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From: Tom Ledyard, RLW Analytics, Inc. and Lynn Hoefgen, Nexus Market Research
Subject: Extended residential logging results
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We have recently removed loggers from the extended metering study performed as part of our impact evaluation of coupon and catalog sales from the 2003 Residential Lighting Programs. The preliminary impact work was based upon short-term metering (2 weeks) in a sample of participants' homes, and is documented in a report titled *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs* by Nexus Market Research and RLW Analytics, Inc., dated October 1, 2004. This memo presents the results of the extended monitoring period, which spanned a nine-month period, from May through February. The following table presents the final hours and coincident factors we recommend using as a result of this study. The detailed methodology and results are presented later in this memo.

Lighting Type	Daily Hours	Summer Coincident Factor	Winter Coincident Factor
CFL	3.2	7.0%	15.2%
Interior Fixture	2.5		
Torchiere	3.3		

Methodology

In April and May of 2004, RLW installed 233 Time of Use (TOU) lighting loggers in 128 homes. A total of 198 of these loggers were installed in Massachusetts and Rhode Island, and another 35 loggers were installed in Vermont. Loggers were installed for a two-week period in May and/or June of 2004 and analysis and savings impacts were developed based upon adjustments to the logger data to reflect annual and estimated coincident peak usage as well as the use of phone survey results to estimate daily hours of use.

Subsequent to these short-term installations, 92 TOU loggers were installed in 44 homes in Massachusetts (40) and Vermont (4) that had participated in the short-term study. In each household, new loggers were installed through mid February of 2005. Some homes with high usage in the initial logging study had an interim visit to install another logger to avoid overruns in logger memory capacity. Figure 1 presents an overview of the overall short- and long-term metering process.

Participants in the extended logging study received a \$75 incentive. Cooperation levels were high and there were more willing participants than we needed for the sample. Extended logging occurred in the subset of 44 homes including all interior fixtures, bulbs,

and torchieres that had been logged during the short-term study. Exterior fixtures represented a small fraction of lighting types installed in the program (less than 4%), and therefore were not included in the extended monitoring.

Figure 1: Overview of Metering Process

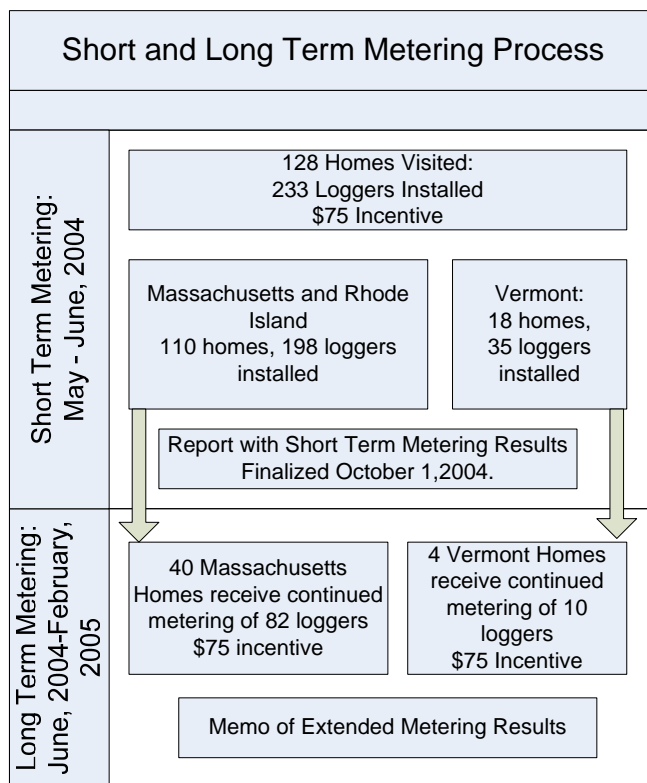


Table 1 presents the locations of each home that was included in the short-term metering. In the long term logging, RLW sought to meter all program purchased lighting in each home visited, regardless of location. With few exceptions, we were able to log the program purchased lighting. It is important to note that exterior logging was not performed in the long term study; although one CFL was installed in an outdoor location was therefore logged. As can be seen in the table, loggers were installed in diverse locations throughout the homes visited, ranging from basements to bedrooms and living rooms.

Table 1: Long-Term Metered Points

Rooms	No. loggers installed
Basement	6
Bathroom	4
Bedroom	18
Closet	1
Den	3
Dining Room	5
Exterior	1
Family Room	4
Foyer	3
Garage	0
Hallway	5
Kitchen	11
Laundry Room	1
Living Room	23
Office	2
Storage	0
Study	5
Total	92

Once loggers were removed, the data from each was downloaded into a computer for analysis. This data provided fifteen-minute interval data for the monitoring period. To estimate the lighting use for the two- to three-month window in which loggers were not installed, RLW substituted the usage data for the same period on the opposite side of the calendar year. That is, usage for non-logged periods in the early spring was projected from logged usage during corresponding sunrise and sunset times recorded during the fall.

Once all of the extended monitoring data were gathered and filled to reflect the full year of lighting use, annual hours of use and summer and winter coincident demand were estimated. The calculation of the annual hours of use, winter coincident factor and summer coincident factor in the long-term monitoring analysis was based upon average values taken from the data gathered and appended to the short-term data. In this regard, the long-term estimates are grounded in actual usage data that reflects a full year of lighting use for each lighting point monitored.

Long-Term Monitoring Results

Table 2 presents the average daily hours of use, average summer coincident factor, and average winter coincident factor from the long-term monitoring study. The winter coincident peak was calculated as the logged percent on-time between the hours of 5 PM and 7 PM from October through May while summer coincident peak was calculated as the logged percent on-time between the hours of 12 noon and 4 PM from June through September. Weighted averages are calculated using the total measure counts in the program population.

Torchieres were the most frequently used technology, averaging 3.2 hours per day. Interior fixtures averaged 3.1 hours per day, while CFL bulbs were used for 2.5 hours per day on average. The simple average summer coincident factor is 8.2%, while the weighted average is 7.0%. For the winter, the simple average is 15.9% and the weighted average is 15.2%.

Table 2: Long-Term Monitoring Results

Updated Impact Parameter	Compact Fluorescent Bulbs (n=32)	Interior Fixtures (n=36)	Torchieres (n=24)	Overall (n=92)
Avg. Daily Hrs. of Use	2.5	3.1	3.2	2.9
Simple Average Summer Coincident Factor	6.3%	10.0%	8.2%	8.2% (7.0% Wgtd)
Simple Average Winter Coincident Factor	14.8%	16.8%	16.1%	15.9% (15.2% Wgtd)

Comparison of Long-Term Results to Short-Term Results

A known drawback to the short-term logger study was that data were collected primarily during months with long periods of sunlight (May and June). Therefore, at the time of the short-term study, many lights required seasonal adjustments for the development of the annual hours of operation and winter coincident operation. To determine the annual hours of operation, RLW used information from a long-term metering study performed for NEES in 1994¹.

The 1994 NEES long-term monitoring study calculated the percentage of total annual hours that fell into each month of the year. These data were then used to annualize the short-term monitored data in the RLW Study by adjusting the monthly hours observed in the short-term metering by the fraction of annual hours determined to fall during those same months in the long-term study. When the short-term metering occurred entirely in one month (i.e., May or June), that month’s fraction was used. In all other instances, the average of the May and June fraction was used.

Table 3 compares the data from the long-term NEES study performed in 1994 that was used to annualize the short-term logger data with the current long-term data gathered in this study. The table shows that participants in the current study had approximately 17.1% fewer hours of annual use than did the participants in the 1994 NEES study. Proportionally, the current study shows more usage during the summer months (June-October) and a usage pattern that is not as heavily weighted toward the winter months. The bolded rows represent the months during which the short-term logging occurred. The cumulative difference between percentage of annual hours in the NEES study and the

¹ Residential Lighting Study, New England Electric Systems, Xenergy, 1994.

current study during the short-term logging months (May and June) is 0.48%, which indicates that the estimated total annual short-term hours are very close to the total annual hours gathered in the long-term study.

Table 3: Comparison of Long-Term Study Results

Month	1994 NEES Study		Current Study	
	Total Hours	Percentage of Total Annual Hours	Total Hours	Percentage of Total Annual Hours
January	136.5	11.36%	97.3	9.76%
February	137.1	11.41%	79.9	8.01%
March	106.8	8.89%	87.0	8.73%
April	96.8	8.05%	76.7	7.69%
May	97.4	8.10%	74.7	7.49%
June	84.8	7.05%	71.5	7.18%
July	70.8	5.89%	69.3	6.96%
August	61.8	5.14%	73.5	7.37%
September	68.1	5.67%	79.8	8.01%
October	83.2	6.92%	92.4	9.27%
November	130.8	10.88%	96.8	9.71%
December	127.9	10.64%	97.9	9.82%
Total	1,202.0	100.00%	996.7	100.00%

In the report summarizing the short-term results, the operating hours from the on-sites were used to leverage telephone survey reported hours of use. This was done for a couple of reasons explained in Section 9 of the original report, the most important of which was to leverage the larger sample size of the phone survey with the greater accuracy of the short-term metering performed in the on-sites. In addition, the truing up of phone survey results by short-term metering results was believed to reduce the effect of perceived selection bias noted in the report with respect to the logged sample having lower logged hours than the overall survey sample likely due to a disproportionate number of efficiency enthusiasts in the logger sample. For similar reasons the long term metering results are calculated the same way as the short-term results. That is, due to concern about weighting the extended metering sample too heavily given its small sample size, and due to concern about possible uncontrolled self-selection effects among the extended metering sample, it was decided to replicate the approach used in the short-term metering results. Specifically, the phone survey and on-site logger information was used to produce "correction factors" that we believe provide the best interpretation of participant hours of use from all of the information available.

The table below provides the information used to refine the short-term phone and on-site data collection results to produce the revised telephone survey estimate of hours. This table also shows the same procedure using the long-term metering results in the logged rows along with the extended logging sample self reported hours of use. These two inputs calculate the correction factor which is then used to adjust the phone sample self-reported hours. The revised telephone survey estimate rows under the long-term study columns provide the daily hours of use that are most appropriate for use in the future.

These estimates include 3.2 hours per day for CFL's, 3.3 for torchieres, and 2.5 for interior fixtures. We recommend the 3.3 hours for torchieres as it is a common estimate between

the bounds around the short-term and long-term studies; and provides a more conservative estimate than the long term study result of 3.7 hours. Exterior fixtures were not included in the long-term monitoring have not been recalculated.

Table 4: Long Term vs Short Term Metering Adjustments and Results

Parameter	Short-Term		Long-Term	
	n	Avg.	n	Avg.
CFLs				
Logged	97	2.6	32	2.5
On-Site Sample Self-Reported	219	3.2	81	3.3
Telephone Sample Self-Reported	1,358	4.2	1,358	4.2
Correction Factor ^a		0.81		0.76
Revised Telephone Survey Estimate		3.4		3.2
Upper Bound		3.7		3.4
Lower Bound		3.1		3.0
Torchieres				
Logged	44	2.5	24	3.2
On-Site Sample Self-Reported	52	2.4	23	2.5
Telephone Sample Self-Reported	263	2.9	263	2.9
Correction Factor ^a		1.04		1.28
Revised Telephone Survey Estimate		3.0		3.7
Upper Bound		3.3		4.1
Lower Bound		2.7		3.3
Interior Fixtures				
Logged	71	2.1	36	3.1
On-Site Sample Self-Reported	92	2.5	42	3.8
Telephone Sample Self-Reported	512	3.1	512	3.1
Correction Factor ^a		0.84		0.82
Revised Telephone Survey Estimate		2.6		2.5
Upper Bound		2.8		2.7
Lower Bound		2.4		2.3
Exterior Fixtures				
Logged	78	4	-	-
On-Site Sample Self-Reported	77	4.3	-	-
Telephone Sample Self-Reported	225	4.8	-	-
Correction Factor ^a		0.93		-
Revised Telephone Survey Estimate		4.5		-
Upper Bound		5.1		
Lower Bound		3.9		

^a Ratio of logged to on-site self-reported hours

Table 5 compares the short-term and long-term annual energy savings per unit by measure type. The adjusted daily hours of use from Table 4 are used in the long-term calculations; the in-service rates and delta watts have not changed between the October report of short-term results and this memo.

Table 5: kWh Annual Energy Savings per Lighting Product

Scenario	CFL Bulbs	Interior Fixtures	Exterior Fixtures	Torchieres
Short-Term				
At time of on-site	29.6	28.6	110.3	85.6
Including Planned installations	40.2	35.4	119.6	87.5
Long-Term				
At time of on-site	35.0	27.2	110.3	113.0
Including Planned installations	47.7	33.7	119.6	115.5

Table 6 calculates total kWh energy savings by sponsor and lighting measure using the on-site annual savings per lighting product shown above. For comparative purposes, the far right column shows what these values were prior to adjustment with the long-term logger data. The total energy savings increased by 1,415,498 kWh with a new overall calculated realization rate of 62.6%.

Table 6: Tracking to On-Site Savings Using Long-Term Hours

Onsite to Tracking Savings						
Utility	CFL Bulbs	Interior Fixtures	Exterior Fixtures	Torchieres	Long-Term Total	Short-Term Total
Number of Products Purchased						
National Grid	52,863	15,085	2,827	3,849	74,624	74,624
NSTAR	32,186	9,836	956	2,634	45,612	45,612
Unitil	600	105	8	79	792	792
WMECo	10,087	2,754	793	1,304	14,938	14,938
Cape Light	4,658	1,725	228	572	7,183	7,183
Vermont	67,394	8,702	1,270	2,116	79,482	79,482
Total	167,788	38,207	6,082	10,554	222,631	222,631
KWh Energy Savings						
National Grid	1,852,270	512,824	311,912	434,859	3,111,865	2,634,975
NSTAR	1,127,767	334,381	105,478	297,589	1,865,215	1,563,358
Unitil	21,023	3,570	883	8,925	34,401	28,381
WMECo	353,439	93,624	87,494	147,326	681,883	575,963
Cape Light	163,212	58,642	25,156	64,624	311,635	261,084
Vermont	2,361,423	295,830	140,123	239,065	3,036,441	2,562,181
Total	5,879,135	1,298,872	671,046	1,192,388	9,041,440	7,625,942
Realization Rate						
National Grid	61.8%	57.2%	172.7%	38.7%	59.9%	50.7%
NSTAR	96.0%	80.2%	235.5%	39.8%	78.3%	65.6%
Unitil	51.5%	36.4%	117.9%	34.3%	44.4%	36.7%
WMECo	89.3%	37.7%	122.3%	76.9%	75.1%	63.5%
Cape Light	93.8%	81.3%	131.5%	39.7%	72.8%	61.0%
Vermont	57.5%	42.8%	138.9%	43.8%	55.7%	47.0%
Total	66.1%	55.6%	160.6%	42.6%	62.6%	52.8%

Table 7 calculates total kWh energy savings using the planned installation annual savings. Again, the far right column shows what these values were prior to adjustment with the

long-term logger data. The total energy savings increased by 1,802,694 kWh, which helped improve the realization rate from 67.5% to 80.0%.

Table 7: Planned Installations to On-Site Savings Using Long-Term Hours

Planned Installations to Tracking Savings						
Utility	CFL Bulbs	Interior Fixtures	Exterior Fixtures	Torchieres	Long-Term Total	Short-Term Total
Number of Products Purchased						
National Grid	52,863	15,085	2,827	3,849	74,624	74,624
NSTAR	32,186	9,836	956	2,634	45,612	45,612
Unitil	600	105	8	79	792	792
WMECo	10,087	2,754	793	1,304	14,938	14,938
Cape Light	4,658	1,725	228	572	7,183	7,183
Vermont	67,394	8,702	1,270	2,116	79,482	79,482
Total	167,788	38,207	6,082	10,554	222,631	222,631
KWh Energy Savings						
National Grid	2,519,809	635,500	338,100	444,522	3,937,931	3,334,768
NSTAR	1,534,203	414,370	114,334	304,202	2,367,109	1,987,345
Unitil	28,600	4,423	957	9,124	43,104	35,716
WMECo	480,815	116,020	94,840	150,599	842,275	712,075
Cape Light	222,032	72,671	27,268	66,060	388,031	325,697
Vermont	3,212,455	366,597	151,888	244,378	3,975,318	3,355,473
Total	7,997,914	1,609,582	727,387	1,218,885	11,553,768	9,751,073
Realization Rate						
National Grid	84.0%	70.9%	187.2%	39.6%	75.7%	64.1%
NSTAR	130.6%	99.4%	255.3%	40.7%	99.3%	83.4%
Unitil	70.0%	45.1%	127.8%	35.0%	55.7%	46.1%
WMECo	121.5%	46.7%	132.5%	78.6%	92.8%	78.5%
Cape Light	127.6%	100.8%	142.5%	40.5%	90.6%	76.1%
Vermont	78.2%	53.0%	150.5%	44.8%	73.0%	61.6%
Total	89.9%	68.9%	174.1%	43.6%	80.0%	67.5%

In the original report from October, we compared the hours of use from this study with figures from previous studies completed in New England. We have replicated this table below with the new estimates of hours of operation. Generally, the daily hours of use estimate for CFLs from this study is slightly lower than other studies consistent with the NSTAR RHU program, but is lower than the other studies with the exception of the NSTAR RHU study. The average hours of use for interior and exterior fixtures in this study are close to the overall fixture average found in previous studies, which did not distinguish between interior versus exterior fixtures. The calculated torchiere result from this study is very close to of those calculated previously, albeit a little lower than that determined in the 2003 New Hampshire study.

Table 8: Daily Hours of Use Comparison with Previous Studies

Study	In-Store Lamps	Catalog Lamps	In-Store Fixtures	Catalog Fixtures	In-Store Torchieres	Catalog Torchieres
Current Study On-Site Daily Hours	3.2		Interior: 2.5 Exterior: 4.5		3.3	
1998 Starlights Study ²	3.4	3.44	3.4	3.44		
2000 Torchiera Study ³					3.46	3.46
2000-01 NU SLC/RL Study ⁴	3.4	4.5	3.0	3.0	3.4	3.4
2002 NSTAR RHU Program ⁵	2.39					
2002-2003 NH RLP Study ⁶	4.7	4.7	3.2	3.2	3.7	3.7

As yet another point of comparison for the new daily hours of use estimates, KEMA recently completed a study of CFL hours of use in California⁷. This study performed long term metering on CFL bulbs installed in a broad array of fixtures and rooms. So as a point of comparison, their hours include both CFLs as lamps as well as CFLs in fixtures. The final estimate of that study was determined to be 2.3 hours per day with an error bound from 1.9 to 2.6 hours. The daily hours from this study have been estimated at 3.2 for CFLs and 2.5 for CFL interior fixtures. Therefore, after consideration of the southern geography of California compared to the states included in this study, the types of lighting logged and an anticipated higher saturation of CFLs in California during and after the energy crisis that may lead to less frequent use, we believe our results seem reasonable in comparison.

² 1998 Process and Impact Evaluation of Joint Utilities Starlights Residential Lighting Program. This study consisted of the performance of 753 telephone surveys.

³ 2000 Xenergy Torchiera Study. The results from this study are based on a participant telephone survey; hours of operation based on survey data and long-term metering data from a previous study.

⁴ 2000-2001 Northeast Utilities SLC and POP Impact Evaluation, April, 2003. This study consisted of a nested sample data collection structure with 613 phone surveys and 153 on-sites.

⁵ 2002 NSTAR Residential High Use Program Operating Hours Realization Study. This study utilized 59 on-sites and 330 lighting loggers to calculate a residential hours of use realization rate. This study does not provide results by lighting type and this study does not provide wattage reduction estimates.

⁶ The 2002-03 Process and Impact Evaluation of the New Hampshire RLP included both a telephone survey of participants and an on-site logger study; results presented here are based on the on-site logger study.

⁷ CFL Metering Study; Kema, Inc. Prepared for Pacific Gas and Electric Company, San Diego Gas and Electric Company and Southern California Edison Company.