Appendix B**.** Market Monitoring Indices

Type	Purpose	Calculation
I. Market Performance Indices		
1. Load Characteristics a. Load profile b. Load distribution c. Load factor	• To identify typical load profiles and nodes where load is more concentrated. • To determine correlation between loads and prices as well as correlation between typical loads and market participant bidding behavior.	$$LoadDist_{r,cn,t} = \frac{\sum_{i \in t} Load_{cn,i}}{\sum_{i \in t} TotalLoad_{r,i}}$$ $$LoadDist_{r,cp,t} = \frac{\sum_{i \in t} TotalLoad_{cp,i}}{\sum_{i \in t} TotalLoad_{r,i}}$$ $$LoadFactor_{r,t} = \frac{\sum_{i \in t} TotalEnergy_{r,c,i}}{\max_{i \in t}(TotalLoad_{r,i})\ x\ NoOfIntervals_t}$$ Where: $TotalLoad_{r,i}$ is the sum of all the loads in region r at interval i
2. Load Forecast Variation	To assess the quality of the market projection processes in estimating expected load requirement.	$$LoadVar_{r,i} = \frac{ActualTotalLoad_{r,i} - ForecastTotalLoad_{r,i}}{ForecastTotalLoad_{r,i}}$$
3. Reserve Margin Index (RMI)	To measure the generation-demand balance, including the operating reserve requirement as demand.	$$RMI_{r,i} = \frac{TotalOffer_{r,i} - (TotalLoad_{r,i} + TotalLoss_{r,i} + TotalRes_{r,i})}{(TotalLoad_{r,i} + TotalLoss_{r,i} + TotalRes_{r,i})}$$

Type	Purpose	Calculation
4. Spot Market Exposure	To calculate the percentage of energy injected (for generators) and withdrawn (for customers) not covered by bilateral contracts.	$$SpotExpo_{cn,t} = \frac{\sum_{i \in t} Energy_{cn,i} - \sum_{i \in t} Bilateral_{cn,i}}{\sum_{i \in t} Energy_{cn,i}}$$ $$SpotExpo_{cp,t} = \frac{\sum_{i \in t} TotalEnergy_{cp,i} - \sum_{i \in t} TotalBilateral_{cp,i}}{\sum_{i \in t} TotalEnergy_{cp,i}}$$ $$SpotExpo_{r,c,t} = \frac{\sum_{i \in t} TotalEnergy_{r,c,i} - \sum_{i \in t} TotalBilateral_{r,c,i}}{\sum_{i \in t} TotalEnergy_{r,c,i}}$$ $$SpotExpo_{gn,t} = \frac{\sum_{i \in t} Energy_{gn,i} - \sum_{i \in t} Bilateral_{gn,i}}{\sum_{i \in t} Energy_{gn,i}}$$ $$SpotExpo_{gp,t} = \frac{\sum_{i \in t} TotalEnergy_{gp,i} - \sum_{i \in t} TotalBilateral_{gp,i}}{\sum_{i \in t} TotalEnergy_{gp,i}}$$ $$SpotExpo_{r,g,t} = \frac{\sum_{i \in t} TotalEnergy_{r,g,i} - \sum_{i \in t} TotalBilateral_{r,g,i}}{\sum_{i \in t} TotalEnergy_{r,g,i}}$$
5. Dispatch Constraints	To assess the effect of system constraints in the economic use of offered capacity. • Calculate the percentage of generation scheduled by merit compared to total capacity offered • Calculate the generation scheduled out of merit due to system constraints	$$SchedByMerit_{r,i} = \frac{\sum_{gn \in g} SchedbyMerit_{r,gn,i}}{TotalOffer_{r,i}}$$

Type	Purpose	Calculation
II. Supply (Generation) Indices		
1. Capacity factor for each generating plant	To determine the extent by which the generating plant is utilized as well as to identify trends, such as whether the capacity factor is decreasing or increasing.	$CapFactorSched_{gp,t} = \frac{\sum_{i \in t} TotalSched_{gp,i} + \sum_{i \in t} TotalRes_{gp,i}}{TotalRegCap_{gp}\ x\ NoOfIntervals_t}$ $CapFactorEnergy_{gp,t} = \frac{\sum_{i \in t} TotalEnergy_{gp,i}}{TotalRegCap_{gp}\ x\ NoOfIntervals_t}$
2. Outage of each generating plant a. Frequency of outages b. Outage factor c. Outage capacity	To measure the reliability of generation and to assess the impact of outages on the spot market.	$OutageFactor_{gp,t} = \frac{\sum_{i \in t} TotalOutageCap_{gp,i}}{TotalRegCap_{gp}\ x\ NoOfIntervals_t}$
3. Capacity gap of each generating plant	To determine if the generator is offering to the market less than its capacity.	$CapGap_{gn,i} = RegCap_{gn,i} - Offer_{gn,i}$ $CapGap_{r,g,i} = \sum_{gn \in g} RegCap_{r,gn,i} - \sum_{gn \in g} Offer_{r,gn,i}$
4. Price Setting Indices a. Price Setting Generators b. Price Setting Frequency	To identify generators that are "price setters" in an interval and the frequency by which these generators set the market prices.	$If\ AcceptedOfferPrice_{gn,i} \geq (95\%)(NodalPrice_{gn,i})$ and $AcceptedOfferPrice_{gn,i} \leq (100\%)(NodalPrice_{gn,i})$, $PriceSetter_{gn,i} = 1$ $PSFI_{gn,t} = \frac{\sum_{i \in t} PriceSetter_{gn,i}}{NoOfIntervals_t}$

Type	Purpose	Calculation
		$If\ \sum_{gn \in gp} PriceSetter_{gn,i} > 1,\ PriceSetter_{gp,i} = 1$ $PSFI_{gp,t} = \frac{\sum_{i \in t} PriceSetter_{gp,i}}{NoOfIntervals_t}$
II. Spot Price Indices		
1. Price Characteristics	To assess spot price levels, distribution, trends and volatility.	
2. Price Forecast Variation	To assess the quality of the market projection processes in estimating expected spot prices.	$PriceVar_{r,i} = \frac{ActualAvgPrice_{r,i} - ForecastAvgPrice_{r,i}}{ForecastAvgPrice_{r,i}}$
3. Spot Price Node Variation Index (SPNVI)	To assess the difference of spot prices in the different market trading nodes.	$SPD_{r,i} = \sqrt{\frac{\sum_{n \in N}\left(NodalPrice_{r,n,i} - AvgPrice_{r,i}\right)^2}{NoOfNodes_{r,i}}}$ $If\ AvgPrice_{r,i} > 0,\ SPNVI_{r,i} = \frac{SPD_{r,i}}{AvgPrice_{r,i}}$

<table>
<tr><th>Type</th><th>Purpose</th><th>Calculation</th></tr>
<tr><td>4. Supply Margin-Price Index (SMPI)</td><td>To identify the intervals with very high or very low prices based on the historical relationship of supply margin and price. Prices within or equal to the upper and lower reference price thresholds are considered as “normal prices”.</td><td>supply margin = system effective supply − (system demand + reserve schedules)

<table><tr><th rowspan="2">Supply Margin, m_s (MW)</th><th colspan="2">Reference Price Threshold (PHP/MWh)</th></tr><tr><th>Upper</th><th>Lower</th></tr><tr><td>$0 \le m_s \le 200$</td><td>27,124</td><td>(3)</td></tr><tr><td>$200 < m_s \le 300$</td><td>27,124</td><td>(4)</td></tr><tr><td>$300 < m_s \le 400$</td><td>23,714</td><td>(4)</td></tr><tr><td>$400 < m_s \le 500$</td><td>20,668</td><td>(5)</td></tr><tr><td>$500 < m_s \le 750$</td><td>17,673</td><td>(1,417)</td></tr><tr><td>$750 < m_s \le 1,000$</td><td>14,784</td><td>(4,306)</td></tr><tr><td>$1,000 < m_s \le 1,250$</td><td>13,658</td><td>(5,452)</td></tr><tr><td>$1,250 < m_s \le 1,500$</td><td>13,090</td><td>(6,026)</td></tr><tr><td>$1,500 < m_s \le 1,750$</td><td>12,754</td><td>(6,336)</td></tr><tr><td>$1,750 < m_s \le 2,000$</td><td>12,563</td><td>(6,528)</td></tr><tr><td>$2,000 < m_s \le 2,250$</td><td>12,475</td><td>(6,615)</td></tr><tr><td>$2,250 < m_s \le 2,500$</td><td>12,421</td><td>(6,669)</td></tr><tr><td>$2,500 < m_s \le 2,750$</td><td>12,282</td><td>(6,808)</td></tr><tr><td>$2,750 < m_s \le 3,000$</td><td>12,229</td><td>(6,861)</td></tr><tr><td>$m_s > 3,000$</td><td>11,587</td><td>(7,640)</td></tr></table></td></tr>
<tr><td>5. Price Spike</td><td>To identify the occurrence of a high spot price</td><td>The threshold for peak hours is PHP 27,000/MWh; the threshold for off-peak hours is PHP 14,000/MWh.</td></tr>
</table>

Type	Purpose	Calculation
6. Sustained High Price	To identify the occurrence of high spot prices for a sustained period.	The threshold is 80% of the price spike threshold for peak hours. Hence the threshold is PHP 21,600/MWh. It must be breached for 10 consecutive hours or more.
7. Price Creep Up	To determine the magnitude of the upward movement of price in terms of percent increase.	There must be a 20% price increase for 4 consecutive days or weeks. The weighted average on the last day or week of a price creep up must be over PHP 9,000/MWh (based on the secondary price cap threshold of PHP 9,000/MWh). Weighted averaging is used to compute daily and weekly prices.
III. Transmission Indices		
1. Transmission Congestion Frequency Indices a. Frequency of constraints b. Duration of constraints (percentage of time in a period)	To assess the impact of transmission congestions on the spot market.	
2. Transmission Congestion Cost Index (TCI)	To compare the impact of congestion in different periods and/or regions.	$TCI_{r,i} = \frac{CongestionCost_{r,i}}{TotalEnergy_{r,g,i}}$ $TCIP_{r,i} = \frac{TCI_{r,i}}{AvgPrice_{r,i}}$ $TCI_{r,t} = \frac{\sum_{i \in t} CongestionCost_{r,i}}{\sum_{i \in t} TotalEnergy_{r,g,i}}$

Type	Purpose	Calculation
		$TCIP_{r,t} = \frac{TCI_{r,t}}{AvgPrice_{r,t}}$ $CongestionCost_{r,i} = ConstrainedCost - UnconstrainedCost$
IV. Structural: Market Concentration Indices	Measure the concentration of a market, to assess if existing conditions facilitate or impede competition.	
1. Market Share	To measure the percentage of capacity or energy that a market participant controls in the monitored market.	$ShareRegCap_{r,gp,t} = \frac{\sum_{i \in t} TotalRegCap_{r,gp,i}}{\sum_{i \in t} TotalRegCap_{r,i}}$ $ShareAvailCap_{r,gp,t} = \frac{\sum_{i \in t} TotalAvailCap_{r,gp,i}}{\sum_{i \in t} TotalAvailCap_{r,i}}$ $ShareOfferCap_{r,gp,t} = \frac{\sum_{i \in t} TotalOffer_{r,gp,i}}{\sum_{i \in t} TotalOffer_{r,i}}$ $ShareUnschedOffer_{r,gp,t} = \frac{\sum_{i \in t} TotalUnschedOffer_{r,gp,i}}{\sum_{i \in t} TotalUnschedOffer_{r,i}}$ $ShareActualGen_{r,gp,t} = \frac{\sum_{i \in t} TotalEnergy_{gp,i}}{\sum_{i \in t} TotalEnergy_{r,i}}$

Type	Purpose	Calculation
		$ShareSpotQty_{r,gp,t} = \frac{\sum_{i \in t} TotalSpotQty_{gp,i}}{\sum_{i \in t} TotalSpotQty_{r,i}}$
2. Herfindahl-Hirschman Index (HHI)	To measure the degree of concentration. Defined as the sum of squares of the market participants' market shares.	$HHIRegCap_{r,gp,t} = \sum_{gn \in g} \left(ShareRegCap_{r,gp,t}\right)^2$ $HHIAvailCap_{r,gp,t} = \sum_{gn \in g} \left(ShareAvailCap_{r,gp,t}\right)^2$ $HHIOfferCap_{r,gp,t} = \sum_{gn \in g} \left(ShareOfferCap_{r,gp,t}\right)^2$ $HHIUnschedOffer_{r,gp,t} = \sum_{gn \in g} \left(ShareUnschedOffer_{r,gp,t}\right)^2$ $HHIActualGen_{r,gp,t} = \sum_{gn \in g} \left(ShareActualGen_{r,gp,t}\right)^2$ $HHISpotQty_{r,gp,t} = \sum_{gn \in g} \left(ShareSpotQty_{r,gp,t}\right)^2$
V. Structural: Pivotal Dynamic Indices	Measure market power (and potential benefit of exercising market power) taking into consideration the variables that change dynamically, mainly demand (energy withdrawn), required spinning (or	

Type	Purpose	Calculation
	operational) reserve and generation availability.	
1. Pivotal Supply Index (PSI)	To measure how critical a particular generator is in meeting the total demand at a particular time	$ResDem_{r,gp,i} = \left(TotalLoad_{r,i} + TotalLoss_{r,i} + TotalRes_{r,i}\right) - \left(TotalOffer_{r,i} - TotalOffer_{gp,i}\right)$ $If\ ResDem_{r,gp,i} > 0, \quad PivotalSupplier_{r,gp,i} = 1$ $PSI_{gp,t} = \frac{\sum_{i \in t} PivotalSupplier_{r,gp,i}}{NoOfIntervals_t}$
2. Residual Supply Index (RSI) a. RSI of a Generating Plant b. RSI of the whole market	• To measure the ratio of the available generation without a Generator to the total generation (including operational reserve) required to supply the demand. • To determine whether there are pivotal suppliers in an interval	$RSI_{r,gp,i} = \frac{\left(TotalOffer_{r,i} - TotalOffer_{gp,i}\right)}{\left(TotalLoad_{r,i} + TotalLoss_{r,i} + TotalRes_{r,i}\right)}$ $MarketRSI_{r,i} = \min_{gp \in g}\left(RSI_{r,gp,i}\right)$
VI. Generator Offer Indices	To determine trends, pattern or strategy in the offer behavior of generators (i.e. offer curves and segments, frequency and quantity of offer changes).	
1. Offer Outlier Detection –	To measure and detect significant changes in offer prices that fall beyond the upper and lower limit reference offers.	Using historical offer prices, the upper and lower limit reference offers are calculated: Tukey's Method $LL = Q_1 - 1.5(Q_3 - Q_1)$ $UL = Q_3 + 1.5(Q_3 - Q_1)$ Median Rule Method

Type	Purpose	Calculation
		$LL = Q_2 - 2.3(Q_3 - Q_1)$ $UL = Q_2 + 2.3(Q_3 - Q_1)$ 2 MADe Method $LL = \tilde{x} - 2(MADe)$ $UL = \tilde{x} + 2(MADe)$ 3 MADe Method $LL = \tilde{x} - 3(MADe)$ $UL = \tilde{x} + 3(MADe)$ $Within\ Limits\ = No.\ of\ P_{subject}\ , \{LL_j \le P_{subject,j} \le UL_j\}$ $Within\ Limits_{generator}\% = \frac{\sum_i^k \left(Within\ Limits_i\right)}{\sum_i^k \left(n_i - P\min_i\right)} x100\%$ $Within\ Limits_{porfolio}\% = \frac{\sum_g^{g_p} \sum_i^k \left(Within\ Limits_{i,g}\right)}{\sum_g^{g_p} \sum_i^k \left(n_{i,g} - P\min_{i,g}\right)} x100\%$ $Higher\,than\ Limits\ = No.\ of\ P_{subject}\ , \{P_{subject,j} > UL_j\}$

Type	Purpose	Calculation
		$$Higher\ than\ Limits_{generator}\% = \frac{\sum_{i}^{k}\left(Higher\ than\ Limits_{i}\right)}{\sum_{i}^{k}\left(n_i - P\min_i\right)} x100\%$$
		$$Higher\ than\ Limits_{portfolio}\% = \frac{\sum_{g}^{g_p}\sum_{i}^{k}\left(Higher\ than\ Limits_{i,g}\right)}{\sum_{g}^{g_p}\sum_{i}^{k}\left(n_{i,g} - P\min_{i,g}\right)} x100\%$$
		$$Lower\ than\ Limits\ = No.\ of\ P_{subject}, \left\{LL_j > P_{subject,j}\right\}$$
		$$Lower\ than\ Limits_{generator}\% = \frac{\sum_{i}^{k}\left(Lower\ than\ Limits_{i}\right)}{\sum_{i}^{k}\left(n_i - P\min_i\right)} x100\%$$
		$$Lower\ than\ Limits_{portfolio}\% = \frac{\sum_{g}^{g_p}\sum_{i}^{k}\left(Lower\ than\ Limits_{i,g}\right)}{\sum_{g}^{g_p}\sum_{i}^{k}\left(n_{i.g} - P\min_{i,g}\right)} x100\%$$

Type	Purpose	Calculation
2. Offer Average Price Difference	To measure the magnitude of change of offers from reference offers in terms of price and percentage	$$PD_{generator,peak/offpeak} = \frac{\sum_{i}^{k}\sum_{j=P\min+1}^{n}\left(P_{subject,j,i} - P_{reference,j,i}\right)}{\left|\sum_{i}^{k}\sum_{j=P\min+1}^{n}P_{reference,j,i}\right|} x100\%$$ $$PD_{portfolio,peak/offpeak} = \frac{\sum_{g=1}^{g_p}\sum_{i}^{k}\sum_{j=P\min+1}^{n}\left(P_{subject,j,i,g} - P_{reference,j,i,g}\right)}{\left|\sum_{g=1}^{g_p}\sum_{i}^{k}\sum_{j=P\min+1}^{n}P_{reference,j,i,g}\right|} x100\%$$
3. Offer Average Percent Difference		$$APD_{generator,peak/offpeak} = \frac{\sum_{i}^{k}\sum_{j=P\min+1}^{n}\left(P_{subject,j,i} - P_{reference,j,i}\right)}{\sum_{i}^{k}\left(n_i - P\min_i\right)}$$ $$APD_{portfolio,peak/offpeak} = \frac{\sum_{g=1}^{g_p}\sum_{i}^{k}\sum_{j=P\min+1}^{n}\left(P_{subject,j,i,g} - P_{reference,j,i,g}\right)}{\sum_{g=1}^{g_p}\sum_{i}^{k}\left(n_{i,g} - P\min_{i,g}\right)}$$ Where: Within Limits = count of price offers per megawatt of a generator that are within limits

Type	Purpose	Calculation
		Lower then Limits = count of price offers per megawatt of a generator that are lower than limits Higher then Limits = count of price offers per megawatt of a generator that are lower than limits Within Limits $_{generator}$% = percentage of total within limit offers to total offers of a generator in an interval/s Lower then Limits $_{generator}$% = percentage of total lower than limit offers to total offers of a generator in an interval/s Higher then Limits $_{generator}$% = percentage of total higher than limit offers to total offers of a generator in an interval/s Within Limits $_{portfolio}$% = percentage of total within limit offers to total offers of generator/s in a portfolio in an interval/s Lower then Limits $_{portfolio}$% = percentage of total lower than limit offers to total offers of generator/s in a portfolio in an interval/s Higher then Limits $_{portfolio}$% = percentage of total higher than limit offers to total offers of generator/s in a portfolio in an interval/s $APD_{generator}$ = the average difference between the average subject offered price and the average reference offered price of a generator. $PD_{generator}$ = Percent Difference on the offered price of a generator between the subject offer and the reference offer. $APD_{portfolio}$ = the average difference between the average subject offered price and the average reference offered price $PD_{portfolio}$ = Percent Difference on the offered price of a portfolio between the subject offer and the reference offer. $P_{subject}$ = Subject Offered price on a particular MW, the average of offers on a particular MW during days with high prices $P_{reference}$ = Reference Offered price on a particular MW, the average of offers on particular MW during days with Normal Prices n = maximum offered MW j = MW value I = starting interval k = ending interval g = generator gp = total number of generators within the portfolio

Type	Purpose	Calculation
		Pmin +1= 1st offered MW value after the Pmin *LL =* Lower Limit *UL =* Upper Limit *Q1 =* First Quartile *Q2 =* Second Quartile, median($\tilde{x}$) *Q3 =* Third Quartille *MAD =* $median\{\lvert x_i - \tilde{x}\rvert\}, i = 1,2,...,n$ *MADe=* $b(MAD)$ *b =* *1.482,* scale factor

Subscripts Notation

i - specific interval
t - specific period
iϵt - all interval ***i*** in period ***t***
r - system or regional (Luzon, Visayas, and Mindanao)
c - customers
cn - customer node
cp - customer group (i.e. Trading Participant, Major Participant Group)
cnϵc - set of customer nodes
cgϵc - set of customer groups
g - generators
gn - generator node
gp - generator group (i.e. Generating Plant, Trading Participant, Major Participant Group)
gnϵg - set of generator nodes
gpϵg - set of generator groups