

Evaluating Baselines for Demand Response Programs

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Introduction

Since the EPACT of 2005 demand response has received increasing attention as though it is a new concept. But demand response has been alive and thriving in some parts of the US since the DSM days and it continues to be a force in lowering demand for electricity during high price periods and/or high demand periods. Basically, demand response programs ask customers to reduce demand in response to a price signal or financial incentive. Typically the request to reduce demand is made for a specific time period on a specific day which is referred to as a **demand response event** or simply an event.

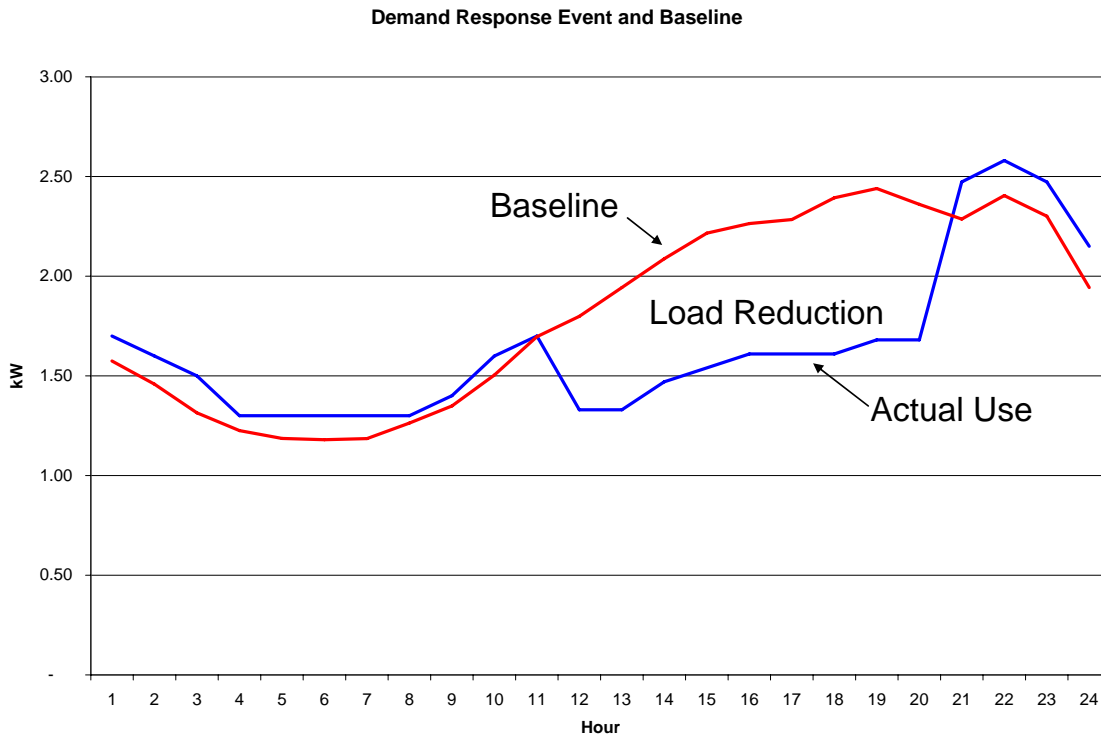
Each event has three key measurement components:

Baseline – The amount of energy the customer *would have consumed* absent a request to reduce.

Actual Use – The amount of energy the customer *actually consumed* during the event period.

Load Reduction – The mathematical difference between the baseline and the actual use.

$$\text{Baseline Demand} - \text{Actual Demand} = \text{Load Reduction}$$



This paper will focus on defining the baseline methodologies currently in use to estimate the load that would have been present without a demand response event and the differing load reduction measurements that exist between these methods when each method is applied to a common set of data. The common set of data is the mean hourly interval

load data for Detroit Edison's residential sample for the months of May through September, 2006. A single day has been chosen as the simulated demand response event day and is consistently used in the analysis. The day chosen is a Wednesday in August, 2006 where the maximum temperature reached 95°F. The event period consists of the hours of 12:00 noon through the hour of 8:00pm. Three load reduction levels, 10%, 20% and 30% will be applied to the event day as representative amounts of load a customer might reduce from their normal usage. For illustrative purposes, five baseline methods will be examined. Those currently used by the ISO's in New England, New York, and California, PJM, plus a fifth method that utilizes the concept of a +90° Average Day. Furthermore, this paper will only address measurement of passive demand response events. Passive demand response events are those requiring an action by the customer to reduce load. Direct load control demand response program load reductions were not considered as part of this analysis as they typically produce a very predictable and predefined load reduction measure.

ISO New England

ISO New England has established rules and operating procedures for customers who decide to participate in a demand resource program. One of those operating procedures is the establishment of the calculation of a baseline, which is the basis for measuring the amount of demand a customer reduced from actual usage in a demand resource program. The baseline calculation described in the following tables and graphs will show the detail necessary to create the baselines used in the settlement of the demand response program. Normally, the actual data collected for and used in the calculations is the responsibility of the demand response provider. These providers can be any entity that has a settlement account, a way of accounting for a rendered service, with ISO New England. The interval demand data is collected from customers and funneled through the ISO's Internet Based Communication System (IBCS) Operating System (OS) which is a software system that performs the baseline calculations and the settlement procedures for the demand response provider.

The baseline creation methodology consists of two calculations based on the type of customer. If a customer is a new participant to a demand resource program, having not participated in any demand resource program before, the calculation of the baseline is the hourly average of the previous 5 business days which are Monday through Friday, excluding holidays and other event days and is known as "Customer Baseline 6". The "6" refers to the day following the previous 5 business days or the sixth day. The equation for this baseline calculation is:

$$\text{Customer Baseline 6} = (\text{Sum Meter kW value for the hour})/5$$

Table 1 shows the 24 hourly loads from the 5 business days with the results of the calculation in the column labeled Customer Baseline 6. The Sum Meter kW value used in the above calculation is the interval load data recorded at the customer premise using a load recording device and is the responsibility of the demand response provider to provide that data to the IBCS OS. The Sum Meter kW values used in the calculation for the 5 business days are labeled Day 1 kW through Day 5 kW.

Table 1: How the calculation creates the Customer Baseline 6.

Hour	Days Averaged to Create Baseline					Customer Baseline 6
	Day 1 kW	Day 2 kW	Day 3 kW	Day 4 kW	Day 5 kW	
1	1.12	1.03	1.14	1.20	1.81	1.26
2	1.01	0.93	0.98	1.08	1.64	1.13
3	0.95	0.88	0.92	0.97	1.49	1.04
4	0.87	0.83	0.88	0.91	1.41	0.98
5	0.86	0.77	0.83	0.93	1.34	0.95
6	0.88	0.85	0.83	0.96	1.30	0.97
7	0.90	0.92	0.89	1.02	1.29	1.00
8	1.03	1.01	1.04	1.05	1.45	1.11
9	1.15	0.99	0.99	1.10	1.53	1.15
10	1.26	1.02	1.09	1.31	1.59	1.25
11	1.24	1.01	1.10	1.52	1.75	1.32
12	1.33	1.11	1.14	1.58	1.86	1.40
13	1.40	1.27	1.23	1.83	2.06	1.56
14	1.50	1.34	1.39	1.98	2.11	1.66
15	1.50	1.40	1.47	2.16	2.21	1.75
16	1.50	1.59	1.62	2.22	2.29	1.84
17	1.63	1.70	1.76	2.25	2.30	1.93
18	1.66	1.68	1.75	2.37	2.41	1.97
19	1.68	1.87	1.89	2.43	2.41	2.06
20	1.56	1.83	1.75	2.24	2.29	1.93
21	1.42	1.71	1.71	2.24	2.26	1.87
22	1.55	1.76	1.71	2.34	2.37	1.94
23	1.45	1.67	1.65	2.24	2.27	1.86
24	1.23	1.35	1.45	1.88	1.99	1.58

Once the “Customer Baseline 6” has been calculated for a customer, that customer is considered a current customer and the following rules apply to calculate the next baseline. When the customer becomes a current participant in the demand resource program which is defined as a customer that has had a “Customer Baseline 6” previously calculated for it then the baseline is calculated using the following formula:

$$\text{New Baseline} = \text{Previous Day Baseline} \cdot 0.9 + \text{Current Day Metered kW} \cdot 0.1$$

A new baseline is calculated every day except weekends, holidays and event days. The new baseline has a weighting factor (.9) of 90% for the previous day and a weighting factor (.1) of 10% for the current day. By putting more weight on the previous day, the calculation method reduces the opportunity for customers to “game” the program. This topic will not be addressed in this paper but will be addressed in future analysis of the uses of baselines in the measurement and validation of demand response programs.

In the example shown in table 2, the previous baseline is the Customer Baseline 6 from table 1. The current day metered data values are the customer’s actual load which is the responsibility of the demand response provider to send to the IBCS OS. The weighting of the previous baseline more than the current day metered data shows the importance of the baseline over the current day metered data. The ISO assumes the baseline better mimics the actual customer load versus relying on the actual metered data which could be “gamed”, be affected by weather conditions or be a daily usage pattern not normal for the customer.

Table 2: Example of How New Baselines Are Created.

Hour	Previous Baseline		Current Day		New Baseline
	Average kW	Average kW*.9	Metered Data kW	Metered Data kW*.1	
1	1.26	1.14	1.75	0.18	1.31
2	1.13	1.01	1.64	0.16	1.18
3	1.04	0.94	1.48	0.15	1.08
4	0.98	0.88	1.34	0.13	1.02
5	0.95	0.85	1.33	0.13	0.98
6	0.97	0.87	1.34	0.13	1.00
7	1.00	0.90	1.30	0.13	1.03
8	1.11	1.00	1.33	0.13	1.14
9	1.15	1.04	1.44	0.14	1.18
10	1.25	1.13	1.63	0.16	1.29
11	1.32	1.19	1.69	0.17	1.36
12	1.40	1.26	1.87	0.19	1.45
13	1.56	1.40	1.93	0.19	1.59
14	1.66	1.50	2.09	0.21	1.71
15	1.75	1.57	2.24	0.22	1.80
16	1.84	1.66	2.28	0.23	1.89
17	1.93	1.74	2.30	0.23	1.96
18	1.97	1.77	2.33	0.23	2.01
19	2.06	1.85	2.45	0.25	2.10
20	1.93	1.74	2.42	0.24	1.98
21	1.87	1.68	2.36	0.24	1.92
22	1.94	1.75	2.48	0.25	2.00
23	1.86	1.67	2.38	0.24	1.91
24	1.58	1.42	1.99	0.20	1.62

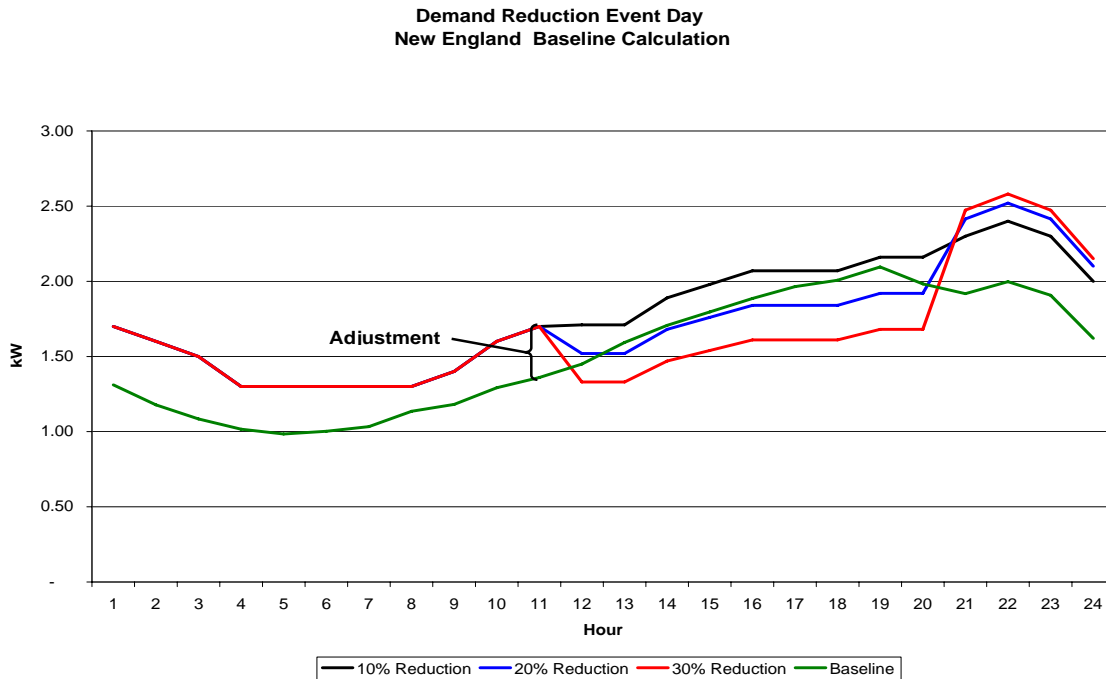
This new baseline would then be used in the settlement of a customers demand reduction during an event day. Table 3 displays the results of applying the new baseline from Table 2 to a simulated event day with the three load reduction levels.

Table 3: Applying the ISO New England New Baseline Calculation

Hour	Actual Customer Load	Customer Load			Calculated Baseline	Demand Response		
		10% Reduction	20% Reduction	30% Reduction		10% Reduction	20% Reduction	30% Reduction
1	1.70	1.70	1.70	1.70	1.31	0.39	0.39	0.39
2	1.60	1.60	1.60	1.60	1.18	0.42	0.42	0.42
3	1.50	1.50	1.50	1.50	1.08	0.42	0.42	0.42
4	1.30	1.30	1.30	1.30	1.02	0.28	0.28	0.28
5	1.30	1.30	1.30	1.30	0.98	0.32	0.32	0.32
6	1.30	1.30	1.30	1.30	1.00	0.30	0.30	0.30
7	1.30	1.30	1.30	1.30	1.03	0.27	0.27	0.27
8	1.30	1.30	1.30	1.30	1.14	0.16	0.16	0.16
9	1.40	1.40	1.40	1.40	1.18	0.22	0.22	0.22
10	1.60	1.60	1.60	1.60	1.29	0.31	0.31	0.31
11	1.70	1.70	1.70	1.70	1.36	0.34	0.34	0.34
12	1.90	1.71	1.52	1.33	1.45	0.26	0.07	(0.12)
13	1.90	1.71	1.52	1.33	1.59	0.12	(0.07)	(0.26)
14	2.10	1.89	1.68	1.47	1.71	0.18	(0.03)	(0.24)
15	2.20	1.98	1.76	1.54	1.80	0.18	(0.04)	(0.26)
16	2.30	2.07	1.84	1.61	1.89	0.18	(0.05)	(0.28)
17	2.30	2.07	1.84	1.61	1.96	0.11	(0.12)	(0.35)
18	2.30	2.07	1.84	1.61	2.01	0.06	(0.17)	(0.40)
19	2.40	2.16	1.92	1.68	2.10	0.06	(0.18)	(0.42)
20	2.40	2.16	1.92	1.68	1.98	0.18	(0.06)	(0.30)
21	2.30	2.30	2.42	2.47	1.92	0.38	0.50	0.56
22	2.40	2.40	2.52	2.58	2.00	0.40	0.52	0.58
23	2.30	2.30	2.42	2.47	1.91	0.39	0.51	0.57
24	2.00	2.00	2.10	2.15	1.62	0.38	0.48	0.53

By applying the new baseline calculation to the three demand reduction levels produces the amount of demand reduction measured against the baseline for the event period of 12:00 noon to 8:00pm., highlighted in light grey. The dark grey shows the difference between the three different demand reduction levels and the calculated baseline. The negative numbers represent the measurement of a value that is less than the

corresponding new baseline value. This means the customer's load was less than the calculated baseline. The graph below shows the relationship between the calculated baseline in green and the three demand reduction levels in black, blue and red.



What is interesting is if the customer reduced their load by 10%, the settlement of the demand resource program for this customer would not measure any demand reduction. Remember the purpose of calculating a baseline is to replicate the amount of energy the customer would have consumed absent a request to reduce. ISO New England recognized this discrepancy and has operating procedures to adjust the new baseline to reflect assumed actual customer usage. This adjustment will be made to the new baseline only if it is an event day. The adjustment calculation from the operating procedures is the average difference between the new baseline and the actual customer load of the two hours prior to the start of the event period. That calculated value is then applied to those two hours and all the hours of the event period but only if the new baseline is less than the customer load at the time of the start of the event. This adjustment calculation and the process of applying the adjustment value to the new baseline to create an adjusted baseline are shown in Table 4.

Table 4: Calculating the Baseline Adjustment

Hour	Customer Load	New Baseline	Adjustment	Adjusted Baseline
1	1.70	1.31		1.31
2	1.60	1.18		1.18
3	1.50	1.08		1.08
4	1.30	1.02		1.02
5	1.30	0.98		0.98
6	1.30	1.00		1.00
7	1.30	1.03		1.03
8	1.30	1.14		1.14
9	1.40	1.18		1.18
10	1.60	1.29	0.325	1.62
11	1.70	1.36	0.325	1.69
12	1.33	1.45	0.325	1.77
13	1.33	1.59	0.325	1.92
14	1.47	1.71	0.325	2.03
15	1.54	1.80	0.325	2.12
16	1.61	1.89	0.325	2.21
17	1.61	1.96	0.325	2.29
18	1.61	2.01	0.325	2.33
19	1.68	2.10	0.325	2.42
20	1.68	1.98	0.325	2.31
21	2.47	1.92		1.92
22	2.58	2.00		2.00
23	2.47	1.91		1.91
24	2.15	1.62		1.62

Hour 10 - 1.60 - 1.29 = .31
 Hour 11 - 1.70 - 1.36 = .34
 Adjustment - .31+.34 = .65/2 = .325

} Adjustment Period

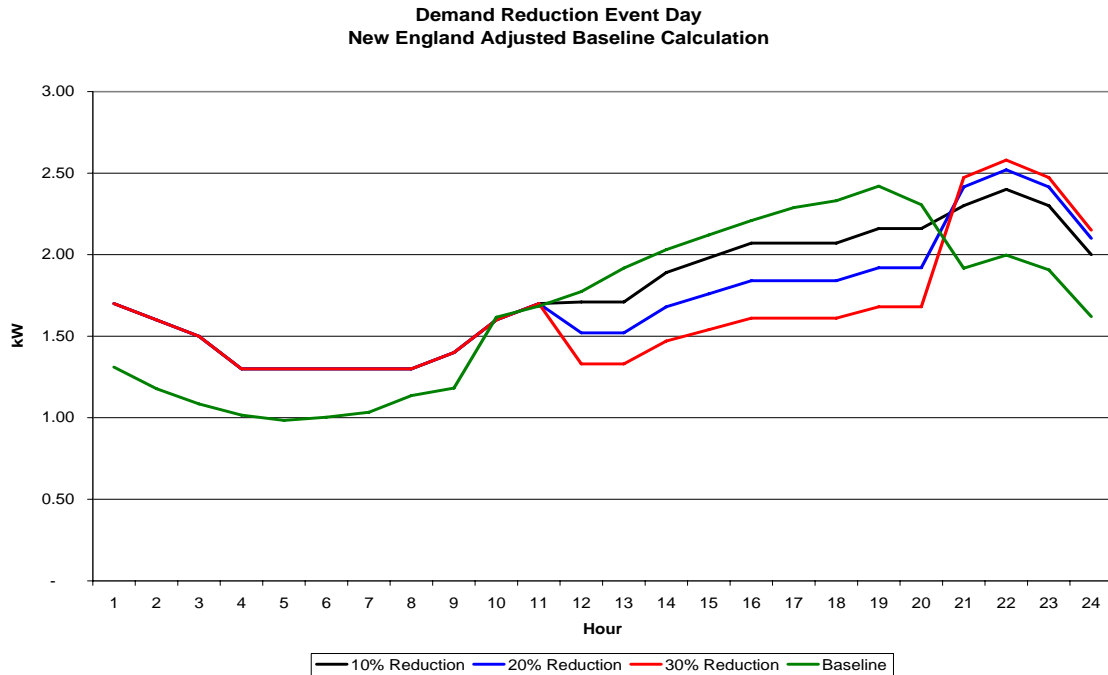
After the baseline has been adjusted, Table 5 shows the difference between the adjusted baseline and the three load reduction levels. This difference is the amount of measured load reduction from those three levels.

Table 5: Applying the ISO New England Adjusted Baseline Calculation

Hour	Actual Customer Load	Customer Load			Adjusted Baseline	Demand Response		
		10% Reduction	20% Reduction	30% Reduction		10% Reduction	20% Reduction	30% Reduction
1	1.70	1.70	1.70	1.70	1.31	0.39	0.39	0.39
2	1.60	1.60	1.60	1.60	1.18	0.42	0.42	0.42
3	1.50	1.50	1.50	1.50	1.08	0.42	0.42	0.42
4	1.30	1.30	1.30	1.30	1.02	0.28	0.28	0.28
5	1.30	1.30	1.30	1.30	0.98	0.32	0.32	0.32
6	1.30	1.30	1.30	1.30	1.00	0.30	0.30	0.30
7	1.30	1.30	1.30	1.30	1.03	0.27	0.27	0.27
8	1.30	1.30	1.30	1.30	1.14	0.16	0.16	0.16
9	1.40	1.40	1.40	1.40	1.18	0.22	0.22	0.22
10	1.60	1.60	1.60	1.60	1.62	(0.02)	(0.02)	(0.02)
11	1.70	1.70	1.70	1.70	1.69	0.01	0.01	0.01
12	1.90	1.71	1.52	1.33	1.77	(0.06)	(0.25)	(0.44)
13	1.90	1.71	1.52	1.33	1.92	(0.21)	(0.40)	(0.59)
14	2.10	1.89	1.68	1.47	2.03	(0.14)	(0.35)	(0.56)
15	2.20	1.98	1.76	1.54	2.12	(0.14)	(0.36)	(0.58)
16	2.30	2.07	1.84	1.61	2.21	(0.14)	(0.37)	(0.60)
17	2.30	2.07	1.84	1.61	2.29	(0.22)	(0.45)	(0.68)
18	2.30	2.07	1.84	1.61	2.33	(0.26)	(0.49)	(0.72)
19	2.40	2.16	1.92	1.68	2.42	(0.26)	(0.50)	(0.74)
20	2.40	2.16	1.92	1.68	2.31	(0.15)	(0.39)	(0.63)
21	2.30	2.30	2.42	2.47	1.92	0.38	0.50	0.56
22	2.40	2.40	2.52	2.58	2.00	0.40	0.52	0.58
23	2.30	2.30	2.42	2.47	1.91	0.39	0.51	0.57
24	2.00	2.00	2.10	2.15	1.62	0.38	0.48	0.53

The ISO New England baseline operating procedures makes the assumption that the actual customer usage two hours prior to an event period reflects what the actual customer usage for those two hours and the entire event period should be. That

assumption is a way of emulating what the customer would have used absent the demand reduction.



The adjustment provision takes into account changes in actual customer usage that occur each day. Without the adjustment to the baseline, those daily change effects to actual customer usage would not measure the assumed proper amount of demand reduction.

New York ISO

New York ISO has created a baseline calculation methodology to use in its Day-Ahead Demand Response Program for approved demand response providers. Their step by step approach uses the data chosen in one step for the next step. 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. The recording and transfer of the interval demand data used in the calculation of the baseline is the responsibility of the DSR.

Step 2: For the day two days prior to the day of a demand response event, 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 shown in Table 6.

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”.

Table 6: Step 2 through Step 4, Populate the Baseline Calculation Window

Date	DayOfWeek	kWh	Acceptable Day	GT 25% of Previous Day	Baseline Window
07/31/06	Monday	39.792	Yes	Yes	1
07/30/06	Sunday	36.019	No	No	
07/29/06	Saturday	37.650	No	No	
07/28/06	Friday	31.226	Yes	Yes	2
07/27/06	Thursday	30.511	Yes	Yes	3
07/26/06	Wednesday	30.647	Yes	Yes	4
07/25/06	Tuesday	29.899	Yes	Yes	5
07/24/06	Monday	26.927	Yes	Yes	6
07/23/06	Sunday	23.244	No	No	
07/22/06	Saturday	23.880	No	No	
07/21/06	Friday	28.995	Yes	Yes	7
07/20/06	Thursday	29.373	Yes	Yes	8
07/19/06	Wednesday	28.798	Yes	Yes	9
07/18/06	Tuesday	32.707	Yes	Yes	10

Step 5: From the 10 days in the “baseline calculation window”, select the 5 highest “average daily event period kWh usage” days.

Table 7: 5 Highest Average Daily Usage Days

Date	DayOfWeek	Baseline Window	5 Highest Days
07/31/06	Tuesday	39.792	1
07/28/06	Friday	31.226	3
07/27/06	Thursday	30.511	5
07/26/06	Wednesday	30.647	4
07/25/06	Tuesday	29.899	
07/24/06	Tuesday	26.927	
07/21/06	Friday	28.995	
07/20/06	Thursday	29.373	
07/19/06	Wednesday	28.798	
07/18/06	Tuesday	32.707	2

Step 6: Of the 5 highest “average daily event period kWh usage” days, average by hour the 24 hourly demand values to create the baseline.

Table 8: Creating the Baseline (average hourly values for 5 highest days)

Hour	Days Averaged to Create Baseline					Customer Baseline
	07/31/06	07/18/06	07/28/06	07/26/06	07/27/08	
1	1.20	1.34	1.14	1.12	1.03	1.17
2	1.08	1.18	0.98	1.01	0.93	1.04
3	0.97	1.07	0.92	0.95	0.88	0.96
4	0.91	1.00	0.88	0.87	0.83	0.90
5	0.93	0.97	0.83	0.86	0.77	0.87
6	0.96	0.97	0.83	0.88	0.85	0.90
7	1.02	1.02	0.89	0.90	0.92	0.95
8	1.05	1.06	1.04	1.03	1.01	1.04
9	1.10	0.99	0.99	1.15	0.99	1.04
10	1.31	1.12	1.09	1.26	1.02	1.16
11	1.52	1.22	1.10	1.24	1.01	1.22
12	1.58	1.23	1.14	1.33	1.11	1.28
13	1.83	1.39	1.23	1.40	1.27	1.42
14	1.98	1.63	1.39	1.50	1.34	1.57
15	2.16	1.62	1.47	1.50	1.40	1.63
16	2.22	1.74	1.62	1.50	1.59	1.73
17	2.25	1.80	1.76	1.63	1.70	1.83
18	2.37	1.80	1.75	1.66	1.68	1.85
19	2.43	1.87	1.89	1.68	1.87	1.95
20	2.24	1.82	1.75	1.56	1.83	1.84
21	2.24	1.60	1.71	1.42	1.71	1.74
22	2.34	1.59	1.71	1.55	1.76	1.79
23	2.24	1.46	1.65	1.45	1.67	1.69
24	1.88	1.22	1.45	1.23	1.35	1.43

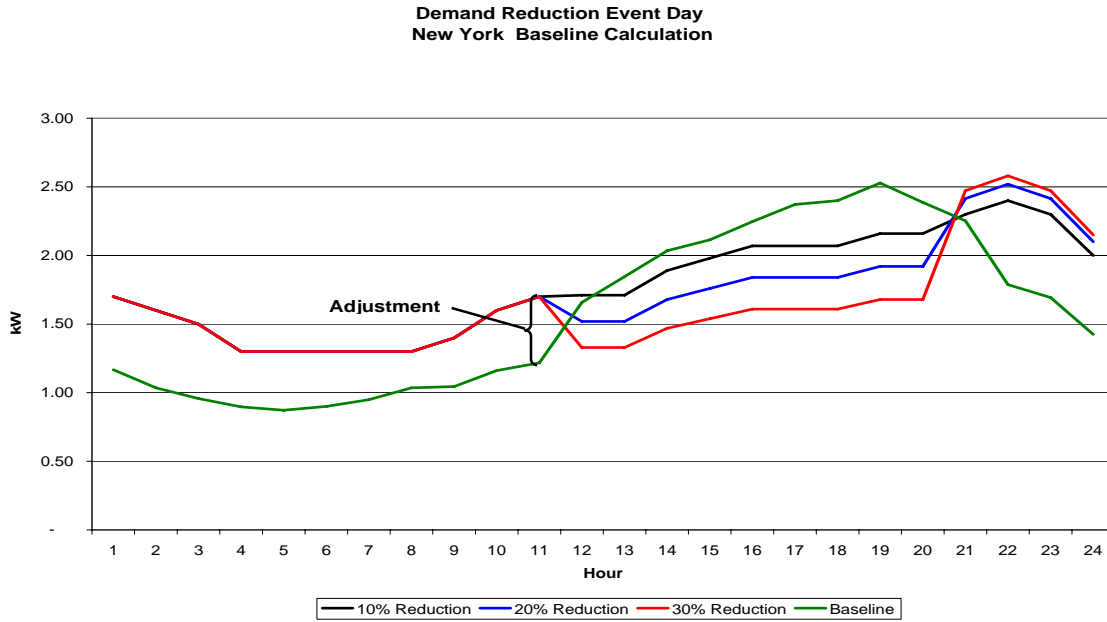
The calculated baseline is then applied to the three demand reduction levels to produce the amount of measured demand reduction in Table 9.

Table 9: Applying the New York ISO Baseline Calculation

Hour	Actual Customer Load	Customer Load			Calculated Baseline	Demand Response		
		10% Reduction	20% Reduction	30% Reduction		10% Reduction	20% Reduction	30% Reduction
1	1.70	1.70	1.70	1.70	1.17	0.53	0.53	0.53
2	1.60	1.60	1.60	1.60	1.04	0.56	0.56	0.56
3	1.50	1.50	1.50	1.50	0.96	0.54	0.54	0.54
4	1.30	1.30	1.30	1.30	0.90	0.40	0.40	0.40
5	1.30	1.30	1.30	1.30	0.87	0.43	0.43	0.43
6	1.30	1.30	1.30	1.30	0.90	0.40	0.40	0.40
7	1.30	1.30	1.30	1.30	0.95	0.35	0.35	0.35
8	1.30	1.30	1.30	1.30	1.04	0.26	0.26	0.26
9	1.40	1.40	1.40	1.40	1.04	0.36	0.36	0.36
10	1.60	1.60	1.60	1.60	1.16	0.44	0.44	0.44
11	1.70	1.70	1.70	1.70	1.22	0.48	0.48	0.48
12	1.90	1.71	1.52	1.33	1.28	0.43	0.24	0.05
13	1.90	1.71	1.52	1.33	1.42	0.29	0.10	(0.09)
14	2.10	1.89	1.68	1.47	1.57	0.32	0.11	(0.10)
15	2.20	1.98	1.76	1.54	1.63	0.35	0.13	(0.09)
16	2.30	2.07	1.84	1.61	1.73	0.34	0.11	(0.12)
17	2.30	2.07	1.84	1.61	1.83	0.24	0.01	(0.22)
18	2.30	2.07	1.84	1.61	1.85	0.22	(0.01)	(0.24)
19	2.40	2.16	1.92	1.68	1.95	0.21	(0.03)	(0.27)
20	2.40	2.16	1.92	1.68	1.84	0.32	0.08	(0.16)
21	2.30	2.30	2.42	2.47	1.74	0.56	0.68	0.74
22	2.40	2.40	2.52	2.58	1.79	0.61	0.73	0.79
23	2.30	2.30	2.42	2.47	1.69	0.61	0.72	0.78
24	2.00	2.00	2.10	2.15	1.43	0.57	0.67	0.72

Without an adjustment for current day weather, the demand response reduction for the three reduction levels does not supply an accurate measurement of the intent of the Day-Ahead Demand Response Program. The New York ISO Day-Ahead Demand Response Program methodology has a provision for adjusting the baseline for the effects of

weather. The adjustment for weather needed to remove the gap is labeled Adjustment in the following graph.



An adjustment factor is calculated and applied to the baseline at the time of the start of the event. The adjustment factor is the average of the fourth and third hours of the customer’s actual usage 4 hours prior to the start of the event divided by the average of the fourth and third hours of the baseline, four hours prior to the start of the event. In the example in Table 10, the customer load values used are for illustrative purposes only. The hours used for the factor calculation do not occur during the event period and have no effect on the factor calculation. This factor is then applied to all the hours of the event period for all three percentage responses to the demand reduction.

Table 10: Calculating Weather Adjustment Factor

Hour	Customer Load	Customer Baseline	Adjustment	Adjusted Baseline
1	1.70	1.17		1.17
2	1.60	1.04		1.04
3	1.50	0.96		0.96
4	1.30	0.90		0.90
5	1.30	0.87		0.87
6	1.30	0.90		0.90
7	1.30	0.95		0.95
8	1.30	1.04		1.04
9	1.40	1.04		1.04
10	1.60	1.16		1.16
11	1.70	1.22		1.22
12	1.33	1.28	1.30	1.66
13	1.33	1.42	1.30	1.85
14	1.47	1.57	1.30	2.04
15	1.54	1.63	1.30	2.12
16	1.61	1.73	1.30	2.25
17	1.61	1.83	1.30	2.38
18	1.61	1.85	1.30	2.40
19	1.68	1.95	1.30	2.53
20	1.68	1.84	1.30	2.39
21	2.47	1.74		2.25
22	2.58	1.79		1.79
23	2.47	1.69		1.69
24	2.15	1.43		1.43

Adjustment Period

Customer Baseline Average of Hours 8&9: $(1.04 + 1.04)/2 = 1.04$

Customer Load Average of Hours 8&9: $(1.30 + 1.40)/2 = 1.35$

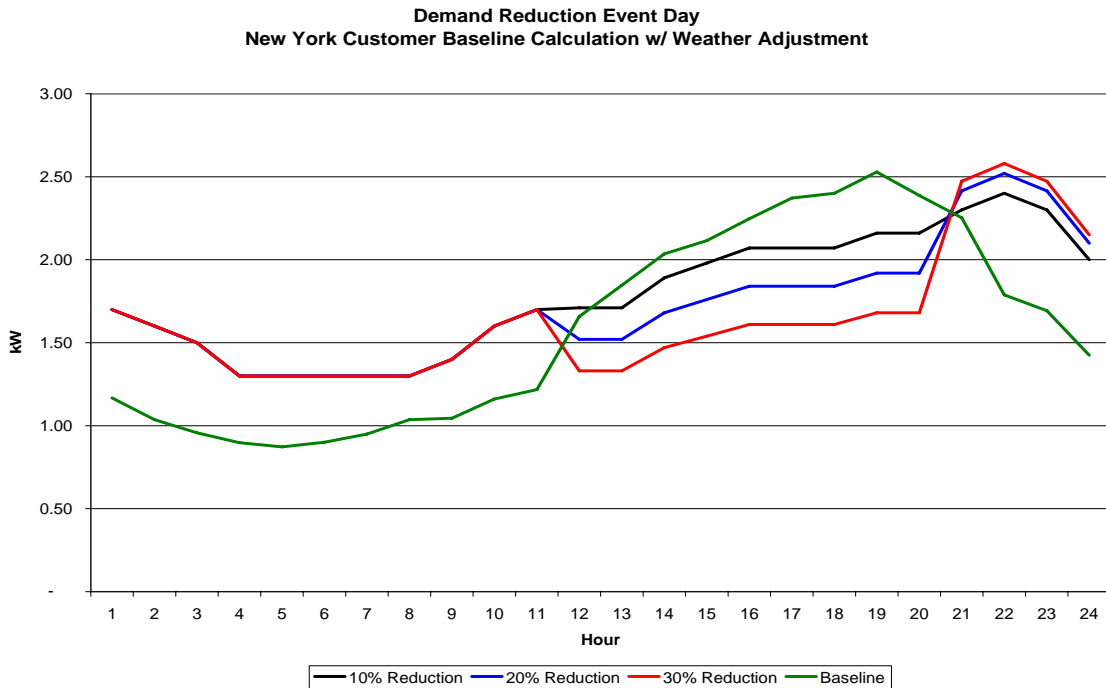
Adjustment: $1.35/1.04 = 1.30$

The methodology assumes the result of the adjustment calculation, the difference of the two averages, is the effect of weather between customer load and the baseline.

Table 11: Applying New York ISO Baseline Calculation w/ Weather Adjustment

Hour	Actual Customer Load	Customer Load			Adjusted Baseline	Demand Response		
		10% Reduction	20% Reduction	30% Reduction		10% Reduction	20% Reduction	30% Reduction
1	1.70	1.70	1.70	1.70	1.17	0.53	0.53	0.53
2	1.60	1.60	1.60	1.60	1.04	0.56	0.56	0.56
3	1.50	1.50	1.50	1.50	0.96	0.54	0.54	0.54
4	1.30	1.30	1.30	1.30	0.90	0.40	0.40	0.40
5	1.30	1.30	1.30	1.30	0.87	0.43	0.43	0.43
6	1.30	1.30	1.30	1.30	0.90	0.40	0.40	0.40
7	1.30	1.30	1.30	1.30	0.95	0.35	0.35	0.35
8	1.30	1.30	1.30	1.30	1.04	0.26	0.26	0.26
9	1.40	1.40	1.40	1.40	1.04	0.36	0.36	0.36
10	1.60	1.60	1.60	1.60	1.16	0.44	0.44	0.44
11	1.70	1.70	1.70	1.70	1.22	0.48	0.48	0.48
12	1.90	1.71	1.52	1.33	1.66	0.05	(0.14)	(0.33)
13	1.90	1.71	1.52	1.33	1.85	(0.14)	(0.33)	(0.52)
14	2.10	1.89	1.68	1.47	2.04	(0.15)	(0.36)	(0.57)
15	2.20	1.98	1.76	1.54	2.12	(0.14)	(0.36)	(0.58)
16	2.30	2.07	1.84	1.61	2.25	(0.18)	(0.41)	(0.64)
17	2.30	2.07	1.84	1.61	2.38	(0.31)	(0.54)	(0.77)
18	2.30	2.07	1.84	1.61	2.40	(0.33)	(0.56)	(0.79)
19	2.40	2.16	1.92	1.68	2.53	(0.37)	(0.61)	(0.85)
20	2.40	2.16	1.92	1.68	2.39	(0.23)	(0.47)	(0.71)
21	2.30	2.30	2.42	2.47	2.25	0.05	0.16	0.22
22	2.40	2.40	2.52	2.58	1.79	0.61	0.73	0.79
23	2.30	2.30	2.42	2.47	1.69	0.61	0.72	0.78
24	2.00	2.00	2.10	2.15	1.43	0.57	0.67	0.72

With the weather adjustment applied to the baseline, the demand response has measured values for all but one hour if the reduction is 10% and for all hours if the reduction is 20% or 30%.



California ISO

The California ISO uses a simpler approach to calculating a baseline when compared to the other ISO's. The baseline is the average of the 3 highest energy usage days of the past 10 days which consist of weekdays, Monday through Friday (Table 12). They do not include holidays, other event days, days that the customer was required to curtail load or a day when rotating outages occurred. A customer contracts with a Demand Response Provider (DRP) who is responsible for collecting and transmitting interval demand data used in the baseline calculation to the ISO. Currently, only hydro pump or aggregated hydro pump customers are eligible to participate but as the system matures, additional types of customers will be able to participate. Though the data used in the calculations is for an average residential customer, the purpose of the paper is to evaluate the process of calculating a baseline with a single set of data to show the characteristics of the different methodologies.

Table 12: 3 Highest Energy Usage Days

Date	DayOfWeek	Energy Use	3 Highest Days
08/01/06	Tuesday	45.395	1
07/31/06	Monday	39.792	2
07/28/06	Friday	31.226	3
07/27/06	Thursday	30.511	
07/26/06	Wednesday	30.647	
07/25/06	Tuesday	29.899	
07/24/06	Tuesday	26.927	
07/21/06	Friday	28.995	
07/20/06	Thursday	29.373	
07/19/06	Wednesday	28.798	

Table 12 shows the 10 business days and the selection of the 3 highest energy usage days. The energy use calculated for the baseline methodology is only utilized to select the days to apply to the baseline calculation based on the rules of the California ISO. The baseline calculation averages by hour the 24 hourly demand values from the selected 3 highest energy usage days to create the baseline.

Table 13: Creating the Baseline

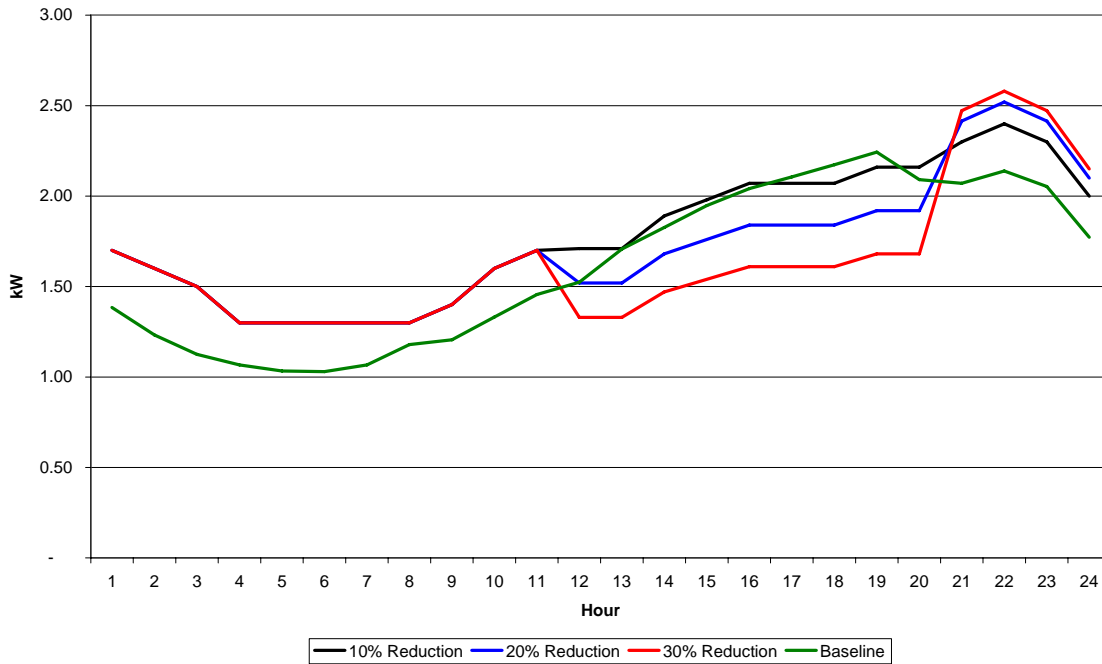
Hour	Days Averaged to Create Baseline			Baseline
	08/01/06	07/31/06	07/28/06	
1	1.81	1.20	1.14	1.38
2	1.64	1.08	0.98	1.23
3	1.49	0.97	0.92	1.13
4	1.41	0.91	0.88	1.07
5	1.34	0.93	0.83	1.03
6	1.30	0.96	0.83	1.03
7	1.29	1.02	0.89	1.07
8	1.45	1.05	1.04	1.18
9	1.53	1.10	0.99	1.21
10	1.59	1.31	1.09	1.33
11	1.75	1.52	1.10	1.46
12	1.86	1.58	1.14	1.52
13	2.06	1.83	1.23	1.71
14	2.11	1.98	1.39	1.83
15	2.21	2.16	1.47	1.95
16	2.29	2.22	1.62	2.04
17	2.30	2.25	1.76	2.11
18	2.41	2.37	1.75	2.17
19	2.41	2.43	1.89	2.24
20	2.29	2.24	1.75	2.09
21	2.26	2.24	1.71	2.07
22	2.37	2.34	1.71	2.14
23	2.27	2.24	1.65	2.05
24	1.99	1.88	1.45	1.77

The difference between the baseline and the three demand response load reduction levels of 10%, 20% and 30% is the measured amount of demand reduction. When the reduction level values in the dark grey shaded area are positive, the value for that hour is greater than the baseline value for that same hour. Those hours will not receive credit for reducing load.

Table 14: Applying the California ISO Baseline Calculation

Hour	Actual Customer Load	Customer Load			Calculated Baseline	Demand Response		
		10% Reduction	20% Reduction	30% Reduction		10% Reduction	20% Reduction	30% Reduction
1	1.70	1.70	1.70	1.70	1.38	0.32	0.32	0.32
2	1.60	1.60	1.60	1.60	1.23	0.37	0.37	0.37
3	1.50	1.50	1.50	1.50	1.13	0.38	0.38	0.38
4	1.30	1.30	1.30	1.30	1.07	0.23	0.23	0.23
5	1.30	1.30	1.30	1.30	1.03	0.27	0.27	0.27
6	1.30	1.30	1.30	1.30	1.03	0.27	0.27	0.27
7	1.30	1.30	1.30	1.30	1.07	0.23	0.23	0.23
8	1.30	1.30	1.30	1.30	1.18	0.12	0.12	0.12
9	1.40	1.40	1.40	1.40	1.21	0.19	0.19	0.19
10	1.60	1.60	1.60	1.60	1.33	0.27	0.27	0.27
11	1.70	1.70	1.70	1.70	1.46	0.24	0.24	0.24
12	1.90	1.71	1.52	1.33	1.52	0.19	(0.00)	(0.19)
13	1.90	1.71	1.52	1.33	1.71	0.00	(0.19)	(0.38)
14	2.10	1.89	1.68	1.47	1.83	0.06	(0.15)	(0.36)
15	2.20	1.98	1.76	1.54	1.95	0.03	(0.19)	(0.41)
16	2.30	2.07	1.84	1.61	2.04	0.03	(0.20)	(0.43)
17	2.30	2.07	1.84	1.61	2.11	(0.04)	(0.27)	(0.50)
18	2.30	2.07	1.84	1.61	2.17	(0.10)	(0.33)	(0.56)
19	2.40	2.16	1.92	1.68	2.24	(0.08)	(0.32)	(0.56)
20	2.40	2.16	1.92	1.68	2.09	0.07	(0.17)	(0.41)
21	2.30	2.30	2.42	2.47	2.07	0.23	0.35	0.40
22	2.40	2.40	2.52	2.58	2.14	0.26	0.38	0.44
23	2.30	2.30	2.42	2.47	2.05	0.25	0.36	0.42
24	2.00	2.00	2.10	2.15	1.77	0.23	0.33	0.38

**Demand Reduction Event Day
California Baseline Calculation**



There is no adjustment provision to the baseline calculation at this time but there is a proceeding before the California Public Utilities Commission, R.07-01-041 to address concerns from interested parties about the baseline calculation. Among the concerns the interveners have is the lack of a provision to adjust the baseline for event day variations like weather or abnormal changes to customer usage. The California ISO expects the baseline methodologies to be expanded and improved in the future.

PJM

The Office of Interconnection is the entity that manages the PJM Interchange Energy Market Economic Load Response program. An end use customer must register with the Office of Interconnection to participate in the Economic Load Response program. The load serving entity responsible for servicing the registered end use customer is also required to collect and transfer the hourly interval demand data from the customers premise to the PJM Interchange Energy Market Economic Load Response program. The baseline calculation is performed against this data to create the baseline used for settlement. The baseline methodology for PJM is similar to that of the New York ISO in that it uses the average of 5 weekdays out of 10 for the baseline calculation. The process to choose the 5 days is somewhat different. The selection process begins with the day two days before the event day. From this starting point, count backward to include 10 weekdays. If there are any holidays or other event days, replace those days with weekdays beginning with the eleventh weekday and so on. For example, if the ninth weekday is a holiday, replace the holiday day with the tenth weekday. That day now becomes the ninth day; add an additional day that now becomes the tenth day.

For each of the 10 selected days, calculate an “Average Daily Event Period Usage” (ADEPU). This is the sum of the 24 hourly values for each of the 10 days. Average the ADEPU for the 10 selected days. This value is the Average Daily Event Period Level (ADEPL). To determine if any of the 10 selected days are acceptable for use in the baseline calculation, divide the ADEPU for each selected day into the ADEPL to create a ratio for each of the 10 selected days. The day is considered acceptable if the calculated ratio is 75% or greater (Table 15).

Table 15: Calculation of ADEPU and ADEPL (1st iteration)

Date	Day Of Week	Average Daily Event Period Usage (ADEPU)	Ratio	Acceptable Day
07/31/06	Monday	39.792	1.307	Yes
07/28/06	Friday	31.226	1.026	Yes
07/27/06	Thursday	30.511	1.002	Yes
07/26/06	Wednesday	30.647	1.007	Yes
07/25/06	Tuesday	29.899	0.982	Yes
07/24/06	Monday	22.527	0.740	No
07/21/06	Friday	28.995	0.952	Yes
07/20/06	Thursday	29.373	0.965	Yes
07/19/06	Wednesday	28.798	0.946	Yes
07/18/06	Tuesday	32.707	1.074	Yes
Average Daily Event Period Level (ADEPL)		30.448		

If a day is not acceptable (07/24/06) then start the 10 day selection process over again but without including the unacceptable day. Table 16 shows the 2nd iteration of the 10 day selection process.

Table 16: Calculation of ADEPU and ADEPL (2nd iteration)

Date	Day Of Week	Average Daily Event Period Usage (ADEPU)	Ratio	Acceptable Day
07/31/06	Monday	39.792	1.235	Yes
07/28/06	Friday	31.226	0.969	Yes
07/27/06	Thursday	30.511	0.947	Yes
07/26/06	Wednesday	30.647	0.951	Yes
07/25/06	Tuesday	29.899	0.928	Yes
07/21/06	Friday	28.995	0.900	Yes
07/20/06	Thursday	29.373	0.912	Yes
07/19/06	Wednesday	28.798	0.894	Yes
07/18/06	Tuesday	32.707	1.015	Yes
07/17/06	Monday	40.264	1.250	Yes
Average Daily Event Period Level (ADEPL)		32.221		

The ADEPU and the ADEPL also need to be recalculated in the 2nd iteration of the selection process. If there is an unacceptable day again, the process needs to repeat itself until there are 10 acceptable days.

After 10 acceptable days are found, the next step is to sort the days by the ADEPU, high to low to determine the five days to be used in the calculation of the baseline, this is shown in (Table 17).

Table 17: Sort the ADEPU

Date	Day Of Week	Average Daily Event Period Usage (ADEPU)	Ratio
07/17/06	Monday	40.264	1.250
07/31/06	Monday	39.792	1.235
07/18/06	Tuesday	32.707	1.015
07/28/06	Friday	31.226	0.969
07/26/06	Wednesday	30.647	0.951
07/27/06	Thursday	30.511	0.947
07/25/06	Tuesday	29.899	0.928
07/20/06	Thursday	29.373	0.912
07/21/06	Friday	28.995	0.900
07/19/06	Wednesday	28.798	0.894

The 5 highest ratio values determine the 5 days to be used in the baseline calculation.

Table 18: Selection of the 5 Days

Date	Day Of Week	Average Daily Event Period Usage (ADEPU)	Ratio
07/17/06	Monday	40.264	1.250
07/31/06	Monday	39.792	1.307
07/18/06	Tuesday	32.707	1.074
07/28/06	Friday	31.226	1.026
07/26/06	Wednesday	30.647	1.007

After the 5 days are selected, average the 24 hourly values for the 5 days by hour to create the baseline (Table 19).

Table 19: Creating the Baseline

Hour	Days Averaged to Create Baseline					Baseline
	07/17/06	07/31/06	07/18/06	07/28/06	07/26/06	
1	1.49	1.20	1.34	1.14	1.12	1.20
2	1.46	1.08	1.18	0.98	1.01	1.06
3	1.29	0.97	1.07	0.92	0.95	0.98
4	1.21	0.91	1.00	0.88	0.87	0.91
5	1.11	0.93	0.97	0.83	0.86	0.90
6	1.08	0.96	0.97	0.83	0.88	0.91
7	1.10	1.02	1.02	0.89	0.90	0.96
8	1.18	1.05	1.06	1.04	1.03	1.04
9	1.29	1.10	0.99	0.99	1.15	1.06
10	1.46	1.31	1.12	1.09	1.26	1.20
11	1.61	1.52	1.22	1.10	1.24	1.27
12	1.65	1.58	1.23	1.14	1.33	1.32
13	1.68	1.83	1.39	1.23	1.40	1.46
14	1.94	1.98	1.63	1.39	1.50	1.62
15	2.00	2.16	1.62	1.47	1.50	1.69
16	2.01	2.22	1.74	1.62	1.50	1.77
17	2.02	2.25	1.80	1.76	1.63	1.86
18	2.23	2.37	1.80	1.75	1.66	1.89
19	2.22	2.43	1.87	1.89	1.68	1.97
20	2.29	2.24	1.82	1.75	1.56	1.84
21	2.03	2.24	1.60	1.71	1.42	1.74
22	2.18	2.34	1.59	1.71	1.55	1.80
23	2.07	2.24	1.46	1.65	1.45	1.70
24	1.64	1.88	1.22	1.45	1.23	1.44

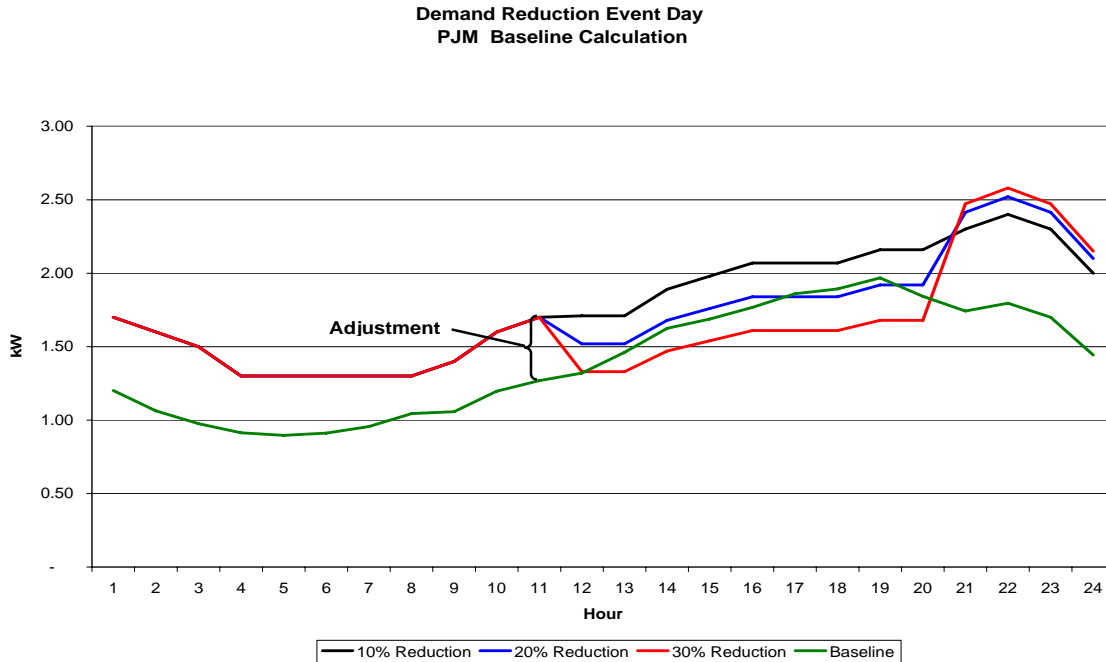
Apply the calculated baseline from Table 19 to the three levels of demand response reduction, 10%, 20%, and 30%. The results are shown in Table 20.

Table 20: Applying the PJM Baseline Calculation

Hour	Actual Customer Load	Customer Load			Calculated Baseline	Demand Response		
		10% Reduction	20% Reduction	30% Reduction		10% Reduction	20% Reduction	30% Reduction
1	1.70	1.70	1.70	1.70	1.20	0.50	0.50	0.50
2	1.60	1.60	1.60	1.60	1.06	0.54	0.54	0.54
3	1.50	1.50	1.50	1.50	0.98	0.52	0.52	0.52
4	1.30	1.30	1.30	1.30	0.91	0.39	0.39	0.39
5	1.30	1.30	1.30	1.30	0.90	0.40	0.40	0.40
6	1.30	1.30	1.30	1.30	0.91	0.39	0.39	0.39
7	1.30	1.30	1.30	1.30	0.96	0.34	0.34	0.34
8	1.30	1.30	1.30	1.30	1.04	0.26	0.26	0.26
9	1.40	1.40	1.40	1.40	1.06	0.34	0.34	0.34
10	1.60	1.60	1.60	1.60	1.20	0.40	0.40	0.40
11	1.70	1.70	1.70	1.70	1.27	0.43	0.43	0.43
12	1.90	1.71	1.52	1.33	1.32	0.39	0.20	0.01
13	1.90	1.71	1.52	1.33	1.46	0.25	0.06	(0.13)
14	2.10	1.89	1.68	1.47	1.62	0.27	0.06	(0.15)
15	2.20	1.98	1.76	1.54	1.69	0.29	0.07	(0.15)
16	2.30	2.07	1.84	1.61	1.77	0.30	0.07	(0.16)
17	2.30	2.07	1.84	1.61	1.86	0.21	(0.02)	(0.25)
18	2.30	2.07	1.84	1.61	1.89	0.18	(0.05)	(0.28)
19	2.40	2.16	1.92	1.68	1.97	0.19	(0.05)	(0.29)
20	2.40	2.16	1.92	1.68	1.84	0.32	0.08	(0.16)
21	2.30	2.30	2.42	2.47	1.74	0.56	0.67	0.73
22	2.40	2.40	2.52	2.58	1.80	0.60	0.72	0.78
23	2.30	2.30	2.42	2.47	1.70	0.60	0.71	0.77
24	2.00	2.00	2.10	2.15	1.44	0.56	0.66	0.71

With a demand response reduction of 10%, no measurable amount of load reduction is found. The load shape values the baseline is representing do not have sufficient load to offset the 10% load reduction. Either the calculated baseline did not represent the actual customer load or the reduction in load from the demand response was not a sufficient amount of reduction to offset the baseline.

The following graph illustrates the difference between the baseline and the customer load. An adjustment amount needs to be applied to shift the baseline to match the actual customer load. This difference is assumed by the PJM Interchange Energy Market Economic Load Response program to be a factor of the effects of weather on customer load.



The PJM Interchange Energy Market Economic Load Response program has two methods of calculating a weather sensitive baseline adjustment, a regression model and an ‘average of hour’ model. The operating procedures state a regression model can be used for any seasonal period and either day-ahead or real-time markets and the ‘average of hour’ model can only be used for the summer period and in the real-time market. The ‘average of hour model’ uses the result of averaging two demand values, (hours 9 & 10 in Table 21) before an event starts for both the calculated baseline and the customer load. The adjustment factor is applied to all hours of the event period to create an adjusted baseline. Table 21 is an example of the PJM average of hour model calculation.

Table 21: Calculating Average of Hour Baseline Weather Adjustment

Hour	Customer Load	Calculated Baseline	Adjusted Baseline	Adjusted Baseline
1	1.70	1.20		1.20
2	1.60	1.06		1.06
3	1.50	0.98		0.98
4	1.30	0.91		0.91
5	1.30	0.90		0.90
6	1.30	0.91		0.91
7	1.30	0.96		0.96
8	1.30	1.04		1.04
9	1.40	1.06		1.06
10	1.60	1.20		1.20
11	1.70	1.27		1.27
12	1.71	1.32	1.33	1.76
13	1.71	1.46	1.33	1.94
14	1.89	1.62	1.33	2.16
15	1.98	1.69	1.33	2.25
16	2.07	1.77	1.33	2.35
17	2.07	1.86	1.33	2.47
18	2.07	1.89	1.33	2.52
19	2.16	1.97	1.33	2.62
20	2.16	1.84	1.33	2.45
21	2.30	1.74		1.74
22	2.40	1.80		1.80
23	2.30	1.70		1.70
24	2.00	1.44		1.44

Customer Baseline Average of Hours 9&10
Customer Load Average of Hours 9&10
Weather Adjustment Factor

$(1.06 + 1.20)/2 = 1.13$
 $(1.40 + 1.60)/2 = 1.50$
 $1.50/1.13 = 1.33 = 33\%$

}

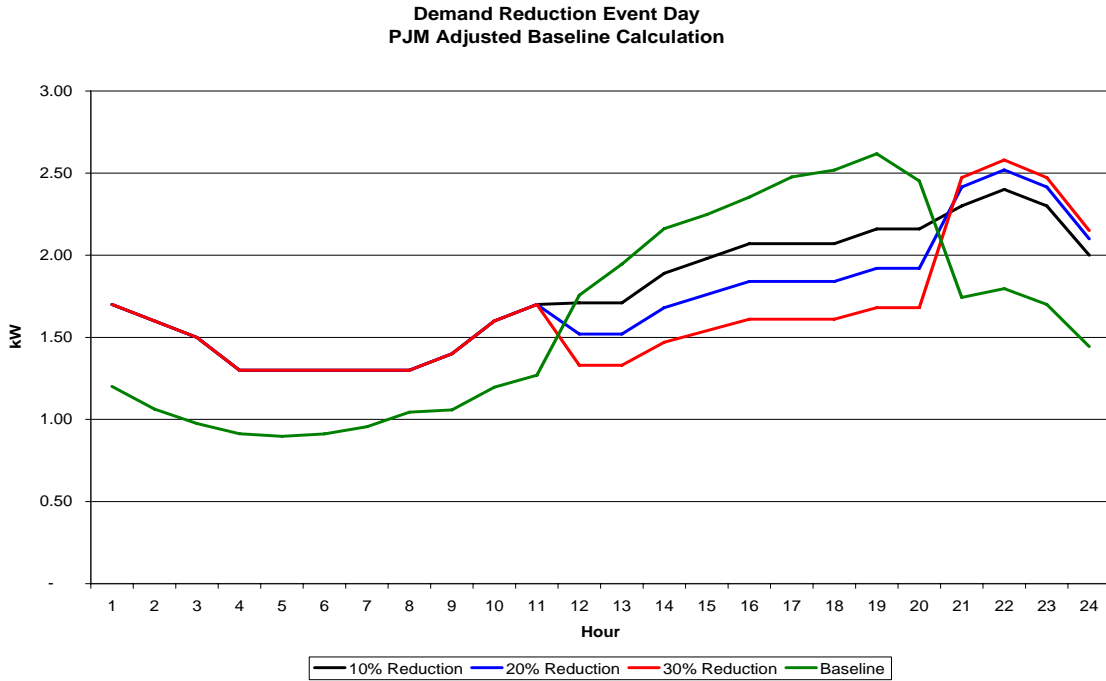
Adjustment Period

The weather adjustment factor must show a greater than 5% difference between the calculated customer load average and the calculated baseline average. From Table 21, the Weather Adjustment Factor of 33% is greater than the 5% difference level. There would be no weather adjustment to the baseline if that factor is less than or equal to 5%.

Table 22: Applying the PJM Baseline Calculation w/ Weather Adjustment

Hour	Actual Customer Load	Customer Load			Adjusted Baseline	Demand Response		
		10% Reduction	20% Reduction	30% Reduction		10% Reduction	20% Reduction	30% Reduction
1	1.70	1.70	1.70	1.70	1.20	0.50	0.50	0.50
2	1.60	1.60	1.60	1.60	1.06	0.54	0.54	0.54
3	1.50	1.50	1.50	1.50	0.98	0.52	0.52	0.52
4	1.30	1.30	1.30	1.30	0.91	0.39	0.39	0.39
5	1.30	1.30	1.30	1.30	0.90	0.40	0.40	0.40
6	1.30	1.30	1.30	1.30	0.91	0.39	0.39	0.39
7	1.30	1.30	1.30	1.30	0.96	0.34	0.34	0.34
8	1.30	1.30	1.30	1.30	1.04	0.26	0.26	0.26
9	1.40	1.40	1.40	1.40	1.06	0.34	0.34	0.34
10	1.60	1.60	1.60	1.60	1.20	0.40	0.40	0.40
11	1.70	1.70	1.70	1.70	1.27	0.43	0.43	0.43
12	1.90	1.71	1.52	1.33	1.76	(0.05)	(0.24)	(0.43)
13	1.90	1.71	1.52	1.33	1.95	(0.24)	(0.43)	(0.62)
14	2.10	1.89	1.68	1.47	2.16	(0.27)	(0.48)	(0.69)
15	2.20	1.98	1.76	1.54	2.25	(0.27)	(0.49)	(0.71)
16	2.30	2.07	1.84	1.61	2.35	(0.28)	(0.51)	(0.74)
17	2.30	2.07	1.84	1.61	2.48	(0.41)	(0.64)	(0.87)
18	2.30	2.07	1.84	1.61	2.52	(0.45)	(0.68)	(0.91)
19	2.40	2.16	1.92	1.68	2.62	(0.46)	(0.70)	(0.94)
20	2.40	2.16	1.92	1.68	2.45	(0.29)	(0.53)	(0.77)
21	2.30	2.30	2.42	2.47	1.74	0.56	0.67	0.73
22	2.40	2.40	2.52	2.58	1.80	0.60	0.72	0.78
23	2.30	2.30	2.42	2.47	1.70	0.60	0.71	0.77
24	2.00	2.00	2.10	2.15	1.44	0.56	0.66	0.71

By applying the weather adjustment to the baseline, the demand reduction is measurable for all hours for any level.



+90°F Average Day

The +90°F Average Day baseline methodology was created to show customer usage for an above average temperature day in the Detroit Edison service territory. The calculation averages all non holiday weekdays, in the months of May through September with a daily high temperature of 90°F or higher. The thought process behind this methodology is that customers on days where the temperature is above 90°F will be using cooling appliances near or at capacity. Generally speaking, these hot days are also when the price of electricity is at its highest in the Midwest and is more likely to experience a demand response event.

Table 23 shows the results of finding the days that have a maximum temperature that is 90°F or greater.

Table 23: Find +90°F Days

Date	Maximum Temperature
08/02/06	95
08/01/06	96
07/31/06	95
07/17/06	92

Using the dates from Table 23, average the 24 hourly values by hour to create the +90°F Average Day baseline. This represents the average demand for a customer for a day that is 90°F or greater. The result of this averaging is shown in Table 24.

Table 24: Creating the Baseline

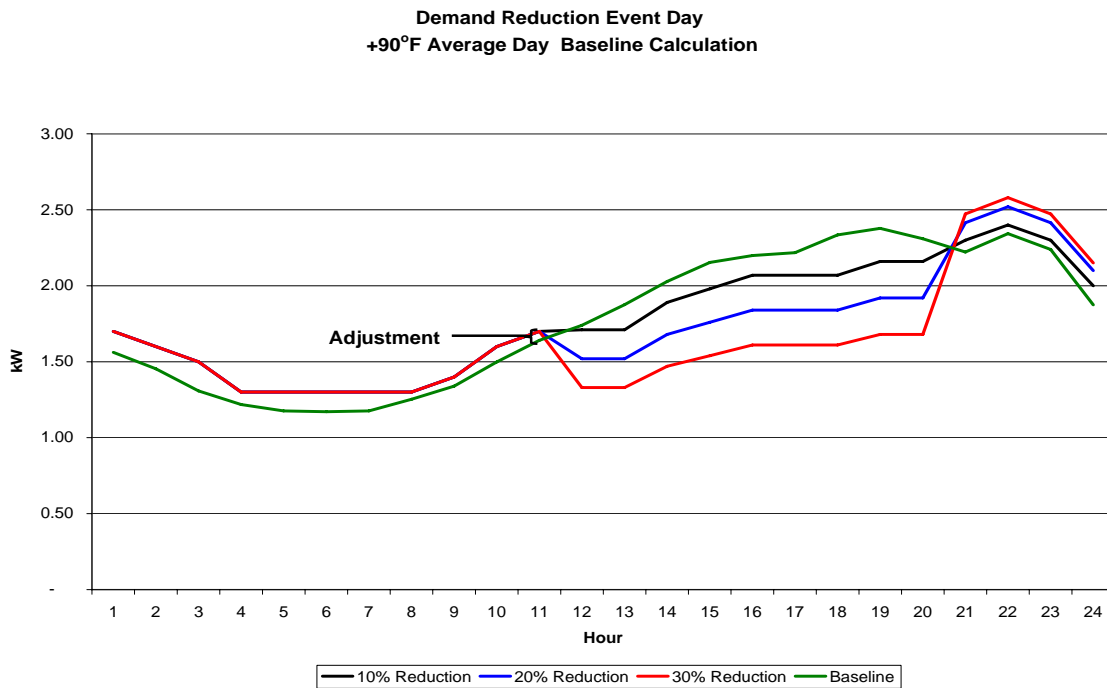
Hour	Days Averaged to Create Baseline				Baseline
	08/02/06	08/01/06	07/31/06	07/17/06	
1	1.75	1.81	1.20	1.49	1.56
2	1.64	1.64	1.08	1.46	1.45
3	1.48	1.49	0.97	1.29	1.31
4	1.34	1.41	0.91	1.21	1.22
5	1.33	1.34	0.93	1.11	1.18
6	1.34	1.30	0.96	1.08	1.17
7	1.30	1.29	1.02	1.10	1.18
8	1.33	1.45	1.05	1.18	1.25
9	1.44	1.53	1.10	1.29	1.34
10	1.63	1.59	1.31	1.46	1.50
11	1.69	1.75	1.52	1.61	1.64
12	1.87	1.86	1.58	1.65	1.74
13	1.93	2.06	1.83	1.68	1.88
14	2.09	2.11	1.98	1.94	2.03
15	2.24	2.21	2.16	2.00	2.15
16	2.28	2.29	2.22	2.01	2.20
17	2.30	2.30	2.25	2.02	2.22
18	2.33	2.41	2.37	2.23	2.33
19	2.45	2.41	2.43	2.22	2.38
20	2.42	2.29	2.24	2.29	2.31
21	2.36	2.26	2.24	2.03	2.22
22	2.48	2.37	2.34	2.18	2.34
23	2.38	2.27	2.24	2.07	2.24
24	1.99	1.99	1.88	1.64	1.87

This baseline calculation is based on an average customer load for a day that has a temperature greater than 90°F. This average assumes these are the 24 hourly load values of a customer on a +90°F day and does not take into consideration any abnormal changes to the customer load on an event day.

Table 25: Applying the +90°F Average Day Baseline Calculation

Hour	Actual Customer Load	Customer Load			Calculated Baseline	Demand Response		
		10% Reduction	20% Reduction	30% Reduction		10% Reduction	20% Reduction	30% Reduction
1	1.70	1.70	1.70	1.70	1.56	0.14	0.14	0.14
2	1.60	1.60	1.60	1.60	1.45	0.15	0.15	0.15
3	1.50	1.50	1.50	1.50	1.31	0.19	0.19	0.19
4	1.30	1.30	1.30	1.30	1.22	0.08	0.08	0.08
5	1.30	1.30	1.30	1.30	1.18	0.12	0.12	0.12
6	1.30	1.30	1.30	1.30	1.17	0.13	0.13	0.13
7	1.30	1.30	1.30	1.30	1.18	0.12	0.12	0.12
8	1.30	1.30	1.30	1.30	1.25	0.05	0.05	0.05
9	1.40	1.40	1.40	1.40	1.34	0.06	0.06	0.06
10	1.60	1.60	1.60	1.60	1.50	0.10	0.10	0.10
11	1.70	1.70	1.70	1.70	1.64	0.06	0.06	0.06
12	1.90	1.71	1.52	1.33	1.74	(0.03)	(0.22)	(0.41)
13	1.90	1.71	1.52	1.33	1.88	(0.17)	(0.36)	(0.55)
14	2.10	1.89	1.68	1.47	2.03	(0.14)	(0.35)	(0.56)
15	2.20	1.98	1.76	1.54	2.15	(0.17)	(0.39)	(0.61)
16	2.30	2.07	1.84	1.61	2.20	(0.13)	(0.36)	(0.59)
17	2.30	2.07	1.84	1.61	2.22	(0.15)	(0.38)	(0.61)
18	2.30	2.07	1.84	1.61	2.33	(0.26)	(0.49)	(0.72)
19	2.40	2.16	1.92	1.68	2.38	(0.22)	(0.46)	(0.70)
20	2.40	2.16	1.92	1.68	2.31	(0.15)	(0.39)	(0.63)
21	2.30	2.30	2.42	2.47	2.22	0.08	0.19	0.25
22	2.40	2.40	2.52	2.58	2.34	0.06	0.18	0.24
23	2.30	2.30	2.42	2.47	2.24	0.06	0.18	0.23
24	2.00	2.00	2.10	2.15	1.87	0.13	0.23	0.28

There is measured reduction of load for all three of the demand response reduction levels in Table 25, but the graph below shows the baseline not completely matching with the customer's actual usage before the start of the event period. Using a baseline without adjusting it to offset the differences between the baseline and actual customer usage for the event day will not completely characterize the intent of creating a baseline. Since the calculated baseline and actual customer usage do not match before the event, an adjustment should be made to this baseline.



For ease of analysis, the ISO New England baseline adjustment calculation seems reasonable because it adjusts by usage rather than by weather as the others do. As the +90°F Average Day method focus is on hourly use (with weather adjustments already built into the data), the ISO New England method is used.

Table 26: Applying the ISO New England Baseline Adjustment Rules to the +90°F Average Day Baseline.

Hour	Customer Load	New Baseline	Adjustment	Adjusted Baseline
1	1.70	1.56		1.56
2	1.60	1.45		1.45
3	1.50	1.31		1.31
4	1.30	1.22		1.22
5	1.30	1.18		1.18
6	1.30	1.17		1.17
7	1.30	1.18		1.18
8	1.30	1.25		1.25
9	1.40	1.34		1.34
10	1.60	1.50	0.080	1.58
11	1.70	1.64	0.080	1.72
12	1.33	1.74	0.080	1.82
13	1.33	1.88	0.080	1.96
14	1.47	2.03	0.080	2.11
15	1.54	2.15	0.080	2.23
16	1.61	2.20	0.080	2.28
17	1.61	2.22	0.080	2.30
18	1.61	2.33	0.080	2.41
19	1.68	2.38	0.080	2.46
20	1.68	2.31	0.080	2.39
21	2.47	2.22		2.22
22	2.58	2.34		2.34
23	2.47	2.24		2.24
24	2.15	1.87		1.87

Adjustment
Period

Hour 10 - 1.60 - 1.50 = .1
 Hour 11 - 1.70 - 1.64 = .06
 Adjustment - .1+.06 = .16/2 = .08

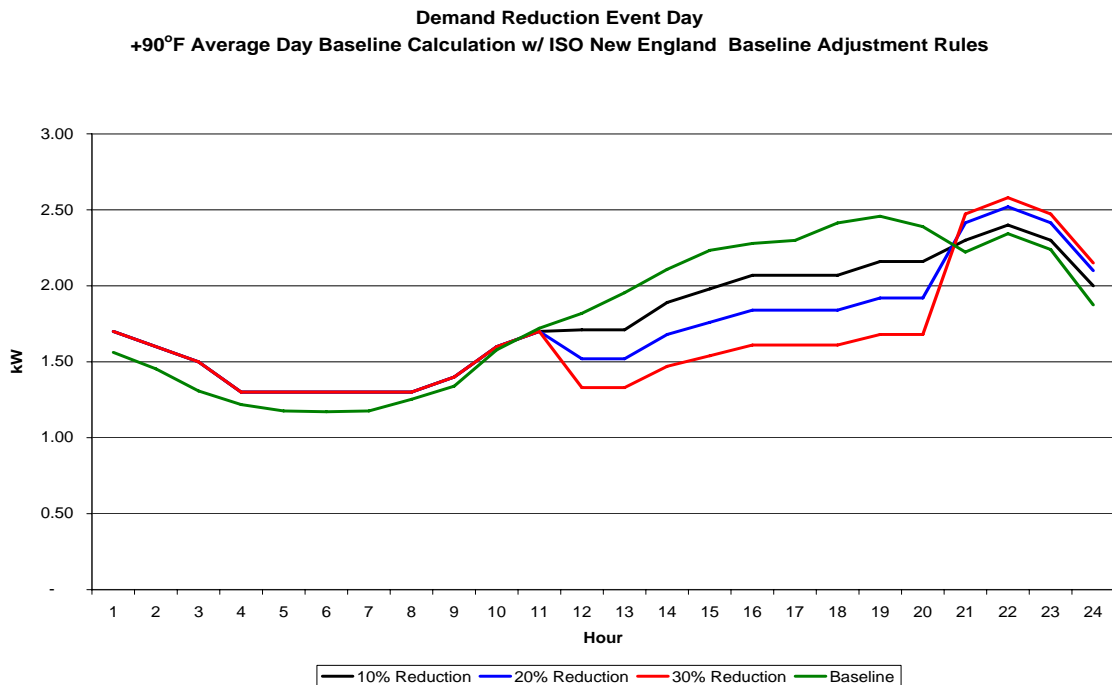
The adjusted baseline now follows the actual customer usage load curve for the two hours prior to the event period. An adjustment is applied under the assumption that the baseline did not fully represent the actual customer usage at the time of the start of the event period. Questions of why the baseline did not align with the actual customer usage when its purpose is to represent that usage could be raised if an adjustment wasn't made.

Table 27 shows the results of applying the adjusted baseline to the demand response reduction levels.

Table 27: Applying the ISO New England Adjusted Baseline Calculation to the +90°F Average Day Baseline Calculation

Hour	Actual Customer Load	Customer Load			Adjusted Baseline	Demand Response		
		10% Reduction	20% Reduction	30% Reduction		10% Reduction	20% Reduction	30% Reduction
1	1.70	1.70	1.70	1.70	1.56	0.14	0.14	0.14
2	1.60	1.60	1.60	1.60	1.45	0.15	0.15	0.15
3	1.50	1.50	1.50	1.50	1.31	0.19	0.19	0.19
4	1.30	1.30	1.30	1.30	1.22	0.08	0.08	0.08
5	1.30	1.30	1.30	1.30	1.18	0.12	0.12	0.12
6	1.30	1.30	1.30	1.30	1.17	0.13	0.13	0.13
7	1.30	1.30	1.30	1.30	1.18	0.12	0.12	0.12
8	1.30	1.30	1.30	1.30	1.25	0.05	0.05	0.05
9	1.40	1.40	1.40	1.40	1.34	0.06	0.06	0.06
10	1.60	1.60	1.60	1.60	1.58	0.02	0.02	0.02
11	1.70	1.70	1.70	1.70	1.72	(0.02)	(0.02)	(0.02)
12	1.90	1.71	1.52	1.33	1.82	(0.11)	(0.30)	(0.49)
13	1.90	1.71	1.52	1.33	1.96	(0.25)	(0.44)	(0.63)
14	2.10	1.89	1.68	1.47	2.11	(0.22)	(0.43)	(0.64)
15	2.20	1.98	1.76	1.54	2.23	(0.25)	(0.47)	(0.69)
16	2.30	2.07	1.84	1.61	2.28	(0.21)	(0.44)	(0.67)
17	2.30	2.07	1.84	1.61	2.30	(0.23)	(0.46)	(0.69)
18	2.30	2.07	1.84	1.61	2.41	(0.34)	(0.57)	(0.80)
19	2.40	2.16	1.92	1.68	2.46	(0.30)	(0.54)	(0.78)
20	2.40	2.16	1.92	1.68	2.39	(0.23)	(0.47)	(0.71)
21	2.30	2.30	2.42	2.47	2.22	0.08	0.19	0.25
22	2.40	2.40	2.52	2.58	2.34	0.06	0.18	0.24
23	2.30	2.30	2.42	2.47	2.24	0.06	0.18	0.23
24	2.00	2.00	2.10	2.15	1.87	0.13	0.23	0.28

After the adjustment to the baseline has been applied the baseline now matches with the actual customer usage.



Conclusions

The goal of this paper was to analyze different baseline calculation methodologies using a single set of data. Understanding of how each method arrived at its goal of representing what a customer's actual usage would have been absent a demand response event is appreciated by how each method derives a baseline using the same data. All of the methodologies accomplish that goal but obtain the results differently. Where three methods use energy and weekdays as deciding factors, the other two just use weekdays. The energy and weekday methods rely on calculating daily energy from 24 hourly values to choose the weekdays. Of the methods that require just weekdays in the selection criteria, the number of weekdays needed is different. All of the methods try to minimize the customer's opportunity to 'game' the process by averaging multiple days together or using energy from multiple days in their calculation. What is evident from the analysis of the different methodologies is that an adjustment to the baseline calculation is needed to most accurately estimate actual customer usage.

ISO New England uses just uses weekdays as the base for its baseline calculation. One of its strengths is the simplicity of the calculation. They have accomplished their goal if it was to create a methodology that all participants could understand from the ISO to the individual customer. But a weakness is that only ISO New England creates a baseline every day whether it needs it or not.

California uses only three weekdays chosen by calculating daily energy. This simplicity could be considered a strength because it only needs to find three weekdays. The major weakness with the California methodology is that it does not yet have any provisions to adjust their baseline to best match the conditions of the event day.

New York ISO and PJM have multi step processes that are fairly complex. A weakness of these processes is an individual customer might have a problem understanding how the whole methodology works. Both New York ISO and PJM rely on selecting the number of weekdays to use in the baseline calculation from a pool of ten weekdays chosen using a daily energy value. Strengths for both methods is the baseline is only calculated when it's needed and having a provision for adjusting the baseline.

The +90°F Average Day method is easily understood but its weakness is that it relies on using 90°F days. If there are too few of these days, the baseline calculation might not create a representative estimate of actual customer usage.

References:

ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources, M-MVDR, Revision: 0, February 28, 2007

NYISO Day-Ahead Demand Response Program Manual, July 2003

CAISO Demand Response Resource User Guide, Guide to Participation in MRTU Release 1, November 29, 2007, Version 3.0

Amended and Restated Operating Agreement of PJM Interconnection, L.L.C.