PUBLIC

WESM 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.

Document Identity: WESM-CVC-005
Issue No.: 5
Reason for Issue: Implementation of WESM enhancements in operations and design
Approval Date:
Publication Date:
Effective Date:

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	
2	06 July 2006		06 July 2006	
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

1.1.1 The *market dispatch optimization model* determines the optimal *dispatch schedule* and nodal prices considering the different inputs from the *Market Operator, System Operator* and from the *Trading Participants* using linear programming. The combination of these inputs may not 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 the *real-time dispatch* in the *WESM* are:

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

1.3 Scope

1.3.1 This *Market Manual* provides the values of the *constraint violation coefficients* in order to establish an appropriate priority order for *soft constraints.* [3]

1.3.2 This *Market Manual* provides the procedures, the criteria and conditions necessary for the execution of *automatic pricing re-runs.*[4]

1.3.3 This *Market Manual* provides the guidelines and procedures for the execution of a market pricing re-run upon the issuance of *pricing error notice.*[5]

1.3.4 This *Market Manual* shall apply to the *Market Operator*, the *System Operator,* and the Trading *Participants* in the *WESM.*

[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

SECTION 2 DEFINITIONS, REFERENCES, AND INTERPRETATION

2.1 Definitions

2.1.1 Unless otherwise 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 as used in this *Market Manual* shall have the following meaning –

a. **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

2.2.1 This *Market Manual* shall be read in association with the following:

a. *WESM Rules*
b. WESM Price Determination Methodology
c. Dispatch Protocol

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

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

3.1.2. The *Market Operator* shall implement the principles and processes provided in this *Market Manual*.

3.2 System Operator

3.2.1. 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

3.3.1. The *Trading Participants* shall provide the necessary information and references for the implementation and subsequent revisions and validation of this *Market Manual,* particularly in the establishment of nodal load shedding or *nodal value of loss 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 priority order of *soft constraints* that can be relaxed considering their *constraint violation coefficients* so that the *market dispatch optimization model* will always find a solution.

4.1.2. The *constraint violation coefficients* shall be set for market *dispatches* so as to ensure that the *market dispatch optimization model* will 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 so as to ensure that 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 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

4.2.1. 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*. Should this *constraint* be violated, it signifies that the *reserve schedules* were unable to meet the *reserve requirement.* It should be noted that it applies for all reserve types.

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

b. Thermal Contingency *Constraint,* where the power flow through a transmission equipment should be within its thermal contingency limit during N-1 *outage* conditions. Should this *constraint* be violated, it means that the results reflect that the power flow through a transmission equipment exceeded its 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. Should this *constraint* be violated, it means that the projected output or schedule of loading level of the relevant generating unit(s) shall be curtailed. If there is more than one generating unit to be curtailed, the curtailment scheme shall follow the methodology defined in the *WESM Price Determination Methodology*.

d. Thermal Base Case Constraint, where the power flow through a transmission equipment should be within its normal (base case) limit. Should this *constraint* be violated, it means that the results reflect that the power flow through a transmission equipment exceeded its normal 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. Should this *constraint* be violated, it means that the power flow through a branch group or *HVDC* link exceeded its normal limits.

f. System Energy Balance Constraint, where the total *generation* scheduled should meet the demand requirement. Should this *constraint* be violated, it could be either that the total *generation* scheduled is beyond the demand requirement (over-generation), or there is a generation deficit or the total *generation* scheduled is unable to meet the demand requirement (under-generation).

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] Should this *constraint* be violated, it means that the *node* is reflective of *load shedding* due to either a deficit in *generation*, or due to a thermal *constraint.*

4.3 Priority Order of Constraint Violation Coefficients

4.3.1 The priority order of *soft constraints* shall be set such that *constraints* resulting in the lowest reduction in the capability of the *network, load* or *generating units* will occur first. A *soft constraint* with a higher priority shall be the last *constraint* to be violated.

4.3.2 The following priority order of *soft constraints*, from highest to lowest priority, shall be as follows:

a. Thermal Base Case *Constraint*
b. Transmission Group *Constraint*
c. Regulating *Reserve Requirement Constraint*
d. Thermal Contingency *Constraint*

[8] *WESM Rules* Clause 3.6.2.3

e. Self-scheduled Generation *Constraint*
f. System Energy Balance Constraint
g. *Nodal VoLL or* Nodal Energy Balance Constraint
h. Fast Contingency *Reserve Requirement Constraint*
i. Slow Contingency *Reserve Requirement Constraint*
j. Delayed Contingency *Reserve Requirement Constraint*

4.3.3 The priority 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 as far from any market clearing price values that may be derived in the *WESM*.

4.3.4 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.

4.3.5 The following table provides the different *soft constraints*, their corresponding *constraint violation coefficients*, which is reflective of the priority order established in this *Market Manual*, and the corresponding action to be undertaken by the *System Operator*.

Priority	Soft Constraint	CVC	SO Action
1	Thermal Base Case *Constraint*	3,000,000	Re-dispatch *generation* and/or drop *load* as necessary.
2	Transmission Group *Constraint*	2,900,000	Re-dispatch *generation* and/or drop *load* as necessary.
3	Regulating *Reserve Requirement*	2,800,000	Larger frequency excursions are expected without regulating *reserve.*
4	Thermal Contingency *Constraint*	2,400,000	Re-dispatch *generation* and/or drop *load* as necessary.
5	Self-Scheduled Generation *Constraint*	1,400,000	Curtail generation and/or drop *load* as necessary.
6	System Energy Balance Constraint	1,300,000	For over-generation, identify generating units to be shut down other units to eliminate excess capacity.
			For under-generation, identify must-run units that can be dispatched or drop load as necessary
7	*Nodal Value of Lost Load or* Nodal Energy Balance Constraint	800,000	Re-dispatch *generation* and/or drop *load* as necessary.
8	Fast Contingency *Reserve Requirement*	400,000	Automatic load drop to cover for loss of *generation* if contingency *reserve* is insufficient.

Priority	Soft Constraint	CVC	SO Action
9	Slow Contingency *Reserve Requirement*	200,000	Automatic load drop to cover for loss of *generation* if contingency *reserve* is insufficient.
10	Delayed Contingency *Reserve Requirement*	100,000	Automatic load drop to cover for loss of *generation* if contingency *reserve* is insufficient.

Table 1. Priority Order and *Constraint Violation Coefficients* of *Soft Constraints*

4.3.6 The Market Operator shall publish all non-zero constraint violation variables in the market information website.

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 priority order of the *constraint violation coefficients* set in 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]

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

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

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 little as possible for each *constraint violation coefficient* so that the *automatic pricing re-run* is 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 ≤ 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 ≤ 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 *Soft constraints* shall have their corresponding constraint relaxation formulas during pricing re-runs *automatic pricing re-runs* as provided in
5.3.2 Table *2* below:

Priority	Soft Constraint	CVC	Violation Variable Value	Delta	Constraint Relaxation during Pricing Re-Run	Re-run Price[11]
1	Thermal Base Case Constraint	3,000,000	x	0.1	x + delta	EDP AND RP
2	Transmission Group Constraint	2,900,000	x	0.1	x + delta	EDP AND RP
3	Regulating Reserve Requirement Constraint	2,800,000	x	0.1	x + delta	EDP AND RP
4	Thermal Contingency Constraint	2,400,000	x	0.1	x + delta	EDP AND RP

[11] EDP refers to *nodal energy dispatch price;* and RP refers to *reserve price*

Priority	Soft Constraint	CVC	Violation Variable Value	Delta	Constraint Relaxation during Pricing Re-Run	Re-run Price[11]
5	Self-Scheduled Generation Constraint	1,400,000	x	0.1	x + delta	EDP AND RP
6	System Energy Balance Constraint	1,300,000	x	0	delta	Excess Price for over-generation
						Shortage Price for under-generation
7	Nodal Energy Balance Constraint	800,000	x	0.1	x + delta	EDP AND RP
8	Fast Contingency Reserve Requirement Constraint	400,000	x	0.1	x + delta	EDP AND RP
9	Slow Contingency Reserve Requirement Constraint	200,000	x	0.1	x + delta	EDP AND RP
10	Delayed Contingency Reserve Requirement Constraint	100,000	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 no dispatch prices can be determined or communicated within the timeframe specified by the *timetable* or the calculated prices are believed to be in error, notwithstanding the application of *automatic pricing re-run*, the *Market Operator* shall issue a *pricing error notice*[12].

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

[12] WESM Rules Clause 3.10.5.1
[13] WESM Rules Clause 3.10.5.2

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/SE data normally contains bad data thus only intervals with isolated loads exceeding the forecast tolerance limits with respect to the total demand or those that result to congestion is issued with pricing error.	Identify the affected load, generator or equipment and reflect the actual generation/load values or status (as necessary) in the market pricing re-run.
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 website* 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

7.1.1. The *Market Operator*, in coordination with the *System Operator*, and in consultation with the *WESM Members* shall regularly review the 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]

7.1.2. The *Market Operator* shall, from time to time, review and update the *automatic pricing re-run* parameters provided in Table 2 of this *Market Manual.*

7.1.3. The *Market Operator* shall, from time to time, review and update the list and description of the solutions being applied for various causes of pricing errors provided in Table 3 of this *Market Manual*.

7.2 Publication and Effectivity

7.2.1. Any amendment or revision to this *Market Manual* shall be approved, published, and deemed effective in accordance with Chapter 8 of the *WESM Rules* and corresponding *Market Manual*.

[14] *WESM Rules* Clause 3.6.2.5