THE PRICE DETERMINATION METHODOLOGY FOR THE PHILIPPINE WHOLESALE ELECTRICITY SPOT MARKET (WESM)

FOREWORD

Republic Act No. 9136, otherwise known as the "Electric Power Industry Reform Act of 2001" ("EPIRA"), which became effective on the 26th of June 2001, provides for the establishment of a wholesale electricity spot market ("WESM") to provide the mechanism for determining the price of electricity not covered by bilateral contracts between sellers and purchasers of electricity.

In accordance and in compliance with the EPIRA, the Department of Energy ("DOE") promulgated the WESM Rules on 28 June 2002 with the joint endorsement of the electric power industry participants. This price determination methodology ("PDM") as referred to in the WESM Rules is issued to give more specific details to the general principles contained in the WESM Rules and shall be subject to the approval of the Energy Regulatory Commission.

1.0 Objectives of the Price Determination Methodology

The PDM is intended to:

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

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

1.1 General Guiding Principles

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

2.0 The WESM Price Determination Methodology

2.1 WESM Characteristics

The following pricing principles shall be adopted:

a. The WESM shall adopt "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.

b. The WESM shall adopt the principle of self commitment whereby participants assume full responsibility for how and when their plants are operated.

c. The WESM shall adopt a full nodal pricing regime for both generation and customers as provided under the WESM Rules. 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.

d. The WESM shall adopt the scheme of ex-ante and ex-post pricing to account for discrepancies between planned (ex-ante) and actual outcomes (ex-post).

2.2 The Market Model

2.2.1 The Market Network Model

The Market Operator shall maintain and publish a Market Network Model, which will be used for the purpose of central scheduling and dispatch, pricing and settlement.

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

The Market Network Model shall be developed by the Market Operator in consultation with electric power industry participants prior to commencement of the spot market and shall be subject to approval by the Philippine Electricity Market Board ("PEM Board").

The Market Network Model shall be adjusted when necessary to accurately reflect power system conditions, within the relevant market time frames. Please refer to Attachment "3" (WESM-MNM-000) for the detailed procedures and criteria for the Market Network Model.

2.2.1.1 Market Trading Nodes

Market Trading Nodes[1], as defined in the WESM Rules, will be identified as follows:

- Generator Nodes; and
- Customer Nodes.

[1] The reader is requested to refer to Appendix A of the WESM Rules concerning the details of the information requirements that must be submitted to the Market Operator.

2.2.1.2 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, Visayas, and Mindanao. Where appropriate, this definition of a reserve pricing zone may be modified or amended subject to further validation.

2.2.2 Dispatch and Pricing Algorithm

2.2.2.1 Description of the Market Dispatch Optimization Model (MDOM)

The MDOM determines the optimal Dispatch Schedule for each of the Trading Interval based on Market Offers/Bids received by the Market Operator subject to the different constraints imposed in line with the physical limitations of the assets of the Network Service Providers and generation assets.

The MDOM likewise determines the Nodal Energy Prices at all trading nodes in the Market Network Model and reserve prices for all Reserve Regions resulting from the optimal dispatch. The resulting Nodal Energy Price at each trading node will be an optimal price such that it is the minimum cost of serving an incremental load at that trading node.

2.2.2.2 The Basic Algorithm of the MDOM

The MDOM aims to maximize the economic gain derived from electricity trades in the market, considering the constraint conditions found or imposed by the system. Economic gain in the market is maximized when the combined producer and consumer surplus is maximized, and the market clearing price approach achieves this result.

The basic algorithm of the MDOM is given in the mathematical formulation below, viz:

OBJECTIVE FUNCTION

Maximize the economic gain from trade, where:

ECONOMIC GAIN =

$$\sum_{i}^{n}(DB)_i(CDB)_i - \sum_{i}^{n}(G)_i(CG)_i - \sum_{i}^{n}(R)_i(CR)_i - (VP)_m$$

where:

DB_i	-	Demand bid quantity (MW) of customer i
CDB_i	-	Price of demand bid of customer i
G_i	-	Energy quantity offer of generator i
CG_i	-	Price of energy offer of generator i
R_i	-	Reserve quantity offer of ancillary services provider i
CR_i	-	Cost of reserve offer of ancillary services provider i
VP_m	-	Penalty for not satisfying constraint at element m of the market network mode where m refers to the particular network element. Network violations refer to thermal and voltage limits

CONSTRAINTS

$G_{i,min} \leq G_i \leq G_{i,max}$	generator offer limits where $G_{i,min}$ is the minimum value and $G_{i,max}$ is the maximum value of the offered block block of quantity of generator i
$G_i + R_i \leq G_{i,max}$	the summation of generator offer plus reserve offer of generator i must be less than or equal the maximum offered quantity $G_{i,max}$
$F_{i,j} \leq Fmax_{i,j}$	the power flows from location i to location j should be less than or equal the network element capacities.
$\sum G_i = \sum D_i$ + Losses	the summation of generation must match the summation of demand (D) plus the consumed losses (L) in delivering the power from generators to loads

And other constraints defined in Section 3.6.1.4 of the WESM Rules.

Note: indices i,j,m,n are counters pertaining to generators, ancillary providers, node locations and transmission elements.

2.2.2.3 The Required Inputs to the MDOM

As a general requirement under the WESM Rules, the following data are needed as inputs to the optimization process:

- Generation Offers;
- Reserve Offers;
- Demand Bids;
- Net Load Forecast;
- Network data;
- Security Limits

- System Snapshot
- Reserve Requirements
- Penalty prices for failing to satisfy any constraints;
- Generator and scheduled load characteristics (e.g. ramp rates, limits, operating reserve response characteristics);
- Market Network Model adjusted to reflect changes in configuration and capacities;
- Absolute minimum requirements for each class of reserve in the region; and
- Contingencies and corresponding constraint violation penalties.

Generators shall submit offers with the following components:

- At most, ten (10) energy offer blocks per unit starting from zero generation;
- Monotonically increasing prices per block, starting from zero generation;
- Ramp rates of generating units;
- Validity period of offers; and
- Operating range (upper & lower limits).

The relevant information that should be supplied by generators and customers with reserve offers shall include the following:

- Maximum response level for the relevant reserve category, expressed in megawatts ("MW");
- For generators, a minimum and maximum energy dispatch level, expressed in MW, at which any automatic governor control (AGC) reserve response will be available;
- For customers, a maximum proportion of the forecast/scheduled load which may be interrupted;
- At most, three (3) reserve offer blocks per aggregate unit;
- Monotonically increasing prices; and
- Validity period of the reserve offers.

The solution of the optimization process shall satisfy the pre-defined constraints. Constraint violation penalties shall be imposed for allowing violations to such constraints in the system. The constraints to be satisfied are:

- Constraints representing limits on generation offer, demand bid and reserve quantities;
- Constraints representing the technical characteristics of reserve facility categories;
- Energy balance equations for each node;
- Constraints representing limitations on the plants ramp rates;
- Constraints defining power system reserve requirements;

- Network constraints;
- Loss and impedance characteristics of market network lines;
- Constraints on HVDC link operation;
- Power flow equations;
- Any overriding constraints; and
- Any additional constraints due to ancillary services or system security requirements.

2.2.2.4 The output of the MDOM

The optimization process will produce the following outputs:

- The cost of the solution;
- Generation output levels (MW) for each generator offer band;
- Reserve for each reserve offer band;
- Scheduled load for each demand bid band;
- Transmission line flows;
- Transmission line and system losses;
- Nodal energy prices at each node; and
- Regional reserve prices.

2.2.2.5 The Determination of the Dispatch Schedule

All generators shall submit offers to the market for all of the energy they intend to produce (irrespective of their commercial contracts with consumers and retailers). The Market Operator will then schedule all the available generation to meet the demand, taking account of the capabilities of the transmission network to transport the energy from producers to consumer. This type of model is known as a gross pool where all energy is traded through the WESM. The gross pool model has been chosen for the Philippines as it provides an equitable (fair equally to all) playing field for competition and allows new entrants to enter the market irrespective of whether they have in advance secured full contract cover from customers for the sale of their energy.

Under the central scheduling process contained in the WESM Rules, the Trading Participants shall submit their respective Market Offers/Bids into the market through the market interface that will be provided by the Market Operator. A generation facility must submit a price and quantity offer to the Market Operator, while the customers (i.e. large industrial consumers and distribution utilities) may submit price and quantity bids.

Using the MDOM, the offers submitted by the generators to the Market Operator are ranked from the lowest to the highest price offer, while bids submitted by the customer 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 Market Operator considers the submitted bids and offers and considers the corresponding limitations and constraints involved in preparing the final dispatch schedule.

In line with the scheduling of generating facilities, the inputs submitted by the market participants in relation to the MDOM are considered in the preparation of the Dispatch Schedule (i.e. the security constrained economic dispatch) that will be submitted by the Market Operator to the System Operator for Central Dispatch.

The security constrained economic dispatch is the Dispatch Schedule followed by generating facilities that considers all constraint parameters present in the system for the relevant time interval that the said facilities will be coming on stream.

2.2.2.6 The Determination of Nodal Prices

The price at a particular node in the system (i.e. the nodal price), signals the *"scarcity value"* of electricity given the supply and demand interaction at that node, and in addition, the relevant opportunity cost of supplying an *"incremental"* (i.e. additional) amount of electricity at that location. Consideration is placed on the incremental amount of electricity supplied at a node because this will alter or affect the flow of energy and losses to other nodes in the system.

In the nodal pricing regime, prices differ across nodes in the network due to the presence of both physical losses and network constraints (congestion). Under an unconstrained system, the market-clearing price ("MCP") is set by one "marginal plant" (i.e. the system marginal price). However, the situation is different if the system is constrained because this will affect the relevant flows of electricity and may result in a situation where there will be more than one marginal plant in the system. This occurrence is brought about by line limitations that may impede the supply of cheaper generators from one area into another. The end effect is for different plants to be setting the MCPs in different nodes in the system due to line constraints.

In the MDOM, said marginal prices at specific locations (i.e. nodal prices) will be computed on the basis of the resulting marginal plants' contribution, in terms of cost, to an incremental load of one megawatt-hour occurring in a particular location or node. If there will be more than one marginal plant that can serve the incremental one megawatt-hour at a particular node as in the case of a constrained system, then the price at that node will be the relative contribution of these marginal plants to the incremental one-megawatt hour load multiplied by the respective marginal plants' price offers. The resulting value is the locational marginal price ("LMP") or nodal price computed by the MDOM.

2.2.2.7 The Price Adjustment to Reflect Transmission Losses

With due consideration to the change in power flows and losses in the system, the respective nodal prices should be adjusted to reflect this condition and signal into the market the relevant cost to produce and purchase electricity at the subject nodes. The various LMPs are adjusted by multiplying with the Loss Factors associated with each location in the system resulting to a loss adjusted LMPs.

$$LMP_i = \Sigma[(\partial G_i/\partial D_i) \text{ x } LF_i \text{ x } P_i\,]$$

Where:

$\partial G_i/\partial D_i$ refers to the relative share of the marginal generator to the incremental load in the system;

P_i refers to the offer price of the i^{th} generator; and

LF_i refers to the loss factor of each location in the system.

2.2.2.8 Loss Factors and Reference Bus

Loss factors are multipliers applied to LMPs generated by MDOM to reflect the incremental loss associated with the delivery and/or consumption of energy in different locations in the system. Loss factors are dynamically computed within the MDOM to fully account the dynamic change in the losses due to a change in load at the various nodes and the contribution of the reference bus (marginal plant or plants in a constrained system) computed by the optimization algorithm. The loss adjustment factors are simultaneously referenced from the reference bus, as in the case of a constrained system, as follows:

$$LF_i \quad = 1 + \partial loss/\partial load \text{ increment}$$

Where:

LF_i refers to the loss factor multiplier applied to each location in the system resulting to loss adjusted LMPs.

$\partial loss$ refers to the change in losses; and

∂load increment refers to the change in load at the various nodes.

2.2.3 Other Market Concerns

2.2.3.1 The Treatment of Bilateral Contracts

The WESM Rules require 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).

2.2.3.2 Line Rental Amounts for Bilateral Contracts

Line Rentals shall be paid by all market participants, calculated in accordance with Section 3.13.12 of the WESM Rules. The Line Rental refers to the economic rental arising from the use of a transmission line. It exists when there is congestion in the transmission system and is already embedded in the resulting nodal prices during the optimization process. The line rental amount can be computed by getting the difference in trading amount (Price x Quantity) between an injection node and an off-take node.

From the settlement formulations in the WESM Rules, Bilateral Contracts are being netted out of the ex-ante and ex-post settlement amounts. In this regard, a specific Line Rental amount shall be charged to bilateral contract quantities to fully account for the line usage of these bilateral energy flows in the market, and allow the settlement accounts to balance. In so doing, the market prevents any "free riding" on the system by the bilateral contract holders since they will have to pay for the same, as required by the market to all market participants.

2.2.3.3 The Treatment of New and Renewable Energy with Intermittent Energy Resource

New and Renewable Energy with Intermittent Energy Resource (NRE-IER) providers shall be required to submit their respective forecast generation ahead of schedule as practicable and consistent with the WESM Timetable (i.e. week ahead, day ahead and hour ahead). These forecasted levels of NRE-IER providers shall then be netted out of the supply requirements needed to meet the load requirements for the relevant time intervals.

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.

2.2.3.4 Administered Price Cap

During Market Suspension and Intervention, the Market Operator shall impose an Administered Price Cap to be used as basis for settlements pursuant to Section 6.8 of the WESM Rules. The Market Operator shall develop and publish an Administered Price Cap duly approved by the ERC. Detailed procedures and provisions on Administered Price Cap shall be subject to a separate filing to the ERC.

2.2.3.5 Treatment of Must Run Generation

The WESM Rules have no provision for must run plants. In some cases however, a plant must run (i.e. not in accordance with the merit order) because it is needed for system reliability and/or to support system security. The System Operator has the responsibility to define system security requirements and nominate which plants are classified as must-run.

Having recognized the importance of must-run plants in the system operation, they must however not be allowed as price setter to lessen its market power. Rather the must-run plants shall be considered as price takers. Detailed procedures for the treatment of must-run plants, as may be necessary, shall be developed in consultation with the industry participants and shall be subject to separate submission to the ERC.

2.2.3.6 The Treatment and Handling of Equivalent Offers

Trading participants with equivalent offers shall be considered in the MDOM on a pro-rata basis. This aims to provide a level playing field for the market participants and maintain operational limitations during dispatch intervals. A pro-rata dispatch with consideration of equipment limitations will be observed to break the tie. This option provides a more realistic approach in comparison to time-stamp tie breaking option since some generators may opt to utilize their standing offers which are not time-stamped.

Schedules will be pro-rated for cases where two or more schedules are optimal. 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.

3.0 Billing and Settlements

The Market Operator shall determine the settlement amount for each Trading Participant based on the settlement formula described in Section 3.13.14 of the WESM Rules.

The Settlement process involves the determination of Ex-Ante and Ex-post Energy Trading Amount, adjusted for bilateral contract quantities in accordance with Section 3.13.7 of the WESM Rules. The method of calculations are described below.

3.1 Determination of Ex-Ante Energy Trading Amount

In accordance with Sec. 3.13.8 of the WESM Rules, the Ex-Ante energy trading amount for each trading node and Trading Interval shall be 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. The Ex-Ante nodal energy prices and quantities are the output of the MDOM, representing the expected prices and quantities at the Market Trading Nodes scheduled by the Market Operator prior to actual dispatch by the System Operator. Their values are dependent on Generation Offers, Reserve Offers, and Demand Bids submitted electronically by the Trading Participants in accordance with the Timetable, and the Net Load Forecast prepared by the Market Operator in accordance with Sec. 3.5.4 of the WESM Rules.

The ex-ante energy trading amount consists of two trading amounts, one representing the Ex-Ante Energy Trading Amount for sellers of energy (i.e. generators) and the second being the Ex-Ante Energy Trading Amount for buyers (i.e. utilities and large industrial customers). The respective working formulations are given as follows:

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

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 necessarily the market clearing price for the trading node where the generator is connected;

$EAQSW_{k,h}^{m}$ is the ex-ante quantity of energy that is supplied by the generator “k” for Trading Interval “h” and metering point “m”; and

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

Where:

$EAETA_{k,h}^{m}$ is the Ex-ante energy trading amount for buyer/customer “k” 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 necessarily the *market clearing price* for the trading node where the buyer/customer is connected;

$EAQSW_{k,h}^{m}$ is the ex-ante quantity of energy that is withdrawn from the system by the buyer/customer “k” for Trading Interval “h” and metering point “m”; and

$BCQ_{s,k,h}^{m}$ is the bilateral contract quantity associated with buyer/customer “k, and the corresponding generator “s” for Trading Interval “h” and metering point “m”.

3.2 Determination of Ex-Post Energy Trading Amount

The ex-post energy trading amount is defined in Sec. 3.13.9 of the WESM rules as the ex-post energy settlement price for that node in that 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). In other words, the ex-post energy trading amount is the product of the ex-post energy settlement price multiplied by the difference between the ex-post and the ex-ante energy settlement quantities.

The Ex-Post nodal energy prices and quantities are the output of the MDOM, representing the actual energy prices and quantities at the Market Trading Nodes. Their values are dependent on Generation Offers, Reserve offers, Demand Bids, Bilateral Contracts and actual node loads as registered in the revenue meters.

For dispatch purpose, a re-dispatch using the Market Dispatch Optimization Model could be done every 15 minutes, which could be reduced further to accurately reflect power system conditions within the one-hour Trading Interval. The ex post energy settlement price shall then be computed based on the weighted average of the quantities metered periodically within the Trading Interval.

The ex-post prices and trading amounts are likewise subdivided into two portions, one representing generators and suppliers, and the other representing the buyers/customers portion of the market.

For Generators: $EPETA_{k,h}^{m} = \Sigma(EPESP_{h}^{m} x ((AQEI_{k,h}^{m} – EAQOM_{k,h}^{m}) – BCQ_{k,b,h}^{m})$

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 necessarily 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";

$EAQOM_{k,h}^{m}$ is the ex-ante energy quantity offered in the market for injection by generator "k", at Trading Interval "h" and metering point "m".

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

For Buyers: $EPETA_{k,h}^{m} = \Sigma(EPESP_{h}^{m} * ((AQEI_{k,h}^{m} – EAQOM_{k,h}^{m}) – BCQ_{k,b,h}^{m})$

Where:

$EPETA_{k,h}^{m}$ is the ex-post energy trading amount for customer/buyer "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 necessarily the market clearing price in the ex-post market;

$AQEI_{k,h}^{m}$ is the actual quantity of energy withdrawn by customer/buyer "k" at Trading Interval "h" and metering point "m";

$EAQOM_{k,h}^{m}$ is the ex-ante energy quantity bidded in the market for injection by generator "k", at Trading Interval "h" and metering point "m".

$BCQ_{k,b,h}^{m}$ is the bilateral contract quantity associated with generator “k”, and the corresponding buyer or customer “b” for Trading Interval “h” and metering point “m”.

The process involved in the determination of ex-post energy settlement quantity and price is similar to that utilized for the ex-ante settlement quantity and price. The only difference is that the net load forecast inputted during the ex-ante shall be replaced by actual load values based on net energy flows through the associated meters from the generation company to the customer side of the meter adjusted for bilateral contracts in accordance with Sec. 3.13.7 of the WESM Rules.