PUBLIC

WESM Manual

Methodology for Determining Pricing Errors and Price Substitution Due to Congestion for Energy Transactions in the WESM Issue 4.0

Abstract	This manual presents the guidelines and criteria for determining what constitutes pricing errors arising due to congestion in the network as well as the guidelines and procedures for the determination of the substitute prices and quantities to be used for settlement of energy transactions in trading intervals where there is pricing error due to network congestion.

Document Identity: WESM-MDPEPS
Issue: 4.0
Reason for Issue: Compliance to Audit Findings
Approval Date: 05 February 2014
Publication Date: 02 April 2014
Effective Date: 17 April 2014

Document Change History

Issue No.	Proponent	Date of Effectivity	Reason for Amendment
1.0	PEMC-MO	27 August 2008	Original document
2.0	PEMC	March 2010	Revised Sections 4 and 5 for consistency with issuances of Energy Regulatory Commission (ERC) in ERC Case No. 2008-051 RC, specifically Decision dated 16 February 2009 and Order dated 17 August 2009. Revised Section 5 on Application of Substitute Generator Energy Prices and added a new section to define guidelines to harmonize methodology with WESM Rules clause 3.10.5 (a) and (b). Revised Section 6 on calculation of customer settlement amounts and added Section 6.4. Added Section 8 on regional settlement. Added Appendices A, B, C, D and E
3.0	PEMC	12 November 2010	Revised Section 8.2.1(b) in order to clarify the manner of computation of ex-post trading amount Added Section 8.3 on computation of line rental
4	PEMC	17 April 2014	Compliance to Audit Findings

Document Approval

Issue No.	RCC Approval	RCC Resolution No.	PEM Board Approval	PEM Board Resolution No.
1	08/27/2008		08/28/2008	
2	10/13/2010		10/27/2010	
3	11/15/2010		11/22/2010	
4	01/08/2014	2014-04	02/05/2014	2014-06

Reference Documents

Document ID	Document Title
	WESM Rules
WESM-CVC	WESM Manual on Constraint Violation Coefficient
WESM-PDM	Revised Price Determination Methodology in the Philippine Wholesale Electricity Spot Market
WESM-BS	WESM Manual on Billing and Settlements
WESM-PEN_MRR	WESM Manual on Criteria and Guidelines for the Issuance of Pricing Error Notices and Conduct of Market Re-Run
	ERC Case No. 2008-051 RC Decision dated 16 February 2009 and Order dated 17 August 2009

Table of Contents

SECTION 1 INTRODUCTION

1.1 BACKGROUND

This manual presents the guidelines and criteria for determining what constitutes pricing errors arising due to congestion in the network as well as the guidelines and procedures for the determination of the substitute prices and quantities to be used for settlement of energy transactions in trading intervals where there is pricing error due to network congestion. The guidelines and procedures set forth in this Manual are intended to address only the pricing results in affected trading intervals. Constraints on and undesirable results in generation dispatch or in supply are not addressed in this Manual.

1.2 PURPOSE

1.2.1 This Manual intends to address the undesirable market pricing situations that arise due to the effects of congestion in the network or the power system, in particular, the occurrence of "extreme spring washer" effects as well as constraint violation coefficients in the market pricing processes. This implements the price substitution methodology approved by the Energy Regulatory Commission (ERC) in ERC Case No. 2008-051 RC in relation to Chapter 3.10.5 and other relevant provisions of the *Wholesale Electricity Spot Market Rules* (the "*WESM Rules*"), as these are amended. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

1.2.2 This Manual establishes the -

a) the criteria for determining what constitutes pricing errors arising from the effects of network congestion brought about by any outage in the transmission network, including extreme nodal price separations and occurrence of constraint violation coefficients; and

b) the guidelines and procedures for the determination of the substitute prices and quantities to be used for settlement of energy transactions in trading intervals where there are congestion-related pricing errors.

1.3 SCOPE

1.3.1 All Market Participants are covered by the guidelines and procedures set forth in this Manual.

1.3.2 Covered transactions. This Manual covers the following transactions

a) Only WESM energy transactions are covered. Trading of reserves is not covered in this Manual.

b) This Manual covers the settlement of energy transactions in trading intervals where a pricing error occurs either in the ex-ante or ex-post market runs due to constraint violation coefficients and extreme nodal price separations arising due to congestion in the network pursuant to WESM Rules clause 3.10.5, as amended. For the avoidance of doubt, the constraint violation coefficients (CVC) arising due to congestion are contingency constraint, base case constraint and transmission constraint group.[1] (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

c) Transactions covered by bilateral contracts will continue to be settled outside of the settlement processes of the WESM and between the contract counterparties in accordance with their contract. For this purpose, the energy transactions covered by bilateral contracts refer to the bilateral contract quantities declared to the Market Operator for settlement purposes pursuant to WESM Rules clause 3.13.1.

[1] Please refer to the WESM Manual Constraint Violation Coefficients.

SECTION 2 DEFINITIONS, REFERENCES AND INTERPRETATION

2.1 DEFINITIONS

Unless otherwise defined, the terms used in this Manual which are defined in the WESM Rules will bear the same meaning as defined in the WESM Rules.

2.2 REFERENCES

This Manual should be read in association with the following:

a) WESM Manual on Constraint Violation Coefficients;
b) Revised Price Determination Methodology in the Philippine Wholesale Electricity Spot Market;
c) WESM Manual on Billing and Settlements;
d) WESM Manual on the Criteria and Guidelines for the Issuance of Pricing Error Notices and Conduct of Market Re-Run; and
e) Relevant Orders of the *Energy Regulatory Commission (*the "ERC")

2.3 INTERPRETATION

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

SECTION 3 RESPONSIBILITIES

3.1 MARKET OPERATOR

3.1.1 The Market Operator shall be responsible for:

a) The development of Procedures, Processes and Systems relevant to the functions contained this Market Manual; and

b) Maintaining and implementing the methodology defined in this manual.

SECTION 4 PRICE SUBSTITUTION MECHANISM

4.1 CRITERIA FOR DETERMINING PRICING ERRORS ARISING DUE TO NETWORK CONGESTION

4.1.1 Pursuant to the WESM Rules clause 3.10.5, as amended, there is pricing error for which price substitution shall be implemented in cases where, due to network congestion, the market pricing solutions show either of the following conditions: (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

a) Constraint violation coefficients, specifically:
   i. contingency constraint
   ii. base case constraint
   iii. transmission group constraint; or

b) Extreme nodal price separations. Extreme nodal price separations occur when the resulting prices show either of the following conditions (the "price triggers"):[2]

   i. Very high prices where-

$$ABS\,[LMP_H / MCP_H] \geq F$$

   ii. Very low or negative prices where

$$ABS\,[(LMP_H - LMP_L) / MCP_H] \geq F$$

where:
- ABS – absolute value
- LMP_H – highest locational marginal price
- LMP_L – lowest locational marginal price
- MCP_H – highest marginal price
- F – a factor which has a value initially set at 1.2[3]

[2] See Decision (16 February 2009) ERC Case No. 2008-051 RC

4.1.2 It is provided, however, that if the resulting MCPH is equal to zero "0" but the results of the market runs indicate network congestion, pricing error due to congestion is still considered to have occurred if the resulting price spread between the highest and lowest nodal prices for a trading interval with congestion meets the price threshold. The price threshold is the average price spread in all the 1400H trading interval of the previous trading year (twelve-month period between 26 December of the previous trading year and 25 December of the following year), excluding those intervals that are subject to price substitution under this Manual and the Administered Price. Price spread is the difference between the highest nodal price and lowest nodal price.[4] (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

4.1.3 Notwithstanding the foregoing, pricing error due to congestion ("congestion pricing error") will only occur if the occurrence of network congestion is indicated in the market runs for the relevant interval. Thus, there is no congestion pricing error in the market runs where the resulting value of the price trigger is equal or greater than the value set for price trigger "F" but the constraint that occurred is not a network congestion. For the avoidance of doubt, the following constraints are not network congestion:[5] (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

a) Constraint indicated in the market runs is actually caused by erroneous input data. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)
b) Localized constraint (whether or not the market runs indicate feasible prices or are reflective of CVCs) such as but not limited to constraint on a radially-connected line or load-end transformer which is the source of the load connected to it or of the step-up transformer in a generating plant. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

4.2 GUIDELINES FOR THE APPLICATION OF PRICING ERROR AND PRICE SUBSTITUTION RULES

4.2.1 Upon integration of the Visayas grid in the WESM, the methodology provided for in this Manual shall apply to both regions, i.e., Luzon and Visayas. It is provided, however, that the application of the methodology shall be limited to the region where the network congestion occurs if the following conditions occur – (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

a) a network congestion exists in one region only; and

[3] Initial value of Trigger Factor "F" is set at 1.2 in the ERC Decision (16 February 2009) in ERC Case No. 2008-51RC but is subject to review pursuant to Section 4.3.
[4] See Appendix C for additional details.
[5] A more detailed discussion of the distinction between network and localized congestion is found in Appendix D of this Manual.

b) the impact of the congestion price is confined only to the region where the network congestion exists[6]

4.2.2 The methodology provided for in this Manual applies where the pricing error is due to network congestion ("congestion pricing errors") as defined in Section 4 of this Manual. WESM Rules clauses 3.10.5 (a) and (b) applies where the pricing error indicated in the ex-ante or ex-post market runs is due to causes other than network congestion ("non-congestion pricing errors"). For the avoidance of doubt, there are two categories of pricing errors in the WESM, as follows – (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

a) Non-congestion pricing error – this category pertains to pricing errors that are not related to network congestion and in which WESM Rules 3.10.5 shall apply. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

b) Congestion pricing error – this category pertains to pricing errors that are associated with the application of the Price Substitution Mechanism for congestion in accordance with this Manual. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

4.2.3 Simultaneous Occurrence of Congestion and Non-Congestion Pricing Errors in a Market Run

a) If the ex-ante market run indicates the simultaneous occurrence of congestion pricing error and non-congestion pricing error, such that the resulting prices reflect constraint violation coefficients ("CVC") or there are no valid prices, WESM Rules clauses 3.10.5 (a) and (b) shall apply. As such, the ex-post prices, if valid, shall serve as ex-ante prices. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

b) If the ex-post market run indicates the simultaneous occurrence of congestion pricing error and non-congestion pricing error, a market re-run shall be performed in accordance with WESM Rules clause 3.10.5 (a). If the resulting prices ("market re-run prices") indicate extreme nodal price separation as defined in this Manual, then the methodology provided for in this Manual shall apply. Otherwise, the market re-run prices shall be used for settlement pursuant to WESM Rules clauses 3.10.5 (a) and (b). (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

4.2.4 Occurrence of Pricing Errors Due to Different Causes in One Trading Interval

a) If the ex-ante market run indicates occurrence of a non-congestion pricing error while the ex-post market run indicates the occurrence of a congestion pricing error, the substitute generator prices and customer prices determined pursuant to this Manual shall also serve as ex-ante prices. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

[6] Confinement of price impact of congestion into one region would exist only if there is a binding limitation in the power flow at the HVDC transmission line that links the Visayas and Luzon regions.

b) If the ex-post market run indicates occurrence of a non-congestion pricing error, a market re-run shall be performed pursuant to WESM Rules clause 3.10.5 (a). If the market re-run prices indicate occurrence of extreme nodal price separation as defined in this Manual, the price substitution methodology set forth in this Manual shall apply. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

4.2.5 **Reference Table**. Table 1 in Appendix A of this Manual presents in further detail the application of the methodology provided for in this Manual and of the Rules on pricing errors set forth in WESM Rules clauses 3.10.5 (a) and (b).

4.3 REVIEW AND REVISION OF THE PRICE TRIGGER ("F")[7]

4.3.1 A periodic review of the appropriateness of the value of the price trigger ("F") shall be made at least once every three months, or as may be necessary, for the first year of implementation of the methodology contained in this Manual. Thereafter, a review shall be conducted on an annual basis. For this purpose, PEMC shall conduct an assessment of the application of the price trigger and the results of the assessment shall be submitted to the WESM Technical Committee for evaluation and for determination as to whether a change in the value of the price trigger is warranted. If a revision is warranted, PEMC shall submit to the WESM Rules Change Committee a proposal to amend this Manual accordingly. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

4.3.2 Any change in the value of the price trigger as a result of the review shall be approved by the Philippine Electricity Market Board (PEM Board) prior to its implementation. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

4.4 ISSUANCE AND PUBLICATION OF PRICING ERROR NOTICES AND SUBSTITUTE PRICES

4.4.1 The issuance and publication pricing error notices, substitute prices, and estimated average load prices as defined in this Manual shall be

a) Immediately after each trading interval when the pricing error occurs through the Market Information Website; or

b) Within two (2) business days after the trading day when the pricing error occurs, upon verification of the Market Operator through a summary of the pricing error notices issued for that trading day; or

c) Prior to the issuance of the preliminary settlement statement for the relevant billing period, after the final validation of the Market Operator.

[7] See Decision (16 February 2009), ERC Case No. 2008-51RC

SECTION 5 METHODOLOGY FOR DETERMINING SUBSTITUTE PRICES AND SETTLEMENT AMOUNTS FOR CONGESTION PRICING ERRORS

5.1 METHODOLOGY FOR DETERMINING SUBSTITUTE GENERATION ENERGY PRICES AND SETTLEMENT AMOUNTS FOR CONGESTION PRICING ERRORS

5.1.1 **Principles and Guidelines.** The determination of the substitute generation energy prices for congestion pricing errors will be in accordance with the following – (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

a) In trading intervals where either the ex-ante or ex-post market runs indicate congestion pricing errors as defined in this Manual, the Market Operator will determine the market clearing price corresponding to the unconstrained solution for that trading interval. The unconstrained solution is derived by a merit order stacking of the available generators based on their bids and offers for the relevant trading interval and taking into consideration the generator outages, security limits and the demand and losses accounted for in the original (i.e., constrained) run. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

b) The substitute generator *ex-ante* or *ex-post* energy prices for each generator scheduled to run during the relevant trading interval will be either of the following:

i. For the generators that were constrained on, the substitute price shall be the offer price[8] for the last offer block of the constrained on generators that was scheduled or cleared for dispatch in the original constrained run ("constrained solution") [9]. The constrained solution refers to the results of the *MDOM* calculations taking into account the constraints pertaining to the identified network congestion. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

ii. The market clearing price in the unconstrained market solution for such trading interval will be used as substitute prices for the generators other than those that were constrained on.

c) For purposes of applying the substitute generation energy prices, constrained on generators are those generation units that were scheduled to run pursuant to the original market solutions but would not have been cleared or cleared at a lower quantity based on the unconstrained solution. The substitute prices will be applied to the scheduled quantities of such generation units for the relevant trading interval.

[8] See ERC Decision (16 February 2009) ERC Case No. 2008-51RC
[9] See ERC Order (17 August 2009), ERC Case No. 2008-51RC

d) The prices calculated or determined using the foregoing will serve as the generator ex-ante or ex-post nodal prices and will stand irrespective of the outcome of any investigations or resolution of any dispute. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

5.1.2 The dispatch schedules arrived at in the original (constrained) market solution for the relevant trading interval will stand and will be the basis for dispatch by the System Operator irrespective of the results of the unconstrained solution. Re-dispatch of generation will be implemented by the System Operator in accordance with relevant provisions of the WESM Rules and manuals, the Philippine Grid Code and other relevant rules, regulations, issuances, guidelines and procedures.

5.1.3 **Generation Energy Settlement Quantities**

In trading intervals where substitute prices are used, the ex-ante or ex-post energy settlement quantities for the generators shall be as determined in accordance with WESM Rules clause 3.13.5 and 3.13.6, as amended.

5.1.4 **Determination of Generator Energy Settlement Amounts**

Except only for the substitution of the prices that are provided for in this Manual, the generator settlement amounts will be calculated in accordance with WESM Rules Section 3.13, the Revised Price Determination Methodology and the WESM Manual on Billing and Settlements.

5.2 METHODOLOGY FOR DETERMINING CUSTOMER TRADING AMOUNTS

5.2.1 **Principles/Guidelines.** The customer trading amount for the market run (i.e., ex-ante or ex-post) of a trading interval in which the price substitution provided for in this Manual is applied will be derived by allocation of the total generator trading amounts for that relevant trading market run in accordance with the following – (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

a) The allocation of the total generator ex-ante and ex-post trading amounts will be in the proportion that the metered energy quantities of the customers at each market trading node bears to the total metered energy quantities of all customers in all market trading nodes. The allocation of the ex-ante and ex-post trading amounts shall be calculated separately. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

b) In determining the customer ex-ante trading amount, the allocation of the trading amount corresponding to the bilateral contract quantities ("BCQ") will be in the proportion that the bilateral contract energy settlement quantities of the customers at each market trading node bears to the total bilateral contract energy settlement quantities of all customers in all market trading nodes. The bilateral contract energy settlement quantities refer to the bilateral contract quantities declared to the Market Operator pursuant to WESM Rules clause 3.13.1.1, as amended. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

c) Customer allocations will be calculated for each market run of each trading interval (i.e., ex-ante and ex-post) that substitute generator prices are used, as summarized in Table 1 presented in the earlier section of this Manual. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

5.2.2 Formula: Customer Trading Amounts

a) The calculation of the customer ex-ante trading amounts are presented in the following formula – (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

$$\text{Ex-Ante } TA_L = [\, \Sigma \text{Ex-Ante } TA_{Gi} \times (MQ_L / \Sigma MQ_L) \,] + \{ \Sigma (BCQ_{Gi} \times EAP_{Gi}) \times [(MQ_L / \Sigma MQ_L) - (BCQ_L / \Sigma BCQ_L)] \}$$

Where:

Ex-Ante TA_L	– ex-ante trading amount corresponding to ex-ante spot quantity (net of bilateral quantity) of load (customer) L
Ex-Ante TA_{Gi}	– ex-ante trading amount corresponding to ex-ante spot quantity (net of bilateral quantity) of generator G connected at node i
MQ_L	– metered quantity of load (customer) L
BCQ_{Gi}	– bilateral contract quantity declared for generator G connected at node i
EAP_{Gi}	– substituted ex-ante price of generator G connected at node i
BCQ_L	– bilateral contract quantity declared for load (customer) L

b) The calculation of the customer ex-post trading amounts are presented in the following formula – (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

$$\text{Ex-Post } TA_L = [\, \Sigma \text{Ex-Post } TA_{Gi} \times (MQ_L / \Sigma MQ_L) \,]$$

Where:

Ex-Post TA_L	– ex-post trading amount of load (customer) L
Ex-Post TA_{Gi}	– ex-post trading amount of generator G connected at node i
MQ_L	– metered quantity of load (customer) L

c) The detailed formulation for the customer trading amounts are presented in Appendix B. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

5.2.3 Estimated Load Prices

a) The Market Operator will calculate and publish the estimated load (customer) reference price based on the allocation determined as provided for in the previous section. The estimated load reference price is indicative and is published for information only and will not be used for settlements of energy transactions.

b) Formula: Estimated Load Reference Price

The estimated load reference price will be calculated according to the following formula -

$$\mathbf{P_L = \Sigma \, (Q_{Gi\text{-}sched} \times P_{Gi\text{-}subs}) \, / \, \Sigma \, Q_{Li\text{-}sched}}$$

Where:

P_L	– indicative average price for loads (customers)
$Q_{Gi\text{-}sched}$	– quantity scheduled in the original (constrained) run of generator G connected at node i
$P_{Gi\text{-}subs}$	– substituted generator price for generator G connected at node i
$Q_{Li\text{-}sched}$	– quantity scheduled in the original (constrained) run of load (customer) L connected at node i

5.2.4 Substitute Load Prices

a) Substitute load (customer) prices shall be calculated in trading intervals where both the following conditions are present – (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

i. a non-congestion pricing error occurs in the ex-ante market run of a trading interval; and (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

ii. a congestion pricing error occurs in the ex-post market run for the same trading interval. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

b) A substitute ex-ante price for each customer participant shall be calculated based on that customer's ex-post trading amount, using the following formula – (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

Substitute Customer Ex-ante Price $= (\text{Ex-Post } TA_L \,/\, MQ_L)$

$= [\Sigma\text{Ex-Post } TA_{Gi} \times (MQ_L \,/\, \Sigma MQ_L)] \,/\, MQ_L$

$= \Sigma\text{Ex-Post } TA_{Gi} \,/\, \Sigma MQ_L$

Where:

Ex-Post TA_L	– ex-post trading amount of load (customer) L
MQ_L	– total metered quantity of load (customer) L
ΣMQ_L	– Sum of all the total metered quantities of loads (customers)

c) The substitute load prices shall stand as substitute ex-ante prices and shall be applied in the manner provided for in WESM Rules 3.10.5 (a) and (b). (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

d) Except only as provided for in the foregoing, no load prices shall be calculated to be used for settlement purposes. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

5.3 REGIONAL SETTLEMENT

5.3.1 Where price substitution is to be applied in one region only pursuant to Section 4.2 of this Manual, the substituted generator prices determined according to this Manual shall be applied only to the generators in the region where the congestion occurs. Subject to the settlement of export and import quantities, the resulting generator trading amounts will be allocated amongst the customers in the same region. For this purpose, export or import quantities refer to the generation that passes through and are measured at the interconnection between regions. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

5.3.2 **Settlement of Export and Import Generator Trading Amounts**

a) Where generation quantity is exported from the region with congestion ("congestion region") to the region without congestion ("non-congestion region"), the following shall apply – (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

b) The generator trading amount corresponding to exported quantity ("export trading amount") shall be deducted from the generator total trading amounts that will be allocated and collected from the customers of the congestion (i.e., exporting) region. The export trading amount will be collected from the customers of the non-congestion (i.e., importing) region. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

c) The export trading amount shall be determined by multiplying the export metered quantities by the nodal price at an assigned reference market trading node in the non-congestion region. The appropriate reference market trading nodes shall be determined by the Market Operator and shall be published at the market information website.[10] (As approved by PEM Board Resolution No. 2010-77 dated 22 November 2010)

[10] Initially, the reference market trading nodes that will be used are the market trading nodes located at Naga, Camarines Sur (Luzon) and Ormoc, Leyte (Visayas).

d) Where generation quantity is imported from non-congestion region, the following shall apply – (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

e) The trading amount corresponding to such quantity ("import trading amount") will be added to the generator total trading amounts that will be allocated to and paid for by the customers in the congestion (i.e., importing) region following the methodology provided for in Section 7 of this Manual. (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

f) The import trading amount shall be determined by multiplying the import metered quantities by the nodal price at an assigned reference market trading node in the non-congestion region. The appropriate reference market trading nodes shall be determined by the Market Operator and shall be published at the market information website.[11] (As approved by PEM Board Resolution No. 2010-73 dated 27 October 2010)

5.3.3 **Computation of Line Rental**

a) Where price substitution is to be applied in one region only pursuant to Section 4.2 of this Manual, and the generator in the congestion region has a bilateral contract quantity with the customer in the normal region, the substitute prices determined according to this Manual shall be applied only to the suppliers' Ex-Ante price while the Location Marginal Price (LMP) will be the basis for the Ex-Ante price of the customer. (As approved by PEM Board Resolution No. 2010-77 dated 22 November 2010)

b) Where price substitution is to be applied in one region only pursuant to Section 5.1 of this Manual, and the customer in the congestion region has a bilateral contract quantity with the supplier in the normal region, no line rental amount is computed. (As approved by PEM Board Resolution No. 2010-77 dated 22 November 2010)

[11] Initially, the reference market trading nodes that will be used are the market trading nodes located at Naga, Camarines Sur (Luzon) and Ormoc, Leyte (Visayas).

SECTION 6 AMENDMENT, PUBLICATION AND EFFECTIVITY

6.1 AMENDMENTS TO THE MANUAL

Any amendment to, or revision to this Manual shall be approved by the PEM Board.

6.2 PUBLICATION AND EFFECTIVITY

Upon approval of the PEM Board, this Manual shall take effect fifteen (15) days from its publication, or such later date as the PEM Board determines, in accordance with the WESM Manual of Procedures for Changes to the WESM Rules (WESM-RCM)

SECTION 7 APPENDICES

Appendix A Application of Substitute Prices

Table 1 - Reference and Application Table

Case Number	RTD RESULTS	SUBSTITUTE PRICE	RTX RESULTS	SUBSTITUTE PRICE
1. No simultaneous occurrence - Pricing error occurring at the RTD Run				
1a	Non-congestion PEN	RTX	Valid	N/A
1b	Network Congestion PEN	PSM	Valid	N/A
2. No simultaneous occurrence - Pricing error occurring at the RTX Run				
2a	Valid	N/A	Non-congestion PEN	MRR
2b	Valid	N/A	Network Congestion PEN	PSM
3. Simultaneous occurrence in same trading interval but in different market runs - Same pricing error category				
3a	Non-Congestion PEN	RTX (using MRR-derived prices)	Non-Congestion PEN	MRR
3b	Network Congestion PEN	PSM	Network Congestion PEN	PSM
4. Simultaneous occurrence in same trading interval but in different market runs - Different pricing error category				
4a	Network Congestion PEN	PSM	Non-Congestion PEN	MRR
4b	Non- Congestion PEN	RTX (using PSM-derived prices)	Network Congestion PEN	PSM
5. Simultaneous occurrence of both pricing error categories in same market run				
5a	Non-Congestion PEN + Network Congestion PEN	RTX	Valid	N/A

Case Number	RTD RESULTS	SUBSTITUTE PRICE	RTX RESULTS	SUBSTITUTE PRICE
5b	Valid	N/A	Non- Congestion PEN + Network Congestion PEN	MRR, then Price Trigger Validation. If triggered, PSM; if not, MRR prices
6. Simultaneous occurrence of both pricing error categories in same trading interval and in same market run				
6a	Non- Congestion PEN + Network Congestion PEN	RTX (using MRR or PSM-derived prices depending on validation)	Non- Congestion PEN + Network Congestion PEN	MRR, then Price Trigger Validation. If triggered, PSM; if not, MRR prices
6b	Non- Congestion PEN + Network Congestion PEN	RTX (using MRR-derived prices)	Non-Congestion PEN	MRR
6c	Non-Congestion PEN + Network-Congestion PEN	RTX (using PSM-derived prices)	Network Congestion PEN	PSM
6d	Non-Congestion PEN	RTX (using PSM or MRR-derived prices depending on validation)	Network Congestion PEN + Non-Congestion PEN	MRR, then Price Trigger Validation. If triggered, PSM; if not, MRR prices
6e	Network Congestion PEN	PSM	Network Congestion PEN + Non-Congestion PEN	MRR, then Price Trigger Validation. If triggered, PSM; if not, MRR prices

Appendix B Detailed Formulation – Customer Trading Amount

The parameters and variables used in the following formulations are described as follows -

Parameter/Variable	Description
BCQ_{Gi}	Bilateral Contract Quantity declared by generator G connected at node i for load (Customer) L
BCQ_{L}	Bilateral Contract Quantity of load (Customer) L as declared by generator G connected at node i
BTA_{L}	Allocated Bilateral Trading amount for load (Customer) L
BTA_{Gi}	Trading amount for generator G
EAP_{Gi}	Ex-ante price of generator G connected at node i
EAP_{L}	Ex-ante price of load (Customer) L at market trading node i
EAQ_{Gi}	Ex-ante quantity of generator G connected at node i
EAQ_{L}	Ex-ante quantity of load (customer) L
EPP_{Gi}	Ex-post price of generator G connected at node i
EPP_{L}	Ex-post price of load (Customer) L at market trading node i
Ex-Ante TA_{Gi}	Ex-Ante trading amount of generator G connected at node i net of bilateral contract amount
Ex-Ante TA_{L}	Ex-Ante trading amount of load (Customer) L net of bilateral contract amount
Ex-Post TA_{Gi}	Ex-Post trading amount of generator G connected at node i
Ex-Post TA_{L}	Ex-Post trading amount of load (Customer) L
GEx-ante TA_{Gi}	Gross Ex-Ante trading amount of generator G connected at node i
GEx-ante TA_{L}	Gross Ex-Ante trading amount of load (Customer) L
LR	Line Rental amount associated with bilateral contract quantities
$MCP_{Unconstrained}$	Market Clearing Price of unconstrained solution
$MQ_{Cons\text{-}on\ Gen}$	Meter Quantity of Constrained-on Generator connected at node i
MQ_{Gi}	Meter Quantity of generator G connected at node i
$MQ_{Other\ Gen}$	Meter Quantity of Generators, other than those that are Constrained-on, connected at node i
$P_{Gi\text{-}subs}$	Substituted generator price for generator (constrained-on and unconstrained) G connected at node i
$P_{L\text{-}subs}$	Substituted load price for load (Customer) L for Case 5 condition
TTA_{Gi}	Total trading amount of generator G connected at node i
TTA_{L}	Total trading amount of load (Customer) L

A. ALLOCATION OF GENERATOR TRADING AMOUNT

A.1 Gross Ex-Ante Trading Amount for load (Customer) L

$$\text{GEx-Ante } TA_{L} = \sum \text{GEx-Ante}TA_{Gi} * \left(\frac{MQ_{L}}{\sum MQ_{L}}\right)$$

$$\text{GEx-Ante } TA_{L} = \left[\sum (EAQ_{Gi}) * (P_{Gi\text{-}subs})\right] * \left(\frac{MQ_{L}}{\sum MQ_{L}}\right)$$

A.2 Ex-Post Trading Amount for load (Customer) L

$$\text{Ex-Post } TA_L = \sum \text{Ex-Post } TA_{Gi} * \left(\frac{MQ_L}{\sum MQ_L}\right)$$

$$\text{Ex-Post } TA_L = \left[\sum (MQ_{Gi} - EAQ_{Gi}) * P_{Gi\text{-subs}}\right] * \left(\frac{MQ_L}{\sum MQ_L}\right)$$

B. ALLOCATION OF BILATERAL TRADING AMOUNT for load (Customer) L

$$BTA_L = \left[\sum (BCQ_{Gi}) * (EAP_{Gi})\right] * \left(\frac{BCQ_L}{\sum BCQ_L}\right)$$

$$BTA_L = \left[\sum (BCQ_{Gi}) * (P_{Gi\text{-subs}})\right] * \left(\frac{BCQ_L}{\sum BCQ_L}\right)$$

C. ALLOCATION OF GENERATOR EX-ANTE TRADING AMOUNT

Customer Ex-Ante Trading Amount: equal to the customer's share in the Generator Gross Ex-Ante Trading Amount minus the customer's share in the Bilateral Trading Amount.

$$\text{Ex-Ante } TA_L = \text{GEx-Ante } TA_L - BTA_L$$

$$\text{Ex-Ante } TA_L = \sum \text{GEx-Ante } TA_{Gi} * \left(\frac{MQ_L}{\sum MQ_L}\right) - \left[\left(\sum BCQ_{Gi}\right) * (EAP_{Gi})\right] * \left(\frac{BCQ_L}{\sum BCQ_L}\right)$$

But,

$$\sum \text{GEx-Ante } TA_{Gi} = \sum \text{Ex-Ante } TA_{Gi} + \sum BTA_{Gi}$$

$$\sum \text{GEx-Ante } TA_{Gi} = \sum \text{Ex-Ante } TA_{Gi} + \sum (BCQ_{Gi}) * (EAP_{Gi})$$

Therefore:

$$\text{Ex-Ante } TA_L = \left[\sum \text{Ex-Ante } TA_{Gi} + \sum (BCQ_{Gi}) * (EAP_{Gi})\right] * \left(\frac{MQ_L}{\sum MQ_L}\right) - \left[\sum (BCQ_{Gi}) * (EAP_{Gi})\right] * \left(\frac{BCQ_L}{\sum BCQ_L}\right)$$

Simplifying;

$$\text{Ex-Ante } TA_L = \sum \text{Ex-Ante } TA_{Gi} * \left(\frac{MQ_L}{\sum MQ_L}\right) + \left[\sum (BCQ_{Gi})*(EAP_{Gi})\right] * \left(\frac{MQ_L}{\sum MQ_L}\right) - \left[\sum (BCQ_{Gi})*(EAP_{Gi})\right] * \left(\frac{BCQ_L}{\sum BCQ_L}\right)$$

$$\text{Ex-Ante } TA_L = \sum \text{Ex-Ante } TA_{Gi} * \left(\frac{MQ_L}{\sum MQ_L}\right) + \left[\sum (BCQ_{Gi})*(EAP_{Gi})\right] * \left[\left(\frac{MQ_L}{\sum MQ_L}\right) - \left(\frac{BCQ_L}{\sum BCQ_L}\right)\right]$$

D. ALLOCATION OF GENERATOR TOTAL TRADING AMOUNT

Customer Total Trading Amount is equal to the customer's share in the Gross Generator Total Trading Amount minus the customer's share in the Trading Amount corresponding to declared bilateral quantities.

$$TTA_L = \text{GEx-Ante } TA_L + \text{Ex-Post } TA_L - BTA_L$$

$$TTA_L = \sum \text{GEx-Ante } TA_{Gi} * \left(\frac{MQ_L}{\sum MQ_L}\right) + \sum \text{Ex-Post } TA_{Gi} * \left(\frac{MQ_L}{\sum MQ_L}\right) - \left[\sum (BCQ_{Gi})*(EAP_{Gi})\right) * \left(\frac{BCQ_L}{\sum BCQ_L}\right)$$

But,

$$\sum \text{GEx-Ante } TA_{Gi} = \sum \text{Ex-Ante } TA_{Gi} + \sum BTA_{Gi}$$

$$\sum \text{GEx-Ante } TA_{Gi} = \sum \text{Ex-Ante } TA_{Gi} + \sum (BCQ_{Gi})*(EAP_{Gi})$$

Therefore:

$$TTA_L = \left[\sum \text{Ex-Ante } TA_{Gi} + \sum (BCQ_{Gi})*(EAP_{Gi})\right] * \left(\frac{MQ_L}{\sum MQ_L}\right) + \sum \text{Ex-Post } TA_{Gi} * \left(\frac{MQ_L}{\sum MQ_L}\right) - \left[\sum (BCQ_{Gi})*(EAP_{Gi})\right] * \left(\frac{BCQ_L}{\sum BCQ_L}\right)$$

Simplifying:

$$TTA_L = \sum \text{Ex-Ante } TA_{Gi} * \left(\frac{MQ_L}{\sum MQ_L}\right) + \sum \text{Ex-Post } TA_{Gi} * \left(\frac{MQ_L}{\sum MQ_L}\right) + \left[\sum (BCQ_{Gi})*(EAP_{Gi})\right] * \left(\frac{MQ_L}{\sum MQ_L}\right) - \left[\sum (BCQ_{Gi})*(EAP_{Gi})\right] * \left(\frac{BCQ_L}{\sum BCQ_L}\right)$$

For;

$$\sum TTA_{Gi} = \sum Ex\text{-}Ante\ TA_{Gi} + \sum Ex\text{-}Post\ TA_{Gi}$$

Then;

$$TTA_L = \sum TTA_{Gi} * \left(\frac{MQ_L}{\sum MQ_L}\right) + \left[\sum (BCQ_{Gi})*(EAP_{Gi})\right] * \left[\left(\frac{MQ_L}{\sum MQ_L}\right) - \left(\frac{BCQ_L}{\sum BCQ_L}\right)\right]$$

E. SETTLEMENT OF LOAD TOTAL TRADING AMOUNT FOR CASES WITH PEN AT RTD and PSM AT RTX)

Using the condition of No Surplus;

Total Trading Amount of the Generators = Total Trading Amount of the Loads
$TTA_{Gi} = TTA_L$

$TTA_{Gi} = (EAQ_{Gi} - BCQ_{Gi})*EAP_{Gi} + (MQ_{Gi} - EAQ_{Gi})*EPP_{Gi}$
$TTA_{Gi} = EAQ_{Gi}*EAP_{Gi} + (MQ_{Gi} - EAQ_{Gi})*EPP_{Gi} - BCQ_G*EAP_{Gi}$

$TTA_L = (EAQ_L - BCQ_L)*EAP_L + (MQ_L - EAQ_L)*EPP_L + LR$
$TTA_L = (EAQ_L - BCQ_L)*EAP_L + (MQ_L - EAQ_L)*EPP_L + BCQ_{Gi}*(EAP_L - EAP_G)$
$TTA_L = EAQ_L *EAP_L + (MQ_L - EAQ_L)*EPP_L - BCQ_{Gi}*EAP_G$

Condition for trading intervals with pricing errors in the ex-ante;

$MQ_{Gi} = EAQ_{Gi}$; $EAP_{Gi} = EPP_{Gi} = P_{Gi\text{-}subs}$

And

$MQ_L = EAQ_L$; $EAP_L = EPP_L = P_{L\text{-}subs}$

Therefore;

$TTA_{Gi} = MQ_{Gi} *EAP_{Gi} + (MQ_{Gi} - MQ_{Gi})*EPP_{Gi} - BCQ_{Gi}* EAP_{Gi}$
$TTA_L = MQ_L *EAP_L + (MQ_L - MQ_L)*EPP_L - BCQ_{Gi}* EAP_G$

Substituting $P_{Gi\text{-}subs}$ for EAP_{Gi} and EPP_{Gi} and $P_{L\text{-}subs}$ for EAP_L and EPP_L

Therefore, we have;

$TTA_{Gi} = MQ_{Gi} * P_{Gi\text{-}subs} + (MQ_{Gi} - MQ_{Gi})* P_{Gi\text{-}subs} - BCQ_{Gi}** P_{Gi\text{-}subs}$
$TTA_{Gi} = MQ_{Gi} * P_{Gi\text{-}subs} - BCQ_{Gi}* P_{Gi\text{-}subs}$

$TTA_L = MQ_L * P_{L\text{-}subs} + (MQ_L - MQ_L)* P_{L\text{-}subs} - BCQ_{Gi}*P_{Gi\text{-}subs}$
$TTA_L = MQ_L * P_{L\text{-}subs} - BCQ_{Gi}*P_{Gi\text{-}subs}$

For, $TTA_{Gi} = TTA_L$

Equating the two equations to determine the substitute price ($P_{L\text{-}Subs}$) for load (Customer) L

$MQ_{Gi} * P_{Gi\text{-}subs} – BCQ_{Gi} * P_{Gi\text{-}subs} = MQ_L * P_{L\text{-}subs} - BCQ_{Gi} * P_{Gi\text{-}subs}$

Simplifying;

$MQ_{Gi} * P_{Gi\text{-}subs} = MQ_L * P_{L\text{-}subs}$

Thus,

$$P_{L\text{-}subs} = \frac{\sum P_{Gi\text{-}subs} * MQ_{Gi}}{\sum MQ_L}$$

$$P_{L\text{-}subs} = \frac{\sum Offer * MQ_{\text{Cons-on Gen}} + MCP_{Unconstrained} * \sum MQ_{\text{Cons-off Gen}}}{\sum MQ_L}$$

Determining the total trading amount;

$$TTA_L = MQ_L * P_{L\text{-}subs} - \sum BCQ_{Gi} * P_{Gi\text{-}subs}$$

Appendix C Occurrences of Constraints during Trading Intervals with Zero Market Clearing Prices (MCP)

It is possible that there could be cases when network congestion occurs but the highest market clearing price is PhP0.00/MWh. In this case, the value of the price trigger factor “F” cannot be determined using the formulation approved since it would result into an undefined number.

The trigger factor “F” is determined using the following -

For very high prices:

$$TF_1 = ABS\left\{\frac{LMP_H}{MCP_H}\right\}$$

For very low prices:

$$TF_2 = ABS\left\{\frac{LMP_H - LMP_L}{MCP_H}\right\}$$

However, if the resulting market clearing price (MCP) is “zero”, the application of the above formulations results into a mathematically undefined number.

$$TF = ABS\left\{\frac{x}{0}\right\} = \text{Undefined Number}$$

Given the above, it is construed that a mathematical approach may not be the best solution for determining the application of the PSM. It could be argued that the Zero MCP may be replaced by a very small number (say 0.000001) such that the mathematical process remains valid. However, such substitution of a very small number would result to a factor that is always greater than 1.2 even if there is a very small nodal price separation. For example:

$$TF = ABS\left\{\frac{0.10}{0.000001}\right\} = 100000$$

The result is that the trigger factor “TF” would be much greater than 1.20.

A logical solution therefore (that considers the basic essence of the price substitution when there is extreme nodal price separation) would be through the application of a threshold level for price separation. That is, if the price separation between the highest and lowest market clearing prices is equal to or greater than a certain price level, then the PSM may be applied, if not, then the PSM will not be applied.

That is apply PSM if there is network congestion, MCP = 0 and,

$$ABS \left\{ LMP_H - LMP_L \right\} \Rightarrow \text{Price Threshold}$$

The remaining question now would be the level of the price threshold. A logical consideration for this would be the average price spread that is encountered in the WESM. Selecting the 1400H trading interval[12] as this expectedly provides the largest price spread since this is the peak trading interval in Luzon), then the price threshold formula would be as follows:

$$PriceThreshold_j = 1.0 \; \frac{\sum(\text{LMPhigh}_{i,j\text{-}1} - \text{LMPlow}_{i,j\text{-}1})}{Total \;\; No.\, of \;\; 1400\, H \;\; Trading \;\; Intervals}$$

Where:

$PriceThreshold_j$	– Price threshold for the current trading year j
LMPhigh	– Highest nodal price for 1400H Trading Hour of trading day i of the previous trading year, j-1
LMPlow	– lowest nodal price for 1400H trading hour of trading day i of the previous trading year, j-1

Hence, when the following conditions exist in a market run:

1. Network congestion
2. Highest MCP is PhP0.00/MWh
3. Price difference between the highest and lowest nodal price is equal to or greater than the Price Threshold calculated for the year the said market run shall be subject to the application of the Price Substitution Mechanism (PSM) for congestion.

Appendix D Network and Localized Congestion

As discussed in the Decision of the Energy Regulatory Commission approving the Price Substitution Methodology (PSM) (ERC Case No. 2008-051 RC), the PSM is to be applied only in cases where there is network congestion. There are, however, congestion that are indicated in the market runs that cannot be considered as network congestion such as cases

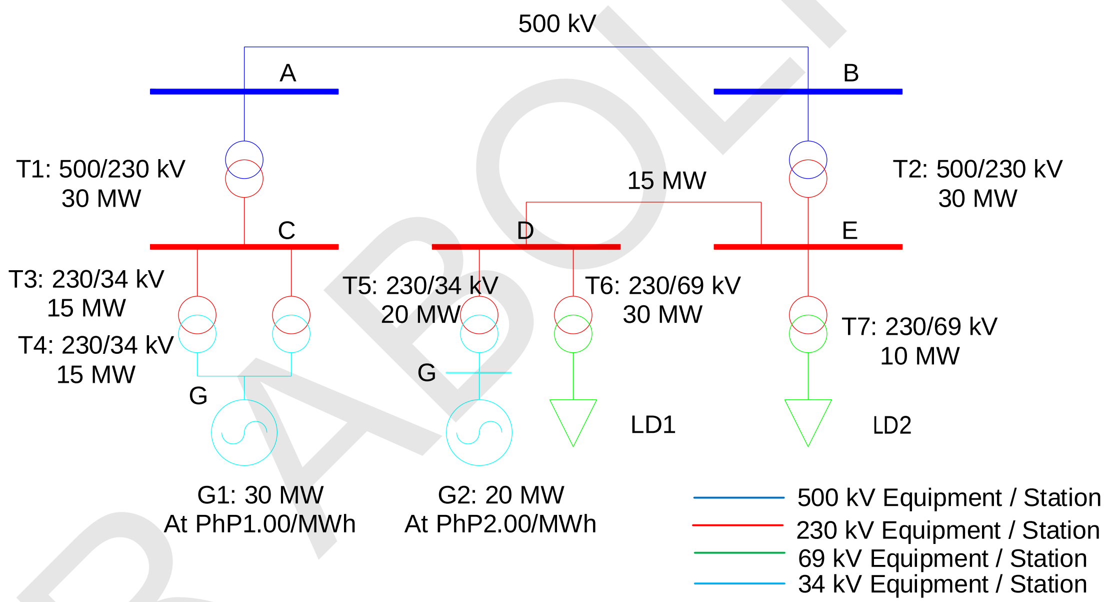
[12] Includes all 1400H trading intervals with valid nodal prices and those subjected to WESM Rules 3.10.5 but excludes those intervals that have been subjected to the PSM (due to the absence of nodal prices when PSM is applied)

of constraints occurring at load-end substations or radially-connected injection on withdrawal point.

For purposes of applying the PSM, network congestion refer to constraints that occur at a certain location or equipment in the network that affects the generator schedule and power flow of the transmission system.

Radial/localized congestion, meanwhile, is a constraint at certain equipments or lines wherein the power flow results to energy withdrawal or energy injection only. That is, the affected equipment or line has no other network connection wherein parallel power flows can occur. As such, localized congestion at the energy withdrawal points (load-end substation transformers) does not affect the generation schedules of the generating units, while generator-end congestions (particularly at generator step-up transformers) only affects the generation schedule of the affected generating unit.

The simplified example below illustrates the difference between network congestions and localized congestions.



Sample Electrical Power System

The foregoing example assumes that there are no losses in the system and that the demand required by loads at nodes LD1 and LD2 are 10 MW and 5 MW, respectively. Thus, the system demand will be supplied by the generating unit G1 since it is able to offer a cheaper price of PhP1.00/MWh at a capacity of 30 MW. Therefore, the nodal prices at nodes G1, C, D, E, LD1 and LD2 are all at PhP1.00/MWh.

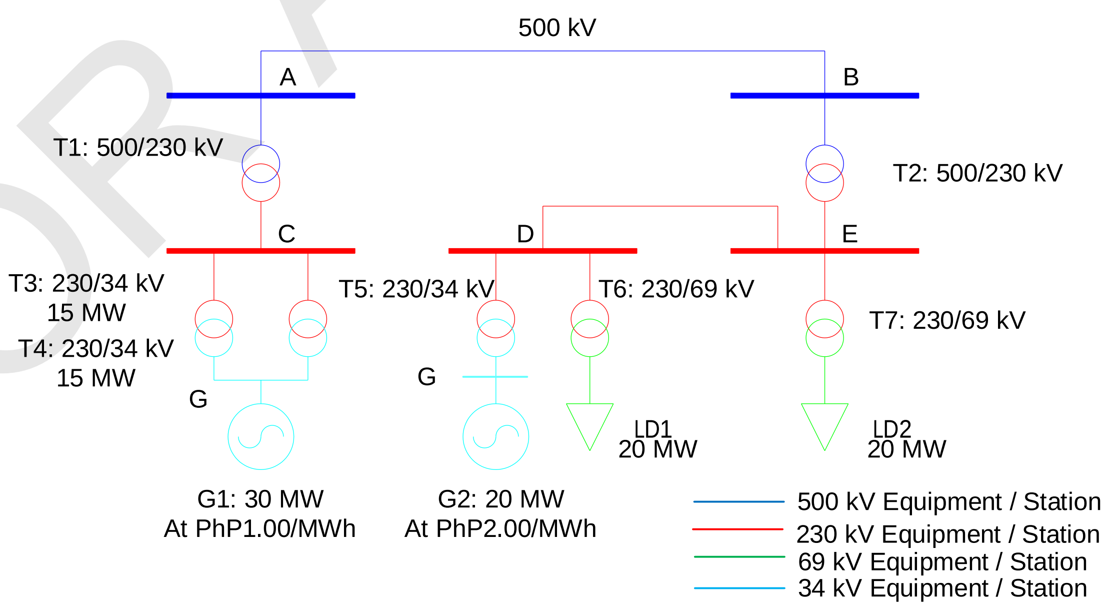
Assuming that the demand required by load LD1 increases from 10 MW to 17 MW, thus increasing the total system demand at 22 MW, then the generation from the generating unit G1 will only be able to produce up to 20 MW since the power that can be delivered from nodes E to D has a limit of 15 MW. Generating unit G2 will have to supply the additional energy requirement at LD1. Therefore, this limitation (constraint) at the D-E 230 kV Line will result into a price separation where the prices at nodes C, E and LD2 are at PhP1.00/MWh, while the price at nodes D and LD1 is PhP2.00/MWh set by G2. Essentially, this can be described as a network congestion. In this example, a generator can be re-dispatched as a result of the transmission constraint.

Congestion at Load-end substation transformer

Considering the same system in the figure above, suppose that the load LD2 increased its power requirement to 11 MW. Under this condition, G1 can supply all the power requirement but supply to LD2 will have to be limited by the capacity of the transformer serving LD2 (transformer T7 which has a capacity of 10 MW only). In which case, the capacity of T7 will result to either a constraint violation or load curtailment (these can either result to a constraint violation coefficient price or Nodal Value of lost load price). But no matter which generator re-dispatch is considered (that is, even if G2 is dispatched) the constraint will still be experienced at T7 since there are no other generators that are directly connected at node LD2 that can be re-dispatched to address the T7 congestion.

Congestion at Generator Step-up Transformers

Consider now the simple network but with no transmission line limitation and no transformer limitations at T1, T2, T5, T6 and T7 (except T3 and T4 at 15 MW each). LD1 and LD2 now have loads of 20 MW each. G1 and G2 are still offering the same price and quantity. In this case, the loads will now be served by G1 and G2 since the total requirements is 40 MW. Now suppose the step-up transformer T3 of G1 trips such that the generation of G1 becomes constrained or limited by the remaining step-up transformer T4. Such conditions can then result to either a binding constraint or a constraint violation at T4 so that price separation will occur between nodes G1 and the rest of the nodes. In which case, G1 will either be priced at P1/MW or be priced at constraint violation coefficient price level while the rest of the nodes remain to be priced at the offer price level of G2. This type of congestion illustrates a localized congestion at the generator step-up transformer.



The sub-station transformers that are considered as load-end or generator step-up transformers are set forth in the prevailing WESM Market Network Model.

Appendix E Regional Settlement

I. SUMMARY OF CASES AND SCENARIOS WITH PSM APPLICATION

a) PSM is manifested Luzon while the HVDC power flow is from Luzon to Visayas

b) PSM is manifested in Luzon while the HVDC power flow is from Visayas to Luzon

c) PSM is manifested in Visayas while the HVDC power flow is from Luzon to Visayas

d) PSM is manifested in Visayas while the HVDC power flow is from Visayas to Luzon

II. APPLICATION OF THE PRICE SUBSTITUTION MECHANISM

Allocation of Generator Ex-Ante Trading Amount

Customer Ex-Ante Trading Amount equal to the customer's share in the Generator Gross Ex-Ante Trading Amount minus the customer's share in the Bilateral Trading Amount.

$$\text{Ex-Ante } TA_L = \text{GEx-Ante } TA_L - BTA_L$$

$$\text{Ex-Ante } TA_L = \sum \text{GEx-Ante } TA_{Gi} * \frac{MQ_L}{\sum MQ_L} - \sum BCQ_{Gi} * EAP_{Gi} * \frac{BCQ_L}{\sum BCQ_L}$$

But,

$$\sum \text{GEx-Ante } TA_{Gi} = \sum \text{Ex-Ante } TA_{Gi} + \sum BTA_{Gi}$$

$$\sum \text{GEx-Ante } TA_{Gi} = \text{Ex-Ante } TA_{Gi} + \sum BCQ_{Gi} * EAP_{Gi}$$

Therefore:

$$\text{Ex-Ante } TA_L = \left(\sum \text{Ex-Ante } TA_{Gi} + \sum BCQ_{Gi} * EAP_{Gi}\right) * \frac{MQ_L}{\sum MQ_L} - \sum BCQ_{Gi} * EAP_{Gi} * \frac{BCQ_L}{\sum BCQ_L}$$

Simplifying;

$$\text{Ex-Ante TA}_L = \sum \text{Ex-Ante TA}_{Gi} * \frac{MQ_L}{\sum MQ_L} + \sum BCQ_{Gi} * EAP_{Gi} * \frac{MQ_L}{\sum MQ_L} - \sum BCQ_{Gi} * EAP_{Gi} * \frac{BCQ_L}{\sum BCQ_L}$$

$$\text{Ex-Ante TA}_L = \sum \text{Ex-Ante TA}_{Gi} * \frac{MQ_L}{\sum MQ_L} + \sum BCQ_{Gi} * EAP_{Gi} * \left(\frac{MQ_L}{\sum MQ_L} - \frac{BCQ_L}{\sum BCQ_L}\right)$$

Allocation of Generator Ex-Post Trading Amount

Customer Ex-Post Trading Amount equal to the customer's share in the Generator Gross Ex-Post Trading Amount

$$\text{Ex-Post TA}_L = \sum \text{Ex-Post TA}_{Gi} * \frac{MQ_L}{\sum MQ_L}$$

$$\text{Ex-Post TA}_L = \sum (MQ_{Gi} - EAQ_{Gi}) * PS_{Gi} * \left(\frac{MQ_L}{\sum MQ_L}\right)$$

Allocation of Generator Total Trading Amount

Customer Total Trading Amount equal to the customer's share in the Gross Generator Total Trading Amount minus the customer's share in the Bilateral Trading Amount.

$$TTA_L = \text{GEx-Ante TA}_L + \text{Ex-Post TA}_L - BTA_L$$

$$TTA_L = \sum \text{GEx-Ante TA}_{Gi} * \frac{MQ_L}{\sum MQ_L} + \sum \text{Ex-Post TA}_{Gi} * \frac{MQ_L}{\sum MQ_L} - \sum BCQ_{Gi} * EAP_{Gi} * \frac{BCQ_L}{\sum BCQ_L}$$

But,

$$\sum \text{GEx-Ante TA}_{Gi} = \sum \text{Ex-Ante TA}_{Gi} + \sum BTA_{Gi}$$

$$\sum \text{GEx-Ante TA}_{Gi} = \text{Ex-Ante TA}_{Gi} + \sum BCQ_{Gi} * EAP_{Gi}$$

Therefore:

$$TTA_L = \left(\sum \text{Ex-Ante } TA_{Gi} + \sum BCQ_{Gi} * EAP_{Gi}\right) * \frac{MQ_L}{\sum MQ_L} + \sum \text{Ex-Post } TA_{Gi} * \frac{MQ_L}{\sum MQ_L} - \sum BCQ_{Gi} * EAP_{Gi} * \frac{BCQ_L}{\sum BCQ_L}$$

Simplifying;

$$TTA_L = \sum \text{Ex-Ante } TA_{Gi} * \frac{MQ_L}{\sum MQ_L} + \sum \text{Ex-Post } TA_{Gi} * \frac{MQ_L}{\sum MQ_L} + \sum BCQ_{Gi} * EAP_{Gi} * \frac{MQ_L}{\sum MQ_L} - \sum BCQ_{Gi} * EAP_{Gi} * \frac{BCQ_L}{\sum BCQ_L}$$

For;

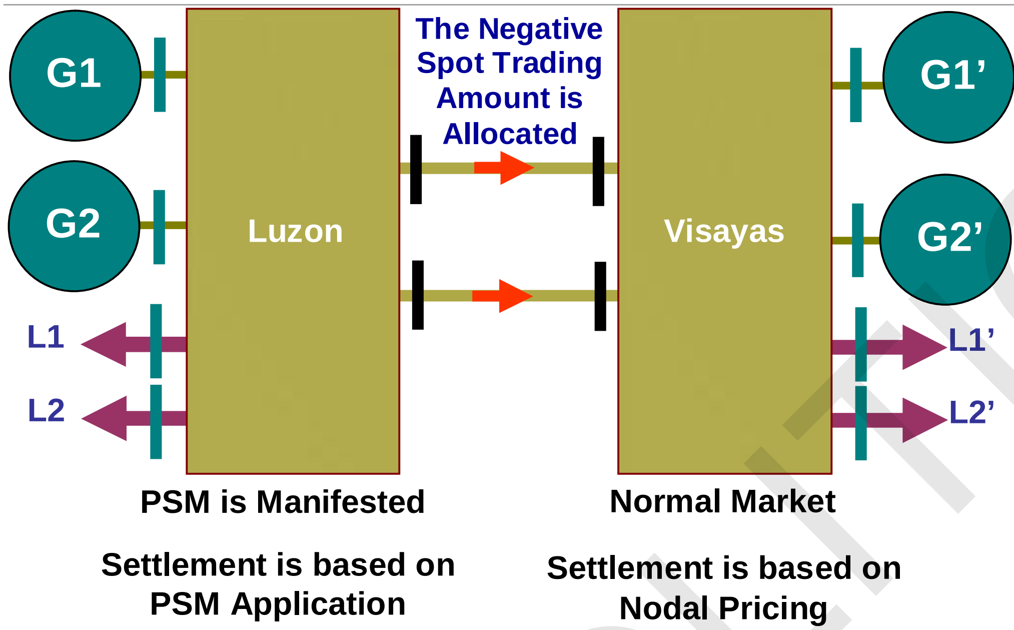
$$\sum TTA_{Gi} = \sum \text{Ex-Ante } TA_{Gi} + \sum \text{Ex-Post } TA_{Gi}$$

Then;

$$TTA_L = \sum TTA_{Gi} * \frac{MQ_L}{\sum MQ_L} + \sum BCQ_{Gi} * EAP_{Gi} * \left(\frac{MQ_L}{\sum MQ_L} - \frac{BCQ_L}{\sum BCQ_L}\right)$$

In the formula shown above, it is assumed that locational marginal price of the HVDC node is also subjected to constrained and unconstrained price. When the WESM Visayas will be implemented, a segregation of pricing of HVDC should be applied so as not to impact the NSS amount. A separate pricing scheme is necessary to settle a region subjected to PSM while the other region is normal or vice versa.

Case 1. PSM in Luzon and Visayas is Normal and Power Flow is from Luzon to Visayas



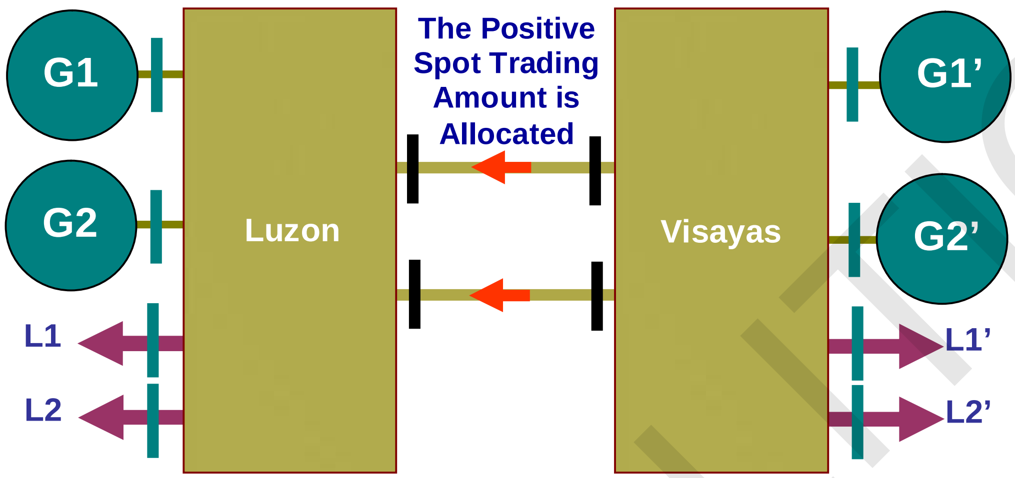
Luzon Settlement:

$$\text{Ex-Ante } TA_L = [\sum(EAQ_{Gi} - BCQ_{Gi}) * PS_{Gi} - (EAQ_{HVDC} * EAP_{Visayas})] * \frac{MQ_L}{\sum MQ_L}$$
$$+ \sum BCQ_{Gi} * EAP_{Gi} * (\frac{MQ_L}{\sum MQ_L} - \frac{BCQ_L}{\sum BCQ_L})$$

$$\text{Ex-Post } TA_L = [\sum(MQ_{Gi} - EAQ_{Gi}) * PS_{Gi} - (MQ_{HVDC} - EAQ_{HVDC}) * EPP_{VIsayas}] * (\frac{MQ_L}{\sum MQ_L})$$

$$TTA_L = (\sum TTA_{Gi} - TTA_{HVDC}) * \frac{MQ_L}{\sum MQ_L} + \sum BCQ_{Gi} * EAP_{Gi} * (\frac{MQ_L}{\sum MQ_L} - \frac{BCQ_L}{\sum BCQ_L})$$

Case 2. PSM in Luzon and Visayas is Normal and Power Flow is from Visayas to Luzon



PSM is Manifested

Settlement is based on PSM Application

Normal Market

Settlement is based on Nodal Pricing

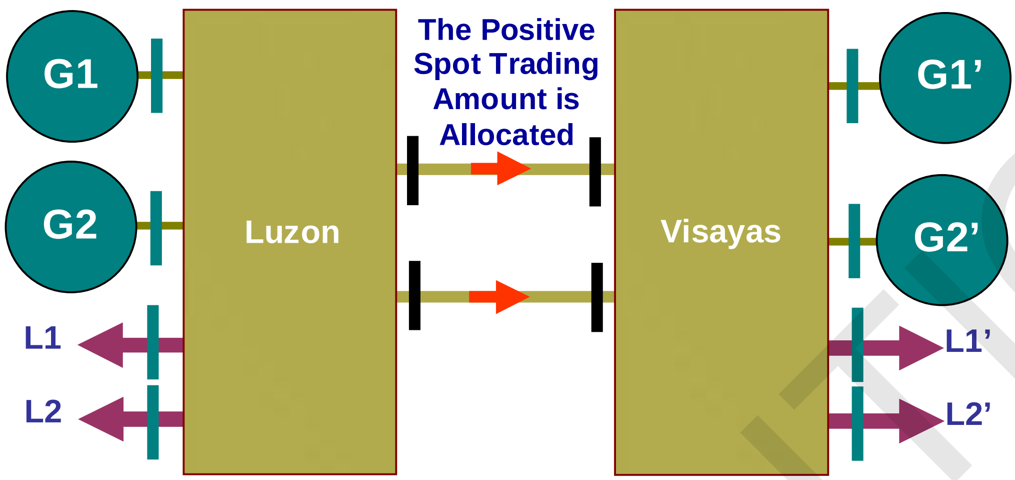
Luzon Settlement:

$$\text{Ex-Ante } TA_L = [\sum(EAQ_{Gi} - BCQ_{Gi}) * PS_{Gi} + (EAQ_{HVDC} * EAP_{Visayas})] * \frac{MQ_L}{\sum MQ_L} + \sum BCQ_{Gi} * EAP_{Gi} * (\frac{MQ_L}{\sum MQ_L} - \frac{BCQ_L}{\sum BCQ_L})$$

$$\text{Ex-Post } TA_L = [\sum(MQ_{Gi} - EAQ_{Gi}) * PS_{Gi} + (MQ_{HVDC} - EAQ_{HVDC}) * EPP_{VIsayas}] * (\frac{MQ_L}{\sum MQ_L})$$

$$TTA_L = (\sum TTA_{Gi} + TTA_{HVDC}) * \frac{MQ_L}{\sum MQ_L} + \sum BCQ_{Gi} * EAP_{Gi} * (\frac{MQ_L}{\sum MQ_L} - \frac{BCQ_L}{\sum BCQ_L})$$

Case 3. PSM in Visayas and Luzon is Normal and Power Flow is from Luzon to Visayas



Normal Market

Settlement is based on Nodal Pricing

PSM is Manifested

Settlement is based on PSM Application

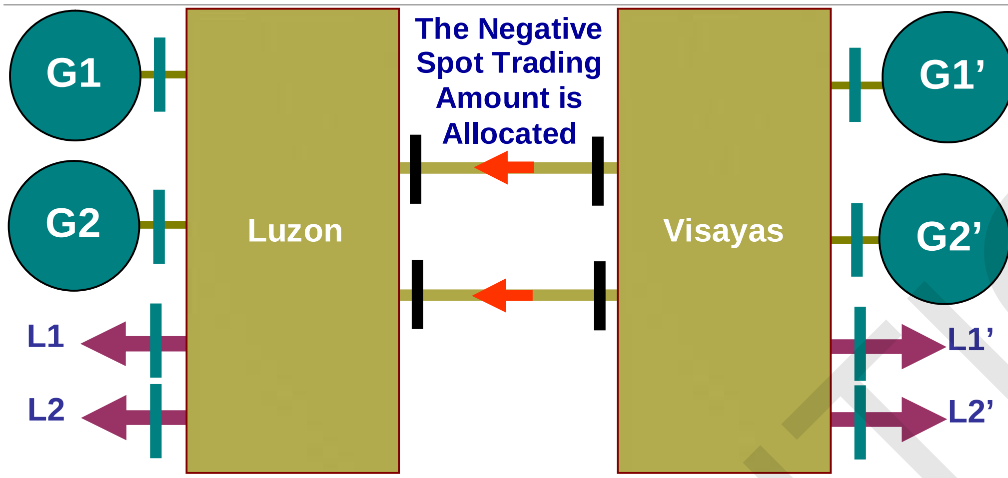
Visayas Settlement:

$$\text{Ex-Ante } TA_L = [\sum(EAQ_{Gi} - BCQ_{Gi}) * PS_{Gi} + (EAQ_{HVDC} * EAP_{Luzon})] * \frac{MQ_L}{\sum MQ_L} + \sum BCQ_{Gi} * EAP_{Gi} * (\frac{MQ_L}{\sum MQ_L} - \frac{BCQ_L}{\sum BCQ_L})$$

$$\text{Ex-Post } TA_L = [\sum(MQ_{Gi} - EAQ_{Gi}) * PS_{Gi} + (MQ_{HVDC} - EAQ_{HVDC}) * EPP_{Luzon}] * (\frac{MQ_L}{\sum MQ_L})$$

$$TTA_L = (\sum TTA_{Gi} - TTA_{HVDC}) * \frac{MQ_L}{\sum MQ_L} + \sum BCQ_{Gi} * EAP_{Gi} * (\frac{MQ_L}{\sum MQ_L} - \frac{BCQ_L}{\sum BCQ_L})$$

Case 4. PSM in Visayas and Luzon is Normal and Power Flow is from Visayas to Luzon



Normal Market

PSM is Manifested

Settlement is based on Nodal Pricing

Settlement is based on PSM Application

Visayas Settlement:

$$\text{Ex-Ante } TA_L = \left[\sum (EAQ_{Gi} - BCQ_{Gi})*PS_{Gi} - (EAQ_{HVDC}*EAP_{Luzon})\right]*\frac{MQ_L}{\sum MQ_L}$$

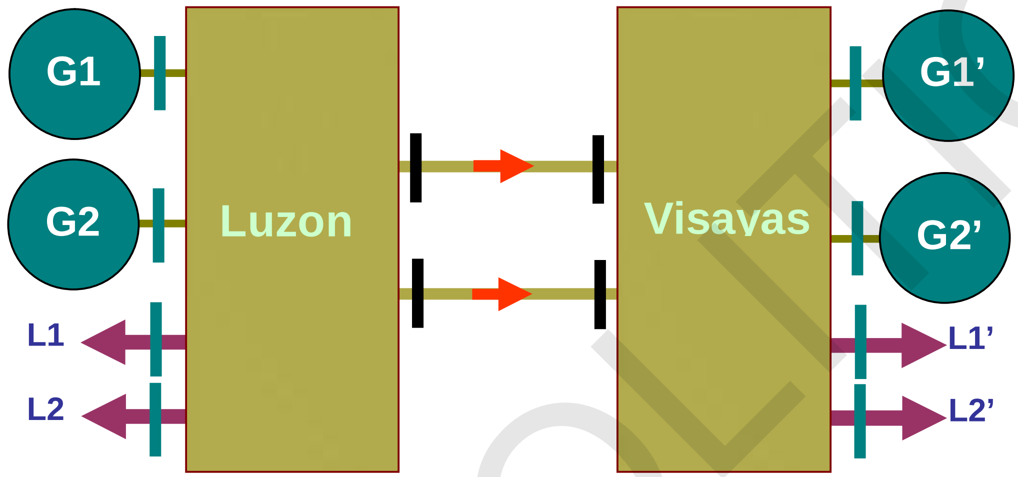
$$+\sum BCQ_{Gi}*EAP_{Gi}*\left(\frac{MQ_L}{\sum MQ_L}-\frac{BCQ_L}{\sum BCQ_L}\right)$$

$$\text{Ex-Post } TA_L = \left[\sum (MQ_{Gi} - EAQ_{Gi})*PS_{Gi} - (MQ_{HVDC} - EAQ_{HVDC})*EPP_{Luzon}\right]*\left(\frac{MQ_L}{\sum MQ_L}\right)$$

$$TTA_L = \left(\sum TTA_{Gi} - TTA_{HVDC}\right)*\frac{MQ_L}{\sum MQ_L}+\sum BCQ_{Gi}*EAP_{Gi}*\left(\frac{MQ_L}{\sum MQ_L}-\frac{BCQ_L}{\sum BCQ_L}\right)$$

III. ILLUSTRATIVE EXAMPLE

a) <u>PSM is manifested Luzon while the HVDC power flow is from Luzon to Visayas</u>



Luzon	Ex-Ante Price (P/MWH)	Meter Quantity (MWH)	Visayas	Ex-Ante Price (P/MWH)	Meter Quantity (MWH)
G1	2500	210	G1'	2350	155
G2	2250	250	G2'	2100	225
L1	2950	180	L1'	2550	155
L2	2850	245	L2'	2700	220
HVDC	2650	13.75	HVDC	2650	-13.75

Luzon	PSM Data (P/MWH)
G1	2350
G2	2300

Luzon Settlement:

Ex-Ante TA_{G1} = 2,350*210
Ex-Ante TA_{G1} = 493,500
Ex-Ante TA_{G2} = 2,300*250
Ex-Ante TA_{G2} = 575,000
$\sum$ TA Gen = 1,068,500
Ex-Ante TA_{HVDC} = 2,650*13.75
Ex-Ante TA_{HVDC} = 36,437.50

$$\text{Ex-Ante } TA_{L1} = (1{,}068{,}500 - 36{,}437.50) * \frac{(180)}{(180 + 245)}$$

Ex-Ante TA_{L1} = 437,108.824

$$\text{Ex-Ante } TA_{L2} = (1{,}068{,}500 - 36{,}437.50) * \frac{(245)}{(180 + 245)}$$

Ex-Ante TA_{L2} = 594,953.676
$\sum$ TA Load = 1,032,062.50

NSS = (1,032,062.50+ 36,437.50) - 1,068,500
NSS = 0.0

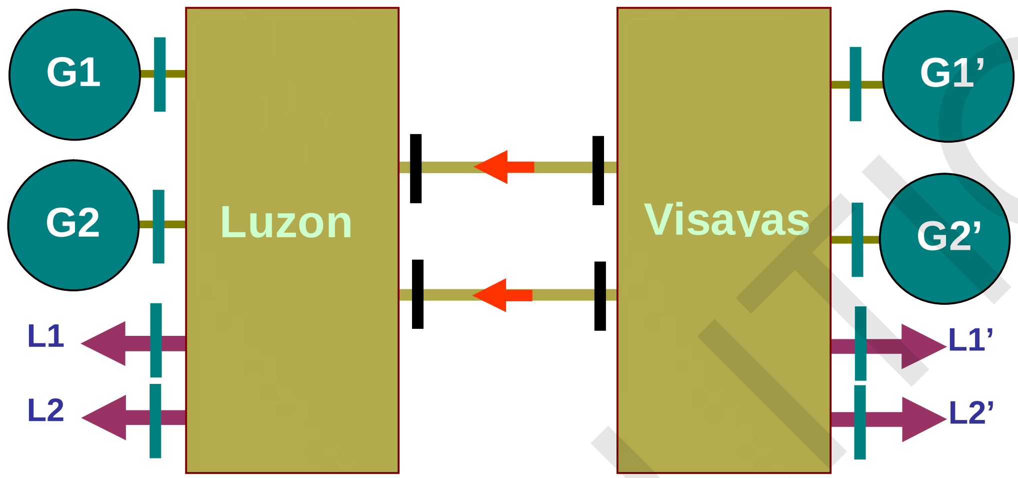
Visayas Settlement:

Ex-Ante TA_{G1} = 2,350*155
Ex-Ante TA_{G1} = 364,250
Ex-Ante TA_{G2} = 2,100*225
Ex-Ante TA_{G2} = 472,500.0
$\sum$ TA Gen = 836,750.0

Ex-Ante TA_{L1} = 2,550*155
Ex-Ante TA_{L1} = 395,250.0
Ex-Ante TA_{L2} = 2,700*220
Ex-Ante TA_{L2} = 594,00.0
$\sum$ TA Load = 989,250.0

NSS = 989,250.0 - (836,750.0 + 36,437.50)
NSS = 116,062.50

b) **PSM is manifested in Luzon while the HVDC power flow is from Visayas to Luzon**



Luzon	Ex-Ante Price (P/MWH)	Meter Quantity (MWH)	Visayas	Ex-Ante Price (P/MWH)	Meter Quantity (MWH)
G1	2500	210	G1'	2350	186.5
G2	2250	250	G2'	2100	225
L1	2950	210	L1'	2550	155
L2	2850	245	L2'	2700	220
HVDC	2650	-17.75	HVDC	2650	17.75

Luzon	PSM Data (P/MWH)
G1	2350
G2	2300

Luzon Settlement:

$\text{Ex-Ante TA}_{G1} = 2,350*210$

$\text{Ex-Ante TA}_{G1} = 493,500$

$\text{Ex-Ante TA}_{G2} = 2,300*250$

$\text{Ex-Ante TA}_{G2} = 575,000$

$\sum \text{TA Gen} = 1,068,500$

Ex-Ante TA_{HVDC} = 2,650*(-17.75)

Ex-Ante TA_{HVDC} = -47,037.50

Ex-Ante TA_{L1} = $(1{,}068{,}500 + 47{,}037.50)^* \dfrac{(210)}{(210 + 245)}$

Ex-Ante TA_{L1} = 514,863.462

Ex-Ante TA_{L2} = $(1{,}068{,}500 + 47{,}037.50)^* \dfrac{(245)}{(210 + 245)}$

Ex-Ante TA_{L2} = 600,674.038

$\sum$ TA Load = 1,115,537.5

NSS = 1,115,537.5 - (1,068,500 + 47,037.50)

NSS = 0.0

Visayas Settlement:

Ex-Ante TA_{G1} = 2,350*186.5

Ex-Ante TA_{G1} = 438,275.0

Ex-Ante TA_{G2} = 2,100*225

Ex-Ante TA_{G2} = 472,500.0

$\sum$ TA Gen = 901,775.0

Ex-Ante TA_{L1} = 2,550*155

Ex-Ante TA_{L1} = 395,250.0

Ex-Ante TA_{L2} = 2,700*220

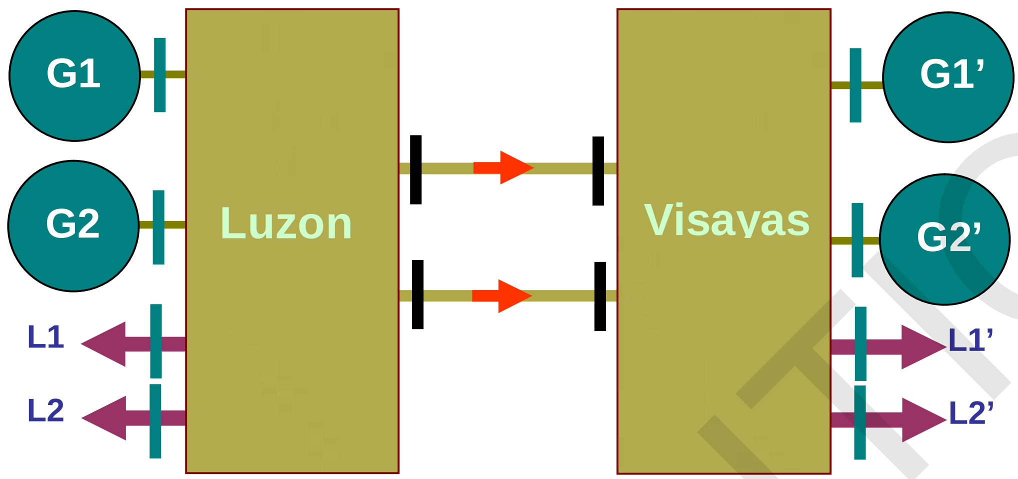
Ex-Ante TA_{L2} = 594,00.0

$\sum$ TA Load = 989,250.0

NSS = 989,250.0 - (901,775.0 + 47,037.50)

NSS = 125,512.50

c) <u>PSM is manifested in Visayas while the HVDC power flow is from Luzon to Visayas</u>



Luzon	Ex-Ante Price (P/MWH)	Meter Quantity (MWH)	Visayas	Ex-Ante Price (P/MWH)	Meter Quantity (MWH)
G1	2500	210	G1'	2350	155
G2	2250	250	G2'	2100	225
L1	2950	180	L1'	2550	155
L2	2850	245	L2'	2700	220
HVDC	2900	13.75	HVDC	2900	-13.75

Visayas	PSM Data (P/MWH)
G1	1750
G2	1735

Luzon Settlement:

$\text{Ex-Ante } TA_{G1} = 2{,}500*210$

$\text{Ex-Ante } TA_{G1} = 525{,}000$

$\text{Ex-Ante } TA_{G2} = 2{,}250*250$

$\text{Ex-Ante } TA_{G2} = 562{,}500$

$\sum \text{TA Gen} = 1{,}087{,}500$

$\text{Ex-Ante } TA_{L1} = 2{,}950*180$

$\text{Ex-Ante } TA_{L1} = 531{,}000$

$\text{Ex-Ante } TA_{L2} = 2{,}850*245$

$\text{Ex-Ante } TA_{L2} = 698{,}250$

$\sum \text{TA Load} = 1{,}229{,}250$

$$\text{Ex-Ante } TA_{HVDC} = 2{,}900*13.75$$
$$\text{Ex-Ante } TA_{HVDC} = 39{,}875.00$$

$$NSS = (1{,}229{,}250 + 39{,}875.00) - 1{,}087{,}500$$
$$NSS = 181{,}625.00$$

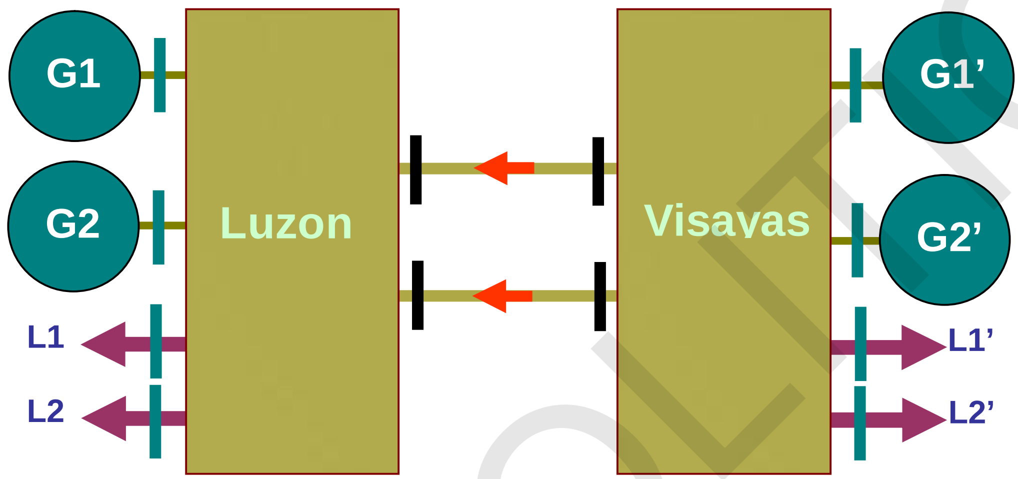
Visayas Settlement:

$$\text{Ex-Ante } TA_{G1} = 1{,}750*155$$
$$\text{Ex-Ante } TA_{G1} = 271{,}250.0$$
$$\text{Ex-Ante } TA_{G2} = 1{,}725*225$$
$$\text{Ex-Ante } TA_{G2} = 388{,}125.0$$
$$\sum TA\ Gen = 659{,}375.0$$

$$\text{Ex-Ante } TA_{HVDC} = 2{,}900*13.75$$
$$\text{Ex-Ante } TA_{HVDC} = 39{,}875.00$$
$$\text{Ex-Ante } TA_{L1} = (659{,}375 + 39{,}875.00)*\frac{(155)}{(155 + 220)}$$
$$\text{Ex-Ante } TA_{L1} = 289{,}023.34$$
$$\text{Ex-Ante } TA_{L2} = (659{,}375 + 39{,}875.00)*\frac{(220)}{(155 + 220)}$$
$$\text{Ex-Ante } TA_{L2} = 410{,}226.67$$
$$\sum TA\ Load = 699{,}250.0$$

$$NSS = 699{,}250.0 - (659{,}375.0 + 39{,}875.00)$$
$$NSS = 0.0$$

d) PSM is manifested in Visayas while the HVDC power flow is from Visayas to Luzon



Luzon	Ex-Ante Price (P/MWH)	Meter Quantity (MWH)	Visayas	Ex-Ante Price (P/MWH)	Meter Quantity (MWH)
G1	2500	210	G1'	2350	186.5
G2	2250	250	G2'	2100	225
L1	2950	210	L1'	2550	155
L2	2850	245	L2'	2700	220
HVDC	2900	-17.75	HVDC	2900	17.75

Visayas	PSM Data (P/MWH)
G1	1750
G2	1735

Luzon Settlement:

Ex-Ante TA_{G1} = 2,500*210

Ex-Ante TA_{G1} = 525,000

Ex-Ante TA_{G2} = 2,250*250

Ex-Ante TA_{G2} = 562,500

$\sum$ TA Gen = 1,087,500

Ex-Ante TA_{L1} = 2,950*210
Ex-Ante TA_{L1} = 619,500.0
Ex-Ante TA_{L2} = 2,850*245
Ex-Ante TA_{L2} = 698,250
$\sum$ TA Load = 1,317,750.0
Ex-Ante TA_{HVDC} = 2,900*(-17.75)
Ex-Ante TA_{HVDC} = -51,475.00

NSS = 1,317,750.0 - (1,087,500.0 + 51,475.00)
NSS = 178,775.00

Visayas Settlement:

Ex-Ante TA_{G1} = 1,750*186.5
Ex-Ante TA_{G1} = 326,375
Ex-Ante TA_{G2} = 1,725*225
Ex-Ante TA_{G2} = 388,125.0
$\sum$ TA Gen = 714,500.0

Ex-Ante TA_{HVDC} = 2,900*(-17.75)
Ex-Ante TA_{HVDC} = -51,475.00

$$\text{Ex-Ante } TA_{L1} = (714{,}500.0 - 51{,}475.00) * \frac{(155)}{(155 + 220)}$$

Ex-Ante TA_{L1} = 274,050.34

$$\text{Ex-Ante } TA_{L2} = (714{,}500.0 - 51{,}475.00) * \frac{(220)}{(155 + 220)}$$

Ex-Ante TA_{L2} = 388,974.67
$\sum$ TA Load = 663,025.0

NSS = (663,025.0 + 39,875.00) - 714,500.0
NSS = 0.0