Weather Sensitive Adjustment Using the WSA Factor Method

Alternate CBLs can be requested within eLRS to compensate for the temperature differences between the CBL basis days and the temperature of the event hour. The Weather Sensitive Adjustment (WSA) factor method is one such alternate CBL that can be requested. The WSA Factor Method adjusts the hourly CBL (up or down) to compensate for the average hourly temperature differences between the CBL basis days and the temperature of the event hour.

The WSA Factor represents the kW change in load for each degree of temperature change within a specified temperature range. The WSA factor is the slope of the line that describes the load and temperature relationship at the customer site between two temperature set points. The WSA Factor or slope of the line is obtained by performing a linear or piecewise linear regression analysis on the load and temperature data from the customer site. There should be at least two years of data used in the linear regression analysis to indicate the normal operation of the facility. Exceptions may be granted by PJM to use less data in cases where the normal operations have changed significantly between years. The analysis data should only include the day types and hours where load reductions are expected. For example, if the customer is only expected to respond during the hours of 8am to 6pm from Monday through Friday during non-holidays, then such historic hours should be used in the regression model.

The hourly CBL Adjustment is obtained by multiplying the WSA Factor by the temperature of the event hour minus the hourly average temperature of the CBL. The hourly average temperature of the CBL is the hourly average of the basis days used for the CBL.

Example 1:

- Hourly average temperature of the CBL for hour ending 12 = 86°
- Event temperature for Hour Ending 12 = 81°
- WSA Factor = 688 kW/°F
  CBL Adjustment for Hour Ending 12 = Temperature Delta * WSA Factor
  = (81° - 86°) * 688 kW/°F = -3440 kW

The CBL is adjusted down because the temperature of the event day is lower than the average hourly temperature of the CBL basis days.

A simple linear regression analysis fits a straight line through the set of points (load and temperature data) in such a way that makes the sum of squared residuals as small as possible. The first and last points of the estimated line are known as the Temperature Set Points. The Slope of the line between the two Temperature Set points is the WSA factor.

A piecewise linear regression analysis fits multiple contiguous straight lines through the set of data points (load and temperature data) in such a way that makes each of the sum of squared residuals as small as possible. The piecewise linear regression analysis results in multiple lines with multiple slopes that estimate the load and temperature relationship of the customer site data. The end points of each of the estimated lines are known as the Temperature Set Points. Determining the number Temperature Set Points can be accomplished by using a Piecewise Linear Regression Break Point algorithm or by data observation at points where the slope of the

data appears to change significantly. Either methodology should result in minimizing the sum of squared residuals for each of the estimated lines.

Example 2:

Calculate WSA Factors applicable for summer curtailments using Piecewise Linear Regression.

Figure 1 shows a scatter plot of load versus temperature for a site. Since future load reductions are expected only on weekdays during hours ending 8 through hours ending 20, the load and temperature data excludes weekends, holidays and hours ending 21 through hours ending 7. Temperature set points are established at the temperatures where the slope of the estimated curve changes significantly. The temperature set points can be seen in Figure 1.

The minimum temperature for a summer WSA adjustment is 60°. Therefore, a regression analysis is not performed on temperature data below 60°. Two linear regression analyses were performed on the data between 60° and 95°. A regression analysis was not performed on temperatures at or above 95° since the air conditioning loading becomes saturated starting at 95° for this facility. When the weather sensitive load becomes saturated, a weather sensitive adjustment is not required.

A piecewise linear regression analysis was performed on the data between 60 and 95 degrees. By observation, it was determined that there is a change in slope beginning at 76 degrees. Therefore, the Temperature set points were determined to be 60, 76 and 95 degrees. The first linear regression analysis was performed using a temperature range of >= 60 and less than 76. The second linear regression analysis was performed using a temperature range of >= 76 and less than 95. Each range of temperatures defines a Set Point. The slopes for each of the Set Points (temperature ranges) were calculated. An additional Temperature Set Point was arbitrarily set at 120 degrees to establish the 0 slope characteristic for the saturated load above 95 degrees. Figure 2 shows the WSA Factors at each of the Temperature set points.

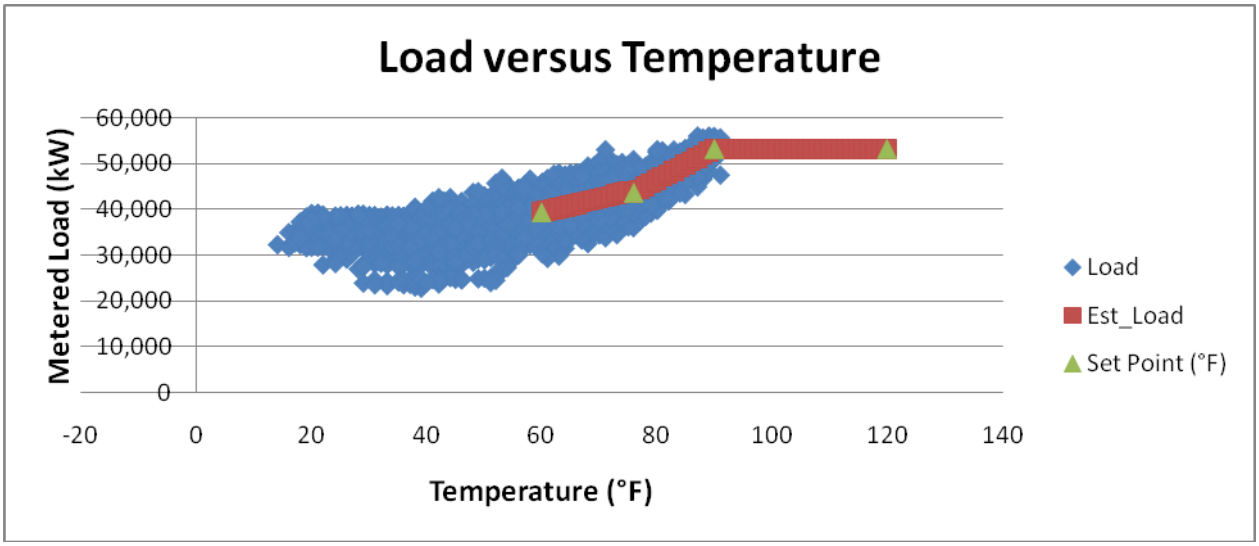

Figure 1: Scatter Plot of Load Versus Temperature

Example 3:

Using the WSA parameters in Figure 2, CBL Adjustments are calculated for hours ending 7, 16, 17 and 18 using the WSA Factor Method. Figure 3 shows the temperatures and the WSA Factors that are used to calculate the CBL Adjustments for each hour of the settlement.

Parameter	Set Point (°F)	Set Point Range (°F)	WSA Factor (kW/°F)
WSA1	60	<60	0
WSA2	76	>=60 <76	305
WSA3	95	>=76 <95	688
WSA4	120	>=95 <120	0

Figure 2: WSA Parameters

	Hour Ending 7	Hour Ending 16	Hour Ending 17	Hour Ending 18
Average CBL Temp (°F)	70	75	82	83
Event Day Temp (°F)	75	86	90	70
Delta Temperature (°F)	5	11	8	-13
WSA Factor (kW/°F)	305	653.182	688	511.231
CBL Adjustment (kW)	1525	7185	5504	-6646

Figure 3: Temps and WSA Factors

An explanation of the CBL Adjustment calculations along with the selection of the WSA factors used for each hour ending of Figure 3 appears below.

Hour Ending 7:
The CBL is to be adjusted upward along the estimated load curve based on the temperature of the settlement event hour. The average CBL temperature is 70° and needs to be adjusted upward to the event temperature of 75°. The CBL and Event temperatures are within the same parameter ranges. Therefore, the WSA Factor is 305 kW/°F.
CBL Adjustment = 5°F * 305 kW/°F = 1525 kW.

Hour Ending 16:
The CBL is to be adjusted upward along the estimated load curve based on the temperature of the settlement event hour. The average CBL temperature is 75° and needs to be adjusted upward to the event temperature of 86°. Since the CBL and Event temperatures are not within the same parameter ranges, a temperature weighted WSA Factor is calculated.
WSA Factor = ((1°F * 305 kW/°F) + (10°F * 688 kW/°F)) / 11°F = 653.182 kW/°F.
CBL Adjustment = 11°F * 653.182 kW/°F = 7185 kW.

Hour Ending 17:
The CBL is to be adjusted upward along the estimated load curve based on the temperature of the settlement event hour. The average CBL temperature is 82° and needs to be adjusted upward to the event temperature of 90°. The CBL and Event temperatures are within the same parameter ranges. Therefore, the WSA Factor is 688 kW/°F.
CBL Adjustment = 8°F * 688 kW/°F = 5504 kW.

Hour Ending 18:
The CBL is to be adjusted downward along the estimated load curve based on the temperature of the settlement event hour. The average CBL temperature is 83° and needs to be adjusted downward to the event temperature of 70°. Since the CBL and Event temperatures are not within the same parameter ranges, a temperature weighted WSA Factor is calculated.
WSA Factor = ((7°F * 688 kW/°F) + (6°F * 305 kW/°F)) / 13°F = 511.231 kW/°F.
CBL Adjustment = -13°F * 511.231 kW/°F = -6646 kW.

Example 4:

Calculate and use WSA Factors applicable for winter curtailments using Piecewise Linear Regression.

A characteristic of a weather sensitive load in the winter is that the load increases as the temperature decreases. This characteristic results in a negative slope or negative WSA factor. Figure 4 shows the results of a piecewise linear regression analysis for a customer site that has weather sensitive loads when the outdoor temperature is less than 60 degrees. The maximum temperature for a winter WSA adjustment is 50° and the minimum temperature for a summer WSA adjustment is 60°. It is assumed that there is no significant heating or cooling between 50° and 60°. Therefore a regression analysis is not performed on data within this temperature range.

For this facility, the heating load saturates out for temperatures less than 20 degrees and therefore the slope or WSA factor equals 0 kW/°F. When the weather sensitive load becomes saturated, a weather sensitive adjustment is not required.

Parameter	Set Point (°F)	Set Point Range (°F)	WSA Factor (kW/°F)
WSA1	20	<20	0
WSA2	40	>=20 <40	-650
WSA3	50	>=40 <50	-225
WSA4	60	>=50 <60	0

Figure 4: WSA Parameter

Using the WSA parameters in Figure 4, CBL Adjustments are calculated for hours ending 7, 15, and 16 using the WSA Factor Method. Figure 5 shows the temperatures and the WSA Factors that are used to calculate the CBL Adjustments for each hour of the settlement.

	Hour Ending 7	Hour Ending 15	Hour Ending 16
Average CBL Temp (°F)	15	40	35
Event Day Temp (°F)	25	20	15
Delta Temperature (°F)	10	-20	-20
WSA Factor (kW/°F)	-325	-650	-487.5
CBL Adjustment (kW)	-3250	13000	9750

Figure 5: Termerature and WSA Factors

An explanation of the CBL Adjustment calculations along with the selection of the WSA factors used for each hour ending of Figure 5 appears below.

Hour Ending 7:
The CBL is to be adjusted along the estimated load curve based on the temperature of the settlement event hour. The average CBL temperature is 15° and needs to be adjusted to the event temperature of 25°. Since the CBL and Event temperatures are not within the same parameter ranges, a temperature weighted WSA Factor is calculated.
WSA Factor = (5°F * 0 kW/°F) + ((15°F * -650 kW/°F)) / 10°F = -325 kW/°F.
CBL Adjustment = 10°F * -325 kW/°F = -3250 kW.
Since the slope or WSA factor is negative and the Delta Temperature is positive, the CBL is adjusted downward.

Hour Ending 15:
The CBL is to be adjusted along the estimated load curve based on the temperature of the settlement event hour. The average CBL temperature is 40° and needs to be adjusted to the event temperature of 20°. The CBL and Event temperatures are within the same parameter ranges. Therefore, the WSA Factor is -650 kW/°F.
CBL Adjustment = -20°F * -650 kW/°F = 13000 kW.
Since the slope or WSA factor is negative and the Delta Temperature is negative, the CBL is adjusted upward.

Hour Ending 16:
The CBL is to be adjusted along the estimated load curve based on the temperature of the settlement event hour. The average CBL temperature is 35° and needs to be adjusted to the event temperature of 15°. Since the CBL and Event temperatures are not within the same parameter ranges, a temperature weighted WSA Factor is calculated.
WSA Factor = ((15°F * -650 kW/°F) + (5°F * 0 kW/°F)) / 20°F = -487.5 kW/°F.
CBL Adjustment = -20°F * -487.5 kW/°F = 9750 kW.

Since the slope or WSA factor is negative and the Delta Temperature is negative, the CBL is adjusted upward.

Zone	Weather Station Short Name	Weather Station
AECO	ACY	Atlantic City International
AEP	CMH	Port Columbus International
APS	PIT	Pittsburgh International
BGE	BWI	Baltimore Washington International
COMED	ORD	Chicago OHare International
DAY	DAY	Cox-Dayton International
DOM	RIC	Richmond International
DPL	PHL	Philadelphia International
DUQ	PIT	Pittsburgh International
JCPL	EWR	Newark International
METED	PHL	Philadelphia International
PECO	PHL	Philadelphia International
PENELEC	JST	Johnstown Airport
PEPCO	DCA	Washington Reagan National
PPL	ABE	Allentown Lehigh Valley International
PSEG	EWR	Newark International
RECO	EWR	Newark International

Table 1: Weather Stations used for each Zone