PUBLIC

WESM Market Manual

CONSTRAINT VIOLATION COEFFICIENTS (CVC) AND PRICING RE-RUNS
Issue No. 5

Abstract	Provides the Constraint Violation Coefficients to be used by the Market Dispatch Optimization Model, as well as the Market Pricing Re-runs involved to correct prices in cases where constraint violations or pricing errors occur.

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Document Change History

Issue No.	Proponent	Date of Effectivity	Reason for Amendment
	MO Subcom	16 June 2005	New Document
	MO Subcom	25 July 2005	Revised/deleted some sections. Change over-generation CVC price to be the same as under generation.
1.0	MO Subcom	04 August 2005	Revised to incorporate comments of RCC
2.0	MO Subcom	06 July 2006	To reflect the PEM Board approved amendments in the CVC prioritization order that will enable the Market Operator and the Trading Participants to readily and effectively address under generation scenario and/or transmission line overloading encountered in the system.
3.0	PEMC	19 February 2014	To reflect the amendments in the CVC prioritization order that is consistent with the operational priorities of system operations in cases of insufficient supply prior to the integration of the reserves in the commercial operations of the WESM.
4.0	PEMC	04 August 2014	Re-submission of approved urgent amendments as general amendments, with further revisions to the values in the CVC priority table.
5.0	PEMC		• Adoption of enhancements to WESM design and operations • Integrated mechanism of pricing re-runs, which abolishes the WESM Manual on the Criteria and Guidelines for the Issuance of Pricing Error Notices and Conduct of Market Re-run (PEN-MRR)

Document Approval

Issue No.	RCC Approval	RCC Resolution No.	PEM Board Approval	PEM Board Resolution No.
1	04 August 2005		17 August 2005	
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3	14 November 2006		17 November 2006	
4	21 February 2014		27 February 2014	
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Reference Documents

Document ID	Document Title
	WESM Rules
WESM-PDM	Price Determination Methodology
WESM-DP	Dispatch Protocol

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SECTION 1 INTRODUCTION

1.1 Background

The *market dispatch optimization model* determines the optimal *dispatch schedule* and nodal prices considering the different inputs from the *Market Operator, System Operator* and *Trading Participants* using linear programming. The combination of these inputs may not always allow the *market dispatch optimization model* to produce a feasible solution thus *constraint violation variables* and associated *constraint violation coefficients* are necessary to ensure that the market *dispatches* and market pricing re-runs always find a solution, if such a solution exists.

1.2 Purpose

1.2.1. The systems, processes, and procedures set out in this *Market Manual* on the determination of *constraint violation coefficients* and market pricing re-runs shall ensure that results of *market projections* and *real-time dispatch* in the *WESM*:

a. Provide economic signals that properly account the economic impact of losses and *constraints* that resulted from the operation of the electricity market;[1] and
b. Are updated and made available to *WESM Participants* to ensure they can make timely and informed commercial and technical decisions.[2]

1.3 Scope

This *Market Manual* provides the following:

a. Values of the *constraint violation coefficients* to establish an appropriate priority order for *soft constraints;* [3]
b. Procedures, criteria and conditions necessary for the execution of *automatic pricing re-runs;*[4] and
c. Guidelines and procedures for the execution of a market pricing re-run upon the issuance of *pricing error notice.*[5]

SECTION 2 DEFINITIONS, REFERENCES, AND INTERPRETATION

2.1 Definitions

2.1.1 Unless defined or the context implies otherwise, the italicized terms used in this *Market Manual* shall bear the same meaning as defined in the *WESM Rules* and other *Market Manuals*.

2.1.2 The following term as used in this *Market Manual* shall have the following meaning –

[1] *WESM Rules* Clauses 3.2.2 and 3.6.1
[2] *WESM Rules* Clause 1.2.5
[3] *WESM Rules* Clauses 10.4.11.1 and 3.6.2.4
[4] *WESM Rules* Clause 3.6.7.8
[5] *WESM Rules* Clause 3.10.5.4

Soft Constraints. *Constraints* which are allowed to be violated in the *market dispatch optimization model* such that the optimization process will produce a solution.

2.2 References

This *Market Manual* shall be read in association with the *WESM Rules* and relevant *Market Manuals.*

2.3 Interpretation

2.3.1 Any reference to a clause in any section of this *Market Manual* shall refer to the particular clause of the same section in which the reference is made, unless otherwise specified or the context provides otherwise.

2.3.2 Where there is a discrepancy or conflict between this *Market Manual* and the *WESM Rules*, the *WESM Rules* shall prevail.

2.3.3 Standards and policies appended to, or referenced in, this *Market Manual* shall provide a supporting framework.

SECTION 3 RESPONSIBILITIES

3.1 Market Operator

The *Market Operator* shall be responsible for the development, validation, maintenance, publication in the *Market Information Web Site*, and revision of this *Market Manual* in coordination with *Trading Participants* and the *System Operator.*

3.2 System Operator

The *System Operator* shall provide the necessary information and references for the implementation and subsequent revisions and validation of this *Market Manual.*

3.3 Trading Participants

The *Trading Participants* shall provide the necessary information and references for the implementation and subsequent revisions and validation of this *Market Manual,* which include but is not limited to the establishment of nodal load shedding or *nodal value of lost load (VOLL)* values.

SECTION 4 CONSTRAINT VIOLATION COEFFICIENT

4.1 Scope

4.1.1. This section provides the values of the *constraint violation coefficients* and the order of relaxing *soft constraints* considering their *constraint violation coefficients* so that the *market dispatch optimization model* shall always find a solution.

4.1.2. The *constraint violation coefficients* shall be set for market *dispatches* to ensure that the *market dispatch optimization model* shall always find a solution which satisfies all constraints, if such a solution exists; and the violated *constraints* are prioritized, such that the network elements, *loads* and *generating units* are physically feasible and reflect the priorities or how the *System Operator* should manage *system security* and *reliability.*[6]

4.1.3. The *constraint violation coefficients* shall also be set for market pricing re-runs to ensure that:

a. The *dispatches* of all network elements, *loads* and *generating units* produced by the market optimization *algorithm* are approximately the same as the original market *dispatches*; and
b. The prices produced by the market optimization *algorithm* shall be appropriate in all the circumstances, taking into consideration the processes defined in *WESM Rules* Clauses 3.6.7 and 3.10 to adjust or override those prices for *market projection, dispatch*, and *settlement* purposes when there are instances of non-zero *constraint violation variable* values.[7]

4.2 Soft Constraints

The following *soft constraints* may be relaxed in the *market dispatch optimization model* and shall have an associated *constraint violation coefficient.*

a. *Reserve Requirement Constraint,* where the total *reserve* schedules should meet the *reserve requirement* for a certain *reserve category* in a certain *reserve region*.

b. Thermal Contingency *Constraint,* where the power flow through a transmission equipment should be within its thermal contingency limit during N-1 *outage* conditions.

c. Self-Scheduled Generation *Constraint*, where the dispatch target of preferential dispatch and non-scheduled generating units shall be equal to their projected output or schedule of loading level, respectively.

d. Thermal Base Case Constraint, where the power flow through a transmission equipment should be within its normal (base case) limit.

e. Transmission Group Constraint, where the power flow through a branch group, or an interconnection equipment between *grids* (i.e. *HVDC* links) should be within its normal limits.

f. System Energy Balance Constraint, where the total *generation* scheduled should meet the demand requirement.

g. *Nodal VoLL or* Nodal Energy Balance Constraint, where the power going into a *node* should be equal to the power going outside of the same *node*. This *constraint* also refers to the nodal energy balance constraint, which may vary from *node* to *node, and/or* be set so as to reflect *load shedding* priorities.[8]

[6] *WESM Rules* Clause 3.6.2.1
[7] *WESM Rules* Clause 3.6.2.2
[8] *WESM Rules* Clause 3.6.2.3

4.3 Order of Constraint Violation Coefficients

4.3.1 The order of relaxing *soft constraints* shall be set such that *constraints* resulting in the lowest reduction in the capability of the *network, load* or *generating units* shall be allowed to occur first, as follows:

a. Delayed Contingency *Reserve Requirement Constraint*
b. Slow Contingency *Reserve Requirement Constraint*
c. Fast Contingency *Reserve Requirement Constraint*
d. *Nodal VoLL or* Nodal Energy Balance Constraint
e. System Energy Balance Constraint
f. Self-scheduled Generation *Constraint*
g. Thermal Contingency *Constraint*
h. Regulating *Reserve Requirement Constraint*
i. Transmission Group *Constraint*
j. Thermal Base Case *Constraint*

4.3.2 The order of *soft constraints* shall be established in the *market dispatch optimization model* through the values of the *constraint violation coefficients*, which shall be set significantly greater than any market clearing price values that may be derived in the *WESM*.

4.3.3 There shall be sufficient grading in between *constraint violation coefficients* to maintain the pre-defined order of priority and resolve possible *dispatch* conflicts between the different *constraint* types should they occur simultaneously.

4.3.4 The following table provides the *constraint violation coefficients*, which is reflective of the order of relaxing *soft constraints* established in Section 4.3.1 of this *Market Manual*, and the corresponding action by the *System Operator*.

Order	Constraint Violation Coefficient Name	CVC	SO Action
1	Delayed Contingency *Reserve Requirement*	100,000	Automatic load drop to cover for loss of *generation* if contingency *reserve* is insufficient.
2	Slow Contingency *Reserve Requirement*	200,000	Automatic load drop to cover for loss of *generation* if contingency *reserve* is insufficient.
3	Fast Contingency *Reserve Requirement*	400,000	Automatic load drop to cover for loss of *generation* if contingency *reserve* is insufficient.
4	*Nodal Value of Lost Load or* Nodal Energy Balance Constraint	800,000	Re-dispatch *generation* and/or drop *load* as necessary.
5	System Energy Balance Constraint	1,300,000	For over-generation, identify generating units to be shut down to eliminate excess capacity.

Order	Constraint Violation Coefficient Name	CVC	SO Action
			For under-generation, identify must-run units that can be dispatched or drop load as necessary
6	Self-Scheduled Generation *Constraint*	1,400,000	The projected output or schedule of loading level of the relevant generating unit(s) shall be curtailed.
7	Thermal Contingency *Constraint*	2,400,000	Re-dispatch *generation* and/or drop *load* as necessary.
8	Regulating *Reserve Requirement*	2,800,000	Re-dispatch *generation* and/or drop *load* as necessary.
9	Transmission Group *Constraint*	2,900,000	Re-dispatch *generation* and/or drop *load* as necessary.
10	Thermal Base Case *Constraint*	3,000,000	Re-dispatch *generation* and/or drop *load* as necessary.

Table 1. Order of *Constraint Violation Coefficients*

4.3.5 The *Market Operator* shall publish all non-zero constraint violation variables in the *Market Information Web Site.*

4.4 Submission of Report to the DOE and ERC

The Market Operator shall submit a semi-annual report to the DOE and ERC on the incidences and causes of constraint violations in the WESM.

SECTION 5 AUTOMATIC PRICING RE-RUNS

5.1 Rationale for Automatic Pricing Re-Runs

5.1.1. At all times, the *market dispatch optimization model* shall find a solution considering the order of the *constraint violation coefficients* in Section 4 of this *Market Manual.*

5.1.2. Should the *market dispatch optimization model* result in one or more non-zero *constraint violation variable* values, then the *dispatch schedules* shall remain the same, but the prices for *energy* and *reserves* shall be determined from an *automatic pricing re-run* of the *market dispatch optimization model* with relaxed *constraints*[9].

5.1.3. The purpose of the *automatic pricing re-runs* is to ensure that the *energy* and *reserve* prices reflect:[10]

[9] WESM Rules Clause 3.6.7.1
[10] WESM Rules Clause 3.6.7.2

a. the marginal costs of supplying *energy* at each *node*;
b. the marginal costs of supplying *reserves*;
c. shortage pricing when there is a shortage of *supply* at a *node* or regional level; and
d. excess pricing when there is an excess of *supply* at a *node* or regional level.

5.2 Process for Automatic Pricing Re-Runs

5.2.1. During the *automatic pricing re-run*, the *soft constraint* that was violated shall be relaxed using the resulting non-zero violation variable, considering a very small value (delta), to allow the *market dispatch optimization model* to be able to find a feasible price.

5.2.2. In case of over-generation and under-generation, the *soft constraint* shall be relaxed by a very small value (delta) to allow the *market dispatch optimization model* to find a feasible price. When the results of the *market dispatch optimization model* reflect a violation greater than delta, then the *automatic pricing re-run* shall reflect the shortage price for under-generation and excess price for over-generation.

5.2.3. The delta shall be set as small as possible for each *constraint violation coefficient* so that the *automatic pricing re-run* shall be reflective of the most accurate price considering the original *dispatch schedules*.

5.2.4. An example related to Section 5.2.1, is provided below:

Should a thermal contingency *constraint* violation occur:

Contingency Power flow $\leq$ Thermal contingency limit + x

Where:

i. Contingency Power flow refers to the power flow through an equipment during an N-1 outage scenario
ii. *x* refers to the violation amount in MW
iii. *Thermal contingency limit* refers to the maximum transmission limit during an N-1 *outage* scenario

Then, its constraint shall be relaxed during the *automatic pricing re-run* similar to the formulation below:

Contingency Power flow $\leq$ Thermal contingency limit + *x* + *delta*

5.2.5. The resulting prices during an *automatic pricing re-run* shall be produced in the *real time dispatch*, along with the original *real time dispatch* schedules produced prior to the relaxation.

5.3 Automatic Pricing Re-Run Parameters

5.3.1 The corresponding constraint relaxation formulas for the *constraint violation coefficients* during pricing re-runs shall be as provided in Table 2 below:

Order	Constraint Violation Coefficient Name	CVC	Violation Variable Value	Delta	Constraint Relaxation during Pricing Re-Run	Re-run Price[11]
1	Deficit Delayed Contingency Reserve Requirement	100,000	x	0.1	x + delta	EDP AND RP
2	Deficit Slow Contingency Reserve Requirement	200,000	x	0.1	x + delta	EDP AND RP
3	Deficit Fast Contingency Reserve Requirement	400,000	x	0.1	x + delta	EDP AND RP
4	Nodal Energy Balance Constraint	800,000	x	0.1	x + delta	EDP AND RP
5	System Energy Balance Constraint	1,300,000	x	0	delta	Excess Price for over-generation Shortage Price for under-generation
6	Self-Scheduled Generation Constraint	1,400,000	x	0.1	x + delta	EDP AND RP
7	Thermal Contingency Constraint	2,400,000	x	0.1	x + delta	EDP AND RP
8	Deficit Regulating Reserve Requirement	2,800,000	x	0.1	x + delta	EDP AND RP
9	Transmission Group Constraint	2,900,000	x	0.1	x + delta	EDP AND RP
10	Thermal Base Case Constraint	3,000,000	x	0.1	x + delta	EDP AND RP

Table 2. Automatic Pricing Re-Run Parameters

SECTION 6 MARKET PRICING RE-RUNS TO ADDRESS PRICING ERRORS

6.1 Guidelines for Issuance of Pricing Error Notices and Conduct of Manual Pricing Re-Runs

6.1.1. In the event where the calculated prices are believed to be in error, notwithstanding the application of *automatic pricing re-run*, the *Market Operator* may issue a *pricing error notice*[12].

[11] EDP refers to *nodal energy dispatch price;* and RP refers to *reserve price*
[12] WESM Rules Clause 3.10.5.1

6.1.2. Upon issuance of a *pricing error notice*, the *Market Operator* shall, as soon as practicable, implement a market pricing re-run,[13] which is also referred to as *manual pricing re-run* in this *Market Manual*.

6.2 Issuance and Publication of Pricing Error Notices

6.2.1. When the pricing error occurs, the *Market Operator* shall issue *pricing error notices* to the *Trading Participants* within the *trading day. Pricing error notices* shall be issued to *Trading Participants* by electronic means, or other alternative means where such electronic means is unavailable for any reason.

6.2.2. Within two (2) *working days* after the *trading day* when the pricing error occurred, the *Market Operator* shall publish in the *market information website* a summary of the *pricing error notices* issued for that *trading day* pursuant to this *Market Manual.*

6.2.3. Where a *pricing error notice* has been issued but the *Market Operator* determines after validation that no pricing error actually occurred as the criteria set forth in this *Market Manual* is not met, the *Market Operator* shall issue an advisory to all *Trading Participants* informing them of the correction.

6.2.4. Likewise, where no pricing error notice has been issued but the *Market Operator* determines after validation that pricing error actually occurred, the *Market Operator* shall issue the *pricing error notice* prior to the issuance of the preliminary settlement statement for the relevant billing period.

6.3 Process for Manual Pricing Re-Runs

6.3.1. The *Market Operator* shall perform the *manual pricing re-run* using the same set of input data used in the original *real time dispatch market run*, with corresponding adjustments or corrections as may be appropriate depending on the cause of the pricing error.

6.3.2. In performing the *manual pricing re-run*, the *Market Operator* shall determine the appropriate solution that shall be applied in the *manual pricing re-run* taking into consideration the applicable solutions for the various causes of erroneous, inconsistent and inappropriate input data, as provided in Table 3 below:

Condition	Description	Solution
Bad and non-updating system snapshot/SE data (breaker status, load levels, etc.)	Bad breaker status may cause isolation of loads and generators or islanding of a group of nodes. The system snapshot/state estimator data may contain bad data thus only intervals with isolated loads exceeding the forecast tolerance limits with	Identify the affected load, generator or equipment and reflect the actual generation/load values or status (as necessary) in the market pricing re-run.

[13] WESM Rules Clause 3.10.5.2

Condition	Description	Solution
	respect to the total demand or those that result to congestion is issued with pricing error.	
Errors resulting from limitations of Market Network modelling	Arise when there is inconsistency between the Market Network Model and the actual power system network	Identify the affected load, generator or equipment and reflect the actual generation/load values or status (as necessary) in the market pricing re-run.

Table 3. Manual Pricing Re-run Conditions and Solutions

6.3.3. If the results of the *manual pricing re-run* indicate nodal price separation that is due to congestion, then the methodology provided for in the relevant *Market Manual* shall apply. Otherwise, the prices from the *manual pricing re-run* shall be used for settlement pursuant to *WESM Rules* Clause 3.10.5.

6.3.4. *Manual pricing re-runs* shall be performed and completed within a reasonable time after the relevant *dispatch interval*, provided that all pricing re-runs shall be completed before the issuance of the final settlement statement for the affected *billing period*.

6.4 Publication of Manual Pricing Re-Run Results

6.4.1. After each *billing period* and upon completion of all manual pricing re-runs, the following information shall be published by the *Market Operator* in the *Market Information Web Site* and disseminated to all *Trading Participants*:

a. Complete list of the pricing errors that occurred during the *billing period*, indicating clearly the affected *dispatch intervals*, including those instances where no pricing error was issued within the *timetable;* and
b. Results of the *manual pricing re-run*, including the resulting market prices.

SECTION 7 AMENDMENT, PUBLICATION AND EFFECTIVITY

7.1 Review and Update

The *Market Operator*, in coordination with the *System Operator*, and in consultation with the *WESM Members* shall regularly review the following:

a. Appropriateness and applicability of *constraint violation variables* and their associated *constraint violation coefficients* levels and revise as maybe necessary to ensure that it reflects the actual conditions of the *network;*[14]
b. A*utomatic pricing re-run* parameters provided in Table 2 of this *Market Manual;* and
c. List and description of the solutions being applied for various causes of pricing errors provided in Table 3 of this *Market Manual*.

[14] *WESM Rules* Clause 3.6.2.5

7.2 Publication and Effectivity

This *Market Manual* or amendments thereto shall be approved, published, and deemed effective in accordance with Chapter 8 of the *WESM Rules* and corresponding *Market Manual*.