Working to Perfect the Flow of Energy

PJM Manual 15:

Cost Development Guidelines

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Prepared by

Cost Development Task Force

Section 8a: Opportunity Cost Calculation

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

- A description of the Opportunity Cost Component
- A detailed explanation of the steps in the Opportunity Cost Calculation

Opportunity Cost Component

The following methodology is approved for computing opportunity costs associated with an externally imposed environmental regulation based run-hour restriction on a generation unit. Examples would include a limit on emissions for the unit imposed by a regulatory agency or legislation~~,~~ or 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~~ may change frequently~~. Given that~~ as electricity and fuel futures ~~can~~ may 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 week.

Definitions

- **N**=number of hours in the month (on-peak/off-peak)
- **y**=year
- **m**=month
- **d**=day of the month
- **h**=hour
- **Peak**=off-peak hours only or on-peak hours only
- **FY**=future year

- **BUSLMP**=LMP at the unit's bus
- **PJMWesternHub**=PJM Western Hub LMP
- **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~~variability 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 Council (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 Council 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.

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Unit participants will submit their input data for the Monitoring Analytics' opportunity cost calculator through a web portal. That information will be stored in a database, and once a day, it will be processed by a SAS program in order to determine unit-specific opportunity costs. Those calculations for opportunity cost can be explained in nine steps.

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 are multiplied by a historical basis adjustment ratio for delivery to the generator's bus ~~creates~~ to calculate monthly delivered bus prices. The three prior calendar year's historical data is used to make this calculation. For example, when computing opportunity costs on July 1, 2009 for a unit without a rolling 12-month run-hour restriction, use historical LMP data from July 1st (2006, 2007 and 2008) to December 31st (2006, 2007, and 2008). For units with a rolling 12-month run-hour restriction, use historical LMP data from the previous three years, beginning on the date calculated three years prior, ending on the previous day. For example, when computing opportunity costs on July 1, 2009 for a unit with a rolling 12-month run-hour restriction, use historical LMP data from July 1st (2006, 2007 and 2008) to June 30th (2007, 2008, and 2009). ~~For example, when computing opportunity costs in 2009, use historical LMP data from 2006, 2007 and 2008.~~ 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

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

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

$$HourlyBasisDifferentialRatio_{June\ 3,2006\ H11} = \frac{BUSLMP_{June\ 3,2006\ H11}}{PJMWHLMP_{June\ 3,2006\ H11}}$$

$$\cancel{HourlyBasisDifferentialRatio_{June\ 3,2007\ H11} = \frac{BUSLMP_{June\ 3,2007\ H11}}{PJMWHLMP_{June\ 3,20076\ H11}}}$$

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

$$\cancel{HourlyBasisDifferentialRatio_{June\ 3,2008\ H11} = \frac{BUSLMP_{June\ 3,2008\ H11}}{PJMWHLMP_{June\ 3,20086\ H11}}}$$

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

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~~In addition, for every month, sum the off-peak hourly basis ratios, and then divide by the number of off-peak hours within that month. 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.

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

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

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

$$MonthlyPeakBasisDifferentialRatio_{June\ 2006}^{peak} = \frac{\sum_{\text{peak hours}}(Hourly\ Basis\ Differential\ RatiosJune\ 2006)}{Number\ of\ peak\ hours\ in\ June\ 2006}$$

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

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

Multiply monthly peak and off-peak basis differential ratios by the respective monthly peak and off-peak PJM Western hub forwards to ~~derive~~ calculate forecasted monthly peak and off-peak bus prices.

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

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

$$Forecasted\ Monthly\ Bus\ Price^{OFFpeak}_{June\ 2010,base\ 2006} = \left[\left(FJMWH^{OFFpeak}_{for\ delivery\ June\ 2010} \right) * \left(MonthlyOffPeakBasisDifferentialRatio^{OFFpeak}_{June\ 2006} \right) \right]$$

$$Forecasted\ Monthly\ Bus\ Price^{OFFpeak}_{June\ 2010,base\ 2007} = \left[\left(FJMWH^{OFFpeak}_{for\ delivery\ June\ 2010} \right) * \left(MonthlyOffPeakBasisRatio^{OFFpeak}_{June\ 2007} \right) \right]$$

$$Forecasted\ Monthly\ Bus\ Price^{OFFpeak}_{June\ 2010,base\ 2008} = \left[\left(FJMWH^{OFFpeak}_{for\ delivery\ June\ 2010} \right) * \left(MonthlyPeakBasisRatio^{OFFpeak}_{June\ 2008} \right) \right]$$

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~~variability scalars to incorporate hourly ~~volatility~~variability into the LMP forecast

Inputs for STEP 2:
Three years historical hourly real-time LMPs ~~prices~~ 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~~variability. Step 2 ~~derives~~ calculates ~~will develop~~ an hourly ~~volatility~~variability scalar. This scalar will later be multiplied ~~against~~ by the monthly bus LMP ~~the~~ forecast calculated in Step 1 to ultimately ~~derive~~ forecast an hourly bus LMP ~~forecast~~ that incorporates historic hourly peak and off-peak LMP ~~volatility~~variability as well as monthly peak and off-peak basis differentials with PJM Western Hub.

First, for each historic month ~~compute~~ calculate the average peak and off-peak price at the unit's bus for each remaining month in the compliance period.

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

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

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

$$\text{HourlyVariabilityRatio}^{\text{base year}}_{y,m,d,h} = \frac{\text{BUSLMP}^{\text{peak}}_{y,m,d,h}}{\frac{\sum_{n=1}^{N^{\text{peak}}_{y,m}}\left(\text{BUSLMP}^{\text{peak}}_{y,m}\right)}{N^{\text{peak}}_{y,m}}}$$

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

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

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

$$\text{HourlyVariabilityRatio}^{\text{base year}}_{y,m,d,h} = \frac{\text{BUSLMP}^{\text{peak}}_{y,m,d,h}}{\frac{\sum_{n=1}^{N^{\text{peak}}_{y,m}}\left(\text{BUSLMP}^{\text{peak}}_{y,m}\right)}{N^{\text{peak}}_{y,m}}}$$

$$\text{HourlyVariabilityRatio}^{\text{base year}}_{y,m,d,h} = \frac{\text{BUSLMP}^{\text{off-peak}}_{y,m,d,h}}{\frac{\sum_{n=1}^{N^{\text{off-peak}}_{y,m}}\left(\text{BUSLMP}^{\text{off-peak}}_{y,m}\right)}{N^{\text{off-peak}}_{y,m}}}$$

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

$$\cancel{HourlyVolatilityScalar_{June3,2006\ H24}} = \frac{BUSLMP_{June\ 3,2006\ H24}}{Average\ Offpeak\ June\ 2006\ BUSLMP}$$

$$\cancel{HourlyVolatilityScalar_{June3,2007\ H24}} = \frac{BUSLMP_{June\ 3,2007\ H24}}{Average\ Offpeak\ June\ 2007\ BUSLMP}$$

$$\cancel{HourlyVolatilityScalar_{June3,2008\ H24}} = \frac{BUSLMP_{June\ 3,2008\ H24}}{Average\ Offpeak\ June\ 2008\ BUSLMP}$$

$$HourlyVariabilityRatio^{base2006}_{June3,2006\ H23} = \frac{BUSLMP_{June\ 3,2006\ H23}}{Average\ OFFpeak\ June\ 2006\ BUSLMP}$$

$$HourlyVariabilityRatio^{base2007}_{June3,2007\ H23} = \frac{BUSLMP_{June\ 3,2007\ H23}}{Average\ OFFpeak\ June\ 2007\ BUSLMP}$$

$$HourlyVariabilityRatio^{base2008}_{June3,2008\ H23} = \frac{BUSLMP_{June\ 3,2008\ H23}}{Average\ OFFpeak\ June\ 2008\ BUSLMP}$$

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

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 Forecasts
Output from STEP 2: Hourly ~~volatility~~variability scalars

Step 3 creates three hourly forecasts from the ~~volatility~~variability scalars developed in step 2 and the monthly bus LMP forecasts ~~prices~~ developed in Step 1. Multiply the hourly ~~volatility~~variability scalars developed in step 2 by the corresponding forecasted monthly bus ~~price~~ LMPs 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

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

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

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

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

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

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:

$$ForecastedBUSLMP_{June\ 3,2009\ H00,base\ 2006} = HourlyVolatilityScalar_{June\ 3,2006\ H00} * ForecastedMonthlyBusPrice^{offpeak}_{June\ 2009}$$

$$ForecastedBUSLMP_{June\ 3,2009\ H00,base\ 2007} = HourlyVolatilityScalar_{June\ 3,2007\ H00} * ForecastedMonthlyBusPrice^{offpeak}_{June\ 2009}$$

$$ForecastedBUSLMP_{June\ 3,2009\ H00,base\ 2008} = HourlyVolatilityScalar_{June\ 3,2008\ H00} * ForecastedMonthlyBusPrice^{offpeak}_{June\ 2009}$$

$$ForecastedBUSLMP^{baseyear2006}_{June\ 3,2009\ H00} = HourlyVariabilityRatio_{June\ 3,2006\ H00} * ForecastedMonthlyBusPrice^{OFFpeak}_{June\ 2009}$$

$$ForecastedBUSLMP^{baseyear2007}_{June\ 3,2009\ H00} = HourlyVariabilityRatio_{June\ 3,2007\ H00} * ForecastedMonthlyBusPrice^{OFFpeak}_{June\ 2009}$$

$$ForecastedBUSLMP^{baseyear2008}_{June\ 3,2009\ H00} = HourlyVariabilityRatio_{June\ 3,2008\ H00} * ForecastedMonthlyBusPrice^{OFFpeak}_{June\ 2009}$$

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

STEP 4: Create a daily fuel ~~volatility~~variability scalar

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

Step 4 creates a daily fuel ~~volatility~~variability scalar using historical 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. For units that have dual fuel types; 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.

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

~~**Example 4.1: Three daily fuel volatility scalars values developed for June 3 in each of three historic years:**~~

$$\cancel{DailyFuelVolatilityScalar_{June\ 3,2006}} = \frac{DeliveredFuelPrice_{June\ 3,2006}}{Average\ June\ 2006\ DeliveredFuelPrice}$$

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

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

Units with Single Fuel Type:

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

Where N_m is the number of days in month m.

Units with Dual Fuel Types:

$$DailyFuelVariabilityRatio_{y,m,d} = \frac{(DeliveredFuelPriceFuelTypeA_{y,m,d} * WeightFuelTypeA) + (DeliveredFuelPriceFuelTypeB_{y,m,d} * WeightFuelTypeB)}{\left(\frac{\sum_{d=1}^{N_m}\left((DeliveredFuelPriceFuelTypeA_{y,m} * WeightFuelTypeA) + (DeliveredFuelPriceFuelTypeB_{y,m} * WeightFuelTypeB)\right)}{N_m}\right)}$$

Example 4.1: Three daily fuel variability scalar values developed for June 3, 2009 for a unit with a single fuel type:

$$DailyFuelVariabilityRatio_{June\ 3,2006} = \frac{DeliveredFuelPrice_{June\ 3,2006}}{Average\ June\ 2006\ DeliveredFuelPrice}$$

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

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

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~~variability*

STEP 5: Create three daily delivered fuel forecasts

> *Inputs for STEP 5:*
> *Platts Forward curve for Fuel from the most recent trading day, for delivery in the compliance period ($/mmBtu) with a daily delivery charge adjustment*
> *Output from STEP 4: Three years historic daily scalars for fuel ~~volatility~~variability*
> *Fuel weights if dual fuel type*
> *Fuel monthly contract price is applicable*

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Step 5 takes fuel ~~futures~~ forwards based on a unit's fuel policy (as approved by the MMU) and the daily delivered fuel scalars from step 4 and multiplies them together to ~~create~~ calculate a fuel forecast that corresponds on an average monthly basis to the fuel futures, yet maintains historical ~~volatility~~variability. The selected fuel forward price should be from the most recent trading day, for delivery in the compliance period. Once determined, a fuel forward index must be used for the duration of the compliance period. For units that have multiple fuel types; the daily delivered fuel scalar will be multiplied by the fuel forward price and their respective weights per fuel type and added together. For units with some or all of their fuel coming from monthly contracts, the daily delivered fuel term will properly weight the monthly contract price and the daily delivered fuel forecast price for each day in a given month.

$$Daily\ DeliveredFuel_{fy,m,d} = DailyFuelVolatilityScalar_{y,m,d} * FuelForward_{fy,m}$$

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

$$DailyDeliveredFuelForecast^{baseyear2006}_{June\ 3,2009,base\ 2006} = DailyFuelVolatilityScalar_{June\ 3,2006} * FuelForward_{June\ 2009}$$

$$DailyDeliveredFuelForecast_{June\ 3,2009,base\ 2007} = DailyFuelVolatilityScalar_{June\ 3,2007} * FuelForward_{June\ 2009}$$

$$DailyDeliveredFuelForecast_{June\ 3,2009,base\ 2008} = DailyFuelVolatilityScalar_{June\ 3,2008} * FuelForward_{June\ 2009}$$

Units with Single Fuel Type:

$$Daily\ DeliveredFuel_{fy,m,d} = DailyFuelVariabilityRatio_{y,m,d} * (WeightSpot_m * FuelForward_{fy,m} + WeightContract_m * ContractPrice_m)$$

Units with Dual Fuel Types:

$$DailyDeliveredFuel_{fy,m,d} =$$

$$DailyDeliveredFuel_{fy,m,d} = DailyFuelVariabilityRatio_{y,m,d} * \left(\left(FuelForwardFuelTypeA_{fy,m} * WeightFuelTypeA_m * WeightSpotFuelTypeA_m\right) + \left(FuelForwardFuelTypeB_{fy,m} * WeightFuelTypeB_m * WeightSpotFuelTypeB_m\right) \right)$$

$$DailyFuelVariabilityRatio_{y,m,d} * \left(WeightSpot_m * \left(FuelForwardFuelTypeA_{fy,m} * WeightFuelTypeA + FuelForwardFuelTypeB_{fy,m} * WeightFuelTypeB\right) + WeightContract_m * ContractPrice_m\right)$$

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

$$DailyDeliveredFuelForecast_{June\ 3,2009}^{baseyear2006} = DailyFuelVariabilityRatio_{June\ 3,2006} * FuelForward_{June\ 2009}$$

$$DailyDeliveredFuelForecast_{June\ 3,2009}^{baseyear2007} = DailyFuelVariabilityRatio_{June\ 3,2007} * FuelForward_{June\ 2009}$$

$$DailyDeliveredFuelForecast_{June\ 3,2009}^{baseyear2008} = DailyFuelVariabilityRatio_{June\ 3,2008} * FuelForward_{June\ 2009}$$

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

Step 6: ~~create~~ Create generating units dispatch cost for each of the three forecasts

Inputs for STEP 6:
~~Expected future~~Average, full load seasonal (May-September / October~~r~~ – April) heat rate ~~for the compliance period~~ of the previous available year
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

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In step 6, take the unit characteristics, future emission allowance prices, the three daily fuel forecasts and create a daily unit dispatch cost for the three forecasts using the appropriate heat rate for the forecast day. Either the FMU adder or the 10% scaling factor may be used but not both. -For each day in the three fuel forecasts, a unit dispatch cost is calculated as follows:

$$UnitDispatchCost_{fy,m,d}^{base\ year} = \left\{\left[UnitHeatRate\left(\frac{mmbtu}{mwh}\right) * DailyDeliveredFuelForecast(\$/mmbtu)_{fy,m,d}^{base\ year}\right] + \left[UnitHeatRate\ (mmbtu/mwh) * UnitNOxEmissionRate(lbs/mmbtu) * Cost\ of\ NOx\left(\frac{\$}{lb}\right)\right] + \right.$$

$$\Big[UnitHeatRate\ (mmbtu/mwh) * UnitSO_2EmissionRate\ (lbs/mmbtu) * Cost\ of\ SO_2\left(\$/_{lb}\right)\Big] +$$

$$\Big[UnitHeatRate\ (mmbtu/mwh) * UnitCO_2EmissionRate\ (lbs/mmbtu) * Cost\ of\ CO_2\left(\$/_{lb}\right)\Big] + VOM + \Big\} + \text{ either a 10\% margin or FMU adder}$$

Example 6.1: Daily dispatch 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

$$UnitDispatchCost =$$

$$\left[\left(\frac{10.35mmbtu}{mwh}\right) * \left(\frac{\$3.01}{mmbtu}\right)\right] +$$
$$\left[\left(\frac{10.35mmbtu}{mwh}\right) * \left(\frac{0.328\ lbs}{mmbtu}\right) * \left(\frac{\$1375.00}{ton}\right) * \left(\frac{ton}{2000\ lbs}\right)\right] +$$
$$\left(\left[\left(\frac{10.35\ mmbtu}{mwh}\right) * \left(\frac{1.2\ lbs}{mmbtu}\right) * \left(\frac{\$200}{ton}\right) * \left(\frac{ton}{2000}lbs\right)\right]\right) +$$
$$\left[\left(\frac{10.345mmbtu}{mwh}\right) * \left(\frac{117lbs}{mmbtu}\right) * \left(\frac{\$8}{ton}\right) * \left(\frac{ton}{2000lbs}\right)\right] + \left(\frac{\$2.22}{MWh}\right)$$

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

$$UnitDispatchCost_{fy,m,d}^{base\ year} = \left(\frac{\$31.16}{MWh}\right) + \left(\frac{\$2.34}{MWh}\right) + \left(\frac{\$1.25}{MWh}\right) + \left(\frac{\$4.85}{MWh}\right) + \left(\frac{\$2.22}{MWh}\right) = \$41.82/MWh$$

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

Step 7: Calculate the runs hours used to date for the current calendar or rolling year

Inputs for Step 7:
Generator real time 5 minute bus MWs for current compliance period

Step 7 calculates the run hours of a generator used in the compliance period to date. Accumulate the running time from the start of the calendar or rolling year to midnight the previous day and round the total run time up to the nearest hour. For example, when computing opportunity costs for a calendar year on July 5, 2009, calculate total run hours from January 1, 2009 to July 4, 2009 11:59:59PM and then round to the nearest hour.

Output from step 7: Generator run hours used to date

Step ~~7~~8: Calculate the margin for every hour in the three hourly forecasts

Inputs for Step ~~7~~8:
Daily Generator Dispatch Cost from Step 6
Hourly Generator bus LMP forecast from Step 3
Generator run hours used to date from Step 7
All future outage information
Unit-specific minimum run time parameter restriction
Unit-specific start up costs
~~Daily Generator Dispatch Cost from Step 6~~
~~Hourly Generator bus LMP forecast from Step 3~~

Step 8 calculates the hourly margins 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 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 a unit. For units with start-up costs, the value of that start-up cost 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. Calculate the total margins for all blocks of hours in the three forecasts:

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

~~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. This methodology assumes no minimum run time, no ramping time restrictions and no startup cost. Calculate the hourly margin for every hour in the three forecasts:~~

~~$HourlyUnitMargin_{y,m,d,h}^{base\ year}$ = max [0, ($ForecastedBUSLMP_{y,m,d,h}^{base\ year}$ – $UnitDispatchCost_{y,m,d}^{baseyear}$)]~~

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 tth overall hour of the time period spanning from the date calculated to the end of the compliance period forecasted.

The $totalNumberofHours$ variable represents the output from Step 7: Generator Run Hours used to date. This variable is 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.

~~If the HourlyUnitMargin < 0, then the HourlyUnitMargin is normalized to zero because the unit would not wish to run in any hour in which its dispatch cost exceeds LMP.~~

~~E~~Example 8.1: Computing 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~~xample 7.1: Computing hourly margins~~

~~$HourlyUnitMargin_{June\ 3,2009\ H07}^{base\ 2006} = ForecastedBUSLMP_{June\ 3,2009\ H07}^{base\ 2006} - UnitDispatchCost_{June\ 3,2009}^{base2006}$~~

~~$HourlyUnitMargin_{June\ 3,2009\ H07}^{base\ 2007} = ForecastedBUSLMP_{June\ 3,2009\ H07}^{base\ 2007} - UnitDispatchCost_{June\ 3,2009}^{base2007}$~~

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~~$HourlyUnitMargin^{base\ 2008}_{June\ 3,2009\ HE7} = ForecastedBUSLMP^{base\ 2008}_{June\ 3,2009\ HE7} - UnitDispatchCost^{base2008}_{June\ 3,2009}$~~

~~$HourlyUnitMargin^{base\ 2006}_{June\ 3,2009\ HE7}$ =max [0, ($53.23 - $41.66)] =$11.57~~

~~$HourlyUnitMargin^{base\ 2007}_{June\ 3,2009\ HE7}$ =max [0, ($55.44 - $57.88)] = $0.00~~

~~$HourlyUnitMargin^{base\ 2008}_{June\ 3,2009\ HE7}$ =max [0, ($49.78 - $49.72)] =$0.06~~

$$TotalMarginBlock^{base\ 2006}_{block\ 3679} = \sum_{i=block}^{i=block+MinRunTime-1} ForecastedBUSLMP^{base\ year}_{y(i),m(i),d(i),h(i)} - UnitDispatchCost^{base\ year}_{y(i),m(i),d(i)} = \sum_{i=3679}^{i=3679+1-1} ForecastedBUSLMP^{base\ 2006}_{y(i),m(i),d(i),h(i)} - UnitDispatchCost^{base\ 2006}_{y(i),m(i),d(i)} = ForecastedBUSLMP^{base\ 2006}_{y(3679),m(3679),d(3679),h(3679)} - UnitDispatchCost^{base\ 2006}_{y(3679),m(3679),d(3679)} = ForecastedBUSLMP^{base\ 2006}_{June\ 3,2009\ HE7} - UnitDispatchCost^{base\ 2006}_{June\ 3,2009} = \$53.23 - \$41.66 = \$11.57$$

 - Similarly,

$$TotalMarginBlock^{base\ 2007}_{block\ \#3679} = ForecastedBUSLMP^{base\ 2007}_{June\ 3,2009\ HE7} - UnitDispatchCost^{base\ 2006}_{June\ 3,2009} = \$55.44 - \$57.88 = -\$2.44$$

$$TotalMarginBlock^{base\ 2008}_{block\ \#3679} = ForecastedBUSLMP^{base\ 2008}_{June\ 3,2009\ HE7} - UnitDispatchCost^{base\ 2006}_{June\ 3,2009} = \$49.78 - \$49.72 = \$0.06$$

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

Output from step ~~7~~8: 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 ~~Three hourly margin forecasts for each hour in the compliance period.~~

~~Step 8: Outages and dates passed~~

~~Input to Step 8: All future maintenance outage information~~

~~For any future date that the unit will be offline, or for any date that has passed, set the margin equal to zero. Therefore, for each of the three forecasts, set all dates that the unit will be unavailable to have zero margins.~~

~~Output from step 8:~~
~~Three hourly margin forecasts for each hour in the compliance period with all future outages and previous days having margins equal to zero.~~

Step 9: ~~Rank the hourly margin forecasts for each of the three years from largest to smallest value~~Determine the opportunity cost adder

Input for Step 9: Three ~~hourly margin forecasts from step 8 adjusted for outages and days passed~~sets of ranked blocks of total margins forecasts

~~For~~ 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. The opportunity cost adder which may be applied to each point on a unit's bid curve will be entered separately into eMkt by the participant.~~each of the three years, rank the hourly margin forecasts from largest to smallest value. Number each by their rank order. The three numbers that correspond to the minimum run hour are averaged together to get the maximum opportunity cost available to the generator.~~

Example 9.1: A unit with 700 run hours left:

~~700th Margin $_{base2006}$ = $2.10/MWh~~
~~700th Margin $_{base2007}$ = $0.00/MWh~~
~~700th Margin $_{base2008}$ = $0.06/MWh~~

The average value of the block which includes the 700th hour$_{base2006}$ = $2.10/MWh
The average value of the block which includes the 700th hour$_{base2007}$ = −$2.14/MWh
The average value of the block which includes the 700th hour$_{base2008}$ = $0.06/MWh
~~The average value of the block which includes the 700th hour$_{base2006}$ =~~
~~The average value of the block which includes the 700th hour$_{base2007}$ = −$2.14/MWh~~
~~The average value of the block which includes the 700th hour$_{base2008}$ =~~

700th hour opportunity cost adder = $\frac{\$2.10+(-\$2.14)+\$0.06}{3}$ = $0.01/MWh

~~700th hour maximum opportunity cost component = $\frac{\$2.10+\$0.00+\$0.06}{3}$ = $0.72/MWh~~

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