Working to Perfect the Flow of Energy

PJM Manual 15:

Cost Development Guidelines

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Prepared by

Cost Development Task Force

Section 8: Opportunity Cost Guidelines

Welcome to the *Opportunity Cost Guidelines* section of the PJM Manual for ***Cost Development Guidelines***. In this section, you will find the following information:

- A description of the PJM Opportunity Cost Guidelines Policy and Definitions (see "Policy and Definitions").

Policy and Definitions

Cost Development Task Force Opportunity Cost Policy

- Opportunity Cost may be a component of cost under certain circumstances.
- Specific business rules for Opportunity Costs have been defined in the Operating Agreement of PJM Interconnection, L.L.C. for various products including energy and regulation.
- Requests for recovery of Opportunity Costs not defined in the Operating Agreement of PJM Interconnection, L.L.C. should be submitted to the PJM MMU for approval.

Opportunity Cost Component for externally imposed run-hour restrictions

The following methodology is approved for computing opportunity costs associated with an externally imposed run-hour restriction on a generation unit. Examples would include a limit on emissions for the unit imposed by a regulatory agency or legislation, a direct run hour restriction in the operating permit, or a heat input limitation defined by a regulatory decision or operating permit. Generators may follow this methodology at their option or may develop and submit alternative methods specific to their units for approval. Requests for recovery of opportunity costs either using other methods or not defined in the Operating Agreement of PJM Interconnection, L.L.C. should be initially submitted to the PJM MMU for approval per Manual 15 Section 8.

Opportunity costs are a distinct component of the cost-based offer. As is the case with any computation of the cost-based offer in Manual M-15, market participants may elect to enter their cost-based offer at a value less than the computed cost-based offer. However, they may not exceed the computed value.

Opportunity costs calculated with this method will change frequently. Given that electricity and fuel futures can change daily, the opportunity costs computed can likewise change daily. Generation owners who include opportunity costs in their cost-based offers must recalculate their opportunity cost no less frequently than once per every 7 days.

Definitions

- N=number of hours in the month (on-peak/off-peak)
- y=year
- m=month
- d=day of the month
- h=hour
- t= Number of hours remaining in the compliance period
- Peak=off-peak hours only or on-peak hours only
- FY=future year
- BUSLMP=LMP at the unit's bus
- PJMWHLMP=PJM Western Hub LMP
- PJMWHFRP= PJM Western Hub Forward Price
- Trading Day=In respect of a particular futures market a day on which that Market open for trading
- Dm=Delivery Month; Month the commodity contract is to deliver the commodity in the future.
- Base year= one of the three historical years used to create volatility in the fuel and power forecasts
- Peak=Peak hours are from 7:00 AM to 11:00 PM (the hour ending 0800 to the hour ending 2300) prevailing local time. Peak days are Mondays through Fridays, excluding North American Electric Reliability Corporation (NERC) holidays.
- Off-peak=Off-peak hours are from midnight to 7:00 AM (the hour ending 0100 to the hour ending 0700) and 11:00 PM to midnight (the hour ending 2400) Mondays through Fridays; also, all day Saturdays and Sundays (the hour ending 0100 to the hour ending 2400) and North American Electric Reliability Corporation holidays
- Frequently mitigated unit (FMU)= A unit that was offer-capped for more than a defined proportion of its real-time run hours in the most recent 12-month period. FMU thresholds are 60 percent, 70 percent and 80 percent of run hours. Such units are permitted a defined adder to their cost-based offers in place of the usual 10 percent adder.
- Unit Cost = Cost of Dispatch without Start Cost
- Unit Dispatch Cost= Cost of Dispatch with Start Cost Included
- All inputs use prevailing width preserving decimal precision of historical record.

STEP 1: Derive Historical Monthly LMP Basis Differential between the generation bus and western hub

> *Inputs required for STEP 1:*
> *Platts-ICE Forward Curve for "PJM west" from the recent trading day,*

> *Three years of historical hourly real-time LMPs at the generation bus, and*
> *Three years of historical hourly real-time PJM Western Hub LMPs*

The mismatch between the location of the forward contract delivery point (Western Hub) and the relevant generator bus can be accounted for in the historic, monthly average basis differential for both peak and off-peak hours. This basis differential can be expressed as the average, over all peak or off-peak hours in a month, of the ratio of the hourly bus LMP to the hourly Western Hub LMP. If this ratio is greater than one, it means the bus LMP is greater than the Western Hub LMP on average. If this ratio is less than one, it means the bus LMP is less than the Western Hub LMP on average.

Platts-ICE Forward Curve for "PJM west" (PJM Western Hub) must be collected for this first step (http://www.platts.com/). These PJM Western Hub Forwards multiplied by a historical basis adjustment ratio for delivery to the generator's bus creates monthly delivered bus prices. The three prior calendar year's historical data is used to make this calculation.. For example, when calculating opportunity costs for July 2, 2010 for a unit with a calendar year compliance period, use historical LMP data from July 2nd (2007,2008,2009) to December 31st (2007,2008,2009). The Opportunity Cost Calculator is also able to provide forecasts for a rolling compliance period (e.g. a rolling 12 months) rather than a calendar year period. For units with a 12 month rolling compliance period, use LMP data from the previous three years, beginning on the date calculated and ending two days previous. For example, when a unit is calculating opportunity cost for July 2nd, 2010 with a rolling 12 month compliance period, use historical LMP data from July 2nd (2007,2008,2009) to June 30th (2008, 2009, 2010). Begin by taking the hourly bus prices for the three prior calendar years at the generator's bus, and for every hour, divide that hour's price by the corresponding price at PJM Western Hub. The historic hourly basis differential in hour h, day d, month m, and year y is

$$\text{HourlyBasisDifferentialRatio}_{y,m,d,h} = \frac{\text{BUSLMP}_{y,m,d,h}}{\text{PJMWHLMP}_{y,m,d,h}}.$$

> NOTE: When PJMWHLMP is zero and the BUSLMP is zero, then the ratio value is one. If PJMWHLMP is zero and the BUSLMP is not zero then value is null and it is not included in the average.

Example 1.1: Three hourly basis differential ratios values for the same hour in each of three historical years:

$$HourlyBasisDifferentialRatio_{June\ 3,2007\ H11} = \frac{BUSLMP_{June\ 3,2007\ H11}}{PJMWHLMP_{June\ 3,2007\ H11}}$$

$$HourlyBasisDifferentialRatio_{June\ 3,2008\ H11} = \frac{BUSLMP_{June\ 3,2008\ H11}}{PJMWHLMP_{June\ 3,2008\ H11}}$$

$$HourlyBasisDifferentialRatio_{June\ 3,2009\ H11} = \frac{BUSLMP_{June\ 3,2009\ H11}}{PJMWHLMP_{June\ 3,2009\ H11}}$$

Once the hourly basis ratios are calculated for every hour during the three-year history, for each historic month take the sum of the on-peak hourly basis differentials in the month, and divide by the number of peak hours in the month (observations). Similarly, for every month, sum the off-peak hourly basis ratios, and then divide by the number of off-peak hours within that month. When calculating the monthly peak basis differential ratio all days in the month will be used for the average. These monthly basis differentials adjust PJM Western Hub monthly peak and off-peak forward prices to expected peak and off-peak monthly forward prices delivered to the generator's bus.

$$\text{Monthly Peak Basis Differential Ratio}_{\text{y.m}}^{\text{Peak}} = \frac{\sum_{\text{Peak Hours}} * \left(\text{Hourly Basis Differential Ratio}_{\text{y.m.d.h}}^{\text{Peak}}\right)}{\text{Number of Peak Hours in month m}}$$

$$\text{Monthly Off-Peak Basis Differential Ratio}_{\text{y.m}}^{\text{Off-Peak}} = \frac{\sum_{\text{Off-Peak Hours}} * \left(\text{Hourly Basis Differential Ratio}_{\text{y.m.d.h}}^{\text{Off-Peak}}\right)}{\text{Number of Off} - \text{Peak Hours in month m}}$$

Example 1.2: Monthly Peak Basis Differentials for the three historical periods:

$$MonthlyPeakBasisDifferentialRatio_{June\ 2007}^{peak} = \frac{\sum_{peak\ \text{hours}} * (Hourly\ Basis\ Differential\ Ratios\ June\ 2007)}{Number\ of\ peak\ hours\ in\ June\ 2007}$$

$$MonthlyPeakBasisDifferentialRatio_{June\ 2008}^{peak} = \frac{\sum_{peak\ \text{hours}} * (Hourly\ Basis\ Differential\ Ratios\ June\ 2008)}{Number\ of\ peak\ hours\ in\ June\ 2008}$$

$$MonthlyPeakBasisDifferentialRatio_{June\ 2009}^{peak} = \frac{\sum_{peak\ \text{hours}} * (Hourly\ Basis\ Differential\ Ratios\ June\ 2009)}{Number\ of\ peak\ hours\ in\ June\ 2009}$$

Multiply monthly peak and off-peak basis differential ratios by the respective monthly peak and off-peak PJM Western hub forwards to derive forecasted monthly peak and off-peak bus prices from the historical year. When calculating the monthly peak basis differential ratio all days in the month will be used for the average.

$$\text{Forecasted Monthly Bus Price}^{\text{Peak}}_{\text{Future y,m}} = \text{PJMWHFRP}^{\text{Peak}}_{\text{Future y,m}} * \text{Monthly Peak Basis Differential Ratio}^{\text{Peak}}_{\text{Base y,m}}$$

Example 1.3: Forecasted monthly bus prices for three historical periods:

$$Forecasted\ Monthly\ Bus\ Price^{Off-Peak}_{June\ 2010,\ \text{Base Year 2007}} = PJMWHFRP^{Off-Peak}_{For\ \text{Delivery}\ June\ 2010} * MonthlyOff - PeakBasisDifferentialRatio^{Off-Peak}_{June\ 2007}$$

$$Forecasted\ Monthly\ Bus\ Price^{Off-Peak}_{June\ 2010,\ \text{Base Year 2008}} = PJMWHFRP^{Off-Peak}_{For\ \text{Delivery}\ June\ 2010} * MonthlyOff - PeakBasisDifferentialRatio^{Off-Peak}_{June\ 2008}$$

$$Forecasted\ Monthly\ Bus\ Price^{Off-Peak}_{June\ 2010,\ \text{Base Year 2009}} = PJMWHFRP^{Off-Peak}_{For\ \text{Delivery}\ June\ 2010} * MonthlyOff - PeakBasisDifferentialRatio^{Off-Peak}_{June\ 2009}$$

> *Outputs from STEP 1:*
> *Three peak and off-peak monthly BUS LMP forecasts for each month remaining in the compliance period*

STEP 2: Derive hourly volatility scalars to incorporate hourly volatility into the LMP forecast

> *Inputs for STEP 2:*
> *Three years historical hourly real-time LMPs at the generation bus*

The monthly futures prices quoted only consider the average peak and off-peak prices for the month and do not consider hourly LMP volatility. Step 2 derives will develop an hourly volatility scalar. This scalar will later be multiplied against the forecast in Step 1 to derive an hourly bus LMP forecast that incorporates historic hourly peak and off-peak LMP volatility as well as monthly peak and off-peak basis differentials from the historical year with PJM Western Hub.

First, for each historic month compute the average peak and off-peak price at the unit's bus for each remaining month in the compliance period. When calculating the monthly average bus LMP all days in the month will be used for the average.

$$\text{Monthly Average Bus LMP}_{y,m}^{Peak} = \frac{\sum_{\text{Peak Hours}} * (\text{Hourly Bus LMP}_{y,m,d,h}^{Peak})}{\text{Number of Peak Hours in month m}}$$

$$\text{Monthly Average Bus LMP}_{y,m}^{Off\text{-}Peak} = \frac{\sum_{\text{Off-Peak Hours}} * (\text{Hourly Bus LMP}_{y,m,d,h}^{Peak})}{\text{Number of Off-Peak Hours in month m}}$$

Next, for every hour, take the hourly bus LMP divided by the relevant monthly average peak or off-peak bus LMP computed above. If the hour is an on-peak hour, divide by the average peak LMP for the month.

$$\text{Hourly Volatility Scalar}_{y,m,d,h}^{Peak} = \frac{\text{BUSLMP}_{y,m,d,h}^{Peak}}{\text{Monthly Average BUSLMP}_{y,m}^{Peak}}$$

If the hour is off-peak, divide that hour by the monthly off-peak average price for the corresponding month.

$$\text{Hourly Volatility Scalar}_{y,m,d,h}^{Off\text{-}Peak} = \frac{\text{BUSLMP}_{y,m,d,h}^{Off\text{-}Peak}}{\text{Monthly Average BUSLMP}_{y,m}^{Off\text{-}Peak}}$$

Example 2.1: Volatility scalar for the each of the three historical years:

$$HourlyVolatiltiyScalar_{June3,2007\ H23} = \frac{BUSLMP_{June\ 3,2007\ H23}}{Average\ Off-Peak\ June\ 2007\ BUSLMP}$$

$$HourlyVolatiltiyScalar_{June3,2008\ H23} = \frac{BUSLMP_{June\ 3,2008\ H23}}{Average\ Off-Peak\ June\ 2008\ BUSLMP}$$

$$HourlyVolatiltiyScalar_{June3,2009\ H23} = \frac{BUSLMP_{June\ 3,2009\ H23}}{Average\ Off-Peak\ June\ 2009\ BUSLMP}$$

Output from STEP 2:
Three ratio values per hour for each of the historical years used for volatility

STEP 3: Create three sets of hourly forecasted bus values

Inputs to STEP 3:
Output from STEP 1: On-peak/off-peak monthly bus LMP Forecast
Output from STEP 2: Hourly volatility scalars

Step 3 creates three hourly forecasts from the volatility scalars developed in step 2 and the monthly bus LMP forecasts developed in Step 1. Multiply the hourly volatility scalars developed in step 2 by the corresponding peak or off-peak from the historical year forecasted monthly bus price calculated in step 1.

The expected or forecasted LMP for hour h, day d, month m, based on year y that is a peak hour is

$$\text{Forecasted BUSLMP}_{y,m,d,h}^{\text{Peak}} = \text{Hourly Volatility Scalar}_{y,m,d,h}^{\text{Peak}} * \text{Forecasted Monthly Bus Price}_{\text{Future}\ \ y,m}^{\text{Peak}}$$

The expected or forecasted LMP for hour h, day d, month m, based on year y that is an off-peak hour is

$$\text{Forecasted BUSLMP}_{y,m,d,h}^{\text{Off-Peak}} = \text{Hourly Volatility Scalar}_{y,m,d,h}^{\text{Off-Peak}} * \text{Forecasted Monthly Bus Price}_{\text{Future}\ \ y,m}^{\text{Off-Peak}}$$

Example 3.1: Forecasted bus LMPs for one hour for each of the three historical base years:

Assume that it is April 5, 2009. To create the set of three forecasted prices for each hour of June 3, 2009:

$$ForecastedBUSLMP_{June\ 3{,}2010\ H23,\ \ Base\ Year\ 2007} = HourlyVolatilityScalar_{June\ 3{,}2007\ H23} * ForecastedMonthlyBusPrice_{June\ 2010}^{Off-Peak}$$

$$ForecastedBUSLMP_{June\ 3{,}2010\ H23,\ \ Base\ Year\ 2008} = HourlyVolatilityScalar_{June\ 3{,}2008\ H23} * ForecastedMonthlyBusPrice_{June\ 2010}^{Off-Peak}$$

$$ForecastedBUSLMP_{June\ 3{,}2010\ H23,\ \ Base\ Year\ 2009} = HourlyVolatilityScalar_{June\ 3{,}2009\ H23} * ForecastedMonthlyBusPrice_{June\ 2010}^{Off-Peak}$$

Outputs from STEP 3:
Three hourly bus LMP forecasts for each hour remaining in the compliance period

STEP 4: Create a daily fuel volatility scalar

Inputs to STEP 4:
Three years historical delivered daily fuel prices at the generator bus ($/mmBtu)
Fuel Weights if dual fuel

Step 4 creates a daily fuel volatility scalar using historic daily delivered fuel prices (as used to develop a unit's TFRC) from the previous three calendar years. Take each daily bus-delivered fuel price and divide it by the monthly average bus delivered fuel price to create a ratio for every day in the three-year history. In calculating monthly average bus price, all days in the month will be used for the average. For units that have dual fuels; the daily delivered fuel prices need to be multiplied by their respective weights and then added together. N_m is the number of days in month m.

Units with Single Fuel Type:

$$\text{Daily Fuel Volatility Scalar}_{\text{y.m.d}} = \frac{\text{Delievered Fuel Price}_{\text{ y.m.d}}}{\frac{\sum_{n=1}^{N_m}(\text{Delivered Fuel Price}_{\text{ y,m}})}{N_m}}$$

Units with Dual Fuel:

$$\text{Daily Fuel Volatility Scalar}_{\text{ y.m.d}} = \frac{\begin{bmatrix} (\text{Delivered Fuel Price Fuel Type A}_{\text{ y.m.d}} * \text{Weight Fuel Type A}) \\ +(\text{ Delivered Fuel Price Fuel Type B}_{\text{ y.m.d}} * \text{Weight Fuel Type B}) \end{bmatrix}}{\frac{\sum_{n=1}^{N_m}\begin{bmatrix} (\text{Delivered Fuel Price Fuel Type A}_{\text{ y.m.}} * \text{Weight Fuel Type A}) \\ +(\text{ Delivered Fuel Price Fuel Type B}_{\text{ y.m.}} * \text{Weight Fuel Type B}) \end{bmatrix}}{N_m}}$$

Example 4.1: Three daily fuel volatility scalars values developed for June 3 in each of three historic years for a unit with a single fuel:

$$DailyFuelVolatilityScalar_{June,3,2007} = \frac{DeliveredFuelPrice_{June\ 3,2007}}{Average\ June\ 2007\ DeliveredFuelPrice}$$

$$DailyFuelVolatilityScalar_{June,3,2008} = \frac{DeliveredFuelPrice_{June\ 3,2008}}{Average\ June\ 2008\ DeliveredFuelPrice}$$

$$DailyFuelVolatilityScalar_{June,3,2009} = \frac{DeliveredFuelPrice_{June\ 3,2009}}{Average\ June\ 2009\ DeliveredFuelPrice}$$

If there is no fuel cost record for a given date, use the previous available value.

Output from STEP 4: Three years of historic daily scalars for fuel volatility

STEP 5: Create three daily delivered fuel forecasts

Inputs for STEP 5:
Platts Forward curve for Fuels from the most recent trading day, for delivery in the compliance period ($/mmBtu) with a daily delivery charge adjustment
Fuel Weights if dual fuel
Fuel contract monthly prices if applicable
Output from STEP 4: Three years historic daily scalars for fuel volatility

Step 5 takes fuel futures and/or contract prices and the daily delivered fuel scalars from step 4 and multiplies them together to create a fuel forecast that corresponds on an average monthly basis to the fuel futures, yet maintains historical volatility. For units that have dual fuels: the fuel forwards for the two fuels will be multiplied by their respective weights (derived from expected use of each fuel), added together, and then multiplied by the daily fuel volatility scalar. For units with some or all of their fuel procured by contract, the contract and fuel forwards are multiplied by their respective weights (derived from expected use of each fuel) and added together and then multiplied by the daily fuel volatility scalar. The current daily delivery charge adjustment will be applied through the compliance period.

<u>Unit with a single fuel:</u>

$$\text{Daily Delivered Fuel}_{y,m,d} = \text{Daily Fuel Volatility Scalar}_{y,m,d} * \Big[\text{Weight Spot}_m * \big(\text{Fuel Forward}_{\text{Future year},m} + \text{Delivery Adjustment}\big) + \big(\text{Weight Contract}_m * \text{Contract Price}_m\big)\Big]$$

$$\text{Where Weight Contract}_m + \text{Weight Spot}_m = 1$$

<u>Unit with dual fuel:</u>

(Permits use of dual fuels for units that may burn multiple fuels or source fuels from different areas at different prices. For units with restrictions on consumption of specific fuels, this method allows accounting for both fuels in the same calculation.)

$$DailyDeliveredFuel_{fy,m,d} = DailyFuelVariabilityScalar_{y,m,d} * [WeightFuelTypeA_m * (WeightContractFuelTypeA_m * ContractPriceFuelTypeA_m + WeightSpotFuelTypeA_m * (DeliveryAdjustmentFuelTypeA + FuelForwardFuelTypeA_{fy,m})) + WeightFuelTypeB_m * (WeightContractFuelTypeB_m * ContractPriceFuelTypeB_m + WeightSpotFuelTypeB_m * (DeliveryAdjustmentFuelTypeB + FuelForwardFuelTypeB_{fy,m}))]$$

$$\text{Where Weight Fuel Type A}_m + \text{Weight Fuel Type B}_m = 1$$

$$\text{Where Weight Contract Type A}_m + \text{Weight Spot Type A}_m = 1$$

$$\text{Where Weight Contract Type B}_m + \text{Weight Spot Type B}_m = 1$$

Example 5.1: Create three daily delivered fuel forecasts from the volatilities of three historic years:

<u>Unit with a single fuel:</u>

$$DailyDeliveredFuelForecast^{Base\ Year\ 2007}_{June\ 3{,}2010,\ \text{Base Year 2007}} = DailyFuelVolatilityScalar_{June\ 3{,}2007} * FuelForward_{June\ 2010}$$

$$DailyDeliveredFuelForecast^{Base\ Year\ 2008}_{June\ 3{,}2010,\ \text{Base Year 2008}} = DailyFuelVolatilityScalar_{June\ 3{,}2008} * FuelForward_{June\ 2010}$$

$$DailyDeliveredFuelForecast^{Base\ Year\ 2009}_{June\ 3{,}2010,\ \text{Base Year 2009}} = DailyFuelVolatilityScalar_{June\ 3{,}2009} * FuelForward_{June\ 2010}$$

<u>Outputs from STEP 5:</u>
Daily generator-bus delivered fuel forecast

Step 6: Create generating unit(s) cost for each of the three forecasts

Inputs for STEP 6:

Expected future full load seasonal (May-September/ October – April) heat rate for the compliance period
Fuel Prices output from Step 5
Unit SO_2, CO_2, and NO_x Emission Rates (lbs/mmBtu)
(Note that the CO_2 adder is in effect only for incurring carbon emission charges)Futures prices for SO_2, CO_2 and NO_x from Evolution Markets ($/ton) modified to $/lb
Maintenance Adder, VOM and FMU as defined in M-15

In step 6, take the unit characteristics, future emission allowance prices, the three daily fuel forecasts and create a daily unit cost for the three forecasts using the appropriate heat rate for the forecast day. Unit costs do not include start costs, start costs will be added later in the calculation of Unit Dispatch Cost. For each day in the three fuel forecasts, a unit dispatch cost is calculated as follows:

$$\text{Unit Cost}_{\text{Future y,m,d}}^{\text{base year}} =$$
$$\Big\{\Big[UnitHeatRate\left({}^{mmbtu}/_{mwh}\right) * DailyDeliveredFuelForecast(\$/mmbtu)_{fy,m,d}^{base\ year}\Big] +$$
$$\Big[UnitHeatRate\ (mmbtu/mwh) * UnitNOxEmissionRate(lbs/mmbtu) * Cost\ of\ NOx\ \left({}^{\$}/_{lb}\right)\Big] +$$
$$\Big[UnitHeatRate\ (mmbtu/mwh) * UnitSO_2EmissionRate(lbs/mmbtu) * Cost\ of\ SO_2\ \left({}^{\$}/_{lb}\right)\Big] +$$
$$\Big[UnitHeatRate\ (mmbtu/mwh) * UnitCO_2EmissionRate(lbs/mmbtu) * Cost\ of\ CO_2\ \left({}^{\$}/_{lb}\right)\Big]$$
$$+\ VOM + FMU\ (if\ applicable)\Big\} * \{Up\ to\ 1.1\ scalar\ factor\ (if\ applicable)\}$$

Example 6.1: Daily unit cost:

Unit heat rate=10.345 mmBtu/MWh

Unit NOx emission rate =0.328 lbs/mmBtu

Unit SO_2 emission rate=1.2 lbs/mmBtu

Unit CO_2 emission rate=117 lbs/mmBtu

DailyDeliveredFuelForecast=$3.01/mmBtu

Combined NOx Allowance cost=$1375/ton

SO_2 Allowance cost=$200/ton

CO_2 emission cost = $8/ton

VOM & Maintenance Adder=$2.22/MWh

FMU= $0.00/MWh

$$\text{Unit Cost}_{\text{Future y,m,d}}^{\text{base year}} =$$

$$\left[\left(\frac{10.345 mmbtu}{mwh}\right) * \left(\frac{\$3.01}{mmbtu}\right)\right] +$$
$$\left[\left(\frac{10.345 mmbtu}{mwh}\right) * \left(\frac{0.328\ lbs}{mmbtu}\right) * \left(\frac{\$1375.00}{ton}\right) * \left(\frac{ton}{2000\ lbs}\right)\right] +$$
$$\left(\left[\left(\frac{10.345\ mmbtu}{mwh}\right) * \left(\frac{1.2\ lbs}{mmbtu}\right) * \left(\frac{\$200}{ton}\right) * \left(\frac{ton}{2000} lbs\right)\right]\right) +$$
$$\left[\left(\frac{10.345 mmbtu}{mwh}\right) * \left(\frac{117 lbs}{mmbtu}\right) * \left(\frac{\$8}{ton}\right) * \left(\frac{ton}{2000 lbs}\right)\right]$$
$$+ \left(\frac{\$2.22}{MWh}\right) + \left(\frac{\$0}{MWh}\right)$$

$$\text{Unit Cost}_{\text{fy,m,d}}^{\text{base year}} = \left(\frac{\$31.14}{MWh}\right) + \left(\frac{\$2.33}{MWh}\right) + \left(\frac{\$1.24}{MWh}\right) + \left(\frac{\$4.84}{MWh}\right) + \left(\frac{\$2.22}{MWh}\right) = \$41.77/MWh$$

Outputs for step 6:
Three forecasts based on historic year factors for daily generator unitcost

Step 7: Calculate the margin for every hour in the three hourly forecasts

Inputs for Step 7:
Daily Generator Unit Cost from Step 6
Hourly Generator bus LMP forecast from Step 3
All future maintenance outage information
Unit-specific minimum run-time parameter restriction
Unit-specific start up costs (cold startup costs for combined cycle and combustion turbine units and hot startup costs for steam units)
Unit economic maximum

Step 7 calculates the hourly margin the generator would receive by comparing the cost offer developed in step 6 against the hourly forecasted bus LMPs developed in step 3. To remove planned outages, for any future date that the unit will be offline, set the outage hours to unavailable for all three forecasts.

For units with minimum run time restrictions, this step calculates total margins in blocks of adjacent hours, based on the sum of the margins of each block and the minimum run time parameter restriction of the unit. Blocks may include additional incremental hours, if these hours are found to be more valuable than an additional block, up to double a unit's minimum run time. Adjacent hour blocks with equal or greater number of hours than double a unit's minimum run time will be split into multiple blocks (however adjacent blocks do not use an additional start cost). For units with start-up costs, the value of the unit's start-up cost divided by economic maximum will be subtracted from the total margin of each block that contains a new start, but not from each subsequent incremental hour added to the block, in order to correctly value hours that do not incur start costs. Calculate the total margins for all blocks of hours in the three forecasts:

$$TotalMarginBlock_{block}^{base\ year} = \sum_{t=block}^{t=block+MinRunTime-1} ForecastedBUSLMP_{y(t),m(t),d(t),h(t)}^{base\ year} - UnitDispatchCost_{y(t),m(t),d(t)}^{baseyear}$$

** Unit Dispatch Cost includes startup when applicable.

Where block ranges from 1 to [totalNumberofHours – MinRunTime + 1] and y(t), m(t), d(t), h(t) are the year, month, day and hour corresponding to the tthoverall hour of the time period spanning from the date calculated to the end of the compliance period forecasted.

The totalNumberofHours variable represents the number of hours left in the compliance period to be forecasted, and is based on the date calculated and whether or not the unit has a rolling 12 month run-hour restriction.

Example 7.1: Calculating total margins with a minimum run time of one hour (i.e. no minimum run time restriction), using historical data from the past three calendar years

This example uses block # 3679:

$$TotalMarginBlock_{\text{block 3679}}^{base\ 2006} = \sum_{t=block}^{t=block+MinRunTime-1} ForecastedBUSLMP_{y(t),m(t),d(t),h(t)}^{base\ year} - UnitDispatchCost_{y(t),m(t),d(t)}^{baseyear} = \sum_{t=3679}^{t=3679+1-1} ForecastedBUSLMP_{y(t),m(t),d(t),h(t)}^{base\ 2006} - UnitDispatchCost_{y(t),m(t),d(t)}^{base\ 2006} = ForecastedBUSLMP_{y(3679),m(3679),d(3679),h(3679)}^{base\ 2006} - UnitDispatchCost_{y(3679),m(3679),d(3679)}^{base\ 2006} = ForecastedBUSLMP_{June\ 3,2009\ H07}^{base\ 2006} - UnitDispatchCost_{June\ 3,2009}^{base\ 2006} = \$53.23 - \$41.77 = \$11.46$$

- Similarly,

$$TotalMarginBlock_{\text{block \#3679}}^{base\ 2007} = ForecastedBUSLMP_{June\ 3,2009\ H07}^{base\ 2007} - UnitDispatchCost_{June\ 3,2009}^{base\ 2006} = \$55.44 - \$57.88 = -\$2.44$$

$$TotalMarginBlock_{\text{block \#3679}}^{base\ 2008} = ForecastedBUSLMP_{June\ 3,2009\ H07}^{base\ 2008} - UnitDispatchCost_{June\ 3,2009}^{base\ 2006} = \$49.78 - \$49.72 = \$0.06$$

At this point, the blocks of hours would be ranked according to the value of their total margins.

Output from step 7: Three sets of ranked blocks of total margin forecasts including each hour in the compliance period, adjusted to include start-up costs for each block that contains a new start, with all future outage hours remove

Step 8: Determine the opportunity cost adder

Input for Step 8: Three sets of ranked blocks of total margin forecasts

For each of the three years, the opportunity cost for that year will be the average total margin of the lowest value block added before the run hour limit was reached. The three opportunity costs will then be averaged to get the opportunity cost adder available to the generator. If the opportunity cost adder is less than 0, the opportunity cost adder will be set to 0.

Example 8.1: A unit with 700 run hours left:

$$\text{The average value of the block which includes the 700th hour}_{\text{base2006}} = \$18.33/\text{MWh}$$
$$\text{The average value of the block which includes the 700th hour}_{\text{base2007}} = \$0/\text{MWh}$$
$$\text{The average value of the block which includes the 700th hour}_{\text{base2008}} = \$1.59/\text{MWh}$$

700th hour opportunity cost adder = $\frac{\$18.33+(0)+\$1.59}{3} = \$6.64/\text{MWh}$

Output from step 9:
Maximum Opportunity Cost Component that can be added to an environmentally run limited generator's cost offer.