Are the Lights Really ON? Leveraging a Cost Effective Approach to Estimate Lighting Usage in Nonresidential Buildings

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ABSTRACT

There are a number of methods by which lighting usage can be estimated within nonresidential buildings. These methods range from the inexpensive, but less accurate – utilizing a facility's business hour schedule – to the more efficient, but more costly – installing onsite monitoring equipment. The difficulty with the first approach is that it ignores the variability in a facility's lighting load shape throughout open hours and does not capture any usage during closed hours or shoulder hours, which generally refer to the hours just before opening and right after closing. The latter approach involves extensive on-site visits that involve the installation of monitoring equipment over a long period of time.

This paper will discuss the methods and findings that were developed from comparing business hours and customer self-reported lighting usage to actual monitored lighting data. These results will provide evaluators with two cost effective methods for obtaining accurate lighting usage estimates within nonresidential buildings. With the self-report method, a ratio (or adjustment factor) of actual logger to self-report usage has been developed for linear and non-linear technologies at the building type and activity area level throughout open business hours. With the second approach, a usage rate (based on actual logger data) has been developed for three periods outside of open hours – an open/closed shoulder rate and a closed rate.

Introduction

This paper discusses methods that evaluators can leverage which are cost effective alternatives to installing onsite monitoring equipment to estimate lighting usage in nonresidential buildings. The paper relies on the results that were garnered from three extensive evaluation studies that were conducted within California (Itron, Inc. 2014a, 2014b; Itron, Inc. et al. 2010). The onsite data collection effort for these studies included the installation of over 3,200 loggers monitoring CFLs and LEDs at more than 900 sites and roughly 5,000 loggers monitoring linear fluorescents at almost 900 sites. Along with the installation of monitoring equipment, auditors also collected business hour schedules from the site contact, including seasonal and holiday hours as well as hourly self-reported estimates of lighting usage by activity area.

This paper will discuss the methods and findings that were developed from comparing business hours and self-reported lighting usage to actual monitored lighting usage. With the self-report method, a ratio (or adjustment factor) of actual logger to self-report usage has been developed for each technology, building type and activity area throughout open business hours. With the second approach, a usage rate (based on actual logger data) has been developed for three periods outside of open hours – an open/closed shoulder rate, which is defined as two hours prior to opening and two hours after close and a closed rate, which is defined as all closed hours not within the shoulder hours.

Background

This paper leverages a method for estimating lighting usage in nonresidential buildings that was first presented at the 2011 IEPEC conference, *"Is the Customer Always Right? A Cost-Effective Method for Estimating Lighting Usage in Commercial Buildings"* and expands upon those findings by including additional logger data that were collected for three impact evaluations prepared by Itron, Inc. for the

California Public Utilities Commission – *2006-2008 Small Commercial Contract Group Direct Impact Evaluation Report* (Sm Com)[1], *2010-2012 Nonresidential Downstream Lighting Impact Evaluation* (NRL)[2] and *2010-2012 LED Impact Evaluation* (LED)[3]. The primary purpose of those studies was to evaluate the California investor owned utilities' energy efficiency claims for each of the program periods detailed above. Each of these evaluations involved an extensive statewide phone survey effort and on-site verification as well as time-of-use data collection for several high impact lighting measures, including CFLs, LEDs and linear technologies installed in nonresidential buildings.

Data Sources

The three main sources of on-site data that were used in this paper from the evaluations detailed above were participant business hours, participant self-reported lighting usage and lighting logger data. Participant business hours were collected as part of the initial phone survey and were confirmed by an auditor at the time of the on-site visit. In order to capture any variability in business hour operations throughout the year, the auditor not only collected the open and close time for each day of the week, but they also captured any seasonal operations and holiday schedules.

Self-reported lighting usage was gathered at the time of the on-site visit. Since different activity areas[4] within a building generally have different lighting usage schedules, the site contact was asked to estimate the operating schedules for each of the activity areas where rebated measures were installed. The site contact was the individual who met with the surveyor onsite and, typically, was most knowledge about the facility's operations. These self-reported operating hours were collected as the percent of time "ON" per hour for each hour in each day of the week.

The time-of-use data were obtained through the installation of lighting loggers. A technical description of the lighting loggers and the installation/extraction procedures can be found in the NRL Report, Appendix G (Itron, Inc. 2014a). Lighting loggers using optical sensors were the predominant type used for these studies, however, when lighting was not accessible, logging was done at the electrical panel where circuit amperage could be collected in order to develop lighting load shapes. As part of the on-site visit, surveyors attempted to log every representative activity area where rebated measures were installed. These loggers were generally in the field for anywhere from four weeks to one year.

Processing of Data

After the loggers were extracted, the data was processed into a percent "ON" per hour format such that the actual lighting usage for each activity area could be compared to the business and self-reported hours of operation. Figure 1 provides a site-specific example of those comparisons. The figure presents the average logger data collected for a typical weekday in the office area of an office building. The vertical axis represents the percent "ON" per hour for that day. The business hours have a value of one when the office building is open and a value of zero during closed hours. Likewise, the site contact self-reported that the lighting within the office area was "ON" eighty percent of the time throughout the open hours.

[1] The Small Com Report can be found at www.CALMAC.org. Study ID: CPU0019.01.
[2] The NRL Report can be found at www.CALMAC.org. Study ID: CPU0078.01.
[3] The LED Report can be found at www.CALMAC.org. Study ID: CPU0101.01.
[4] Activity areas are defined as areas within the facility that have different occupancy and usage patterns. For example, the restroom(s) in a retail establishment may have a different usage pattern throughout business hours than the retail sales area.

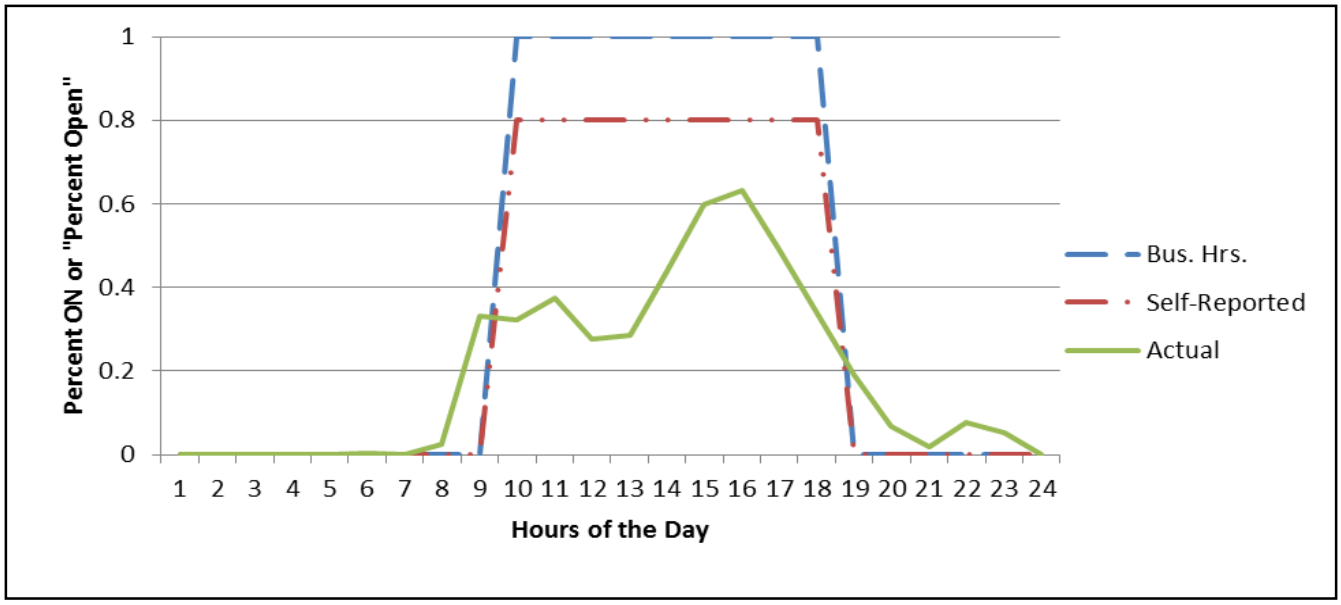

Figure 1. Actual, Self-Reported Lighting Usage and Business Hours for a Logger Monitoring an Office

Figure 1 reveals a few important distinctions that, ultimately, represent the motivation behind this analysis. The first is that business hours may not be a reliable proxy to use in developing usage shapes and lighting load impacts. Customer self-reported lighting usage, which was garnered from the on-site visit, is 20% less than business hour estimates throughout the open period. The second is that actual lighting usage, which was garnered from monitoring data, is much less than both business hour and self-report estimates throughout open hours and there is significant hourly variability throughout that time frame. The third is that business hours and self-reports (in this case) do not account for any lighting usage throughout time periods prior to open or after close.

However, the intent of this analysis was not to accurately predict lighting usage at a single site, but rather for a large sample of similar technologies, building types and space types. In order to aggregate these adjustments and usage rates, logger data was compared to the business hours of the facility and each self-reported schedule at the facility. As mentioned above, for each hour in each day, four usage periods were generated for each facility – Open, Open Shoulder, Closed Shoulder and Closed. The actual and self-reported usage rates were then calculated for each logger by use period within the site and each logger was aggregated to a site-activity area level by measure. This aggregation only occurred when there was more than one logger installed in similar space types. The aggregation from individual loggers to activity areas was done based on the number of lamps that each logger was monitoring.

Results

Two sets of data were generated from the analysis detailed above – business hour usage rates and self-reported adjustment factors. The results from the usage rates can be applied by knowing business operating hours, building type and activity areas and, in the case of the adjustment factors, by knowing the customer self-reported operating schedules which is typically gathered from on-site data collection.

Business Hour Rates

The business hour rates represent the actual average usage found in the logger sample for each use period by technology, building type and activity area. The usage rate represents a constant factor than can be applied to all hours within each use period and includes data from normal operation schedules as well as seasonal operations, where applicable. If a participant had more than one business operating

schedule and logger data was collected during those times, the single hourly average usage rate for that logger (for each use period) was developed by weighting the number of days in the year represented in each schedule. Each individual logger was then weighted by the total number of lamps represented by the logger along with the total number of hours associated with each use period.

Table 1 and Table 2 present the results from that aggregation. Building type-activity area combinations for which at least 6 sites were monitored are included in these tables. The "Other" building type and "Other Miscellaneous" activity area represent all the unique building type or building type-space types where there were less than 6 sites represented in the sample.

Self-Report Adjustment Factors

The adjustment factor represents the actual monitored usage divided by the self-reported use. Again, these ratios were generated at the technology, building type and activity area level much like the business hour rates, but are applied only for the open period. The reason why adjustment factors were not developed for the shoulder and closed periods is that self-reported usage was often claimed to be zero during these periods. A zero value cannot be adjusted by a multiplicative factor, therefore a constant factor is more appropriate when analyzing the closed and shoulder periods.

Table 1 and Table 2 present the results associated with the adjustment factor analysis. The self-reported usage can then be multiplied by the adjustment factor to generate a proxy percent "ON" value throughout the open hours by technology, building type and activity area. Also presented are the averages by technology and building type alone.

Table 1: Self-Reported Adjustment Factors – Non-Linear Fluorescent

Building Type	Activity Area	Number of Sites	Self-Reported Adjustment		Business Hour Usage Rates		
			Self-Reported Usage	Adjustment Factor	Open Shoulder	Closed Shoulder	Closed
Assembly	Classroom	8	9%	0.53	0.00	0.03	0.01
	Dining	15	57%	0.88	0.25	0.34	0.16
	HallwayLobby	67	69%	0.87	0.35	0.32	0.16
	Kitchen/Break Room	15	34%	0.58	0.14	0.15	0.06
	Office	28	67%	0.53	0.07	0.14	0.05
	OtherMisc	34	58%	0.85	0.18	0.23	0.10
	Recreation	16	39%	0.40	0.05	0.10	0.04
	Religious Worship	31	25%	0.64	0.04	0.09	0.03
	Restrooms	53	35%	0.84	0.18	0.23	0.11
	Storage	38	27%	0.88	0.11	0.11	0.05
	All	**119**	**50%**	**0.79**	**0.17**	**0.21**	**0.09**
Education – Primary/Secondary	OtherMisc	15	70%	0.68	0.04	0.14	0.04
	Restrooms	17	38%	0.97	0.06	0.09	0.03
	Storage	6	28%	0.34	0.02	0.04	0.02
	All	**26**	**60%**	**0.71**	**0.05**	**0.12**	**0.04**
Grocery	OtherMisc	7	70%	0.98	0.64	0.13	0.04
	Storage	6	36%	1.54	0.10	0.10	0.02
	All	**9**	**56%**	**1.13**	**0.43**	**0.12**	**0.04**
Health/Medical-Clinic	Comm/Ind Work	6	36%	0.12	0.00	0.01	0.00
	HallwayLobby	47	82%	0.79	0.29	0.36	0.15
	Kitchen/Break Room	8	43%	0.95	0.75	0.82	0.21
	Office	28	85%	0.49	0.11	0.19	0.03
	OtherMisc	12	55%	0.26	0.04	0.11	0.03
	Restrooms	32	15%	1.04	0.03	0.05	0.01
	Storage	13	9%	3.82	0.06	0.05	0.05
	All	**77**	**52%**	**0.42**	**0.24**	**0.30**	**0.10**
Lodging	Comm/Ind Work	13	28%	1.14	0.05	0.01	0.01
	Dining	10	70%	0.91	0.06	0.18	0.07
	Guest Rooms	93	34%	0.24	0.10	0.05	0.07
	HallwayLobby	55	81%	0.87	0.21	0.19	0.25
	Kitchen/Break Room	12	51%	0.67	0.40	0.27	0.13
	Office	13	81%	0.42	0.05	0.09	0.07
	OtherMisc	13	46%	1.18	0.02	0.06	0.09
	Restrooms	39	32%	0.22	0.16	0.15	0.09
	Storage	13	27%	0.70	0.43	0.22	0.14
	All	**109**	**38%**	**0.36**	**0.11**	**0.08**	**0.08**
Office – Large	HallwayLobby	21	86%	0.85	0.28	0.69	0.42
	Office	6	90%	0.69	0.34	0.44	0.25
	OtherMisc	8	41%	0.68	0.05	0.15	0.08
	Restrooms	11	30%	1.82	0.24	0.37	0.13
	All	**28**	**72%**	**0.87**	**0.26**	**0.53**	**0.31**

Office - Small	Conference Room	9	29%	0.87	0.06	0.11	0.01
	HallwayLobby	47	73%	0.76	0.29	0.33	0.15
	Kitchen/Break Room	12	44%	0.85	0.06	0.08	0.03
	Office	39	82%	0.76	0.07	0.25	0.03
	OtherMisc	13	50%	0.71	0.45	0.17	0.28
	Restrooms	90	19%	0.93	0.06	0.08	0.03
	Storage	22	33%	0.66	0.13	0.14	0.03
	All	**151**	**55%**	**0.77**	**0.16**	**0.20**	**0.08**
Other	OtherMisc	22	54%	0.83	0.24	0.24	0.37
	All	**22**	**54%**	**0.83**	**0.24**	**0.24**	**0.37**
Other Industrial	HallwayLobby	14	88%	0.82	0.13	0.21	0.04
	Office	11	81%	0.57	0.03	0.09	0.04
	OtherMisc	9	48%	0.74	0.19	0.19	0.09
	Restrooms	29	13%	1.32	0.08	0.04	0.01
	Storage	7	25%	0.49	0.06	0.06	0.02
	All	**49**	**63%**	**0.73**	**0.09**	**0.12**	**0.04**
Restaurant	Dining	101	87%	0.91	0.24	0.32	0.06
	HallwayLobby	43	82%	0.80	0.43	0.38	0.29
	Kitchen/Break Room	33	93%	0.90	0.49	0.33	0.11
	Office	16	35%	1.16	0.29	0.27	0.12
	OtherMisc	8	62%	0.92	0.39	0.23	0.12
	Restrooms	70	52%	0.98	0.31	0.31	0.14
	RetailSales	10	94%	0.80	0.40	0.52	0.31
	Storage	54	42%	1.11	0.28	0.19	0.09
	All	**170**	**82%**	**0.90**	**0.30**	**0.34**	**0.12**
Retail – Large	Office	4	97%	0.98	0.61	0.13	0.03
	OtherMisc	6	90%	0.96	0.39	0.51	0.27
	Restrooms	13	35%	1.35	0.25	0.26	0.13
	RetailSales	23	95%	1.02	0.20	0.10	0.02
	Storage	8	33%	0.25	0.07	0.05	0.06
	All	**39**	**95%**	**1.02**	**0.20**	**0.10**	**0.02**
Retail – Small	Auto Repair Workshop	6	80%	0.63	0.19	0.29	0.15
	Comm/Ind Work	9	80%	0.82	0.16	0.06	0.02
	HallwayLobby	23	85%	0.63	0.30	0.28	0.17
	Kitchen/Break Room	9	40%	0.62	0.12	0.13	0.09
	Office	28	64%	1.19	0.39	0.37	0.28
	OtherMisc	14	72%	0.58	0.15	0.19	0.02
	Restrooms	126	15%	1.16	0.05	0.06	0.03
	RetailSales	98	87%	0.98	0.31	0.19	0.09
	Services	9	96%	0.91	0.34	0.43	0.17
	All	**227**	**79%**	**0.96**	**0.27**	**0.19**	**0.10**
Warehouse	OtherMisc	11	83%	0.72	0.10	0.21	0.07
	Restrooms	15	6%	0.90	0.01	0.01	0.00
	All	**24**	**62%**	**0.73**	**0.08**	**0.17**	**0.06**

The results from the adjustment factor analysis for non-linear technologies (CFLs and LEDs) reveal that site contacts generally over-estimate lighting usage in their facilities for most building types. For example, the average overall self-reported lighting usage throughout open hours in office – small was 55%. However, the overall adjustment factor is .77, which reveals that actual usage, on average, was roughly 25 % lower.[5] For retail – large, site contacts were generally accurate in predicting usage throughout open hours (1.02 adjustment factor). This was driven predominantly by an almost identical self-report to actual in retail sales areas.

[5] A 42% actual divided by the 55% self-report yields an adjustment factor of .77 throughout open hours.

The results from the usage rate analysis reveal that facilities experience measured lighting loads throughout closed hours. The most significant loads come during the two hours prior to opening and two hours after close (the shoulder periods). For example, the average usage for restaurants for each hour in the open and closed shoulder period was .30 and .34, respectively. Likewise, the usage rate throughout all other closed hours was .12 with the most significant load being generated in retail sales areas and hallways/lobbies.

Table 2: Self-Reported Adjustment Factors – Linear Fluorescent

Building Type	Activity Area	Number of Sites	Self-Reported Adjustment		Business Hour Usage Rates		
			Self-Reported Usage	Adjustment Factor	Open Shoulder	Closed Shoulder	Closed
Assembly	Classroom	30	64%	0.47	0.05	0.12	0.02
	Conference Room	7	55%	0.55	0.14	0.27	0.06
	Dining	14	63%	0.64	0.27	0.11	0.06
	HallwayLobby	32	91%	0.42	0.17	0.33	0.13
	Kitchen/Break Room	31	43%	0.83	0.18	0.22	0.07
	Office	43	66%	0.57	0.26	0.20	0.06
	OtherMisc	28	91%	0.61	0.35	0.33	0.20
	Recreation	21	75%	0.63	0.11	0.26	0.06
	Religious Worship	8	30%	0.31	0.05	0.06	0.04
	Restrooms	23	47%	1.45	0.42	0.47	0.28
	Storage	24	45%	0.78	0.37	0.36	0.15
	All	**70**	**76%**	**0.57**	**0.21**	**0.26**	**0.11**
Education – Primary/Secondary	Classroom	48	76%	0.67	0.03	0.14	0.02
	HallwayLobby	24	78%	1.00	0.22	0.45	0.16
	Kitchen/Break Room	22	62%	0.98	0.22	0.26	0.07
	Office	32	76%	0.91	0.13	0.25	0.06
	OtherMisc	24	76%	0.74	0.11	0.37	0.06
	Restrooms	23	46%	1.24	0.10	0.22	0.04
	Storage	11	10%	1.49	0.02	0.12	0.02
	All	**59**	**74%**	**0.72**	**0.07**	**0.20**	**0.04**
Grocery	OtherMisc	6	84%	0.71	0.09	0.29	0.09
	RetailSales	14	95%	1.01	0.54	0.31	0.16
	Storage	7	73%	0.97	0.33	0.22	0.15
	All	**14**	**91%**	**0.96**	**0.45**	**0.30**	**0.15**
Health/Medical-Clinic	Comm/Ind Work	15	81%	0.79	0.06	0.30	0.04
	HallwayLobby	40	91%	0.89	0.24	0.46	0.18
	Kitchen/Break Room	19	68%	0.87	0.21	0.37	0.05
	Office	44	69%	0.83	0.17	0.29	0.06
	OtherMisc	17	77%	0.52	0.05	0.27	0.01
	Patient Rooms	10	28%	0.51	0.06	0.20	0.02
	Restrooms	15	22%	1.38	0.07	0.17	0.06
	Storage	18	32%	1.18	0.02	0.06	0.02
	All	**54**	**75%**	**0.73**	**0.15**	**0.32**	**0.08**
Laundry	OtherMisc	7	100%	0.93	0.54	0.52	0.34
	All	**7**	**100%**	**0.93**	**0.54**	**0.52**	**0.34**

Office - Large	Comm/Ind Work	6	88%	0.74	0.37	0.54	0.24
	Conference Room	13	33%	0.92	0.04	0.09	0.04
	HallwayLobby	16	94%	0.85	0.43	0.48	0.26
	Kitchen/Break Room	12	82%	0.93	0.36	0.52	0.23
	Office	22	90%	0.77	0.42	0.55	0.25
	OtherMisc	10	44%	1.00	0.32	0.38	0.27
	Storage	11	55%	0.99	0.10	0.12	0.11
	All	**26**	**82%**	**0.80**	**0.39**	**0.51**	**0.24**
Office - Small	Comm/Ind Work	17	79%	0.77	0.14	0.22	0.10
	Conference Room	22	58%	0.80	0.17	0.17	0.02
	Copy Room	11	80%	0.96	0.24	0.16	0.01
	HallwayLobby	52	89%	0.84	0.19	0.21	0.05
	Kitchen/Break Room	38	69%	0.84	0.17	0.23	0.04
	Office	92	82%	0.76	0.14	0.24	0.05
	OtherMisc	16	75%	0.81	0.36	0.22	0.15
	Restrooms	13	40%	0.84	0.05	0.14	0.05
	Storage	34	52%	0.84	0.13	0.10	0.04
	All	**105**	**78%**	**0.79**	**0.16**	**0.22**	**0.05**
Other	OtherMisc	12	40%	1.65	0.18	0.14	0.02
	All	**12**	**40%**	**1.65**	**0.18**	**0.14**	**0.02**
Other Industrial	Auto Repair Workshop	7	92%	0.99	0.47	0.07	0.06
	Comm/Ind Work	83	85%	0.85	0.28	0.32	0.14
	Conference Room	16	9%	0.81	0.00	0.02	0.01
	HallwayLobby	40	83%	0.76	0.33	0.36	0.23
	Kitchen/Break Room	25	56%	1.34	0.20	0.25	0.06
	Office	66	73%	0.90	0.12	0.18	0.05
	OtherMisc	20	66%	0.94	0.10	0.38	0.09
	Restrooms	23	14%	3.27	0.15	0.15	0.08
	RetailSales	6	84%	0.95	0.35	0.30	0.22
	Storage	53	74%	0.88	0.18	0.18	0.08
	All	**133**	**75%**	**0.90**	**0.23**	**0.27**	**0.11**
Restaurant	Dining	19	79%	0.82	0.15	0.20	0.04
	Kitchen/Break Room	21	91%	0.92	0.60	0.57	0.22
	OtherMisc	13	93%	0.90	0.26	0.26	0.03
	Storage	11	79%	0.89	0.52	0.30	0.05
	All	**29**	**85%**	**0.88**	**0.33**	**0.33**	**0.10**
Retail – Large	Auto Repair Workshop	7	78%	1.04	0.50	0.39	0.02
	Comm/Ind Work	6	97%	0.94	0.49	0.49	0.29
	Conference Room	7	18%	1.41	0.05	0.09	0.02
	HallwayLobby	11	96%	0.95	0.77	0.53	0.17
	Kitchen/Break Room	12	80%	0.95	0.47	0.45	0.29
	Office	25	80%	0.96	0.38	0.43	0.14
	OtherMisc	9	93%	0.73	0.58	0.39	0.21
	Restrooms	11	74%	1.28	0.59	0.70	0.44
	RetailSales	32	97%	0.99	0.61	0.58	0.41
	Storage	35	94%	0.61	0.52	0.48	0.31
	All	**51**	**94%**	**0.82**	**0.56**	**0.51**	**0.31**
Retail – Small	Auto Repair Workshop	45	85%	0.88	0.13	0.29	0.03
	Comm/Ind Work	38	94%	0.91	0.25	0.30	0.09
	HallwayLobby	39	84%	0.95	0.15	0.19	0.05
	Kitchen/Break Room	33	81%	0.79	0.17	0.16	0.04
	Office	84	82%	0.84	0.10	0.16	0.01
	OtherMisc	23	84%	0.89	0.17	0.13	0.03
	Restrooms	19	24%	0.91	0.05	0.12	0.02
	RetailSales	104	96%	0.96	0.15	0.15	0.04
	Services	15	93%	0.91	0.27	0.33	0.09
	Storage	75	68%	1.03	0.16	0.22	0.06
	All	**208**	**88%**	**0.93**	**0.16**	**0.20**	**0.04**

Warehouse	Comm/Ind Work	14	91%	0.76	0.24	0.14	0.06
	Conference Room	12	30%	1.04	0.02	0.05	0.01
	HallwayLobby	20	70%	0.73	0.26	0.10	0.04
	Kitchen/Break Room	17	57%	0.90	0.19	0.17	0.05
	Office	44	85%	0.69	0.18	0.13	0.06
	OtherMisc	22	45%	0.76	0.05	0.08	0.02
	Restrooms	17	23%	1.52	0.13	0.13	0.04
	Storage	58	71%	0.83	0.21	0.20	0.06
	All	**87**	**73%**	**0.78**	**0.19**	**0.16**	**0.05**

The results from the adjustment factor analysis for linear technologies yield similar results to the non-linear lighting analysis for some building types and different results for others. The similarities and differences result from both the self-reported lighting usage as well as the accuracy of the self-report. For example, the overall self-reported usage for non-linear and linear technologies throughout open hours for Retail-Small were 79% and 88%, respectively. However, the adjustment factors for each technology (.96 and .93) reveal that site contacts over-estimated usage by a similar margin.

The results from the business factor analysis for linear technologies also reveal that facilities experience measured lighting loads throughout closed hours. For some building types like retail – large and office – large, those loads are quite substantial.

Application of Results

By applying the adjustment factors to the open time period and the usage rates to the closed and shoulder time periods, 8,760 load shapes can be developed at the measure and activity area level for each building type. As mentioned above, these estimation techniques are meant to be applied to a large sample of sites and are not meant to accurately predict usage at a single site. For the adjustment factors and usage rates, since business hours can vary considerably from one site to another, they are applied to each site in the sample individually and then aggregated together. Figure 2 provides an example of this for a non-linear technology (CFL or LED) installed in an office area of an office building. An adjustment factor of .76 was multiplied by the self-reported usage during open hours (from Table 1) and business rates (from Table 1) were applied to the closed and shoulder period for each site. These individual site profiles were then aggregated together to create a population-wide estimate of usage.

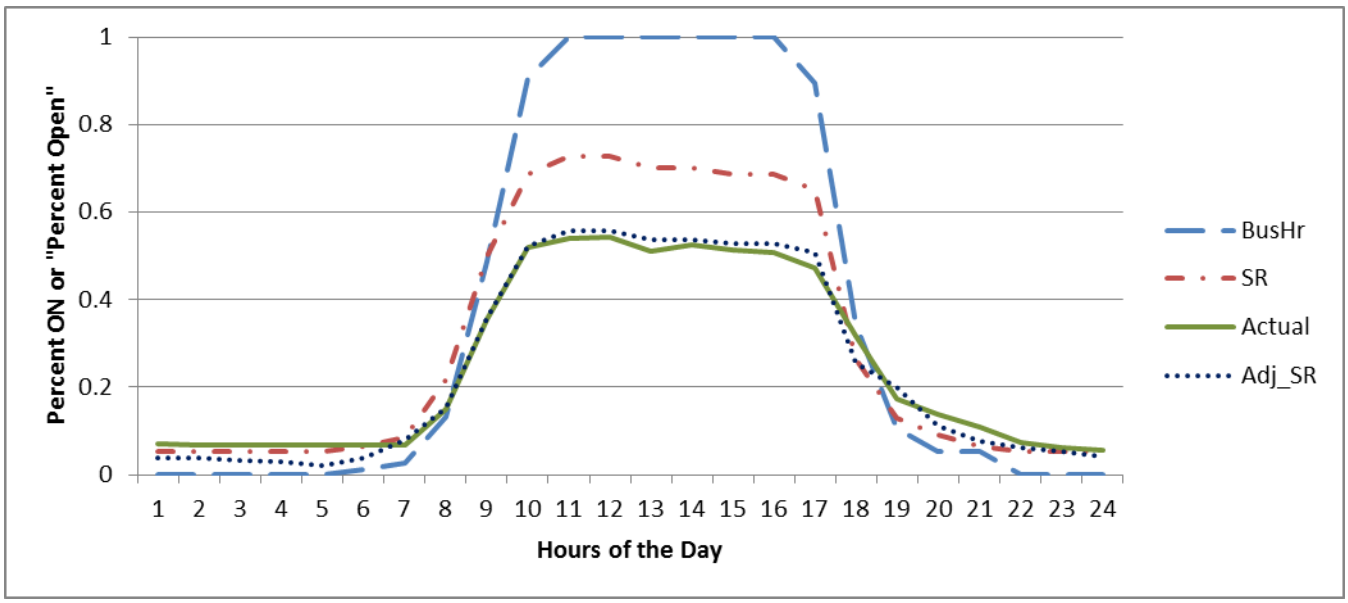

Figure 2. Population Business Hours, Self-Report, Actual Usage and Self-Report Adjustment/Usage Rate

Conclusion

These results will provide evaluators with two cost effective methods for obtaining accurate lighting usage estimates within nonresidential buildings. Evaluators can apply these methods by using data collected throughout the on-site verification process. These data include the facility's business hour schedule and the self-reported lighting schedule for each activity area of measure installation. Likewise, evaluators can properly weight the activity area lighting load shapes to the site level by confirming the number of measure installations (by activity area). Evaluators can then apply the adjustment factors to the self-reported usage data collected on-site and apply the usage rates to the business operating hours to develop more reliable estimates of lighting load shapes. Furthermore, since these results are developed at the technology, building type, activity area and use period level, evaluators can better understand lighting operation nuances at a much more disaggregated level than by relying simply on annual operating hour estimates.

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