PUBLIC

WESM Manual

Procedure for Determining Ex-Post Nodal Energy Prices
Issue 2.0

Abstract	This document describes the calculation of ex-post nodal energy prices for the WESM.

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　　　　　　　　　　　Ex-Post Nodal Energy Prices

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Document Approval

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Document Change History

Issue No.	Modifier	Date	Synopsis/Reason for Change
1.0	PEMC-MO	01 May 2006	Original Document
2.0	PEMC	29 September 2010	Inputs in the determination of ex-post nodal energy prices was revised to exclude contingency list *(Approved by the PEM Board as Urgent Amendments on 27 October 2010 and as General Amendments on 28 April 2011)*

Related Document

Document ID	Document Title
	WESM Rules, as amended
	WESM Dispatch Protocol Manual, Issue 5.0
	Criteria and Guidelines for the Issuance of Pricing Error Notices and Conduct of Market Re-Run, Issue 1.0

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1.   INTRODUCTION

1.1   About this Manual

This document describes the process of determining ex-post nodal energy prices as set forth in clause 3.10.7 of the WESM Rules, including the procedures to be employed in establishing network configuration and other constraints, pursuant to clause 3.10.6 (d) and (e).   For purposes of clarification, a description on the ex-ante process is also been included.

1.2   Purpose

To provide the procedure for determining ex-post nodal energy price and for establishing the network configuration and constraints to be assumed, in accordance with clause 3.10.7 in relation to clauses 3.10.6 (d) and (e) of the WESM Rules.

1.3   Scope

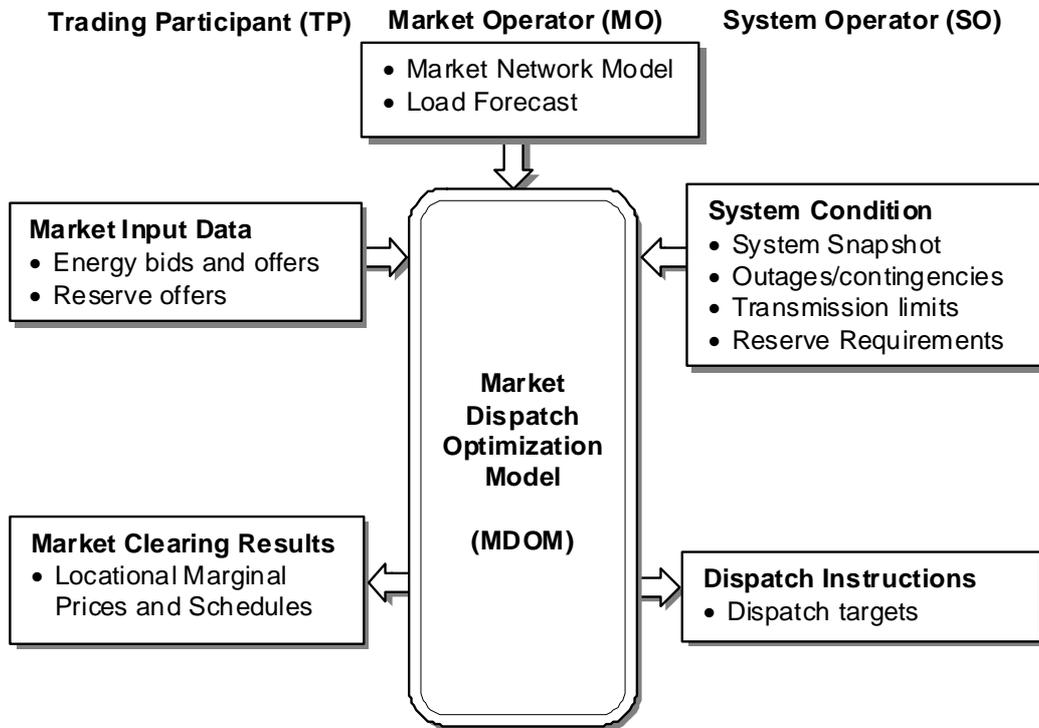This document describes the necessary inputs, process and output pertaining to ex-post nodal energy price.

1.4   Intended Audience

This document is intended for use by the Market Operator (the "MO") and the System Operator (the "SO") and the trading participants.

1.5   Background

The WESM adopts the scheme of ex-ante and ex-post pricing in any trading interval to account for discrepancies between planned and actual market dispatch. For any trading interval, the trading participants may submit market offers or bids to the market through the Market Management System (the "MMS") Market Participant Interface. At the start of any trading interval, the Market Dispatch Optimization Model (the "MDOM") will schedule all the available generation, taking into account the capabilities and configuration of the transmission network to transport energy from generators to customers as well as the limitations of the individual generating resources to meet the forecasted load at the end of that trading interval. The resulting schedules and prices are known as ex-ante schedules and prices. At the end of the trading interval, the MDOM will again perform the optimization process, taking into account the capabilities and configuration of the transmission network to transport the energy and the limitations of the individual generating resources to meet the actual load at each node represented in the Market Network Model to determine the ex-post prices.

Figure 1 below provides an overview of the scheduling and pricing process.

Figure 1. Market Pricing and Scheduling Overview

2.   DEFINITION OF TERMS

The following terms as used in this document have the same meaning as defined in the WESM Rules. For convenience, the definitions in the WESM Rules are copied as follows -

Constraint	A limitation on the capability of any combination of network elements, loads generating units or ancillary service providers such that it is, or deemed by the System Operator to be, unacceptable to adopt the pattern of transfer, consumption, generation or production of electrical power or other services that would be most desirable if the limitation were removed.
Constraint Violation Coefficients	Coefficients set by the Market Operator in accordance with WESM Rules clause 3.6.2. The Market Operator is to ensure that, if constraints shall be violated, such violation will occur in appropriate priority order.

Contingency List	Contains the definition of credible contingencies for power system security analysis. It includes a list of pre-defined outage scenarios that are most likely to occur in the system in faulty conditions.
Demand Bid	A standing bid or market bid to buy electricity submitted, or such bid revised by a customer in accordance with clauses 3.5.6, 3.5.9, 3.5.12, or 3.5.13, and containing the information specified in Appendix A1 of the WESM Rules.
Dispatch Schedule	The target loading levels in MW for each scheduled generating unit or scheduled load and for each reserve facility for the end of that trading interval, determined by the Market Operator through the use of market dispatch optimization model in accordance with WESM Rules clause 3.8.1.
Energy Management System (EMS)	A system of computer-aided tools used by the System Operator to monitor, control, and optimize the performance of the generation and transmission systems.
Ex-Ante	A matter determined in relation to a trading interval before that trading interval commences.
Ex-Ante Dispatch Process	Process where dispatch targets is set for the end of a trading interval, immediately preceding the beginning of that trading interval. Also known as Real-Time Dispatch (RTD) process.
Ex-Ante Nodal Energy Price	The price determined by the Market Operator for a particular market network node and trading interval, immediately prior to commencement of that trading interval, directly from the dispatch optimization for that trading interval in accordance with WESM Rules clause 3.10.2.
Ex-Post	A matter determined in relation to a trading interval after that trading interval concludes.
Ex-Post Dispatch Process	Process where dispatch is set for the end of a trading interval, immediately after the trading interval concludes. Also known as Real-Time Ex-Post (RTX) Process.

Ex-Post Nodal Energy Price	The price determined by the Market Operator for a particular market node and trading interval, after the end of that trading interval in accordance with WESM Rules clause 3.10.6.
Generation offer	A standing offer, or market offer to supply electricity, submitted or revised by a generation company in accordance with WESM Rules clauses 3.5.5, 3.5.9, 3.5.10 or 3.5.11.
Load	The amount of energy consumed in a defined period via node.
Market Dispatch Optimization Model (MDOM)	The optimization model which contains the mathematical algorithm approved by the PEM Board to be used for the purposes of determining dispatch schedules and energy prices, and preparing market projections based on the price determination methodology approved by the ERC.
Market Network Model	A mathematical representation of the power system, which will be used for the purpose of determining dispatch schedules and energy prices, and preparing market projections.
Market Offer	A generation offer for a particular trading interval of a particular trading day in the current market horizon, whether formed from a standing offer in accordance with WESM Rules clause 3.5.10 or revised by the relevant trading participant in accordance with WESM Rules clause 3.5.11.
Nodal Energy Price	The energy price at a node determined ex ante or ex-post. This is also the Locational Marginal Price (the "LMP") in the WESM.
Outage Schedules	Schedule for shutting down or de-rating of generation and transmission facilities.
Reserve Requirements	Demands for regulation reserve, contingency reserve and other relevant types of reserves. They are determined based on system loading, maximum generator tripping and other considerations.

Security limits | Limits imposed by the System Operator on generation and transmission equipment to maintain system security and reliability.

System Snapshot | The power system status at a certain time and is generated by the Energy Management System of the System Operator.

Trading interval | A 1-hour period commencing on the hour.

Trading Participant | A customer or generation company.

Transmission limits | Generally, thermal limits of individual transmission facilities.

3. RESPONSIBILITIES

3.1. The MO is responsible for the development, maintenance, publication, revision of this document in consultation with Trading Participants and the System Operator.

3.2. The PEM Board shall approve this document and any subsequent revisions and issuances.

4. REAL TIME DISPATCH PROCESS

For each trading interval, two dispatch processes are involved which are performed on a rolling timeline[1]. These are the Real-Time Ex-Ante Dispatch (the "RTD") which is initiated at five (5) minutes prior to the start of the trading interval and the Real-Time Ex-Post Dispatch (the "RTX") which is initiated at the end of the trading interval.

The RTD or Ex-Ante process takes into account the following:

- Market offers and bids from trading participants for the trading interval
- Load forecast for the end of the trading interval as determined via the Load Predictor methodology (the "LDP").
- Latest system configuration and state (generation and load levels) as determined from the power system snapshot provided every five (5) minutes by the SO Energy Management System (the "EMS") and reflected in the Market Network Model.

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[1] i.e. these processes are executed on an hourly basis.

- Latest system condition and requirements as provided by the SO through the following:
  - Reserve Requirements
  - Outage Schedule
  - Security Limits
  - Transmission Limits
  - Contingency List
  - Load Pattern

Information from the SO are provided to the MO anytime. Updates should, however, be received before the start of the RTD process to be considered in the optimization process.

The RTX or Ex-Post process uses the same offers and bid that are submitted by the trading participants for the ex-ante dispatch process of each trading interval; the latest EMS snapshot to determine system configuration and state (generation and load levels) and any updated system condition and requirements as provided by the SO on any relevant over-riding constraints in the power system. However, the RTX process uses the actual load as determined from the power system snapshot instead of the LDP load forecast.

For both dispatch processes, the market network configuration and state is reflected in the Market Network Model from the information provided by the power system snapshot. In this manner, consistency is maintained between the Market Network Model and the actual network configuration. The latest system condition and requirements are reflected as over-riding constraints through the information provided by the SO which enables the Market Dispatch Optimization Model to consider any relevant constraints to represent system security conditions or actual generation performance. However, the contingency list is not used in the Ex-Post dispatch process so as not to alter the network condition pertaining to the duration of the trading interval.

The real-time dispatch process can continue up to two hours (i.e., two trading intervals) from the time the last snapshot is received by the Market Management System (the "MMS").

Figure 1 below shows the Real Time processes

Figure 1. RTD and RTX Processes

Information provided by SO as per Dispatch Protocol:
- Reserve requirements
- Outage Schedules
- Contingency list
- Transmission Limits
- Security Limits
- Load pattern

Submitted information prior to start of each Real-Time Process is considered in the optimization process.

☐ - Power System Snapshot provided by the EMS to MMS every five (5) minutes.

Trading Interval

Real-Time Dispatch (RTD) every 5 minutes before the start of Trading Interval. Utilizes snapshot provided by EMS at 5 minutes before the start of the interval and other over-riding constraints provided by the SO prior to the start of the RTD run.

Real-Time Ex-Post (RTX) runs at every end of the Trading Interval. Utilizes snapshot provided by EMS at the top of the hour and other over-riding constraints as provided by the SO prior to the start of the RTX run.

5.   REAL TIME DISPATCH SCHEDULES AND PRICES

The Real Time Ex-Ante Dispatch (RTD) determines hour-ahead ex-ante schedules and prices. These ex-ante schedules are used to instruct generators to produce energy and allocate reserves for the end of the trading interval. The ex-ante prices determined are then paired with the ex-ante schedules to determine the Ex-Ante settlement amount of each Trading Participant.

The Real-Time Ex-Post Dispatch (RTX) also determines ex-post schedules and prices. However, the prices determined in the ex-post process are paired with the metered quantities to determine the Ex-Post Settlement amount of each Trading Participant.

6.   MARKET RE-RUN FOR REAL-TIME EX-POST DISPATCH PROCESS

When pricing error is issued in Ex-Post, the Market Operator shall perform an Ex-Post market re-run in accordance with the WESM Manual on Criteria and Guidelines for the Issuance of Pricing Error Notices and Conduct of Market Re-Run.

7. PROCEDURE FOR EX-POST NODAL ENERGY PRICE

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                   ╱   Latest EMS         ╲         ┌─────────────────────┐
                  ╱    Information?         ╲───N──▶│ Retrieve Previous   │
                  ╲                         ╱       │ EMS information     │
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                    │ Determine Power    │◀──────────────────┘
                    │ System             │
                    │ Configuration      │
                    │ based on System    │
                    │ snapshot           │
                    └─────────┬──────────┘
                              ▼
                    ┌────────────────────┐
                    │ Determine Nodal    │
                    │ Loads based on the │
                    │ System snapshot    │
                    └─────────┬──────────┘
                              ▼
                    ┌────────────────────┐
                    │ Retrieve Bids and  │
                    │ Offers of TPs for  │
                    │ the Interval       │
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                    ┌────────────────────┐
                    │ Perform Market     │
                    │ Dispatch           │
                    │ Optimization       │
                    └─────────┬──────────┘
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                   ╱   Results           ╲      ┌────────────────────────┐
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                  ╲    in Error?           ╱    │ Optimization Model     │
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                    │ Publish Ex-Post    │
                    │ Nodal Energy       │
                    │ Prices             │
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                        │     End      │
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Note:
Latest EMS information pertains to the following:

- Snapshot
- Reserve requirements
- Outage Schedule
- Security Limits
- Transmission Limits
- Load Pattern