Working to Perfect the Flow of Energy

PJM Manual 15:

Cost Development Guidelines

Revision:

Effective Date:

Prepared by
Cost Development Task Force

PJM Manual 15

Cost Development Guidelines

Table of Contents

Table of Exhibits

<div style="border:1px solid black">

Section 9: Energy Market Opportunity Cost and Non-Regulatory Opportunity Cost Guidelines

</div>

9.1 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 pursuant to the Cost and Methodology Approval Process.

9.2 Basis for Opportunity Cost to be included in Cost Offers

There are two~~three~~ reasons for application of Opportunity Costs as contained in this section.

9.2.1 Energy Market Opportunity Costs

Energy ~~and Environmental~~ Market Opportunity Costs associated with an externally imposed ~~run~~environmental 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.

9.2.2 Non-Regulatory Opportunity Cost: Physical Equipment Limitations:

Physical Equipment Limitations must have supporting evidence submitted by the generation owner. Documentation such as an OEM recommendation or bulletin and/or insurance carrier restrictions would meet this criterion. Only limitations that cause the unit to experience a restriction in the number of starts or run hours would be eligible for Non-Regulatory Opportunity Cost.

9.2.3 Non-Regulatory Opportunity Cost: Fuel Limitations

Fuel Limitations are eligible for Non-Regulatory Opportunity Costs for a fuel supply limitation, for up to one year, resulting from an event of force majeure.

Force Majeure is defined as: Any cause beyond the control of the affected Interconnection Party or Construction Party, including but not restricted to, acts of God, flood, drought, earthquake, storm, fire, lightning, epidemic, war, riot, civil disturbance or disobedience, labor dispute, labor or material shortage, sabotage, acts of public enemy, explosions, orders, regulations or restrictions imposed by governmental, military, or lawfully established civilian authorities, which, in any of the foregoing cases, by exercise of due diligence such party could not reasonably have been expected to avoid, and which, by the exercise of due diligence, it has been unable to overcome. Force Majeure does not include (i) a failure of performance that is due to an affected party's own negligence or intentional wrongdoing; (ii) any removable or remediable causes (other than settlement of a strike or labor dispute)

which an affected party fails to remove or remedy within a reasonable time; or (iii) economic hardship of an affected party.

9.3 Calculation Method Options: Two Methodologies for calculating Opportunity Cost

Generators may opt to follow one of the two the following methodologies; the difference between the methodologies being the applicable time period. Generators may develop alternative methods specific to their units and submit those methods for approval. Requests for recovery of opportunity costs using other methods not defined in the Operating Agreement of PJM Interconnection, L.L.C. should be initially submitted to the PJM MMU for evaluation under the Cost and Methodology Approval Process.

Energy Market Opportunity Costs and Non-Regulatory 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.

9.3.1 Long Term Method (greater than 30 days)

This method uses monthly forward prices as the basis for forecasts of fuel and electricity costs in the future. 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 long term opportunity cost no less frequently than once per every 7 days.

9.3.2 Short Term Method (30 days or less)

This method uses daily forward prices as the basis for forecasts of fuel and electricity costs in the future. Generation owners who include opportunity costs in their cost-based offers must recalculate their short term opportunity cost every day.

9.4 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

- DAPJMWHFRP=Day Ahead 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.

9.5 Long Term Methodology

9.5.1 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:

$$\text{HourlyBasisDifferentialRatio}_{\text{June } 3,2007 \text{ H11}} = \frac{\text{BUSLMP}_{\text{June } 3,2007 \text{ H11}}}{\text{PJMWHLMP}_{\text{June } 3,2007 \text{ H11}}}$$

$$\text{HourlyBasisDifferentialRatio}_{\text{June } 3,2008 \text{ H11}} = \frac{\text{BUSLMP}_{\text{June } 3,2008 \text{ H11}}}{\text{PJMWHLMP}_{\text{June } 3,2008 \text{ H11}}}$$

$$\text{HourlyBasisDifferentialRatio}_{\text{June } 3,2009 \text{ H11}} = \frac{\text{BUSLMP}_{\text{June } 3,2009 \text{ H11}}}{\text{PJMWHLMP}_{\text{June } 3,2009 \text{ H11}}}$$

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 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.

$$\text{MonthlyPeakBasisDifferentialRatio}_{y,m}^{\text{peak}} = \frac{\sum_{\text{peak hours}} \left(\text{HourlyBasisDifferentialRatios}_{y,m,d,h}^{\text{peak}} \right)}{\text{Number of Peak Hours in month m}}$$

$$\text{MonthlyOffPeakBasisDifferentialRatio}_{y,m}^{peak}$$

$$= \frac{\sum_{\text{off}-\text{peak hours}} \left(\text{HourlyBasisDifferentialRatios}_{y,m,d,h}^{off-peak}\right)}{\text{Number of Off} - \text{Peak Hours in month m}}$$

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

$$\text{MonthlyPeakBasisDifferentialRatio}_{\text{June 2007}}^{peak}$$

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

$$\text{MonthlyPeakBasisDifferentialRatio}_{\text{June 2008}}^{peak}$$

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

$$\text{MonthlyPeakDifferentialBasisRatio}_{\text{June 2009}}^{peak}$$

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

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.

$$\text{Forecasted Monthly Bus Price}_{fy,m}^{peak} = \left[\text{PJMWestern Hub}_{fy,m}^{peak} * \text{MonthlyPeakBasisRatio}_{y,m}^{peak} \right]$$

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

$$\text{Forecasted Monthly Bus Price}_{\text{June 2010,base 2007}}^{\text{OFFpeak}}$$

$$= \left[(\text{PJMWHFRP}_{\text{for delivery June 2010}}^{\text{OFFpeak}}) * (\text{MonthlyOffPeakBasisDifferentialRatio}_{\text{June 2007}}^{\text{OFFpeak}}) \right]$$

$$\text{Forecasted Monthly Bus Price}_{\text{June 2010,base 2008}}^{\text{OFFpeak}}$$

$$= \left[(\text{PJMWHFRP}_{\text{for delivery June 2010}}^{\text{OFFpeak}}) * (\text{MonthlyOffPeakBasisDifferentialRatio}_{\text{June 2008}}^{\text{OFFpeak}}) \right]$$

$$\text{Forecasted Monthly Bus Price}_{\text{June 2010,base 2009}}^{\text{OFFpeak}}$$

$$= \left[(\text{PJMWHFRP}_{\text{for delivery June 2010}}^{\text{OFFpeak}}) * (\text{MonthlyOffPeakBasisDifferentialRatio}_{\text{June 2009}}^{\text{OFFpeak}}) \right]$$

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

9.5.2 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.

$$\text{MonthlyAverageBusLMP}_{y,m}^{\text{peak}} = \frac{\sum_{\text{peak hours}} \left(\text{HourlyBusLMP}_{y,m,d,h}^{\text{peak}} \right)}{\text{Number of Peak Hours in month m}}$$

$$\text{MonthlyAverageBusLMP}_{y,m}^{\text{off-peak}} = \frac{\sum_{\text{off-peak hours}} \left(\text{HourlyBusLMP}_{y,m,d,h}^{\text{off-peak}} \right)}{\text{Number of Off-Peak Hours in month m}}$$

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.

$$\text{HourlyVolatilityScalar}_{y,m,d,h}^{\text{peak}} = \frac{\text{BUSLMP}_{y,m,d,h}^{\text{peak}}}{\text{MonthlyAverageBusLMP}_{y,m}^{\text{peak}}}$$

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

$$\text{HourlyVolatilityScalar}_{y,m,d,h}^{\text{off}-\text{peak}} = \frac{\text{BUSLMP}_{y,m,d,h}^{\text{off}-\text{peak}}}{\text{MonthlyAverageBusLMP}_{y,m}^{\text{off}-\text{peak}}}$$

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

$$\text{HourlyVolatilityScalar}_{\text{June 3,2007 H23}} = \frac{\text{BUSLMP}_{\text{June 3,2007 H23}}}{\text{Average Offpeak June 2007 BUSLMP}}$$

$$\text{HourlyVolatilityScalar}_{\text{June 3,2008 H23}} = \frac{\text{BUSLMP}_{\text{June 3,2008 H23}}}{\text{Average Offpeak June 2008 BUSLMP}}$$

$$\text{HourlyVolatilityScalar}_{\text{June 3,2009 H23}} = \frac{\text{BUSLMP}_{\text{June 3,2009 H23}}}{\text{Average Offpeak June 2009 BUSLMP}}$$

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

9.5.3 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:

$$\text{ForecastedBUSLMP}_{y,m,d,h}^{\text{peak}} = \text{HourlyVolatilityScalar}_{y,m,d,h}^{\text{peak}} * \text{ForecastedMonthlyBusPrice}_{fy,m}^{\text{peak}}$$

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

$$\text{ForecastedBUSLMP}_{y,m,d,h}^{off-peak}$$
$$= \text{HourlyVolatilityScalar}_{y,m,d,h}^{off-peak} * \text{ForecastedMonthlyBusPrice}_{fy,m}^{off-peak}$$

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

Assume that it is April 5, 2010. To create the set of three forecasted prices for each hour of June 3, 2010:

$$\text{ForecastedBUSLMP}_{\text{June }3,2010\text{ H23,base }2007}$$
$$= \text{HourlyVolatilityScalar}_{\text{June }3,2007\text{ H23}} * \text{ForecastedMonthlyBusPrice}_{\text{June }2010}^{offpeak}$$

$$\text{ForecastedBUSLMP}_{\text{June }3,2010\text{ H23,base }2008}$$
$$= \text{HourlyVolatilityScalar}_{\text{June }3,2008\text{ H23}} * \text{ForecastedMonthlyBusPrice}_{\text{June }2010}^{offpeak}$$

$$\text{ForecastedBUSLMP}_{\text{June }3,2010\text{ H23,base }2009}$$
$$= \text{HourlyVolatilityScalar}_{\text{June }3,2009\text{ H23}} * \text{ForecastedMonthlyBusPrice}_{\text{June }2010}^{offpeak}$$

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

9.5.4 Step 4: Create a daily fuel volatility scalar

Inputs to STEP 4:
Three years historical delivered daily fuel prices at the generator bus ($/mBTU)
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:

$$DailyFuelVolatilityScalar_{y,m,d} = \frac{DeliveredFuelPrice_{y,m,d}}{\frac{\left(\sum_{n=1}^{N_m}\left(DeliveredFuelPrice_{y,m}\right)\right)}{N_m}}$$

Units with Dual Fuel:

$$DailyFuelVolatilityScalar_{y,m,d} =$$

$$\frac{\left(\begin{array}{c}\left(DeliveredFuelPriceFuelTypeA_{y,m,d} * WeightFuelTypeA\right) + \\ \left(DeliveredFuelPriceFuelTypeB_{y,m,d} * WeightFuelTypeB\right)\end{array}\right)}{\frac{\sum_{n=1}^{N_m}\left(\begin{array}{c}\left(DeliveredFuelPriceA_{y,m} * WeightA\right) + \\ \left(DeliveredFuelPriceB_{y,m} * WeightB\right)\end{array}\right)}{N_m}}$$

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*

9.5.5 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 ($/mBTU) 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.

Unit with a single fuel:

$$\text{DailyDeliveredFuel}_{fy,m,d} =$$

$$\left[\begin{array}{c} \text{DailyFuelVolatilityScalar}_{y,m,d} \ * \\ \left((\text{WeightSpot}_m * \text{FuelForward}_{fy.m}) + (\text{WeightContract} * \text{ContractPrice}) \right) \end{array} \right]$$

$$\text{Where WeightContract}_m + \text{WeightContract}_m = 1$$

Unit with dual fuel:

(Permits the 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.)

$$\begin{aligned} \text{aily eliveredFuel}_{fy,m,d} \\ = \ \text{ailyFuelVariabilityScalar}_{y,m,d} \\ * \left[\text{WeightFuelType}_m \right. \\ * \left(\text{Weight ontractFuelType}_m * \text{ontractPriceFuelType}_m \right. \\ + \text{WeightSpotFuelType}_m * (\text{elivery djustmentFuelType} \\ + \text{FuelForwardFuelType}_{fy,m})) + \text{WeightFuelTypeB}_m \\ * \left(\text{Weight ontractFuelTypeB}_m * \text{ontractPriceFuelTypeB}_m \right. \\ + \text{WeightSpotFuelTypeB}_m * (\text{elivery djustmentFuelTypeB} \\ \left. + \text{FuelForwardFuelTypeB}_{fy,m})) \right] \end{aligned}$$

$$\text{Where WeightFuelTypeA}_m + \text{WeightFuelTypeB}_m = 1$$

$$\text{Where WeightContractFuelTypeA}_m + \text{WeightSpotFuelTypeA}_m = 1$$

$$\text{Where WeightContractFuelTypeB}_m + \text{WeightSpotFuelTypeB}_m = 1$$

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

Unit with a single fuel:

$$\text{DailyDeliveredFuelForecast}_{\text{June 3,2009,base 2007}}^{\text{base 2007}}$$
$$= \text{DailyFuelVolatilityScalar}_{\text{June 3,2007}} * \text{FuelForward}_{\text{June 2010}}$$

$$\text{DailyDeliveredFuelForecast}_{\text{June 3,2009, base 2008}}^{\text{base 2008}}$$
$$= \text{DailyFuelVolatilityScalar}_{\text{June 3,2008}} * \text{FuelForward}_{\text{June 2010}}$$

$$\text{DailyDeliveredFuelForecast}_{\text{June 3,2009, base 2009}}^{\text{base 2009}}$$
$$= \text{DailyFuelVolatilityScalar}_{\text{June 3,2009}} * \text{FuelForward}_{\text{June 2010}}$$

Outputs from STEP 5:
Daily generator-bus delivered fuel forecast

9.5.6 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/mBTU)
(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 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:

$$\text{UnitCost}_{\text{fy,m,d}}^{\text{base year}} =$$

$$\left\{ \left[\text{UnitHeatRate}\left(\frac{\text{mBTU}}{\text{mwh}}\right) * \text{DailyDeliveredFuelForecast}\left(\frac{\$}{\text{mBTU}}\right)_{\text{Future y,m,d}}^{\text{base year}} \right] + \right.$$

$$\left[\text{UnitHeatRate}\left(\frac{\text{mBTU}}{\text{mwh}}\right) * \text{UnitNOxEmissionRate}\left(\frac{\text{lbs}}{\text{mBTU}}\right) * \text{Cost of NOx}\left(\frac{\$}{\text{lb}}\right) \right] +$$

$$\left[\text{UnitHeatRate}\left(\frac{\text{mBTU}}{\text{mwh}}\right) * \text{UnitSO}_2\text{EmissionRate}\left(\frac{\text{lbs}}{\text{mBTU}}\right) * \text{Cost of SO}_2\left(\frac{\$}{\text{lb}}\right) \right] +$$

$$\left[\text{UnitHeatRate} \left(\frac{\text{mBTU}}{\text{mwh}} \right) * \text{UnitCO}_2\text{EmissionRate} \left(\frac{\text{lbs}}{\text{mBTU}} \right) * \text{Cost of CO}_2 \left(\frac{\$}{\text{lb}} \right) \right] + \text{VOM} + \right\}$$
$$+ \text{ either a} \left\{ \begin{array}{l} \text{10\% margin} \\ \text{FMU adder} \end{array} \text{or} \right.$$

Example 6.1: Daily unit cost:

Unit heat rate=10.35 mBTU/MWh

Unit NOx emission rate =0.328 lbs/mBTU

Unit SO_2 emission rate=1.2 lbs/mBTU

Unit CO_2 emission rate=117 lbs/mBTU

DailyDeliveredFuelForecast=$5.56/mBTU

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

$$\text{UnitCost} =$$

$$\left[\left(\frac{10.35\text{mbtu}}{\text{mwh}} \right) * \left(\frac{\$5.56}{\text{mbtu}} \right) \right] +$$
$$\left[\left(\frac{10.35\text{mbtu}}{\text{mwh}} \right) * \left(\frac{0.328 \text{ lbs}}{\text{mbtu}} \right) * \left(\frac{\$1375.00}{\text{ton}} \right) * \left(\frac{\text{ton}}{2000 \text{ lbs}} \right) \right] +$$
$$\left(\left[\left(\frac{10.35 \text{ mbtu}}{\text{mwh}} \right) * \left(\frac{1.2 \text{ lbs}}{\text{mbtu}} \right) * \left(\frac{\$200}{\text{ton}} \right) * \left(\frac{\text{ton}}{2000} \text{lbs} \right) \right] \right) +$$
$$\left[\left(\frac{10.345\text{mbtu}}{\text{mwh}} \right) * \left(\frac{117\text{lbs}}{\text{mbtu}} \right) * \left(\frac{\$8}{\text{ton}} \right) * \left(\frac{\text{ton}}{2000\text{lbs}} \right) \right]$$
$$+ \left(\frac{\$2.22}{\text{MWh}} \right) + \left(\frac{\$0}{\text{MWh}} \right)$$

$$\text{UnitCost}_{\text{fy,m,d}}^{\text{base year}} = \left(\frac{\$58.58}{\text{MWh}} \right) + \left(\frac{\$2.33}{\text{MWh}} \right) + \left(\frac{\$1.24}{\text{MWh}} \right) + \left(\frac{\$4.84}{\text{MWh}} \right) + \left(\frac{\$2.22}{\text{MWh}} \right) = \$69.21/\text{MWh}$$

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

9.5.7 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 runtime 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 the total margins in blocks of adjacent hours, based on the sum of the margins of each block and the minimum runtime parameter restriction of the unit. Blocks may include additional incremental hours, if these hours are found to be more valuable than the additional block, up to double the unit's minimum runtime. 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 startup 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.

$$
\text{TotalMarginBlock}_{\text{block}}^{\text{base year}}
= \sum_{t=\text{block}}^{t=\text{block}+\text{MRT}-1} \left(\text{ForecastedBusLMP}_{y(t),m(t),d(t),h(t)}^{\text{base year}} - \text{UnitDispatchCost}_{\text{future } y,m,d}^{\text{base year}} \right)
$$

**MRT= minimum run time

***Unit Dispatch cost includes startup when applicable

Where the block ranges from one to $[\text{total number of hours} - \text{min run time} + 1]$ and $y(t)$, $m(t)$, $d(t)$, $h(t)$ are the year, month, day and hour corresponding to the tth overall hour of the time period spanning from the date calculated to the end of the compliance period forecasted.

The $\text{totalNumberofHours}$ 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 runtime of one hour (i.e. no minimum runtime restriction), using historical data from the past three calendar years

This example uses block # 3788:

$$\text{TotalMarginBlock}_{\text{block 3788}}^{2007}$$

$$= \sum_{t=\text{block}}^{t=\text{block}+\text{MRT}-1} \left(\text{ForecastedBusLMP}_{y(t),m(t),d(t),h(t)}^{\text{base year}} - \text{UnitDispatchCost}_{\text{future } y,m,d}^{\text{base year}} \right)$$

$$= \sum_{t=3788}^{t=3788+1-1} \left(\text{ForecastedBusLMP}_{y,m,d,h(t)}^{2007} - \text{UnitDispatchCost}_{y,m,d(t)}^{2007} \right)$$

$$= \text{ForecastedBusLMP}_{y,m,d,h(3788)}^{2007} - \text{UnitDispatchCost}_{y,m,d,h(3788)}^{2007}$$

$$= \text{ForecastedBusLMP}_{\text{June 3,2010 H07}}^{2007} - \text{UnitDispatchCost}_{\text{June 3,2010}}^{2007} =$$
$$\$78.27 - \$69.21 = \$9.06$$

Similarly,

$$\text{TotalMarginBlock}_{\text{block 3788}}^{2008}$$

$$= \text{ForecastedBusLMP}_{\text{June 3,2010 H07}}^{2008} - \text{UnitDispatchCost}_{\text{June 3,2010}}^{2008}$$

$$= \$58.00 - \$52.41 = 5.59$$

And

$$\text{TotalMarginBlock}_{\text{block 3788}}^{2009}$$

$$= \text{ForecastedBusLMP}_{\text{June 3,2010 H07}}^{2009} - \text{UnitDispatchCost}_{\text{June 3,2010}}^{2009}$$

$$= \$63.78 - \$76.72 = -\$12.94$$

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 startup costs for each block that contains a new start, with all future outage hours removed*

9.5.8 Step 8: Determine the opportunity cost component

For each of the three years, the opportunity cost component 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 component available to the generator. If the final opportunity cost component is less than zero then the opportunity cost component will be set to zero..

Example 8.1: A unit with 700 run hours:

The average value of the block which includes the $700\text{th hour}_{\text{base 2007}} = \$7.99/\text{MWh}$

The average value of the block which includes the $700\text{th hour}_{\text{base 2008}} = \$-2.54/\text{MWh}$ The average value of the block which includes the $700\text{th hour}_{\text{base 2009}} = \$10.59/\text{MWh}$

$$700\text{th hour opportunity cost component} = \frac{\$7.99 + (-\$2.54) + 10.59}{3} = \$5.33/\text{MWh}$$

Output from step 8:
Maximum Opportunity Cost Component that can be included in an environmentally run limited generator's cost offer.

9.6 Short Term Methodology

Short Term Opportunity Costs are of limited duration where the event lasts 30 days or less. The Short Term Method modifies the method in Section 9.5 to capture intra-month price movements in fuel and electricity markets on a daily basis. The proposal requires generators to recalculate opportunity costs everyday during the short-term episode, using daily forward prices for both fuel and electricity costs instead of monthly forwards.

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

Inputs required for Step 1:
Platts-ICE Daily Forward Price 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

As before with Opportunity Costs, PJM Western Hub (Western Hub) is a liquid trading point for forward LMP prices. 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 peak and off-peak hours. The basis differential is an average for the peak or off-peak hours intra-month of the hourly bus LMP to the hourly

Western Hub LMP. The result is a ratio of the bus to the hub by time. If this ratio is greater than one, it means the bus LMP is greater than the Western Hub LMP. If this ratio is less than one, it means the bus LMP is less than the Western Hub LMP on average. The resultant ratio can be applied to the PJM Western Hub to shape it into the specific generator bus.

Platts-ICE Forward Curve for "PJM west" (PJM Western Hub) must be collected for this first step (http://www.platts.com/). The PJM Western Hub daily forward prices are multiplied by the historical basis adjustment ratio or shaping factor at the generator's bus to approximate the intra-month delivered bus prices.

Begin by taking the hourly intra-month 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 9.1: Three hourly basis differential ratios values for the same hour in each of three historical years:

$$\text{HourlyBasisDifferentialRatio}_{\text{June 3,2007 H11}} = \frac{\text{BUSLMP}_{\text{June 3,2007 H11}}}{\text{PJMWHLMP}_{\text{June 3,2007 H11}}}$$

$$\text{HourlyBasisDifferentialRatio}_{\text{June 3,2008 H11}} = \frac{\text{BUSLMP}_{\text{June 3,2008 H11}}}{\text{PJMWHLMP}_{\text{June 3,2008 H11}}}$$

$$\text{HourlyBasisDifferentialRatio}_{\text{June 3,2009 H11}} = \frac{\text{BUSLMP}_{\text{June 3,2009 H11}}}{\text{PJMWHLMP}_{\text{June 3,2009 H11}}}$$

Once the hourly basis ratios are calculated for every hour in the historic period take the sum of the on-peak hourly basis differentials, and divide by the number of peak hours. Similarly sum the off-peak hourly basis ratios , for the month then divide by the number of off-peak hours. When calculating the intra-month peak basis differential ratio, all days in the month will be used for the average . The intra-month basis differentials adjust PJM Western Hub daily peak and off-peak DA prices to expected peak and off-peak daily forward prices delivered to the generator's bus.

$$\text{MonthlyPeakBasisDifferentialRatio}_{y,m}^{\text{peak}} = \frac{\sum_{\text{peak hours}} \left(\text{HourlyBasisDifferentialRatios}_{y,m,d,h}^{\text{peak}} \right)}{\text{Number of Peak Hours in month m}}$$

$$\text{MonthlyOffPeakBasisDifferentialRatio}_{y,m}^{peak}$$

$$= \frac{\sum_{\text{off-peak hours}} \left(\text{HourlyBasisDifferentialRatios}_{y,m,d,h}^{\text{off-peak}} \right)}{\text{Number of Off} - \text{Peak Hours in month m}}$$

Example 9.2: Monthly Peak Basis Differentials for the three historical periods:

$$\text{MonthlyPeakBasisDifferentialRatio}_{\text{June 2007}}^{peak}$$

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

$$\text{MonthlyPeakBasisDifferentialRatio}_{\text{June 2008}}^{peak}$$

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

$$\text{MonthlyPeakDifferentialBasisRatio}_{\text{June 2009}}^{peak}$$

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

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

$$\text{Forecasted Monthly Bus Price}_{fy,m}^{peak}$$

$$= \left[\left(\text{PJMWestern Hub}_{fy,m}^{peak} \right) * \left(\text{MonthlyPeakBasisRatio}_{y,m}^{peak} \right) \right]$$

Example 9.3: Forecasted monthly bus prices for three historical periods:

$$\text{Forecasted Monthly Bus Price}_{\text{June 2010,base 2007}}^{\text{OFFpeak}}$$

$$= \left[(\text{PJMWH}_{\text{for delivery June 2010}}^{\text{OFFpeak}}) * (\text{MonthlyOffPeakBasisDifferentialRatio}_{\text{June 2007}}^{\text{OFFpeak}}) \right]$$

$$\text{Forecasted Monthly Bus Price}_{\text{June 2010,base 2008}}^{\text{OFFpeak}}$$

$$= \left[(\text{PJMWH}_{\text{for delivery June 2010}}^{\text{OFFpeak}}) * (\text{MonthlyOffPeakBasisDifferentialRatio}_{\text{June 2008}}^{\text{OFFpeak}}) \right]$$

$$\text{Forecasted Monthly Bus Price}_{\text{June 2010,base 2009}}^{\text{OFFpeak}}$$

$$= \left[(\text{PJMWH}_{\text{for delivery June 2010}}^{\text{OFFpeak}}) * (\text{MonthlyOffPeakBasisDifferentialRatio}_{\text{June 2009}}^{\text{OFFpeak}}) \right]$$

Outputs from Step 1:
Three peak and off-peak monthly BUS LMP forecasts for the remaining days in a month

9.6.2 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

Daily forward prices are the average peak and off-peak prices for the next day and do not include hourly LMP volatility. Step 2 derives an hourly volatility scalar. This scalar will later be multiplied against the forecasted prices in Step 1 to develop an hourly bus LMP forecast that incorporates historic hourly peak and off-peak LMP volatility.

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

$$MonthlyAverageBusLMP_{y,m}^{peak} = \frac{\Sigma_{peak\ hours} \left(HourlyBusLMP_{y,m,d,h}^{peak} \right)}{Number\ of\ Peak\ Hours\ in\ month\ m}$$

$$MonthlyAverageBusLMP_{y,m}^{off-peak} = \frac{\Sigma_{off-peak\ hours} \left(HourlyBusLMP_{y,m,d,h}^{off-peak} \right)}{Number\ of\ Off-Peak\ Hours\ in\ month\ m}$$

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.

$$HourlyVolatilityScalar_{y,m,d,h}^{peak} = \frac{BUSLMP_{y,m,d,h}^{peak}}{MonthlyAverageBusLMP_{y,m}^{peak}}$$

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

$$HourlyVolatilityScalar_{y,m,d,h}^{off-peak} = \frac{BUSLMP_{y,m,d,h}^{off-peak}}{MonthlyAverageBusLMP_{y,m}^{off-peak}}$$

Example 10.1: Volatility scalar for the each of the three historical years:

$$HourlyVolatilityScalar_{June\ 3,2007\ H23} = \frac{BUSLMP_{June\ 3,2007\ H23}}{Average\ Offpeak\ June\ 2007\ BUSLMP}$$

$$HourlyVolatilityScalar_{June\ 3,2008\ H23} = \frac{BUSLMP_{June\ 3,2008\ H23}}{Average\ Offpeak\ June\ 2008\ BUSLMP}$$

$$HourlyVolatilityScalar_{June\ 3,2009\ H23} = \frac{BUSLMP_{June\ 3,2009\ H23}}{Average\ Offpeak\ June\ 2009\ BUSLMP}$$

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

9.6.3 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:

$$\text{ForecastedBUSLMP}_{y,m,d,h}^{peak} = \text{HourlyVolatilityScalar}_{y,m,d,h}^{peak} * \text{ForecastedMonthlyBusPrice}_{fy,m}^{peak}$$

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

$$\text{ForecastedBUSLMP}_{y,m,d,h}^{off-peak}$$
$$= \text{HourlyVolatilityScalar}_{y,m,d,h}^{off-peak} * \text{ForecastedMonthlyBusPrice}_{fy,m}^{off-peak}$$

Example 11.1: Forecasted bus LMPs for one hour for each of the three historical base years:

To create the set of three forecasted prices for each hour of June 3, 2010:

$$\text{ForecastedBUSLMP}_{\text{June } 3,2010 \text{ H00,base } 2007}$$
$$= \text{HourlyVolatilityScalar}_{\text{June } 3,2007 \text{ H00}} * \text{ForecastedMonthlyBusPrice}_{\text{June } 2010}^{offpeak}$$

$$\text{ForecastedBUSLMP}_{\text{June } 3,2010 \text{ H00,base } 2008}$$
$$= \text{HourlyVolatilityScalar}_{\text{June } 3,2008 \text{ H00}} * \text{ForecastedMonthlyBusPrice}_{\text{June } 2010}^{offpeak}$$

$$\text{ForecastedBUSLMP}_{\text{June } 3,2010 \text{ H00,base } 2009}$$
$$= \text{HourlyVolatilityScalar}_{\text{June } 3,2009 \text{ H00}} * \text{ForecastedMonthlyBusPrice}_{\text{June } 2010}^{offpeak}$$

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

9.6.4 Step 4: Fuel Price

Fuel Weights if dual fuel
Contract Fuel Prices in Applicable

In the short term method, no volatility is applied to the fuel prices. Take the Day Ahead Price for the appropriate fuel, add the delivery adder and this is the appropriate fuel price to use.

For units that have dual fuels; the daily delivered fuel prices need to be multiplied by their respective weights and then added together. If there is no fuel cost record for a given date, use the previous available value.

For units with some or all of their fuel procured by contract, the contract and DA fuel prices 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.

Unit with a single fuel:

$$
\begin{aligned}
\text{Daily Delivered Fuel}_{y,m,d} = \\
\text{WeightSpot}_m * (\text{Day Ahead Fuel Price} + \text{Delivery Adjustment}) \\
+ (\text{Weight Contract}_m * \text{Contract Price}_m)
\end{aligned}
$$

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

Unit with dual fuel:

The following equation 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.

$$
\begin{aligned}
\text{Daily DeliveredFuel}_{fy,m,d} \\
= \Big[\text{WeightFuelType}_m \\
* \big(\text{Weight ContractFuelType}_m * \text{ContractPriceFuelType}_m \\
+ \text{WeightSpotFuelType}_m * (\text{Delivery AdjustmentFuelType} \\
+ \text{FuelForwardFuelType}_{fy,m})\big) + \text{WeightFuelTypeB}_m \\
* \big(\text{Weight ContractFuelTypeB}_m * \text{ContractPriceFuelTypeB}_m \\
+ \text{WeightSpotFuelTypeB}_m * (\text{Delivery AdjustmentFuelTypeB} \\
+ \text{FuelForwardFuelTypeB}_{fy,m})\big) \Big]
\end{aligned}
$$

Where Weight Fuel Type A $_m$ + Weight Fuel Type B $_m$ = 1

Where Weight Contract Type A $_m$ + Weight Spot Type A $_m$ = 1

Where Weight Contract Type B $_m$ + Weight Spot Type B $_m$ = 1

Outputs from Step 4:
Daily generator-bus delivered fuel forecast

9.6.5 Step 5: Create generating unit's cost for each of the three forecasts

Inputs for Step 5:
Expected future full heat rate intra-month
Fuel Prices output from Step 4
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 5, 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:

$$\text{UnitCost}_{fy,m,d}^{\text{base year}} =$$

$$\left\{ \left[\text{UnitHeatRate}\left(\frac{\text{mBTU}}{\text{mwh}}\right) * \text{DailyDeliveredFuelForecast}\left(\frac{\$}{\text{mBTU}}\right)_{\text{Future y,m,d}}^{\text{base year}} \right] + \right.$$

$$\left[\text{UnitHeatRate}\left(\frac{\text{mBTU}}{\text{mwh}}\right) * \text{UnitNOxEmissionRate}\left(\frac{\text{lbs}}{\text{mBTU}}\right) * \text{Cost of NOx}\left(\frac{\$}{\text{lb}}\right) \right] +$$

$$\left[\text{UnitHeatRate}\left(\frac{\text{mBTU}}{\text{mwh}}\right) * \text{UnitSO}_2\text{EmissionRate}\left(\frac{\text{lbs}}{\text{mBTU}}\right) * \text{Cost of SO}_2\left(\frac{\$}{\text{lb}}\right) \right] +$$

$$\left[\text{UnitHeatRate}\left(\frac{\text{mBTU}}{\text{mwh}}\right) * \text{UnitCO}_2\text{EmissionRate}\left(\frac{\text{lbs}}{\text{mBTU}}\right) * \text{Cost of CO}_2\left(\frac{\$}{\text{lb}}\right) \right] + \text{VOM} + \right\}$$

$$+ \text{ either a} \begin{cases} 10\% \text{ margin} \\ \text{FMU adder} \end{cases} \text{or}$$

Example 12.1: 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

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

$$= \left[\left(\frac{10.345\,mmBtu}{MWh} \right) * \left(\frac{\$3.01}{mmBtu} \right) \right]$$

$$+ \left[\left(\frac{10.345\,mmbtu}{MWh} \right) * \left(\frac{0.328\,lbs}{mmBtu} \right) * \left(\frac{\$1375.00}{ton} \right) * \left(\frac{ton}{2000\,lbs} \right) \right]$$

$$+ \left[\left(\frac{10.345\,mmbtu}{MWh} \right) * \left(\frac{1.2\,lbs}{mmBtu} \right) * \left(\frac{\$200.00}{ton} \right) * \left(\frac{ton}{2000\,lbs} \right) \right]$$

$$+ \left[\left(\frac{10.345\,mmbtu}{MWh} \right) * \left(\frac{117\,lbs}{mmBtu} \right) * \left(\frac{\$8.00}{ton} \right) * \left(\frac{ton}{2000\,lbs} \right) \right] + \left(\frac{\$2.22}{MWh} \right) + \left(\frac{\$0}{MWh} \right)$$

$$\text{Unit Cost}$$

$$= \left(\frac{\$31.14}{MWh} \right) + \left(\frac{\$2.33}{MWh} \right) + \left(\frac{\$1.24}{MWh} \right) + \left(\frac{\$4.84}{MWh} \right) + \left(\frac{\$2.22}{MWh} \right)$$

$$= \frac{\$41.77}{MWh}$$

Outputs for step 5:
Three forecasts based on historic year factors for daily generator unit cost

9.6.6 Step 6: Calculate the margin for every hour in the three hourly forecasts

Step 6 calculates the hourly margin the generator would receive by comparing the cost offer developed in step 5 against the hourly forecasted bus LMPs developed in step 3.

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:

$$
\text{TotalMarginBlock}_{\text{block}}^{\text{base year}}
= \sum_{t=\text{block}}^{t=\text{block}+\text{MRT}-1} \left(\text{ForecastedBusLMP}_{y(t),m(t),d(t),h(t)}^{\text{base year}} - \text{UnitDispatchCost}_{\text{future y,m,d}}^{\text{base year}} \right)
$$

**MRT= minimum run time

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 intra-month period.

The totalNumberofHours variable represents the number of hours left intra-month to be forecasted, and is based on the date.

Example 13.1: 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:

$$TotalMarginBlock_{block\ 3679}^{2007}$$

$$= \sum_{t=block}^{t=block+MRT-1} \left(ForecastedBusLMP_{y(t),m(t),d(t),h(t)}^{base\ year} - UnitDispatchCost_{future\ y,m,d}^{base\ year}\right)$$

$$= \sum_{t=3679}^{t=3679+1-1} \left(ForecastedBusLMP_{y(t),m(t),d(t),h(t)}^{2007} - UnitDispatchCost_{future\ y,m,d}^{2007}\right)$$

$$= ForecastedBusLMP_{y,m,d,h(3679)}^{2007} - UnitDispatchCost_{y,m,d,h(3679)}^{2007}$$

$$= ForecastedBusLMP_{June\ 3,2010\ H07}^{2007} - UnitDispatchCost_{June\ 3,2010}^{2007} =$$
$$\$53.23 - \$41.77 = \$11.46$$

Similarly

$$TotalMarginBlock_{block\ 3679}^{2008}$$

$$= ForecastedBusLMP_{June\ 3,2010\ H07}^{2008} - UnitDispatchCost_{June\ 3,2010}^{2008}$$

$$= \$55.44 - \$57.88 = -\$2.44$$

And

$$TotalMarginBlock_{block\ 3679}^{2009}$$

$$= ForecastedBusLMP_{June\ 3,2010\ H07}^{2009} - UnitDispatchCost_{June\ 3,2010}^{2009}$$

$$= \$49.78 - \$49.72 = \$0.06$$

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

> Output from step 6: 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 removed

9.6.7 Step 7: Determine the opportunity cost adder

> Input for Step 7: 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.

<div align="center">Example 14.1: A unit with 700 run hours left:</div>

The average value of the block which includes the 700th hour$_{\text{base 2007}} = \$18.33/\text{MWh}$

The average value of the block which includes the 700th hour$_{\text{base 2008}} = \$-2.50/\text{MWh}$

The average value of the block which includes the 700th hour$_{\text{base 2009}} = \$1.59/\text{MWh}$

700th hour opportunity cost adder $= \dfrac{\$18.33 + (-2.50) + \$1.59}{3} = \$5.81/\text{MWh}$

Output from step 7:
Maximum Opportunity Cost Component that can be added to an environmentally run limited generator's cost offer.