C&I Lighting Load Shape Project
FINAL Report

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Prepared for the Regional Evaluation, Measurement and Verification Forum

a project facilitated by Northeast Energy Efficiency Partnerships (NEEP)

Submitted to NEEP

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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.

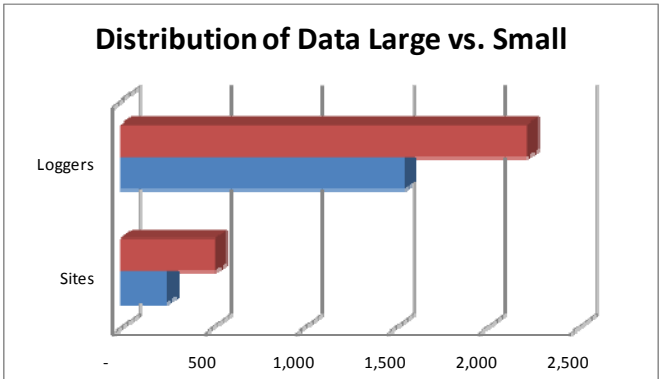
The expansion process created hourly daily profiles, where each hour's percent on represented the simple average for all the same hour and same day type. When no holiday data were available in the logger files the Sunday profile data were used for the holiday profile.

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

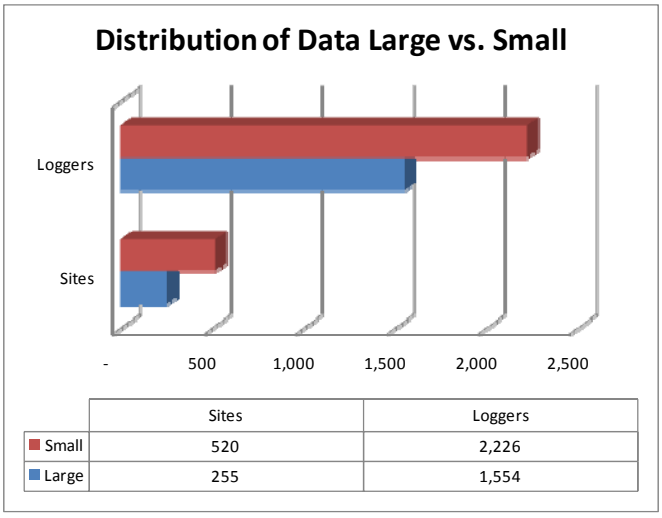
The expansion process created hourly daily profiles, where each hour's percent on represented the simple average for all the same hour and same day type. When no holiday data were available in the logger files the Sunday profile data were used for the holiday day type profile.

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.