| | | Test OS2: Market Fee Settlement Amount | PASS | 2008 |
| | | Test OS3: NCS, CO and NCC Settlement Amounts | | |
| Settlement | Other Settlement | Test OS1: Reconciliation Settlement Amount | PASS | 2008 |
| | | | PASS | 2008 |
| | | Test OS2: Market Fee | | |

| System | Subject | Test | Result | Year |
|---------------------------|------------------------------------|---|--------|------|
| | | Settlement Amount Test OS3: NCS, CO and NCC Settlement Amounts | PASS | 2008 |
| Settlement | Meter Data Warehouse | Peak determination methodology relating to Temperature Dependent Loads | PASS | 2008 |
| Market Systems | Non-STEM | Maximum Alternative Maximum Stem Price calculation | PASS | 2008 |
| Market Systems | Non-STEM | Incremental Reserve Capacity Ratio calculation | PASS | 2008 |
| Market Systems | Non-STEM | Prudential Requirements calculation | PASS | 2008 |
| Market Systems | STEM & Non- STEM | Change to the resource plan calculation | PASS | 2009 |
| Settlement | Other Settlement | Settlement of intermittent load generators | PASS | 2009 |
| Market Systems | Reserve Capacity | Supplementary Reserve Capacity calculation | PASS | 2009 |
| Settlement | Reserve Capacity | Change of Reserve Capacity date range from August - 30 November inclusive to 1 June - 30 September | PASS | 2010 |
| Settlement | Reserve Capacity | Early Certified Reserve Capacity calculation | PASS | 2010 |
| Settlement | Ancillary Service Settlement | Treatment of negative MCAP on the settlement of Ancillary Services | PASS | 2010 |
| Settlement | Reserve Capacity | Calculation of net STEM shortfall | PASS | 2010 |
| Settlement | Reserve Capacity | Determination of capacity shortfall for curtailable loads | PASS | 2010 |
| Settlement | Ancillary Service Settlement | Ancillary Service Availability Cost calculation | PASS | 2011 |
| Market Systems | STEM | Inclusion of more than 50 participants in STEM auction and dispatch merit order calculations | PASS | 2011 |
| Settlement | Capacity Refunds | Capacity Refunds calculation: Relief from capacity refund and unauthorised deviation penalties for consequential outages (RC_2010_23) | PASS | 2011 |

We have reviewed the relevant IMO IT system change control logs and have confirmed that, other than set out in section 3.3, the above software has not been materially changed since the referenced tests were performed.

3.3 2011-12 market software certification

3.3.1 Certification of core market software

There were 11 releases of new settlement software between 13 August 2011 and 10 August 2012. There were 15 releases of new market systems software in the same period.

Most of these changes maintained certification without additional testing, as they did not involve changes that would be expected to have material impact on prices or quantities. The changes are set out in Table 2, along with the certification status of the software version. Versions that were implemented without certification are **shown in bold**.

Table 2: Software changes in the 2011-12 audit period

| System | Version number | Changes to calculations affecting market outcomes? | Certification status | Comment |
|------------|---------------------------|--|---------------------------------------|--|
| Settlement | PST 2.2.3 Update 28 | No | Maintained | |
| Settlement | PST 2.5 Update 10 | No | Maintained | |
| Settlement | PST 2.5 update 11 | Yes | Not certified | Not Material Includes changes to ancillary services settlement calculations for RC_2010_33. While the calculations are core to the settlements process, the changes will only make a difference in certain limited circumstances, which have not occurred, and incorrect implementation should be readily apparent. |
| Settlement | PST 2.5 updates 12 and 16 | Yes | Certified after implementation | Not Material Includes changes to remove Network Control Service quantities from calculation of Monthly Settlement Amounts. This change was identified in the previous audit as having been implemented but not yet made. In any case, there were no NCS contracts in the audit period, so these calculations were never exercised. While certification was not performed at the time, later certification testing showed the calculations to be correctly implemented. |
| Settlement | PST 2.5 update 13 | No | Maintained | |
| Settlement | PST 2.5 | | Not certified | Not material |

| System | Version number | Changes to calculations affecting market outcomes? | Certification status | Comment |
|-------------------|--------------------|--|----------------------|--|
| | update 15 | | | Includes changes to capacity refund calculations for partially commissioned intermittent generators for RC_2010_22. Certification testing found an error in the calculations around output in past periods. The error is unlikely to have significant impact. The version was implemented with the known error in place. A fix for the error has been developed and is scheduled for imminent certification and deployment. |
| Settlement | PST 2.5 update 17 | Yes | Certified | Includes changes to net STEM shortfall calculations to include facility level dynamics. |
| Settlement | PST 2.5 update 18 | No | Maintained | |
| Settlement | PST 2.5 update 19 | No | Maintained | |
| Settlement | PST 2.5 update 21B | No | Maintained | |
| Settlement | PST 2.5 Update 22 | Yes | Certified | Includes changes to capacity refund calculations for late commissioning facilities. |
| WEMS | 2.6.6 | No | Maintained | |
| WEMS | 2.6.7 | Yes | Certified | Corrected issue restricting the number of participants used in calculation of MCAP, UDAP and DDAP. |
| WEMS | 2.6.8 | No | Maintained | |
| WEMS | 2.7.37 | No | Maintained | |
| WEMS | 2.7.39 | No | Maintained | |
| WEMS | 2.7.41 | No | Maintained | |
| WEMS | 2.8.28 | No | Maintained | |
| WEMS | 2.8.29 | No | Maintained | |
| WEMS | 3.0.18 | No | Maintained | |
| WEMS | 3.0.21 | Yes | Not certified | Not material |

| System | Version number | Changes to calculations affecting market outcomes? | Certification status | Comment |
|-------------|----------------|--|----------------------|--|
| | | | | Includes a minor change to the calculation of Reserve Capacity Obligations for Demand Side Programmes, related to RC_2010_29. This rule change commenced on 1 October 2011, but substantive systems change will not be made until late 2012. Certification testing will include this already implemented change. No DSP dispatch occurred in the audit period, meaning that the calculation will not be exercised prior to certification. |
| WEMS | 3.1.36 | No | Maintained | Includes changes for new balancing and LFAS markets, but functionality is not live. |
| WEMS | 3.1.41 | No | Maintained | Includes changes for new balancing and LFAS markets, but functionality is not live |
| WEMS | 3.1.43 | Yes | Certified | Includes live functionality for new balancing and LFAS markets. |
| WEMS | 3.1.44 | Yes | Certified | Includes changes to calculation of Balancing Merit Order where participants submit based on their resource plan quantities. |
| WEMS | 3.1.45 | No | Maintained | |

All of the above software has either been tested by PA, or the IMO testing has been reviewed and accepted by PA. PA has then certified that the above software complies with the requirements of the Market Rules.

3.3.2 Certification of tools outside core market systems

In addition to certification of core market systems, PA has certified changes to supporting tools as shown in Table 3.

Table 3: 2011-2012 supporting tool certification

| System | Subject | Test | Date certified |
|--|------------------|--|----------------|
| Protected Excel Workbook | Reserve Capacity | Calculation of Relevant Level for Certified Reserve Capacity for Intermittent Generators | 13 August 2012 |
| IMO Relevant Demand Calculation Program | Reserve Capacity | Calculation of relevant demand for Demand Side Programmes | 4 July 2012 |
| Protected Excel Workbook | Reserve Capacity | Calculation of Demand Side | 2 July 2012 |

| System | Subject | Test | Date certified |
|---|------------------|--|------------------|
| | | Program Deficit Refunds (version 10) | |
| Protected Excel Workbook | Reserve Capacity | Calculation of Demand Side Program Deficit Refunds (version 8) | 1 June 2012 |
| Protected Excel Workbook | Reserve Capacity | Calculation of Demand Side Program Deficit Refunds (version 6) | 2 December 2011 |
| Protected Excel Workbook | Reserve Capacity | Calculation of Maximum Reserve Capacity Price (version 231111) | 23 November 2011 |
| Protected Excel Workbook | Reserve Capacity | Calculation of Maximum Reserve Capacity Price (version 201011) | 25 October 2011 |
| Protected Excel Workbook | Reserve Capacity | Estimation of Transmission Connection Costs | 14 November 2011 |
| Non Temperature Dependent Load calculation tool | Reserve capacity | Assessment of temperature dependence of intermittent loads | 6 October 2011 |

3.3.3 Rule changes not yet implemented in software

We also note a number of rule changes which have already commenced, but have not yet been reflected in IMO software. This means that the IMO's core market software cannot be certified to comply with the Market Rules as follows:

Table 4: 2011-2012 market rule changes not yet implemented in core market software

| System | Subject | Rule change reference | Commenced | Change | Comment |
|---------------------|---------|--------------------------|-----------------|---|---|
| WEMS and Settlement | Various | RC_2010_29 RC_2011_08 | 1 December 2011 | Introduction of demand side programmes and removal of curtailable loads | <p>Not material</p> <p>Delaying implementation was a conscious decision, and the IMO has put significant effort into ensuring it remains compliant during the period before full systems implementation is complete.</p> <p>Several supporting tools have been developed to support current manual processes. Where relevant, these tools have been certified, and are noted in Table 3 above.</p> <p>Systems development is well advanced, with implementation and certification planned for late 2012.</p> |

3.4 Opinion

Other than the non-compliances identified above, IMO software is certified to comply with the requirements of the Market Rules.

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