C&I Lighting Load Shape Project
FINAL Report

July 19, 2011

Prepared for the Regional Evaluation, Measurement and Verification Forum

a project facilitated by Northeast Energy Efficiency Partnerships (NEEP)

Submitted to NEEP

NORTHEAST ENERGY EFFICIENCY PARTNERSHIPS
FACILITATING PARTNERSHIPS TO ADVANCE ENERGY EFFICIENCY

Northeast Energy Efficiency Partnerships, Inc.
91 Hartwell Avenue
Lexington, MA 02421

Prepared by KEMA

KEMA, Inc.
200 Court Street
Middletown, CT 06457
Fax: (860) 346-5533

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Preface

The Regional EM&V Forum

The Regional EM&V Forum (Forum) is a project managed and facilitated by Northeast Energy Efficiency Partnerships, Inc. The Forum's purpose is to provide a framework for the development and use of common and/or consistent protocols to measure, verify, track and report energy efficiency and other demand resource savings, costs and emission impacts to support the role and credibility of these resources in current and emerging energy and environmental policies and markets in the Northeast, New York, and Mid-Atlantic regions. Jointly sponsored research is also conducted as part of this effort. For more information, see www.neep.org/emv-forum.

Acknowledgments

Stephen Carlson from KEMA managed the project, assisted by many colleagues. Stephen Waite served as technical advisor to NEEP throughout this project.

Subcommittee for the C&I Lighting Loadshape Project

A special thanks and acknowledgment from Elizabeth Titus on behalf of EM&V Forum staff and contractors is extended to this project's subcommittee members and beta testers, many of whom provided input during the development of this project: Iqbal Al-Azad and Jim Cunningham (New Hampshire Public Utility Commission), Tom Belair (Public Service of New Hampshire), Bill Blake and Dave Jacobson (National Grid), Judeen Byrne, Victoria Engel-Fowles and Helen Kim (NYSERDA), Mary Cahill (New York Power Authority), Elizabeth Crabtree (Efficiency Maine), Niko Dietsch (US EPA), Kristy Fleischmann, Mary Straub and Sheldon Switzer (Baltimore Gas and Electric), Gene Fry (Northeast Utilities), Ethan Goldman and Nikola Janjic (VEIC - Efficiency Vermont), Kristin Graves (Consolidated Edison), Paul Gray (United Illuminating), Colin High (Metro Washington Council of Governments), Doug Hurley (consultant to Cape Light Compact), Huilan Li and Dan Norfolk (Maryland Public Service Commission), Debbie Kanner, Teri Lutz and Gary Musgrave (Allegheny Power), Taresa Lawrence (District of Columbia Department of Energy), Laura Magee (PepCo Holding Company), Arthur Maniaci (New York ISO), Kim Oswald (consultant to CT Energy Efficiency Board), Ralph Prahl (consultant to MA Energy Efficiency Advisory Council), Allison Reilly (NESCAUM), Marilyn Ross (Massachusetts Public Service Commission), Earle Taylor (consultant to Northeast Utilities), and Dave Weber (NSTAR).

1. Executive Summary

This project developed weather normalized 8,760 (representing every hour of the year) lighting end-use load shapes representative of hourly savings for efficient commercial lighting equipment . These load shapes were based on results of previous evaluation studies, including metering, that were conducted for various program administrators in the EMV Forum region. This project builds upon the original SPWG C&I Lighting Coincidence Factor Study[1] (March 2007) facilitated by NEEP, by including additional data and developing a site-level lighting logger spreadsheet tool.

1.1 Identification of Data Sources

The data sources used consisted entirely of interval lighting meter data collected for evaluating energy efficiency impacts. All of the data were mined from existing data that consisted of short-term (typically 3-4 weeks) metered data of interior C&I lighting equipment that was installed through an energy efficiency program. The data were collected primarily by KEMA (formerly RLW Analytics) as part of energy efficiency program evaluation work conducted from 2000 through the present. The data sources were identified through a review of internal KEMA sources and by the "promising" lighting studies list identified in the "End-Use Load Data Update Project" prepared for the Northwest Power and Conservation Council and Northeast Energy Efficiency Partnership, by KEMA[2]. Additionally, the project sponsors provided any interval lighting data that they had available and these data were included in the tool. Table 1-1 lists the number of projects and the number of loggers used to create the lighting spreadsheet tool.

[1] The Coincident Factor Study – Residential and Commercial Lighting Measures, 2007, by RLW Analytics is available at: www.neep.org/uploads/EMV Forum/EMV Studies/NECPUC CF Report with Bias and New CI Analysis.pdf.

[2] The End Use Load Data Update Project – Final Report Phase 1, 2009, by KEMA for NEEP and Regional EM&V Forum sponsors is available at www.neep.org/emv-forum/forum-products-and-guidelines.

Table 1-1: Lighting Interval Data by Sponsor

Sponsors	Number of Projects	Number of Loggers
Cape Light Compact (CLC)	19	169
National Grid (NGRID)	245	1230
New Hampshire Electric Cooperative (NHEC)	16	59
NSTAR	144	857
Northeast Utilities (NU)	261	1102
NYSERDA	39	127
United Illuminating (UI)	24	109
Unitil	27	127
Total	**775**	**3780**

1.2 Development of Site Level Profiles

The data primarily consisted of two key components, the metered data files (logger files) and the site-level lighting savings analysis spreadsheets. This project differed from the original SPWG study because in this project the individual logger profile data were aggregated into site-level data. The prior work treated each logger as an individual observation, with each logger having an equal weight. The current work weights each logger based upon the percentage of kW reduction that the logger represents at the site. The logger weights were developed using the lighting savings analysis spreadsheets, which also provided information about lighting controlled fixtures and information about the heating and cooling systems that was used for interactive calculations.

The use of site level data, as opposed to logger level data, should eliminate the possibility of loggers that represent a low amount of load receiving the same weight as loggers that represent a large amount of load at a facility. This removes one source of potential bias that existed in the previous SPWG Coincidence Factor study.

1.3 Data Expansion

The data consisted primarily of on/off transition data collected from Dent Instrument Time of Use (TOU) Lighting Loggers or Onset HOBO lighting loggers. These data consisted of short- term data typically installed for about a three to four-week period. It is widely accepted that for most C&I buildings there is very little seasonal variation and short- term data can be utilized to create a relatively accurate annual operating profile.

A day type methodology that created eight average day types (Monday through Sunday and Holidays) was utilized to calculate the annual profiles. The holiday list was consistent with ISO-

NE and PJM holidays and included New Year's Day, Memorial Day, Independence Day, Labor Day, Veteran's Day, Thanksgiving Day, and Christmas Day.

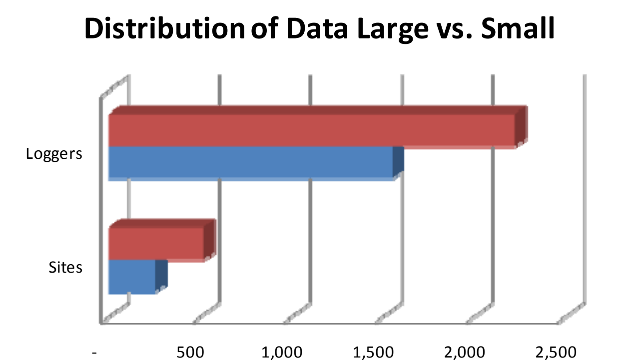
The expansion process created hourly daily profiles, where each hour's percent on represented the simple average for all the same hour and same day type. When no holiday data were available in the logger files the Sunday profile data were used for the holiday profile.

1.4 Data Segmentation

The site-level data were segmented based upon two separate criterion, size and business type. The sites were categorized as either large or small, primarily based upon the program type. In relatively small number of cases where the program could include both large and small customers, those participants that had a kW reduction of 10 kW or less were considered small.

Figure 1-1 provides an illustration of the distribution of the site and logger level data based on the Large and Small size categories. In terms of site-level data, there are more than twice as many small sites as large sites, but at the logger level about 59% of the loggers are from small sites and 41% are from large sites. This is not surprising as the average number of loggers per site at large sites is about six loggers, while small sites average just over four loggers.

Figure 1-1: Distribution of Data Large versus Small



	Sites	Loggers
Small	520	2,226
Large	255	1,554

The definitions of the primary business type categories primarily follow those used by the Commercial Buildings Energy Consumption Survey (CBECS) conducted by the U.S. Energy Information Administration (EIA). The distribution of the interval logger data and site level data by fifteen business type categories used to segment the data are provided in Table 1-2 below.

Table 1-2: Distribution of Data by Business Type

Business Type	Sites	Loggers
Education	90	632
Grocery	21	91
Lodging	11	66
Manufacturing	105	490
Medical	18	128
Municpal/Public Order & Safety	21	91
Office	127	723
Other	45	148
Public Assembly	44	226
Religious	7	25
Restaurant	19	63
Retail	140	595
Service	50	174
University/College	10	73
Warehouse	67	255
Total	**775**	**3780**

1.5 Results

Table 1-3 provides the annual energy savings per 100 kW of lighting load reduction by category without interactive effects. Each estimated factor is presented with the relative precision of each estimate at the 80% and 90% two-tail confidence intervals. As a reminder, relative precision at the 80% two-tail interval is equivalent to that of the 90% one-tail.

Table 1-3: Annual Savings by Category without Interactive Effects

Profile Type	Connected Reduction (kW)	Full Load Equivalent Hours (FLEH)	Annual Lighting Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	4,656	465,598	4.2%	5.4%
SMALL	100	3,335	333,527	3.4%	4.3%
EDUCATION	100	2,456	245,635	6.7%	8.5%
GROCERY	100	6,019	601,901	6.9%	8.9%
LODGING	100	4,808	480,826	23.4%	30.0%
MANUFACTURING	100	4,781	478,153	7.4%	9.5%
MEDICAL	100	4,007	400,695	14.4%	18.5%
MUNICIPAL	100	3,116	311,645	15.6%	20.0%
OFFICE	100	3,642	364,168	7.4%	9.5%
OTHER	100	4,268	426,813	15.1%	19.4%
PUBLIC ASSEMBLY	100	3,035	303,513	11.8%	15.1%
RELIGIOUS	100	2,648	264,797	25.1%	32.2%
RESTAURANT	100	4,089	408,865	13.2%	17.0%
RETAIL	100	4,103	410,336	5.2%	6.6%
SERVICE	100	3,521	352,129	10.5%	13.4%
UNIVERSITY/COLLEGE	100	3,416	341,557	14.9%	19.2%
WAREHOUSE	100	4,009	400,909	8.4%	10.8%

Interactive effects were also calculated for each of six weather regions. The weather regions were established in a previous EMV Forum C&I Unitary HVAC load shape study; they provide meaningful weather categorizations within the overall Forum area. Weather data files were developed based on typical meteorological year data from a representative city within each region. The C&I Lighting Load Shape tool also utilized the same six weather files as the NEEP C&I Unitary HVAC Load Shape tool[3]. Each weather region produced slightly different Total Annual Savings results when Interactive Effects were included. Table 1-4 through Table 1-9, provide the Interactive Savings per 100 kW of Connected Reduction for the seventeen profiles using the six weather files. Note that the Full Load Equivalent Hours (FLEH) of the lighting remain unchanged along with Annual Lighting Savings (shown in the third column) which does not include Interactive Savings and is the same as the Annual Lighting Savings shown above in the fourth column of Table 1-3.

Table 1-4: Annual Savings with Interactive Effects using Mid-Atlantic Weather

Profile Type	Connected Reduction (kW)	Annual Lighting Savings (kWh)	Interactive Savings (kWh)	Total Annual Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	465,598	36,685	502,283	4.2%	5.4%
SMALL	100	333,527	18,889	352,416	3.4%	4.3%
EDUCATION	100	245,635	9,049	254,684	6.7%	8.5%
GROCERY	100	601,901	71,492	673,393	6.9%	8.9%
LODGING	100	480,826	18,795	499,621	23.4%	30.0%
MANUFACTURING	100	478,153	32,079	510,232	7.4%	9.5%
MEDICAL	100	400,695	34,995	435,690	14.4%	18.5%
MUNICIPAL	100	311,645	17,756	329,401	15.6%	20.0%
OFFICE	100	364,168	21,917	386,085	7.4%	9.5%
OTHER	100	426,813	9,157	435,970	15.1%	19.4%
PUBLIC ASSEMBLY	100	303,513	18,397	321,910	11.8%	15.1%
RELIGIOUS	100	264,797	28,506	293,303	25.1%	32.2%
RESTAURANT	100	408,865	43,398	452,263	13.2%	17.0%
RETAIL	100	410,336	31,768	442,104	5.2%	6.6%
SERVICE	100	352,129	27,607	379,736	10.5%	13.4%
UNIVERSITY/COLLEGE	100	341,557	22,194	363,751	14.9%	19.2%
WAREHOUSE	100	400,909	14,882	415,791	8.4%	10.8%

[3] More information about the weather data files is available in the HVAC Loadshape Report, available at www.neep.org/emv-forum, under Forum Products. Detailed lighting loadshapes (8760 results) are available in the lighting loadshape tool, also available as a Forum Product.

Table 1-5: Annual Savings with Interactive Effects using NE-Mass Weather

Profile Type	Connected Reduction (kW)	Annual Lighting Savings (kWh)	Interactive Savings (kWh)	Total Annual Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	465,598	28,132	493,730	4.2%	5.4%
SMALL	100	333,527	13,491	347,018	3.4%	4.3%
EDUCATION	100	245,635	6,810	252,445	6.7%	8.5%
GROCERY	100	601,901	56,198	658,099	6.9%	8.9%
LODGING	100	480,826	10,827	491,653	23.4%	30.0%
MANUFACTURING	100	478,153	25,448	503,601	7.4%	9.5%
MEDICAL	100	400,695	27,677	428,372	14.4%	18.5%
MUNICIPAL	100	311,645	12,603	324,248	15.6%	20.0%
OFFICE	100	364,168	13,819	377,987	7.4%	9.5%
OTHER	100	426,813	4,541	431,354	15.1%	19.4%
PUBLIC ASSEMBLY	100	303,513	13,641	317,154	11.8%	15.1%
RELIGIOUS	100	264,797	20,964	285,761	25.1%	32.2%
RESTAURANT	100	408,865	32,032	440,897	13.2%	17.0%
RETAIL	100	410,336	23,505	433,841	5.2%	6.6%
SERVICE	100	352,129	20,706	372,835	10.5%	13.4%
UNIVERSITY/COLLEGE	100	341,557	14,228	355,785	14.9%	19.2%
WAREHOUSE	100	400,909	9,128	410,037	8.4%	10.8%

Table 1-6: Annual Savings with Interactive Effects using NE-North Weather

Profile Type	Connected Reduction (kW)	Annual Lighting Savings (kWh)	Interactive Savings (kWh)	Total Annual Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	465,598	25,317	490,915	4.2%	5.4%
SMALL	100	333,527	12,179	345,706	3.4%	4.3%
EDUCATION	100	245,635	6,310	251,945	6.7%	8.5%
GROCERY	100	601,901	52,118	654,019	6.9%	8.9%
LODGING	100	480,826	7,067	487,893	23.4%	30.0%
MANUFACTURING	100	478,153	23,222	501,375	7.4%	9.5%
MEDICAL	100	400,695	25,908	426,603	14.4%	18.5%
MUNICIPAL	100	311,645	10,899	322,544	15.6%	20.0%
OFFICE	100	364,168	11,420	375,588	7.4%	9.5%
OTHER	100	426,813	2,885	429,698	15.1%	19.4%
PUBLIC ASSEMBLY	100	303,513	12,487	316,000	11.8%	15.1%
RELIGIOUS	100	264,797	19,343	284,140	25.1%	32.2%
RESTAURANT	100	408,865	29,547	438,412	13.2%	17.0%
RETAIL	100	410,336	21,561	431,897	5.2%	6.6%
SERVICE	100	352,129	19,432	371,561	10.5%	13.4%
UNIVERSITY/COLLEGE	100	341,557	11,852	353,409	14.9%	19.2%
WAREHOUSE	100	400,909	6,968	407,877	8.4%	10.8%

Table 1-7: Annual Savings with Interactive Effects using NE-South Coastal Weather

Profile Type	Connected Reduction (kW)	Annual Lighting Savings (kWh)	Interactive Savings (kWh)	Total Annual Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	465,598	29,091	494,689	4.2%	5.4%
SMALL	100	333,527	14,325	347,852	3.4%	4.3%
EDUCATION	100	245,635	7,199	252,834	6.7%	8.5%
GROCERY	100	601,901	58,133	660,034	6.9%	8.9%
LODGING	100	480,826	11,410	492,236	23.4%	30.0%
MANUFACTURING	100	478,153	26,302	504,455	7.4%	9.5%
MEDICAL	100	400,695	28,742	429,437	14.4%	18.5%
MUNICIPAL	100	311,645	13,295	324,940	15.6%	20.0%
OFFICE	100	364,168	14,873	379,041	7.4%	9.5%
OTHER	100	426,813	5,023	431,836	15.1%	19.4%
PUBLIC ASSEMBLY	100	303,513	14,343	317,856	11.8%	15.1%
RELIGIOUS	100	264,797	21,962	286,759	25.1%	32.2%
RESTAURANT	100	408,865	33,681	442,546	13.2%	17.0%
RETAIL	100	410,336	24,790	435,126	5.2%	6.6%
SERVICE	100	352,129	21,938	374,067	10.5%	13.4%
UNIVERSITY/COLLEGE	100	341,557	15,233	356,790	14.9%	19.2%
WAREHOUSE	100	400,909	9,779	410,688	8.4%	10.8%

Table 1-8: Annual Savings with Interactive Effects using NY-Inland Weather

Profile Type	Connected Reduction (kW)	Annual Lighting Savings (kWh)	Interactive Savings (kWh)	Total Annual Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	465,598	28,706	494,304	4.2%	5.4%
SMALL	100	333,527	14,331	347,858	3.4%	4.3%
EDUCATION	100	245,635	7,235	252,870	6.7%	8.5%
GROCERY	100	601,901	57,778	659,679	6.9%	8.9%
LODGING	100	480,826	11,027	491,853	23.4%	30.0%
MANUFACTURING	100	478,153	25,999	504,152	7.4%	9.5%
MEDICAL	100	400,695	28,528	429,223	14.4%	18.5%
MUNICIPAL	100	311,645	13,183	324,828	15.6%	20.0%
OFFICE	100	364,168	14,758	378,926	7.4%	9.5%
OTHER	100	426,813	4,882	431,695	15.1%	19.4%
PUBLIC ASSEMBLY	100	303,513	14,480	317,993	11.8%	15.1%
RELIGIOUS	100	264,797	22,655	287,452	25.1%	32.2%
RESTAURANT	100	408,865	34,033	442,898	13.2%	17.0%
RETAIL	100	410,336	24,875	435,211	5.2%	6.6%
SERVICE	100	352,129	21,977	374,106	10.5%	13.4%
UNIVERSITY/COLLEGE	100	341,557	15,187	356,744	14.9%	19.2%
WAREHOUSE	100	400,909	9,565	410,474	8.4%	10.8%

Table 1-9: Annual Savings with Interactive Effects using NY-Urban Coastal Weather

Profile Type	Connected Reduction (kW)	Annual Lighting Savings (kWh)	Interactive Savings (kWh)	Total Annual Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	465,598	35,995	501,593	4.2%	5.4%
SMALL	100	333,527	18,571	352,098	3.4%	4.3%
EDUCATION	100	245,635	8,889	254,524	6.7%	8.5%
GROCERY	100	601,901	69,801	671,702	6.9%	8.9%
LODGING	100	480,826	19,344	500,170	23.4%	30.0%
MANUFACTURING	100	478,153	31,580	509,733	7.4%	9.5%
MEDICAL	100	400,695	34,098	434,793	14.4%	18.5%
MUNICIPAL	100	311,645	17,682	329,327	15.6%	20.0%
OFFICE	100	364,168	21,674	385,842	7.4%	9.5%
OTHER	100	426,813	9,145	435,958	15.1%	19.4%
PUBLIC ASSEMBLY	100	303,513	18,192	321,705	11.8%	15.1%
RELIGIOUS	100	264,797	27,861	292,658	25.1%	32.2%
RESTAURANT	100	408,865	42,851	451,716	13.2%	17.0%
RETAIL	100	410,336	31,339	441,675	5.2%	6.6%
SERVICE	100	352,129	26,965	379,094	10.5%	13.4%
UNIVERSITY/COLLEGE	100	341,557	21,902	363,459	14.9%	19.2%
WAREHOUSE	100	400,909	14,932	415,841	8.4%	10.8%

The following tables (Table 1-10 and Table 1-11) provides the coincident demand impacts per 100 kW of Connected Reduction by category during the ISO-NE On-peak Winter Performance hours with and without interactive effects. Although there are three New England weather files, the results were identical when the NE-North and NE-South Coastal weather files were used so they are shown in Table 1-11. Each estimated factor is presented with the relative precision of each estimate at the 80% and 90% two-tail confidence intervals. As a reminder, relative precision at the 80% two-tail interval is equivalent to that of the 90% one-tail.

Table 1-10: ISO-NE Winter On-peak Demand Reduction using NE-Mass Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	59.3	-0.6	58.7	4.6%	5.9%
SMALL	100	37.2	-0.3	36.9	5.7%	7.4%
EDUCATION	100	28.7	0.0	28.7	11.6%	14.9%
GROCERY	100	84.7	0.0	84.7	6.6%	8.5%
LODGING	100	54.6	-1.4	53.2	21.6%	27.7%
MANUFACTURING	100	49.7	0.0	49.7	11.1%	14.2%
MEDICAL	100	50.5	0.0	50.5	16.0%	20.5%
MUNICIPAL	100	35.5	-0.3	35.2	23.6%	30.2%
OFFICE	100	42.7	-1.4	41.3	9.4%	12.0%
OTHER	100	49.2	-1.1	48.1	18.9%	24.3%
PUBLIC ASSEMBLY	100	46.0	0.0	46.0	13.1%	16.8%
RELIGIOUS	100	51.4	0.0	51.4	26.4%	33.9%
RESTAURANT	100	63.0	0.0	63.0	17.7%	22.8%
RETAIL	100	51.7	0.0	51.7	8.9%	11.4%
SERVICE	100	32.1	0.0	32.1	25.6%	32.8%
UNIVERSITY/COLLEGE	100	41.1	-1.2	39.9	19.8%	25.4%
WAREHOUSE	100	44.9	-1.0	43.9	12.5%	16.0%

Table 1-11: ISO-NE Winter On-peak Demand Reduction using NE-North Weather and NE-South Coastal Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	59.3	-0.7	58.6	4.6%	5.9%
SMALL	100	37.2	-0.3	36.9	5.7%	7.4%
EDUCATION	100	28.7	0.0	28.7	11.6%	14.9%
GROCERY	100	84.7	0.0	84.7	6.6%	8.5%
LODGING	100	54.6	-1.4	53.2	21.6%	27.7%
MANUFACTURING	100	49.7	0.0	49.7	11.1%	14.2%
MEDICAL	100	50.5	0.0	50.5	16.0%	20.5%
MUNICIPAL	100	35.5	-0.3	35.2	23.6%	30.2%
OFFICE	100	42.7	-1.4	41.3	9.4%	12.0%
OTHER	100	49.2	-1.1	48.1	18.9%	24.3%
PUBLIC ASSEMBLY	100	46.0	0.0	46.0	13.1%	16.8%
RELIGIOUS	100	51.4	0.0	51.4	26.4%	33.9%
RESTAURANT	100	63.0	0.0	63.0	17.7%	22.8%
RETAIL	100	51.7	0.0	51.7	8.9%	11.4%
SERVICE	100	32.1	0.0	32.1	25.6%	32.8%
UNIVERSITY/COLLEGE	100	41.1	-1.2	39.9	19.8%	25.4%
WAREHOUSE	100	44.9	-1.0	43.9	12.5%	16.0%

The ISO-NE Winter Seasonal Peak coincident demand reductions were calculated for each of the seventeen profile types using the three New England weather files and in this case, the results were the same for all three weather files. Table 1-12 provides the coincident demand impacts per 100 kW of Connected Reduction by profile type during the ISO-NE Winter Seasonal Peak Performance hours with and without interactive effects.

Table 1-12: ISO-NE Winter Seasonal Peak Demand Reduction using All Three New England Weather Files

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	59.0	-0.6	58.4	5.1%	6.5%
SMALL	100	35.3	-0.3	35.0	6.5%	8.4%
EDUCATION	100	27.8	0.0	27.8	11.6%	14.9%
GROCERY	100	82.2	0.0	82.2	6.6%	8.5%
LODGING	100	54.4	-1.4	53.0	21.6%	27.7%
MANUFACTURING	100	50.0	0.0	50.0	11.1%	14.2%
MEDICAL	100	48.9	0.0	48.9	16.0%	20.5%
MUNICIPAL	100	35.4	-0.3	35.1	23.6%	30.2%
OFFICE	100	41.2	-1.3	39.9	9.4%	12.0%
OTHER	100	48.3	-1.2	47.1	18.9%	24.3%
PUBLIC ASSEMBLY	100	43.4	0.0	43.4	13.1%	16.8%
RELIGIOUS	100	52.0	0.0	52.0	26.4%	33.9%
RESTAURANT	100	59.6	0.0	59.6	17.7%	22.8%
RETAIL	100	49.6	0.0	49.6	8.9%	11.4%
SERVICE	100	29.3	0.0	29.3	25.6%	32.8%
UNIVERSITY/COLLEGE	100	39.8	-1.2	38.6	19.8%	25.4%
WAREHOUSE	100	44.7	-1.0	43.7	12.5%	16.0%

The following tables (Table 1-13 through Table 1-15) provides the coincident demand impacts per 100 kW of Connected Reduction by category during the ISO-NE On-peak Summer Performance hours with and without interactive effects. In this case, the three New England weather files each resulted in different Total Coincident Reduction values due to differences in the Coincident Interactive Reductions. Each estimated factor is presented with the relative precision of each estimate at the 80% and 90% two-tail confidence intervals. As a reminder, relative precision at the 80% two-tail interval is equivalent to that of the 90% one-tail.

Table 1-13: ISO-NE Summer On-peak Demand Reduction using NE-Mass Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	72.6	12.1	84.7	2.7%	3.4%
SMALL	100	68.1	9.2	77.4	2.2%	2.9%
EDUCATION	100	50.9	4.2	55.2	5.9%	7.5%
GROCERY	100	90.8	21.4	112.2	3.6%	4.6%
LODGING	100	56.0	7.0	63.0	23.5%	30.2%
MANUFACTURING	100	75.9	10.4	86.2	4.2%	5.4%
MEDICAL	100	70.1	12.1	82.3	8.7%	11.2%
MUNICIPAL	100	50.4	7.1	57.5	11.9%	15.2%
OFFICE	100	71.2	12.1	83.3	3.7%	4.7%
OTHER	100	67.3	5.0	72.3	10.1%	13.0%
PUBLIC ASSEMBLY	100	60.3	8.2	68.6	9.1%	11.7%
RELIGIOUS	100	34.6	8.2	42.8	42.4%	54.4%
RESTAURANT	100	77.0	18.2	95.2	10.6%	13.6%
RETAIL	100	79.9	13.8	93.7	2.7%	3.4%
SERVICE	100	79.2	13.6	92.8	5.1%	6.5%
UNIVERSITY/COLLEGE	100	61.7	11.0	72.7	9.3%	12.0%
WAREHOUSE	100	70.1	7.8	77.9	4.6%	5.9%

Table 1-14: ISO-NE Summer On-peak Demand Reduction using NE-North Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	72.6	12.2	84.9	2.7%	3.4%
SMALL	100	68.1	9.2	77.3	2.2%	2.9%
EDUCATION	100	50.9	4.2	55.1	5.9%	7.5%
GROCERY	100	90.8	21.5	112.3	3.6%	4.6%
LODGING	100	56.0	7.0	62.9	23.5%	30.2%
MANUFACTURING	100	75.9	10.5	86.3	4.2%	5.4%
MEDICAL	100	70.1	12.3	82.4	8.7%	11.2%
MUNICIPAL	100	50.4	7.1	57.4	11.9%	15.2%
OFFICE	100	71.2	12.1	83.3	3.7%	4.7%
OTHER	100	67.3	5.0	72.3	10.1%	13.0%
PUBLIC ASSEMBLY	100	60.3	8.2	68.5	9.1%	11.7%
RELIGIOUS	100	34.6	8.1	42.7	42.4%	54.4%
RESTAURANT	100	77.0	18.0	95.0	10.6%	13.6%
RETAIL	100	79.9	13.7	93.6	2.7%	3.4%
SERVICE	100	79.2	13.5	92.7	5.1%	6.5%
UNIVERSITY/COLLEGE	100	61.7	10.9	72.6	9.3%	12.0%
WAREHOUSE	100	70.1	7.8	77.9	4.6%	5.9%

Table 1-15: ISO-NE Summer On-peak Demand Reduction using NE-South Coastal Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	72.6	12.5	85.1	2.7%	3.4%
SMALL	100	68.1	10.0	78.1	2.2%	2.9%
EDUCATION	100	50.9	4.6	55.5	5.9%	7.5%
GROCERY	100	90.8	22.0	112.8	3.6%	4.6%
LODGING	100	56.0	7.6	63.6	23.5%	30.2%
MANUFACTURING	100	75.9	10.7	86.5	4.2%	5.4%
MEDICAL	100	70.1	12.5	82.6	8.7%	11.2%
MUNICIPAL	100	50.4	7.7	58.1	11.9%	15.2%
OFFICE	100	71.2	13.1	84.3	3.7%	4.7%
OTHER	100	67.3	5.5	72.7	10.1%	13.0%
PUBLIC ASSEMBLY	100	60.3	8.9	69.2	9.1%	11.7%
RELIGIOUS	100	34.6	8.9	43.5	42.4%	54.4%
RESTAURANT	100	77.0	19.6	96.7	10.6%	13.6%
RETAIL	100	79.9	15.0	94.9	2.7%	3.4%
SERVICE	100	79.2	14.7	93.9	5.1%	6.5%
UNIVERSITY/COLLEGE	100	61.7	11.9	73.6	9.3%	12.0%
WAREHOUSE	100	70.1	8.5	78.6	4.6%	5.9%

The ISO-NE Summer Seasonal Peak coincident demand reductions were calculated for each of the seventeen profile types using the three New England weather files and in this case, the results were the same for all three weather files. Table 1-16 provides the coincident demand impacts per 100 kW of Connected Reduction by profile type during the ISO-NE Winter Seasonal Peak Performance hours with and without interactive effects.

Table 1-16: ISO-NE Summer Seasonal Peak Demand Reduction using All Three New England Weather Files

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	75.5	13.4	89.0	2.8%	3.6%
SMALL	100	72.4	11.3	83.8	2.1%	2.7%
EDUCATION	100	58.4	5.6	63.9	5.9%	7.5%
GROCERY	100	91.3	22.9	114.2	3.6%	4.6%
LODGING	100	57.4	8.3	65.7	23.5%	30.2%
MANUFACTURING	100	81.0	11.8	92.7	4.2%	5.4%
MEDICAL	100	74.4	13.7	88.1	8.7%	11.2%
MUNICIPAL	100	56.1	9.1	65.2	11.9%	15.2%
OFFICE	100	75.2	14.8	90.0	3.7%	4.7%
OTHER	100	69.3	6.0	75.4	10.1%	13.0%
PUBLIC ASSEMBLY	100	61.4	9.7	71.0	9.1%	11.7%
RELIGIOUS	100	39.3	10.7	50.0	42.4%	54.4%
RESTAURANT	100	75.8	20.7	96.5	10.6%	13.6%
RETAIL	100	82.5	16.5	99.1	2.7%	3.4%
SERVICE	100	80.4	16.0	96.4	5.1%	6.5%
UNIVERSITY/COLLEGE	100	66.5	13.7	80.2	9.3%	12.0%
WAREHOUSE	100	74.1	9.6	83.6	4.6%	5.9%

Table 1-17 provides the coincident demand reductions by profile type during the PJM Summer performance hours both with and without interactive effects. There was only one weather file (Mid-Atlantic) in the tool from the PJM region used to calculate the Total Coincident Reduction per 100 kW of Connected Reduction. Each estimated factor is presented with the relative precision of each estimate at the 80% and 90% two-tail confidence intervals. As a reminder, relative precision at the 80% two-tail interval is equivalent to that of the 90% one-tail, which is used by PJM.

Table 1-17: PJM Summer Coincident Demand Reduction with Interactive Effects

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	68.1	12.1	80.2	3.3%	4.2%
SMALL	100	58.7	9.1	67.9	2.9%	3.7%
EDUCATION	100	42.4	4.0	46.4	7.5%	9.7%
GROCERY	100	89.9	22.5	112.4	4.0%	5.1%
LODGING	100	55.4	8.0	63.4	22.7%	29.1%
MANUFACTURING	100	66.7	9.7	76.5	6.1%	7.9%
MEDICAL	100	64.7	11.9	76.6	10.7%	13.7%
MUNICIPAL	100	43.0	7.0	50.0	17.1%	22.0%
OFFICE	100	63.1	12.4	75.5	4.7%	6.1%
OTHER	100	62.0	5.4	67.4	12.0%	15.4%
PUBLIC ASSEMBLY	100	56.6	8.9	65.5	9.8%	12.6%
RELIGIOUS	100	36.1	9.8	46.0	34.6%	44.4%
RESTAURANT	100	73.1	19.8	92.9	12.5%	16.1%
RETAIL	100	71.9	14.3	86.2	3.9%	5.0%
SERVICE	100	66.7	13.2	79.9	8.0%	10.3%
UNIVERSITY/COLLEGE	100	55.8	11.4	67.2	12.5%	16.0%
WAREHOUSE	100	61.6	7.9	69.5	6.4%	8.3%

Peak demand reduction value tables for ISO-NE On-peak and Seasonal peak periods were also created for the Large and Small customer types that excluded sites with lighting controls. These tables were created using the three New England weather files to calculate the interactive effects. Table 1-18 and Table 1-19 the demand impacts for the Large and Small customer types with no lighting controls for the ISO-NE Winter On-Peak and Seasonal Peak hours respectively.

Table 1-18: ISO-NE Winter On-peak with no Controls using all three NE Weather Files

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	63.3	-0.7	62.6	4.5%	5.8%
SMALL	100	38.5	-0.3	38.2	5.7%	7.4%

Table 1-19: ISO-NE Winter Seasonal with no Controls using all three NE Weather Files

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	63.1	-0.7	62.4	4.9%	6.3%
SMALL	100	36.6	-0.3	36.3	6.5%	8.4%

Table 1-20 through Table 1-22 provide the ISO-NE Summer On-Peak demand reduction values for the Large and Small business types excluding lighting controls and using the three New England weather files.

Table 1-20: ISO-NE Summer On-Peak with No Controls using NE-Mass Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	76.0	12.7	88.7	2.6%	3.3%
SMALL	100	69.2	9.4	78.5	2.2%	2.8%

Table 1-21: ISO-NE Summer On-Peak with No Controls using NE-North Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	76.0	12.8	88.8	2.6%	3.3%
SMALL	100	69.2	9.3	78.5	2.2%	2.8%

Table 1-22: ISO-NE Summer On-Peak with No Controls using NE-South Coastal Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	76.0	13.0	89.0	2.6%	3.3%
SMALL	100	69.2	10.1	79.3	2.2%	2.8%

Table 1-23 provides the ISO-NE Summer Seasonal Peak demand reduction values for the Large and Small business types without lighting controls. Only one table of results is shown, because the Summer Seasonal Peak results are the same using any of the three New England weather files.

Table 1-23: ISO-NE Summer Seasonal with No Controls using all NE Weather Files

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	78.7	13.4	92.7	2.2%	2.9%
SMALL	100	73.3	11.3	84.8	2.0%	2.5%

2. Project Overview

This project builds upon the initial work conducted for the New England State Program Working Group (SPWG) C&I Lighting Coincidence Factor analysis, which was conducted by KEMA (formerly RLW Analytics) and was completed in the Spring of 2007. The original work consisted of a report that provided C&I Lighting Coincidence Factors for developing demand reduction values for the ISO-NE Forward Capacity Market (FCM). The current project involves the use of a significant amount of new primary data collected from evaluation studies conducted since the completion of the original project.

This project involves the creation of an MS Excel spreadsheet tool to be used by members of the Regional Evaluation, Measurement and Verification Forum (the Forum) to calculate and quantify the hourly benefits of efficient lighting measures installed at commercial and industrial facilities. The underlying data used for the development of the spreadsheet tool consists of interval meter data that were collected to evaluate energy efficiency programs in the Northeast. The Forum is a regional project – facilitated and managed by NEEP – that represents New York and states in New England and the mid-Atlantic. The benefits of C&I lighting energy efficiency projects include avoided capacity costs resulting from reduced electric demand during peak hours, avoided energy costs resulting from energy savings during seasonal and on/off-peak periods and reduced emissions during High Electric Demand Days. Therefore, the objective of the present study is the development of lighting load factor data for every hour of the calendar year. The annual load shape data must also be adaptable to different program participant populations located within the service territories of Forum members. The load shape data were aggregated by facility type in order to provide for the calculation of aggregate load shapes that reflect the facility composition of different Program Administrator (PA) customer populations.

The Forum recently completed an inventory and assessment of completed existing end-use and load shape data studies as Phase 1 of its Load Shape Study Project. Based on the results of the Phase 1 review and analysis and informal feedback from Forum members, the project subcommittee has determined that the existing data are sufficient in quality and quantity to derive reasonable estimates of C&I lighting load shapes to be used by Forum members for the applications listed above. Therefore, the scope of work described below is limited to the compilation and analysis of existing measured data that will be available at the time of project initiation.

The following sections of this report document the data sources used to develop the spreadsheet tool. The report also describes the data analysis methods used to roll up the logger-level data into site-level and then segment the site-level data into size categories and then into aggregate profiles that were then used in the lighting spreadsheet tool.

3. Input Data Analysis Methodology

This section will provide a description of the process used to identify the source data, discuss the process that utilized to develop site level profiles and provide data characteristics.

3.1 Identification of Data Sources

The data sources consisted entirely of interval lighting meter data collected for evaluating energy efficiency impacts. All of the data were mined from existing of short-term (typically 3-4 weeks) metered data of interior C&I lighting equipment that was installed through an energy efficiency program. The primary source of the data was program evaluation conducted by KEMA (formerly RLW Analytics) as part of energy efficiency program evaluation work conducted from 2000 through the present. The data sources were identified by a review of internal KEMA sources and by the "promising" lighting studies list identified in the "End-Use Load Data Update Project Report" prepared for the Northwest Power and Conservation Council and Northeast Energy Efficiency Partnership, by KEMA. Additionally, the project sponsors provided any recent interval lighting data not included in the 2007 SPWG study, that they had available and these data were included in the tool. Table 3-1 provides a list of the number of projects and the number of loggers used to create the lighting spreadsheet tool.

Table 3-1: Lighting Interval Data by Sponsor

Sponsors	Number of Projects	Number of Loggers
Cape Light Compact (CLC)	19	169
National Grid (NGRID)	245	1230
New Hampshire Electric Cooperative (NHEC)	16	59
NSTAR	144	857
Northeast Utilities (NU)	261	1102
NYSERDA	39	127
United Illuminating (UI)	24	109
Unitil	27	127
Total	**775**	**3780**

3.2 Development of Site Level Profiles

The data primarily consisted of two key components, the metered data files (logger files) and the site-level lighting savings analysis spreadsheets. As previously stated, this project differed from the original SPWG study because in this project the individual logger profile data were aggregated into site-level data. The prior work treated each logger as an individual observation, with each logger having an equal weight. The current work weights each logger based upon the percentage of kW reduction that the logger represents at the site. The logger weights were developed using the lighting savings analysis spreadsheets, which also provided information about lighting controlled fixtures and information about the heating and cooling systems that was used for interactive calculations.

The use of site level data, as opposed to logger level data, should eliminate the possibility of loggers that represent a low amount of load receiving the same weight as loggers that represent a large amount of load at a facility. This removes one source of potential bias that existed in the previous SPWG Coincidence Factor study.

3.3 Data Expansion

This section of the report will discuss the methods utilized to develop annual 8,760 hourly profiles using the site-level profiles. The data consisted primarily of on/off transition data collected from Dent Instrument Time of Use (TOU) Lighting Loggers or Onset HOBO lighting loggers. These data consisted of short- term data typically installed for about a three to four-week period. It is widely accepted that for most C&I buildings there is very little seasonal variation and short- term data can be utilized to create a relatively accurate annual operating profile. Notable exceptions are facilities that do exhibit a high degree of seasonality like education-schools and university-colleges and to a lesser extent lodging. The annual expansions for these facilities were limited by the duration of the available data. In future work, we recommend further examination of the issue of seasonality across all of the business sectors as long-term data becomes available. Additional emphasis should be placed on the education and university-colleges sectors to address their seasonal operating schedules.

A day type methodology that created eight average day types (Monday through Sunday and holidays) was utilized to calculate the annual profiles. The holiday list was consistent with ISO-NE and PJM holidays and included the following:

- New Year’s Day
- Memorial Day
- Independence Day
- Labor Day
- Veteran’s Day
- Thanksgiving Day
- Christmas Day

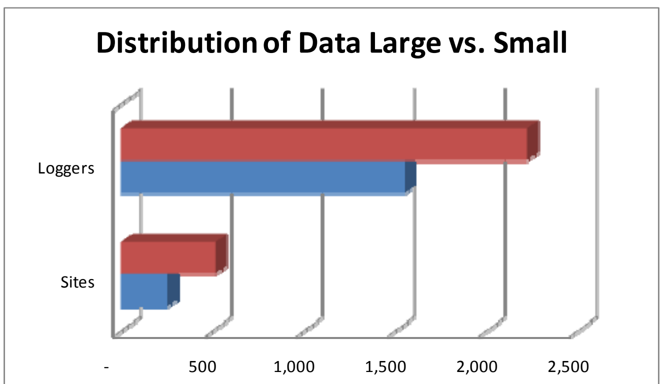
The expansion process created hourly daily profiles, where each hour's percent on represented the simple average for all the same hour and same day type. When no holiday data were available in the logger files the Sunday profile data were used for the holiday day type profile.

3.4 Data Segmentation

The site-level data were segmented based upon two separate criterion, size and business type. The sites were categorized as either large or small, primarily based upon the program type. The primary factor for determining the size category was the program name and the type of customers that are the typical program participants. If the program name contained the word "Small", for example, Small Business Solutions, or the program targeted small customers, then the site was small. Conversely, if the program targeted larger customers, then the site was large. In relatively small number of cases where the program could include both large and small customers, those participants that had a kW reduction of 10 kW or less were considered small.

Figure 3-1 provides an illustration of the distribution of the site and logger level data based on the large and small size categories. In terms of site-level data, there are more than twice as many small sites as large sites, but at the logger level about 59% of the loggers are from small sites and 41% are from large sites. This is not surprising as the average number of loggers per site at large sites is about six loggers, while small sites average just over four loggers.

Figure 3-1: Distribution of Data Large versus Small



	Sites	Loggers
Small	520	2,226
Large	255	1,554

The definitions of the primary business type categories primarily follow those used by the Commercial Buildings Energy Consumption Survey (CBECS) conducted by the U.S. Energy Information Administration (EIA). The primary segments are as follows;

- Education – Schools
- Grocery – Food Sales
- Health Care – Hospital
- Lodging
- Manufacturing – Industrial
- Municipal - Public Order and Safety
- Office
- Other
- Public Assembly
- Religious – Worship
- Restaurant – Food Service
- Retail – Mercantile
- Service
- University – College
- Warehouse – Storage

The **Education – Schools** category includes buildings used for academic or technical classroom instruction, such as elementary, middle and high schools. This category does not include universities, colleges and career or adult education, which are fall under the University – College category. This category also includes pre-school or daycare and religious schools.

The **Grocery – Food Sales** category includes buildings primarily used for wholesale or retail food sales. This category does not include refrigerated food distribution centers, which were categorized as Warehouse – Storage. This category includes grocery stores, food markets and convenience stores with or without gas stations.

The **Health Care – Hospital** category includes buildings used as diagnostic and treatment facilities, which includes medical offices that have diagnostic and or medical treatment equipment. This category does not include medical offices that do not contain diagnostic or medical treatment equipment, which are categorized as Office buildings. This category includes hospitals, rehabilitation centers, dialysis centers and veterinary locations.

The **Lodging** category includes buildings used to offer multiple accommodations for short-term or long-term residents, including skilled nursing and other residential care buildings. This category includes motels, hotels, inns, dormitories, retirement homes, convents or monasteries, shelters and orphanages.

The **Manufacturing and Industrial** category includes buildings primarily used for the production of goods including primary and secondary metals, mining, paper and pulp, forest products and other agricultural products.

The **Municipal, Public Order and Safety** category includes buildings used for the preservation of law and order or public safety. This category includes police station, fire station, department of public works, jail, penitentiary and courthouse or probation office.

The **Office** category includes buildings used for general office space, professional office, or administrative offices. Medical offices are included if they do not have diagnostic medical equipment. This category includes administrative or professional offices, government offices, mixed-use offices, bank or other financial institutions, sales offices, contractor offices, non-profit or social services, research and development, city hall, religious offices and call centers.

The **Other** category includes buildings that are not easily classifiable into any of the other categories listed here. This category includes building that are mixed use with no clear dominate activity and infrastructure type buildings like those associated with bridges and tunnels, waste water treatment, phone switches, and data centers.

The **Public Assembly** category includes buildings that people gather for social or recreational activities (Public Assembly) and buildings used for the preservation of law and order or public safety. This category includes community center, lodge, meeting hall, convention center, senior center, gymnasium, health club, bowling alley, ice rink, field house, museum, theater, cinema, sports arena, casino, night club, library, funeral home, exhibition hall, broadcasting studio and transportation terminal.

The **Religious – Worship** category includes buildings in which people gather for religious activities such as chapels, churches, mosques, synagogues and temples.

The **Restaurant – Food Service** category includes buildings used for the preparation and sale of food and beverages for immediate consumption either on the premises or take-out. This category includes fast food restaurants, sit down restaurants, cafes, coffee shops, doughnut shops, bars and cafeterias.

The **Retail – Mercantile** category includes buildings used for the display and sale of goods other than food. This category includes retail stores, liquor stores, rental centers, vehicle dealerships and art galleries.

The **Service** category includes buildings in which some type of service is provided, other than food service or retail sales of goods. This category includes vehicle service and repair shop, gas station, car wash, repair shop, Laundromat, dry cleaner, post office, postal center, photo shop, beauty parlor, barber shop, copy center, printing shop and kennel.

The **University – College** category includes buildings used for academic or technical classroom instruction for adults. This category does not include elementary, middle and high schools which are covered in the Education – Schools category or dormitories; fraternity and sorority houses that are covered in the Lodging category; or administrative buildings that are covered in the office category. This category includes classrooms and laboratory facilities at universities and colleges including community colleges and post high vocational training facilities.

The **Warehouse – Storage** category includes building used to store goods, manufactured products, merchandise, raw materials or personal belongings. This category includes refrigerated warehouse, non-refrigerated warehouse, distribution or shipping center and self-storage facilities.

Table 3-2 provides the distribution of the interval logger data and site level data by the fifteen business type categories used to segment the data. The top three categories, in terms of number of sites, were Retail, Office and Manufacturing, which all had over 100 sites. The bottom three categories, in terms of site counts, were Religious, University/College and Lodging, but with the exception of Religious-Worship all categories had at least 10 site level observations.

Table 3-2: Distribution of Data by Business Type

Business Type	Sites	Loggers
Education	90	632
Grocery	21	91
Lodging	11	66
Manufacturing	105	490
Medical	18	128
Municpal/Public Order & Safety	21	91
Office	127	723
Other	45	148
Public Assembly	44	226
Religious	7	25
Restaurant	19	63
Retail	140	595
Service	50	174
University/College	10	73
Warehouse	67	255
Total	**775**	**3780**

3.5 Overview of Aggregate Profile Development

This section of the report provides an outline of the process for the development of the seventeen annual aggregate profiles (Large, Small and the 15 Business Types) that are utilized in the lighting spreadsheet tool. Figure 3-2-2 provides a flow chart of the process that was used to develop the aggregate profiles, which utilized the interval logger data and the lighting analysis spreadsheets as inputs to create a data key that contains logger level information. The following steps contain a high-level description of the SAS code that was used to process the data and create the aggregate 8760 load profiles.

Step 1: Import Data

Automated macro pulls all .csv files from specified path to create a single dataset containing all loggers, because the data for this project came from a collection of other projects, the logger data are not in a uniform format. The macro takes data from different logger types in different formats and creates a single data set with hourly percent on.

Step 2: Identify Day of Week Type

For the combined dataset, determine day of week (1-7) for each observation in the data.

Step 3: Holiday Listing

Run holiday macro that creates a list of all holidays over a range of years. Match up holiday list to the hourly percent on data file to identify an eighth day of week type, which will denote a holiday.

Step 4: Merge Data Key to Meter Data

Merge data key to meter data to provide meter level weights for each site. The data key contains supplemental information such as building type and building size that is associated with specific meters.

Step 5: Calculate Weights

The weights were calculated using the kW reduction value listed for each meter at each site, if no kW reduction value was present then use connected kW.

Step 6: Aggregate to Site Level Profile

Using weights from Step 5 calculate the weighted 8760 profile at the site level. Building level profiles were created by taking meter data and calculating hourly weighted averages for each day of week type; for example, Monday 12 am, Monday 1 am...Sunday 11:00 pm. These weighted hourly averages were then expanded to a calendar year for each day of week type / hour.

Figure 3-2: Flow Chart of Aggregate Profile Development Process

Step 7: Group by Business Type and Size Type

The site level profiles from Step 6 were grouped by business type and size type, so that relative precision calculation can be performed.

Step 8: Calculate Relative Precision

The relative precision is the standard error of the hours for a determined period multiplied by the z-coefficient for a given level of confidence (e.g. 1.645 for 90% two-tailed confidence). A separate precision was calculated for each period (ISO NE summer, ISO NE winter, PJM summer, and all hours). If for example, to calculate the precision for ISO-NE summer for the grocery building type, the standard error was calculated for all hours between 2 pm and 5 pm. This standard error was then multiplied by the z-coefficient to calculate the relative precision for the grocery building type. The number of observations (N) is equal to the number of sites for the type being calculated.

Step 9: Aggregate to Building Type and Size Type Profile

Site level 8760 profiles were averaged together by hour for each building type and for the large and small size types, with each site given a weight of one.

3.6 Development of Interactive Effects

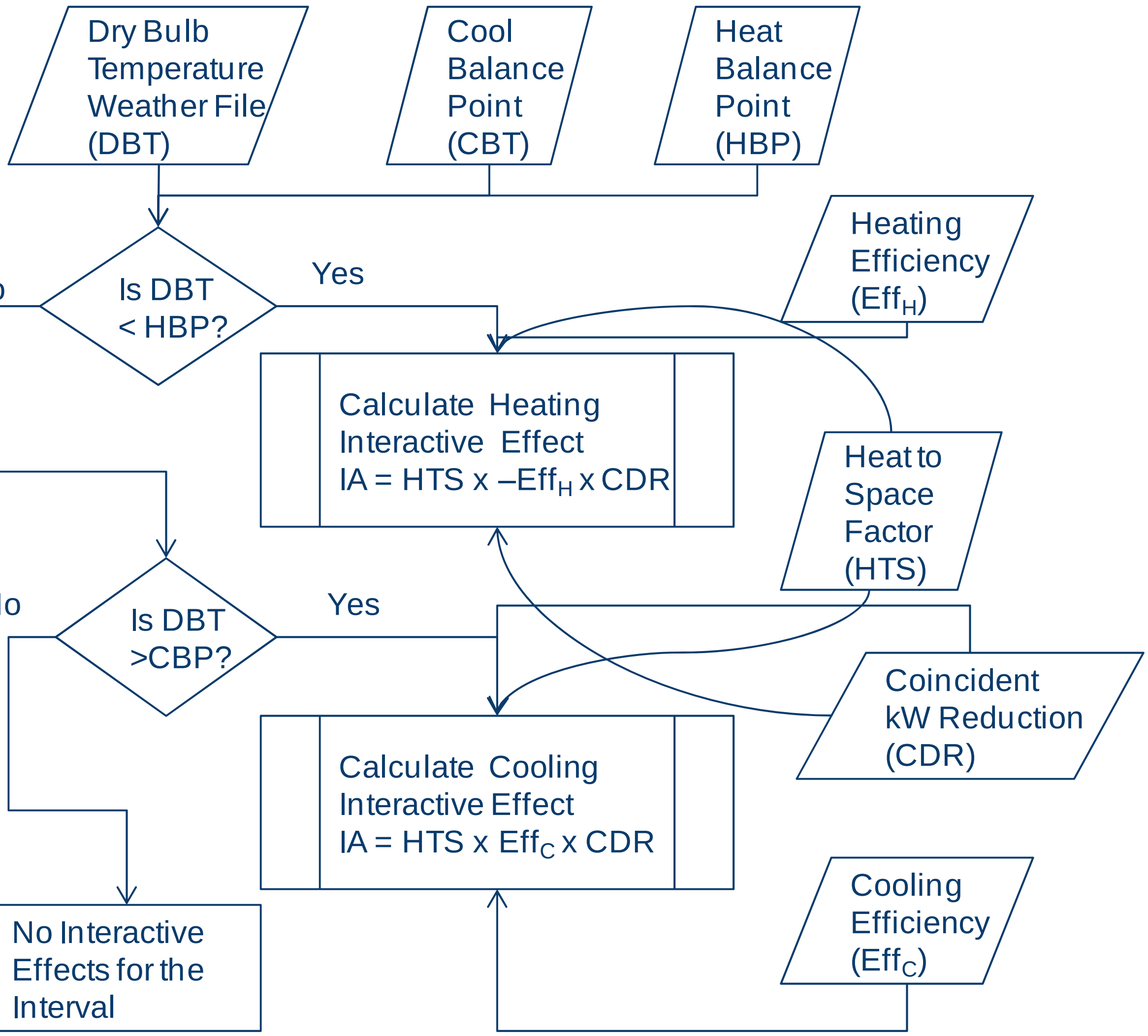
This section of the report describes the methods used to calculate the site level interactive effects. There are several key variables that needed to be defined for each sector in order to evaluate the interactive impacts in a systematic manner as follows:

- **Heat To Space Factor (HTS)** – 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 and other factors such as the placement of the lighting either directly in the space (not vented) vented to the return air or vented to supply and return air [typical value is 0.9 to 0.8]
- **Balance Point (BP_C or BP_H)** represents the outdoor temperature at which the facility is expected to be in Cooling or Heating mode, which are typically 65ºF and 55ºF respectively

- **HVAC Efficiency (Eff_H or Eff_C) –** 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 spreadsheet tool utilizes the direct input of five static variables for both the heating and cooling interactive calculations maintained in the spreadsheet. These static variables are the Heat to Space Factor, the Heating Efficiency, the Cooling Efficiency, the Heating Balance Point and the Cooling Balance Point. The spreadsheet uses the selected weather file and the percent on times the kW reduction [Coincident Demand Reduction (CDR)] for the selected profile during each interval to calculate the Interactive Effects. Figure 3-3 provides a flowchart that summarizes the interactive effect calculation for each interval.

Figure 3-3: Flowchart of Interactive Effect Interval Calculations



The interactive effect calculation is driven by the dry bulb temperature (DBT) in the user selected weather file and there are three states as follows:

- **State 1 Heating Mode:** occurs when the DBT is less than the Heating Balance Point (HBP). The Heating Interactive Effect calculation is performed and results are negative so Coincident Demand Reduction (CDR) for the interval is reduced.
- **State 2 Cooling Mode:** occurs when the DBT is greater than the Cooling Balance Point (CBP). The Cooling Interactive Effect calculation is performed and results are positive so Coincident Demand Reduction (CDR) for the interval is increased.

- **State 3 Neutral Mode:** occurs when the DBT is greater than or equal to the HBP and less than or equal to the CBP. This is the dead band zone where there are no interactive effects calculated.

The first step in the interactive calculation is to read in the Dry Bulb Temperature (DBT) from the user selected weather file to determine whether the building is in heating mode (State1), cooling mode (State 2), or neutral mode (State 3).

If during the hour the building HVAC system is in heating mode then the following equation is used to calculate the interactive heating penalty;

IA_{kW} = (CDR x HTS x - Eff_H) 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)

HTS = Heat to Space Factor [decimal percentage]

Eff_H = The sector average electrical Heating system efficiency (1/COP[4])

If during the hour the building HVAC system is in cooling mode then the following equation is used to calculate the interactive cooling benefit;

IA_{kW} = (CDR x HTS x Eff_C) 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)

HTS = Heat to Space Factor [decimal percentage]

Eff_C = The sector average electrical Cooling system efficiency (1/COP)

Finally, when the DBT is in the neutral mode for the building type there is no heating or cooling, and there are no interactive effects calculated for the hour.

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[4] COP or Coefficient of Performance is a dimensionless measure used in analysis of HVAC equipment, derived as a ratio of output energy (e.g. BTUs of heating or cooling delivered) divided by input energy (e.g. BTUs of electricity consumed)

The interactive effects across any time-period are equal to the sum of the heating and cooling interactive effects during the period. Table 3-3 provides the default static interactive variables used to calculate the interactive effects for each of the 17 profile types. As shown in Table 3-3 the Heating Efficiency Factor (Eff_H) has a negative sign because there is a reduction in savings when the building is electrically heated and thus the third column is labeled, Heating Penalty Factor. Similarly, the Cooling Efficiency Factor (Eff_C) is positive because there is an increase in savings when the building is electrically cooled and thus the fourth column is labeled, Cooling Bonus Factor.

Table 3-3: Default Static Interactive Variable

Profile Type	Heat to Space	Heating Penalty Factor	Cooling Bonus Factor	Heating Balance Point	Cooling Balance Point
LARGE	0.8	0.014	0.222	50	60
SMALL	0.8	0.011	0.196	55	65
EDUCATION	0.8	0.000	0.119	55	65
GROCERY	0.8	0.000	0.313	50	60
LODGING	0.8	0.032	0.182	55	65
MANUFACTURING	0.8	0.000	0.182	50	60
MEDICAL	0.8	0.000	0.231	50	60
MUNICIPAL	0.8	0.010	0.204	55	65
OFFICE	0.8	0.039	0.247	55	65
OTHER	0.8	0.029	0.109	55	65
PUBLIC_ASSEMBLY	0.8	0.000	0.197	55	65
RELIGIOUS	0.8	0.000	0.341	55	65
RESTAURANT	0.8	0.000	0.341	55	65
RETAIL	0.8	0.000	0.250	55	65
SERVICE	0.8	0.000	0.248	55	65
UNIVERSITY_COLLEGE	0.8	0.037	0.257	55	65
WAREHOUSE	0.8	0.028	0.161	55	65

The default static heating and cooling factors shown in Table 3-3 were calculated using the system type results frequencies reported in the lighting analysis spreadsheet for each heating and cooling system type observed in the dataset. The logger-level system types were weighted based upon the amount of kW reduction for each system to determine site level frequencies. The site level frequencies each had a total weight of one and frequencies of the heating and cooling equipment types for each site within an aggregate profile type (large, small and the 15 business types) were summed and divided by the number of sites to calculate profile type frequencies. Within each aggregate profile type, the heating and cooling equipment type frequencies each had a total of one. The frequencies within a profile type for each heating and cooling equipment type were multiplied by the appropriate heating or cooling electrical input ratio to calculate the heating and cooling efficiency for each profile type.

Table 3-4 provides the default efficiency values used for each of the cooling equipment types identified in the lighting analysis spreadsheets. The Cooling Electrical Input Ratio (C-EIR) shown in the last column is the value used for Cooling Efficiency (Eff_C) in the Cooling Interactive Calculation.

Table 3-4: Default Cooling Efficiency Values by Equipment Type

Cooling Equipment Type	kW/Ton	COP	C-EIR
Packaged DX	1.20	2.931	0.341
Window DX	1.30	2.705	0.370
Chiller <200 Ton	0.75	4.689	0.213
Chiller >200 Ton	0.64	5.527	0.181
Air to Air Heat Pump	0.90	3.908	0.256
Water to Air Heat Pump	0.84	4.200	0.238
Refrigerated	2.30	1.529	0.654

Table 3-5 provides the default efficiency values that were used for each of the heating equipment types identified in the lighting analysis spreadsheets. The Heating Electrical Input Ratio (H-EIR) shown in the last column is the value used for Heating Efficiency (Eff_H) in the Heating Interactive Calculation.

Table 3-5: Default Heating Efficiency Values by Equipment Type

Heating Equipment Type	COP	H-EIR
Air to Air Heat Pump	1.50	0.667
Electric Resistance	1.00	1.000
Water to Air Heat Pump	2.80	0.357

3.7 Percentage of Lighting Controls

The interval lighting dataset included some loggers that monitored the operation of lighting controlled fixtures, which consisted primarily of occupancy sensors controls. These data were included in the site level and aggregate profile, because they represent the observed operating hours at the facilities.

Figure 3-4 provides the percentage of lighting controls in the data segmented by large and small sites. The data shows the percentage of sites that had some form of lighting controls within the large and small site categories. The data shows that the presence of lighting controls are more than twice as high at large sites (26.7%) than at small sites (11.2%).

Figure 3-4: Percentage of Lighting Controls Large vs. Small

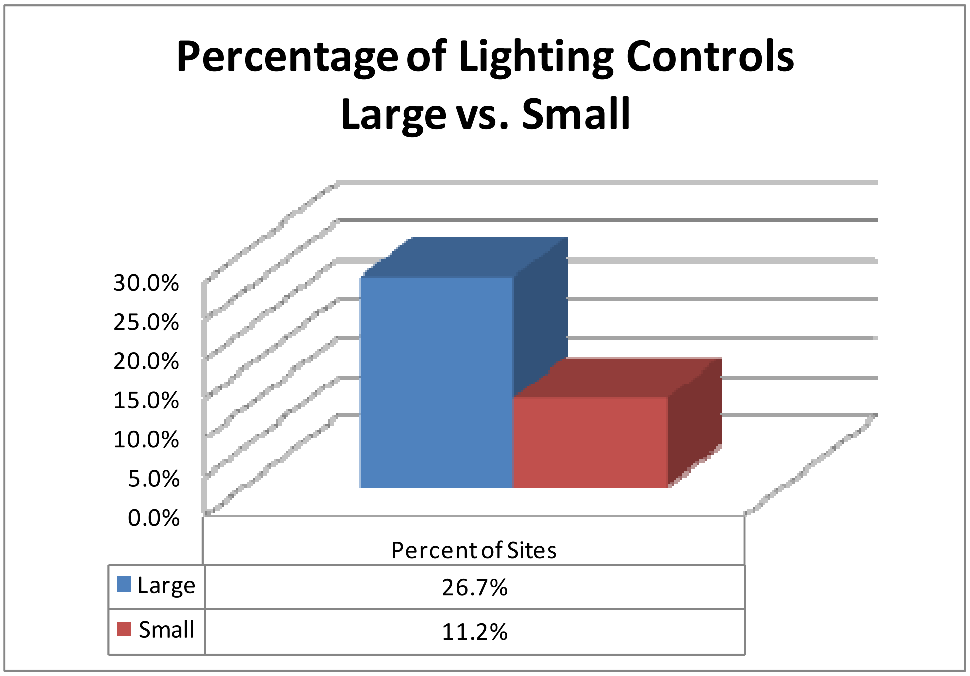


Table 3-6 provides the distribution of the percentage of sites with lighting controls by business type. The percentage of sites with lighting controls across all sectors is 16.8%, shown at the bottom of the table. There was a large amount of variation between the business types with respect to frequencies of lighting controls. At the high-end, business types like warehouse and university/college have 49.3% and 40% of facilities with lighting controls. Conversely, there were no restaurant sites that had lighting controls in the dataset. In general, the frequency of lighting controls in the various business types seem reasonable. However these data are shown here for informational purposes and are not meant to imply that these are expected penetration rates for lighting controls among the different business sectors.

Table 3-6: Distribution of Lighting Controls by Business Types

Business Type	Number of Controlled Sites	Total Sites	Percent of Controlled Sites
Education	14	90	15.6%
Grocery	5	21	23.8%
Lodging	2	11	18.2%
Manufacturing	16	105	15.2%
Medical	3	18	16.7%
Municipal	4	21	19.0%
Office	25	127	19.7%
Other	6	45	13.3%
Public Assembly	5	44	11.4%
Religious	1	7	14.3%
Restaurant	0	19	0.0%
Retail	9	140	6.4%
Service	3	50	6.0%
University/College	4	10	40.0%
Warehouse	33	67	49.3%
All Sectors	130	775	**16.8%**

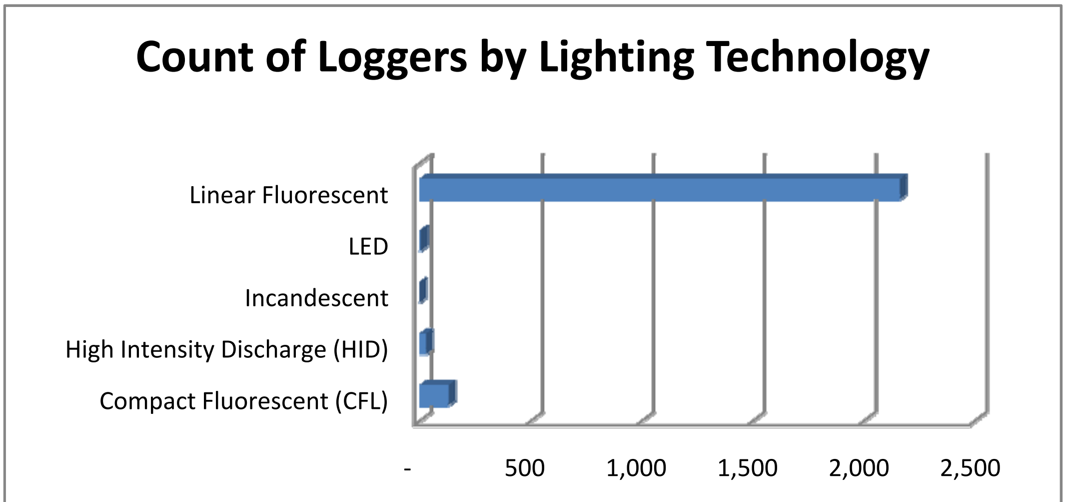
3.8 Distribution of Lighting Technologies

The dataset was analyzed to determine the number of loggers monitoring different lighting technology types. Five lighting technologies categories were used as follows;

- Compact Fluorescents (CFL)
- High Intensity Discharge (HID)
- Incandescent
- Light Emitting Diode (LED), and
- Linear Fluorescent

The lighting technology field was not fully populated and 1,449 loggers (38% of the total loggers) did not have a lighting technology identified. Figure 3-5 provides the number of the logger files for each of the lighting technology types. Linear fluorescent lighting is the dominant technology, which makes up 93% of the loggers with an identified lighting technology. Compact fluorescent lighting is the only other technology with significant representation in the dataset consisting of about 6% of the loggers.

Figure 3-5: Distribution of Loggers by Lighting Technology

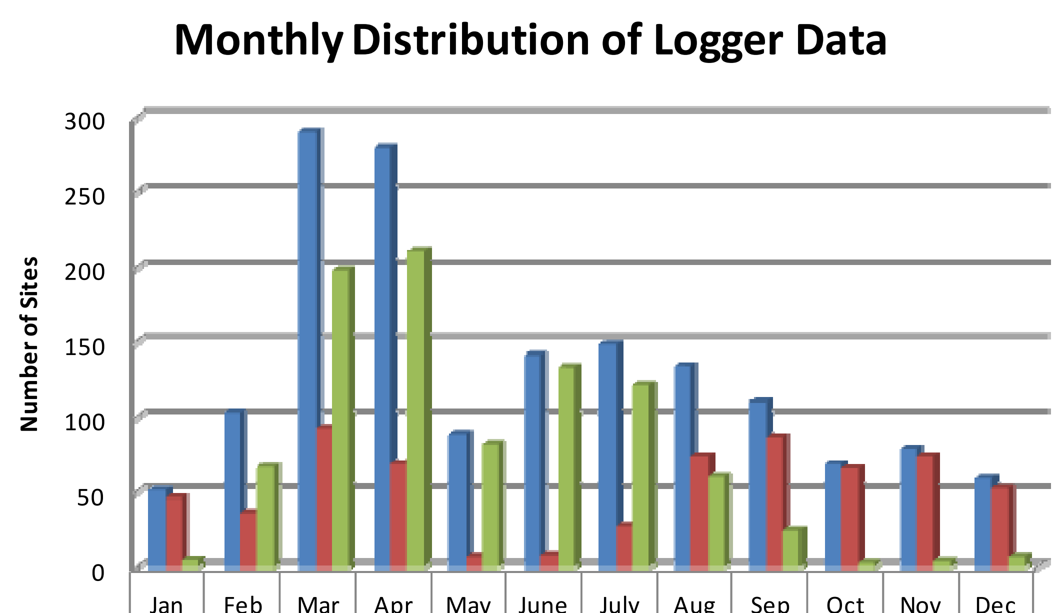


	Compact Fluorescent (CFL)	High Intensity Discharge (HID)	Incandescent	LED	Linear Fluorescent
Count Of Loggers	130	30	1	5	2,165

3.9 Seasonality of Logger Data

The underlying logger data used in the spreadsheet tool was collected during different months throughout the year. These short-term data (typically 3 to 4 weeks) were expanded to create the annual load profiles used in the spreadsheet tool using the data expansion methods described in section 3.3 Data Expansion. It is widely accepted that for most C&I buildings there is very little seasonal variation and short- term data can be utilized to create a relatively accurate annual operating profile. Notable exceptions are facilities that do exhibit a high degree of seasonality like education-schools and university-colleges and to a lesser extent lodging. This section of the report provides the site–level distribution of the logger data on a monthly basis.

Figure 3-6: Monthly Distribution of Site Level Logger Data



	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
All	51	103	290	279	88	141	148	134	110	69	78	59
Large	46	36	92	69	7	8	27	74	86	66	74	52
Small	5	67	198	210	81	133	121	60	24	3	4	7

These data are provided for illustrative purposes. In this study, no seasonal adjustment factors were applied to the data due to the lack of appropriate long term data. **Error! Reference source not found.** provides the monthly distribution of the site-level logger data for all sites, Large sites and Small sites. In order for a site to have data counted for a month there had to be at least seven days of data collected within the month. The graph clearly shows that the months of March and April contain the most number of total sites with 290 and 279 respectively. Note that the there are a large number of Small sites with June, July, and August data which is coincident with the PJM and ISO-NE peak months. The total number of sites is higher than the 775 sites reported previously because one site can have data for more than one month.

4. Presentation of Results

This section of the report will provide the results produced by the spreadsheet for energy savings, ISO-NE Summer and Winter On-peak periods, ISO-NE Summer and Winter Seasonal Peak periods and PJM Summer peak period.

Peak period definitions vary by ISO territory. Accordingly, the Load Shape Tool and this report include the three peak period definition options originally specified in the RFP.

- ISO-NE On-Peak Period: The ISO-NE summer "Demand Resource On-Peak Hours," are defined as 1 PM to 5 PM on non-holiday weekdays during June, July, and August. The ISO-NE Winter On-peak hours are 5 PM to 7 PM on non-holiday weekdays during January and December.
- PJM On-Peak Period: The PJM On-Peak Period is structurally identical to the first, except that it will encompass the hours from 2 PM to 6 PM instead of 1 PM to 5 PM.
- ISO-NE FCM Seasonal Peak: The FCM Summer Seasonal Peak includes all non-holiday weekday hours in June, July and August during which the ISO New England Real-Time System Hourly Load is greater than 90% of the most recent "50/50" System Peak Load Forecast for the summer season.

The Summer Seasonal Peak hours used in the C&I lighting tool are the same hours that were used in the NEEP C&I Unitary HVAC Load Shape tool. The Winter Seasonal Peak hours had to be developed specifically for the C&I Lighting Load Shape tool since they were not defined for the HVAC tool. Since C&I lighting usage patterns are dependent upon schedule factors like hour of day and not determined by hourly temperature, the primary focus for determining the winter Seasonal Performance hours was on getting the correct frequency distribution of the hours.

4.1 Annual Energy savings

Table 4-1 provides the annual energy savings per 100 kW of lighting load reduction by category without interactive effects. Each estimated factor is presented with the relative precision of each estimate at the 80% and 90% two-tail confidence intervals. As a reminder, relative precision at the 80% two-tail interval is equivalent to that of the 90% one-tail.

Table 4-1: Annual Savings by Category without Interactive Effects

Profile Type	Connected Reduction (kW)	Full Load Equivalent Hours (FLEH)	Annual Lighting Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	4,656	465,598	4.2%	5.4%
SMALL	100	3,335	333,527	3.4%	4.3%
EDUCATION	100	2,456	245,635	6.7%	8.5%
GROCERY	100	6,019	601,901	6.9%	8.9%
LODGING	100	4,808	480,826	23.4%	30.0%
MANUFACTURING	100	4,781	478,153	7.4%	9.5%
MEDICAL	100	4,007	400,695	14.4%	18.5%
MUNICIPAL	100	3,116	311,645	15.6%	20.0%
OFFICE	100	3,642	364,168	7.4%	9.5%
OTHER	100	4,268	426,813	15.1%	19.4%
PUBLIC ASSEMBLY	100	3,035	303,513	11.8%	15.1%
RELIGIOUS	100	2,648	264,797	25.1%	32.2%
RESTAURANT	100	4,089	408,865	13.2%	17.0%
RETAIL	100	4,103	410,336	5.2%	6.6%
SERVICE	100	3,521	352,129	10.5%	13.4%
UNIVERSITY/COLLEGE	100	3,416	341,557	14.9%	19.2%
WAREHOUSE	100	4,009	400,909	8.4%	10.8%

The C&I Lighting Load Shape tool also utilized the same six weather files as the NEEP C&I Unitary HVAC Load Shape tool and each file produced slightly different savings Total Annual Savings when Interactive Effects were included. Table 4-2 through Table 4-7, provide the Interactive Savings per 100 kW of Connected Reduction for the seventeen profiles using the six weather files.   Note that the Full Load Equivalent Hours (FLEH) of the lighting would remain unchanged along with Annual Lighting Savings (shown in the third column) which does not include Interactive Savings and is the same as the Annual Lighting Savings shown above in the fourth column of Table 4-1

Table 4-2: Annual Savings with Interactive Effects Mid-Atlantic Weather

Profile Type	Connected Reduction (kW)	Annual Lighting Savings (kWh)	Interactive Savings (kWh)	Total Annual Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	465,598	36,685	502,283	4.2%	5.4%
SMALL	100	333,527	18,889	352,416	3.4%	4.3%
EDUCATION	100	245,635	9,049	254,684	6.7%	8.5%
GROCERY	100	601,901	71,492	673,393	6.9%	8.9%
LODGING	100	480,826	18,795	499,621	23.4%	30.0%
MANUFACTURING	100	478,153	32,079	510,232	7.4%	9.5%
MEDICAL	100	400,695	34,995	435,690	14.4%	18.5%
MUNICIPAL	100	311,645	17,756	329,401	15.6%	20.0%
OFFICE	100	364,168	21,917	386,085	7.4%	9.5%
OTHER	100	426,813	9,157	435,970	15.1%	19.4%
PUBLIC ASSEMBLY	100	303,513	18,397	321,910	11.8%	15.1%
RELIGIOUS	100	264,797	28,506	293,303	25.1%	32.2%
RESTAURANT	100	408,865	43,398	452,263	13.2%	17.0%
RETAIL	100	410,336	31,768	442,104	5.2%	6.6%
SERVICE	100	352,129	27,607	379,736	10.5%	13.4%
UNIVERSITY/COLLEGE	100	341,557	22,194	363,751	14.9%	19.2%
WAREHOUSE	100	400,909	14,882	415,791	8.4%	10.8%

Table 4-3: Annual Savings with Interactive Effects NE-Mass Weather

Profile Type	Connected Reduction (kW)	Annual Lighting Savings (kWh)	Interactive Savings (kWh)	Total Annual Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	465,598	28,132	493,730	4.2%	5.4%
SMALL	100	333,527	13,491	347,018	3.4%	4.3%
EDUCATION	100	245,635	6,810	252,445	6.7%	8.5%
GROCERY	100	601,901	56,198	658,099	6.9%	8.9%
LODGING	100	480,826	10,827	491,653	23.4%	30.0%
MANUFACTURING	100	478,153	25,448	503,601	7.4%	9.5%
MEDICAL	100	400,695	27,677	428,372	14.4%	18.5%
MUNICIPAL	100	311,645	12,603	324,248	15.6%	20.0%
OFFICE	100	364,168	13,819	377,987	7.4%	9.5%
OTHER	100	426,813	4,541	431,354	15.1%	19.4%
PUBLIC ASSEMBLY	100	303,513	13,641	317,154	11.8%	15.1%
RELIGIOUS	100	264,797	20,964	285,761	25.1%	32.2%
RESTAURANT	100	408,865	32,032	440,897	13.2%	17.0%
RETAIL	100	410,336	23,505	433,841	5.2%	6.6%
SERVICE	100	352,129	20,706	372,835	10.5%	13.4%
UNIVERSITY/COLLEGE	100	341,557	14,228	355,785	14.9%	19.2%
WAREHOUSE	100	400,909	9,128	410,037	8.4%	10.8%

Table 4-4: Annual Savings with Interactive Effects NE-North Weather

Profile Type	Connected Reduction (kW)	Annual Lighting Savings (kWh)	Interactive Savings (kWh)	Total Annual Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	465,598	25,317	490,915	4.2%	5.4%
SMALL	100	333,527	12,179	345,706	3.4%	4.3%
EDUCATION	100	245,635	6,310	251,945	6.7%	8.5%
GROCERY	100	601,901	52,118	654,019	6.9%	8.9%
LODGING	100	480,826	7,067	487,893	23.4%	30.0%
MANUFACTURING	100	478,153	23,222	501,375	7.4%	9.5%
MEDICAL	100	400,695	25,908	426,603	14.4%	18.5%
MUNICIPAL	100	311,645	10,899	322,544	15.6%	20.0%
OFFICE	100	364,168	11,420	375,588	7.4%	9.5%
OTHER	100	426,813	2,885	429,698	15.1%	19.4%
PUBLIC ASSEMBLY	100	303,513	12,487	316,000	11.8%	15.1%
RELIGIOUS	100	264,797	19,343	284,140	25.1%	32.2%
RESTAURANT	100	408,865	29,547	438,412	13.2%	17.0%
RETAIL	100	410,336	21,561	431,897	5.2%	6.6%
SERVICE	100	352,129	19,432	371,561	10.5%	13.4%
UNIVERSITY/COLLEGE	100	341,557	11,852	353,409	14.9%	19.2%
WAREHOUSE	100	400,909	6,968	407,877	8.4%	10.8%

Table 4-5: Annual Savings with Interactive Effects NE-South Coastal Weather

Profile Type	Connected Reduction (kW)	Annual Lighting Savings (kWh)	Interactive Savings (kWh)	Total Annual Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	465,598	29,091	494,689	4.2%	5.4%
SMALL	100	333,527	14,325	347,852	3.4%	4.3%
EDUCATION	100	245,635	7,199	252,834	6.7%	8.5%
GROCERY	100	601,901	58,133	660,034	6.9%	8.9%
LODGING	100	480,826	11,410	492,236	23.4%	30.0%
MANUFACTURING	100	478,153	26,302	504,455	7.4%	9.5%
MEDICAL	100	400,695	28,742	429,437	14.4%	18.5%
MUNICIPAL	100	311,645	13,295	324,940	15.6%	20.0%
OFFICE	100	364,168	14,873	379,041	7.4%	9.5%
OTHER	100	426,813	5,023	431,836	15.1%	19.4%
PUBLIC ASSEMBLY	100	303,513	14,343	317,856	11.8%	15.1%
RELIGIOUS	100	264,797	21,962	286,759	25.1%	32.2%
RESTAURANT	100	408,865	33,681	442,546	13.2%	17.0%
RETAIL	100	410,336	24,790	435,126	5.2%	6.6%
SERVICE	100	352,129	21,938	374,067	10.5%	13.4%
UNIVERSITY/COLLEGE	100	341,557	15,233	356,790	14.9%	19.2%
WAREHOUSE	100	400,909	9,779	410,688	8.4%	10.8%

Table 4-6: Annual Savings with Interactive Effects NY-Inland Weather

Profile Type	Connected Reduction (kW)	Annual Lighting Savings (kWh)	Interactive Savings (kWh)	Total Annual Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	465,598	28,706	494,304	4.2%	5.4%
SMALL	100	333,527	14,331	347,858	3.4%	4.3%
EDUCATION	100	245,635	7,235	252,870	6.7%	8.5%
GROCERY	100	601,901	57,778	659,679	6.9%	8.9%
LODGING	100	480,826	11,027	491,853	23.4%	30.0%
MANUFACTURING	100	478,153	25,999	504,152	7.4%	9.5%
MEDICAL	100	400,695	28,528	429,223	14.4%	18.5%
MUNICIPAL	100	311,645	13,183	324,828	15.6%	20.0%
OFFICE	100	364,168	14,758	378,926	7.4%	9.5%
OTHER	100	426,813	4,882	431,695	15.1%	19.4%
PUBLIC ASSEMBLY	100	303,513	14,480	317,993	11.8%	15.1%
RELIGIOUS	100	264,797	22,655	287,452	25.1%	32.2%
RESTAURANT	100	408,865	34,033	442,898	13.2%	17.0%
RETAIL	100	410,336	24,875	435,211	5.2%	6.6%
SERVICE	100	352,129	21,977	374,106	10.5%	13.4%
UNIVERSITY/COLLEGE	100	341,557	15,187	356,744	14.9%	19.2%
WAREHOUSE	100	400,909	9,565	410,474	8.4%	10.8%

Table 4-7: Annual Savings with Interactive Effects NY-Urban Weather

Profile Type	Connected Reduction (kW)	Annual Lighting Savings (kWh)	Interactive Savings (kWh)	Total Annual Savings (kWh)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	465,598	35,995	501,593	4.2%	5.4%
SMALL	100	333,527	18,571	352,098	3.4%	4.3%
EDUCATION	100	245,635	8,889	254,524	6.7%	8.5%
GROCERY	100	601,901	69,801	671,702	6.9%	8.9%
LODGING	100	480,826	19,344	500,170	23.4%	30.0%
MANUFACTURING	100	478,153	31,580	509,733	7.4%	9.5%
MEDICAL	100	400,695	34,098	434,793	14.4%	18.5%
MUNICIPAL	100	311,645	17,682	329,327	15.6%	20.0%
OFFICE	100	364,168	21,674	385,842	7.4%	9.5%
OTHER	100	426,813	9,145	435,958	15.1%	19.4%
PUBLIC ASSEMBLY	100	303,513	18,192	321,705	11.8%	15.1%
RELIGIOUS	100	264,797	27,861	292,658	25.1%	32.2%
RESTAURANT	100	408,865	42,851	451,716	13.2%	17.0%
RETAIL	100	410,336	31,339	441,675	5.2%	6.6%
SERVICE	100	352,129	26,965	379,094	10.5%	13.4%
UNIVERSITY/COLLEGE	100	341,557	21,902	363,459	14.9%	19.2%
WAREHOUSE	100	400,909	14,932	415,841	8.4%	10.8%

4.2 ISO-NE On-peak Performance Hours

The following tables (Table 4-8 and Table 4-9) provides the coincident demand impacts per 100 kW of Connected Reduction by category during the ISO-NE On-peak Winter Performance hours with and without interactive effects. Although there are three New England weather files the results were identical when the NE-North and NE-South Coastal weather files were used so they are shown in Table 4-9. Each estimated factor is presented with the relative precision of each estimate at the 80% and 90% two-tail confidence intervals. As a reminder, relative precision at the 80% two-tail interval (ISO-NE M&V requirement) is equivalent to that of the 90% one-tail (PJM M&V requirement).

Table 4-8: ISO-NE Winter On-peak Demand Reduction using NE Mass Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	59.3	-0.6	58.7	4.6%	5.9%
SMALL	100	37.2	-0.3	36.9	5.7%	7.4%
EDUCATION	100	28.7	0.0	28.7	11.6%	14.9%
GROCERY	100	84.7	0.0	84.7	6.6%	8.5%
LODGING	100	54.6	-1.4	53.2	21.6%	27.7%
MANUFACTURING	100	49.7	0.0	49.7	11.1%	14.2%
MEDICAL	100	50.5	0.0	50.5	16.0%	20.5%
MUNICIPAL	100	35.5	-0.3	35.2	23.6%	30.2%
OFFICE	100	42.7	-1.4	41.3	9.4%	12.0%
OTHER	100	49.2	-1.1	48.1	18.9%	24.3%
PUBLIC ASSEMBLY	100	46.0	0.0	46.0	13.1%	16.8%
RELIGIOUS	100	51.4	0.0	51.4	26.4%	33.9%
RESTAURANT	100	63.0	0.0	63.0	17.7%	22.8%
RETAIL	100	51.7	0.0	51.7	8.9%	11.4%
SERVICE	100	32.1	0.0	32.1	25.6%	32.8%
UNIVERSITY/COLLEGE	100	41.1	-1.2	39.9	19.8%	25.4%
WAREHOUSE	100	44.9	-1.0	43.9	12.5%	16.0%

Table 4-9: ISO-NE Winter On-Peak Demand Reduction using NE-North Weather and NE-South Coastal Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	59.3	-0.7	58.6	4.6%	5.9%
SMALL	100	37.2	-0.3	36.9	5.7%	7.4%
EDUCATION	100	28.7	0.0	28.7	11.6%	14.9%
GROCERY	100	84.7	0.0	84.7	6.6%	8.5%
LODGING	100	54.6	-1.4	53.2	21.6%	27.7%
MANUFACTURING	100	49.7	0.0	49.7	11.1%	14.2%
MEDICAL	100	50.5	0.0	50.5	16.0%	20.5%
MUNICIPAL	100	35.5	-0.3	35.2	23.6%	30.2%
OFFICE	100	42.7	-1.4	41.3	9.4%	12.0%
OTHER	100	49.2	-1.1	48.1	18.9%	24.3%
PUBLIC ASSEMBLY	100	46.0	0.0	46.0	13.1%	16.8%
RELIGIOUS	100	51.4	0.0	51.4	26.4%	33.9%
RESTAURANT	100	63.0	0.0	63.0	17.7%	22.8%
RETAIL	100	51.7	0.0	51.7	8.9%	11.4%
SERVICE	100	32.1	0.0	32.1	25.6%	32.8%
UNIVERSITY/COLLEGE	100	41.1	-1.2	39.9	19.8%	25.4%
WAREHOUSE	100	44.9	-1.0	43.9	12.5%	16.0%

Table 4-10 provides the ISO-NE Winter On-Peak demand reduction values for the Large and Small business types excluding sites with lighting controls and the three New England weather files. The results were using each of the New England weather files so only one table is shown.

Table 4-10: ISO-NE Winter On-peak with no Controls using all three NE Weather Files

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	63.3	-0.7	62.6	4.5%	5.8%
SMALL	100	38.5	-0.3	38.2	5.7%	7.4%

The following tables (Table 4-11 through Table 4-13) provides the coincident demand impacts per 100 kW of Connected Reduction by category during the ISO-NE On-peak Summer Performance hours with and without interactive effects. In this case, the three New England weather files each resulted in different Total Coincident Reduction values due to differences in the Coincident Interactive Reductions. Each estimated factor is presented with the relative precision of each estimate at the 80% and 90% two-tail confidence intervals. As a reminder, relative precision at the 80% two-tail interval (ISO-NE M&V requirement) is equivalent to that of the 90% one-tail (PJM M&V requirement).

Table 4-11: ISO-NE Summer On-peak Demand Reduction using NE Mass Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	72.6	12.1	84.7	2.7%	3.4%
SMALL	100	68.1	9.2	77.4	2.2%	2.9%
EDUCATION	100	50.9	4.2	55.2	5.9%	7.5%
GROCERY	100	90.8	21.4	112.2	3.6%	4.6%
LODGING	100	56.0	7.0	63.0	23.5%	30.2%
MANUFACTURING	100	75.9	10.4	86.2	4.2%	5.4%
MEDICAL	100	70.1	12.1	82.3	8.7%	11.2%
MUNICIPAL	100	50.4	7.1	57.5	11.9%	15.2%
OFFICE	100	71.2	12.1	83.3	3.7%	4.7%
OTHER	100	67.3	5.0	72.3	10.1%	13.0%
PUBLIC ASSEMBLY	100	60.3	8.2	68.6	9.1%	11.7%
RELIGIOUS	100	34.6	8.2	42.8	42.4%	54.4%
RESTAURANT	100	77.0	18.2	95.2	10.6%	13.6%
RETAIL	100	79.9	13.8	93.7	2.7%	3.4%
SERVICE	100	79.2	13.6	92.8	5.1%	6.5%
UNIVERSITY/COLLEGE	100	61.7	11.0	72.7	9.3%	12.0%
WAREHOUSE	100	70.1	7.8	77.9	4.6%	5.9%

Table 4-12: ISO-NE Summer On-peak Demand Reduction using NE North Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	72.6	12.2	84.9	2.7%	3.4%
SMALL	100	68.1	9.2	77.3	2.2%	2.9%
EDUCATION	100	50.9	4.2	55.1	5.9%	7.5%
GROCERY	100	90.8	21.5	112.3	3.6%	4.6%
LODGING	100	56.0	7.0	62.9	23.5%	30.2%
MANUFACTURING	100	75.9	10.5	86.3	4.2%	5.4%
MEDICAL	100	70.1	12.3	82.4	8.7%	11.2%
MUNICIPAL	100	50.4	7.1	57.4	11.9%	15.2%
OFFICE	100	71.2	12.1	83.3	3.7%	4.7%
OTHER	100	67.3	5.0	72.3	10.1%	13.0%
PUBLIC ASSEMBLY	100	60.3	8.2	68.5	9.1%	11.7%
RELIGIOUS	100	34.6	8.1	42.7	42.4%	54.4%
RESTAURANT	100	77.0	18.0	95.0	10.6%	13.6%
RETAIL	100	79.9	13.7	93.6	2.7%	3.4%
SERVICE	100	79.2	13.5	92.7	5.1%	6.5%
UNIVERSITY/COLLEGE	100	61.7	10.9	72.6	9.3%	12.0%
WAREHOUSE	100	70.1	7.8	77.9	4.6%	5.9%

Table 4-13: ISO-NE Summer On-peak Demand Reduction using NE South Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	72.6	12.5	85.1	2.7%	3.4%
SMALL	100	68.1	10.0	78.1	2.2%	2.9%
EDUCATION	100	50.9	4.6	55.5	5.9%	7.5%
GROCERY	100	90.8	22.0	112.8	3.6%	4.6%
LODGING	100	56.0	7.6	63.6	23.5%	30.2%
MANUFACTURING	100	75.9	10.7	86.5	4.2%	5.4%
MEDICAL	100	70.1	12.5	82.6	8.7%	11.2%
MUNICIPAL	100	50.4	7.7	58.1	11.9%	15.2%
OFFICE	100	71.2	13.1	84.3	3.7%	4.7%
OTHER	100	67.3	5.5	72.7	10.1%	13.0%
PUBLIC ASSEMBLY	100	60.3	8.9	69.2	9.1%	11.7%
RELIGIOUS	100	34.6	8.9	43.5	42.4%	54.4%
RESTAURANT	100	77.0	19.6	96.7	10.6%	13.6%
RETAIL	100	79.9	15.0	94.9	2.7%	3.4%
SERVICE	100	79.2	14.7	93.9	5.1%	6.5%
UNIVERSITY/COLLEGE	100	61.7	11.9	73.6	9.3%	12.0%
WAREHOUSE	100	70.1	8.5	78.6	4.6%	5.9%

Table 4-14 through Table 4-16 provide the ISO-NE Summer On-Peak demand reduction values for the Large and Small business types excluding sites with lighting controls using the three New England weather files.

Table 4-14: ISO-NE Summer On-Peak with No Controls using NE-Mass Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	76.0	12.7	88.7	2.6%	3.3%
SMALL	100	69.2	9.4	78.5	2.2%	2.8%

Table 4-15: ISO-NE Summer On-Peak with No Controls using NE-North Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	76.0	12.8	88.8	2.6%	3.3%
SMALL	100	69.2	9.3	78.5	2.2%	2.8%

Table 4-16: ISO-NE Summer On-Peak with No Controls using NE-South Coastal Weather

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	76.0	13.0	89.0	2.6%	3.3%
SMALL	100	69.2	10.1	79.3	2.2%	2.8%

4.3 ISO-NE Seasonal Peak Period

The ISO-NE Winter Seasonal Peak coincident demand reductions were calculated for each of the seventeen profile types using the three New England weather files and in this case, the results were the same for all three weather files. Table 4-17 provides the coincident demand impacts per 100 kW of Connected Reduction by profile type during the ISO-NE Winter Seasonal Peak performance hours with and without interactive effects. Each estimated factor is presented with the relative precision of each estimate at the 80% and 90% two-tail confidence intervals. As a reminder, relative precision at the 80% two-tail interval (ISO-NE M&V requirement) is equivalent to that of the 90% one-tail (PJM M&V requirement).

Table 4-17: ISO-NE Winter Seasonal Peak Demand Reduction using All Three New England Weather Files

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	59.0	-0.6	58.4	5.1%	6.5%
SMALL	100	35.3	-0.3	35.0	6.5%	8.4%
EDUCATION	100	27.8	0.0	27.8	11.6%	14.9%
GROCERY	100	82.2	0.0	82.2	6.6%	8.5%
LODGING	100	54.4	-1.4	53.0	21.6%	27.7%
MANUFACTURING	100	50.0	0.0	50.0	11.1%	14.2%
MEDICAL	100	48.9	0.0	48.9	16.0%	20.5%
MUNICIPAL	100	35.4	-0.3	35.1	23.6%	30.2%
OFFICE	100	41.2	-1.3	39.9	9.4%	12.0%
OTHER	100	48.3	-1.2	47.1	18.9%	24.3%
PUBLIC ASSEMBLY	100	43.4	0.0	43.4	13.1%	16.8%
RELIGIOUS	100	52.0	0.0	52.0	26.4%	33.9%
RESTAURANT	100	59.6	0.0	59.6	17.7%	22.8%
RETAIL	100	49.6	0.0	49.6	8.9%	11.4%
SERVICE	100	29.3	0.0	29.3	25.6%	32.8%
UNIVERSITY/COLLEGE	100	39.8	-1.2	38.6	19.8%	25.4%
WAREHOUSE	100	44.7	-1.0	43.7	12.5%	16.0%

Table 4-18 provides the ISO-NE Winter Seasonal Peak demand reduction values for the Large and Small business types excluding lighting controls and using the three New England weather files.

Table 4-18: ISO-NE Winter Seasonal with no Controls using all three NE Weather Files

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	63.1	-0.7	62.4	4.9%	6.3%
SMALL	100	36.6	-0.3	36.3	6.5%	8.4%

The ISO-NE Summer Seasonal Peak coincident demand reductions were calculated for each of the seventeen profile types using the three New England weather files and in this case, the results were the same for all three weather files. Table 4-19 provides the coincident demand impacts per 100 kW of Connected Reduction by profile type during the ISO-NE Winter Seasonal Peak Performance hours with and without interactive effects.

Table 4-19: ISO-NE Summer Seasonal Peak Demand Reduction using All Three New England Weather Files

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	75.5	13.4	89.0	2.8%	3.6%
SMALL	100	72.4	11.3	83.8	2.1%	2.7%
EDUCATION	100	58.4	5.6	63.9	5.9%	7.5%
GROCERY	100	91.3	22.9	114.2	3.6%	4.6%
LODGING	100	57.4	8.3	65.7	23.5%	30.2%
MANUFACTURING	100	81.0	11.8	92.7	4.2%	5.4%
MEDICAL	100	74.4	13.7	88.1	8.7%	11.2%
MUNICIPAL	100	56.1	9.1	65.2	11.9%	15.2%
OFFICE	100	75.2	14.8	90.0	3.7%	4.7%
OTHER	100	69.3	6.0	75.4	10.1%	13.0%
PUBLIC ASSEMBLY	100	61.4	9.7	71.0	9.1%	11.7%
RELIGIOUS	100	39.3	10.7	50.0	42.4%	54.4%
RESTAURANT	100	75.8	20.7	96.5	10.6%	13.6%
RETAIL	100	82.5	16.5	99.1	2.7%	3.4%
SERVICE	100	80.4	16.0	96.4	5.1%	6.5%
UNIVERSITY/COLLEGE	100	66.5	13.7	80.2	9.3%	12.0%
WAREHOUSE	100	74.1	9.6	83.6	4.6%	5.9%

Table 4-20 provides the ISO-NE Summer Seasonal Peak demand reduction values for the Large and Small business types without lighting controls. Only one table of results is shown, because the Summer Seasonal Peak results are the same using any of the three New England weather files.

Table 4-20: ISO-NE Summer Seasonal with No Controls using all NE Weather Files

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	78.7	13.4	92.7	2.2%	2.9%
SMALL	100	73.3	11.3	84.8	2.0%	2.5%

4.4 PJM Performance Hours

Table 4-21 provides the coincident demand reductions by profile type during the PJM Summer performance hours both with and without interactive effects. There was only one weather file (Mid-Atlantic) in the tool from the PJM region used to calculate the Total Coincident Reduction per 100 kW of Connected Reduction. Each estimated factor is presented with the relative precision of each estimate at the 80% and 90% two-tail confidence intervals. As a reminder, relative precision at the 80% two-tail interval (ISO-NE M&V requirement) is equivalent to that of the 90% one-tail (PJM M&V requirement).

Table 4-21: PJM Summer Coincident Demand Reduction with Interactive Effects

Profile Type	Connected Reduction (kW)	Coincident Lighting Reduction (kW)	Coincident Interactive Reduction (kW)	Total Coincident Reduction (kW)	RP@ 80% CI two-tail	RP @ 90% CI two-tail
LARGE	100	68.1	12.1	80.2	3.3%	4.2%
SMALL	100	58.7	9.1	67.9	2.9%	3.7%
EDUCATION	100	42.4	4.0	46.4	7.5%	9.7%
GROCERY	100	89.9	22.5	112.4	4.0%	5.1%
LODGING	100	55.4	8.0	63.4	22.7%	29.1%
MANUFACTURING	100	66.7	9.7	76.5	6.1%	7.9%
MEDICAL	100	64.7	11.9	76.6	10.7%	13.7%
MUNICIPAL	100	43.0	7.0	50.0	17.1%	22.0%
OFFICE	100	63.1	12.4	75.5	4.7%	6.1%
OTHER	100	62.0	5.4	67.4	12.0%	15.4%
PUBLIC ASSEMBLY	100	56.6	8.9	65.5	9.8%	12.6%
RELIGIOUS	100	36.1	9.8	46.0	34.6%	44.4%
RESTAURANT	100	73.1	19.8	92.9	12.5%	16.1%
RETAIL	100	71.9	14.3	86.2	3.9%	5.0%
SERVICE	100	66.7	13.2	79.9	8.0%	10.3%
UNIVERSITY/COLLEGE	100	55.8	11.4	67.2	12.5%	16.0%
WAREHOUSE	100	61.6	7.9	69.5	6.4%	8.3%

5. Description of Spreadsheet Tool

This section of the report will briefly describe how to use the spreadsheet tool and the results produced from the spreadsheet tool.

5.1 User Input Panel

There five basic inputs that the user must select at a minimum to operate the tool and depending on those there may be four additional inputs that need to be defined by the user. The user Inputs are selected on the "Panel" worksheet tab and the main five are the following;

- Step 1 Select Model Type - options are
  - Large
  - Small
  - Building Type - if selected user must allocate % for the 15 categories that totals to 1.0 the options are
    - Education
    - Grocery
    - Lodging
    - Manufacturing
    - Medical
    - Municipal
    - Office
    - Public Assembly
    - Religious
    - Restaurant
    - Retail
    - Service
    - University / College
    - Warehouse

- Step 2 Provide Total kW Reduction – accepts numerical value greater than zero

- Step 3 Select Peak Definition – options are
  - PJM Summer
  - ISO-NE Summer
  - ISO-NE Winter
  - User Defined – if selected then need to select
    - Month/s
    - Day Type/s (seven days of the week plus holidays)
    - Hour/s

- Step 4 Select Weather Region – used only for calculation of Interactive Effects

- Mid Atlantic
- NE-Mass
- NE-North
- NE-South Coastal
- NY-Inland
- NY-Urban Coastal

- Step 5 Select Relative Precision
  - 90% Energy Savings (90% Confidence two tail z-value=1.645)
  - PJM ISO-NE Demand Confidence Interval (z –value 1.282)

5.2 Model Outputs

Once the user has defined the desired inputs and clicked the generate button, the following outputs will be provided:

- Output Annual kWh savings (sum over 8,760 hours)
- Output Period kWh savings (sum over specified hours)
- Output Period kW reduction (average over specified hours)
- Output Period kWh savings as per cent of Annual kWh savings
- Output number of Period hours
- Output estimated precision of aggregated load shape (LS) Parameter estimate

(Note: Load Shape (LS) Parameters will be calculated for the Aggregated LS and each Disaggregated LS.)

1. Aggregated Load Shape in modified EEI format (based on user-specified weights)

6. Recommendations

The new C&I lighting spreadsheet tool utilizes a robust dataset to provide estimates of energy savings and demand impacts for fifteen different business types and large and small commercial and industrial facilities. The tool leverages existing interval metered lighting datasets that have been collected to evaluate C&I lighting programs in the Northeast over recent years. Although the dataset is robust in terms of number loggers and the number of sites included, the relatively short duration of the metering periods make it difficult to assess the seasonality. The primary recommendation is for the collection of more long term monitoring data so that the effects of using short term (3-4 weeks typically) data to extrapolate annual operating hours could be examined. KEMA was involved in a C&I lighting baseline study for the state of Maryland that installed loggers for a period of about nine months. These data were not available in time to be included in this study or load shape tool, However, they and any other viable data sources could be utilized to inform the issue of seasonal usage patterns for C&I lighting, or in an update. This type of effort would be particularly useful for business types that are known to have a seasonal operating difference like Education or University/College.

Some of the sponsors have expressed some concern about the potential for different operating schedules for different lighting technology types, particularly compact fluorescents versus linear fluorescent lighting. The implication being that compact fluorescent lighting would have lower operating hours than linear fluorescent when installed at the same type of facility. The existing dataset does not contain a large percentage of compact fluorescent lighting so it would not be meaningful to use the small number of observation to draw conclusions about differences in operating schedules. It would be useful to collect additional metering data on compact fluorescent lighting so a rigorous analysis of operating differences by lighting technology could be conducted.

Additionally there is the potential to further segment the existing data set, particularly the business types with robust sample sizes, like Offices and Retail, into large and small categories. This would result in a Large Office and Small Office Business type options or a Large Retail and Small Retail. The Manufacturing sector also had a robust sample and it could be further segmented based the number of shifts i.e. one-shift, two-shifts and three-shifts. KEMA would be available to explore these recommendations and any others that the sponsors might request under a new scope of work.

7. Appendix – A ISO-NE Seasonal Hours

7.1 ISO-NE Summer Seasonal Hours

A detailed discussion of the process for developing the ISO-NE Seasonal Peak hours is provided in the "C&I Unitary HVAC Load Shape Project Final Report" prepared for the Regional Evaluation, Measurement and Verification Forum by KEMA, June 2011. Table 7-1 provides a list of the final set of hours that were used.

Table 7-1: Final Set of FCM Season Peak Hours

				EastMass			NE-North			NE-South		
Month/ Day	Hour Ending	8760 hour	2010 Daytype	Temp. (°F)	THI (°F)	ISO-NE S_Load (MW)	Temp. (°F)	THI (°F)	ISO-NE S_Load (MW)	Temp. (°F)	THI (°F)	ISO-NE S_Load (MW)
7/19	13	4789	Tuesday	78.08	73.52	25,008	87.98	77.88	25,117	89.06	82.04	26,002
7/19	14	4790	Tuesday	75.02	72.32	24,898	91.04	78.54	25,066	93.02	83.10	25,848
7/19	15	4791	Tuesday	75.02	71.99	24,805	89.96	77.68	24,894	93.02	83.10	25,848
7/19	16	4792	Tuesday	75.02	71.99	24,805	89.06	77.55	24,930	91.04	82.70	25,956
7/19	17	4793	Tuesday	73.94	71.18	24,656	87.98	77.01	24,856	87.98	80.90	25,846
7/20	13	4813	Wednesday	75.92	74.55	25,469	91.04	80.33	25,604	89.06	77.82	25,014
7/20	14	4814	Wednesday	75.02	74.10	25,409	89.96	79.46	25,432	91.04	77.90	24,830
7/20	15	4815	Wednesday	75.02	73.23	25,161	89.96	79.19	25,351	89.96	77.68	24,889
7/22	13	4861	Friday	75.92	72.44	24,865	84.02	76.82	25,123	91.94	78.99	24,996
7/22	14	4862	Friday	73.94	70.86	24,562	84.92	76.94	25,086	91.94	80.18	25,274
7/22	15	4863	Friday	75.92	72.17	24,787	84.02	76.82	25,123	89.96	79.79	25,383
7/22	16	4864	Friday	75.02	71.72	24,727	82.94	76.55	25,130	89.06	79.93	25,508
7/22	17	4865	Friday	73.04	70.41	24,503	78.98	73.97	24,679	89.06	79.34	25,369
7/26	13	4957	Tuesday	78.98	72.78	24,727	86	77.21	25,079	95	79.28	24,752
7/26	14	4958	Tuesday	82.04	73.40	24,667	84.92	76.67	25,005	95	80.52	25,043
7/26	15	4959	Tuesday	82.94	73.85	24,727	84.02	75.90	24,845	95	79.88	24,891
7/26	16	4960	Tuesday	80.06	73.65	24,892	82.04	75.83	24,987	93.92	79.34	24,875
7/27	13	4981	Wednesday	84.92	74.24	24,688	86	77.21	25,079	93.92	83.87	25,938
7/27	14	4982	Wednesday	84.02	73.52	24,551	84.92	76.67	25,005	93.02	83.10	25,848
8/15	13	5437	Monday	80.06	76.35	25,667	91.04	80.92	25,784	91.94	83.15	25,970
8/15	14	5438	Monday	82.04	77.34	25,799	91.94	81.37	25,845	91.94	82.88	25,907
8/15	15	5439	Monday	78.98	75.81	25,595	91.94	81.96	26,025	91.04	82.70	25,956
8/15	16	5440	Monday	75.92	74.55	25,469	91.94	81.69	25,943	89.96	82.49	26,015
8/15	17	5441	Monday	75.92	74.28	25,392	91.04	81.51	25,963	87.08	81.05	25,971
8/15	18	5442	Monday	77	75.09	25,541	87.98	80.31	25,851	84.02	79.19	25,847

7.2 ISO-NE Winter Seasonal Peak Hours

The ISO-NE Winter Seasonal Peak hours were selected using a similar process that looked at the frequency of Seasonal Peak hours from the past periods. The Winter Seasonal Peak hours for ISO-NE were analyzed over the last five winter seasons to determine the hours where the real-time system load exceeded 90% of the most recent CELT 50/50 forecasted Winter peak. Table 7-2 summarizes the distribution of winter Seasonal Peak hours as well as the distribution of the hours used in the tool and Table 7-3 shows the actual hours.

Table 7-2: Distribution of Winter Seasonal Peak Hours

	Frequency of Hour Ending				Total
Winter Season	**18**	**19**	**20**	**21**	**Hours**
2005/2006	13	13	7	2	35
2006/2007	4	6	2		12
2007/2008	3	3	1		7
2009/2010	7	6	2	1	16
2010/2011	8	8	3		19
Totals	35	36	15	3	89
Average	7	7.2	3	1.5	
In Tool	10	10	5		25

Table 7-3: Winter Seasonal Peak Hours Used in Lighting Tool

				Dry Bulb Temperature		
Date	**Month**	**Hour**	**Day Type**	**NE-Mass**	**NE-North**	**NE-South Coastal**
1/4/2010	1	18	2	28.04	26.06	30.92
1/4/2010	1	19	2	26.06	26.06	28.94
1/4/2010	1	20	2	24.98	24.08	30.02
1/5/2010	1	18	3	19.04	30.92	32
1/5/2010	1	19	3	17.96	30.92	28.04
1/5/2010	1	20	3	17.06	32	28.94
1/8/2010	1	18	6	26.96	12.02	30.02
1/8/2010	1	19	6	24.08	10.94	28.94
1/8/2010	1	20	6	23	8.96	28.04
1/19/2010	1	18	3	21.92	28.94	28.94
1/19/2010	1	19	3	21.92	28.04	30.92
1/25/2010	1	18	2	30.02	10.04	23
1/25/2010	1	19	2	30.02	6.08	19.04
2/8/2010	2	18	2	30.92	24.98	8.06
2/8/2010	2	19	2	30.02	24.08	8.06
2/16/2010	2	18	3	26.06	26.06	30.02
2/16/2010	2	19	3	24.98	21.02	28.04
12/3/2010	12	18	6	26.96	23	26.96
12/3/2010	12	19	6	26.06	21.92	26.06
12/7/2010	12	19	3	26.96	28.04	30.92
12/7/2010	12	20	3	26.96	21.92	28.04
12/14/2010	12	18	3	32	19.94	26.96
12/15/2010	12	18	4	30.92	24.08	26.96
12/15/2010	12	19	4	30.92	24.08	26.96
12/15/2010	12	20	4	30.02	23	26.06

8. Appendix – B Addressing Statistical Sampling Bias and Measurement Error

The following sections refer to on-site data collection procedures utilized by KEMA (formerly RLW Analytics) to mitigate sampling bias and measurement error for lighting logger studies. The dataset used for this study consisted of 604 sites of the total 775 sites (78%) that utilized the KEMA methods. The authors have no first-hand knowledge of the data collection procedures utilized for the remaining 171 sites, but have no reason to doubt the accuracy of the data.

Section 7.1 of the ISO-NE M&V Manual of Demand Reduction Value from Demand Resources provides a list of different biases 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 several specific potential causes for bias that need to be addressed. These include:

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

8.1 Accuracy and Calibration of Measurement Tools

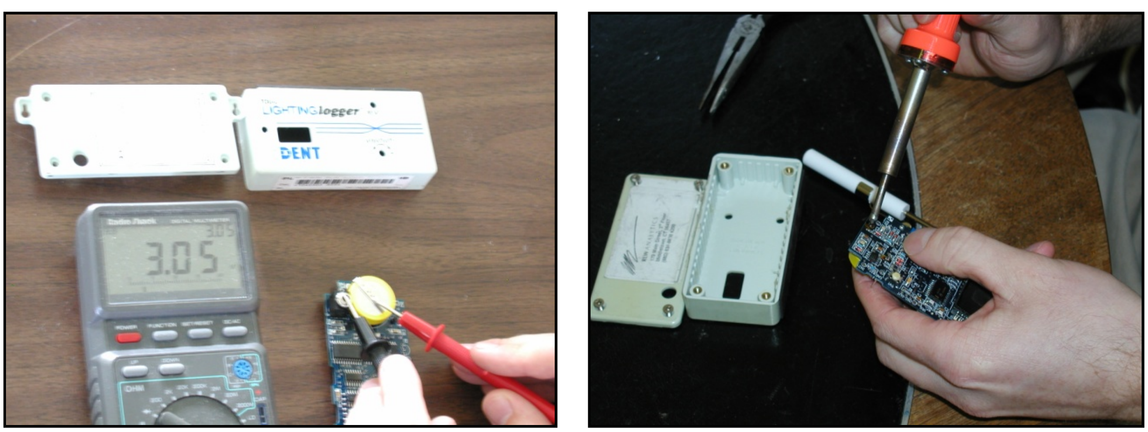
Most of the data used in the development of the C&I Lighting CF came from Dent Instruments Time Of Use (TOU) Lighting Loggers. These loggers use a photocell and an internal time lock to measure when the lights go on and off. The logger software exports interval data in a text format that provides the 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. No power measurement data were used in the calculation of the CFs and therefore the only 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 (Section 12.1 of the PJM M&V Manual) specifies that measurement tools must be synchronized in time within an accuracy of ±2 minutes per month with the National Institute of Standards and Technology ("NIST") clock. The Dent TOU Lighting

Logger contains a solid state circuit that exceeds the ±2 minutes per month standard for time drift. The Onset lighting loggers that were used to collect some of the data also contains a solid state circuit that exceeds the ±2 minutes per month standard for time drift. KEMA (formerly 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. There are some issues that occur in the spring and fall when clocks are adjusted to and from daylight savings time. All of the files that spanned the time changes were adjusted in the SAS processing of the data prior to use in the savings analyses.

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 battery that typically provides 3.2 Volts, but the loggers will continue to function properly until the voltage drops below 2.6 Volts. KEMA (formerly 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 of battery testing and maintenance are maintained on the network drive of the KEMA (formerly RLW) server, which is backed up on a daily basis. Figure 8-1 shows a KEMA (formerly RLW) technician testing the lighting logger battery voltage and soldering a new battery into an older logger.

Figure 8-1: Testing and Replacement of Lighting Logger Battery



8.2 Measurement Error

There are essentially two sources of measurement error that are germane to the use of Lighting Loggers, the first related to the clock and the second related to the calibration of the photocell sensor so that the logger only records the operation of the lighting and not daylight.

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 8-2 provides photos of typical lighting logger installations as well as the calibration procedure.

Figure 8-2: Lighting Logger Installation and Calibration

8.3 Sensor Placement Bias

Sensor placement bias refers to the bias that may arise when the sampling of 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. This is primarily a concern at C&I Facilities where fixtures with low use may be excluded from monitoring or emergency lighting that operates continuously may be monitored and assumed to be representative of the whole lighting system when it in fact 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 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 of input, 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 was a situation in which an existing EMS control system could provide detailed printouts of hours of operation, thus avoiding the need to monitor lighting circuits. A third instance consisted of 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 stratified statistical 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.

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.

8.4 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 that 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. In the samples used in this report, dropout and site substitution were extremely rare to nonexistent. Thus when a randomly selected representative sample design was developed and all sites participated, there was no selection bias. Selection bias is typically more problematic with residential lighting, which is not a part of this study.

8.5 Other Possible Bias

One other possible source of significant bias was the potential for meter bias. This 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, 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.

8.6 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." [5] Despite this challenge, KEMA (formerly RLW) has routinely taken steps, as described above, to avoid, mitigate, and/or eliminate potential sources of bias from the evaluation work which provided the data used in this study.

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