Coincidence Factor Study
Residential and Commercial Industrial Lighting Measures

Prepared for;
New England State Program Working Group (SPWG)

For use as an
Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM)

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Prepared for:
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Program Working Group (SPWG)

Prepared by:

RLW ANALYTICS
179 Main Street
Middletown, CT 06457
(860) 346-5001

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Executive Summary

The New England State Program Working Group (SPWG)[1] contracted with RLW to calculate coincidence factors for residential and commercial and industrial lighting measures that could be consistently applied to energy efficiency programs that may bid into the ISO-NE Forward Capacity Market (FCM) in any of the New England states. As directed by the SPWG, the focus of this effort was on lighting measures.

Resulting coincidence factors presented in this report were developed to work as common values accepted by all New England states for the FCM that can be applied or used as appropriate for measures installed by energy efficiency programs in the New England states that have supported this research effort.

This section of the report describes the analytical results and conclusions for the calculation of the Coincidence Factors (CFs) for the Residential and Commercial and Industrial Lighting measures. Energy Efficiency demand reductions can be classified in the Forward Capacity Market (FCM) as one of three different types of assets, based upon the performance hours that will be used for evaluation. The most straight forward type of asset is On-Peak, because the performance hours are fixed and defined as follows:

- Summer On-Peak: average weekday from 1-5 PM throughout June, July and August.
- Winter On-Peak: average weekday from 5-7 PM throughout December and January.

ISO-NE hourly load data and forecast data were obtained for the past several years from recent energy efficiency program evaluations throughout New England, as described in Appendix A. They were analyzed to determine Seasonal Peak performance hours and Critical Peak performance hours which are defined as follows:

- **Seasonal Peak Hours** occur when Real Time load is equal to or greater than 90% of the 50/50 seasonal peak load forecast during Summer (June – August) or Winter (December and January) months.

[1] Represented by the state regulatory agencies (CT DPUC, Maine PUC, MA DOER, NH PUC, RI PUC, and VT PSB) and associated energy efficiency program administrators (Cape Light Compact, Efficiency Maine, Efficiency Vermont, National Grid (MA, NH & RI), Northeast Utilities (CT&MA), NSTAR, PSNH, United Illuminating, and Unitil (MA&NH)).

- **Critical Peak Performance Hours** occur when the Day Ahead Load forecast is equal to or greater than 95% of the 50/50 seasonal peak load forecast during Summer (June – August) or Winter (December and January) months and also includes shortage hours.
  - **Shortage hours** occur during Operating Procedure 4 (OP4) level 6 or higher events, at level 6 the 30-minute operating reserve begins to be depleted.

Coincidence Factors (CFs) are defined in this study as the fractions of the connected (or rated) load (based on actual lighting Watts, motor nameplate horsepower and efficiency, AC rated capacity and efficiency, etc.) reductions that actually occur during each of the seasonal demand windows. They are the ratio of the actual demand reductions during the coincident windows to the maximum connected load reductions. Under this definition other issues such as diversity and load factor are automatically accounted for, and only the coincidence factor will be necessary to determine coincident demand reductions from readily observable equipment nameplate (rated) information. In other words, coincident demand reduction will simply be the product of the coincidence factor and the connected equipment load kW reduction.

Residential Lighting Coincidence Factor Results

Table i - 1 and Table i - 2 provide the un-weighted and weighted, Summer On-Peak and Winter On-Peak CFs as well as the associated relative precisions for all residential lighting. The CFs were developed using only metered data that were acquired during the winter (December and January) or summer (June, July and August) peak months and the number of loggers used in the analysis is provided in the tables. The weighted CFs were developed by weighting the logger files based upon the connected load that the logger represents and in most cases the weighted results are slightly higher than the un-weighted results. The CFs for the summer range from a low of 0.06 for June to a high of 0.094 for August, with the average summer CF between 0.076 un-weighted and 0.082 weighted. If the average is carried to only two decimal places than the result is a summer average CF of 0.08 for both methodologies. The relative precision for the average summer on-peak period is ±6.1% at the 80% confidence interval.

	Summer On-Peak Hours 1PM - 5PM			
Data Period	**Sample Size n**	**Un-weighted CF**	**Weighted CF**	**Un-weighted Rel Precision**
June	210	0.060	0.069	±11.6%
July	102	0.081	0.086	±12.5%
August	189	0.094	0.092	±8.7%
Average Summer	501	0.076	0.082	±6.1%

Table i - 1: Summer On-Peak CFs and Relative Precisions Residential Lighting

	Winter On-Peak Hours 5PM - 7PM			
Data Period	**Sample Size n**	**Un-weighted CF**	**Weighted CF**	**Un-weighted Rel Precision**
December	282	0.263	0.281	±6.5%
January	264	0.301	0.320	±6.5%
Average Winter	546	0.286	0.298	±4.5%

Table i - 2: Winter On-Peak CFs and Relative Precisions Residential Lighting

The winter CFs as expected are higher than the summer CFs ranging from 0.263 for December to 0.320 for January with the average winter CF for all lighting at 0.286 un-weighted and 0.298 weighted. The relative precisions is better during the winter peak periods primarily because the CFs are higher and there is less variation in the data, i.e. the Coefficient of Variation (Cv) is lower. The relative precision of the average winter un-weighted CF is ±4.5% at the 80% confidence interval and the December and January relative precisions are both better than ±10% at the 80% confidence interval.

The Seasonal Summer and Winter Peak performance hours were calculated using historical load data and the 50/50 Seasonal Peak Forecasts from the most recent Capacity Energy Loads and Transmission (CELT) reports. The seasonal peak performance hours were weighted based upon the frequency distribution of the hours observed where the load met or exceeded 90% of the 50/50 seasonal peak forecast and these values were used to calculate a weighted CF for each of the measure types. Table i - 3 and Table i - 4 provide the Summer Seasonal Peak and Winter Seasonal Peak CFs for all residential lighting. The CFs during the summer months range from a low of about 0.08 for June to a high of 0.10 for August, with an Average Summer CF of about 0.09. The relative precision during each of the summer months is within the range of ±10% at the 80% confidence interval. The Winter Seasonal Peak CFs as expected, are higher than the Summer Seasonal Peak CFs ranging from 0.25 in December to 0.28 in January with an Average Winter Seasonal Peak CF for all lighting at 0.26.

	Summer Seasonal Peak Hours (90% of 50/50 Peak)			
Data Period	Sample Size n	Un-weighted CF	Calculated CV	Calculated Rel Precision
June	210	0.075	2.275	±6.3%
July	102	0.091	1.884	±5.3%
August	189	0.104	1.747	±5.2%
Average Summer	501	0.088	1.967	±3.6%

Table i - 3: Summer Seasonal Peak CFs and Relative Precisions Residential Lighting

	Winter Seasonal Peak Hours (90% of 50/50 peak)			
Data Period	Sample Size n	Un-weighted CF	Calculated CV	Calculated Rel Precision
December	282	0.249	1.23	±4.5%
January	264	0.279	1.19	±4.5%
Average Winter	546	0.264	1.21	±3.2%

Table i - 4: Winter Seasonal Peak CFs and Relative Precisions Residential Lighting

Table i - 5 and Table i - 6 presen ts a comparison of the CFs calculated for the On-Peak Performance hours and the Seasonal Peak Performance hours for both the summer and winter periods. The results show that the Summer Seasonal Peak CF increases over the Summer On-Peak for each month during the summer period and the Average Summer CF increases by 16% from 0.076 to 0.088. The increase is due to a wider range of hours being included in the weighted average calculation including more evening hours, when the CFs are higher. The reverse is true for the Winter Seasonal Peak CFs, which is lower than the Winter On-Peak CFs with the Average Winter CF decreasing by 8% from about 0.29 to 0.26. The decrease is due to a wider range of hours being included in the weighted average calculation including more morning and afternoon hours, when the CFs are lower.

Data Period	On-Peak Un-weighted CF	Seasonal Un-weighted CF	% Change Seasonal/ On-Peak
June	0.060	0.075	126%
July	0.081	0.091	112%
August	0.094	0.104	111%
Average Summer	0.076	0.088	116%

Table i - 5: Comparison of Summer On-Peak and Seasonal Peak CFs Residential Lighting

Data Period	On-Peak Un-weighted CF	Seasonal Un-weighted CF	% Change Seasonal/ On-Peak
December	0.263	0.249	95%
January	0.301	0.279	93%
Average Winter	0.286	0.264	92%

Table i - 6: Comparison of Winter On-Peak and Seasonal Peak CFs Residential Lighting

Commercial & Industrial Lighting Coincidence Factor Results

A similar Coincidence Factor analysis was also conducted for Commercial and Industrial Lighting and Occupancy Sensor measures. The logger data were analyzed by sector so that results could be applied to multiple programs with different participation rates among the different sectors. Table i - 7and Table i - 8 provide the On-Peak CFs for the ten C&I sectors along with the associated relative precisions and total estimated CFs based on a logger weighted strategy and weighting each sector equally. The Summer On-Peak CFs indicates that the Grocery sector has the highest CF of about 0.95, while the Other sector has the lowest CF of about 0.54. All of the sectors have relative precisions that are within ± 5% at the 80% confidence interval. The Grocery sector also had the highest Winter On-Peak CF of about 0.78, while the School sector had the lowest CF of about 0.34. Once again the relative precisions were all quite good with each sector exceeding ± 10% at the 80% confidence interval. As expected the Winter On-Peak CFs were lower than the Summer On-Peak CFs for all of the C&I lighting sectors, because the performance hours occur later in the day as C&I facilities are shutting down and lighting is being switched off.

	Summer On-Peak Hours 1PM - 5PM				
Sector Type	Sample Size n	Calculated CF	Logger Weight	Calculated CV	Calculated Rel Precision
Grocery	37	0.948	0.026	0.179	±1.9%
Manufacturing	169	0.729	0.119	0.488	±2.4%
Medical (Hospital)	58	0.769	0.041	0.425	±3.6%
Office	259	0.750	0.183	0.438	±1.7%
Other	192	0.543	0.136	0.675	±3.1%
Restaurant	43	0.811	0.030	0.347	±3.4%
Retail	166	0.824	0.117	0.342	±1.7%
University/College	70	0.680	0.049	0.483	±3.7%
Warehouse	59	0.781	0.042	0.359	±3.0%
School	362	0.633	0.256	0.503	±1.7%
Total Weighted by Logger		0.704	1.000		
Total Equal Weight by Sector		0.747			

Table i - 7: Summer On-Peak CFs and Relative Precision C&I Lighting

	Winter On-Peak Hours 5PM - 7PM				
Sector Type	Sample Size n	Calculated CF	Logger Weight	Calculated CV	Calculated Rel Precision
Grocery	37	0.776	0.026	0.474	±7.1%
Manufacturing	169	0.399	0.119	0.983	±6.9%
Medical (Hospital)	58	0.603	0.041	0.593	±7.1%
Office	259	0.537	0.183	0.725	±4.1%
Other	192	0.426	0.136	0.804	±5.3%
Restaurant	43	0.663	0.030	0.557	±7.7%
Retail	166	0.655	0.117	0.592	±4.2%
University/College	70	0.523	0.049	0.679	±7.4%
Warehouse	59	0.496	0.042	0.787	±9.3%
School	362	0.343	0.256	1.010	±4.8%
Total Weighted by Logger		0.480	1.000		
Total Equal Weight by Sector		0.542			

Table i - 8: Winter On-Peak CFs and Relative Precision C&I Lighting

Table i - 9and Table i - 10 provide the Summer and Winter Seasonal-Peak CFs for the ten C&I sectors along with the associated relative precisions and total estimated CFs based on a logger weighted strategy and weighting each sector equally (which is the simple average of the CFs across all sectors. The Seasonal Peak Performance Hours were determined by analysis of historic ISO-NE Load Data and Forecast Data to determine the frequency distribution for each hour where the demand was greater than or equal to 90% of the seasonal forecast. A simple probabilistic weighting scheme was applied based upon the number of observation during each hour as described in section

3 of this report. The Summer Seasonal-Peak CFs indicates that the Grocery sector has the highest CF of about 0.90, while the Other sector has the lowest CF of about 0.48. All of the sectors have relative precisions that are within ± 5% at the 80% confidence interval during the Summer Seasonal Peak hours. The Grocery sector also had the highest Winter On-Peak CF of about 0.78, while the School sector had the lowest CF of about 0.34. Once again the relative precisions were all quite good with each sector exceeding ± 10% at the 80% confidence interval. As expected the Winter On-Peak CFs were lower than the Summer On-Peak CFs for all of the C&I lighting sectors, because the performance hours occur later in the day as C&I facilities are shutting down and lighting is being switched off.

	Summer Seasonal Peak Hours (90% of 50/50 Peak)				
Sector Type	Sample Size n	Calculated CF	Logger Weight	Calculated CV	Calculated Rel Precision
Grocery	37	0.904	0.026	0.23	±1.5%
Manufacturing	169	0.671	0.119	0.52	±1.7%
Medical (Hospital)	58	0.740	0.041	0.45	±2.5%
Office	259	0.702	0.183	0.48	±1.2%
Other	192	0.476	0.136	0.75	±3.0%
Restaurant	43	0.775	0.030	0.40	±2.5%
Retail	166	0.795	0.117	0.38	±1.2%
University/College	70	0.650	0.049	0.51	±2.5%
Warehouse	59	0.727	0.042	0.41	±2.2%
School	362	0.599	0.256	0.48	±1.1%
Total Weighted by Logger		0.660	1.000		
Total Equal Weight by Sector		0.704			

Table i - 9: Summer Seasonal Peak CFs and Relative Precision C&I Lighting

	Winter Seasonal Peak Hours (90% of 50/50 Peak)				
Sector Type	Sample Size n	Calculated CF	Logger Weight	Calculated CV	Calculated Rel Precision
Grocery	37	0.770	0.026	0.44	±4.6%
Manufacturing	169	0.432	0.119	0.91	±4.2%
Medical (Hospital)	58	0.618	0.041	0.58	±4.5%
Office	259	0.539	0.183	0.71	±2.6%
Other	192	0.428	0.136	0.80	±4.4%
Restaurant	43	0.644	0.030	0.59	±5.3%
Retail	166	0.647	0.117	0.59	±2.7%
University/College	70	0.528	0.049	0.60	±4.2%
Warehouse	59	0.535	0.042	0.70	±5.6%
School	362	0.388	0.256	0.85	±2.7%
Total Weighted by Logger		0.497	1.000		
Total Equal Weight by Sector		0.553			

Table i - 10: Winter Seasonal Peak CFs and Relative Precision C&I Lighting

Table i - 11 provides a comparison of the Summer On-Peak and Seasonal Peak CFs for each of the C&I sectors, which shows that for every sector the Summer Seasonal CFs are lower than the Summer On-Peak CFs. This means that if the C&I lighting were classified as Summer Seasonal Peak assets the demand reductions would be lower.

	Summer		% Change
Sector Type	On-Peak CF	Seasonal CF	Seasonal / On-Peak
Grocery	0.948	0.904	95%
Manufacturing	0.729	0.671	92%
Medical (Hospital)	0.769	0.740	96%
Office	0.750	0.702	94%
Other	0.543	0.476	88%
Restaurant	0.811	0.775	96%
Retail	0.824	0.795	96%
University/College	0.680	0.650	96%
Warehouse	0.781	0.727	93%
School	0.633	0.599	95%
Total Weighted by Logger	0.704	0.660	94%
Total Equal Weight by Sector	0.747	0.704	94%

Table i - 11: Comparison of Summer On-Peak and Seasonal Peak CFs C&I Lighting

Table i - 12 provides a similar comparison of the Winter On-Peak and Seasonal Peak CFs for each of the C&I Lighting sectors. In this case the results are mixed, with 7 of the 10 sectors showing an increase in the Winter Seasonal Peak CFs compared to the Winter On-Peak CF. This seems to indicate that in general for the winter, C&I lighting would have more demand reduction if classified as a Seasonal Peak asset.

	Winter		% Change
Sector Type	On-Peak CF	Seasonal CF	Seasonal / On-Peak
Grocery	0.776	0.770	99%
Manufacturing	0.399	0.432	108%
Medical (Hospital)	0.603	0.618	103%
Office	0.537	0.539	101%
Other	0.426	0.428	100%
Restaurant	0.663	0.644	97%
Retail	0.655	0.647	99%
University/College	0.523	0.528	101%
Warehouse	0.496	0.535	108%
School	0.343	0.388	113%
Total Weighted by Logger	0.480	0.497	104%
Total Equal Weight by Sector	0.542	0.553	102%

Table i - 12: Comparison of Winter On-Peak and Seasonal Peak CFs C&I Lighting

Commercial & Industrial Occupancy Sensor Coincidence Factor Results

Table i - 13 and Table i - 14 present the Summer On-Peak and Winter On-Peak CFs for occupancy sensors for seven of the ten C&I sectors as well as the total CFs for all seven sectors on a logger weighted basis and by weighting each sector equally. During the Summer On-Peak Period the occupancy sensors installed in the University/College sector had the highest CF of about 0.30, while the Other sector had the lowest CF of about 0.02. The Summer On-Peak CF for the remaining sectors ranged from about 0.21 for Manufacturing to 0.27 for the Office Sector. During the Winter On-Peak the Office sector had the highest CF of about 0.31 and the Other sector had the lowest CF of 0.09. The CFs for the remaining sectors ranged from a low of about 0.17 for the Warehouse sector to a high of about 0.23 for the University/College sector. The relative precision for all of the CFs were estimated by calculating the relative precision of the occupancy sensors profiles, since only aggregate savings profiles were developed for the analysis. In this case we would recommend using the logger weighted Total CFs since the relative precision for individual sector results are not that good particularly during the Winter period.

	Summer On-Peak Hours 1PM - 5PM				
Data Period	Sample Size n	Calculated CF	Logger Weight	Estimated CV	Estimated Rel Precision
Manufacturing	12	0.210	0.035	0.688	±12.7%
Medical	59	0.234	0.170	0.602	±5.0%
Office	69	0.270	0.199	0.559	±4.3%
Other	56	0.017	0.161	0.793	±6.8%
University/College	16	0.304	0.046	0.678	±10.9%
Warehouse	77	0.266	0.222	0.646	±4.7%
School	58	0.239	0.167	0.828	±7.0%
Total Weighted by Logger		0.217	1.000		
Total Equal Weight by Sector		0.154			

Table i - 13: Summer On-Peak CFs and Relative Precision C&I Occupancy Sensors

	Winter On-Peak Hours 5PM - 7PM				
Sector Type	Sample Size n	Calculated CF	Logger Weight	Estimated CV	Estimated Rel Precision
Manufacturing	12	0.190	0.035	1.301	±34.1%
Medical	59	0.213	0.170	0.840	±9.9%
Office	69	0.309	0.199	1.087	±11.9%
Other	56	0.089	0.161	1.053	±12.8%
University/College	16	0.233	0.046	0.827	±18.8%
Warehouse	77	0.175	0.222	1.082	±11.2%
School	58	0.173	0.167	1.527	±18.2%
Total Weighted by Logger		0.197	1.000		
Total Equal Weight by Sector		0.138			

Table i - 14: Winter On-Peak CFs and Relative Precision C&I Occupancy Sensors

Table i - 15 and Table i - 16 provide the Summer Seasonal Peak and Winter Seasonal Peak CFs for the occupancy sensors for seven of the ten C&I sectors. Once again during the Summer Seasonal Peak hours the University/College sector occupancy sensors had the highest CF of about 0.28 and the Other sector had the lowest CF of about 0.02. The CFs for the remaining sectors ranged from about 0.20 to 0.27. The Winter Seasonal Peak CFs were similar to the Winter On-Peak results with the Office sector having the highest CF of about 0.30 and the Other sector having the lowest CF of about 0.07. Once again the relative precision of the CFs were estimated by using the occupancy sensor profiles and the results are better than for the On-Peak periods because the results were taken across more hours. The Summer Seasonal Peak estimated relative precisions for each of the sectors are all within ±10% at the 80% confidence interval, and Winter estimated relative precisions are also within that range for most of the sectors.

	Summer Seasonal Peak Hours (90% of 50/50 Peak)				
Data Period	Sample Size n	Calculated CF	Logger Weight	Estimated CV	Estimated Rel Precision
Manufacturing	12	0.198	0.035	0.712	±8.9%
Medical	59	0.239	0.170	0.649	±3.6%
Office	69	0.274	0.199	0.606	±3.2%
Other	56	0.024	0.161	0.808	±4.6%
University/College	16	0.283	0.046	0.720	±7.6%
Warehouse	77	0.246	0.222	0.700	±3.3%
School	58	0.209	0.167	0.739	±4.2%
Total Weighted by Logger		0.208	1.000		
Total Equal Weight by Sector		0.147			

Table i - 15: Summer Seasonal-Peak CFs and Relative Precision C&I Occupancy Sensors

	Winter Seasonal Peak Hours (90% of 50/50 Peak)				
Data Period	Sample Size n	Calculated CF	Logger Weight	Estimated CV	Estimated Rel Precision
Manufacturing	12	0.172	0.035	1.063	±17.3%
Medical	59	0.221	0.170	0.827	±6.3%
Office	69	0.296	0.199	0.966	±6.9%
Other	56	0.066	0.161	0.990	±7.7%
University/College	16	0.231	0.046	0.819	±11.9%
Warehouse	77	0.183	0.222	0.986	±6.6%
School	58	0.159	0.167	1.140	±8.7%
Total Weighted by Logger		0.191	1.000		
Total Equal Weight by Sector		0.133			

Table i - 16: Winter Seasonal-Peak CFs and Relative Precision C&I Occupancy Sensors

Table i - 17 and Table i - 18 provide a comparison of the Summer and Winter On-Peak and Seasonal Peak CFs for occupancy sensors for seven C&I sectors as well as the totals for all seven sectors calculated on a logger weighted and sector weighted basis. The results for the Summer period show that the Summer Seasonal CFs are lower than the On-Peak CFs for four of the seven sectors and for the total CF using both calculation methods. The results for the Winter period are similar, with five of the sectors having lower Seasonal Peak CFs and lower Total CFs using both calculation methods. Classifying the occupancy sensors as Seasonal Peak assets would result in a slight reduction in demand savings during both periods.

Sector Type	Summer On-Peak CF	Summer Seasonal CF	% Change Seasonal / On-Peak
Manufacturing	0.210	0.198	94%
Medical	0.234	0.239	102%
Office	0.270	0.274	101%
Other	0.017	0.024	144%
University/College	0.304	0.283	93%
Warehouse	0.266	0.246	92%
School	0.239	0.209	87%
Total Weighted by Logger	0.217	0.208	96%
Total Equal Weight by Sector	0.154	0.147	96%

Table i - 17: Comparison of Summer On-Peak and Seasonal Peak CFs Occupancy Sensors

Sector Type	Winter On-Peak CF	Winter Seasonal CF	% Change Seasonal / On-Peak
Manufacturing	0.190	0.172	90%
Medical	0.213	0.221	104%
Office	0.309	0.296	96%
Other	0.089	0.066	75%
University/College	0.233	0.231	99%
Warehouse	0.175	0.183	105%
School	0.173	0.159	92%
Total Weighted by Logger	0.197	0.191	97%
Total Equal Weight by Sector	0.138	0.133	96%

Table i - 18: Comparison of Winter On-Peak and Seasonal Peak CFs Occupancy Sensors

1 Introduction

The New England State Program Working Group (SPWG)[2] contracted with RLW to calculate coincidence factors for residential and commercial and industrial lighting measures that could be consistently applied to energy efficiency programs that may bid into the ISO-NE Forward Capacity Market (FCM) in any of the New England states. As directed by the SPWG, the focus of this effort was on lighting measures.

Resulting coincidence factors presented in this report were developed to work as common values accepted by all New England states for the FCM that can be applied or used as appropriate for measures installed by energy efficiency programs in the New England states that have supported this research effort.

1.1 Primary Goals and Objectives

The primary goal of this task was to combine enough load shapes for the Residential Lighting, C&I Lighting and Occupancy Sensor measures to obtain the average summer and winter peak coincidence factor with a statistical precision of at least ±10% at a confidence level of 80% using a two-tail confidence interval.

The defining objective of this study was to develop new and/or revised coincidence factors that can be used to evaluate the demand impacts of residential and C&I lighting programs that are suitable for submission into the ISO-NE Forward Capacity Market (FCM).

The summer and winter on-peak hours are defined as follows:

- Summer On-Peak: average weekday from 1-5 PM throughout June, July and August.
- Winter On-Peak: average weekday from 5-7 PM throughout December, January

[2] Represented by the state regulatory agencies (CT DPUC, Maine PUC, MA DOER, NH PUC, RI PUC, and VT PSB) and associated energy efficiency program administrators (Cape Light Compact, Efficiency Maine, Efficiency Vermont, National Grid (MA, NH & RI), Northeast Utilities (CT&MA), NSTAR, PSNH, United Illuminating, and Unitil (MA&NH)).

ISO-NE hourly load data and forecast data were obtained for the past several years and were analyzed to determine Seasonal Peak performance hours and Critical Peak performance hours which are defined as follows:

- **Seasonal Peak Hours** occur when Real Time load is equal to or greater than 90% of the 50/50 seasonal peak load forecast during Summer (June – August) or Winter (December and January) months.
- **Critical Peak Performance Hours** occur when the Day Ahead Load forecast is equal to or greater than 95% of the 50/50 seasonal peak load forecast during Summer (June – August) or Winter (December and January) months and also includes shortage hours.
    - **Shortage hours** occur during Operating Procedure 4 (OP4) level 6 or higher events, at level 6 the 30-minute operating reserve begins to be depleted.

Coincidence factors are defined in this study as the fractions of the connected (or rated) load (based on actual lighting Watts, motor nameplate horsepower and efficiency, AC rated capacity and efficiency, etc.) reductions that actually occur during each of the seasonal demand windows. They are the ratio of the demand reductions during the coincident windows to the maximum connected load reductions. Under this definition other issues such as diversity and load factor are automatically accounted for, and only the coincidence factor will be necessary to determine coincident demand reductions from readily observable equipment nameplate (rated) information. In other words, coincident demand reduction will simply be the product of the coincidence factor and the connected equipment load kW reduction. In the case of residential lighting the connected kW reduction will be baseline wattage for the fixture minus the wattage for fixture divided by 1,000 W/kW. There should be no net adjustments made to these numbers that adjust for operating hours however if there are net impacts that adjust for installation rates these numbers should be used to calculate impacts.

2 Description and Methodology

RLW reviewed all of the logger and impact load shape data that were available from past evaluations. The measures were then binned into the unique measure categories and individual measure data were grouped and averaged to inform the results of this task. The formula below illustrates how the logger data were used to calculate the summer and winter peak coincidence factors for each load shape.

$$CF = \left(\frac{CE}{peakhrs * connkW} \right)$$

where,

CF = Coincidence factor (coincident with the various system peak windows),

CE = Coincident energy: Total kWh of the measure loads during the system peak windows, a.k.a. "coincident peak window energy".

$peakhrs$ = Number of hours in the system peak window,

$connkW$ = Total "connected" kW (rated full load, as determined from nameplate data) of the equipment being measured.

The number of load shapes needed to achieve 80% ±10% precision at the measure level is calculated using the following formula:

$$n = \left(\frac{z * cv}{D} \right)^2$$

where,

n = sample size

z = 1.282 at the 80% confidence interval

cv = coefficient of variation of the target variable (standard deviation / mean)

D = desired relative precision = 0.10

Since the number of load shapes available for this analysis could not be predicted, RLW attempted to identify enough applicable load shapes to obtain the desired precision and calculate the actual coefficient of variation (Cv) of the resulting coincidence factors. From these, the statistical precisions were calculated by utilizing the resulting sample size "n" and solving the function for "D".

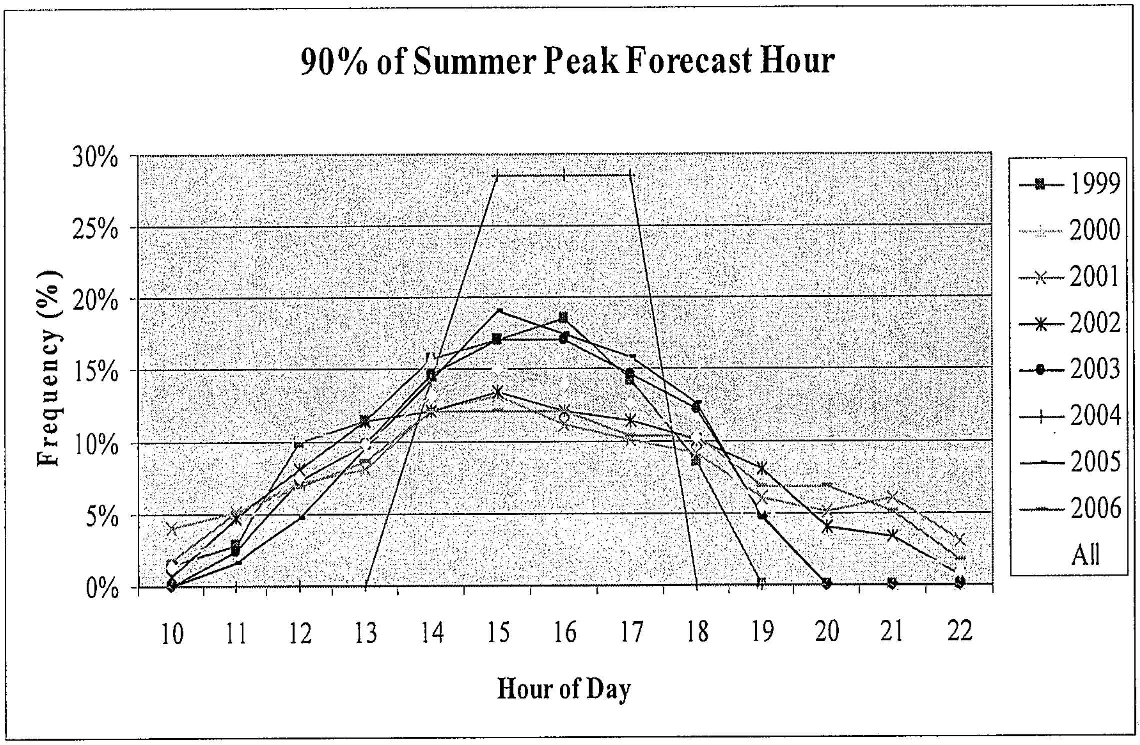
3 Calculating Seasonal Peak Performance Hours

The Seasonal Peak Performance hours have been defined by ISO-NE to include the summer (June – August) and winter (December and January) hours where the system load meets or exceeds 90% of the 50/50 forecast for the seasonal peak demand as provided in the most recent CELT report. In order to estimate the Seasonal Peak performance hours, hourly system load data from ISO-NE were used starting from 1999 through the summer of 2006, along with the seasonal peak forecasts as provided in Table 1.

S eason Code	Forecast (MW)	Season	Season Code	Forecast (MW)	Season
S1999	22,890	Summer 1999	W9900	20,920	Winter 1999/00
S2000	23,465	Summer 2000	W0001	21,200	Winter 2000/01
S2001	24,115	Summer 2001	W0102	21,470	Winter 2001/02
S2002	24,680	Summer 2002	W0203	21,730	Winter 2002/03
S2003	25,170	Summer 2003	W0304	22,085	Winter 2003/04
S2004	25,760	Summer 2004	W0405	22,450	Winter 2004/05
S2005	26,545	Summer 2005	W0506	22,600	Winter 2005/06
S2006	27,025	Summer 2006			

Table 1: Seasonal Peak Forecasts

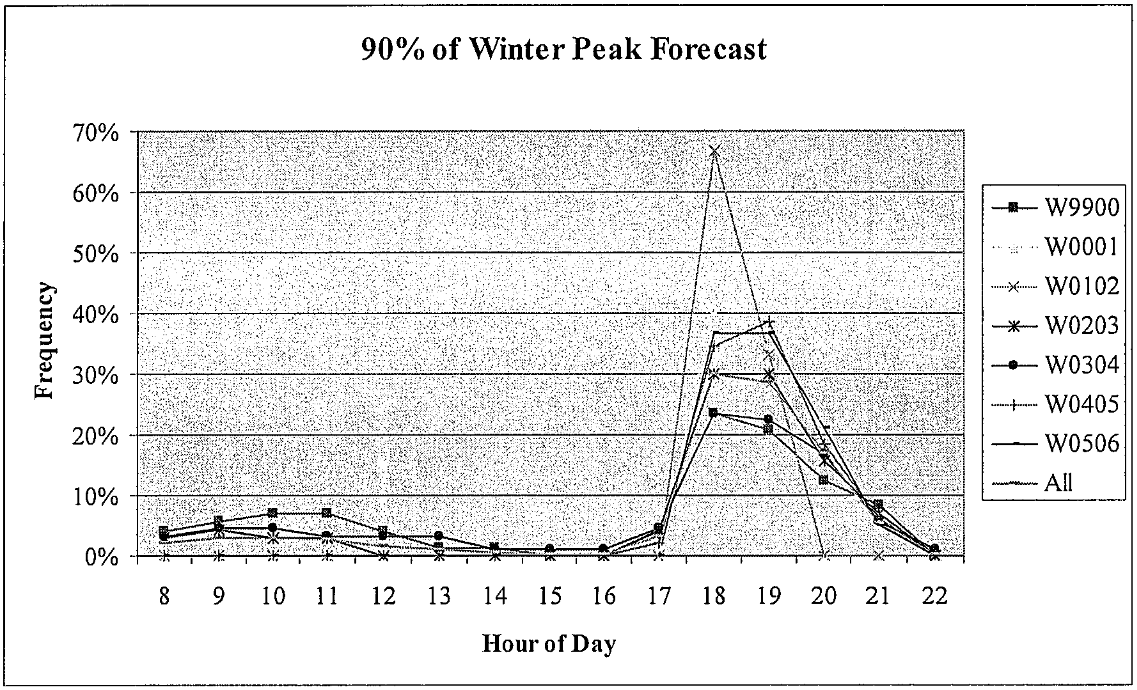
The hourly load data for the summer and winter periods were then analyzed to determine the frequency distribution for each hour where the demand was greater than or equal to 90% of the seasonal forecast. A simple probabilistic weighting scheme was applied based upon the number of observation during each hour. Figure 1 provides a graphical presentation of the distribution of the summer seasonal peak performance hours, along with a table showing the weighted summer average results for all of the years. Note that using the 90% criteria there were 506 performance hours during the eight year period, which equates to an annual average of about 63 summer performance hours. The number of hours was driven by the ambient weather conditions and ranged from a high of 149 hours during the summer 2002 season to a low of seven hours during the summer 2004 season. The table below the graph shows that the performance hours can range from hour ending 10 AM to hour ending 10 PM, with most of the observations occurring during the afternoon hours from 12 PM to 6 PM.



Hour Ending	101	112		13	14	15	16	17	18	192	0212	2		Total
# of Observations	7	203	8	50	67	76	71	64	52	271	514		5	506
Summer Average	1%	4%	8%	10%	13%	15%	14%	13%	10%	5%	3%	3%	1%	100%

Figure 1: Distribution of Summer Seasonal Peak Hours

Figure 2 provides a graphical presentation of the distribution of the winter seasonal peak performance hours, along with a table showing the weighted winter average results for all of the years. Note that using the 90% criteria there were 362 performance hours during the seven season period, which equates to an annual average of about 52 winter performance hours. The number of hours was driven by the ambient weather conditions and ranged from a high of 89 hours during the winter 2003/2004 season to a low of three hours during the winter 2001/2002 season. The table below the graph shows that the performance hours can range from hour ending 8 AM to hour ending to hour ending 10 PM, with most of the observations occurring during the evening hours from 5 PM to 8 PM.



Hour Ending	8	9	10	111	213		141	5	161	7	18	19	20	212	2	Total
# of Observations	8	111	1	10	6	4	2	1	1	121	09	104	62	20	1	362
Summer Average	2%	3%	3%	3%	2%	1%	1%	0%	0%	3%	30%	29%	17%	6%	0%	100%

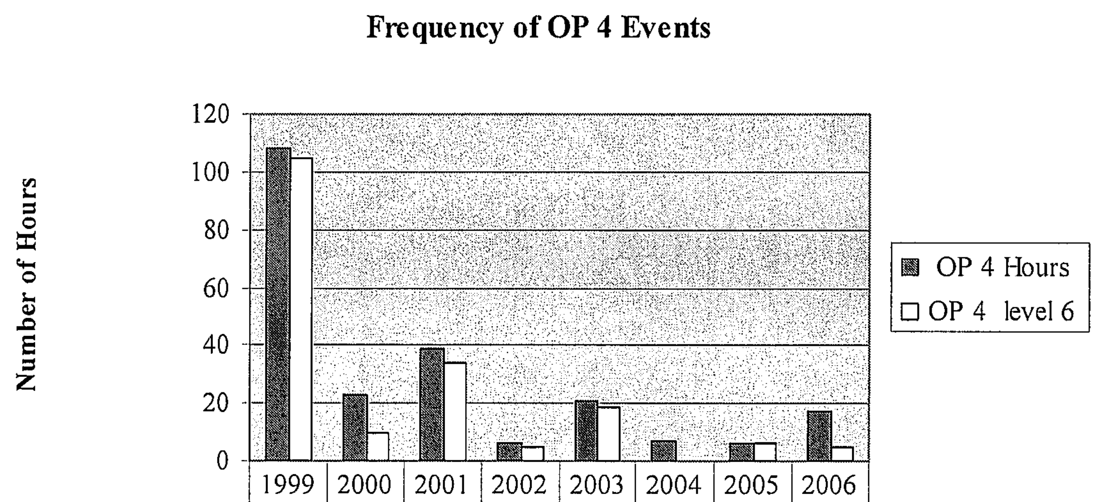
Figure 2: Distribution of Winter Seasonal Peak Hours

4 Calculation of Critical Peak Performance Hours

The calculation of the Critical Peak performance hours is somewhat more complex than that of the Seasonal Peak hours because of the use of the Day-Ahead load forecast as the trigger mechanism and the inclusion of shortage hours. ISO-NE load data prior to implementation of SMD starting May 1, 2003 did not include Day-Ahead Load forecast. The DA load forecasts appear to be consistently lower than the actual hourly load during most hours and all performance hours. Additionally there has been a significant decrease in the number of OP4 event hours over the last three years that calls into question the validity of including older data prior to 2002 as illustrated in Figure 3. Looking at the number of OP 4 level 6 event hours, there were 105 hours in 1999 and 34 hours in 2001, but only a total of 35 event hours from 2002 to 2006. OP 4 events are usually caused by extreme weather and typically occur during the summer months.[3] The summer of 2001, 2003 and 2005 were all fairly comparable from a temperature standpoint, with

[3] There were three OP 4 event hours in the current dataset that occurred on January 17, 2000.

2005 being the hottest of the three, but note that OP 4 Level 6 or greater event hours dropped from 34 hours in 2001 to 19 hours in 2003 and then to 6 hours in 2005.[4]



	1999	2000	2001	2002	2003	2004	2005	2006
OP 4 Hours	108	23	39	6	21	7	6	17
OP 4 level 6	105	10	34	5	19	0	6	5

Figure 3: Frequency of OP 4 Events by Year

Using the post SMD load data and comparing the difference between the Day-Ahead Load Forecast and the Actual Load reveals an alarming disparity between the two values when the 95% threshold is applied. Table 2 presents the results of the Critical Peak Performance hours under a couple of different scenarios. If the rules are strictly applied and the hours are determined based upon 95% of the Day Ahead forecast hours and OP4 level 6 hours than there would have been a total of 28 performance hours during the four summer periods and zero hours during the three winter periods. Note that when 95% of the actual load is used to calculate the Critical Peak hours the summer hours increase eight fold from six hours to 48 hours and the winter hours increased from zero to 23. There appears to be a systematic flaw in the Day-Ahead load forecast that causes the forecasted load to be consistently lower than the actual load during times of high system load. As a result the Day-Ahead load forecast rarely reaches the 95 percentile of the

[4] OP 4 level 6 event hours were calculated using "OP 4 Action During A Deficiency Appendix A" which indicates that 104.6 MW of load relief is provided prior to level since, therefore any OP4 event hour less than 104.6 MW was counted as an OP 4 event less than level 6.

50/50 peak forecast and there are no critical peak hours that occur during the winter. This makes it impossible to calculate CFs for Critical peak hours during the winter and the results from summer calculation highly suspect. Therefore, no Critical Peak Coincidence Factors were calculated for this report.

		95% of DA Peak	95% of Load	OP 4	OP 4 Level 6
Season	**Year**	**Count of Hours**	**Count of Hours**	**Count of Hours**	**Count of Hours**
Summer	2003	0	5	17	17
Summer	2004	0	0	7	0
Summer	2005	0	13	6	0
Summer	2006	6	30	17	5
Summer	**Total**	**6**	**48**	**47**	**22**
Winter	"03/04"	0	17	0	0
Winter	"04/05"	0	6	0	0
Winter	"05/06"	0	0	0	0
Winter	**Total**	**0**	**23**	**0**	**0**

Table 2: Analysis of Post SMD Critical Peak Performance Hours

5 Residential Lighting Coincidence Factor Analysis

The following sections examine the primary the primary data available for analysis, provide residential profiles and the resulting Coincidence Factors (CFs) during On-Peak and Seasonal Peak hours and calculate the relative precision of the CF estimates.

5.1 Available Primary Metered Data for Residential Lighting

The primary data available for the residential lighting project were collected from evaluation projects that were conducted in all six New England States over the last few years. The program evaluation efforts focused on measuring impacts for three residential lighting measure categories as follows;

- Compact Fluorescent Bulbs,
- Compact Fluorescent Fixtures, and
- Torchieres

Table 3 provides a listing of the quantity of logger files used for this analysis divided by measure type and interior or exterior location. There were a total 875 logger files included in the analysis, 795 of which monitored interior fixtures while the remaining 80 capture the operation of exterior fixtures.[5]

Measure Type	Interior	Exterior	Total
Compact Fluorescent Bulb	451	28	479
Compact Fluorescent Fixture	214	51	265
Torchiere	130	1	131
Total	**795**	**80**	**875**

Table 3: Residential Logger Data

In order to accurately capture the operating profiles during the winter and summer periods as defined by ISO-NE only the data from loggers installed during those months were used in the analysis. This resulted in a decrease in the overall logger data available for the analysis, however many of the loggers were installed for an extended period of time with many installed for nine months. Table 4 provides a breakdown of the loggers used in the analysis by month and by fixture type. There were a total of 546 loggers available for the winter months and 501 loggers available for the summer months.

	Residential Lighting Type			
Data Period	**Bulbs**	**Fixtures**	**Torchieres**	**Total**
December	127	94	61	282
January	164	60	40	264
Average Winter	**291**	**154**	**101**	**546**
June	67	97	46	210
July	40	38	24	102
August	89	63	37	189
Average Summer	**196**	**198**	**107**	**501**

Table 4: Seasonal Residential Logger Data

5.2 Analysis of Weighted vs. Un-weighted Residential Lighting Data

Figure 4 presents a graphical comparison of the weighted and un-weighted profiles for the residential lighting during the three summer months (June, July and August) and the average for the summer season. The weighted profiles were determined using the connected wattage associated with each of the logger profiles. The shapes and magnitudes of the profiles during each month are virtually identical during most of the hours of the day and particularly during

[5] The use of the term "fixture" is meant to be generic and applies to each of the measure types.

performance hours (1:00 PM to 5:00 PM). Although during the months of June and July the weighted profiles are slightly higher during the summer performance hours and this does result in an increase in the weighted summer average profile as well.

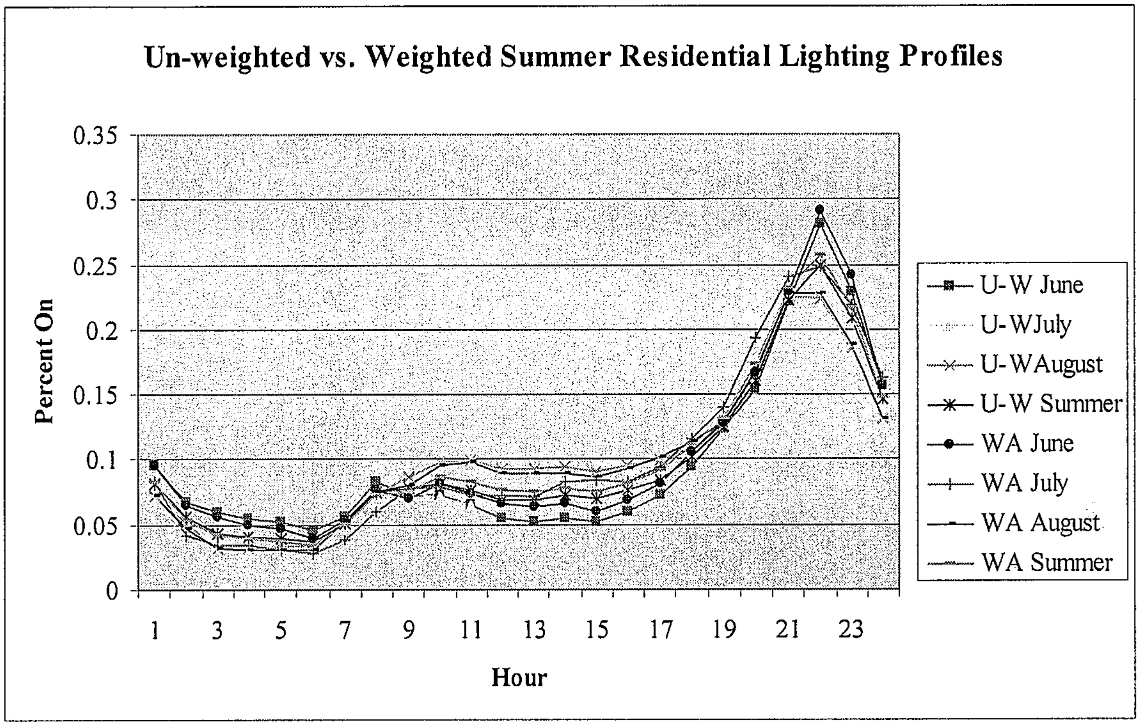


Figure 4: Comparison of Un-weighted and Weighted Summer Lighting Profiles

Figure 5 provides the same graphic for the winter residential profiles, which compares the weighted and un-weighted profiles for the months of December and January along with the winter average. Once again the weighted and un-weighted profiles have similar shapes and are fairly close in magnitude during the winter performance hours (5:00 PM to 7:00 PM). However, the weighted profiles particularly for the month of January have higher percent on values during the performance hours than the un-weighted profiles resulting in an increase in the winter average profile during the winter hours.

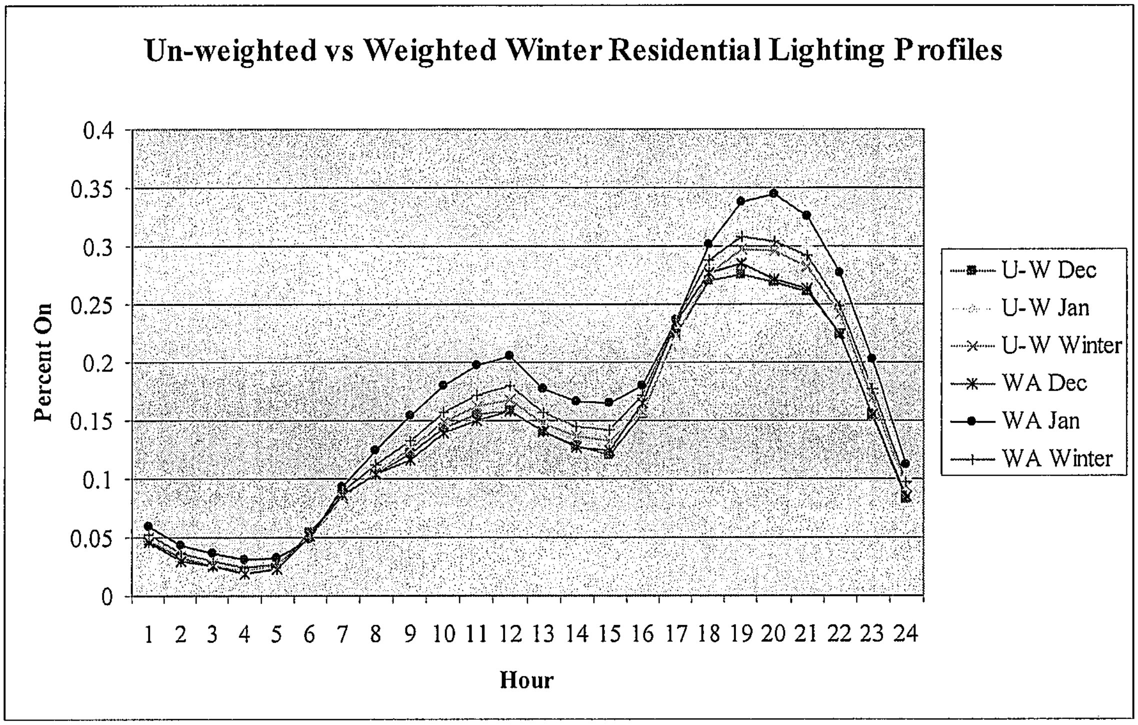


Figure 5: Comparison of Un-weighted and Weighted Winter Lighting Profiles

5.3 Residential Lighting On-Peak Coincidence Factors

Table 5 provides a summary of the Summer On-Peak CFs for each of the three summer months and the summer average for all residential lighting. The sample sizes and calculated relative precision are also included in the table. The summer CFs range from a low of 0.060 for June, to a high of 0.094 for August, with the summer average CF of 0.076 un-weighted and 0.82 weighted. The relative precision for the most of the summer months are close to ±10% at the 80% confidence interval, with the summer average having a relative precision of ±6.1% at the 80% confidence interval.

	Summer On-Peak Hours 1PM - 5PM			
Data Period	Sample Size n	Un-weighted CF	Weighted CF	Un-weighted Rel Precision
June	210	0.060	0.069	±11.6%
July	102	0.081	0.086	±12.5%
August	189	0.094	0.092	±8.7%
Average Summer	501	0.076	0.082	±6.1%

Table 5: Summer On-Peak CFs and Relative Precisions Residential Lighting

Table 6 provides the winter sample size, weighted and un-weighted On-Peak CFs, and relative precision for the winter months. The winter CFs range from a low of 0.263 for December, to a high of 0.320 for January, with the winter average CF of 0.286 un-weighted and 0.298 weighted. The relative precision for both of the winter months is ±6.5% at the 80% confidence interval, with the winter average having a relative precision of ±4.5% at the 80% confidence interval.

	Winter On-Peak Hours 5PM - 7PM			
Data Period	Sample Size n	Un-weighted CF	Weighted CF	Un-weighted Rel Precision
December	282	0.263	0.281	±6.5%
January	264	0.301	0.320	±6.5%
Average Winter	546	0.286	0.298	±4.5%

Table 6: Winter On-Peak CFs and Relative Precisions Residential Lighting

5.4 Calculating Residential Lighting Seasonal Peak Coincidence Factors

The weighted seasonal peak performance hours were developed so that they could be used to estimate the seasonal peak performance coincidence factors. Since the performance hours are dynamic and will vary based upon ambient weather conditions it is impossible to determine the performance hours with 100% accuracy prior to the seasonal peak period and therefore we will only provide one estimate for each period using the average data. Presumably discrepancies in actual hours that occur during a month can be addressed during the 90-day resettlement period.

Table 7 provides the Summer Seasonal Peak Coincidence Factors (CFs) for the each of the three summer months and the summer average for all residential lighting. The monthly Summer Seasonal Peak CFs ranged from 0.075 for June, to 0.104 for August, with the average Summer Seasonal Peak CF of 0.088. Note that the estimated relative precision is less than ±10% for each of the summer months and the average relative precision is ±3.6% at the 80% confidence interval.

	Summer Seasonal Peak Hours (90% of 50/50 Peak)			
Data Period	Sample Size n	Un-weighted CF	Calculated CV	Calculated Rel Precision
June	210	0.075	2.275	±6.3%
July	102	0.091	1.884	±5.3%
August	189	0.104	1.747	±5.2%
Average Summer	501	0.088	1.967	±3.6%

Table 7: Summer Seasonal Peak Coincidence Factors Residential Lighting

Table 8 provides the Winter Seasonal Peak Coincidence Factors (CFs) for the each of the two winter months as well as the winter average for all residential lighting. The Winter Seasonal Peak monthly CFs range from 0.249, for December to 0.279 for January, and the average Winter Seasonal Peak CF is about 0.26. Note that for each month the estimated relative precision is better than ±5%, with the Winter Seasonal Average having a relative precision of ±3.2% at the 80% confidence interval.

	Winter Seasonal Peak Hours (90% of 50/50 peak)			
Data Period	Sample Size n	Un-weighted CF	Calculated CV	Calculated Rel Precision
December	282	0.249	1.23	±4.5%
January	264	0.279	1.19	±4.5%
Average Winter	546	0.264	1.21	±3.2%

Table 8: Winter Seasonal Peak Coincidence Factors Residential Lighting

5.5 Comparison of Residential Lighting On-Peak and Seasonal Peak Results

Table 9 and Table 10 provide a comparison of the CFs calculated for the On-Peak Performance hours and the Seasonal Peak Performance hours. Note that the Summer Seasonal Peak CFs is higher for all months and the Average Summer CF increases by 16% from 0.08 to 0.09. The increase is due to a wider range of hours being included in the weighted average calculation including more evening hours, when the CFs are higher. Therefore classifying the residential lighting as a Seasonal Peak asset during the summer period would result in an increase in demand reduction.

Data Period	On-Peak Un-weighted CF	Seasonal Un-weighted CF	% Change Seasonal/ On-Peak
June	0.060	0.075	126%
July	0.081	0.091	112%
August	0.094	0.104	111%
Average Summer	0.076	0.088	116%

Table 9: Comparison of Summer On-Peak and Seasonal Peak CFs Residential Lighting

The reverse is true for the Winter Seasonal Peak CFs, which are lower than the Winter On-Peak CFs with the average winter CF decreasing by 8% from 0.286 to 0.264. The decrease is due to a wider range of hours being included in the weighted average calculation including more morning and afternoon hours, when the CFs are lower. This means that classifying the residential lighting measures as a Seasonal Peak asset during the winter period would result in a decrease in demand reduction.

Data Period	On-Peak Un-weighted CF	Seasonal Un-weighted CF	% Change Seasonal/ On-Peak
December	0.263	0.249	95%
January	0.301	0.279	93%
Average Winter	0.286	0.264	92%

Table 10: Comparison of Winter On-Peak and Seasonal Peak CFs Residential Lighting

6 Commercial and Industrial Lighting

A similar Coincidence Factor (CF) analysis was performed for Commercial and Industrial (C&I) Lighting as was previously described for the Residential Lighting and On-Peak and Seasonal Peak CFs were developed for both the summer and winter periods. The C&I Lighting analysis was performed by segmenting the logger data into ten different sectors so that C&I Lighting programs with diverse participation rates among the sectors could use the results and apply them to their own programs. The following sections will provide information about the primary data that were available for the analysis and the resulting CFs and estimated relative precisions.

6.1 C&I Lighting Logger Data

The C&I Lighting logger data were analyzed by developing ten different customer sectors and further dividing the data based upon whether occupancy sensors were used to control the fixtures. Table 11 provides a breakdown of the C&I logger data that were used in the analysis by building type and also whether the lighting was controlled by occupancy sensors. There were a total of 1,764 logger files used in the analysis, 1,415 without occupancy sensor control and 349 with occupancy sensors.

	Occupancy Sensor		
Building Type	**No**	**Yes**	**Total**
Grocery	37	2	39
Manufacturing	169	12	181
Medical	58	59	117
Office	259	69	328
Other	192	56	248
Restaurant	43		43
Retail	166		166
University/College	70	16	86
Warehouse	59	77	136
School	362	58	420
Total	**1415**	**349**	**1764**

Table 11: C&I Lighting Logger Data

6.2 Commercial & Industrial Lighting Profiles

The C&I Lighting data for each sector were analyzed separately and were used to develop hourly profiles for Non-Occupancy Sensor and Occupancy Sensor Controlled Lighting. Figure 6 shows the profiles for the lighting without occupancy sensors, which shows that the Grocery sector has the highest Coincidence Factor (CF) during the performance hours, and the Other sector generally has the lowest. Most of the remaining C&I sectors have a CF of around 0.80 during the summer performance hours, with Schools and Universities at the lower end of the spectrum.

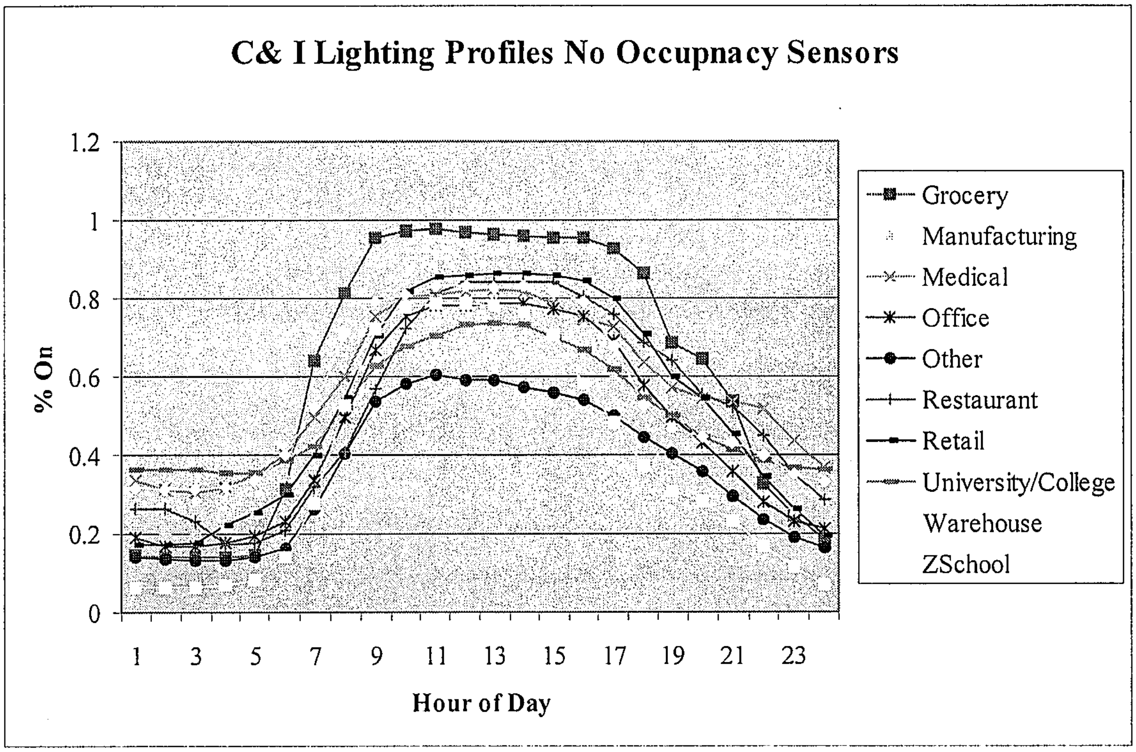


Figure 6: C&I Profiles for Non-Occupancy Sensor Lighting

Figure 7 provides the sector level profiles for the lighting that is controlled by occupancy sensors, which shows that the Manufacturing sector generally has the highest percent on of any of the sectors and the University/College sector has the lowest percent on during the performance hours.[6] Note that each of the sectors profiles exhibit significantly lower operating percentages than the non-occupancy sensor controlled lighting for the same sectors in the previous graph. The CFs for the

[6] Although there were two occupancy sensor logger files for the Grocery sector they were not included in the graph or analysis, because the sample was too small and not representative of the grocery lighting.

occupancy sensors were calculated by subtracting the aggregate occupancy sensor profiles from the aggregate non-occupancy sensor controlled profiles for each of the sectors to calculate the occupancy sensor savings profiles.

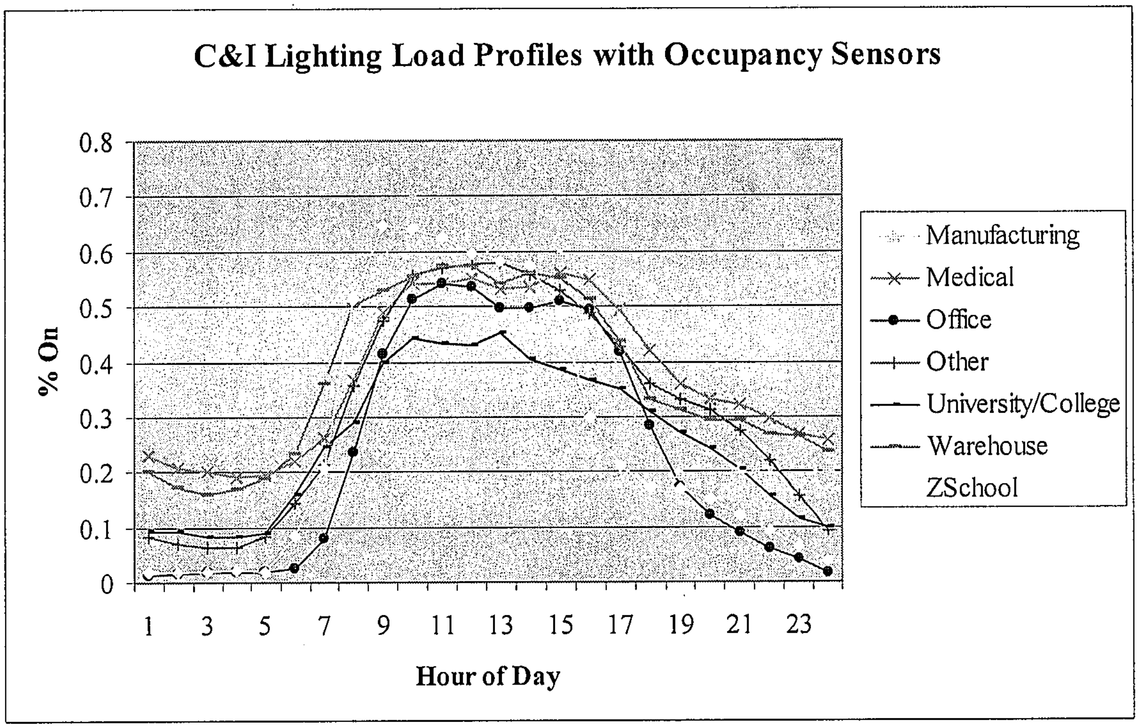


Figure 7: C&I Profiles for Occupancy Sensor Controlled Lighting

6.3 Commercial & Industrial Lighting Coincidence Factors

The C&I Lighting CFs were developed for both the Summer and Winter On-Peak and Seasonal Peak using the performance hours as previously defined and the sector specific lighting and occupancy sensors profiles as presented in the previous section.

6.4 On-Peak C&I Lighting Coincidence Factors

Table 12 provides the Summer On-Peak Coincidence Factors (CFs) for the 10 C&I customer sectors as well as total CF estimates based upon logger weighted results and weighting each sector equally. The logger weighted results were weighted by the number of loggers so the School sector had the highest number of loggers (362) and a weight of 0.256 (362/1415) or approximately 26% of the total CF. The logger weights for each sector are provided in the fourth column of the table. The Grocery sector has the highest Summer On-Peak CF of about 0.95, while the Other sector has the lowest at about 0.54. The Retail and Office sectors each have CFs above 0.80, while the remaining non-education sectors are all above 0.70. The two education sectors School and University/College both have CFs above 0.60. The Coefficient of Variation (CV) and relative precision are also provided and the relative precision for each of the sectors is better than ± 5% at the 80% confidence interval.

	Summer On-Peak Hours 1PM - 5PM				
Sector Type	Sample Size n	Calculated CF	Logger Weight	Calculated CV	Calculated Rel Precision
Grocery	37	0.948	0.026	0.179	±1.9%
Manufacturing	169	0.729	0.119	0.488	±2.4%
Medical (Hospital)	58	0.769	0.041	0.425	±3.6%
Office	259	0.750	0.183	0.438	±1.7%
Other	192	0.543	0.136	0.675	±3.1%
Restaurant	43	0.811	0.030	0.347	±3.4%
Retail	166	0.824	0.117	0.342	±1.7%
University/College	70	0.680	0.049	0.483	±3.7%
Warehouse	59	0.781	0.042	0.359	±3.0%
School	362	0.633	0.256	0.503	±1.7%
Total Weighted by Logger		0.704	1.000		
Total Equal Weight by Sector		0.747			

Table 12: Summer On-Peak Coincidence Factors C&I Lighting

Table 13 provides the Winter On-Peak CFs for each of the sectors, as well as estimated total CFs based logger weighted results and weighting each sector equally. Once again the Grocery sector had the highest CF of almost 0.78, which was lower than the Summer On-Peak value because the performance hours occur later in the day. The Schools sector had the lowest CF at about 0.34, which was not unexpected due to the time period of the performance hours. The relative precision for each of the sectors was better than ± 10% at the 80% confidence interval.

	Winter On-Peak Hours 5PM - 7PM				
Sector Type	Sample Size n	Calculated CF	Logger Weight	Calculated CV	Calculated Rel Precision
Grocery	37	0.776	0.026	0.474	±7.1%
Manufacturing	169	0.399	0.119	0.983	±6.9%
Medical (Hospital)	58	0.603	0.041	0.593	±7.1%
Office	259	0.537	0.183	0.725	±4.1%
Other	192	0.426	0.136	0.804	±5.3%
Restaurant	43	0.663	0.030	0.557	±7.7%
Retail	166	0.655	0.117	0.592	±4.2%
University/College	70	0.523	0.049	0.679	±7.4%
Warehouse	59	0.496	0.042	0.787	±9.3%
School	362	0.343	0.256	1.010	±4.8%
Total Weighted by Logger		0.480	1.000		
Total Equal Weight by Sector		0.542			

Table 13: Winter On-Peak Coincidence Factors C&I Lighting

6.5 Seasonal Peak C&I Lighting Coincidence Factors

Table 14 provides the Summer Seasonal Peak CFs for each of the ten C&I sectors, along with the total CFs. All of the Seasonal Peak CFs were calculated using the probabilistic hourly values that were developed using historical ISO-NE load and load forecasts as described in the Seasonal Peak analysis section of this report. The sector level results are similar to the Summer On-Peak results however every Seasonal Peak value is lower. This is due to the fact that there are more evening hours included in the CF calculation where the lighting operates at a reduced percent on. Once again note that the relative precision for each of the C&I sector CFs is better than ± 5% at the 80% confidence interval.

	Summer Seasonal Peak Hours (90% of 50/50 Peak)				
Sector Type	Sample Size n	Calculated CF	Logger Weight	Calculated CV	Calculated Rel Precision
Grocery	37	0.904	0.026	0.23	±1.5%
Manufacturing	169	0.671	0.119	0.52	±1.7%
Medical (Hospital)	58	0.740	0.041	0.45	±2.5%
Office	259	0.702	0.183	0.48	±1.2%
Other	192	0.476	0.136	0.75	±3.0%
Restaurant	43	0.775	0.030	0.40	±2.5%
Retail	166	0.795	0.117	0.38	±1.2%
University/College	70	0.650	0.049	0.51	±2.5%
Warehouse	59	0.727	0.042	0.41	±2.2%
School	362	0.599	0.256	0.48	±1.1%
Total Weighted by Logger		0.660	1.000		

Table 14: Summer Seasonal Peak Coincidence Factors C&I Lighting

Table 15 provides the Winter Seasonal Peak CFs for each of the ten C&I sectors, along with the total CFs. Once again all of the Seasonal Peak CFs were calculated using the probabilistic hourly values that were developed using historical ISO-NE load and load forecasts as described in the Seasonal Peak analysis section. The sector level results are similar to the Winter On-Peak results however most of the Seasonal Peak values are slightly higher. This is due to the fact that there are more morning and afternoon hours included in the CF calculation where the lighting operates at a higher percent on. Once again note that the relative precision for each of the C&I sector CFs is better than ± 10% at the 80% confidence interval.

	Winter Seasonal Peak Hours (90% of 50/50 Peak)				
Sector Type	**Sample Size n**	**Calculated CF**	**Logger Weight**	**Calculated CV**	**Calculated Rel Precision**
Grocery	37	0.770	0.026	0.44	±4.6%
Manufacturing	169	0.432	0.119	0.91	±4.2%
Medical (Hospital)	58	0.618	0.041	0.58	±4.5%
Office	259	0.539	0.183	0.71	±2.6%
Other	192	0.428	0.136	0.80	±4.4%
Restaurant	43	0.644	0.030	0.59	±5.3%
Retail	166	0.647	0.117	0.59	±2.7%
University/College	70	0.528	0.049	0.60	±4.2%
Warehouse	59	0.535	0.042	0.70	±5.6%
School	362	0.388	0.256	0.85	±2.7%
Total Weighted by Logger		0.497	1.000		
Total Equal Weight by Sector		0.553			

Table 15: Winter Seasonal Peak Coincidence Factors C&I Lighting

6.6 Comparison of On-Peak and Seasonal Peak C&I Lighting CFs

Table 16 provides a comparison of the Summer On-Peak and Seasonal Peak CF for each of the C&I Lighting sectors, which shows that for all sectors the On-Peak CF is higher than the Seasonal Peak CF. This is due to inclusion of more evening hours in the Seasonal Peak CF calculation when the percent on for the lighting is lower. This means that if the C&I Lighting measures were classified as Summer Seasonal Peak assets instead of Summer On-Peak assets the demand reduction would be lower. Table 17 provides the same comparison for the Winter On-Peak and Seasonal Peak CFs for C&I Lighting. In this case the results are mixed, with 7 of the 10 sectors showing an increase in the Winter Seasonal Peak CFs compared to the Winter On-Peak CF. This seems to indicate that in general for the Winter, C&I Lighting would have more demand reduction if classified as a Seasonal Peak asset.

	Summer		% Change
Sector Type	On-Peak CF	Seasonal CF	Seasonal / On-Peak
Grocery	0.948	0.904	95%
Manufacturing	0.729	0.671	92%
Medical (Hospital)	0.769	0.740	96%
Office	0.750	0.702	94%
Other	0.543	0.476	88%
Restaurant	0.811	0.775	96%
Retail	0.824	0.795	96%
University/College	0.680	0.650	96%
Warehouse	0.781	0.727	93%
School	0.633	0.599	95%
Total Weighted by Logger	0.704	0.660	94%
Total Equal Weight by Sector	0.747	0.704	94%

Table 16: Comparison of Summer On-Peak and Seasonal Peak CFs C&I Lighting

	Winter		% Change
Sector Type	On-Peak CF	Seasonal CF	Seasonal / On-Peak
Grocery	0.776	0.770	99%
Manufacturing	0.399	0.432	108%
Medical (Hospital)	0.603	0.618	103%
Office	0.537	0.539	101%
Other	0.426	0.428	100%
Restaurant	0.663	0.644	97%
Retail	0.655	0.647	99%
University/College	0.523	0.528	101%
Warehouse	0.496	0.535	108%
School	0.343	0.388	113%
Total Weighted by Logger	0.480	0.497	104%
Total Equal Weight by Sector	0.542	0.553	102%

Table 17: Comparison of Winter On-Peak and Seasonal Peak CFs C&I Lighting

6.7 Commercial & Industrial Occupancy Sensor Coincidence Factors

The C&I Occupancy Sensor CFs were developed for both the Summer and Winter On-Peak and Seasonal Peak using the performance hours as previously defined and the sector specific occupancy sensors profiles identified previously. There were no individual occupancy sensor savings profiles developed instead the savings profiles were determined by subtracting the aggregate occupancy profile for a sector from the aggregate lighting profile for the sector. As a result the relative precision of the CFs cannot be calculated directly instead it has been estimated by calculating the relative precision of the occupancy sensor profiles during the performance hours.

6.8 On-Peak C&I Occupancy Sensor Coincidence Factors

Table 18 provides the Summer On-Peak CFs for each of the C&I customer sectors with Occupancy Sensor data as well as total CF estimates based upon logger weighted results and weighting each sector equally. The University/College sector has the highest summer On-Peak CF of about 0.30, which represents the percent of time connected load controlled by occupancy sensors would be off during those hours. The 30% reduction number is similar to the reduction number that occupancy sensor vendors have used to promote their products and represents a reasonable top end estimate. The Other sector had the lowest CF at about 0.02 and most of the remaining sectors had CFs ranging from 0.21 to 0.27, which seem to be reasonable. Estimates for the Coefficient of Variation (CV) and relative precision are also provided. Since there were no direct Occupancy Sensors savings profiles developed the estimated CV and relative precision were calculated for the occupancy sensor profiles during the performance hours. Note, that the relative precision for the most of the sectors is under ±10% at the 80% confidence interval.

	Summer On-Peak Hours 1PM - 5PM				
Data Period	Sample Size n	Calculated CF	Logger Weight	Estimated CV	Estimated Rel Precision
Manufacturing	12	0.210	0.035	0.688	±12.7%
Medical	59	0.234	0.170	0.602	±5.0%
Office	69	0.270	0.199	0.559	±4.3%
Other	56	0.017	0.161	0.793	±6.8%
University/College	16	0.304	0.046	0.678	±10.9%
Warehouse	77	0.266	0.222	0.646	±4.7%
School	58	0.239	0.167	0.828	±7.0%
Total Weighted by Logger		0.217	1.000		
Total Equal Weight by Sector		0.154			

Table 18: Summer On-Peak Coincidence Factors C&I Occupancy Sensors

Table 19 provides the Winter On-Peak CFs for each of the C&I customer sectors with Occupancy Sensor data as well as total CF estimates based upon logger weighted results and weighting each sector equally. The Office sector has the highest winter On-Peak CF of about 0.31, which represents the percent of time connected load controlled by occupancy sensors would be off during those hours. The Other sector had the lowest CF at about 0.09 and most of the remaining sectors had CFs ranging from 0.17 to 0.23, which seem to be reasonable. Estimates for the Coefficient of Variation (CV) and relative precision are also provided. Since there were no direct Occupancy Sensors savings profiles developed the estimated CV and relative precision were calculated for the occupancy sensor profiles during the performance hours. Note, that the relative precision for all but one of the sectors is greater than ±10% at the 80% confidence interval. In this case the logger weighted average CF of about 0.20 might be the most reliable estimate to use.

	Winter On-Peak Hours 5PM - 7PM				
Sector Type	**Sample Size n**	**Calculated CF**	**Logger Weight**	**Estimated CV**	**Estimated Rel Precision**
Manufacturing	12	0.190	0.035	1.301	±34.1%
Medical	59	0.213	0.170	0.840	±9.9%
Office	69	0.309	0.199	1.087	±11.9%
Other	56	0.089	0.161	1.053	±12.8%
University/College	16	0.233	0.046	0.827	±18.8%
Warehouse	77	0.175	0.222	1.082	±11.2%
School	58	0.173	0.167	1.527	±18.2%
Total Weighted by Logger		0.197	1.000		
Total Equal Weight by Sector		0.138			

Table 19: Winter On-Peak Coincidence Factors C&I Occupancy Sensors

6.9 Seasonal Peak C&I Occupancy Sensor Coincidence Factors

Table 20 provides the Summer Seasonal Peak CFs for each of the C&I customer sectors with Occupancy Sensor data as well as total CF estimates based upon logger weighted results and weighting each sector equally. The University/College sector has the highest Summer On-Peak CF of about 0.28, which represents the percent of time connected load controlled by occupancy sensors would be off during those hours. The Other sector had the lowest CF at about 0.02 and most of the remaining sectors had CFs ranging from 0.20 to 0.27, which seem to be reasonable. Estimates for the Coefficient of Variation (CV) and relative precision are also provided. Since there were no direct Occupancy Sensors savings profiles developed the estimated CV and relative precision were calculated for the occupancy sensor profiles during the performance hours. Note, that the relative precision for the all of the sectors is under ±10% at the 80% confidence interval.

	Summer Seasonal Peak Hours (90% of 50/50 Peak)				
Data Period	Sample Size n	Calculated CF	Logger Weight	Estimated CV	Estimated Rel Precision
Manufacturing	12	0.198	0.035	0.712	±8.9%
Medical	59	0.239	0.170	0.649	±3.6%
Office	69	0.274	0.199	0.606	±3.2%
Other	56	0.024	0.161	0.808	±4.6%
University/College	16	0.283	0.046	0.720	±7.6%
Warehouse	77	0.246	0.222	0.700	±3.3%
School	58	0.209	0.167	0.739	±4.2%
Total Weighted by Logger		0.208	1.000		
Total Equal Weight by Sector		0.147			

Table 20: Summer Seasonal Peak Coincidence Factors C&I Occupancy Sensors

Table 21 provides the Winter Seasonal Peak CFs for each of the C&I customer sectors with Occupancy Sensor data as well as total CF estimates based upon logger weighted results and weighting each sector equally. The Office sector has the highest Winter On-Peak CF of about 0.30, which represents the percent of time connected load controlled by occupancy sensors would be off during those hours. The Other sector had the lowest CF at about 0.07 and most of the remaining sectors had CFs ranging from 0.16 to 0.23, which seem to be reasonable. Estimates for the Coefficient of Variation (CV) and relative precision are also provided. Since there were no direct Occupancy Sensors savings profiles developed the estimated CV and relative precision were calculated for the occupancy sensor profiles during the performance hours. Note, that the relative precision for the all but two of the sectors is better than ±10% at the 80% confidence interval.

	Winter Seasonal Peak Hours (90% of 50/50 Peak)				
Data Period	**Sample Size n**	**Calculated CF**	**Logger Weight**	**Estimated CV**	**Estimated Rel Precision**
Manufacturing	12	0.172	0.035	1.063	±17.3%
Medical	59	0.221	0.170	0.827	±6.3%
Office	69	0.296	0.199	0.966	±6.9%
Other	56	0.066	0.161	0.990	±7.7%
University/College	16	0.231	0.046	0.819	±11.9%
Warehouse	77	0.183	0.222	0.986	±6.6%
School	58	0.159	0.167	1.140	±8.7%
Total Weighted by Logger		0.191	1.000		
Total Equal Weight by Sector		0.133			

Table 21: Winter Seasonal Peak Coincidence Factors C&I Occupancy Sensors

6.10 Comparison of On-Peak and Seasonal Peak C&I Occupancy Sensor CFs

Table 22 and Table 23 provide a comparison of the Summer and Winter On-Peak and Seasonal Peak CFs for occupancy sensors for seven C&I sectors as well as the totals for all seven sectors calculated on a logger weighted and sector weighted basis. The results for the Summer period show that the Summer Seasonal CFs are lower than the On-Peak CFs for four of the seven sectors and for the total CF using both calculation methods. The results for the Winter period are similar, with five of the sectors having lower Seasonal Peak CFs and lower Total CFs using both calculation methods. Classifying the occupancy sensors as Seasonal Peak assets would result in a slight reduction in demand savings during both periods.

	Summer		% Change
Sector Type	**On-Peak CF**	**Seasonal CF**	**Seasonal / On-Peak**
Manufacturing	0.210	0.198	94%
Medical	0.234	0.239	102%
Office	0.270	0.274	101%
Other	0.017	0.024	144%
University/College	0.304	0.283	93%
Warehouse	0.266	0.246	92%
School	0.239	0.209	87%
Total Weighted by Logger	0.217	0.208	96%
Total Equal Weight by Sector	0.154	0.147	96%

Table 22: Comparison of Summer On-Peak and Seasonal Peak CFs Occupancy Sensors

	Winter		% Change
Sector Type	On-Peak CF	Seasonal CF	Seasonal / On-Peak
Manufacturing	0.190	0.172	90%
Medical	0.213	0.221	104%
Office	0.309	0.296	96%
Other	0.089	0.066	75%
University/College	0.233	0.231	99%
Warehouse	0.175	0.183	105%
School	0.173	0.159	92%
Total Weighted by Logger	0.197	0.191	97%
Total Equal Weight by Sector	0.138	0.133	96%

Table 23: Comparison of Winter On-Peak and Seasonal Peak CFs Occupancy Sensors

6.11 C&I Lighting Interactive Effects

There are significant electrical interactions with C&I lighting and occupancy sensors that can occur between the buildings HVAC system and the lighting. These interactive effects can be positive or negative depending upon whether the facility is using electrical cooling or electrical heating coincident with the operation of the lighting. We believe that calculating the impact of interactive effects should not be included in the Coincidence Factors for lighting or occupancy sensors, but rather the CFs should be used as a component in the equation to evaluate the interactive component of the demand impact. The decision whether to include interactive impacts in the C&I Lighting demand impacts is up to the individual entity responsible for evaluating their FCM project. There is a fairly high degree of variation across C&I sectors with respect to the distribution and efficiency of electrical HVAC equipment as well as variations within the sectors across different ISO-NE Load zones and it is beyond the scope of this report to develop these interactive demand impacts. The following sections discuss a recommended generic approach for evaluating the interactive C&I Lighting impacts.

There are several key variables that need to be defined for each sector in order to evaluate the interactive impacts in a systematic manner as follows:

- **Outside Air Factor (OAF)** – A ratio that defines the percentage of heat that the HVAC system would have to remove (cooling) or replace (heating) due to the average percentage of outside air, which dilutes the impact of the reduction [if average OA is 20% than the OAF would be 1.0 – 0.20 = 0.8]

- **HVAC Coincidence Factor (CF_H or CF_{AC})** – A ratio that defines the coincident operation of the electrical heating or electrical cooling equipment during the performance hours (will vary based upon ambient temperature)
- **HVAC Diversity Factor (DF_H or DF_{AC})** – A ratio that accounts for the percentage of lighting or occupancy sensor demand reduction in non-conditioned space
- **HVAC Saturation Factor (SF_H or SF_{AC})** - A ratio that accounts for the percentage of electrical heating or electrical cooling within a particular customer sector (heating SFs are expected to be quite low on the order of about 0.1 or lower, while air conditioning SFs are expected to quite high in the 0.9 to 1.0 range for most sectors)
- **HVAC Efficiency (Eff_H or Eff_{AC})** – The estimated efficiency of the overall heating or cooling system for each of the sectors based upon the distribution of electrical heating and cooling technologies.

The equation to define the cooling interactive effects for a specific C&I sector would be as follows:

$IA_{kW} = (CDR \times OAF \times CF_{AC} \times DF_{AC} \times SF_{AC}) / Eff_{AC}$ where,

IA_{kW} = The average Interactive impacts during the performance hours (kW)

CDR = The Coincident Demand Reduction for the lighting measure during the performance hours (kW)

OAF = The Outside Air Factor [1.0 - OA]

CF_{AC} = The Air Conditioning Coincidence Factor [AC percent on during peak hours]

DF_{AC} = The Air Conditioning Diversity Factor [percentage of conditioned space]

SF_{AC} = The Air Conditioning Saturation Factor [percentage of sector using electrical AC]

Eff_{AC} = The sector average electrical AC system efficiency (COP)

The equation for calculating interactive effects for lighting with electric heating would be similar to the example above, except the resulting value would be negative.

7 Addressing Statistical Sampling Bias and Measurement Error

Section 7.1 of the ISO-NE M&V Manual of Demand Reduction Value from Demand Resources provides a laundry list of different bias that could arise when evaluating demand impacts of demand resources. Since this study involves the development of Coincidence Factors for Residential and Commercial Lighting measures through the use of engineering based direct measurements there are a specific set of potential causes for bias that need to be addressed as follows;

- The accuracy and calibration of measurement tools,
- Measurement error,
- Sensor placement bias, and
- Sample selection bias.

7.1 Accuracy and Calibration of Measurement Tools

All of the data used in the development of the Residential and C&I Lighting CF came from Dent Instruments Time Of Use (TOU) Lighting Loggers. These loggers use a photocell and an internal time lock to measure when the lights go on and off and the logger software exports out interval data in a text format that provides the percent on time during each interval in the metering period. These interval data files were used to develop the Coincidence Factors presented in this study. There are no power measurement data used in the calculation of the CFs and therefore the only possible source of error for these data is related to the accuracy and calibration of the internal time clocks in the lighting loggers.

Section 10.2 of the ISO-NE M&V manual specifies that must be synchronized in time within an accuracy of ±2 minutes per month of with the National Institute of Standards and Technology ("NIST"). The Dent TOU Lighting Logger contains a solid state circuit that exceeds the ±2 minutes per month standard for time drift. RLW standard operating procedure for all lighting projects is to synchronize all lighting loggers at the start of a lighting project to a desk top computer clock that is linked to our network server and maintained in synch with the NIST clock. This procedure also allows us to confirm that the logger is communicating properly and providing data output. Periodically we also check the battery voltage of the loggers to make sure that the voltage is sufficient to power the unit. The loggers are equipped with a 3.0 Volt, that typically provides 3.2 Volts, but the loggers will continue to function properly until the voltage drops below 2.6 Volts. RLW replaces all batteries when the voltage is below 3.0 Volts, which usually occurs after the loggers have been in use for three years or more. Records battery testing and maintenance are maintained on the network drive of the RLW server, which is backed up on a daily basis. Figure 8 shows an RLW technician testing the lighting logger battery voltage and soldering a new battery into an older logger.

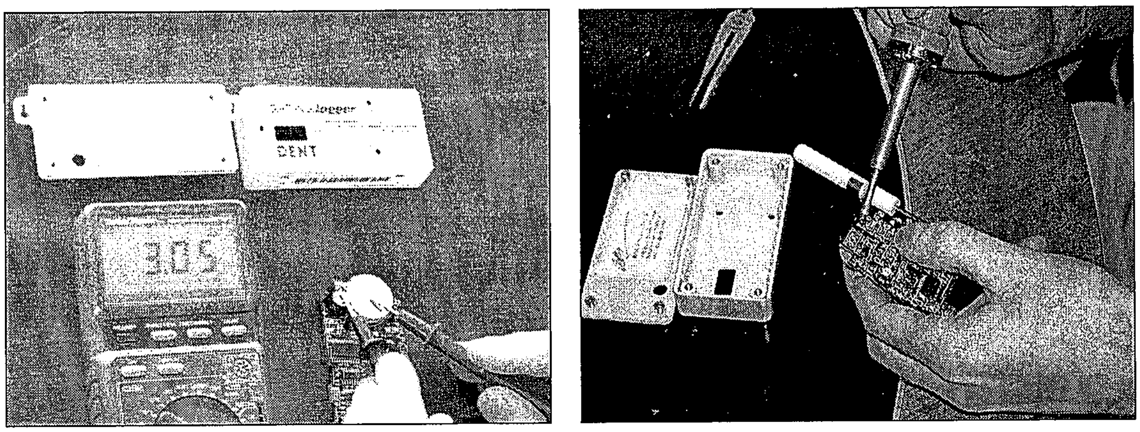


Figure 8: Testing and Replacement of Lighting Logger Battery

7.2 Measurement Error

There are essentially two sources of measurement error that are germane to the use of Lighting Loggers, the first being related to the clock and the second involves the calibration of the photocell sensor so that the logger only records the operation of the lighting and not daylight. The accuracy of the time clocks has already been addressed in the previous section although there are some issues that occur in the spring and fall when clocks are adjusted to and from daylight savings time. This issue actually occurred with a fairly large portion of the loggers that were installed for an extended monitoring period of approximately nine months and all of the files that spanned the time changes were adjusted in the SAS processing of the data.

The placement and calibration of loggers to insure that they only monitor the operation of the subject lighting fixture is typically very easy for Commercial and Industrial lighting because the fixtures are typically fluorescent 2'x4' troffer style fixtures that are located in a drop ceiling. When ambient light is a concern fiber optic wands are used, which fit over the photocell of the lighting logger and can be directed at the intended light source. The loggers are also equipped with a sensitivity screw that can be calibrated in the field so that the logger only registers an "on" reading when the lights are actually on. Figure 9 provides photos of typical lighting logger installations as well as the calibration procedure.

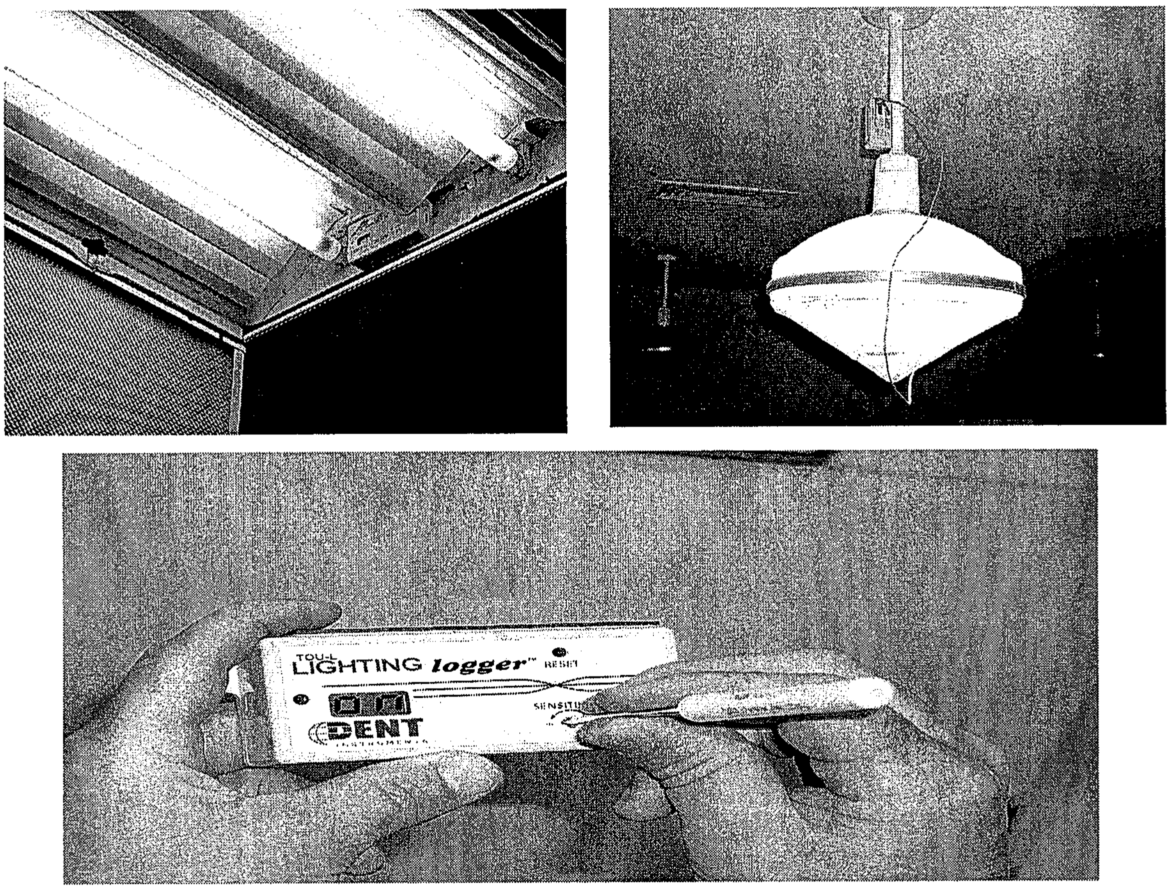


Figure 9: Lighting Logger Installation and Calibration

7.3 Sensor Placement Bias

Sensor placement bias refers to the bias that may arise when sampling fixtures at a facility does not accurately represent the operating schedule for the overall lighting system. This type of bias does not occur for residential lighting because monitoring typically includes all of the participating lighting at a residential facility. Primarily this is a concern at C&I Facilities where fixtures with low use may be excluded from monitoring and or emergency lighting that operates continuously maybe monitored and assumed to be representative of the whole lighting system when it represents only a small percentage of the lighting. The placement of the monitoring equipment is arguably the most critical and difficult stage of energy monitoring. A blend of statistics, engineering judgment, and consideration of customer impact typically contributes to a site monitoring plan. Since the fixtures or machinery chosen for monitoring were generally utilized to represent a larger portion of the lighting population, it was important to select items which were considered representative of other non-monitored equipment. The end result of intelligent equipment placement was high coverage for the combined metered and meter-represented areas over the entire lighting installation.

Monitoring decisions were based on several sources, including knowledge gained during the file review, information provided by the site representative, and direct observation of the site's space make-up and hours of use. As such, many specific monitoring decisions were not made until the evaluation team actually examined the facility and energy efficiency measures. In the instances of statistically sampled monitoring plans, backups were pre-selected according to measure savings stratifications. The goal of the measurement equipment installation was to find representative circuits based on savings, measure-type and hours of operation.

There were a number of instances when the monitoring of specific circuits would provide no real benefit to the calculation of energy savings. One instance was a circuit where there were no occupancy controls and hours of operation were clearly 24 hours per day. Exit signs and safety/security lighting are good examples of this case. A second instance, were circuits where an EMS control system can already provide detailed printouts of hours of operation. A third instance, were circuits which were clearly insignificant to the overall savings of the facility, such as storage closets or isolated restrooms.

In monitoring lighting applications, it is important to determine the control system for the fixtures. If the lighting is all on one circuit which is controlled by a breaker, placement of the monitoring device is less crucial to obtaining an accurate measure of the hours of operation. If the lighting is controlled by motion sensors, it may be necessary to place lighting loggers in separate locations to accurately measure the hours of operation.

In the case of larger measure installations, where high monitoring coverage was limited by the quantity of available monitoring equipment, a statistically stratified sample of the measures was drawn. Based upon this sample, monitoring equipment was installed on units which were identified to represent the non-monitored population of measures with statistically-designed precision. This approach was widely employed for motor measures.

The Coincidence Factors produced for this study were developed from a compilation of representative logger files from a large group of randomly selected sites that were representative of the lighting populations of several C&I Lighting programs implemented throughout New England.

7.4 Sample Selection Bias

Sample selection bias can occur during the recruitment process when a randomly selected and representative sample is compromised by the dropout and substitution of sites they may cause some type of selection bias due to their inclusion in the sample at rates higher or lower than their frequency in the population. Sample selection bias was not usually a problem for the C&I lighting samples because it was very rare that any of the primary sites drop out of the sample and when a randomly selected representative sample design was developed and implemented there was no selection bias.

The problem of selection bias was primarily related to residential lighting samples, which typically have much higher refusal rates than C&I lighting studies. The fact that residential customers in the primary sample refuse to participate in the on-site portion of a study does not necessarily result in selection bias. There must be some fundamental difference between the population and the sample customers that causes them to operate their residential lighting differently. It was generally recognized that residential customers can be categorized as either generally home during weekday daytime hours (general business hours 9:00 AM – 5:00 PM) or generally not home during weekday daytime hours. Since customer recruitment typically occurs during the daytime hours it was much easier to recruit the first group of customers because they were there during the day to answer the phone.

In order to mitigate this type of selection bias RLW conducted residential recruitment calls during evening and weekend hours when most residential customers were home to answer the phone and attempts multiple recruitment calls before moving to a backup site, which was also selected at random. Another issue that arises was the problem of scheduling on-site visits with residential customers that were generally not home during daytime hours, which was when on-sites were typically scheduled. In an effort to mitigate that problem we used a two pronged approach of flexible scheduling during early morning, evening and weekend hours and cash incentives of $50 to $100 to compensate the customer for any inconvenience.[7]

One important fact to consider in any discussion of selection bias is that it only occurs when there is actually a discernable difference in the operation of the equipment between the general population and the sample. When considering the residential lighting example the performance hours being evaluated primarily included the On-Peak hours of 1:00 PM – 5:00 PM during the summer (June –August) and 5:00 PM -7:00 PM during the winter (December –January). Since in general residential customers operate lighting when they are in a space and it is dark there would be very little difference between customers that are mostly home during the day and those that are not, during the summer performance hours because they occur during daylight hours when lights are generally off in both types of households. During the winter performance hours of 5:00 PM – 7:00 PM during December and January it is generally dark during those hours, but both types of households are also generally occupied during those hours as well, because working families generally start to arrive home around 5:00 PM. Therefore due to the nature of the measure being evaluated and the performance hours being considered the effects of any selection bias were also mitigated by the fact that there was little difference in the operating schedules of the measures being evaluated by the two groups of customers.

7.5 Other Possible Bias

There was also one other possible source of significant bias that should be discussed and that was the potential for meter bias that can occur when leading or trailing zeroes in the logger data were left in the logger output file. The Dent lighting loggers were equipped with a reset button that must be depressed by using the head of a pen or some other pointy object. This was typically done at the time each logger was installed so that the metered data would only reflect the actual metering period. After the loggers were collected the logger data file would be trimmed to the start of the collection day so that no leading or trailing zero data would be included. However

[7] In a recently completed residential lighting study in Maine we found that some customers that refused to schedule on on-site for a $50 incentive were convinced to schedule when called back and offered a $100 incentive.

there was one set of residential lighting loggers that contained a large number of loggers with leading zeroes that were not trimmed from the log files. Initially these log files were providing lower coincidence factor results for the winter performance season however the problem was discovered and corrected.

7.6 Bias Summary

As discussed in the California Evaluation Framework Study, "it is usually extremely difficult to objectively quantify the magnitude of the bias or even its direction." [8] We have always been aware of potential sources of bias and have tried our best to mitigate or eliminate them from our evaluation work and the data that were used in this study. We did not deliberately exclude sample projects or data, we utilized good measurement techniques in the field studies that produced the data, and employed recruiting techniques to limit selection bias. We believe that the results of this study are accurate and relatively free of bias.

[8] The California Evaluation Framework, Project Number: K2033910, TecMarket Works, et al, June 2004.

Appendix A – Data Sources

Residential Lighting Logger Data Sources

As mentioned in the body of the report there were a total of 875 Residential lighting logger files available for this analysis. Table A - 1 provides the distribution of the Residential lighting logger data by state and measure type, which shows that Massachusetts had the most logger data with a total of 323 logger files and Rhode Island had the fewest with 18 logger files. All of the New England states were represented in the sample.

Measure Type	CT	MA	ME	NH	RI	VT	Total
Compact Fluorescent Bulb	196	114	90	51	9	19	**479**
Compact Fluorescent Fixture	75	135	0	26	7	22	**265**
Torchiere	37	74	0	14	2	4	**131**
Total	**308**	**323**	**90**	**91**	**18**	**45**	**875**

Table A - 1: Distribution of Residential Logger Data by State

Table A - 2 provides a distribution of the residential lighting logger data by program name, program year and year that the data were collected.

Program Name	Program Year	Data Year	# of Loggers
Mass. Residential Lighting	2004	2004 -2005	318
New Hampshire Res. Lighting	2003	2003	91
NU Lighting Catalog	1996	1997	110
NU & UI Lighting Catalog	2000 -2001	2002	266
Maine Residential Lighting	2006	2007	90
		Total	875

Table A - 2: Distribution of Residential Lighting Data by Program and Year

Commercial & Industrial Lighting Logger Data Sources

Table A - 3 and Table A - 4 provide the distribution of the C&I Lighting Logger and Occupancy Sensor data by state, which shows that two thirds of the lighting and about 60% of the occupancy sensor data comes form Massachusetts.

	C&I Lighting Logger Counts by State					
Sector Type	**CT**	**MA**	**NH**	**RI**	**UNK**	**Total**
Grocery	3	32	0	0	2	**37**
Manufacturing	52	83	0	19	15	**169**
Medical	31	27	0	0	0	**58**
Office	22	174	12	36	15	**259**
Other	19	114	1	33	25	**192**
Restaurant	0	27	0	15	1	**43**
Retail	24	85	3	41	13	**166**
University/College	1	48	10	3	8	**70**
Warehouse	11	34	4	7	3	**59**
School	8	308	12	25	9	**362**
Total	**171**	**932**	**42**	**179**	**91**	**1415**

Table A - 3: Distribution of C&I Lighting Data by State

	C&I Occupancy Sensor Logger Counts by State					
Sector Type	**CT**	**MA**	**NH**	**RI**	**UNK**	**Total**
Grocery	0	2	0	0	0	**2**
Manufacturing	0	11	1	0	0	**12**
Medical	48	11	0	0	0	**59**
Office	7	48	4	8	2	**69**
Other	21	26	0	3	6	**56**
University/College	0	9	0	5	2	**16**
Warehouse	0	50	4	23	0	**77**
School	11	42	0	5	0	**58**
Total	**87**	**199**	**9**	**44**	**10**	**349**

Table A - 4: Distribution of Occupancy Sensor Data by State

Table A - 5 and Table A - 6 provide the distribution of the C&I Lighting Logger and Occupancy sensor data by Program, Program Year and Data Year.

Program Name	Program Description	Program Year	Data Year	# of Loggers
BSCS	Lg Retrofit and New Construction	2004	2005	122
Custom Svcs.	CI Custom Retrofit	2004	2005	42
D 2000+	CI New Construction	1999 & 2002	2003	222
ECC	CI New Construction	1996	1998	19
EI D2 Custom Ltg	Retrofit and New Construction	2004	2005	65
EI&CI Lighting	Small and Large CI Retrofit	2000	2000	188
Multi SBS Lght	Multi-State Small Business Services Lighting	2003	2004	496
NGrid Lght Controls	Lighting Controls	2005	2006	12
NU Express	Small and Large CI Retrofit	1997-1998	1999	59
SBS	Small Business Services	UNK	UNK	91
UNK	Unknown	UNK	UNK	99
			Total	**1415**

Table A - 5: Distribution of C&I Lighting Data By Program

Program Name	Program Description	Program Year	Data Year	# of Loggers
BSCS	Lg Retrofit and New Construction	2004	2005	79
Custom Svcs.	CI Custom Retrofit	2004	2005	30
ECC	CI New Construction	1996	1998	29
EI D2 Custom Ltg	Retrofit and New Construction	2004	2005	18
EI&CI Lighting	Small and Large CI Retrofit	2000	2000	2
Multi SBS Lght	Multi-State Small Business Services Lighting	2003	2004	3
Municipal Lght	Municipal Lighting Retrofit	2005	2006	32
NGrid Lght Controls	Lighting Controls	2005	2006	126
NU Express	Small and Large CI Retrofit	1997 -1998	1999	11
O&M	Operation and Maintenance	1998	1999	5
UNK	Unknown	UNK	UNK	14
			Total	**349**

Table A - 6: Distribution of C&I Occupancy Sensor Data by Program