INDEPENDENT MARKET OPERATOR

Independent Assurance Report - Audit 2: Compliance of the IMO's market software systems and processes for software management

FINAL REPORT

4 November 2015

EXECUTIVE SUMMARY

This independent assurance report sets out the results of the market audit by PA Consulting Group in carrying out its audit of the compliance of IMO's market software and processes for software management with the Wholesale Electricity Market Rules (Electricity Rules) and Market Procedures.

Scope

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

Audit period

The period covered by the audit is 1 August 2014 to 31 July 2015.

Approach

Our audit has been conducted in accordance with Australian Auditing and Assurance Standards Board's '*Framework for Assurance Engagements*', ASAE 3000 '*Assurance Engagements Other than Audits and Reviews of Financial Information*'.

Our approach is briefly described below:

- Our review of the IMO's software management processes and controls provides limited assurance under ASAE 3000. To provide limited assurance, we have examined documented processes and interviewed IMO staff and reviewed other pertinent information and documentation to compare these to operational practices to assess compliance with the Electricity Rules.

- Our review of software changes and of market software compliance with the Electricity Rules and Market Procedures provides reasonable assurance under ASAE 3000. To do this we have identified all rule and market system changes implemented since the last audit, and determined whether rule changes have been appropriately implemented in market systems, and whether all system changes have been certified as required by clause 2.36.1(d) of the Electricity Rules. Note that PA certifies changes to the IMO's market software on a release by release basis (during the Audit Year). Our approach to certification provides reasonable assurance under ASAE 3000.

We performed one site visit in August 2015 over a period of one week.

Summary of non-compliance incidents

We have not observed any incidents of non-compliance with the Electricity Rules and Market Procedures.

General comments on the IMO's processes for software management

The IMO has continued to improve its IT processes and practices. High levels of automation were already in place for the WEMS development process, as noted during the previous audit, so the changes during this audit year are refinements rather than any major changes to procedures.

There were no substantive changes to process documentation during this audit year.

The IMO has less ability to control settlement system development practices than it does for WEMS, as the settlement system is developed by a third party vendor. Nevertheless, the management of settlement software has continued to improve over the course of the audit year; however, opportunities for further improvement still remain, particularly in the automation of deployments.

Opinion

Our opinion is as follows and is subject to the inherent limitations and qualifications set out in Section 1.3.3.

We have not observed anything that causes us to believe that the IMO's processes for software management have not been compliant with the Wholesale Electricity Market Rules and Market Procedures during the Audit Period in all material respects.

It is our opinion that the IMO's core market software systems correctly implement the calculations embodied in the Electricity Rules and Market Procedures, in all material respects.

PA Consulting Group

Stephen James Thornton

Member of PA's Management Group

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1   INTRODUCTION

This independent assurance report sets out the results of the market audit by PA Consulting Group in carrying out its assessment of the compliance of IMO's market software systems and processes for software management with the Wholesale Electricity Market Rules (Electricity Rules) and Market Procedures.

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:

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

1.2   Audit period

The period covered by the audit is 1 August 2014 to 31 July 2015.

1.3   Market audit process

1.3.1   Approach

We have approached the audit in two components, respectively examining[1]:

1.   The 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 through interviews with IMO staff and inspections of process records; and
- Reviewed the compliance of operational practices with the Electricity Rules.
- Observed the replication of market outputs using a past version of market software to assess compliance with clause 2.36.1(b).

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;

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[1] We performed one site visit in August 2015 over a period of one week.

- 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.

1.3.2   Auditing standard and level of assurance

Our audit has been conducted in accordance with Australian Auditing and Assurance Standards Board's '*Framework for Assurance Engagements*', ASAE 3000 '*Assurance Engagements Other than Audits and Reviews of Financial Information*'.

Our review of the IMO's software management processes and controls provides limited assurance under ASAE 3000.

Our review of the IMO's software changes and the compliance of IMO's market software with the Electricity Rules and Market Procedures provides reasonable assurance under this standard.

1.3.3   Inherent limitations

As in previous years, we note that there are limitations to any external audit. Audits are not an absolute guarantee of the truth or reliability of agency information or the effectiveness of internal controls. They may not identify all matters of significance. This is because external audit techniques involve:

- Professional judgement as to "good industry and market operational practice"
- The use of sample testing
- An assessment of the effectiveness of internal control structures and
- An assessment of risk.

A market audit does not guarantee every procedure and action carried out in the operation of the electricity market in the audit report, nor does it examine all evidence and every transaction. However, our audit procedures should identify errors or omissions significant enough to adversely affect the decisions of market participants.

Our opinion with respect to the compliance of IMO's market software systems and processes for software management with the Electricity Rules and Market Procedures are therefore subject to the following caveats:

1. Our audit procedures did not include assessing irregularities such as fraudulent or illegal activities. As such, our audit should not be relied upon to disclose such irregularities. However, in the event that we were to detect any fraudulent or illegal activity, we would report this to the IMO. No such findings have been made during this audit.

2. Our audit is not designed to detect all weaknesses in control procedures as it is not performed continuously throughout the audit period and is performed on a sample basis. Specifically, our business process reviews assessing the use of controls were undertaken after the end of the audit year. As such:

    a. Although our findings are indicative of the IMO's practices during the audit year, they do not constitute definitive evidence that the IMO applied those controls during the audit year.

    b. Projections of our findings to future periods carry the risk that:

        i.   Controls may become inadequate over time due to changes in the Electricity Rules or the IMO's business processes, procedures and systems

        ii. The degree of compliance with the control procedures we have reviewed deteriorates over time.

1.3.4   Materiality

Where non-compliant procedures or actions are identified, these are classified as being:

- Material, in that they do not comply with the Electricity Rules and may affect decisions made by market participants, affect the outcome of the market or otherwise affect the financial position of one or more rule participants, or
- Non-material, in that:
  – They do not comply with the wording of the Electricity Rules but do comply with the intention of the Electricity Rules, or
  – They do not comply with the Electricity Rules but they are not likely to affect decisions made by market participants, affect the outcome of the market or otherwise affect the financial position of one or more rule participants.

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.

1.5   Acknowledgements

PA would like to thank the managers and staff of IMO who willingly provided information and shared in discussions while we carried out this market audit.

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: IT Support Pack;
- Internal Procedure: Software Configuration Management Plan; and
- Internal Procedure: WEMS IT Disaster Recovery Plan

2.1 The IMO's software obligations under the Electricity Rules

The Electricity Rules set out certain obligations with respect to the IMO's software management systems and controls.

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:

   a. *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;*

   b. *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;*

   c. *ensure that appropriate testing of new software versions is conducted;*

   d. *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*

   e. *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.*

Rule 2.36.2 defines a 'version' as follows:

A "version" of the software referred to in clause 2.36.1 means any initial software used and any changes to the software that could have a material effect on the prices or quantities resulting from the use of the software.

2.2 Changes to software management processes and controls

The IMO has continued to improve its IT processes and practices. High levels of automation were already in place, as noted during the previous audit, so the changes during this audit year are refinements rather than any major changes to procedures.

There were no substantive changes to process documentation during this audit year.

The IMO has less ability to control settlement system development practices than it does for WEMS, as the settlement system is developed by a third party vendor, while WEMS is effectively developed in house by the IMO. Nevertheless, the IMO does have ability to manage some parts of the settlement system release lifecycle. The management of settlement software has continued to improve over the course of the audit year; however, opportunities for further improvement still remain, particularly in the automation of deployments.

2.2.1 Changes to documentation, frameworks and tools

There were no substantive changes to the Software Configuration Management Plan or IT Support Pack documents during the audit year.

Workflow processes in JIRA (the IMO's workflow tool, used for development activities as well as operational support) are now well established and applied consistently. A continuous build system implemented using Bamboo, and automated testing using JUnit are also well established for the IMO-developed software systems (WEMS, GBB, SPARTA). In addition, the IMO has implemented automated running of some certification regression test cases for WEMS using Cucumber.

2.2.2 Changes to practice

The WEMS change, test and release cycle continues to perform well. The IMO has automated build and deployment activities, to the point where there is limited scope for manual error in the release process. An important improvement that has been made during the year is to tag versions of deployment scripts with the software releases that used them. This ensures that previous software releases can be redeployed using exactly the same deployment scripts that were originally used.

The settlements system is developed by a third party, so there are some differences to the procedures and tools used. The change approval process, as implemented in JIRA, is the similar, with the vendor having implemented a JIRA system that is accessible by the IMO. A change control board (CCB) process has been started with the software vendor during the audit year to ensure change decisions are made on a consistent basis. Testing and deployment is tracked in the IMO's JIRA system. Code management and build is performed by the vendor. Deployment still involves a large number of manual steps, increasing the scope for human error and the possibility of not being able to reproduce a previous release. The IMO has a long-term goal of automating the release process.

2.3 Comments on IMO Compliance with the Electricity Rules

Subject to Section 2.3.2, the IMO's software management processes remain sufficient to comply with the Electricity 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, JIRA records and database entries;
- 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. The IMO was able to reproduce past results exactly for a sample case[2];

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[2] Specifically, the final balancing prices for 1 August 2014, which were generated using WEMS version 3.10-99-59 which was deployed into production on 25 June 2014.

- With respect to 2.36.1(c), the IMO conducts appropriate testing of all new releases of the market software prior to their being placed in service;
- With respect to 2.36.1(d), the IMO has ensured that all software versions are covered by an independent certification prior to implementation, subject to the observations noted in section 2.3.1;
- With respect to 2.36.1(e), the IMO provides documentation on the functionality of the market software and the IMO also holds release artefacts including detailed release notes for each release. 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   Testing of software releases

The testing of IMO-developed software releases by the IMO consists of:

1.   A set of automated unit test scripts that are run automatically as part of the build process

2.   A set of manually executed functional test scripts that are performed by specialist test staff

The automated unit tests are run on every software build, so every version released into production will have had the full set of these tests run on it prior to release.

A full set of manual functional tests is not generally run on the same software versions that are released into production. This is due to the agile development process that has been adopted by the IMO, which results in a numerous and frequent software builds being generated prior to the release version. As a result, several software builds typically occur during the running of the manual tests, so a significant proportion of the tests will have been run on software builds that preceded the build that was actually put into production.

While this is not ideal, it represents a reasonable compromise between the conflicting objectives of rigorous software testing, and timely release of important software enhancements and fixes. As such, we do not consider it a breach of 2.36.1(c).

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 'market software systems' 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. We do note that the IMO has begun to use its source control systems to manage versioning of some of these tools, and we recommend that it continues to expand the scope of source control to other spreadsheet tools.

2.4   Opinion

We have not observed anything that causes us to believe that the IMO's processes for software management do not comply with the Electricity Rules, in all material respects.

3 COMPLIANCE OF 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 Settlement 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

Software testing and certification under MR 2.36.1(d) is carried out on a release by release basis throughout the year. Below, we describe the approaches used for that testing.

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 Electricity 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 audits 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 Electricity Rules. Since the 2008-9 year, we have determined the status of the market software by:

- Examining the IMO's market software change procedures to ensure that they are robust;
- Examining various records of changes made to the market software systems (including change process logs, release notes and system audit trails) 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, if there are no changes made to the software since the last time it was certified, we may deduce that the software continues to comply with the Electricity Rules.

If changes are made to the software, we plan and conduct tests to exercise any new or changed calculations, and other calculations that are likely to have been affected.

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

This incremental approach provides a cost-effective means for providing assurance on compliance when changes to the market are incremental in nature, but it becomes less meaningful as time goes on and/or if major changes are introduced to the market.

3.2   Market software certification prior to the 2014-15 audit period

This section provides a summary of the full set of tests previously conducted on the core IMO market software systems along with the results of those tests. The core market software systems are comprised of:

- WEMS – Wholesale Electricity Market Systems, a software system built and maintained by the IMO, and incorporating proprietary components provided by ABB
- POMAX Settlements – a software system provided by the vendor Brady Energy
- POMAX Metering – a software system provided by the vendor Brady Energy

WEMS certification relies on the chain of certification testing back to the comprehensive testing conducted in 2007-8. We conducted comprehensive testing of new WEMS components for the introduction of balancing and load following markets in 2012.

Settlements certification is based on the chain of certification testing back to the comprehensive testing conducted in 2014 for the new settlements version 3.4.6.

For the 2008-2011 audit periods, the information presented is organised around the tests conducted. Table 1 sets out:

- The features of Market Systems software which have been tested;
- The nature of the tests conducted.

For the 2011-2014 audit periods, Table 2 sets out the specific market software component releases, and their certification status. Releases with certification status of 'maintained' did not require additional testing, as they did not involve changes that would be expected to have material impact on prices or quantities.

Table 1: Summary of previous tests conducted 2008-2011

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
		NST 4 Reserve Capacity Obligation Quantities	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
Market Systems	STEM	Inclusion of more than 50 participants in STEM auction and dispatch merit order calculations	PASS	2011

Table 2: Production software changes in the 2011-14 audit periods

System	Version number	Changes to calculations affecting market outcomes?	Certification status
WEMS	2.6.6	No	Maintained
WEMS	2.6.7	Yes	Certified
WEMS	2.6.8	No	Maintained
WEMS	2.7.37	No	Maintained
WEMS	2.7.39	No	Maintained

System	Version number	Changes to calculations affecting market outcomes?	Certification status
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	Certified
WEMS	3.1.36	No	Maintained
WEMS	3.1.41	No	Maintained
WEMS	3.1.43	Yes	Certified
WEMS	3.1.44	Yes	Certified
WEMS	3.1.45	No	Maintained
WEMS	3.2.8	No	Maintained
WEMS	3.3.12	No	Maintained
WEMS	3.4.11	Yes	Certified
WEMS	3.5.6	Yes	Certified
WEMS	3.6.12	Yes	Certified
WEMS	3.6.13	No	Maintained
WEMS	3.6.15	No	Maintained
WEMS	3.6.16	No	Maintained
WEMS	3.7.9	No	Maintained
WEMS	3.7.12	No	Maintained
WEMS	3.7.13	Yes	Certified
WEMS	3.8.5	No	Maintained
WEMS	3.8.6	No	Maintained
WEMS	3.9.2	Yes	Certified
WEMS	3.9.2 (AS-2456)	Yes	Certified
WEMS	3.10.99-15	Yes	Certified
WEMS	3.10.99-59	No	Maintained
Metering	11 update 14	Yes	Certified

We have reviewed the relevant IMO IT system change control logs (including release notes, JIRA records, and database 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 2014-15 market software certification

3.3.1 Certification of core market software

There were three releases of new settlement software between 1 August 2014 and 31 July 2015, and one release of metering software. There were nine releases of new market systems software in the same period.

Settlements software was comprehensively tested in Q4 2014 for the new settlements version 3.4.6.

Most changes maintained certification without additional testing, as they did not involve changes that would be expected to have material impact on prices or quantities. All releases having material impact on market prices or quantities were certified prior to release. The changes are set out in Table 3, along with the certification status of the software version. Table 3 only includes releases implemented in the production environment, and does not include versions which were only implemented in a development or test environment.

Table 3: Production software changes in the 2014-15 audit period

System	Version number	Release date	Changes to calculations affecting market outcomes?	Certification status	Comment
Metering	11.0.20	7/10/2014	No	Maintained	
Settlements	3.4.6	3/11/2014	Yes	Certified	Note that for this release we carried out comprehensive certification testing.
Settlements	3.4.7	2/12/2014	No	Maintained	
Settlements	3.4.8	11/03/2015	Yes	Certified	
WEMS	3.10-99-63	1/10/2014	No	Maintained	
WEMS	3.10-99-71	3/11/2014	No	Maintained	
WEMS	3.11.374-57	4/12/2014	No	Maintained	
WEMS	3.11.374-63	4/12/2014	No	Maintained	
WEMS	3.11.374-81	28/01/2015	No	Maintained	
WEMS	3.11.374-84	27/02/2015	No	Maintained	
WEMS	3.11.374-94	18/03/2015	No	Maintained	
WEMS	3.11.374-116	29/04/2015	No	Maintained	
WEMS	3.11.374-128	15/07/2015	No	Maintained	

Where the above software is designated 'Certified', it has either been tested by PA, or the IMO testing has been reviewed and accepted by PA. PA has then certified that the software complies with the requirements of the Electricity Rules.

3.3.2 Certification of tools outside core market systems

There were no certifications of changes to supporting tools (e.g. SPARTA, spreadsheet tools. etc.)

3.3.3 Rule changes in the audit period

There were two Electricity Rule changes commencing between 1 August 2014 and 31 July 2015. Neither of these rule changes required any changes to market software.

3.3.4 Rule changes from previous audit periods

All rule changes from previous periods have been incorporated into the market software.

3.4 Opinion

It is our opinion that the IMO's core market software systems correctly implement the calculations embodied in the market rules, in all material respects.

PA

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We are an employee-owned firm of over 2,500 people, operating globally from offices across North America, Europe, the Nordics, the Gulf and Asia Pacific.

We are experts in energy, financial services, life sciences and healthcare, manufacturing, government and public services, defence and security, telecommunications, transport and logistics.

Our deep industry knowledge together with skills in management consulting, technology and innovation allows us to challenge conventional thinking and deliver exceptional results with lasting impact.