

//Review letter DACE 20110815.docx

August 15, 2011

Mr Paul Murphy  
Chief Executive Officer  
Independent Electricity System Operator  
Station A, Box 4474  
Toronto, ON  
M5W 4E5  
Canada

Dear Mr Murphy:

### **Opinion with respect to the Enhanced Day-Ahead Commitment Process Clearing Engine**

PA Consulting Group, Inc. ("PA") has been asked by Independent Electricity System Operator, ("IESO") to review the implementation of the Enhanced Day-Ahead Commitment software and systems for compliance with its design and the relevant Market Rules. There are two components to this review, corresponding to two software components:

- *The market clearing software* associated with the Enhanced Day Ahead Commitment process which comprises the Day Ahead Calculation Engine (DACE) -- part of the Day Ahead Optimization System (DAOS) -- as well as modifications to the Market Information Management (MIM) software to generate pseudo-unit parameters.
- *The settlement software* associated with Enhanced Day Ahead Commitment process which comprises the Commercial Reconciliation System (CRS) which has been modified to incorporate the settlement rules for EDAC, in particular rules governing guarantee payments and failure charges.

This opinion covers the market clearing software. A separate letter will address the settlement software.

### **Scope of the Evaluation**

This opinion represents our best determination based on our experience and expertise and relies on our document review and testing during the period from Nov., 2010 to June, 2011. It is not and cannot be in the form of an absolute guarantee. Our opinion assumes that the IESO will continue to operate its software with care, as configured, with parameters in the range of those provided to us for testing, in the manner intended, and with data that conform to the requirements of the Market Rules and which fall within their range of expected values. Over time, actual results that are consistently in compliance with the Market Rules will continue to confirm that the IESO's software operates in strict accordance with those Market Rules.

Our evaluation did not cover, and this opinion does not cover, the following:

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PA Consulting Group, Inc

- The interface software and database which calculate, read, transfer and store the data used by the DACE software;
- Manual processes or procedures of the IESO used for the Day Ahead Commitment Process outside of the automated system.

### **Nature of the Tests Conducted**

We have tested the DACE software by both:

- Building our own separate models based on the formulation set out in the approved market rule amendments to determine whether we get the same results as does the DACE; and
- Using mathematical testing techniques (right-hand-side incrementation — i.e., sequential changing or incrementing of a system or market parameter, such as the load at a given bus, the value of a given generator's bid or the thermal capability of a line) to determine whether the optimization software is operating in accordance with the formulation.

The testing we carried out included both the physical results (e.g., dispatch quantities) and the pricing results.

We tested the DACE on the full IESO model; however, we were able to identify a relatively small subsystem of the IESO grid to use as a test bed, so that all flows to and from the remainder of the IESO grid, and dispatch and commitment in the remainder of the IESO grid, would be unchanged throughout our tests. Effectively we have been able to test on a reduced model (the small subsystem) which contains all the important elements present in the full power system and is tractable for manual or spreadsheet calculation.

We followed a testing plan which included different test problems that were designed to effectively cover the full range of functionality that the DACE is required to have under the market rules. The test plan ensured that all constraints specified in the market rules were tested.

During our testing, we identified seven results that were or could have been at variance with the Market Rules:

- As we varied unit startup costs the results of the DACE would depart from optimality. This variance was eventually traced to an undocumented algorithm parameter. By changing this parameter to tighten the optimality tolerance in the algorithm, the variances were eliminated.
- Several of the software switches did not appear to function as documented (we tested various settings, not initially knowing which settings IESO would use). The vendor provided a fix and additional explanation of switch functionality.
- The downward ramping constraint was being improperly applied to units being shut down. The vendor corrected this and PA verified the fix.
- A test of the ramping of dispatchable loads generated an error in the third party mathematical programming solver used by the vendor. The error was actually associated with the formulation of an interchange ramp rate constraint. The vendor corrected the inputs to the solver and PA verified the fix.

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- PA identified a condition under which the calculation engine can produce a sub-optimal commitment for generation units which are supplying operating reserves when also ramping down and, based on a review of vendor documents, determined that there was probably an additional condition enforced in the software that was not present in the Market Rule. IESO has submitted for approval a Market Rule amendment (MR-382) to include the additional condition. PA verified that its test results are compatible with the revised Market Rule.
- PA observed additional sub-optimal unit commitments that appear to depend on ramp rate constraints; however, these results would not have been caused by the additional constraints referenced above. The vendor provided a new release of the software. IESO reran PA's tests and PA reviewed the results to verify the fix.
- In its tests of the response of system costs changes in load or generation at particular nodes, PA determined that DACE was producing incorrect LMP values in cases with an active transmission constraint. IESO has submitted for approval a Market Rule amendment (also in MR-382) to correct the computation, and has drafted a change order with its vendor to revise DACE. PA has reviewed this market rule amendment, and is satisfied that, if implemented, this would address this variance. As the change has not yet been completed, PA has not tested that implementation.

All of these variances have been rectified, assuming the correct implementation of the change order mentioned in the last bullet.

IESO Management has provided a response to this, which is enclosed.

### Opinion

As a result of our examination of the Market Rules and our testing of the Enhanced Day Ahead Commitment process software, we are able to provide the following opinion with respect to the Day Ahead Calculation Engine (DACE) software and its formulation:

*"Subject to the limitations and qualifications expressed in the "Scope of the Evaluation" section, we have determined that, assuming the change order related to the computation of Locational Marginal Prices is appropriately implemented, the IESO Day Ahead Calculation Engine software version 1.1.9 as at June 23, 2011 performs all functions, and correctly calculates dispatch and prices for Energy and Operating Reserves in the Enhanced Day-Ahead Market administered by the IESO, in compliance with the Market Rules including Amendments anticipated to be approved on September 9, 2011".*

Yours truly



Gregg Edeson  
Member of PA's Management Group

Encl: IESO Management Response

## IESO Management Response in Response to PA's External Review Findings

An external review of the implementation of the *market clearing software* associated with the Enhanced Day Ahead Commitment process for compliance with its design and the relevant Market Rules was completed on June 23, 2011.

An action plan to address the review's findings is outlined below:

Review's Finding	IESO Management Response	Target Completion Date
<i>"As we varied unit startup costs the results of the DACE would depart from optimality. This variance was eventually traced to an undocumented algorithm parameter. By changing this parameter to tighten the optimality tolerance in the algorithm, the variances were eliminated."</i>	The finding was fixed by IESO's vendor for the <i>market clearing software</i> . PA retested and confirmed that the fix addressed the finding.	Completed within the review period
<i>"Several of the software switches did not appear to function as documented (we tested various settings, not initially knowing which settings IESO would use). The vendor provided a fix and additional explanation of switch functionality."</i>	The finding was fixed by IESO's vendor for the <i>market clearing software</i> . PA retested and confirmed that the fix addressed the finding.	Completed within the review period
<i>"The downward ramping constraint was being improperly applied to units being shut down. The vendor corrected this and PA verified the fix."</i>	The finding was fixed by IESO's vendor for the <i>market clearing software</i> . PA retested and confirmed that the fix addressed the finding.	Completed within the review period
<i>"A test of the ramping of dispatchable loads generated an error in the third party mathematical programming solver used by the vendor. The error was actually associated with the formulation of an interchange ramp rate constraint. The vendor corrected the inputs to the solver and PA verified the fix."</i>	The finding was fixed by IESO's vendor for the <i>market clearing software</i> . PA retested and confirmed that the fix addressed the finding.	Completed within the review period
<i>"PA identified a condition under which the calculation engine can produce a sub-optimal commitment for generation units which are supplying operating reserves when also ramping down and, based on a review of vendor</i>	On July 14, 2011 IESO has submitted for approval a Market Rule Amendment Proposal MR-00382 to amend Appendix 7.5, Section 4.9, Section 5.10 and Section 6.9.	September 9, 2011

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Review's Finding	IESO Management Response	Target Completion Date
<p><i>documents, determined that there was probably an additional condition enforced in the software that was not present in the Market Rule. IESO has submitted for approval a Market Rule amendment (MR-382) to include the additional condition. PA verified that its test results are compatible with the revised Market Rule.</i></p>	<p>The finding will be considered fixed pending Market Rule Amendment approval by IESO Board on September 9, 2011.</p>	
<p><i>“PA observed additional sub-optimal unit commitments that appear to depend on ramp rate constraints; however, these results would not have been caused by the additional constraints referenced above. The vendor provided a new release of the software. IESO reran PA’s tests and PA reviewed the results to verify the fix.”</i></p>	<p>The finding was fixed by IESO’s vendor for the <i>market clearing software</i>. IESO retested and PA verified the test results and confirmed that the fix addressed the finding.</p>	<p>Completed within the review period</p>
<p><i>“In its tests of the response of system costs changes in load or generation at particular nodes, PA determined that DACE was producing incorrect LMP values in cases with an active transmission constraint. IESO has submitted for approval a Market Rule amendment (also in MR-382) to correct the computation, and has drafted a change order with its vendor to revise DACE. PA has reviewed this market rule amendment, and is satisfied that, if implemented, this would address this variance. As the change has not yet been completed, PA has not tested that implementation.”</i></p>	<p>On July 14, 2011 IESO has submitted for approval a Market Rule Amendment Proposal MR-00382 to amend Appendix 7.5, Section 4.12 and Section 6.12. We expect to get the Market Rule Amendment approved by the IESO Board on September 9, 2011.</p> <p>Pending approval of the Market Rule Amendment IESO will issue a change order to its <i>market clearing software</i> vendor to revise the software based on the revised market rules.</p> <p>The finding will be considered fixed pending Market Rule Amendment approval by IESO Board on September 9, 2011 and the implementation of the vendor's change order prior to EDAC In-Service date.</p>	<p>Prior to EDAC In-Service date</p>