The Price Determination Methodology for the Philippine Wholesale Electricity Spot Market

(Revision 23 January 2006)

FOREWORD

The establishment of the Philippine Wholesale Electricity Spot Market (the "WESM") is mandated by Republic Act No. 9136, otherwise known as the "Electric Power Industry Reform Act of 2001" (the "EPIRA"). The WESM is to provide the mechanism for determining the price of electricity not covered by bilateral contracts between sellers and purchasers of electricity.

Pursuant to the mandate of the EPIRA, the Department of Energy (the "DOE") jointly with the electric power industry participants formulated the detailed rules for the WESM, i.e., the *WESM Rules*. The *WESM Rules* were promulgated by the DOE on 28 June 2002. Among other things, the *WESM Rules* provided for the mechanism for determining the prices of electricity in the market not covered by bilateral contracts. This price determination methodology (the "PDM") contained in the *WESM Rules* is required by the EPIRA to be approved by the Energy Regulatory Commission (the "Commission").

The Price Determination Methodology for the WESM contained in this document was formulated compliant with the *WESM Rules* and in consultation with the industry participants. Such consultations were conducted through, initially, the WESM Technical Working Group (the "WESM-TWG"), later the Interim Rules Change Committee, and the Philippine Electricity Market Board (the "PEM Board"). This Price Determination Methodology gives the specific details as to how dispatch schedules and locational marginal prices (i.e., nodal prices) are calculated in the *Market Dispatch Optimization Model* (the "MDOM") as provided for in *WESM Rules* clause 3.6.

1. Objectives of the Price Determination Methodology

The Price Determination Methodology (the "PDM") aims to –

1.1. Provide the market participants with the specific principles by which energy and reserves in the WESM will be priced.

1.2. Provide the specific computational formula that will enable the market participants to verify the correctness of the charges being imposed.

2. General Guiding Principles

The EPIRA and the WESM Rules are the main guiding documents for this PDM.

3. The Electricity Market Model of the WESM

The following characteristics and pricing principles are adopted:

3.1. The WESM adopts locational pricing to provide the correct economic signals to market participants when they properly account for the economic impact of losses and constraints that result from the operation of the electricity network.[1]

3.2. The WESM adopts the *gross pool* concept where each generator submits offers for both price and quantity for energy for central scheduling and dispatch.[2]

3.3. The WESM adopts the principle of self-commitment whereby participants assume full responsibility for how and when their plants are operated.[3]

3.4. The WESM adopts a full nodal pricing regime for both generation and customers. Nodal pricing is a mechanism for revealing, at different points in the system, the cost incurred to ensure sufficient power flows to meet all loads in all locations.[4]

3.5. The WESM adopts the scheme of *ex-ante* and *ex-post* pricing to account for discrepancies between planned (ex-ante) and actual outcomes (ex-post).[5]

4. Dispatch and Pricing Algorithm

4.1. Description of the Market Dispatch Optimization Model

The Market Dispatch Optimization Model (the "MDOM") performs market-clearing computations. It receives information on system conditions and requirements from the

[1] WESM Rules clause 3.6.1.3,3.6.1.4,3.6.1.5
[2] WESM Rules clause 3.5.5
[3] WESM Rules Section 3.5.5, 3.5.9, 3.5.10, 3.5.11)
[4] WESM Rules clause 3.2.2.3 (A), as amended. See DOE Circular DC-2004-07-008 in Annex B
[5] WESM Rules 3.10.1

System Operator as well as *market offers* and bids from *trading participants*. It then processes this information to come up with an optimum scheduling of energy and reserves that will maximize economic gains for the *trading participants* taking into consideration the physical limitations of the transmission network and of the facilities of the *trading participants*. It utilizes *linear programming* techniques to create a *security constrained economic dispatch* and calculate nodal energy prices for all *market trading nodes* in the *Market Network Model* (the "MNM") and reserve prices for all reserve regions. The *nodal energy prices* are the *locational marginal prices* used to compute charges and payments while the *dispatch schedules* is used to dispatch generators to maintain balance in the power system.

4.2. Basic *Algorithm* of the MDOM

The MDOM aims to maximize the economic gain derived from electricity trades in the market, considering the constraints imposed by existing system conditions.

The objective of the MDOM is to maximize:

> Value of dispatched load based on demand bids,
> Minus the cost of dispatched generation based on generation offers,
> Minus the cost of dispatched reserves based on reserve offers,
> Minus the cost of constraint violation based on constraint violation coefficients.

The algorithm of the MDOM is given in the mathematical formulation below.[6] The detailed formulation is contained in Appendix III-2.

OBJECTIVE FUNCTION

Maximize the economic gain from trade, where:

$$\textit{Economic Gain} = \left\{ \sum_{i}^{E_D} \sum_{j} \left[\left(DB_{i,j}\right)\left(PDB_{i,j}\right) \right] - \sum_{i}^{E_G} \sum_{j} \left[\left(G_{i,j}\right)\left(PG_{i,j}\right) \right] - \sum_{i}^{E_R} \sum_{k}^{N_K} \sum_{j} \left[\left(R_{i,j,k}\right)\left(PR_{i,j,k}\right) \right] - \left(CVP\right) \right\}$$

i $\in$ resources (generators and dispatchable loads)
j $\in$ energy and reserve offer blocks
k $\in$ reserve types

Where:

[6] WESM Rules clause 3.6.1.3

$PDB_{i,j}$	The price per quantity element of the j^{th} Energy Bid block of the i^{th} Dispatchable Load.
$PG_{i,j}$	The price per quantity element of the j^{th} Energy Offer block of the i^{th} Generator (or dispatchable load).
$PR_{i,j,k}$	The price per quantity element of the j^{th} Reserve Offer block of the k^{th} Reserve Type of the i^{th} Resource.
Gi,j	The MW quantity of the jth Energy Offer block of the ith Generator (or dispatchable load).
Ri,j,k	The MW quantity of the jth Reserve Offer block of the kth Reserve Type of the ith Resource.
DBi,j	The MW quantity of the "jth" Energy Bid block of the ith Dispatchable Load.
CVP	The sum of penalty costs for soft constraints violations based on the constraint violation coefficients, where: CVP = $\sum_t [\ CVC_t * Q_t\ ]$ CVC_t = Constraint violation penalty cost for Constraint Violation Type "t" Q_t = Constraint violation quantity for Constraint Violation Type "t" [7]
E_D	Total number of dispatchable loads with energy demand bids.
E_G	Total number of generators with energy offers.
E_R	Total number of resources (generators or dispatchable load) with reserve offers.
N_K	Total number of reserve resources for each reserve type "k"

Subject to the following *constraints*:

Relevant WESM Rules clause	Constraint Equation	Constraint
3.6.1.4.(a), (d), (j)	$G_{\min,RRDN,i} \le G_i \le G_{\max,RRUP,i}$	Generator Resource Energy Constraint – the minimum and maximum generation of a generating unit (G_i) is dependent on its ability to ramp-down or ramp-up to its minimum and maximum generation.

[7] Refer to section 4.9 for the types of constraint violation and Appendix III-1 for additional details on the formulation of constraint violation coefficients.

Relevant WESM Rules clause	Constraint Equation	Constraint
	$R_{i,k} \le \mathrm{R}_{\max,i,k}$	Reserve Resource Constraint - the reserve schedule for resource "*i*" of reserve category "*k*"[8] should be less than or equal to maximum reserve for category "*k*" of resource "*i*" Where: k=1, Regulation reserve k=2, Contingency reserve k=3, Dispatchable reserve k=4, Interruptible load reserve
3.6.1.4 (b)	$(R_{i,k=1} + R_{i,k=2} + R_{i,k=3}) + G_i \le G_{\max,i}$	Reserve and Energy Constraint – the sum of reserve schedule for each reserve category "*k*" plus the energy schedule (G_i), for each resource generator "*i*", must be less than or equal to the maximum stable generation *(G_{max})* of generator resource "*i*".
	$R_{i,k=4} \le DB_i$	Interruptible load reserve schedule for customer "i" should be less than or equal to energy schedule for dispatchable load (*DB*) for customer "*i*".
3.6.1.4 (c), (i)	$[P_n] = [B][\theta]$	Nodal Energy Balance Constraint – The total power *(P)* at node "*n*" must be equal to the injected power by the generator at node "*n*" less the total MW power withdrawn by customers at node "*n*." This is represented in the constraint equations as the product of transmission network admittance "*B*" and nodal angle "*θ*".

[8] Please see Section 9. Reserve Categories for the different categories of reserves in WESM.

Relevant WESM Rules clause	Constraint Equation	Constraint
3.6.1.4 (e)	$\sum_{i}\sum_{j} R_{i,j,k} + Q_{R_{k,a}} = R^{req}{}_{k,a}$	Area *"a"* Reserve Requirement Constraint for each reserve type *"k"* - the Reserve requirement (*R^{req}*) for each area shall be satisfied by local generators or dispatchable loads on each specified area *"a."* Where: $Q_{R_{k,a}}$ refers to the MW amount by which each reserve type *"k"* was violated in area *"a."* $R_{i,j,k}$ refers to the MW quantity of the j^{th} reserve offer block of the i^{th} resource.
3.6.1.4 (f)	$Pflow_{m,n} \le P_{L,l}$	Line flow constraint for any line *"l"* where: $Pflow_{m,n}$ = MW power flow from node *"m"* to *"n"*. $P_{L,l}$ = MW limit of line *"l"* connecting node *"m"* to *"n"*.

Relevant WESM Rules clause	Constraint Equation	Constraint
3.6.1.4 (g)	$\sum_i \sum_j G_{i,j} + Q_{UG} = \sum_i DB_i + \sum_a P_{Loss,a} + Q_{OG}$	System Energy Balance Constraint - the sum of the MW quantity of the "*j*th" Energy Offer block of the "*i*th" Generator plus the sum of the total system under generation (Q_{UG}) is equal to the total MW quantity of the load (*DB*) for all customer "*i*" plus the sum of all network losses (P_{Loss}) plus the sum of the total system over-generation (Q_{OG}). If no under-generation or over-generation is present, Q_{UG} and Q_{OG} are zero.
3.6.1.4 (h)	$\sum_i \sum_j G_{i,j,a} - \sum_i DB_{i,a} - P_{Loss,a} + Q_{TCG_a,import} \geq ImportLimit_a$	Regional Energy Import Constraints - The sum of the MW quantity of the "*j*th" Energy Offer block of the "*i*th" Generator in area "*a*" less the sum of the total MW quantity of the load (*DB*) for all customer "*i*" in area "*a*" less the MW value of loss in area "*a*" plus the MW value of the import limit ($Q_{TCGa,import}$) that was violated should be greater than or equal to the import MW limit of area "*a*." If there is no import limit violation then $Q_{TCGa,import}$ is zero.

Relevant WESM Rules clause	Constraint Equation	Constraint
3.6.1.4 (h)	$\sum_i \sum_j G_{i,j,a} - \sum_i DB_{i,a} - P_{Loss,a} + Q_{TCG_a,\text{export}} \geq ExportLimit_a$	Regional Energy Export Constraints - the sum of the MW quantity of the j^{th} Energy Offer block of the i^{th} Generator in area "*a*" less the sum of the total MW quantity of the load (*DB*) for all customer "*i*" in area "*a*" less the MW value of loss in area "*a*" plus the MW value of the export limit ($Q_{TCGa,export}$) that was violated should be greater than or equal to the import MW limit of area "*a*." If there is no export limit violation then ($Q_{TCGa,export}$) is zero.
3.6.1.4 (k)	$G_i - R_{i,k=1} \geq G_{\min,i}$	Regulation headroom constraint - The head-room constraint is imposed on REG reserve resources in order to schedule the energy output of the generator resource "*i*" with consideration of its minimum stable generation limit.

4.3. Required Inputs to the MDOM

The MDOM receives input data from three sources, namely, the *System Operator*, the *trading participants* and the *Market Operator*. The information provided is as required in the *WESM Rules.*

System Operator

Network data;
System snapshot;
Reserve requirements for each type of reserve in a reserve region;

Outage schedules;
Contingency List;
Transmission limits;
Security limits; and
Load pattern.

Trading Participants

Registration Data;
Generation Offers;
Reserve Offers;
Demand Bids; and
Optional Load Forecast.

Market Operator

Market Network Model;
Load Forecast; and
Constraint Violation Coefficient.

Appendix A.1 of the WESM Rules details the information to be supplied with offers to supply and to buy electricity while Appendix A.2 provide details on the information to be supplied by network service provider.

4.4. The Output of the MDOM

The optimization process will produce the following outputs:

System Marginal Price;
Generation output levels for each generating resource;
Scheduled load for each dispatchable load;
Reserve schedule for each generating resource;
Transmission line flows;
Transmission losses;
Energy prices at each market trading node; and
Regional reserve prices.

4.5. Determination of the Dispatch Schedule

All generators will submit offers to the market for all the energy they intend to produce irrespective of their contracts with their customers. The *Market Operator* will then schedule all the available generation to meet the forecasted load, taking into account the capabilities of the transmission network to transport the energy from generators to costumers and the limitations of the individual generating resources. Customers with *dispatchable loads* have the option to post their demand bids in the market. This dispatch model where all energy is traded through the WESM is known as the *gross pool*.

Pursuant to the central scheduling process set in the *WESM Rules*, the *trading participants* will submit their respective *market offers* or bids to the market through the market interface that will be provided by the *Market Operator*. The generators must submit a price and quantity offer to the *Market Operator*, while the customers may submit price and quantity bids.

The *Market Operator* considers the submitted bids and offers and the corresponding limitations and constraints in preparing the final *dispatch schedule*. The resulting *dispatch schedule* is the schedule followed by generating facilities and takes account of all *constraint* parameters present in the system for the relevant time interval in order to maintain power balance in the *grid*.

Through the MDOM, the offers submitted by the generators are ranked from the lowest to the highest price offer, while the bids submitted by the customers are ranked from the highest to the lowest price offer. Generating facilities that are scheduled to run are stacked based on their price offers until the total generation matches the total load requirement for a particular trading interval.

The inputs to the MDOM submitted by the *trading participants* are likewise considered in the preparation of the dispatch schedule.

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

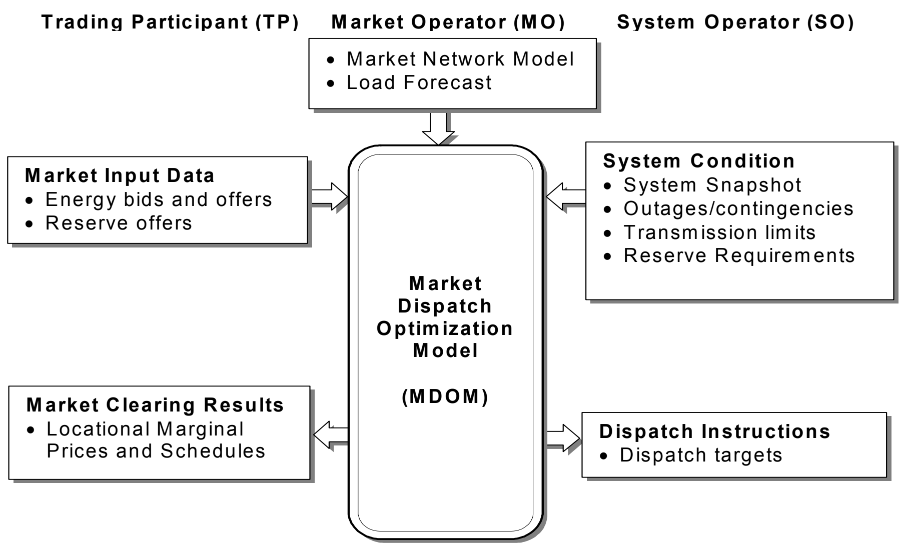


Figure 1. Market Pricing and Scheduling Overview

4.6. Determination of Nodal Prices

The price at a particular node in the system (i.e. *nodal price*), signals the economic value of the electricity given the supply and demand interaction at that node. It represents the benefit of supplying electricity or the cost of consuming electricity at that location under the specific system conditions that were considered in the dispatch scheduling process.

Nodal prices will differ across nodes in the network due to the presence of physical losses or network constraints (i.e., congestion).

In an unconstrained system, the market price is set by one *marginal plant* (i.e., the system marginal price). This price is adjusted for each node to consider transmission losses, and the resulting value is the *locational marginal price* (the "LMP").

Where the system is constrained, the relevant flows of electricity are affected as the line limitations arising from the constraint may impede the supply of cheaper electricity from one area to another. In such cases, there may be more than one *marginal plant* setting the marginal price for the different nodes on either side of the constraint.

4.7. Price Adjustment to Reflect Transmission Losses and Congestion

The nodal prices are to be adjusted to reflect changes in power flows and losses as well as any congestion in the system, and signal to the market the relevant cost to produce and purchase electricity at the relevant market trading nodes. Specifically, the various nodal prices are to be adjusted by considering transmission loss factors and cost of congestion in each location in the system, thus, resulting in the *locational marginal prices*.

Locational marginal prices are the economic value of energy at each node considering the *marginal price* of generation, transmission losses and congestion, as given by the following formula:

LMPi =	Marginal Generator Price	+	Marginal Transmission Loss Price	+	Marginal Congestion Price

In mathematical form:

$$LMPi = \lambda + \left[\left(\frac{1}{TLF_i} - 1 \right) * \lambda \right] + \sum \mu_j a_{ij}$$

Where:

LMP_i	=	*Locational Marginal Price* at location "*i*"
λ	=	The system marginal price based on marginal plant offer
TLF_i	=	*Transmission Loss Factor* at location "i"
u_j	=	Price corresponding to j^{th} transmission constraint[9]

[9] μ_j is the price associated with the change of the schedules of the generators within the optimization process to prevent overloading a constrained transmission line or lines.

a_{ij} = Sensitivity factor relating the contribution of generation at location "*i*" to the energy flow related to constraint "*j*"[10]

The three terms defined in the mathematical equation are -

- The first term is the *system marginal price* which is the price set by the marginal generator scheduled in any trading interval or period.
- The second term is the change in the *system marginal price* due to losses and location.
- The third term is the change in the *system marginal price* due to transmission constraints.

For an unconstrained optimization, the u_j has a zero value, thus:

$$LMPi = \lambda + \left[\left(\frac{1}{TLF} - 1 \right) * \lambda \right]$$

Simplifying further:

$$LMPi = \left[\frac{\lambda}{TLF_i} \right]$$

4.8. Transmission Loss Factors

Transmission loss factors (the "TLF") are scaling factors applied on the *nodal prices* to account for the network loss associated with the delivery or with the consumption of energy at different locations in the system. *Transmission loss factors* are dynamically computed within the MDOM to fully account for the dynamic change in the losses due to a change in load at the various nodes.

The *transmission loss factor* at location "*i*" is defined as follows:

$$TLF_i = \left[1 - \frac{\partial P_{loss}}{\partial P_i} \right]$$

Where:

[10] The sensitivity factor a_{ij} represents the amount of power (MW) flow change in a constrained line or lines due to the change of the schedules of the generators to prevent overloading the constrained line or lines.

TLF_i = *Transmission loss factor* applied at location "*i*"

$\frac{\partial P_{loss}}{\partial P_i}$ = The incremental change in loss due to the incremental change of power at location "*i*".

4.9. Constraint Violation Coefficients

The *constraint violation coefficients* (the "CVCs") listed in *WESM Rules* clauses 3.6.1.3 (c) and 3.6.2 correspond to soft constraints in the MDOM and are associated with *constraint violation prices*. The CVCs are incorporated in the MDOM to ensure that, if constraints shall be violated, the violation will occur in an appropriate priority order that takes account of the security and reliability of the power system and the implementability of the resulting *dispatch schedule*.

The following are the types of CVCs incorporated in the MDOM:

- Deficit Interruptible Load Reserve
- Deficit Dispatchable Reserve
- Deficit Regulating Reserve
- Deficit Contingency Reserve
- Nodal Value of Lost Load
- Contingency
- Under-generation/Over-generation
- Base Case Constraint
- Transmission Constraint Group (TCG) constraint

If any of these CVCs are encountered by the MDOM, the associated CVC prices will be reflected in the *nodal prices* to signal the risks to the power system of violating the constraint/s.

If CVCs are indicated in the ex-ante nodal prices or when the resulting prices are believed to be in error, the *Market Operator* may issue a pricing error notice in which case the ex-post prices calculated at the end of that the relevant *trading interval* shall be substituted to the ex-ante prices. This is pursuant to clause 3.10.5 of the WESM Rules.[11]

4.10. Tie breaking/Handling of Equivalent Offers

In cases where two or more schedules are optimal, the MDOM will pro-rate the dispatch to the affected *trading participants* while observing equipment limitations. The pro-rating rules will be based on the size of the *MW block* of the price curves containing the non-unique schedules.[12]

Appendix III-2 presents two examples of the application of the pro-rating rules.

[11] See in Annex H, *Constraint Violation Coefficients*
[12] See Appendix III-2 for the sample application of the tie-breaking rules.

5. Relevant Market Timetable[13]

5.1. Submission of Bids and Offers

5.1.1. Standing Bids/Offers

A *standing offer/bid* remains valid until it is revised by a new *standing offer/bid*. Offers/Bids for specific trading days and *trading intervals* may be overridden by an offer/bid revision. Once the period covered by the offer/bid revision has expired, however, the standing offer/bid is again in effect.

A revision of a *standing offer/bid* may be done at anytime in accordance with the market *timetable*[14]**.** The changes will, however, take effect from the end of the *trading interval* covered by the last published or initiated week-ahead projection (i.e. from current day, *D,* plus seven days) and before the week-ahead projection is initiated, or at *D* plus eight days after the revision is submitted. Any revisions within the time in which the revision of *standing offer/bid* has not yet taken effect must be done as revision offer/bid, discussed below, and not as revised standing offers/bids.

5.1.2. Revision Bids/Offers

For the week-ahead market projection covering D+1 to D+7, all offer/bid revisions for scheduled generation or load facilities are to be submitted and confirmed by the *trading participants* before 0900h of the current day, *D*.

For the day-ahead market projections, all offer/bid revisions for scheduled generation or load facilities are to be submitted and confirmed by the *trading participants* before 0000h, 0400h, 0800h, 1200h, 1600h, 2000h of the current day, *D*.

For the current trading day, all offer revisions for scheduled generation or load facilities are to be submitted and confirmed before gate closure, which is four hours before the start of the *trading interval* for which the offers/bids being revised are made.

5.2. Week Ahead Dispatch Process

The Week-Ahead Market Projection (the "WAP") requires all relevant data to have been submitted by 0900h. The WAP is *run* everyday at 0900 hours to determine the market projections for the next seven days. After the *run* is completed, the resulting prices and schedules are published to the *trading participants*. The *Market Operator* may also *run* additional week-ahead projections in the event that there are material changes. The

[13] See Annex E, *Dispatch Protocol*, and Annex K, *Billings and Settlement Manual* for the specific details on the timetable of the dispatch processes and settlement, respectively.
[14] For the details of the market timetable, see the *Dispatch Protocol* in Annex E.

results of the additional projections are likewise communicated to the *trading participants*.

5.3. Day-Ahead Dispatch Process

The Day-Ahead Market Projection (the "DAP") is *run* and published every four hours. The DAP *run* before 1200h on a given day covers the *trading intervals* up to the end of that day. The DAP *run* on or after 1200h covers the *trading intervals* until the end of the next trading day (i.e., at 1200h, the DAP calculates prices and schedules for the next 36 intervals).

The *Market Operator* may also *run* additional day-ahead projections in the event there are material changes and this is communicated to the *trading participants*.

5.4. Real-Time Dispatch (Ex-Ante Dispatch)

The *ex-ante* real-time dispatch is *run* five minutes prior to the start of a *trading interval* using the latest snapshot of the power system and cleared offers and bids to the market. After each *run*, the resulting prices and schedules are then published. The resulting *dispatch schedule* is also sent to the *System Operator* to be used as the basis for physical dispatch target for the end of the *trading interval*.

5.5. Real-Time Dispatch (Ex-Post Dispatch)

At the end of each *trading interval*, the ex-post real-time dispatch is *run* using the latest snapshot of the power system and the bids/offers used in the calculation of ex-ante prices. For settlement purposes, the calculated ex-post prices and revenue meter quantities are used.

6. Market Network Model

The *Market Operator* is to maintain and publish a *Market Network Model*, which will be used for the determination of the *dispatch schedules* and *nodal prices*, pursuant to *WESM Rules* clause 3.2.1. The *Market Network Model* is developed by the *Market Operator* in consultation with electric power industry participants and is approved by the Philippine Electricity Market Board ("*PEM Board*").

The *Market Network Model* is a sound representation of the power system elements. It provides information on the technical characteristics and limitations of the power system that may materially affect the dispatch of generating units and the electricity prices in the market.

The *Market Network Model* is automatically adjusted to accurately reflect power system conditions thru the system snapshot provided by SO.[15]

7. Market Trading Nodes

[15] See Annex G, *Market Network Model Manual* for details of the procedures for updating the Market Network Model.

The *market trading nodes*, as defined in the *WESM Rules* clause 3.2.2, are classified as either (1) generator nodes or (b) customer Nodes

8. Pricing Zones

8.1. Reserve Pricing Zones

The *Market Operator* shall group the *market trading nodes* into reserve pricing zones. Initially, the reserve pricing zones shall consist of three (3) separate zones, namely, Luzon grid, Visayas grid, and Mindanao grid. Whenever appropriate, this definition of reserve pricing zones may be modified or amended subject to further validation.

8.2. Customer Pricing Zones

Originally, *WESM Rules* clause 3.2.3 provided that customer *market trading nodes* may be grouped into *customer pricing zones* and all customers within a *customer pricing zone* shall pay the same price for electricity consumed within the zone at the same time interval.

The *WESM Rules* were, however, amended such that nodal pricing shall be adopted for customers and customer zonal pricing shall become optional and not mandatory.[16]

9. Reserve Categories

Four reserve categories have been defined for co-optimization in the MDOM, consistent with *WESM Rules* clause 3.6.1.1. The reserve categories are as follows -

- Regulation Reserve (REG) - the ability to respond to small fluctuations in system frequency including but not limited to those caused by load or generation changes. This is also termed as “Load Following and Frequency Regulation.”

- Contingency Reserve (CON) - the ability to respond to a significant decrease in system frequency including but not limited to a decrease in system frequency in an interconnected AC network as a result of a credible contingency affecting one (or more) generation companies within that network, or transmission flows into that network. This is also termed as “Spinning Reserve.”

- Dispatchable Reserve (DIS) - the ability to respond to a re-dispatch performed by the *System Operator* during a *trading interval*, on either a regular or an ad hoc basis. This is also termed as “Back-up Reserve.”

- Interruptible Load (ILD) - the ability of a Customer to disconnect loads from the Grid within a very short notice in response to a frequency deviation or a request of the *System Operator*.

[16] See Annex B, *DOE Circular DO-2004-07-008* for the amendments to WESM Rules clauses 3.2.2.3(A), 3.2.3.1 and 3.2.3.2.

Prior to the commencement of the spot market for ancillary services,[17] procurement of reserves can be facilitated by the *System Operator* outside the market through competitive bidding or negotiated contracts.[18] The procedures and related cost recovery mechanisms for reserve trading in WESM will be submitted to the Commission for approval in a separate and independent filing.

10. Bilateral Contracts

10.1. Treatment of Bilateral Contracts

WESM Rules clause 3.5.5.1 requires all generators to submit offers to the market for all of the energy they intend to deliver irrespective of their commercial contracts with consumers and retailers.

Trading participants with bilateral contracts that prefer their bilateral contracts to be accounted for in the market settlements will notify the *Market Operator* of their bilateral contract quantities and their counterparties.[19]

10.2. Line Rental Amounts for Bilateral Contracts

WESM Rules clause 3.13.7 provides for the adjustment of the energy settlement quantity to net out bilateral contract quantities in the market settlement trading amount of a particular *trading participant*. In such cases, specific line rental amounts shall be charged corresponding to the bilateral contract quantities that were netted out. This is in order to fully account for the line usage of these bilateral energy flows in the market, and to allow the market settlement accounts to balance. In so doing, the bilateral contract holders will likewise pay for the line rental amounts as required of all market participants. Thus, a *trading participant* that notifies the *Market Operator* of its bilateral contract quantity must likewise identify the counterparty to its bilateral contract as well as the party that will pay the line rental trading amount associated with the bilateral contract quantity submitted.[20]

For bilateral contracts that are netted out of or settled outside the market, the line rental amount that will be charged to the bilateral contract quantity is the price differential between the sending and receiving nodes. *WESM Rules* clause 3.13.12 provides for the formula for the calculation of the line rental amounts for each transmission line in the Market Network Model, and is represented as follows:.

$$\text{Line rental} = P_R Q_R - P_S Q_S$$

Where:

Q_R = expected flow of energy out of the receiving node of the market network line as determined by the MDOM.

P_R = ex-ante nodal settlement price at the receiving node.

[17] See WESM Rules clause 10.3.23
[18] See WESM Rules clause 10.3.2.1
[19] See WESM Rules clauses 3.13.1 and 3.13.7
[20] See WESM Rules clause 3.13.1.1 (b), as amended in Annex B, *DOE Circular DC-2004-07-008*.

Q_S = expected flow of energy into the sending node.
P_S = ex-ante nodal settlement price at the sending node of the market network line as determined by the MDOM.

For bilateral contracts that are netted out of or settled outside the market, the bilateral contract quantity, *BCQ*, would be equal to both Q_R and Q_S, such that:

$$\text{Line rental amount} = P_R{*}BCQ - P_S{*}BCQ = (P_R - P_S){*}BCQ$$

11. Treatment of New and Renewable Energy with Intermittent Energy Resource

Providers of new and renewable energy with intermittent energy resource (the "NRE-IER") are required to submit their respective forecast generation as ahead of schedule as practicable and consistent with the *WESM timetable* (i.e. week ahead, day ahead and hour ahead).[21] These forecasted levels are to be netted out from the supply requirements corresponding to the load requirements for the relevant time intervals. The NRE-IER is treated as a non-scheduled generation by the WESM and, as such, is treated as a price taker.

The market shall provide adequate levels of reserve (i.e. within the relevant zones), taking into account the probability of the NRE-IER provider not being able to fulfill its schedule.

12. Treatment of Must Run Generation

Under the *Dispatch Criteria for Must Run Units*[22] , the *System Operator* can nominate certain generating plants to run, not in accordance with the merit order, but in order to maintain system reliability or to support system security. In nominating these must-run plants, the *System Operator* will consider the following criteria (a) system voltage requirement; (b) thermal limits of transmission lines and power equipment; and (c) system tests of Transco facilities/equipment

Even as the importance of nominating must-run plants is recognized, it is likewise recognized that these plants should not be allowed to set the prices in the WESM but should rather be considered as price-takers. This is to obviate their gaining unnecessary commercial advantage or market power.

13. Billings and Settlements

The *Market Operator* shall determine the settlement amount for each *trading participant* based on the settlement formula described in WESM Rules clause 3.13.14.

The settlement process involves the determination of *ex-ante energy trading amount* and *ex-post energy trading amount*, adjusted for *bilateral contract* quantities in accordance with *WESM Rules*

[21] See WESM Rules clause 3.5.5.5,
[22] See Annex D, *Dispatch Criteria for Must Run Units*

clause 3.13.7. The methods of calculations are described below. Particular details on the timeline and implementation of the settlement provisions of the *WESM Rules* are detailed in the *Billings and Settlement Manual.*[23]

13.1. Determination of Ex-Ante Trading Amount

The *ex-ante energy trading amount* for each trading node and *trading interval* is determined as the *ex-ante energy settlement price* for that node in that *trading interval* multiplied by the *ex-ante energy settlement quantity* for that node in that *trading interval.*[24] The *ex-ante nodal energy prices* and quantities are outputs of the MDOM representing the expected prices and quantities at the *market trading nodes* and are scheduled by the *Market Operator* prior to actual *dispatch* by the *System Operator*. Their values depends on generation offers, reserve offers, and demand bids submitted by the *trading participants* at the times set in the market timetable[25], and the *net load forecast* prepared by the *Market Operator.*[26]

The working formulations for determining trading amounts of generators and customers are as follows:

For Generators: $EAETA_{k,h}^{m} = (EAESP_{h}^{m} \times (EAQSI_{k,h}^{m} - BCQ_{k,b,h}^{m}))$

Where:

$EAETA_{k,h}^{m}$ represents the *ex-ante energy trading amount* for Generator "*k*" at *trading interval* "*h*" and *metering point* "*m*";

$EAESP_{h}^{m}$ is the *ex-ante energy settlement price* for the *trading interval* "*h*" and *metering point* "*m*", which is the market clearing price for the trading node where the generator is connected;

$EAQSI_{k,h}^{m}$ is the *ex-ante* quantity of energy that is scheduled for injection by the generator "*k*" for *trading interval "h"* and *metering point* "*m*"; and

$EAQSI_{k,h}^{m} = 0.5 \times (XAGQ_{k,h}^{m} + XAIGQ_{k,h}^{m})$[27]

$XAGQ_{k,h}^{m}$ is the *ex-ante* target quantity for generator "*k*" at *trading interval* "*h*" and *metering point* "*m*";

$XAIGQ_{k,h}^{m}$ is the *ex-ante* initial quantity for generator "*k*" at *trading interval* "*h*" and *metering point* "*m*";

and

[23] See Annex K, *Billings and Settlements Manual*
[24] See WESM Rules clause 3.13.8.
[25] See Annex E, *Dispatch Protocol*, for the timeline on the submission of offers/bids into the WESM.
[26] See WESM Rules clause 3.5.4
[27] See WESM Rules clause 3.13.5.1

$BCQ_{k,b,h}^{m}$ is the *bilateral contract* quantity associated with generator "*k*", and the corresponding buyer or customer "*b*" for *trading interval "h"* and *metering point* "*m*".

For Buyers: $EAETA_{b,h}^{m}=(EAESP_{h}^{m} \times (EAQSW_{b,h}^{m}-BCQ_{k,b,h}^{m}))$

Where:

$EAETA_{b,h}^{m}$ is the *ex-ante energy trading amount* for buyer/customer "*b*" for *trading interval* "*h*" and *metering point* "*m*";

$EAESP_{h}^{m}$ is the *ex-ante energy settlement price* in *trading interval* "*h*" and *metering point* "*m*" which is the market clearing price for the trading node where the buyer/customer is connected;

$EAQSW_{b,h}^{m}$ is the *ex-ante* quantity of energy that is withdrawn from the system by the buyer/customer "*b*" for *trading interval* "*h*" and *metering point* "*m*";

$EAQSW_{b,h}^{m}=0.5 \times (XALQ_{b,h}^{m}+XAILQ_{b,h}^{m})$

$XALQ_{b,h}^{m}$ is the *ex-ante* target quantity for buyer/customer "*b*" for *trading interval* "*h*" and *metering point* "*m*";

$XAILQ_{b,h}^{m}$ is the *ex-ante* initial quantity for buyer/customer "*b*" for *trading interval* "*h*" and *metering point* "*m*";

and

$BCQ_{k,b,h}^{m}$ is the *bilateral contract* quantity associated with buyer/customer "*b*", and the corresponding generator "*k*" for *trading interval* "*h*" and *metering point* "*m*"..

13.2. Determination of Ex-Post Energy Trading Amount

The *ex-post energy trading amount* for each *market trading node* and *trading interval* is the product of the *ex-post energy settlement price* multiplied by the difference between the *ex-post energy settlement quantity* and the *ex-ante energy settlement quantity.*[28]

The *ex-post nodal energy prices* and quantities are outputs of the MDOM and represent the actual energy prices and quantities at particular *market trading nodes*. Their values

[28] See WESM Rules clause 3.13.9

depends on generation offers, reserve offers, demand bids, bilateral contracts and actual node loads as registered in the revenue meters.

The *ex-post* prices and trading amounts for generators and customers or buyers are determined as follows -

For Generators: $EPETA_{k,h}^{m} = (EPESP_{h}^{m} \times (AQEI_{k,h}^{m} - EAQSI_{k,h}^{m}))$

Where:

$EPETA_{k,h}^{m}$ is the *ex-post energy trading amount* for generator "*k*" at *trading interval "h"* and *metering point "m"*;

$EPESP_{h}^{m}$ is the ex-post energy settlement price in *trading interval* "*h*" and *metering point* "*m*" which is the market clearing price in the *ex-post* market for the trading node where the generator is connected;

$AQEI_{k,h}^{m}$ is the actual quantity of energy injected by generator "*k*" at *trading interval* "*h*" and *metering point* "*m*";

$EAQSI_{k,h}^{m}$ is the *ex-ante* energy quantity scheduled in the market for injection by generator "*k*", at *trading interval* "*h*" and *metering point* "*m*".

For Buyers: $EPETA_{b,h}^{m} = (EPESP_{h}^{m*} \times (AQEI_{b,h}^{m} - EAQSW_{b,h}^{m}))$

Where:

$EPETA_{b,h}^{m}$ is the *ex-post energy trading amount* for customer/buyer "*b*" at *trading interval* "*h*" and *metering point* "*m*";

$EPESP_{h}^{m}$ is the *ex-post energy settlement price* in *trading interval* "*h*" and *metering point* "*m*" which is necessarily the market clearing price in the *ex-post* market;

$AQEI_{b,h}^{m}$ is the actual quantity of energy withdrawn by customer/buyer "*b*" at *trading interval* "*h*" and *metering point* "*m*";

$EAQSW_{b,h}^{m}$ is the *ex-ante* energy quantity scheduled in the market for withdrawal by customer/buyer "*b*", at *trading interval* "*h*" and *metering point* "*m*".

Net load forecasts are utilized in the *ex-ante* calculation while actual load values provided by the Energy Management System snapshot of the power system are utilized for *ex-post* calculations. Except for this difference in the inputs, the MDOM process involved in the determination of *ex-post energy settlement quantity* and price is similar to that utilized for determining the *ex-ante settlement quantity* and price.

13.3. Allocation of Net Settlement Surplus

The surplus or deficit resulting from the aggregate settlement transactions is termed in the *WESM Rules* as the *net settlement surplus.*[29] *Net settlement surplus* arises when the total payments of customers exceeds the total payments to generators. This generally happens when there is congestion in the power system. In some circumstances (e.g. loop flows, forecasting error, etc.), the payments to generators exceed payments from customers which then results to a deficit in the net settlement.

The *net settlement surplus* may be[30]:

- retained by the *Market Operator* to fund deficit settlement as a result of transactions required in clause 3.13.14 of the WESM Rules;
- flowed back to the *trading participants* in accordance with the procedures to be developed under clause 3.13.16.3 of the *WESM Rules*, and;
- may be used by the *Market Operator* to establish and support the market for *Financial Transmission Rights* subject to the approval of the *PEM Board*.

The settlement surplus will also be accounted for and taken into account when setting allowable charges under any regulatory instruments applying to the *Market Operator*.[31]

The *Market Operator* will develop procedures on the possible uses of *net settlement surplus* subject to approval by the *PEM Board*; and, continuously review the procedures on possible uses of such surplus to the extent the *Market Operator* considers it to be reasonably necessary to promote WESM objectives. Any changes made on the procedures are approved the *PEM Board*.[32]

In regard to this, the *Market Operator* shall publish summary reports on the amount of any *net settlement surplus* being generated and every year thereafter, publish a review of the underlying factors giving rise to the surplus, and attempt to identify any binding constraints which may have caused or contributed to such

[29] WESM Rules clause 3.13.16.1
[30] See WESM Rules clause 3.13.16.2 and 3.13.16.3, as amended by *DOE Circular DO-2004-07-008,* in Annex B.
[31] See WESM Rules clause 3.13.16.2, as amended by *DOE Circular DO-2004-07-008,* in Annex B.
[32] See WESM Rules clause 3.13.16.2, as amended by *DOE Circular DO-2004-07-008,* in Annex B.

surplus.[33] The *Market Operator* will also determine, in consultation with *trading participants* and *network service providers*, and subject to approval by the *PEM Board*, whether the *net settlement surplus* generated by any particular set of *constraints* is of such magnitude as to justify development of a regime similar to that implemented in the *WESM Rules* with respect to transmission line rentals and transmission rights.[34]

14. Administered Price Cap

The *WESM Rules* authorizes *the Market Operator* to impose an *administered price* cap during *market suspension* or *intervention*. The *administered price cap* is to be used as basis for settlements.[35]

The term *administered price cap* implies that a price ceiling will be imposed. More appropriately, however, what should be imposed is the price itself that will be used for settlement purposes, rather than merely a ceiling.

The methodology for determining the administered prices are being developed and will be presented for approval by the Commission in a separate, independent filing.

[33] See WESM Rules clause 3.13.16.3, as amended by *DOE Circular DO-2004-07-008,* in Annex B.
[34] See WESM Rules clause 3.13.16.3, as amended by *DOE Circular DO-2004-07-008,* in Annex B.
[35] See WESM Rules clause 6.2.3

Appendix III-1
Detailed Formulation of the Market Dispatch Optimization Model

The *Market Dispatch Optimization Model* (the "MDOM") determines the schedules and prices for both energy and reserves. The objective of the MDOM is to maximize:

- Value of dispatched load based on demand bids,
- Minus the cost of dispatched generation based on generation offers,
- Minus the cost of dispatched reserves based on reserve offers,
- Minus the cost of constraint violation based on constraint violation coefficients.

The MDOM simultaneously solves the economic gain maximization problem for both energy and reserves in a *trading interval* and correspondingly produces energy and reserve schedules, nodal energy prices and area reserve prices for different reserve types.

The maximization problem is subject to different constraints, which include:

- System energy balance,
- Regional energy import/export constraints,
- Area reserve requirements constraints,
- Resource Energy Constraint,
- Reserve Resource Constraint,
- Reserve-Energy Constraint,
- Transmission Constraint

REQUIRED INPUTS TO THE MDOM

The MDOM receives input data from three sources, namely, the *System Operator*, the *trading participants* and the *Market Operator*.

1 System Operator

The *System Operator* sends its input data in the form of a flat-file to the Market Management System (MMS). These flat-files form part of the pre-processing process and become input parameters to the MDOM. The flat-files from the *System Operator* are described below.

1.1 System Snapshot

The *system snapshot* contains the latest power system condition provided by the *System Operator's* Energy Management System (the "EMS") at five-minute intervals to the MMS. The snapshot provides the level of power injected or withdrawn from the system at different market trading nodes which are monitored by remote telemetering units (RTU). It also provides the latest topology (i.e. configuration) of the power system as represented in the EMS topology and represented in the *Market Network Model* used by the MDOM.

1.2 Reserve Requirements

Regulation (REG), contingency (CON), dispatchable (DIS) and interruptible (ILD) reserves as determined by the *System Operator*. Reserve requirements are provided by the *System Operator* in accordance with the *Dispatch Protocol*[36]. The reserve requirements are used in the *area reserve constraints* of the MDOM.

1.3 Outage Schedule

The *outage schedule* contains the planned transmission line, equipment or facility outages as approved by the *System Operator*. The *outage schedule* is provided by the *System Operator* in accordance with the *Dispatch Protocol*. The outage schedule overrides information such as bids, offers and telemetry data. The outage schedule is used in the pre-processing to determine outage resources, so that the resources are not considered in the dispatch optimization process.

1.4 Contingency List

The contingency list contains pre-defined line or equipment outage condition to comply with the single outage contingency (N-1) criterion specified in the *System Security and Reliability Guidelines*. This criterion specifies that the grid shall continue to operate in the normal state following the loss of one generating unit, transmission line, or transformer.

The list is used to implement contingency analysis in the dispatch optimization process and is used in pre-processing to include additional constraints in the system to comply with the single outage contingency (N-1) criterion. The contingency list is provided by the *System Operator* in accordance with the *Dispatch Protocol*.

1.5 Transmission Limits

The *transmission limits* contains the latest power transmission limits of transmission lines and transformers as determined by the SO. The transmission limit data imposed by the SO overrides the default transmission limit values of the *Market Network Model*. This also enables the SO to selectively override the transmission limit values of individual or groups of transmission lines for security and reliability purposes. In pre-processing, this allows the combination of both

[36] See Annex E, *Dispatch Protocol*.

overridden and default transmission limit values for the *Market Network Model* to be used in the *transmission constraint* of the MDOM. Transmission limits are provided by the *System Operator* in accordance with the *Dispatch Protocol*.

1.6 Security Limits

The *security limits* contains the latest operating limits of generators and transmission line branch groups (including the high-voltage direct current (HVDC) link between Luzon and Visayas grids). The security limits are used by the System Operator to override prevailing resource information such as minimum stable loading (G_{min}[37]), and maximum stable loading (G_{max}) of generators and transmission line branch group flow limits for power system security purposes. This overriding constraint supersedes the registered resource limit information such as generator G_{min} and the maximum generation offered by the Trading Participant. After pre-processing, the overriding security limit values affect all related constraint equations that use resource limits and line or branch group flow limits. Security limits are provided by the *System Operator* in accordance with the *Dispatch Protocol*.

1.7 Load Pattern Data

The load pattern data contains the latest relative magnitudes of MW and MVar for each customer node used for the Similar Day Load Forecast Methodology[38] applied in the market projections (DAP and WAP workflows of the MDOM). Load patterns are provided by the *System Operator* in accordance with the *Dispatch Protocol*.

2 Trading Participants

2.1 Trading Participant Registration Data

Upon registration as *WESM trading participants*, they shall provide the following information which becomes default inputs to the MDOM, subject to confirmation by the SO:

- Generator limits (Minimum and maximum generator stable loading).
- Ramp-up and Ramp-down rates.
- Maximum response level for the relevant reserve type.

2.2 Generator Energy Offer

Generators shall submit their energy offer considering the following:

- At most ten (10) energy offer blocks per (aggregate) unit

[37] Gmin is also known as Pmin and Gmax is also known as Pmax. Gmin and Gmax have been used only for consistency in the formulation notation and parameter name.
[38] See *Load Forecasting Methodology*, Annex C.

- Shall be for a minimum block size of five (5) MW
- Monotonically increasing prices per block
- Ramp-Up rate (RRUP) and Ramp-Down rate (RRDN)
- Validity period of offers
- Operating range of the energy offer (upper and lower limit)

2.3 Resource Operating Reserve Offer

Resource (Generators or dispatchable loads) shall submit offers for operating reserves considering the following:

- The operating reserve type which may be regulation, contingency, dispatchable or interruptible load.
- At most three (3) operating reserve offer blocks per aggregate unit
- A minimum block size of one (1) MW
- Monotonically increasing operating reserve price per block
- Validity period of the operating reserve offer

2.4 Customer Demand Bid

Customers or loads that are classified as *dispatchable loads* may submit a maximum proportion of the forecasted/scheduled load which may be interrupted.

Dispatchable loads shall submit offers considering the following:

- At most, ten (10) energy offer blocks per take-off point.
- Minimum block size of one (1) MW
- Monotonically decreasing prices per block
- Validity period of bids

2.5 Customer Forecast

Customers may opt to submit forecast for any particular *trading interval* subject to the validation rules indicated in the *Load Forecasting Methodology*[39] for WESM.

[39] See Annex C, *Load Forecasting Methodology*.

3 Market Operator

3.1 Market Network Model

The *Market Network Model* is the electrical representation of physical transmission network elements, e.g. transmission lines, generators, transformers, loads and breakers. It is based on the transmission network data provided by the *System Operator* to the *Market Operator*.

3.2 Load Forecast

The *Market Operator* prepares nodal load forecasts used in the market projections and real-time dispatch through the Similar Day Load Forecast and Load Predictor methodologies, respectively, as described in the *Load Forecasting Methodology*.[40]

3.3 Constraint Violation Coefficient

Constraint Violation Coefficients (the "CVC's") correspond to the constraint penalty values inputted by the Market Operator to the MDOM. CVCs are ranked and graded such that if constraints are not satisfied, the MDOM will still continue to find a solution but reflecting the CVC prices in the nodal prices.

- Deficit Interruptible Load Reserve
- Deficit Dispatchable Reserve
- Deficit Regulating Reserve
- Deficit Contingency Reserve
- Nodal Value of Lost Load
- Contingency
- Under-generation/Over-generation
- Base Case Constraint
- Transmission Constraint Group (TCG) constraint

OUTPUT OF THE MDOM

The optimization process will produce the following outputs:

- System Marginal Price
- Generation Schedules
- Dispatchable Load Schedule
- Regulation Reserve Schedule
- Contingency Reserve Schedule
- Dispatchable Reserve Schedule
- Interruptible Load Reserve Schedule
- Generator Node Energy Price

[40] See Annex C, *Load Forecasting Methodology*.

- Load Node Energy Price
- Regional Reserve Prices for each Reserve Category
- Transmission Line flows
- Transmission Line and System Losses

GLOSSARY OF FORMULATION INDICES, VARIABLES AND PARAMETERS

INDICES

The following indices are used

k indexes reserve types

k=1 refers to regulating reserve type

k=2 refers to contingency reserve type

k=3 refers to dispatchable reserve type

k=4 refers to interruptible load reserve type

i indexes resources (generators or dispatchable loads)

j indexes resource offers or bids

a indexes energy and reserve areas

l indexes transmission lines

PARAMETERS

E_d	Total number of dispatchable loads with energy demand bids.
E_g	Total number of generators with energy offers.
E_r	Total number of resources (generators or dispatchable load) with reserve offers.
N_k	Total number of reserve resources for each reserve type "*k*"
$PDB_{i,j}$	The price per quantity element of the j^{th} Energy Bid block of the i^{th} Dispatchable Load.
$PG_{i,j}$	The price per quantity element of the j^{th} Energy Offer block of the i^{th} Generator (or dispatchable load).
$PR_{i,j,k}$	The price per quantity element of the j^{th} Reserve Offer block of the k^{th} Reserve Type of the i^{th} Resource.
CVC_{UG_j}	The j^{th} price of the Under Generation Penalty Cost Function for system energy balance corresponding to the amount of Q_{UG}.
CVC_{OG_j}	The j^{th} price of the Over Generation Penalty Cost Function for system energy balance corresponding to the amount of Q_{OG}.

$CVC_{R_{j,k,a}}$	The j^{th} price of the Reserve Penalty Cost Function for reserve type *k in reserve area a* corresponding to the amount of $Q_{R_{k,a}}$.
$CVC_{TCG_{j,a}}$	The j^{th} price of the Transmission Constraint Group (TCG) Penalty Cost Function corresponding to import/export constraint at area *a*.
$CVC_{BC_{j,l}}$	The j^{th} price of the Base Case Penalty Cost Function for normal line limit violations of any line *l*.
$CVC_{C_{j,l}}$	The j^{th} price of the Contingency Penalty Cost Function for contingency line limit violations of any line *l*.
$R^{req}{}_{k,a}$	The MW Reserve requirement of reserve type k in *reserve area a*.
$G_{max(t),i}$	The time-varying input high limit for each generator i or the negative of the time-varying input maximum load for each dispatchable load i.
$G_{min(t),i}$	The time varying input low limit for each generator i or Zero for each dispatchable load i.
$G_{\min,RRDN,i}$	Ramp Limited minimum MW level of generator (or dispatchable load) resource "*i*".
$G_{\max,RRUP,i}$	Ramp Limited maximum MW level of generator (or dispatchable load) resource "*i*".
$G_{\max,i,j}$	Maximum generator offer tranche j for resource *i*.
$PD_{i,a}$	The MW quantity of the i^{th} Load in area *a*.
$R_{offer\max,i,k,a}$	Maximum reserve limit from the offer for category *k* for resource *i* in reserve area a.
$R_{ramp\max,i,k,a}$	Maximum reserve ramp-time-limited for category *k* of resource *i* in reserve area a.
$ImportLimit_a$	Import MW limit of area *a* corresponding to the HVDC line MW flow limit.
$ExportLimit_a$	Export MW limit of area *a* corresponding to the HVDC line MW flow limit.
$RRUP_i$	Ramp-up rate of generator (or dispatchable load) resource *i*.
$RRDN_i$	Ramp-down rate generator (or dispatchable load) resource *i*.
$G_{min,i}$	Minimum stable loading of generator *i*. (also known as Pmin)
$G_{max,i}$	Maximum registered capacity of generator *i*.

$[B]$	A matrix of transmission network admittance.
$[H]$	A matrix of line-node references (with +/- admittance elements for both ends of a line).
$[P_L]$	A vector of transmission line limits.
B_l	Admittance of the line *l*.
$P_{L,l}$	Transmission line limit of line *l*.
$[a]$	Sensitivity Coefficient matrix defining the variation of line flows as a function of nodal injection changes calculated by NSA and supplied to NCD.

VARIABLES

$G_{i,j}$	The MW quantity of the j^{th} Energy Offer block of the i^{th} Generator (or dispatchable load).
$R_{i,j,k}$	The MW quantity of the j^{th} Reserve Offer block of the k^{th} Reserve Type of the i^{th} Resource.
$DB_{i,j}$	The MW quantity of the "j^{th}" Energy Bid block of the i^{th} Dispatchable Load.
CVP	The sum of penalty costs for soft constraints violations based on the constraint violation coefficients.
Q_{UG}	The MW quantity by which the system load exceeds the system generation.
Q_{OG}	The MW quantity by which the system generation exceeds the system load.
$Q_{R_{k,a}}$	The MW quantity by which the operating reserve requirement of type *k* for *reserve area a* was not satisfied.
Q_{TCG_a}	The MW quantity by which the import/export limit of corresponding Transmission Constraint Group (TCG) for area *a* is violated.
Q_{BC_l}	The MW quantity by which the line limit of any line *l* is violated.
Q_{C_l}	The MW quantity by which the contingency line limit of any line *l* is violated.
$P_{Loss,a}$	Sum of all network losses in area *a*.

$Q_{TCG_a,import}$	The MW value of the import limit that was violated (slack variable for energy import constraint for area a).
$Q_{TCG_a,export}$	The MW value of the export limit that was violated (slack variable for energy export constraint for area a).
G_i	The MW level of generator resource *i* that is $G_i = \sum_j G_{i,j}$ where *j* denotes the offer tranche.
$R_{i,k}$	Reserve schedule for resource *i* of reserve type *k* in *reserve area* a that is $R_{i,k} = \sum_j R_{i,j,k}$ where *j* denotes the offer(or bid) tranche.
$R_{\max,i,k}$	Maximum Reserve contribution for reserve type *k* of resource *i* in reserve area a which is the minimum of $R_{offer\max,i,k,a}$ and $R_{ramp\max,i,k,a}$
DB_i	The MW schedule of Dispatchable Load *i* that is $DB_i = \sum_j DB_{i,j}$ where *j* corresponds to the bid tranche.
P_n	Net power injection for each node.
$Pflow_{m,n}$	Power flow in the line between nodes m and n.
$[\theta]$	A matrix of nodal angles.
$[P_n]$	A matrix of nodal power injection
$\Delta\theta_l$	Angle difference between sending and receiving nodes for line l.
$a_{i,l}$	Sensitivity coefficient defining the variation of line flow in line *l* as a function of nodal injection changes by resource *i* calculated by in NSA and supplied to NCD.

OBJECTIVE FUNCTION

Maximize the *Economic Gain* from trade, where:

Economic Gain = $\left\{\sum_{i}^{E_D}\sum_{j}\left[\left(DB_{i,j}\right)\left(PDB_{i,j}\right)\right]-\sum_{i}^{E_G}\sum_{j}\left[\left(G_{i,j}\right)\left(PG_{i,j}\right)\right]-\sum_{i}^{E_R}\sum_{k}^{N_K}\sum_{j}\left[\left(R_{i,j,k}\right)\left(PR_{i,j,k}\right)\right]-(CVP)\right\}$

i $\in$ resources (generators and dispatchable loads)
j $\in$ energy and reserve offer blocks
k $\in$ reserve types

CONSTRAINT VIOLATIONS PENALTY COST

The Constraint Violation Penalty Cost is defined as follows:

$$CVP = \left\{\begin{array}{l} CVC_{UG_j}(Q_{UG}) + CVC_{OG_j}(Q_{OG}) \\ +\sum_{k}\sum_{a}\left[CVC_{R_{j,k,a}}\left(Q_{R_{k,a}}\right)\right]+\sum_{a}\left[CVC_{TCG_{j,a}}\left(Q_{TCG_a}\right)\right] \\ +\sum_{l}\left[CVC_{BC_{j,l}}\left(Q_{BC_l}\right)\right]+\sum_{l}\left[CVC_{C_{j,l}}\left(Q_{C_l}\right)\right] \end{array}\right\}$$

j $\in$ constraint violation coefficient block
k $\in$ reserve types
a $\in$ energy and reserve area
l $\in$ transmission lines

OPTIMIZATION CONSTRAINTS

In the optimization process, the following constraints must be observed.

1. System Energy Balance Constraint

$$\sum_{i}\sum_{j} G_{i,j} + Q_{UG} = \sum_{i} PD_i + \sum_{a} P_{Loss,a} + Q_{OG}$$

If no under-generation or over-generation is present, Q_{UG} and Q_{OG} are zero. The two terms are also known as “slack-variables” in optimization theory.

2. Regional Energy Import/Export Constraints

The amount of energy a region could import/export must not violate its scheduled resource and load.

$$\sum_i \sum_j G_{i,j,a} - \sum_i PD_{i,a} - P_{Loss,a} + Q_{TCG_a,import} \geq \textit{ImportLimit}_a$$

and

$$\sum_i \sum_j G_{i,j,a} - \sum_i PD_{i,a} - P_{Loss,a} + Q_{TCG_a,export} \geq \textit{ExportLimit}_a$$

With no import/export violation, $Q_{TCG_a,import}$ and $Q_{TCG_a,export}$ are zero.

3. Area Reserve Requirement Constraint

The *reserve requirement* for each area shall only be satisfied by local generators on each specified area “*a.*”

For Regulating Reserve requirement in reserve area *a*.

$$\sum_i \sum_j R_{i,j,k} + Q_{R_k,a} = R^{req}{}_{k,a}$$, *k=1 and i ∈ facilities in reserve area a*

For Contingency Reserve requirement in reserve area *a*.

$$\sum_i \sum_j R_{i,j,k} + Q_{R_{k,a}} = R^{req}{}_{k,a}$$, *k=2 and i ∈ facilities in reserve area a*

For Dispatchable Reserve requirement in reserve area *a*.

$$\sum_i \sum_j R_{i,j,k} + Q_{R_{k,a}} = R^{req}{}_{k,a}$$, *k=3 and i ∈ facilities in reserve area a*

For Interruptible Load Reserve requirement in reserve area *a*

$$\sum_i \sum_j R_{i,j,k} + Q_{R_{k,a}} = R^{req}{}_{k,a}$$, *k=4 and i ∈ facilities in reserve area a*

4. Resource Energy Constraint

For a dispatchable resource (i.e. generator or dispatchable load), a number of limits are applied which covers the ramp capability to satisfy its energy schedule:

- Maximum operating capability denoted by $G_{max,RRUP,i,(t)}$
- Minimum stable generation denoted by $G_{min,RRDN,i,(t)}$
- Ramp-Up Rate denoted by RRUP
- Ramp-Down Rate denoted by RRDN

The high and low operating limits ($G_{max,RRUP,i,(t)}$, $G_{min,RRDN,i,(t)}$) are the generating limits used for a given time point (t). They are a function of the operating capability, minimum generation and ramp rates.

Where:

$$G_{max,RRUP,i\ (t+1)} = G_{max,RRUP,\ i\ (t)} + \Delta t * RRUP$$

$$G_{min,RRDN,\ i\ (t+1)} = G_{min,RRDN,\ i\ (t)} - \Delta t * RRDN$$

$\Delta t = 1$ *hour*[41]

The Resource Energy Constraint, therefore, is:

$$G_{\min,RRDN,i} \leq G_i \leq G_{\max,RRUP,i}$$

where

$$G_i = \sum_j G_{i,j} \quad j \in \textit{generator offer tranche of resource i}$$

and the size of each offer tranche is respected:

$$G_{i,j} \leq G_{\max,i,j}$$

In addition to ramping limits the Resource Energy Constraint is implemented in conjunction with two further sources of constraint that must be respected:

- The maximum offer quantity.
- The stable minimum and maximum operating limits.

[41] At present the trading interval is set at 1 hour. The MMS may be configured in the future to operate at a shorter trading interval.

Respecting the participant offers for resource i gives the constraint:

$G_i \leq G_{max,i,J}$

Where J is the highest offer made for resource i.

The minimum stable operating limit must be always equal to the registered minimum stable operating limit, $G_{min,i}$. Hence the constraint:

$G_{min,i} \leq G_i \leq G_{max,i}$

Where the resource is also offering reserves, this energy constraint is replaced by a constraint that combines the energy and reserves limits. This will be discussed in later sections.

5. Reserve Resource Constraint

Reserve schedule from a generator depends on its relationship with energy and reserve effectiveness factors.

For a generator, its maximum reserve contribution is capped by $R_{\max,i,k}$ the maximum reserve contribution for reserve type *k* of resource *i*. The maximum contribution is the minimum of $R_{offer\max,i,k,a}$ (maximum reserve limit from the resource *i* offer) and $R_{ramp\max,i,k,a}$ (ramp-limited capacity of resource *i*). The reserve resource constraint therefore is:

$$R_{i,k} \leq R_{\max i,k} = \min\left(R_{offer\max,i,j,k,a}, R_{ramp\max,i,k,a}\right)$$

The size of each offer tranche is respected:

$R_{i,j,k} \leq R_{max,i,j,k}$

$R_{i,k} \leq \Sigma R_{i,j,k}$

6. Reserve-Energy Generation Constraint

The energy and reserve schedules are "co-optimized" by observing the following constraints.

6.1. Regulation Headroom Constraints

The head-room constraint is imposed on regulating reserve resources (k=1) in order to schedule the energy output (G_i) of the generator resource "*i*" with consideration of its minimum stable generation limit ($G_{min,i}$).

$$G_i - R_{i,k=1} \geq G_{\min,i}$$

6.2. Reserve and Energy Constraints

The maximum stable generation of generator resource "*i*" must not be violated in the energy and reserve scheduling by imposing the following constraint.

$$(R_{i,k=1} + R_{i,k=2} + R_{i,k=3}) + G_i \leq G_{\max,i}$$

This is the same for the interruptible load reserve category *(ILD, k=4)*. Interruptible load reserve schedule for customer *i* should be less than or equal to energy schedule for dispatchable load (DB) for customer *i*.

$$R_{i,k=4} \leq DB_i$$

7. Transmission Constraint

Transmission constraints are derived from the nodal energy balance constraints and line flow constraints. The nodal energy balance is defined as:

$$[P_n] = [B][\theta]$$

The line flow constraint for any line "*l*" from bus *m* to bus *n* is defined as

$$Pflow_{m,n} \leq P_{L,l}$$

While the line flow constraints are defined as,

$$[H][\theta] \leq [P_L]$$

For an individual transmission line *l*, the flow constraint has the following form:

$$B_l \Delta\theta_l \leq P_{L,l}$$

Substituting the nodal power balance equation into the line flow constraints equation and defining sensitivity matrix [a] as $[a] = [H][B]^{-1}$, the line flow constraints, in sensitivity form, is

$$[a][P_n] \leq [P_L]$$

For an individual transmission line *l*, the flow constraint, in sensitivity form, is expressed as

$\sum_{i} a_{i,l} \, P_i \leq P_{L,l}$ where $P_i = G_i$,

Appendix III-2 - Tie-Breaking Policy- Illustrative Example

The WESM tie-breaking policy is to consider the *trading participants* with equal offers in the dispatch optimization on a pro-rata basis.

In the event that there are two or more equivalent offers providing two or more optimal schedules, the dispatch requirements shall be pro-rated. The prorating rules will be based on the size of the *MW Block* of the *price curves* containing the non-unique schedules. Only that part of the *price curve* within the bid/offer's availability region will be used. This policy is simple, fair, and cost-effective to implement.

Consider the following example.

EXAMPLE 1

Generator A has a maximum capacity of 70 MW while Generator B has a maximum capacity of 90 MW (Figure 10. Generator A and B are both at the same location and have the same offer price curve (Figures 2 and 3).

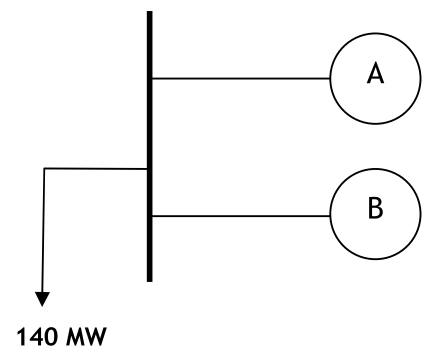


Figure 1

Offer Block of Gen A.

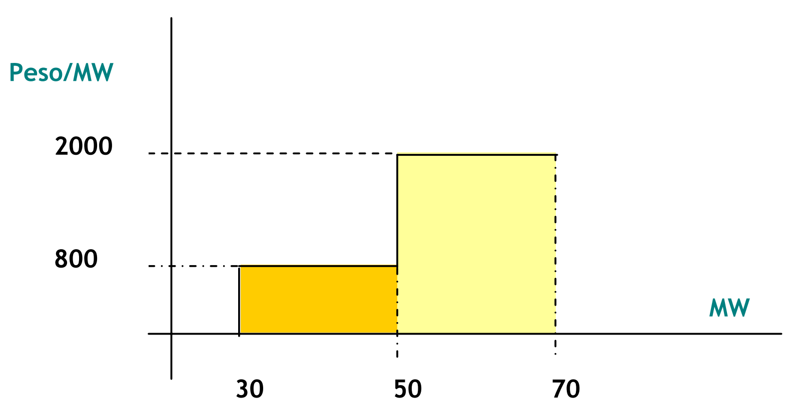


Figure 2

Offer Block of Gen. B

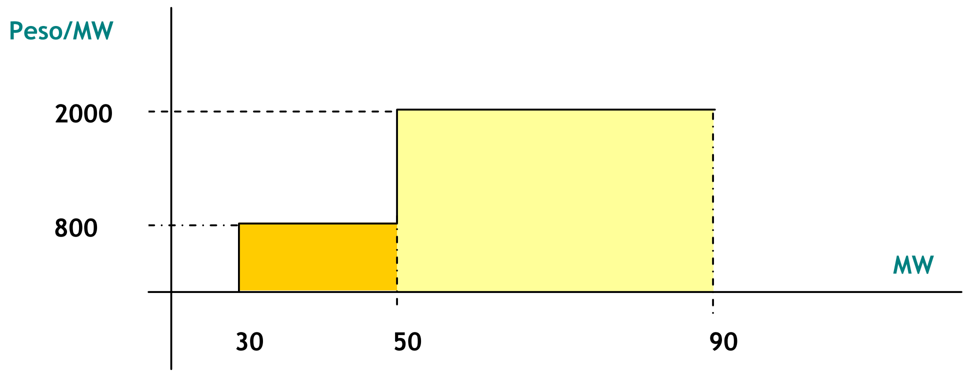


Figure 3

Contestable energy offer block (for tie-breaking)
Offer block already cleared for dispatch

Givens:

Locational Marginal Price = P2,000
Total Load = 140 MW

Solution:

Both generators have the same price but their P_{max} are different. Initially, both generators will supply the 100 MW by dispatching 50 MW each. The remaining 40 MW will be dispatched as follows:

Generator A:

Remaining Output MW = 70MW – 50MW = 20 MW

Generator B:

Remaining Output MW = 90MW – 50MW = 40 MW

The remaining MW will be pro-rated as follows:

Gen_A = $20MW * \left[\frac{40MW}{40MW + 20MW} \right]$

= 13.33333 MW

$$Gen\_B = 40MW * \left[\frac{40MW}{40MW + 20MW} \right]$$

= 26.6666667 MW

Hence,

Gen_A + Gen_B = 13.33333 MW + 26.6666667 MW = 40 MW

Figures 4 and 5 present the resulting dispatch from this example.

Generator A

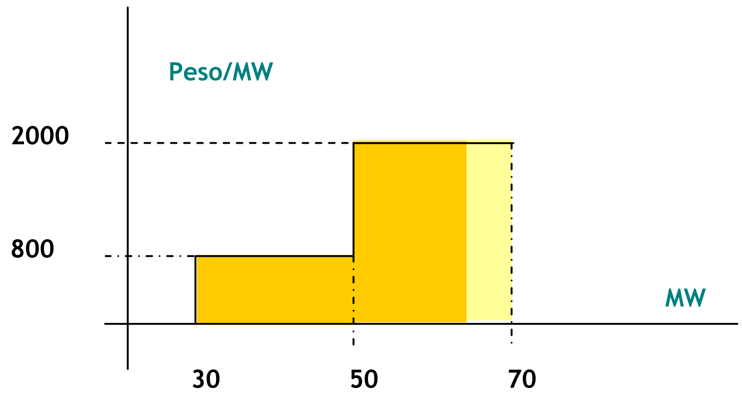


Figure 4

Generator B

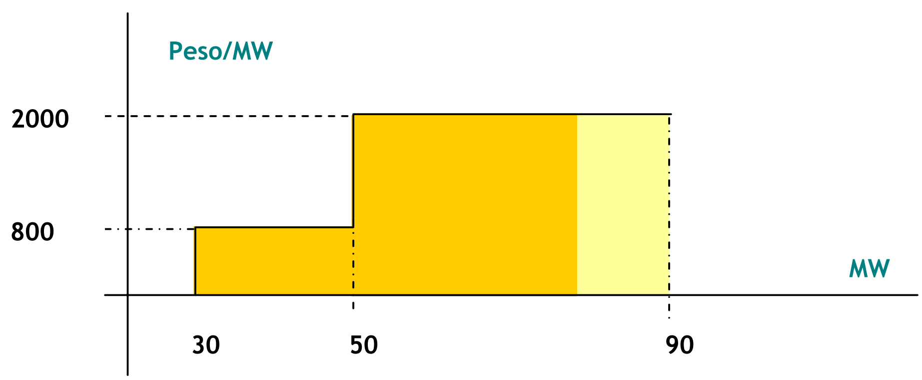


Figure 5

Remaining available energy in the offer block
Dispatched quantity after tie-breaking

EXAMPLE 2

The following example illustrates how the tie-breaking policy applies if the quantity and prices are the same:
The same conditions as in Example 1 are applied but with Generators A and B having equal price and quantity blocks.

Offer Block of Gen A.

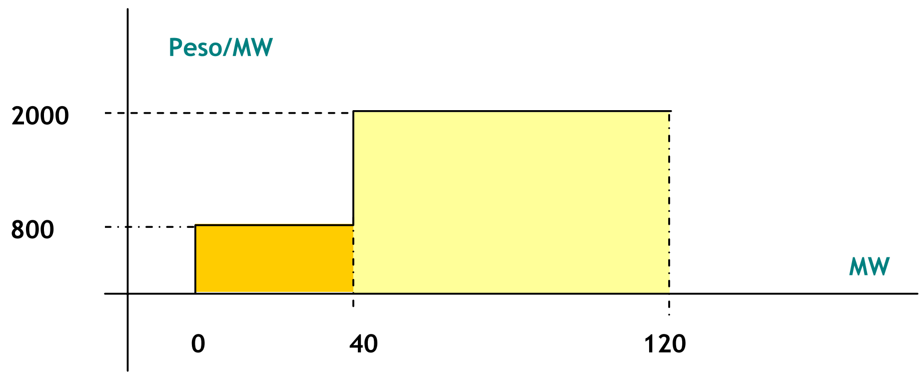


Figure 6

Offer Block of Gen. B

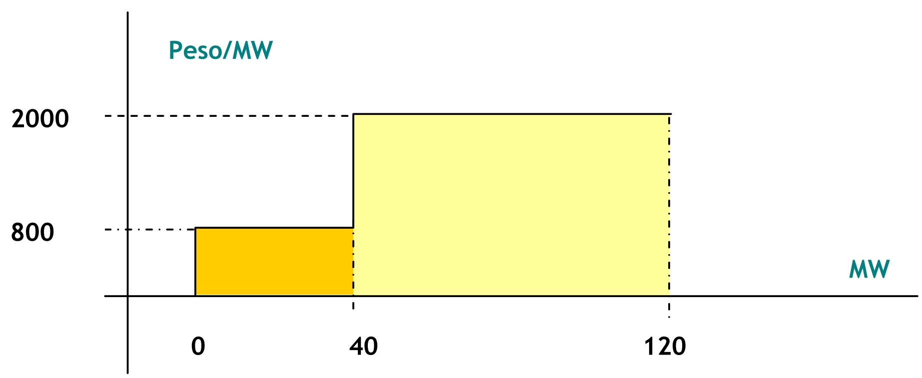


Figure 7

Contestable energy offer block (for tie-breaking)
Dispatched quantity before tie-breaking

Given:

Total Load = 140 MW

Solution:

Both generators have the same price and generation offer quantity available. Since both generators have a Pmin of 40 MW, this will be automatically dispatched (shown as orange blocks in Figures 6 and 7). This leaves a remainder of 60 MW of energy of the total 140MW demand.

The graphs show that there is still 80MW of energy available from the generation offer blocks of each of the two generators. The tie-breaking formula is then applied to calculate the amount of dispatch for each generator to satisfy the remaining energy requirement of 60MW:

Dispatch of Gen = energy offer block size x (generation needed / total available energy)

Energy offer block size	=	80MW for both Gen A and Gen B.
Generation needed	=	140MW – (2 x 40MW) = 60MW
Total available energy	=	∑(energy offer block size)
	=	80MW + 80MW = 160MW

Thus,

Dispatch of Gen A	=	80MW * (60MW / 160MW) = 30MW
Dispatch of Gen B	=	80MW * (60MW / 160MW) = 30MW

So that,

Gen A + Gen B = 30MW + 30MW
= 60MW.

The final dispatch of the generators will then be:

Generator Dispatch = Dispatched Quantity before tie-breaking
+ Pro-rated dispatch of offer block after tie-breaking

Hence,

Generator A	=	40MW + 30MW
	=	**70MW**
Generator B	=	40MW + 30MW
	=	**70MW**

The resulting dispatch schedule are shown in figures 8 and 9 below:

Offer Block of Gen A.

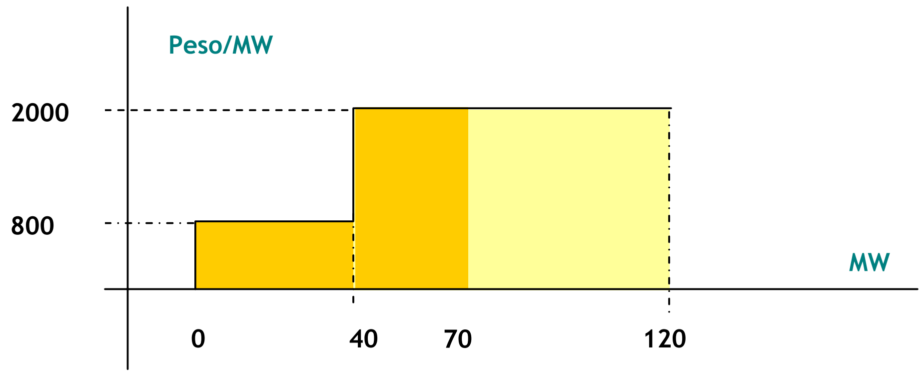


Figure 8

Offer Block of Gen. B

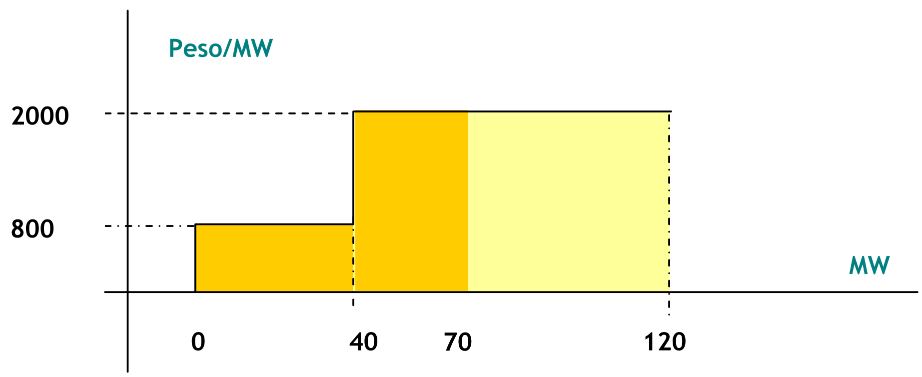
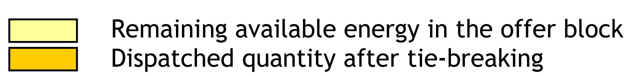


Figure 9



Glossary of Terms

Terms	Definition
A	
Act	Refers to republic Act no. 9136 also known as the "Electric Power Industry Reform Act of 2001".
Administered Price Cap	A price cap imposed by the *Market Operator* to the *trading participants* during market suspension and intervention to be used for settlements. Said price cap shall be developed and published by the *Market Operator* for ERC approval.
Algorithm	The process/processes applied by the MDOM in computing the dispatch schedules and prices.
Ancillary Services Provider	A person or entity providing ancillary services and registered as such with the *Market Operator*.
B	
Bilateral Contract	A contract between parties, the net effect of which is that a defined quantity of electricity has been sold by one party to another, at a particular node.
C	
Central Dispatch	The process of scheduling by the *Market Operator* and issuing direct instructions to electric power industry participants by the *System Operator* to achieve the economic operation of the transmission system while maintaining its quality, stability, reliability and security.
Constraint	A limitation on the capability of any combination of network elements, loads generating units or ancillary service providers such that it is, or deemed by the *System Operator* to be, unacceptable to adopt the pattern of transfer, consumption, generation or production of electrical power or other services that would be most desirable if the limitation were removed.
Constraint violation	A constraint is violated when the loadings of network elements, loads generating units or ancillary services providers involved in that constraint combine in such a way as to exceed the limit specified by that constraint.
Constraint Violation Coefficient Price	The price associated with the *Constraint Violation Coefficients*.

Terms	Definition
Constraint Violation Coefficients	Coefficients set by the *Market Operator* in accordance with *WESM Rules* clause 3.6.2. The *Market Operator* is to ensure that, if constraints shall be violated, such violation will occur in appropriate priority order.
Contingency List	Contains the definition of credible contingencies for power system security analysis. It includes a list of pre-defined outage scenarios that are most likely to occur in the system in faulty conditions.
Customer Load Forecast	The hourly demand forecast provided by customers at their respective market trading node as defined in the *Market Network Model,* which forecast is to be used in the determination of market projections and real time dispatch in accordance with WESM timetable.
Customer Pricing Zone	A *zone* within which all *customers* will face the same price for electricity consumed, as published by the *Market Operator* in accordance with *WESM Rules* clause 3.2.3.1.
D	
Day Ahead Dispatch Process	A pre-dispatch process covering the results obtained in the day-ahead projections.
Demand Bid	A standing bid or market bid to buy electricity submitted, or such bid revised by a customer in accordance with clauses 3.5.6, 3.5.9, 3.5.12, or 3.5.13, and containing the information specified in Appendix A1 of the *WESM Rules*.
Dispatch	The act by which the *System Operator* initiates all or part of the response offered or bid by a scheduled generating unit or scheduled load in accordance with clause 3.8.2 of WESM rules.
Dispatch Schedule	The target loading levels in MW for each scheduled generating unit or scheduled load and for each reserve facility for the end of that trading interval, determined by the *Market Operator* through the use of market dispatch optimization model in accordance with *WESM Rules* clause 3.8.1.
Dispatchable load	A load which is able to respond to dispatch instructions and so may be treated as a scheduled load in the dispatch process.
DOE	The Department of Energy which is government agency created pursuant to Republic Act No. 7638 and whose expanded functions are provided in the Act.

Terms	Definition
E	
Economic gain	The benefit that will be received by consumers in the economic dispatch optimization.
Economic Rental	Means, for a *constraint* in the *market dispatch optimization model* where the constraint is in linear programming canonical form (that is, for a maximizing optimization model, the sum of the variable terms is less than or equal to the constant term), the *shadow price* of the *constraint* multiplied by the constant term of said *constraint*.
Emergency	An event or situation described in clauses 6.3.1.1 and 6.3.1.2 of the *WESM Rules*
End-user	Any person or entity requiring the supply and delivery of electricity for its own use.
Energy	Generally, active energy and/or reactive energy. For purposes of this document, means active energy only.
Energy Balance Equation	An equation determined by the *Market Operator* in accordance with *WESM Rules* clause 3.6.1.4 (c), representing the balance between generation, load and transmission flows at a particular node of the *market network model*.
Energy Management System (EMS)	A system of computer-aided tools used by the *System Operator* to monitor, control, and optimize the performance of the generation and transmission systems.
Energy Regulatory Commission	The independent, quasi-judicial regulatory body created under the *Act*, otherwise ERC or Commission.
Ex-Ante	A matter determined in relation to a *trading interval* before that *trading interval* commences.
Ex-Ante Dispatch Process	Process where *dispatch* targets is set for the end of a *trading interval,* immediately preceding the beginning of that *trading interval*.
Ex-Ante Energy Settlement Price	The *ex-ante nodal energy price* or the *ex-ante zonal reserve price,* as may be appropriate, determined in accordance with clause 3.10.2 or clause 3.10.3, both of the *WESM Rules*.
Ex-Ante Energy Settlement Quantity	The gross amount determined by the *Market Operator* in accordance with *WESM Rules* clause 3.13.5, and adjusted for *bilateral contracts* in accordance with clause 3.13.7.

Terms	Definition
Ex-Ante Energy Trading Amount	Determined as the *ex-ante energy settlement price* for a node in a *trading interval* multiplied by the *ex-ante energy settlement quantity* (in MWh) for that node in that *trading interval*.
Ex-Ante Nodal Energy Price	The price determined by the *Market Operator* for a particular *market network node* and *trading interval,* immediately prior to commencement of that *trading interval,* directly from the *dispatch optimization* for that *trading interval* in accordance with *WESM Rules* clause 3.10.2.
Ex-Post	A matter determined in relation to a *trading interval* after that *trading interval* concludes.
Ex-Post Dispatch Process	Process where *dispatch* is set for the end of a *trading interval,* immediately after the *trading interval* concludes.
Ex-Post Energy Settlement Price	The *ex-post nodal energy price* or the *ex-post zonal energy price,* as appropriate, determined in accordance with *WESM Rules* clause 3.10.9
Ex-Post Energy Settlement Quantity	The amount determined by the *Market Operator* accordance with *WESM Rules* clause 3.13.6.
Ex-Post Energy Trading Amount	The *ex-post energy settlement price* for a node in a *trading interval* multiplied by the *ex-post energy settlement quantity* for that node in that *trading interval* (in MWh); minus the *ex-post energy settlement price* for that node in that *trading interval* multiplied by the *ex-ante energy settlement quantity* for that node in that *trading interval* (in MWh).
Ex-Post Nodal Energy Price	The price determined by the *Market Operator* for a particular *market node* and *trading interval,* after the end of that *trading interval* in accordance with *WESM Rules* clause 3.10.6.
F	
Facility	A generic term associated with apparatus equipment, buildings and necessary supporting resources for the generation, transmission, supply, sale and consumption of electricity.
Financial Transmission Right	The right to financial compensation based on differences between *nodal energy prices* at different *market trading nodes*.
Formulation	A mathematical representation of an optimization model.
G	

Terms	**Definition**
Generating facility	A facility, consisting of one or more *generating units*, where electric energy is produced from some other form of energy by means of a suitable apparatus.
Generating unit	A single machine generating electricity and all the related equipment essential to its functioning as single entity and having a nameplate rating of one (1) MW or more.
Generation	The production of electrical power by converting one form of energy to another in a *generating unit*.
Generation offer	A standing offer, or *market offer* to supply electricity, submitted or revised by a generation company in accordance with *WESM Rules* clauses 3.5.5, 3.5.9, 3.5.10 or 3.5.11.
Generator node	A *market trading node* at which electricity will normally be sold to the *spot market* and which is classified as a *generator node* in accordance with *WESM Rules* clause 3.2.2.2.
Grid	The high voltage backbone system of interconnected transmission lines, substations and related facilities, located in each of Luzon, Visayas and Mindanao, or as may otherwise be determined by the ERC in accordance with Section 45 of the Act.
Gross Pool	The dispatch model where all energy is traded through the WESM.
<u>I</u>	
Intervention	A measure taken by the *System Operator* when the grid is in extreme state condition as established in the Philippine Grid Code arising from a threat to system security, force majeure or emergency. During such event, the *administered price cap* shall be used for settlements In the WESM
<u>L</u>	
Linear Programming	A mathematical procedure for minimizing or maximizing a linear function of several variables, subject to a finite number of linear restrictions on these variables.
Line rental	The economic rental arising from the use of a *transmission line*, calculated as the difference in value between flows out of the receiving node of the line and flows into the sending node, in accordance with *WESM Rules* clause 3.13.12.

Terms	Definition
Load	The amount of energy consumed in a defined period via node.
Load Forecast	Has the same meaning as net load forecast
Load Pattern	Represents the relative magnitudes of MW and MVar values on individual loads. The load pattern data is used to distribute system/zonal load to individual loads, i.e. nodal load.
Locational Marginal Price (LMP)	This is the marginal value of the objective function at each bus at the solution of the optimization problem.
M	
Marginal Plant	The generating unit or plant whose price offer corresponds to the system marginal price for a given *trading interval*.
Market Dispatch Optimization Model (MDOM)	The optimization model which contains the mathematical algorithm approved by the *PEM Board* to be used for the purposes of determining dispatch schedules and energy prices, and preparing market projections based on the *price determination methodology* approved by the ERC.
Market Network Model	A mathematical representation of the power system, which will be used for the purpose of determining dispatch schedules and energy prices, and preparing market projections.
Market Offer	A generation offer for a particular *trading interval* of a particular trading day in the current market horizon, whether formed from a standing offer in accordance with *WESM Rules* clause 3.5.10 or revised by the relevant *trading participant* in accordance with *WESM Rules* clause 3.5.11.
Market Operator	The entity responsible for the operation of the *spot market* governed by the *PEM Board* in accordance with *WESM Rules* clause 1.4 which, for the avoidance of doubt, is the Autonomous Group Market Operator (the "AGMO") for a period of twelve months from the *spot market* commencement date and thereafter the entity to which the functions, assets and liabilities of the AGMO are transferred in accordance with Section 30 of the *Act*.

Terms	**Definition**
Market Price	A generic term covering prices for *energy* and *reserve, ex-ante or ex-post, nodal or zonal,* as appropriate.
Market Suspension	An event wherein the ERC declares the operation of the spot market to be suspended in cases of natural calamities or national and international security emergencies. During such event, the *administered price cap* shall be used for settlements in the WESM.
Market Trading Nodes	Those nodes at which electricity will be either bought or sold from the spot market, defined in accordance with clause 3.2.2 of the *WESM Rules*.
Market Transaction	A sale or purchase of electricity, or other services, made through the *spot market*.
Meter	A device which measures and records the consumption or production of electricity.
Metering Point	The point of physical connection of the device measuring the current in the power conductor.
MW block	Represents the quantity portion of the market offers/bids of the *trading participants*.
N	
Net Load Forecast	A forecast, prepared in accordance with the procedures developed under *WESM Rules* clause 3.5.4, of the *load,* net of any non-scheduled generation, to be matched, along with any *scheduled load,* by generation from scheduled *generation facilities*.
Net Settlement Surplus	The *settlement surplus* remaining after all *market transactions* have been accounted for. This remainder is assumed to be attributable to *economic rentals* arising from other binding constraints. Also termed settlement surplus
Network Data	These are electrical parameters used to represent the transmission system or network.
Network Service Provider	A person or entity that engages in the activity of owning, controlling, or operating a *transmission or distribution system* and who is registered with the *Market Operator in* that capacity under *WESM Rules* clause 2.3.4.
Nodal Energy Price	The energy price at a *node* determined *ex ante* or *ex-post*. This is also the Locational Marginal Price (the "LMP") in the WESM.
Node	A *connection point* on a *network,* or junction point within a *network* model, whether physical or notional.

Terms	**Definition**
Non Dispatchable Load Energy	The MW energy requirement of non-dispatchable load.
<u>O</u>	
Objective Function	Function to be minimized or maximized, representing, e.g., cost or profit.
Opportunity Cost	The economic loss suffered by some party as a result of losing an opportunity, such as the opportunity to sell energy in the *spot market*.
Outage Schedules	Schedule for shutting down or de-rating of generation and transmission facilities
Over generation	*Constraint Violation Coefficient* for the system condition whereby the generation in the system exceeds the total demand. This also corresponds to system energy balance constraint. This condition is also known as excess generation.
<u>P</u>	
PEM Board	The group of directors serving from time to time on the board that is responsible for governing the *WESM*.
Plant	Any equipment involved in generating, utilizing or transmitting electrical energy.
Power System	The integrated system of transmission and distribution networks for the supply of electricity in the Philippines.
Price Curve	The price curve of a generator energy offer is defined by up to ten (10) blocks as follows: the nth block (P/MW) defines the price between the nth and (n+1st) MW points. The last non-zero MW break point and slope (P/MW) defines the price until the maximum generation. The blocks must be monotonically non-decreasing.
Price Determination Methodology	A document which provides specific details as to how dispatch schedules and locational marginal prices (nodal prices) are calculated in the Market Dispatch Optimization Model (MDOM) as provided in clause 3.6 of the *WESM Rules*.
<u>R</u>	

Terms	Definition
Receiving node	For a *transmission line,* the *node* from which there is a net flow of electricity out of that line in a particular *trading interval* to be accounted for in determining the *line rental,* in accordance with *WESM Rules* clause 3.13.12. For a *transmission right,* the *node* to which the issuer of the *transmission right* is deemed to guarantee transfer of electricity, to be advised to the *Market Operator* in accordance with *WESM Rules* clause 3.13.2.
Regional Reserve Price	The price for *reserve* in a particular *supply* zone, and *trading interval*, determined in accordance with *WESM Rules* clause 3.10.10. Also known as zonal reserve price.
Reserve Category	A particular kind or class of reserve as provided for in *WESM Rules* clause 3.3.4.2. These are regulating, contingency, dispatchable and interruptible load reserves.
Reserve Offer	A *standing offer* or *market offer* to supply reserves, submitted or revised by a customer or a generation company in accordance with *WESM Rules* clauses 3.5.7, 3.5.8, 3.5.10 or 3.5.11.
Reserve Requirements	Demands for regulation reserve, contingency reserve and other relevant types of reserves. They are determined based on system loading, maximum generator tripping and other considerations
Reserve Region or Reserve Zone	A zone of the *power system* from which a particular reserve category can be supplied to meet a particular locationally specific requirement.
Run	A particular instance of the *market dispatch optimization model* performed for a particular *trading interval,* or a set of such instances of the *model* performed for all the *trading intervals* in a market horizon.
<u>S</u>	
Security-constrained economic dispatch	Process of apportioning the total load on a system between the various generating plants to achieve the greatest economy of operation and taking account of the limitations of the power system.
Scenario	A *net load forecast* covering a market horizon.

Terms	**Definition**
Scheduled Load	A *load* which is able to respond to *dispatch* instructions, and has been bid into the *spot market* using a *demand bid* and so may be scheduled and dispatched via the scheduling and dispatch procedures.
Security limits	Limits imposed by the *System Operator* on generation and transmission equipment to maintain system security and reliability.
Self-commitment	The principle whereby participants assume full responsibility for how and when their plants are operated.
Sending node	For a *transmission line,* the *node* into which there is a net flow of electricity out of that line in a particular *trading interval* to be accounted for in determining the *line rental* in accordance with *WESM Rules* clause 3.13.12. For a *transmission right,* the *node* from which the issuer of the transmission right is deemed to guarantee transfer of electricity, to be advised to the *Market Operator* in accordance with *WESM Rules* clause 3.13.2.
Settlement	The activity of producing bills and credit notes for *WESM Members* in accordance with clause 3.13, and with the processes defined in clause 3.14, both of the *WESM Rules*.
Settlement Amount	The amount payable by or to a *trading participant* in respect of a billing period as determined by the *Market Operator* under *WESM Rules* clause 3.13.14.
Settlement Price	An *ex-ante* or *ex-post energy settlement price*.
Settlement Quantity	An *ex-ante* or *ex-post energy settlement quantity,* or a *zonal reserve settlement quantity*.
Settlement Surplus	The *settlement surplus* remaining after all *market transactions* have been accounted for. This remainder is assumed to be attributable to *economic rentals* arising from other binding constraints.
Spot Market	The wholesale electricity spot market (*WESM*).

Terms	Definition
Standing Bid / Offer	A standing offer to sell energy or reserve, or a bid to buy energy, submitted by the relevant *trading participant* in accordance with *WESM Rules* clauses 3.5.5, 3.5.6, 3.5.7 or 3.5.8, and revised from time to time in accordance with *WESM Rules* clause 3.5.9, and effective until overridden by submission of a specific *market offer* in accordance with *WESM Rules* clause 3.5.11
State Estimator	A system forming part of the *Energy Management System* of the *System Operator* which determines the status of the power system through system snapshots.
Supplier	Any person or entity licensed by the ERC to sell, broker, market or aggregate electricity to end-users, and registered with the *Market Operator* as a customer under *WESM Rules* clause 2.3.2.
Supply	The sale of electricity by a party other than a generation company or a distribution utility in the franchise area of a distribution utility using the wires of such distribution utility.
System marginal price	The price set by the marginal plant scheduled in any trading period or interval.
System Operator	The party identified as the *System Operator* pursuant to the Philippine Grid Code which is the party responsible for generation dispatch, the provision of ancillary services, and operation and control to ensure safety, power quality, stability, reliability and security of the *grid*.
System Snapshot	The power system status at a certain time and is generated by the state estimator in the Energy Management System of the *System Operator*.
T	
Tie Breaking Rules	Prorating rules which are based on the size of the *MW Block* of the price curves containing the non-unique schedules.
Timetable	The timetable prepared by the *Market Operator* for operation of the *spot market* in accordance with *WESM Rules* clause 3.4.2.
Trading Amount	The amount to be paid by, or paid to a *trading participant,* or *Network Service Provider* in respect of *energy, reserve, line rentals,* or *transmission rights* calculated in accordance with *WESM Rules* clauses 3.13.7, 3.13.8, 3.13.9, 3.13.10, or 3.13.14 respectively.

Terms	**Definition**
Trading interval	A 1-hour period commencing on the hour.
Trading Participant	A *customer* or *generation company*.
Transmission Constraint Group	*Constraint Violation Coefficient* for the import-export c*onstraint* between two regions or areas of the power system.
Transmission limits	Generally, thermal limits of individual transmission facilities.
Transmission Line	A power line that is part of a *transmission network*
Transmission Loss Factor	Scaling factors applied on the *nodal prices* to account for the network loss associated with the delivery or consumption of energy at different locations in the system.
Transmission Network	A *network* operating at nominal *voltages* of 220 kV and above plus: (a) any part of a *network* operating at nominal *voltages* between 66kV and 220 kV that operates in parallel with and provides support to the higher *voltage transmission network;* (b) any part of a *network* operating at nominal *voltages* between 66 kV and 220 kV that does not operate in parallel with and provide support to the higher *voltage transmission network* but is deemed by the government *to* be part of the *transmission network*.
Transmission System	The *transmission network* together with the connection assets associated with the *transmission network,* which is *connected to* another *transmission* or *distribution system*.
<u>U</u>	
Under generation	*Constraint Violation Coefficient* for the system condition where the demand exceeds the total maximum generation in the system. This also corresponds to system energy balance constraint. This is also known as deficit generation.
<u>V</u>	
Voltage	The electronic force or electric potential between two points that give rise to the flow of electricity.
<u>W</u>	
Week Ahead Dispatch Process	A pre-dispatch process covering the results obtained in the week ahead projections.
WESM Rules	The detailed rules that govern the administration and operation of the *WESM*.