Customer Baseline (CBL) Calculation for New York ISO

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(Technical Report)

Abstract- In this report, the performance of customer baselines are analyzed for the residential customers. In this report, the classic analyses of CBL methods, i.e., baseline accuracy and bias are employed. This analysis is done for two scenarios of with and without prior curtailment event. CBL calculation procedure is shown for one individual and then it extends to all the customers in the dataset.

Index terms: Customer Baseline (CBL), Demand Response (DR), percent accuracy metrics, percent bias metrics

INTRODUCTION

The electricity markets are developing steadily over many years of restructuring and competition. However, due to the isolation of the demand side from the electricity market, the demand-side is plagued with many inefficiencies. To solve this problem, recent studies demonstrate that demand response (DR) programs can provide a reasonable response to such challenges. These programs can potentially create a number of possibilities for the system operators and utilities to improve both economic and technical indices of their system. As a matter of fact, power system operators can compensate lack of their supply during the peak time with DR resources [1].

Although DR programs look very promising in theory, in practice host of problems make them difficult to implement. These problems root in diversity of customers, loads and heterogeneity in types of DR programs [2-3]. Because of all these complications, policy makers are concerned about the way load aggregators compensate customers. Many DR programs rely on customer baseline (CBL) to compensate customers. CBL is a counterfactual consumption level, i.e. the amount of electricity that customers would have consumed in the absence of DR event. CBL is also a basis to measure DR programs' performance. Moreover, a well-designed baseline could benefit all stakeholders by aligning their incentives, actions and interests.

In this report, a CBL method employed by NYISO is examined on a residential data. The data is described in the following sections. The accuracy and bias metrics are utilized to evaluate the performance of this method.

DATA

For this report, the Irish CER smart metering trial dataset [4] has been used. This dataset contains measurements of around 5000 customers over 1.5 years and it is available to the public. The customers consist of residential houses and small and medium-sized enterprises. The measurements started in July 2009 and ended in December 2010. In this report, the data of 110 Customers from Nov. 24th to Dec. 17th 2010 are used for the analysis.

The following are the description of the data.

Holidays in Ireland:

- Nov. 27 Saturday
- Nov. 28 Sunday
- Dec. 4 Saturday
- Dec. 5 Sunday
- Dec. 11 Saturday
- Dec. 12 Sunday

TABLE 1: THE DESCRIPTION OF THE DAYS IN DATA

Day 1	(Wed) Nov. 24	Day 13	(Mon) Dec. 6
Day 2	(Thur) Nov. 25	Day 14	(Tue) Dec. 7
Day 3	(Fri) Nov. 26	Day 15	(Wed) Dec. 8
Day 4	(Sat) Nov. 27	Day 16	(Thur) Dec. 9
Day 5	(Sun) Nov. 28	Day 17	(Fri) Dec. 10
Day 6	(Mon) Nov. 29	Day 18	(Sat) Dec. 11
Day 7	(Tue) Nov. 30	Day 19	(Sun) Dec. 12
Day 8	(Wed) Dec. 1	Day 20	(Mon) Dec. 13
Day 9	(Thur) Dec. 2	Day 21	(Tue) Dec. 14
Day 10	(Fri) Dec. 3	Day 22	(Wed) Dec. 15
Day 11	(Sat) Dec. 4	Day 23	(Thur) Dec. 16
Day 12	(Sun) Dec. 5	Day 24	(Fri) Dec. 17

NYISO CBL CALCULATION ALGORITHM

New York ISO CBL methodology in its Day-Ahead Demand Response Program for approved demand response providers is as follows [5].

The goal for the baseline calculation is to select the 5 highest “average daily kWh usage” days from a pool of 10 days that meet the calculation criteria defined in Steps 1-4.

Step 1: The process starts when a Demand Side Resource (DSR) contracts to be in the Day-Ahead Demand Response Program.

Step 2: For the day two days prior to event day, calculate an “average daily event period kWh usage” value for that day which is the sum of the 24 hourly demands. If the day chosen for this step is a weekend, holiday, event day or curtailment day then select the next day going backward that does meet the above criteria. This value is stored in the “baseline calculation window”. The “baseline calculation window” can be looked at as a storage file for the 10 selected days necessary to calculate the baseline.

Step 3: Select the next previous day which is the day before the Step 2 day. If the day chosen for this step is a weekend, holiday, event day or curtailment day then select the next day going backward that does meet the above criteria. Calculate an “average daily event period kWh usage” value for that day.

Step 4: Compare the “average daily event period kWh usage” from Step 2 to Step 3 “average daily event period kWh usage”. If the Step 3 “average daily event period kWh usage” is greater than 25% of the “average daily event period kWh usage” from step 2, include the Step 3 “average daily event period kWh usage” in the “baseline calculation window”. Otherwise, discard the Step 3 “average daily event period kWh usage”.

Step 5: The process repeats itself using step 3 and Step 4 until 10 days have been placed into the “baseline calculation window”.

RESULTS AND DISCUSSION

The CBL is calculated for two scenarios, one with two prior curtailment events before the main event and the other with no prior curtailment event. Figure 1 shows the total consumption for all 24 days of data. In both scenarios, the event day is 20^{th} day of the dataset. In scenario 1, there are two prior curtailment events in days 14 and 15.

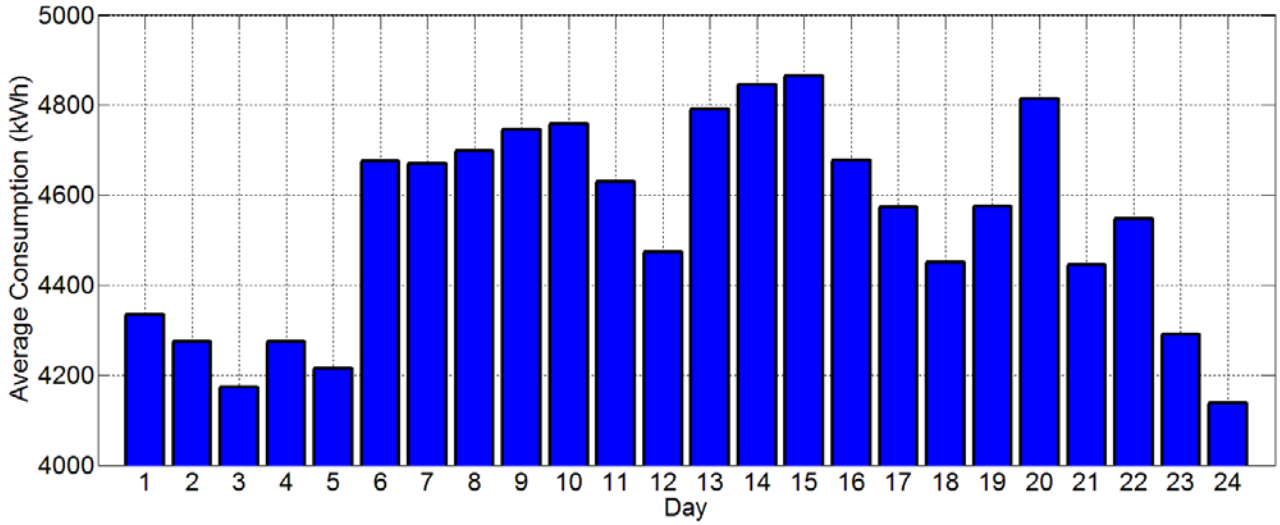

Figure 1: aggregate consumption (kWh) for all the days in the dataset

A) Scenario 1

a) CBL for customer ID1349 in scenario 1 without adjustment

In this section, CBL for one customer is calculated. The advantage of this task is that, one can observe all the details and challenges of CBL calculation. Many of such details and challenges will even out in the aggregated calculation of CBL for all the customers.

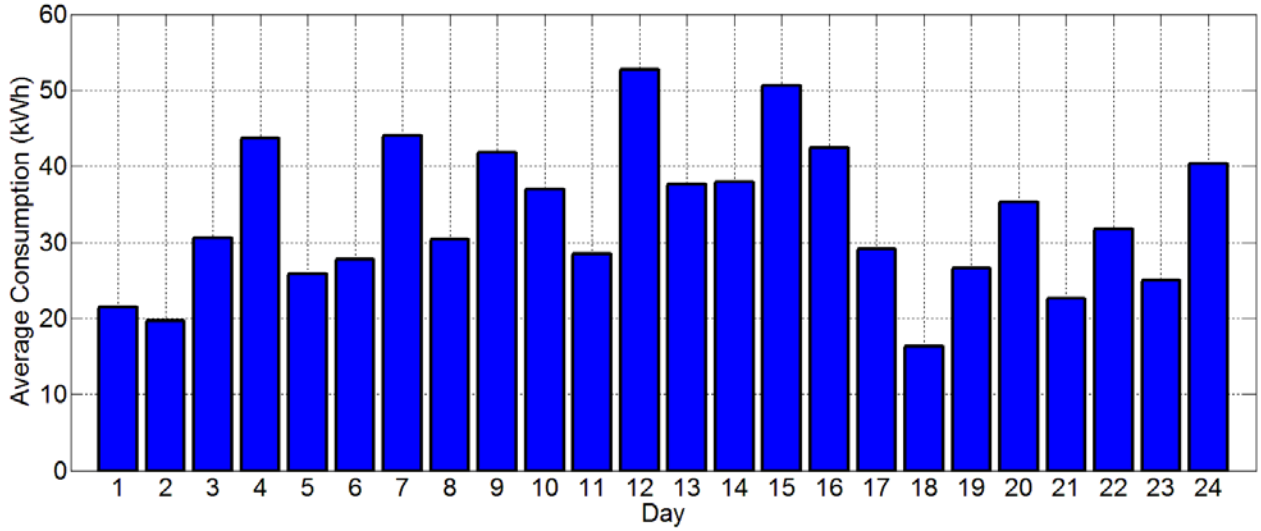

Figure 2: consumption (kWh) for all the days in the dataset for customer ID1349

The steps taken for finding baseline calculation window is shown in table 2.

TABLE 2: STEPS TAKEN ACCORDING TO STEPS 4 AND 5 OF ALGORITHM

Date	kWh	Is it non-holiday, non-curtailment day?	Is it greater than 25% of previous day?	Baseline window
Day 18 Sat, Dec. 11	16.322	No	-	-
Day 17 Fri, Dec. 10	29.108	Yes	Yes	1
Day 16 Thu, Dec. 9	42.39	Yes	Yes	2
Day 15 Wed, Dec. 8	50.608	No	-	-
Day 14 Tue, Dec. 7	37.951	No	-	-
Day 13 Mon, Dec. 6	37.612	Yes	Yes	3
Day 12 Sun, Dec. 5	52.743	No	-	-
Day 11 Sat, Dec. 4	28.518	No	-	-
Day 10 Fri, Dec. 3	36.97	Yes	Yes	4
Day 9 Thur, Dec. 2	41.839	Yes	Yes	5
Day 8 Wed, Dec. 1	30.41	Yes	Yes	6
Day 7 Tue, Nov. 30	43.962	Yes	Yes	7
Day 6 Mon, Nov. 29	27.77	Yes	Yes	8
Day 5 Sun, Nov. 28	25.805	No	-	-
Day 4 Sat, Nov. 27	43.706	No	-	-
Day 3 Fri, Nov. 26	30.594	Yes	Yes	9
Day 2 Thur, Nov. 25	19.709	Yes	Yes	10

After finding the baseline calculation window, the next step is to find the five highest average daily consumption, this task is done in table 3 and the five highest average consumption days are color coded by green.

TABLE 3: THE FIVE HIGHEST AVERAGE DAILY CONSUMPTION (COLOR CODED BY GREEN)

Date	kWh	Is it non-holiday, non-curtailment day?	Is it greater than 25% of previous day?	Baseline window
Day 17 Fri, Dec. 10	29.108	Yes	Yes	1
Day 16 Thu, Dec. 9	42.39	Yes	Yes	2
Day 13 Mon, Dec. 6	37.612	Yes	Yes	3
Day 10 Fri, Dec. 3	36.97	Yes	Yes	4
Day 9 Thur, Dec. 2	41.839	Yes	Yes	5
Day 8 Wed, Dec. 1	30.41	Yes	Yes	6
Day 7 Tue, Nov. 30	43.962	Yes	Yes	7
Day 6 Mon, Nov. 29	27.77	Yes	Yes	8
Day 3 Fri, Nov. 26	30.594	Yes	Yes	9
Day 2 Thur, Nov. 25	19.709	Yes	Yes	10

The CBL is calculated by using the five highest average daily consumption and then it is compared with the actual data of event day. Figure 3 illustrates this comparison.

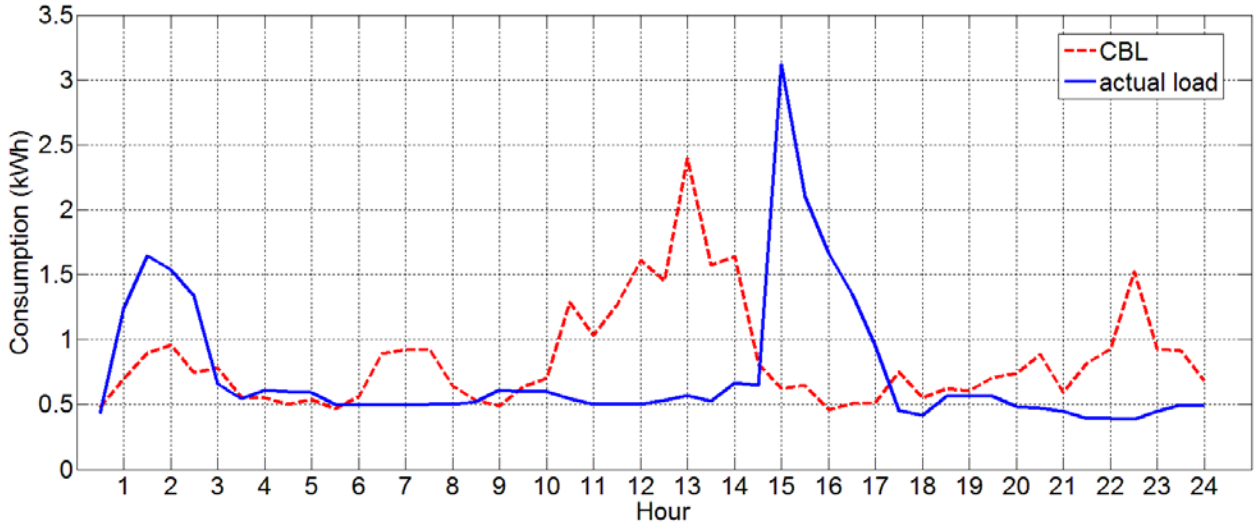

Figure 3: CBL versus actual data of event day

According to CBL results, the metrics of percent accuracy and percent bias are calculated as follows. Percent accuracy is the percent value of average of all the absolute values of difference between CBL and actual data in each interval whereas percent bias is the percent value of average of all the real values of difference between CBL and actual data in each interval. For this customer in scenario 1, the percent accuracy for whole period is 0.49 kWh and percent Bias for whole period is 0.10 kWh.

b) CBL for customer ID1349 in scenario 1 with adjustment

The adjustment of CBL based on the event day morning data becomes a standard procedure which can help to improve CBL accuracy. According to North American Energy Standards Board (NAESB) [6], an adjustment to a high X of Y baseline is necessary to more accurately reflect load conditions of the event day. The adjustment is defined by time frame of adjustment, multiplicative or additive.

Time frame of adjustment is normally 2-4 hours before the start of the event. The time frame must have two properties. It must be at least one hour earlier from the event not to overlap with people who start the load reduction sooner. Also, it should not be too far away from the event. The inappropriate choice of time frame could penalize customers for early curtailment and inadvertently reward some others for temporary increase of their loads. In what follows both multiplicative and additive adjustment are applied to the case at hand.

1) Multiplicative adjustment

The adjustment factor is the ratio of the average of the third and fourth hours of the customer's actual usage four hours prior to the start of the event and the average of the third and fourth hours of the customer's baseline four hours prior to the start of the event. Figure 4 illustrates CBL with multiplicative adjustment compared to CBL without adjustment and actual data. In multiplicative adjustment case, the percent accuracy for whole period with multiplicative adjustment is 0.42 kWh

and percent Bias for whole period with multiplicative adjustment is -0.03 kWh which shows an improvement.

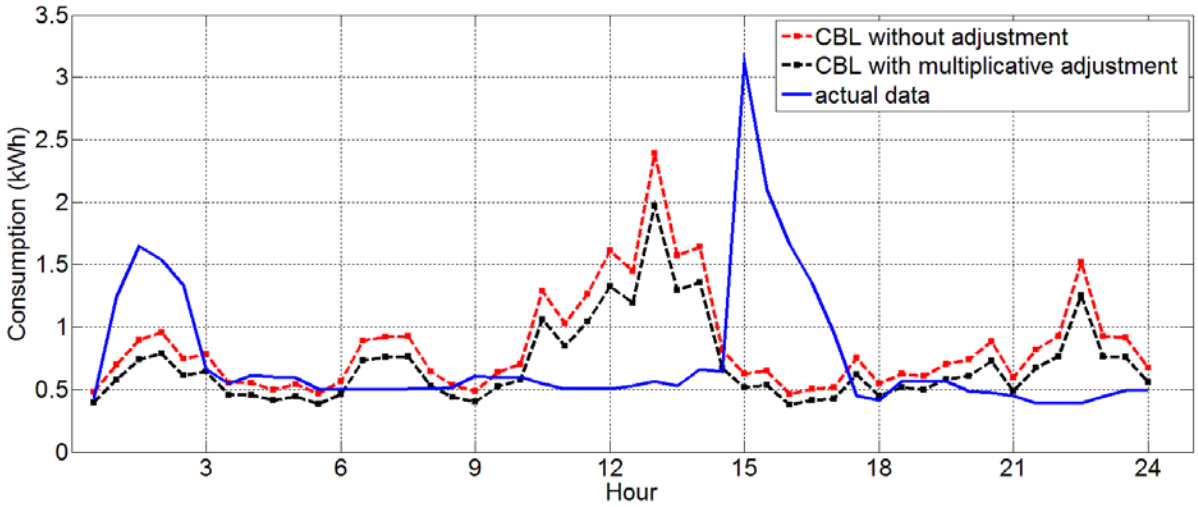

Figure 4: CBL with and without multiplicative adjustment versus actual data of event day

2) Additive Adjustment

The adjustment factor is the ratio of the average of the third and fourth hours of the customer's actual usage four hours prior to the start of the event and the average of the third and fourth hours of the customer's baseline four hours prior to the start of the event. Figure 5 illustrates CBL with additive adjustment compared to CBL without adjustment and actual data. In additive adjustment case, the percent accuracy for whole period with multiplicative adjustment is 0.47 kWh and percent Bias for whole period with multiplicative adjustment is -0.0038 kWh which does not shows any improvement.

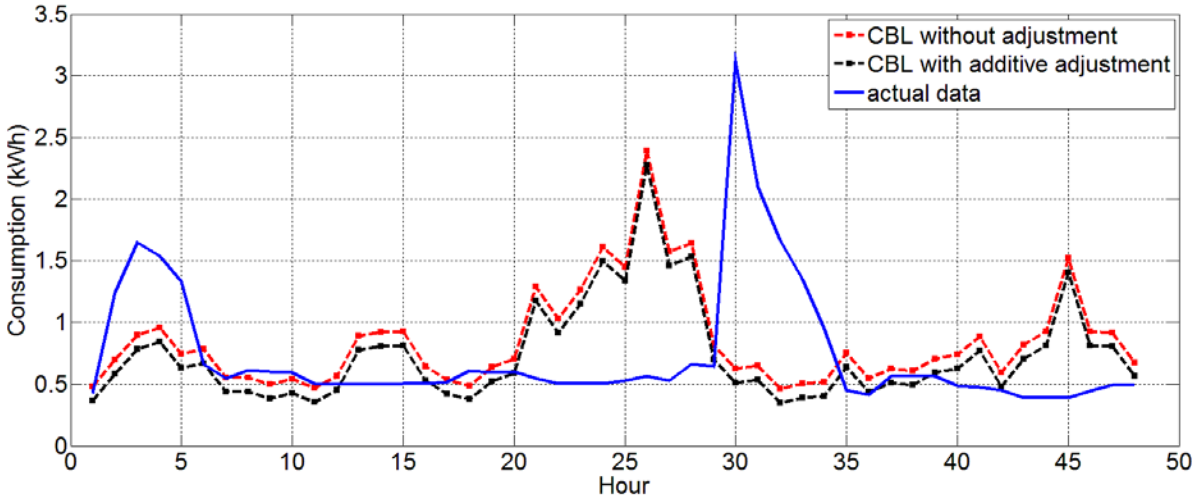

Figure 5: CBL with and without additive adjustment versus actual data of event day

c) CBL for all 110 customers

In this section, CBL for all the customer are calculated. After observing the results for an individual case, it is beneficial to see how the metrics are in the aggregate manner. The average of the percent accuracy for whole period without adjustment for all the customers is 0.42 kWh and the percent Bias for whole period without adjustment for all the customers is +0.09 kWh. In case of multiplicative adjustment, the aforementioned metrics become 0.40 kWh and -0.08 kWh, respectively which show a slight improvement. In additive adjustment, the aforementioned metrics become 0.46 kWh and -0.13 kWh, respectively which does not show any improvement

B) Scenario 2

In this scenario, there is not any prior curtailment event. It is assumed that the curtailment events have residual effect on the behavior of the customers. Therefore, it is decided to study both scenarios.

a) CBL for customer ID1349 in scenario 2 without adjustment

The steps taken for finding baseline calculation window is shown in table 4.

TABLE 4: STEPS TAKEN ACCORDING TO STEPS 4 AND 5 OF ALGORITHM

Date	kWh	Is it non-holiday, non-curtailment day?	Is it greater than 25% of previous day?	Baseline window
Day 18 Sat, Dec. 11	16.322	No	-	-
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Day 8 Wed, Dec. 1	30.41	Yes	Yes	8
Day 7 Tue, Nov. 30	43.962	Yes	Yes	9
Day 6 Mon, Nov. 29	27.77	Yes	Yes	10
Day 5 Sun, Nov. 28	25.805	No	-	-
Day 4 Sat, Nov. 27	43.706	No	-	-

After finding the baseline calculation window, the next step is to find the five highest average daily consumption, this task is done in table 5 and the five highest average consumption days are color coded by green.

TABLE 5: THE FIVE HIGHEST AVERAGE DAILY CONSUMPTION (COLOR CODED BY GREEN)

Date	kWh	Is it non-holiday, non-curtailment day?	Is it greater than 25% of previous day?	Baseline window
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Day 9 Thur, Dec. 2	41.839	Yes	Yes	7
Day 8 Wed, Dec. 1	30.41	Yes	Yes	8
Day 7 Tue, Nov. 30	43.962	Yes	Yes	9
Day 6 Mon, Nov. 29	27.77	Yes	Yes	10

The CBL is calculated by using the five highest average daily consumption and then it is compared with the actual data of event day. Figure 6 illustrates this comparison.

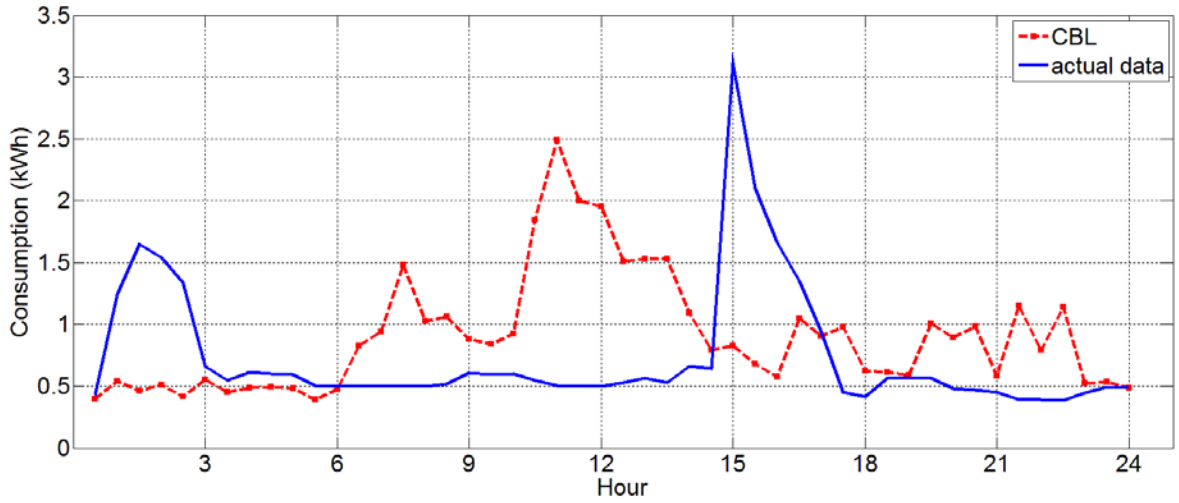

Figure 6: CBL versus actual data of event day

According to CBL results, the metrics of percent accuracy and percent bias are calculated as follows. Percent accuracy is the percent value of average of all the absolute values of difference between CBL and actual data in each interval whereas percent bias is the percent value of average of all the real values of difference between CBL and actual data in each interval. For this customer in scenario 1, the percent accuracy for whole period is 0.57 kWh and percent Bias for whole period is 0.16 kWh.

b) CBL for customer ID1349 in scenario 2 with adjustment

As previously discussed, adjustment based on the morning data of the event day can improve the CBL accuracy. In what follows both multiplicative and additive adjustment are applied to the case at hand in scenario 2.

1) Multiplicative adjustment

The adjustment factor is the same as the one previous discussed. Figure 7 illustrates CBL with multiplicative adjustment compared to CBL without adjustment and actual data. In multiplicative adjustment case, the percent accuracy for whole period with multiplicative adjustment is 0.42 kWh and percent Bias for whole period with multiplicative adjustment is -0.30 kWh which shows an improvement.

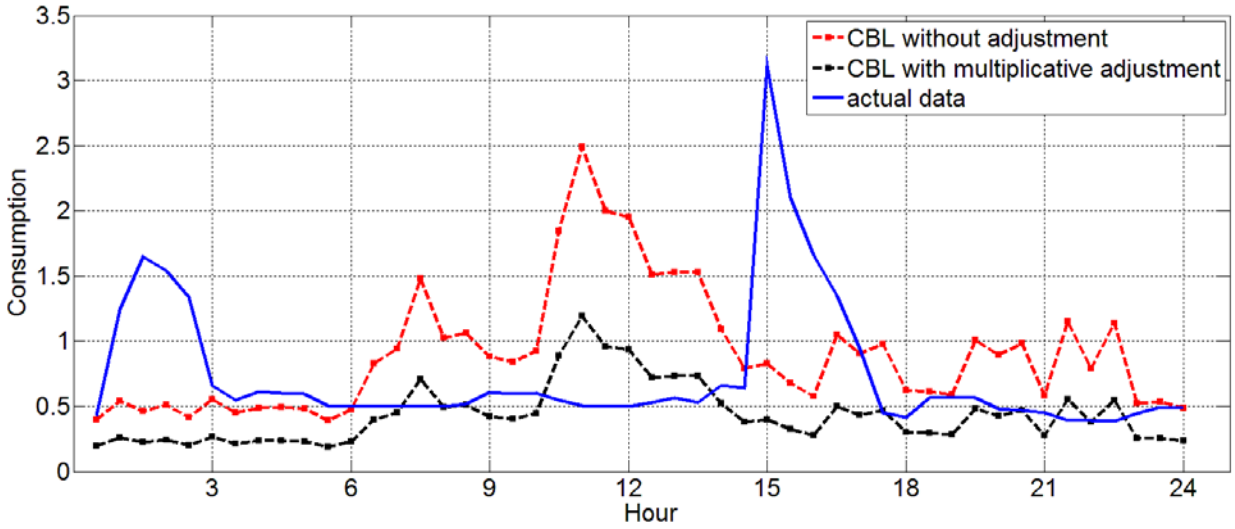

Figure 7: CBL with and without multiplicative adjustment versus actual data of event day

2) Additive Adjustment

The adjustment factor is the same as the one previous discussed. Figure 8 illustrates CBL with additive adjustment compared to CBL without adjustment and actual data. In additive adjustment case, the percent accuracy for whole period with multiplicative adjustment is 0.65 kWh and percent Bias for whole period with multiplicative adjustment is -0.41 kWh which does not shows any improvement.

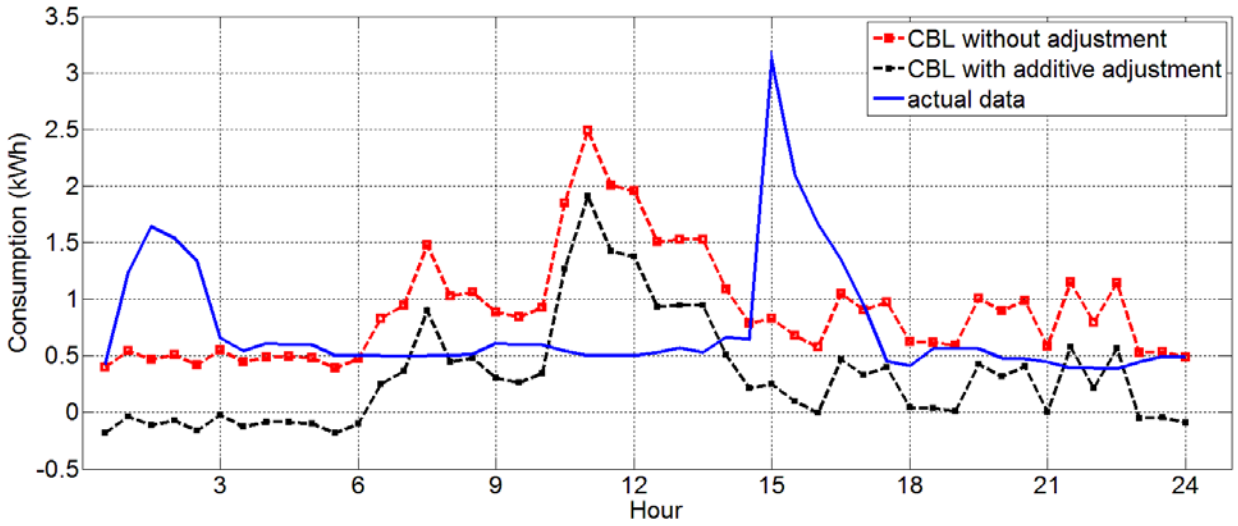

Figure 8: CBL with and without additive adjustment versus actual data of event day

c) CBL for all 110 customers

In this section, CBL for all the customer are calculated. The average of the percent accuracy for whole period without adjustment for all the customers is 0.39 kWh and the percent Bias for whole period without adjustment for all the customers is +0.02 kWh. In case of multiplicative adjustment, the aforementioned metrics become 0.38 kWh and -0.12 kWh, respectively which show a slight improvement. In additive adjustment, the aforementioned metrics become 0.44 kWh and -0.17 kWh, respectively which does not show any improvement

CONCLUSION

In this report, the performance of customer baselines are analyzed for the residential customers. In this report, the classic analyses of CBL methods, i.e., baseline accuracy and bias are employed. This analysis is done for two scenarios of with and without prior curtailment event. CBL calculation procedure is shown for one individual and then it extends to all the customers in the dataset. CBL with and without adjustment are analyzed. For adjustment, two popular adjustment methods of multiplicative and additive adjustment are utilized. The results show an improvement for multiplicative case, but it shows a deteriorating effect for an additive adjustment case.

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