Final Report

Commercial Prescriptive Lighting Efficiency Program Evaluation

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Submitted to:

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1. Executive Summary

This report provides the results of the measurement and verification (M&V) of Sacramento Municipal Utility District's (SMUD's) Commercial Prescriptive Lighting Incentive Program (CPLI) implemented during 2012 and 2013. CPLI offered by SMUD is designed to provide financial incentives to commercial and industrial customers for the retrofit or installation of energy efficient lighting fixtures.

The purpose of the Commercial Prescriptive Lighting Program is to enable SMUD's commercial and industrial customers to:

- Use energy more efficiently and reduce commercial / industrial energy costs per unit of output;
- Manage their energy use and cost;
- Realize the benefits of improved lighting technology on their commercial businesses and industrial processes; and
- Provide environmental and local economic benefits.

During the 2012-2013 program years, a total of 1,250 rebates were issued to commercial prescriptive lighting projects in SMUD's service territory. SMUD issued rebates to a total of 1,070 unique facilities during the 2012-2013 program years, representing 302 different facility end-use types[1]. Table 1-1 shows the total number of rebates issued per project year.

Table 1-1. Rebated Projects by Program Year.

Year	*Qty. of Projects*	*Unique Facilities[2]*
2012	530	469
2013	720	637
Total	**1,250**	**1,070**

Table 1-2 below shows SMUD's projected program savings and ADM's verified program savings per year.

[1] End-use types were determined by 2007 NAICS code information provided to ADM by SMUD in their program tracking database.

[2] Some facilities had projects in both program years. The grand total amount in this category represents the unique number of facilities that participated in the program throughout both program years. Each year's total represents the number of unique facilities that participated during that program year. Therefore, 2013 unique facility total shared overlapping sites with the 2012 unique facility total. The year totals, thus, will not sum to the overall total for the program.

Table 1-2. kWh and kW Savings by Program Year.

Year	*Expected kWh Savings*	*Realized kWh Savings*	*Realization Rate*	*Peak kW Savings*
2012	14,867,113	13,325,441	89.6%	2,079
2013	18,612,715	14,900,522	80.1%	3,048
Total	**33,479,828**	**28,225,963**	**84.3%**	**5,128**

These M&V results were determined using a sampling methodology that achieved ±10 percent precision at the 90 percent confidence level for each program year separately, and ±7 percent precision for the two program years combined.

Other key findings from this study included:

- Weekly lighting profiles for 80 projects;
- Overall 91.6% average persistence rate of rebated fixtures;
- Average effective useful life of 11.6 years for T8 linear fluorescent fixtures; and
- Average effective useful life of 7.2 years for LEDs.

This program's overall realization rate of 84.3% reflects variances between projected ex ante estimates and verified ex post savings. This is a result of differences in fixtures verified as still installed and operating, as well as variances between stated hours of use on the rebate applications and verified hours of use developed from customer interviews and monitoring data.

Table 1-3 below presents the results of the persistence study, which was conducted in tandem with the impact analysis. Persistence is defined fraction of kWh savings realized at the end of the program year that still occurs today. The same sample weights used for gross impact evaluation are used to develop the program-level persistence values from individual project-level values.

Table 1-3. Verified Persistence of Installed Fixtures

Year	*Average Persistence Rate*
2012	93.5%
2013	89.9%
Total	91.6%

Overall, the prescriptive program is operating well for most customers. Customers were largely satisfied with their experience the program and few noted any issues with the participation process.

The estimated technical potential for LED lighting in the nonresidential sector is 673,270 MWh. Depending on the incentive level, achievable potential is estimated to be approximately 8% of technical potential (51,970 MWh). In comparison, two years of operation for the current standard lighting incentive program – *inclusive of all lamp types and not just LEDs* - generated approximately 28,000 MWh of energy savings. Consequently, the analysis indicates that amount

energy savings potential from LED lighting applications is greater than what could be funded through the total program budget. One half of the total achievable energy savings is from replacement of standard linear fluorescent lighting and approximately one-third is from replacement of high-intensity discharge lighting.

2. Introduction, Objectives and General Methodology

2.1 Program Description

The Commercial Prescriptive Lighting Incentive Program (CPLI) offered by SMUD is designed to provide financial incentives to commercial and industrial customers for the retrofit or installation of energy efficient lighting fixtures.

The purpose of the Commercial Prescriptive Lighting Program is to enable SMUD's commercial and industrial customers to:

- Use energy more efficiently and reduce commercial/industrial energy costs per unit of output;
- Manage their energy use and cost;
- Realize the benefits of improved lighting technology on their commercial businesses and industrial processes; and
- Provide environmental and local economic benefits.

The Prescriptive Commercial Lighting Efficiency Program is a contractor driven program that in years' past has primarily served the smaller commercial market. In this program, lighting contractors are approaching the customers directly to offer incentives to replace the old lighting systems with energy efficiency lighting systems.

This program was first offered in summer of 2001 funded by a SB5X grant contract with the California Energy Commission. The program was discontinued in August of 2002, but reopened again in 2003. Originally, this initiative sought to obtain immediate peak load reduction and energy savings in the hard-to-reach small commercial sector through the replacement of old lighting systems with energy efficiency lighting fixtures and lamps. The program has since opened to large commercial customers, with an incentive cap of 50% of project cost. The incentives from this initiative are designed to cover a significant portion of the cost of the lighting equipment installed and are paid directly to the lighting contractors, who provided the primary mechanism for marketing and implementation of the initiative. Eligible technologies include T-8 lamps and electronic ballasts, tubular LED lamps (TLEDs), delamping, compact fluorescent lamps (CFLs), LED exit signs, and occupancy sensors.

During the 2012-2013 program years, a total of 1,250 rebates were issued to commercial prescriptive lighting projects in SMUD's service territory which were expected to provide savings of 33,479,828 kWh.

2.2 Objectives

As specified in SMUD's RFP, there are two sets of research objectives for this project, totaling 21 individual objectives. These objectives are as follows for program years 2012 through 2013:

One set of objectives pertain to examining the persistence of savings achieved by participants in the Commercial Prescriptive Lighting Incentive Program during 2012-2013. The objectives for the persistence and impact study are as follows:

- Verify the persistence of annual energy and peak load savings as compared to the verified program savings in 2012 and 2013.
- Verify program-installed measures still in place and properly installed as specified by program requirements.
- Verify summer peak coincidence and operating hours.
- Has there been a business turnover and/or occupant change?
- Is the equipment used differently than it was originally? Less? More? Has it been modified?
- Provide a description of the program participants' business types.
- Develop appropriate EULs for the program.
- Develop lighting load shapes of participants.
- Conduct a decision-maker survey to assess responses for participation, knowledge and satisfaction with the Commercial Prescription Lighting Program.
- Document program assumptions and new revised assumptions due to evaluation results.

The second set of objectives pertains to analyzing market potential for the program. The objectives for the market potential analysis are as follows:

- Estimate potential for commercial and industrial customers to install solid state lighting within the next 3 to 5 years
- Estimate potential for TLED and LED fixtures and lamps.
- Does having previously upgraded lighting influence future intentions to upgrade?
- Relative to other investment opportunities, how does lighting rank?
- What methods do the target audiences use to evaluate energy efficiency lighting investments?
- If target audiences are interested in upgrading, what methods are they willing to use to pay for the upgrades?

- Cost information for all measures (materials, labor, and incremental cost if applicable to better set rebates)?
- Market barriers for high efficiency lighting and how best to address these
- Are the target audiences aware of the program?

2.3 General Methodology

The overall objective for the impact evaluation of the Commercial Prescriptive Lighting Incentive Program was to determine the persistence of energy savings (kWh) and peak demand (kW) reductions resulting from program projects during 2012 and 2013.

The approach for the impact evaluation had the following main features.

- Available documentation (e.g., rebate forms) was reviewed for a sample of projects, with particular attention given to the calculation procedures and documentation for savings estimates.
- On-site data collection and monitoring was conducted for a sample of projects to provide the information needed for estimating savings and demand reductions.
- Gross savings were estimated by analyzing data for retrofitted fixtures on wattages before and after retrofit and hours of operation before and after the retrofit.
- A customer survey was conducted from a sample of program participants to gather information on their decision making, their likes and dislikes of the program, and other factors in determining participation in the program.

2.4 Organization of Report

This report on the persistence of impact savings and market potential study for the Commercial Prescriptive Lighting Incentive Program for 2012 and 2013 is organized as follows:

- Chapter 3 presents and discusses the specific methodology and gross savings estimates derived from the persistence study.
- Chapter 4 presents and discusses the results of the customer satisfaction survey.
- Chapter 5 presents and discusses the results obtained from the market potential study.
- Chapter 6 discusses the conclusions and recommendations of ADM's evaluation of the program.
- Appendix A provides the data collection form used for the sites for which measurement and verification data were collected.
- Appendix B provides the survey form used for the market potential and customer satisfaction survey.

- Appendix C gives a visual representation of lighting profiles from monitoring data, organized by NAICS 2007 code.

3. Persistence Study Methodology and Findings

This chapter describes the methodologies employed to determine the persistence of energy savings from the 2012 and 2013 Commercial Prescriptive Lighting Incentive Program. This chapter will also discuss the results of the persistence study.

3.1.1 Review Tracking Database and Ex Ante Assumptions

SMUD provided to ADM a tracking database for all projects rebated through the 2012 and 2013 CPLI program. The tracking database was examined for duplicate entries. Duplicate projects were removed from the program population prior to calculating ex ante savings and sampling precision.

Ex ante savings values were also compared against the savings values given on the rebate forms. SMUD consistently used adjustment factors to calculate savings and demand reduction in the rebate forms. In the rebate form calculations, a factor of 0.7905 for kW reductions and 0.799 for kWh savings were used. These values reflect gross and net impact realization rates from previous program evaluations. Per SMUD's instruction, the kW and kWh values from the rebate forms were used as the final ex ante values in ADM's analysis. As ADM only had rebate forms available for the projects in our sample, we determined a method for adjusting savings for all projects that were not included in the sample.

In order to adjust all savings for projects in the tracking database, ADM calculated an adjustment factor by dividing the rebate form values by the tracking database ex ante values for every project in our sample. This exercise was done for both kW demand reduction and kWh savings. The percentage differences between the rebate forms and the tracking database values were found to be consistent between projects. These percent differences in our sample were averaged for kW demand reductions and kWh savings, and then multiplied by the tracking database values. ADM used a value of 0.927 for kW demand reduction and 0.94 for kWh savings. This created adjusted or "corrected" ex ante values for each project in the program. The adjusted *ex ante* values were used as the basis for reporting.

3.1.2 Customer Surveying

ADM used a list of commercial and industrial program participants from the 2012-2013 programs to select a sample to complete telephone interviews. These surveys collected data needed to assess responses for participation, knowledge and satisfaction with the Commercial Prescription Lighting Incentive Program in 2012 and 2013.

Data collected via participant surveying is used in assessing:

- Advertising effectiveness and customer awareness of the program;
- Customers' reasons for their participation in the program;
- Customer satisfaction with various program factors; and
- Recommendations for program improvement.

The survey instrument may be found in Appendix B.

3.1.3 Sampling for Site Visits

Statistical precision achieved for the evaluation of the CPLI program was measured by the number of on-site visits conducted to verify installation and operation of unique projects. The rebate forms provided to ADM by SMUD were used as field guides to verify installed lighting equipment. ADM field staff also used a customized form to record location, date and fixtures observed by installed lighting monitoring equipment.

Data of installed lighting recorded included:

- Room of installation (e.g., retail floor, office, kitchen);
- Lamp Type (e.g., linear fluorescent, CFL, TLED);
- Wattage of fixtures;
- Lighting controls (if any); and,
- Hours of use.

While on site, ADM installed photo-sensitive loggers on T8 linear fluorescent, CFL, TLED and LED fixtures to monitor lighting operation. The monitoring effort took place between August 2015 and October 2015. The average length of time monitoring equipment remained *in situ* was 22 days.

The logger data was used to develop estimates of annual hours of operation. ADM was able to conduct monitoring for 80 projects at 72 unique facilities[3].

ADM calculated that the sample size needed to meet precision requirements was 88 projects; however, ADM conducted on-site verification visits to 92 different projects. ADM was able to verify persistence rates and savings for 90 projects, which comprised our final sample that we used to extrapolate to program level kWh savings and kW reductions. ADM used a stratified sampling approach to extrapolate final gross savings and demand reduction for the program. The actual precision of the sample is ±6.9% at the 90% (90±6.9%) confidence interval, with 90±10% precision achieved separately for each program year. Of the 90 projects in the final sample, 44 were selected from the 2012 program and 46 from the 2013 program. Realization rates for each program year are calculated exclusively with projects from that program year.

The population statistics for the final sample design are given in Table 3-1.

[3] ADM attempted to conduct monitoring at all 90 projects; however, field staff was only granted permission by facility management to install monitoring equipment for 80 of those projects.

Table 3-1. Population Statistics Used for Sample Design for Program Savings

	Stratum 5	*Stratum 4*	*Stratum 3*	*Stratum 2*	*Stratum 1*	***Totals***
Strata boundaries (kWh)	18,000 <	18,001 - 60,000	60,001 - 175,000	175,001 - 375,000	>375,000	
Number of projects	909	224	76	28	13	**1,250**
Total kWh savings	5,667,184	6,970,164	7,406,537	7,033,294	6,402,649	**33,479,828**
Average kWh Savings	6,235	31,117	97,454	251,189	492,511	**26,784**
Standard deviation of savings	4,205	11,071	31,293	66,655	114,101	**65,694**
Coefficient of variation	0.67	0.40	0.40	0.40	0.40	**2.45**
Final design sample	31	18	17	18	6	**90**

3.2 Gross Electricity Estimate Methodology

To calculate annual gross energy savings resulting from the program, ADM used the standard engineering algorithm shown below.

$$Annual\ kWh\ savings\ = Qty * \left(\frac{\Delta Watts}{1000}\right) * Hours * HCIF$$

Where:

ΔWatts = Average delta watts for specified measure. Delta watts for T8s, CFLs, LEDs and TLEDs were determined by the difference in watts between the previously installed equipment and the watts of the installed fixture.

Qty = Quantity of fixtures verified as installed and operating on site.

Hours = Average hours of use per year = 365 days in year * daily usage (hours/day) for commercial fixtures determined from metering effort.

HCIF = Heating and Cooling Interaction Factor. The HCIF adjusts for HVAC related impacts associated with installing energy efficient lighting in air-conditioned spaces.

The techniques for estimating each of the parameters in the above algorithm, based on either primary or secondary data, are described below.

3.2.1 Delta Watts

Delta watts represent the difference between the wattage of the efficient lighting measure and the wattage of the assumed baseline lighting measure. The wattage for baseline and efficient lighting measures rebated through the program was available in the individual projects' SMUD rebate forms. ADM field staff verified on site that the installed efficient fixtures matched the description in the rebate form(s).

3.2.2 Quantity of Fixtures Installed

ADM field staff used the SMUD rebate form as a primary guide for verifying quantity of fixtures as still installed and operating. Invoice forms and other documentation regarding individual projects were not available for the evaluation. The quantity of fixtures installed also informed the persistence rate for each project in the sample. When using the quantity in the savings calculation, ADM used the total number of fixtures verified as installed on-site.

Table 3-2 shows the quantity of installed fixtures by type and year as verified by ADM field staff on-site at sampled projects.

Table 3-2. Verified Incentivized Units by Program Year

Year	*T8/T5 Linear Fluorescent*	*LED*	*Occupancy Sensors*	*LED Exit Signs*	*Total*
2012	4,295	4,185	1,717	0	10,197
2013	5,024	10,318	181	23	15,246
Total	**9,319**	**14,503**	**1,898**	**23**	**25,743**

3.2.3 Hours of Use (HOU) Methodology

Hours of use were determined through direct monitoring of rebated lighting for a sample projects. Because ADM's approach included direct monitoring of commercial light fixtures, the development of a lighting load curve was based on primary data within the SMUD service territory. ADM conducted the lighting metering study in two to four week increments at each facility beginning in August 2015 and ending in October 2015. As the program fixtures were installed in indoor commercial applications, hours of use are usually consistent throughout the year (with the exception of holidays), so effects for seasonality were not included in our hours of use methodology. ADM installed lighting loggers in sampled facilities near fixtures associated with rebate projects for the purpose of calculating HOU.

Each logger was extrapolated to full annual usage by using a model for determining varying hours of use between weekdays, weekends and holidays. The data from each photosensitive logger was uploaded into files which produced a likelihood of operation for each hour on weekdays, weekends, and if applicable, on holidays. A calculation was then done accounting for each type of day in a full year to extrapolate the data to annual hours of usage. Blended lighting profiles and annual hours of use for each type of facility end-use (organized by 2007 NAICS code) are given in Appendix D.

3.2.4 Heating Cooling Interactive Factors

Heating Cooling Interactive Factors (HCIF) were developed by ADM for the SMUD territory in 2012. To develop the HCIF values, ADM used calibrated DEER prototype eQuest models with Sacramento-area TMY3 weather data. Each facility in the evaluation sample was mapped to one of the facility types listed in Table 3-3 below, and the corresponding energy and demand interactive factors were applied to the lighting energy savings and demand reduction. If a lighting project was determined to have been installed in an area that was not space conditioned, an HCIF value of 1 was used in the analysis.

Table 3-3. HCIF Values

Facility Type	*kWh HCIF*	*kW HCIF*	*Facility Type*	*kWh HCIF*	*kW HCIF*
Primary School	1.076	1.485	Small Office	1.105	1.331
Secondary School	1.053	1.449	Large Office	1.106	1.234
Community College	1.141	1.513	Full Service Restaurant	1.101	1.320
University	1.176	1.378	Fast Food	1.089	1.301
Hospital	1.107	1.048	Small Retail	1.113	1.362
Nursing Home	1.129	1.384	Large 1-story Retail	1.118	1.388
Hotel	1.203	1.179	3-story Retail	1.077	1.387
Motel	1.026	1.350	Conditioned Storage	1.024	1.257
Light Manufacturing	1.081	1.331	Small Office	1.105	1.331

3.2.5 Savings from Occupancy Sensors

During the on-site visit, ADM staff verified that the lighting controls had been installed and was operating as expected. The baseline lighting operating hours were estimated through an interview with facility staff and were corroborated by an examination of photo-sensor monitoring data. Post-controls hours were determined by actual monitored hours of use.

Lighting controls energy savings are calculated as:

$$kWh\ Savings = \sum W * (HOU_{base} - HOU_{efficient}) * HCIF / 1000$$

Where:

W = Wattage controlled by each occupancy sensor.

HOU_{base} = Estimated lighting operating hours before controls.

$HOU_{efficient}$ = Verified lighting operating hours after controls.

HCIF = HVAC interactive factor.

The summation symbol $\sum$ represents a sum over the occupancy sensors in the project.

3.3 Gross kWh Results

ADM estimated realized kWh savings of 13,325,441 in 2012 and 14,900,522 in 2013. The realized savings are extrapolated from sampled projects through ratio estimation.

Table 3-4. Realized Gross kWh Savings

Year	*Expected kWh Savings*	*Realized kWh Savings*	*Realization Rate*
2012	14,867,113	13,325,441	89.6%
2013	18,612,715	14,900,522	80.1%
Total	**33,479,828**	**28,225,963**	**84.3%**

ADM was able to replicate SMUD's *ex ante* savings figures, having had access to the rebate application calculations and formulas. The difference between *ex ante* and *ex post* estimates are due to differences between reported and verified overall numbers of fixtures installed and still operating, along with variances between reported and verified hours. The latter issue tends to manifest particularly in the hospitality sector. Table 3-5 summarizes the gross realization rate for energy savings by several facility types[4]. The hospitality sector in particular had a low realization rate. The main driver may be applicant confusion regarding hours of use – the hotels and motels are indeed "24/7" facilities, and some applicants – particularly in the 2013 program year- reported 8760 hour of use. Most of the rebated lamps, however, were screw-in LEDs in guest rooms, and did not experience high hours of use.

Table 3-5. Gross Realization Rate by Facility Type

Sector	*Number Sampled*	*kWh Realization Rate*
Retail	14	86%
Hospitality	12	23%
Food Service	7	88%
Leased Commercial Buildings	6	83%
Other	51	107%

3.4 Peak Load (kW) Impact Estimate Methodology

The calculation for peak demand savings applies a Peak Coincident Factor (CF) to the verified kW reduction. The summer peak coincidence factor is the fraction of lighting wattage reduction that occurs during the peak demand window.

ADM used the following algorithm for calculating gross peak demand savings for each project:

$$Peak\ kW\ savings\ = Qty * \left(\frac{\Delta Watts}{1000}\right) * CF * HCIF$$

Where:

[4] Only those facilities that have significant number of sample points are listed, and the rest are aggregated in the "other" category

ΔWatts = Average delta watts for specified measure. Delta watts for T8s, CFLs, LEDs and TLEDs were determined by the difference in watts between the previously installed equipment and the watts of the installed fixture.

Qty = Quantity of fixtures verified as installed and operating on site.

CF = Summer peak coincidence factor per project.

HCIF = Heating and Cooling Interaction Factor. The HCIF adjusts for HVAC related impacts associated with installing energy efficient lighting in air-conditioned spaces.

The SMUD summer peak period for commercial customers spans from 4 PM – 7 PM, Monday through Friday, June 1st through September 30th. The monitoring and on-site interviews informed the calculations to determine the fraction of lighting that operates during the summer peak period at sampled projects.

3.5 Peak Load (kW) Impact Estimate Results

Coincidence factors were calculated for each lighting profile used in the persistence savings analyses. Each project-level analysis included one to five unique lighting profiles, primarily derived from monitoring efforts, and secondarily from site contact interviews on lighting operation hours.

Peak demand reductions are extrapolated to the project population through ratio estimation, and are summarized in Table 3-6 below.

Table 3-6. Peak kW Reductions

Year	*Expected Peak kW Reduction*	*Realized Peak kW Reduction*
2012	2,527	2,079
2013	3,170	3,048
Total	**5,697**	**5,128**

A factor contributing to the lower than expected realized peak kW reductions was that multiple 2012 project sites had lighting that turned off between 4 and 5 pm.

Blended lighting profiles and annual hours of use for each type of facility end-use (organized by 2007 NAICS code) are given in Appendix D.

3.6 Persistence Rate Methodology

ADM's measurement and verification effort for SMUD's 2012 and 2013 CPLI Program took place between August and October 2015. Impact savings are calculated at least two years after the fact. In this timeframe, the types and quantities of lamps at participants' facilities may have changed for various reasons. It is important to attribute variances between reported and verified conditions to either persistence or verification. When discrepancies were found between on-site findings and reported fixture types and quantities, ADM attempted to attribute the discrepancies to persistence or to verification based on site-specific conditions and evidence. For example, in

one scenario the site contact indicated that the original lamps associated with a rebate were recently upgraded again. In this scenario, the discrepancy is attributed to lamp persistence rather than to verification. In another example, on-site inspection results indicated that it was unlikely that a facility would ever have the capacity to utilize the quantity of LEDs that were originally reported in the application. In this case, the discrepancy would not be attributed to persistence, because the issue is more likely associated with contractor documentation than with lamp attrition.

Our on-site effort was focused on establishing if measures listed on the SMUD rebate application met the following criteria:

- Equipment was installed as described.
- Equipment was still operating and functioning properly.

When scheduling on-site visits, ADM staff made a note to record 1) if the facility was still in operation under the same business as given on the rebate application; 2) if the facility was closed or otherwise unoccupied; and 3) if the end-use/business type had changed since the project occurred.

ADM verified the persistence of energy efficient fixtures by comparing the type of fixtures listed as installed on the rebate application with the type of fixtures found on site. The SMUD rebate application as used as the primary data source on measure-level information, as invoices and initial lighting audit forms were not available for the evaluation to verify model numbers or actual specs of post-retrofit and baseline fixtures.

After the on-site verification visit, ADM was able to calculate a persistence rate for each measure at each project in our sample. In addition to site-specific persistence rates, an overall occupancy rate was determined from the customer outreach effort associated with the on-site inspections. The overall persistence rate is the product of the occupancy rate and the weighted average of the site-specific persistence rates.

3.7 Persistence Study Results

ADM staff made a total of 199 calls to participant facilities and was able to schedule on-site visits for 92 facilities. Staff took detailed notes on the results of each call, and we were able to determine how many of those facilities were still operating under the same business name and type as they were when the projects were first installed. Table 3-7 gives the summary of the facility end-use persistence rates.

Table 3-7. Persistence of End-Use at Participant Facilities

Metric	*Quantity*	*Percentage*
Original Occupant	175	87.9%
Changed Occupant	11	5.5%
Closed business/unoccupied	13	6.5%
Total calls made	**199**	**100.0%**

The table indicates an effective vacancy rate of 6.5%. The occupancy rate is taken to be 93.5%, and is one factor of the overall persistence rate. The second factor is the weighted average persistence rate of the fixtures in ADM's on-site verification sample.

ADM's on-site inspections and customer interviews discovered that most of the lamps that were installed during 2012 and 2013 are still operable today. The weighted average fixture persistence rate for the 2012 program is 100.0%, and for the 2013 program is 96.2%[5].

The overall persistence rate is the product of the market occupancy rate, and the average fixture persistence rate for each program year. The average persistence rate achieved for each program year is given in Table 3-8 below.

Table 3-8. Persistence of Installed Fixtures

Year	*Average Persistence Rate*
2012	93.5%
2013	89.9%
Total	**91.6%**

3.8 Effective Useful Life

The effective useful life (EUL) of fixtures was determined by taking the rated lifetime of the fixture (hours) and dividing it by the annual operating hours (hours per year) in the SMUD service territory to determine the number of years the fixture will function. EULs per fixture type were defined as the ratio between the fixtures' rated useful life in hours, to annual hours of operation. The EUL determination is described with the following equation:

$$\frac{Rated\ Lifetime\ Hours}{Measured\ Operating\ hours} = Life\ in\ years$$

The denominator, *Measured Operating Hours* is determined on a site-specific basis through data logging and on-site interviews. The numerator, *Rated Lifetime Hours*, is determined separately by fixture type as discussed below.

For energy efficient linear fluorescent fixtures such as T8s and T5s, DEER protocol stipulates "linear fluorescent technologies with electronic ballasts have EUL/RUL values based on typical

[5] The two sites that showed evidence of fixture attrition actually replaced the initial LED reflector lamp with new LED reflector lamps. The persistence of the original lamps is technically zero, but the customer installed new efficient lamps in 2015. This may be an example of market transformation or 'spillover', provided that the recent lighting upgrade was not rebated by SMUD in 2015.

electronic ballast rated hours. The DEER EUL has a default rated life of 70,000 hours for electronic ballasts and a maximum EUL of 15 years" [6] Therefore, a value of 70,000 hours was used for *Rated Lifetime Hours*, but the resulting EUL was capped at 15 years.

The *Rated Lifetime Hours* was estimated separately for three general types of LEDs: A-lamps, MR16 reflectors, and PAR reflectors. Depending on the make, model, and vintage of LEDs, the rated lifetime can vary from less than 25,000 hours to greater than 50,000 hours. ADM did not have access to specific rated lifetimes for each lamp rebated in the program, and therefore developed market estimates for each type of LED lamp by consulting the Energy Star database of certified light bulbs. The average lifetime, in hours, listed by Energy Star are shown in Table 3-9 below.

Table 3-9. Rated Hours by Lamp Type from Energy Star database.

Lamp Type	*Rated Hours*
A19	25,494
MR16	25,819
PAR	27,337

Occupancy sensors and LED exit signs are assigned the DEER 2014 EULs of 8 years and 16 years respectively.

Using the above methodology, ADM calculated the EUL of energy efficient linear fluorescent lighting as being 11.6 years. For LEDs, this calculation yielded a EUL of 7.2 years.

Table 3-10 gives the EUL per fixture type. Using ex post savings for each measure in our sample, we created a weighted EUL to calculate program-level lifetime kWh savings for the 2012 and 2013 CPLI programs.

Table 3-10. EULs

Type	*Average Lifetime (years)*
LED Lighting	7.2
Linear Fluorescent with Electronic Ballast	11.6
Exit Lighting	16.0
Occupancy Sensors	8.0
Ex Post Weighted EUL	**8.3**

[6] DEER 2013 code update: http://www.deeresources.com/files/DEER2013codeUpdate/download/EUL-RUL_CalculatingDEERValuesForLighting_2014-02-05.pdf

3.9 Lifetime Savings

ADM calculated lifetime kWh savings for the 2012 and 2013 CPLI program using the following formula:

$$Lifetime\ kWh = EUL * kWh_{expost}$$

Where:

EUL = Ex post weighted EUL from Table 3-10.

kWh_{expost} = Verified ex post savings per project.

Lifetime kWh savings per project were summed by year and are presented in Table 3-11.

Table 3-11. Lifetime kWh Savings

Program Year	*Resulting Lifetime kWh Savings*
2012	105,395,580
2013	132,495,245
Total	**237,890,825**

3.10 Sampled Project Savings

The ex post verified savings for the 90 projects in our sample are presented in Table 3-12 below. These savings were used to calculate stratum realization rates which were then extrapolated to all projects in that stratum for the program. *Ex ante* savings were multiplied by the realization rate to calculate *ex post* verified savings for the program. The persistence rate per project is also provided in the table below.

Table 3-12. Verified kWh Savings by Sampled Project

ADM Project ID	*Program Year*	*Name*	*Verified kWh*	*Verified kW*	*kWh Realization Rate*
130001	2013	Mercy San Juan Hospital	1,003,996	108.52	138.91%
120011	2012	State Dept of Veteran Affairs	474,278	120.29	155.13%
130012	2013	Mercy San Juan Hospital	460,253	49.75	138.90%
120004	2012	Unisource	288,830	51.30	72.82%
120009	2012	Furniture USA	268,555	45.99	76.98%
130014	2013	Beck's Furniture (Folsom Blvd)	178,054	59.34	66.10%
130019	2013	Robert Freiheit Dba Liberty Associates	262,752	43.91	129.51%
120008	2012	Mercy Folsom	488,001	52.58	138.56%
120021	2012	American Furniture Galleries	253,250	84.29	152.85%
120013	2012	Beck's Furniture (Folsom Blvd)	239,942	79.96	111.38%
130018	2013	Beck's Furniture (Folsom Blvd)	190,482	63.48	111.38%
130003	2013	Hilton Garden Inn	184,305	20.93	34.79%
120002	2012	California State Surplus	165,304	41.08	31.00%

ADM Project ID	*Program Year*	*Name*	*Verified kWh*	*Verified kW*	*kWh Realization Rate*
		Warehouse			
130024	2013	J L Haley Enterprises, Inc.	160,541	33.05	89.52%
120032	2012	Mather Aviation	159,332	48.81	155.73%
130017	2013	Elk Grove Unified School District	152,298	65.94	70.35%
120029	2012	County of Sacramento	151,136	17.25	130.96%
120010	2012	AT&T #IA010	151,017	13.85	46.70%
130016	2013	Balbir S Sohal	133,086	36.47	52.53%
120036	2012	Pacific Storage Co Inc.	125,803	20.48	134.07%
130041	2013	Beck's Furniture (55th Street)	125,444	28.72	116.79%
130050	2013	Cintas Inc	121,255	17.35	150.60%
130004	2013	Red Lion Hotel (formerly the Woodlake Hotel)	112,496	16.73	21.47%
120054	2012	Calstar	104,321	21.68	171.21%
130051	2013	Furnitalia Inc	102,995	33.34	131.26%
120037	2012	Depot Park (City of Sacramento)	81,424	23.93	92.15%
130015	2013	Naturwood Home Furnishings	80,531	23.71	30.84%
120060	2012	Depot Park (City of Sacramento)	80,214	20.42	154.41%
130042	2013	Red Lion Hotel (formerly the Woodlake Hotel)	76,747	11.37	79.77%
120071	2012	Grocery Outlet Sacramento Warehouse	75,979	13.58	171.71%
120048	2012	Expo Furniture Gallery	71,669	20.34	109.28%
120067	2012	Grocery Outlet Sacramento Warehouse	69,716	14.85	152.53%
120015	2012	Naturwood Furniture	62,069	18.99	29.42%
130073	2013	D & L Furniture LLC	60,046	20.50	108.13%
130006	2013	Prestige Hospitality-Comfort Inn	59,028	9.43	13.29%
120020	2012	City of Elk Grove	51,845	8.14	30.27%
130106	2013	Safeway Inc	45,366	6.40	137.50%
130142	2013	Safeway Inc	39,094	5.54	145.15%
120056	2012	Leland Stanford Mansion	38,655	8.25	66.37%
130139	2013	Filco	37,242	11.83	136.85%
130053	2013	Breathe California in Sacramento	36,867	10.08	48.01%
120084	2012	Barbara Guthrie	35,514	11.00	94.58%
120105	2012	County of Sacramento	35,452	4.05	130.96%
120066	2012	Tokyo Buffet	32,955	8.92	71.18%
130022	2013	Hyatt Equities Llc	30,942	5.90	17.10%
120108	2012	Network Delivery System	30,298	9.71	115.66%
130025	2013	Best Value Capitol Inn	28,878	5.22	16.23%
120017	2012	Best Western	27,356	1.40	14.59%
130052	2013	Hyatt Equities Llc	25,658	4.41	33.22%
130021	2013	Joon S Choi	25,362	5.77	13.43%
120146	2012	Folsom Auto Center	22,287	5.55	115.69%

ADM Project ID	*Program Year*	*Name*	*Verified kWh*	*Verified kW*	*kWh Realization Rate*
130292	2013	Emily L Schell	21,358	7.23	206.52%
130118	2013	Saca, Anton J dba Filco	19,911	8.20	66.02%
120126	2012	Comfort Furniture	18,396	6.08	81.97%
130266	2013	State of California Dept of General Services	18,175	6.23	156.84%
130309	2013	Winding Way Seniors, Llc	16,508	3.11	169.92%
120161	2012	Duncan's Automotive	16,198	4.31	94.53%
130213	2013	Steve J Collins	16,394	6.54	105.78%
120204	2012	Pisor Fences Div. Inc.	14,816	1.45	125.22%
120189	2012	Helen Jones Gallery	14,619	5.63	113.78%
130316	2013	Myles L Brown	13,986	5.51	150.61%
130094	2013	L C 3 S Inc	13,845	2.86	34.60%
130293	2013	Tofanelli Inc	13,355	4.52	129.37%
130259	2013	Ronica Jo Anderson	13,318	3.35	110.50%
130317	2013	Les Carter	13,224	4.10	142.96%
130304	2013	Christopher Parvizyar	10,544	3.11	105.85%
130098	2013	Econo Lodge	10,451	1.47	26.89%
120252	2012	Pioneer Fleet Services Inc.	9,701	2.79	109.81%
130241	2013	Colmax Llc	9,595	2.49	70.40%
130308	2013	Greg M Ward	9,315	3.35	94.55%
130107	2013	Sharif Financial Corp	49,042	16.84	148.92%
130261	2013	Robert Claney	7,827	2.70	65.66%
120344	2012	Reagor Pet Hospital	7,200	2.86	137.90%
120244	2012	Casual Elements	7,028	1.76	77.76%
130271	2013	Billie J Kanelos	6,853	1.84	59.96%
120351	2012	Warren F Brandle MD	6,438	2.21	128.43%
120419	2012	No #1 Buffet	6,354	1.35	193.66%
120283	2012	Norcal Roofing Inc.	6,107	1.19	82.38%
130056	2013	Surf Motel	5,961	2.20	7.96%
120300	2012	Volvo Rents	5,546	1.92	85.97%
120218	2012	PV Hardware LLC	3,718	1.16	34.16%
120421	2012	Wongs	2,378	0.75	72.77%
120360	2012	Arden High Tech Auto Repair Inc.	2,145	0.68	45.56%
130229	2013	M N Sharif	9,745	4.54	69.14%
120279	2012	Aerospace Museum of CA	658	0.22	8.77%
120051	2012	Depot Park (City of Sacramento)	0	0.00	0.00%
120254	2012	Aqua FX Spa & Salon	0	0.00	0.00%
120314	2012	Casual Elements	0	0.00	0.00%
130029	2013	Geweke Natomas 11 LP DBA Hampton Inn	0	0.00	0.00%
130332	2013	98 Cents & Up	0	0.00	0.00%

4. Customer Satisfaction Survey Findings

4.1 Overall Telephone Survey Findings

This section describes program participant responses to questions regarding the program participation process and program satisfaction. In total, 100 program participants completed the survey.

Table 4-1 displays survey respondent building types compared to the general population of nonresidential SMUD customers. As shown, the distribution of building types associated with survey respondents generally parallels the distribution of building types. However, office spaces were underrepresented in the sample, while warehouses were somewhat overrepresented.

Table 4-1 Survey Respondent and Population Building Types

Building Type	*Percent of Respondents*	*Percent in Population*
Ag & Pumping	4%	2%
College	1%	<1%
Construction	5%	3%
Food/Liquor	1%	1%
Hotel	3%	0%
Industrial	3%	3%
Misc	15%	13%
Office	22%	55%
Refr Warehouse	1%	<1%
Residential	1%	1%
Restaurant	15%	4%
Retail Store	7%	2%
TCU	2%	7%
Warehouse	17%	8%
Unknown	3%	<1%

Self-reported building size for survey respondents is Table 4-2. As shown, most respondents reported that their buildings were smaller than 25,000 square feet.

Table 4-2 Distribution of Participant Building Sizes

Building Size	*Percent of Respondents (n = 100)*
Less than 5,000 square feet	47%
Between 5,000 and 25,000 square feet	39%
More than 25,000 square feet to 50,000 square feet	1%
More than 50,000 square feet to 100,000 square feet	3%
More than 100,000 square feet to 500,000 square feet	0%
More than 500,000 square feet to 1 million square feet	1%
More than 1 million square feet	0%
Don't know	8%
Refused	1%

More than one-half (58%) of survey respondents were the proprietor or owner for the site. Other common positions held by respondents were facilities managers (16%), and President/CEO (10%).

Table 4-3 Survey Respondent Job Title

Response	*Percent of Respondents (n = 100)*
Proprietor/Owner	58%
Facilities Manager	16%
President/CEO	10%
Other facilities management/maintenance position	7%
Other financial/administrative position	5%
Chief Financial Officer	1%
Energy Manager	0%
Other	1%
Refused	2%

4.2 Source of Program Awareness

The most common means by which respondents learned of the program was through direct contact by SMUD staff. Sixty percent of respondents reported learning of the program through direct outreach by program staff. Friends and colleagues were other common sources of awareness. Only 12% of respondents reported learning of the program from a vendor or building contractor.

Table 4-4 Source of Program Awareness

Source of Program Awareness	*Percent of Respondents (n = 100)*
Approached directly by SMUD Staff	60%
Friends or colleagues (i.e., word of mouth)	13%
An equipment vendor or building contractor	12%
The SMUD website	3%
An architect, engineer or energy consultant	2%
Received an information brochure on the Prescriptive Lighting Program	1%
Past experience with the program	1%
Some other way	1%
Don't Know	7%

4.3 Application Process and Project Completion

Fifty-five percent of the survey respondents worked on the application for the rebated lighting project. These participants provided responses to a series of follow-up questions regarding their experience in completing the applications process.

The majority of respondents indicated that the information provided on how complete the application process for the rebate was clear, as shown in Figure 4-1. Three survey respondents provided additional information on what was unclear about the forms. The two issues raised by these respondents were that the references to spec sheets and other items were not terms that were familiar to the participant and that the forms were somewhat confusing.

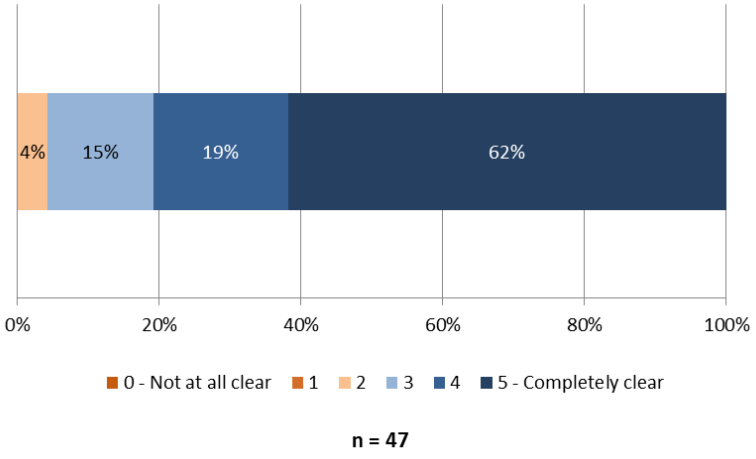


Figure 4-1 Clarity of Information on How to Complete Application

As shown in Table 4-5, nearly all respondents (93%) indicated that they did not have any difficulty completing or submitting the application materials. One respondent that reported difficulty stated they had difficulty finding qualifying lamps that met their temperature needs.

Table 4-5 Difficulty with Application Completion or Submission

Did you have difficulty completing or submitting the application?	*Percent of Respondents (n = 55)*
Yes	2%
No	93%
Don't know	5%

Seventy-five percent of respondents reported that they had a clear sense of whom to go for assistance with the application.

Fifteen percent of respondents reported that they contacted a program staff member with questions or concerns during the course of their program participation. Figure 4-2 displays these respondents reported satisfaction with the timeliness and thoroughness of staff's response. As shown, 85% of respondents were satisfied with the thoroughness of the response and 78% were satisfied with the timeliness of staff's response.

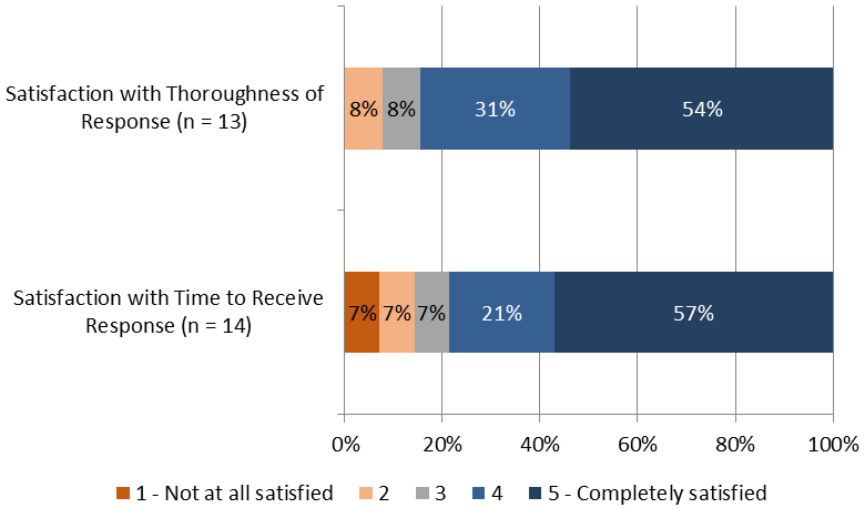


Figure 4-2 Satisfaction with Staff Interactions

Sixty-one percent of respondents reported that the amount of the rebate they received was about what they were expecting. Another 15% reported that the amount exceeded their expectations. However, 13% of respondents indicated that the rebate was less than what they expected.

Table 4-6 Comparison of Rebate to Expectations

Response	*Percent of Respondents (n = 100)*
It was much less	7%
It was somewhat less	6%
It was about the amount expected	61%
It was somewhat more	5%
It was much more	10%
Don't know	11%

4.4 Experience with Contractor

Seventy-five percent of the interviewed respondents reported that they used a contractor to install the energy efficient lighting in their facilities. Eighty-percent of these respondents utilized contractors that they had not previously worked with.

Sixty-two percent of respondents reported that the contractor promoted the rebate while 21% stated that they did not (the remaining 17% did not know if the contractor promoted the rebate). The relatively large number of respondents that reported their contractor did not promote the rebate suggests that additional education of contractors providing services in SMUD's service territory may represent an opportunity to increase program activity.

As shown in Figure 4-3, 95% of respondents were satisfied with the installation of the lighting equipment performed by their contractor.

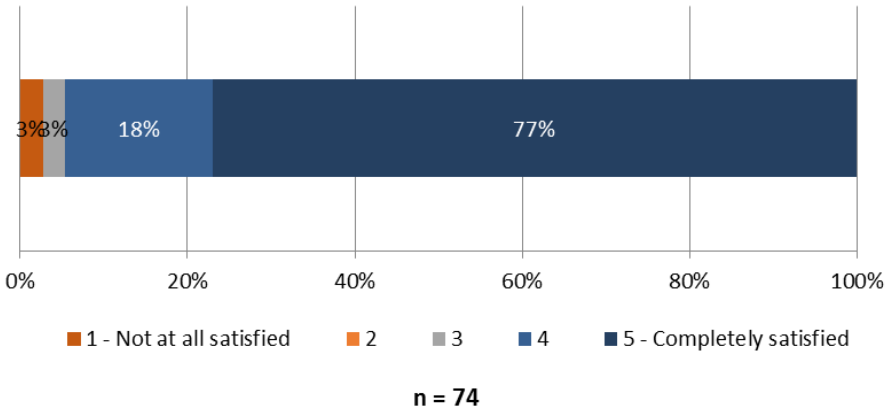


Figure 4-3 Satisfaction with Installation

4.5 Program Satisfaction

Figure 4-4 summarizes participant satisfaction with the program. Ninety-two percent of respondents reported that they were satisfied with the program overall. The program component that the largest share of respondents reported dissatisfaction with was the time to receive the rebate. Time to receive the rebate is typically the aspect that program participants are least satisfied with and the fact that 80% of respondents were satisfied with the time to receive the rebate suggests that this is not an area of significant concern.

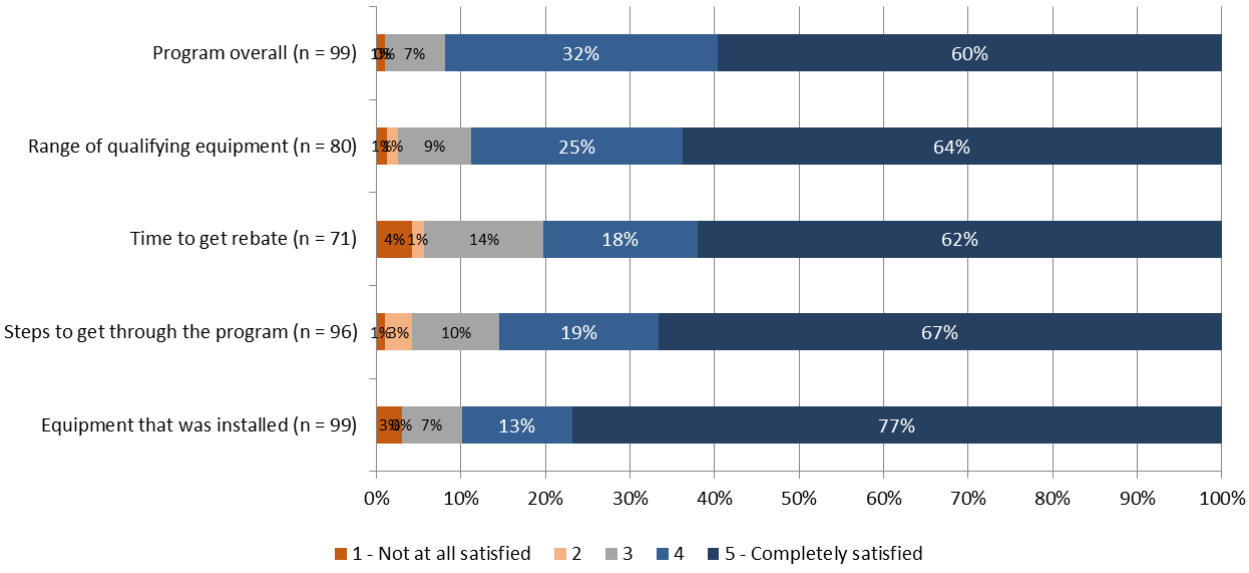


Figure 4-4 Participant Satisfaction

Nine respondents that reported dissatisfaction with one or more aspects of the program provided additional information on the reason for their dissatisfaction. Their responses are summarized in Table 4-7. As shown, three respondents were dissatisfied with the installation. These respondents

stated that the contractor had left a mess, that they did not retrofit all of the lights the customer wanted upgraded, and that multiple contractors failed to show-up to perform the work.

Three participants also reported that they were dissatisfied with some aspect of the lighting. The specific reasons provided were that there is not enough light since the retrofit, the lights made noise, and the lamps did not last very long.

Other stated reasons for dissatisfaction included having not received the rebate, difficulty getting the lighting material, and a lack of staff responsiveness to inquiries.

Table 4-7 Reasons for Dissatisfaction

Reasons for Dissatisfaction	*Number of Respondents (n = 9)*
Unhappy with contractor installation	3
Dissatisfied with lighting quality, amount, or other aspects	3
Never received rebate	2
Difficulty getting lighting materials	1
Program staff not responsive to inquiries	1

4.6 Conclusions

Overall, the prescriptive program is operating well for most customers. Customers were largely satisfied with their experience the program and few noted any issues with the participation process. The following points below summarize the key findings from the survey of customer satisfaction:

- Few customers identified issues with the application process. A clear majority of customers reported that the application process was clear and only one customer noted any difficulty completing or submitting the application.
- Most customers that had contact with program staff during the course of participating were satisfied with those interactions.
- Only 3% of customers reported any dissatisfaction with the contractor they worked with.

Ninety-two percent of customers were satisfied with the program overall. The aspect of the program that the largest share of customers noted any dissatisfaction was the time to receive the rebate. However, only 5% of customers were dissatisfied with this aspect of the program.

5. Market Potential Study Findings

This chapter discusses the methodology and results from the analysis of the potential for LED lighting retrofits among SMUD nonresidential customers.

5.1 Study Data Sources

This section provides an overview of the data sources used in the analysis of LED lighting market potential.

5.1.1 Analysis of Nonresidential Customer Data

ADM analyzed program participation and nonresidential account data to assess the level of program participation generated from the customer base in 2012 and 2013. This analysis provides insight into the current rate of participation among building types and provides context for the overall program potential.

5.1.2 SMUD Customer Survey

ADM attempted to complete a survey of SMUD's nonresidential customer base to collect data on facility lighting and customer decision making about lighting projects. The primary data needed from the customer survey was data on decision making factors related to the adoption of energy efficient lighting. However, ADM was unable to complete the survey due to very high level of nonresponse. Two versions of the survey and multiple screening protocols were utilized, but only nine responses were obtained for a total of 55.5 hours of dialing.

As an alternative, data on customer decision making regarding potential lighting projects was collected through administration of a program participant survey. In total, 100 survey responses were collected. A limitation of using program participant data is that the data collected on program participant decision making may not be representative of nonparticipants. On the one hand, because the respondents have previously completed energy efficiency projects, they may have a greater tendency to implement efficiency improvements or to be more responsive to incentives than the general population. On the other hand, because the respondents had completed a lighting efficiency project during the 2012 or 2013 program years, they may be less likely to implement additional energy efficiency projects. To verify the responses were provided, ADM compared the SMUD survey results against results from a study performed in another jurisdiction and found them comparable (described in further detail in Section 5.5.2.4).

5.1.3 Secondary Data Sources

A variety of secondary data sources were utilized to estimate technical and market potential. These data sources are summarized in Table 5-1. Section 5.5 describes how this information was used to model LED lighting potential in greater detail.

Table 5-1 Secondary Data Sources Used in Potential Study

Secondary Data Source	*Data Utilized*
ADM (2014). Commercial Energy Use in the SMUD Service Territory. Prepared for Sacramento Municipal Utility District (SMUD).	Lighting type saturations.
EnerNOC Utility Solutions Consulting (2013). Ameren Illinois Energy Efficiency Market Potential Assessment. Report Number 1404 Volume 2: Market Research Figure 7-2	Take-rate comparison
Siemens (2010). Economics of Energy Upgrades. Includes survey responses from 910 decision makers. Figure 6 and Figure 7.	Take-rate comparison
U.S. Energy Information Administration Form 861	Average SMUD per kWh industrial and commercial charge.
Itron (2006) California Commercial End-Use Survey. Prepared for California Energy Commission	Hours of operation for commercial facilities.
California Statewide Commercial Sector Energy Efficiency Potential Study, California Energy Commission, July 9, 2002, Study ID #SW039A, Final Report, Volume 1 of 2.	Lighting share of energy use for manufacturing facilities.
Navigant Consulting (2012) 2010 U.S. Lighting Market Characterization. Prepared for U.S. Department of Energy	Distribution of installed wattage by lighting type in commercial, industrial and outdoor facilities.
Navigant Consulting (2012). Energy savings potential of solid-state lighting in general illumination applications. Prepared for the U.S. Department of Energy.	LED lighting pricing forecast.

5.1.4 Contractor Interviews

ADM completed interviews with a sample of contractors that provide lighting services to businesses in SMUD's service territory. The objective of the interviews was to gain perspective on the market for LED lighting, to assess market barriers to adoption, and to gauge the effectiveness of SMUDs incentive programs for encouraging businesses to adopt energy efficient lighting.

Fifty-five lighting product and service providers working with the Sacramento Municipal Utility District (SMUD) service territory were contacted for an interview. Of those contacted, thirteen refused an interview and twenty-seven could not be reached after multiple e-mail and telephone interview requests. In total, interviews were completed with fifteen contractors.

5.2 Nonresidential Population and 2012 and 2013 Program Participation

Table 5-2 displays the share of sites that participated in the program during the 2012 and 2013 program years. As shown, overall, 1.3% of the sites in SMUD's service territory participated in the lighting program during the 2012 and 2013 program years. This participation rate is generally similar to participation rates for other nonresidential lighting programs.[7] The level of participation was greatest for hotels, with 17% of the sites in the service territory participating in the program.

Table 5-2 Share of Sites Participating in Program during 2012 - 2013

Building Type	*Percent of Sites that Participated (2012 and 2013)*
Ag & Pumping (N = 1,466)	1.9%
College (N = 250)	1.2%
Construction (N = 2,132)	2.1%
Food/Liquor (N = 759)	1.4%
Health Care (N = 549)	0.9%
Hotel (N = 259)	17.4%
Industrial (N = 1,850)	2.9%
Mining & Extraction (N = 96)	1.0%
Misc (N = 9,258)	1.7%
National Security (N = 84)	0.0%
Office (N = 40,125)	0.5%
Refr Warehouse (N = 149)	0.7%
Residential (N = 430)	0.5%
Restaurant (N = 2,654)	4.6%
Retail Store (N = 1,303)	2.7%
School (N = 1,061)	3.5%
TCU (N = 5,115)	0.8%
Warehouse (N = 5,970)	3.3%
Unknown (N = 52)	0.0%
Total	1.3%

[7]Annual participation rates for Efficiency Vermont and Xcel Minnesota Lighting Efficiency Programs were 3.6% and 1.3%, respectively.

York, D., Neubauerer, M., Nowak, S., and Molina, M. (2015). Expanding the energy efficiency pie: Serving more customers, saving more energy through high program participation. American Council for an Energy-Efficient Economy.

5.3 Participant Survey Findings

This section describes results from the survey of program participants that pertain to the likelihood of implementing future lighting projects.

5.3.1 Planned Projects

Interior fluorescent lighting was the most common lighting type with 84% of respondents reporting that this lighting type was present in their facility. Additionally, 60% of customers reported that their buildings had exterior lighting and 22% reported that they had refrigerated case lighting. Only 12% reported the presence of HID lighting, although respondents were most likely to report that they did not know if they had this type of lighting.

Table 5-3 General Lighting Types Present at Facilities

Lighting Type	*Yes*	*Don't know / Refused*
Interior fluorescent	84%	3%
Interior HID	12%	16%
Refrigerated case lighting	22%	2%
Exterior lighting	60%	1%

Survey respondents estimated the likelihood of replacing their current lighting installed in their facility in the next three years with more efficient lighting. Their responses are summarized in Figure 5-1. As shown, customers with interior HID lighting reported that they were most likely to replace it with energy efficient lighting.

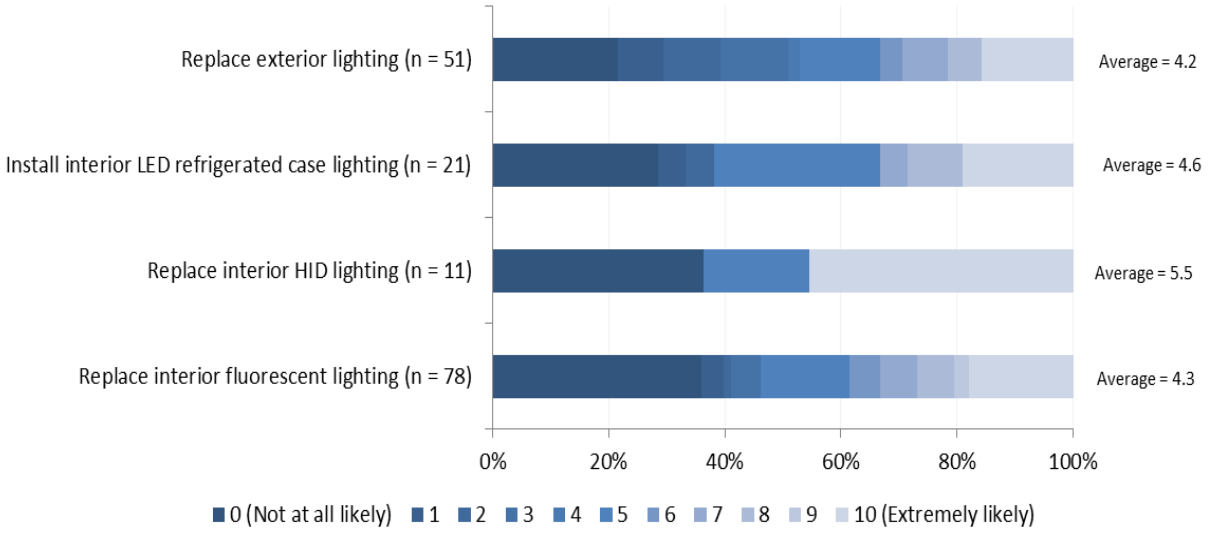


Figure 5-1 Likelihood of Completing Energy Efficient Lighting Upgrades in Next Three Years Regardless of Cost

5.3.2 Organizational Approach to Energy Efficiency

Table 5-4 summarizes customers' reported approaches to energy efficiency. Approximately one-third of survey respondents reported that their organization had been aggressive in their efforts to make their facility as efficient as possible, whereas 48% stated that there was more they could do to save energy.

Table 5-4 Approach to Energy Efficiency

Organizational Approach to Energy Efficiency	*Percent of Respondents*
We don't really pay much attention to energy efficiency.	4%
We try to watch our energy use, but we haven't done much in terms of replacing equipment with more energy efficient equipment.	16%
We have replaced some equipment with more efficient equipment, but we haven't done everything we could to save energy.	48%
We have been aggressive in our efforts to make the facility as energy efficient as possible.	32%
Don't Know	0%
Refused	0%

5.3.3 Incentive Design Preferences

Survey respondents provided likelihoods of participating in a lighting incentive program with varying incentive designs. The results are displayed in Figure 5-2. As shown, respondents were most likely to participate in a direct install program that provided energy efficient lighting equipment at no cost beyond standard lighting equipment. Survey respondents also indicated a relatively high likelihood of participating in a program that offered instant discounts on lighting equipment. In comparison, the average likelihood of participating in a standard rebate program that provides a rebate check for completed projects garnered the lowest average likelihood of participating.

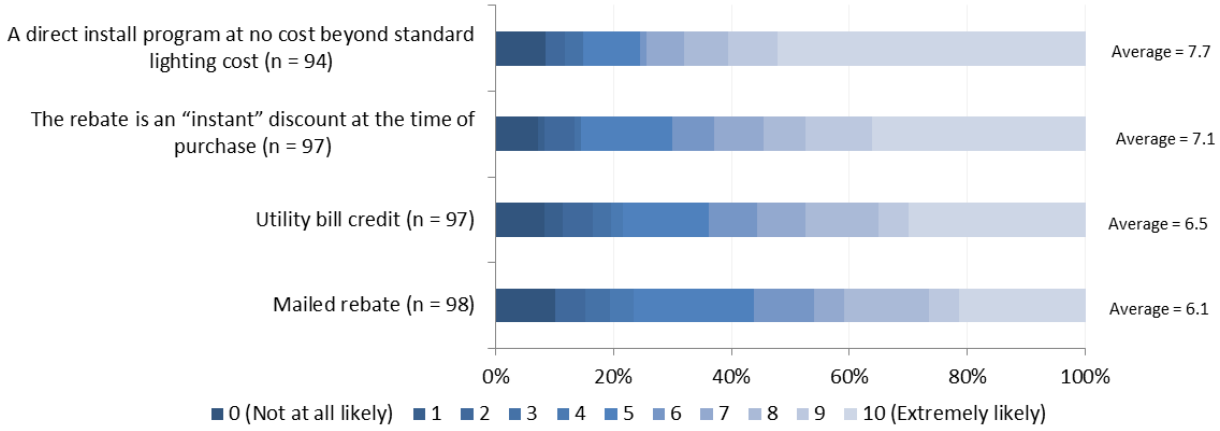


Figure 5-2 Likelihood of Program Participation for Varying Program Designs

5.4 Contractor Interview Findings

ADM completed interviews with a sample of contractors that provide lighting services to businesses in SMUD's service territory. The objective of the interviews was to gain perspective on the market for LED lighting, to assess market barriers to adoption, and to gauge the effectiveness of SMUDs incentive programs for encouraging businesses to adopt energy efficient lighting.

Fifty-five lighting product and service providers working with the Sacramento Municipal Utility District (SMUD) service territory were contacted for an interview. Of those contacted, thirteen refused an interview and twenty-seven could not be reached after multiple e-mail and telephone interview requests. In total, interviews were completed with fifteen contractors.

Contractors contacted represented a diverse collection of product and service providers. Most identified themselves as general lighting and electric services providers. Two contractors specifically identified themselves as installation contractors, and two classified themselves as equipment vendors. Only two contractors claimed to exclusively focus on lighting. Eighty percent of respondents did not report working with any specific business types.

Two-thirds of respondents reported that at least half of their business is comprised of lighting equipment and services. On average, lighting equipment and services represents 76% of business among the contractors contacted. Nine out of 15 contractors work on both new construction and retrofit projects, while the remaining six either specialize in retrofits or did not provide a response. In addition, most contractors reported an emphasis on high-efficiency lighting—only four contractors reported an equal emphasis on high- and standard-efficiency lighting. On average, 92% of the lighting installed by the contacted contractors in the past year has been high-efficiency lighting.

5.4.1 Customer Familiarity with LED Benefits and Costs

Respondents reported a wide variety of effects of the growth of LEDs on their lighting product line. Four contractors reported that the primary focus of their lighting business is selling LED lighting, so while that business is dependent on LED lighting, the growth of LED lighting has not caused their business to change focus. Six respondents reported that the growth of LED lighting has had a positive impact on their lighting business, including one respondent that stated that LEDs have brought the lighting business "back to life." The remaining respondents either did not think that the growth of LED lighting had had a noticeable effect on their lighting product line or did not know if it has impacted their product line.

When discussing customer's prior knowledge of LED costs and benefits, six contractors reported that there is a fair degree of diversity among customers—either some customers are very well-informed while others are not or individual customers may be well-informed about the benefits of LED lighting but not the costs. Five respondents reported that customers are generally well-informed, and two reported that customers are generally not well-informed.

Contractors discussed the aspects of LED lighting cost and benefits that customers are typically not well informed about. Three contractors stated that their customers were well informed and did not note any aspect of LED lighting that customers were not familiar with.

The cost of an LED lighting project was the aspect of LED lighting that contractors most commonly noted their customers are not familiar with. However, other aspects LED lighting that customers are not familiar with that were noted were the longevity of the lamps, the quality of the light, the energy savings, the variety of applications available, and the varying quality of LED lamps and luminaires made by different manufacturers.

5.4.2 Interest in High Efficiency Lighting Measures

Eighty-seven percent of respondents reported a high or very high level of interest in LED lighting among their customers. When asked to consider the degree of customer interest by project type, eight respondents reported that the level of interest in LED lighting does not vary significantly with lighting end use, while four respondents reported that interior lighting applications tend to be the most popular. These responses are summarized in Table 5-5.

Table 5-5 Level of Interest by End-Use Type

Response	*Number of Respondents*
Interest is the same for all end uses	8
Interest in interior lighting is higher	4
Interest in exterior lighting is higher	1
Businesses with longer operating hours are more interested	1

Seven contractors reported that customers do not consistently have a specific application in mind when considering the purchase of LEDs. Three contractors reported that exterior applications, especially parking lots and garages, are generally most popular. Offices and warehouses were other applications of interest to customers.

When asked whether there are any lighting applications that are particularly hard to sell to customers, nine contractors reported that they had encountered no such specific application. The remaining contractors gave varying responses but a common theme was that customers are less interested in higher cost applications. One contractor noted that customers were not interested in projects with payback periods that exceeded three years. One contractor noted that customers are less interested in interior upgrades, while another expressed an opposing view that exterior retrofits were of less interest to customers. Additionally, over the course of the interview, several contractors noted that retrofit applications tend to be more popular than the installation of new fixtures.

Eight contractors reported that customer business type does not significantly influence a customer's likelihood of selecting energy efficient lighting. Those contractors who did claim that some business types are less likely to install energy efficient lighting provided a variety of responses, but the primary underlying reason for disinterest in LED lighting was that particular businesses are not able to afford energy efficient lighting or do not view LED lighting as cost effective.

Some business types that were identified as more likely to install LED lighting were technology companies, large office buildings, gas stations, and warehouses. The most commonly provided explanations as to why these business types are more likely to adopt energy efficient lighting were that high hours of operation and large volumes of light make the potential savings from efficient lighting greater, and some businesses have an intrinsic desire to save energy.

Nine contractors reported that they had encountered customers who opted for non-LED lighting after LED lighting had been recommended. In all cases, the cost of LEDs was the primary factor which persuaded customers to install the less-efficient measure.

5.4.3 Incidence of LED Lighting Recommendations

All respondents reported that they will recommend LED lighting in most, if not all situations. When asked if any particular customer characteristics would dissuade them from recommending LEDs, five said that they would be less inclined to recommend LEDs if the cost was outside the customer's budget or would not be a cost effective project. Related factors noted included not recommending LED when operating hours were short or for specific interior applications where costs are too high.

5.4.4 Customer Decision-Making and Program Incentives

Eight contractors stated that initial costs are a primary factor that their customers consider when deciding whether to install high efficiency lighting. Six contractors also identified the payback period as an important factor, with most noting that customers prefer a payback of less than two years. Other factors that customers consider include overall light quality, rebate amount, and maintenance costs.

Thirteen contractors were aware of the current lighting incentives offered by SMUD, and eleven actively inform customers about the SMUD lighting incentives. Approximately 69% of customers are already aware of the SMUD lighting incentives before discussing them with their contractor, but this number varied significantly from contractor to contractor (25-100%).

Most contractors stated that their customers completing qualifying work also apply for SMUD incentives. However, two contractors reported that qualifying customers sometimes do not apply for SMUD incentives if the project is very small or if they do not want to complete the paperwork.

Nine contractors felt that the SMUD incentives are very effective at motivating customers to pursue high-efficiency lighting options, while three felt that they are somewhat effective and one felt that they are not effective at all. The contractor who felt that the incentives are not effective commented that incentive levels are too low. Figure 5-3 summarizes the contractor's perceptions of effectiveness of incentives.

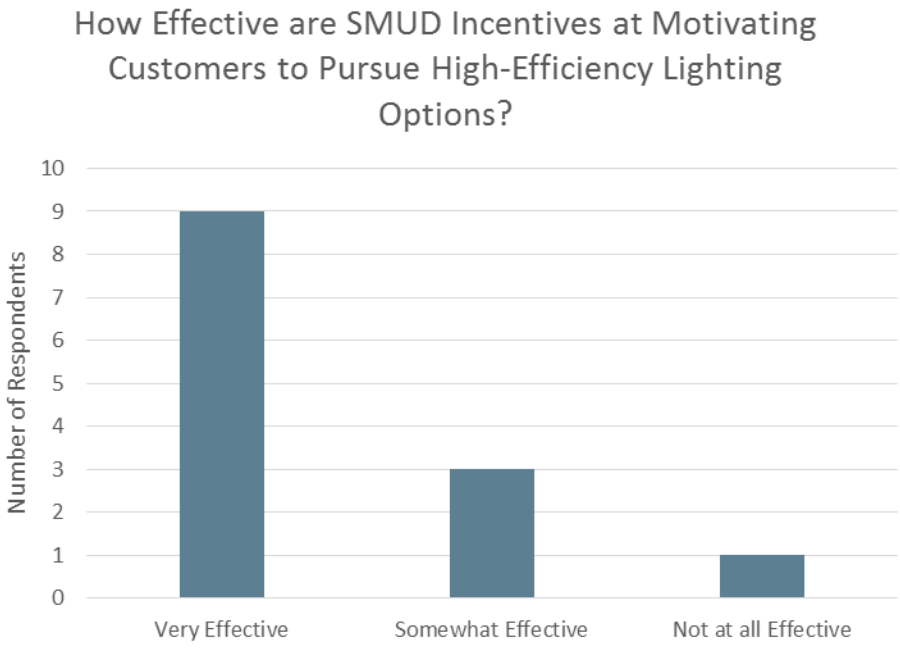


Figure 5-3 Effectiveness of SMUD Incentives

5.4.5 Contractor Recommendations

Contractors provided a wide variety of commentary on and suggestions for improvements in SMUD's lighting rebate programs. Multiple respondents suggested that the rebates were key factors in customer decision making and noted that rebates should be kept as high as possible. Additionally, some contractors provided suggestions for improving the program, as summarized below:

- Prevent unlicensed contractors from participating in the program;
- Improve consistency in outreach to contractors and incentive levels; and
- Allow lamps that qualify on the Lighting Design Lab LED Qualified Products Lists (QPL).

5.4.6 Summary of Findings

The interview responses indicate that contractors are actively promoting LED lighting projects and that there is a high level of interest among the customer base. However, some barriers to completing LED projects were identified. The most commonly identified barrier was the cost of LED lighting. The issue of cost was raised repeatedly by respondents during the interviews.

In addition to costs, some respondents identified that a lack of understanding of the benefits of LED lighting may also present a barrier to customer implementation. Contractors noted that the some customers are not aware of the quality of the light provided by LEDs. Lack of knowledge of lighting quality may particularly impact retailers decisions about lighting because these customers are particularly focused on the quality of light provided by store lighting. The

longevity of the LEDs is another aspect of lighting that customers are not consistently aware of. Moreover, customers may not always account for the savings resulting from reduced replacement costs that result from the longer lifetime of LEDs, as contractors reported initial cost and payback were primary decision factors (as opposed to lifetime costs).

5.5 Market Potential Analysis

This section summarizes the methodology and findings from the analysis of LED nonresidential market potential.

5.5.1 Methodology for Estimating Technical Potential

ADM drew upon multiple data sources to estimate the technical potential for LED lighting. The inputs utilized to model technical potential were as follows:

- Total square feet of building space by facility type;
- Total annual electricity consumption for interior lighting by facility type;
- Total annual electricity consumption for exterior lighting; and
- Share of baseline lighting type present in each facility.

The sources for these inputs and how they were used to estimate potential are described below

5.5.1.1 Annual Electricity Use for Commercial Facility Interior Lighting and Exterior Lighting

The total square feet of space and annual electricity consumption for interior lighting in each building type in SMUD's service territory, was obtained from the California Commercial End-Use Survey (CEUS).[8] Exterior lighting total energy consumption was also obtained from CEUS.

5.5.1.2 Annual Electricity Use for Industrial Facility Lighting

The total square feet of space and annual electricity consumption for industrial facilities was calculated by subtracting total annual electricity consumption for commercial facilities from total nonresidential consumption. To estimate the share of lighting electricity use, the share of energy used by industrial facilities was taken from the California Statewide Commercial Sector Energy Efficiency Potential Study.[9] This study indicated that lighting accounts for 10% of industrial electricity consumption. However, given that the study was published in 2002 and the advancements in lighting efficiency that have occurred since then, ADM assumed that the share of energy used by lighting declined to 9%.

[8] Itron (2006) California Commercial End-Use Survey. Prepared for California Energy Commission

[9] California Statewide Commercial Sector Energy Efficiency Potential Study, California Energy Commission, July 9, 2002, Study ID #SW039A, Final Report, Volume 1 of 2.

5.5.1.3 Annual Electricity Use for Exterior Lighting

The total square feet of space and annual electricity consumption for lighting in each building type in SMUD's service territory was obtained from the California Commercial End-Use Survey (CEUS).[10]

5.5.1.4 Estimation of Technical Potential

The technical potential energy savings from installing LED lighting was developed using energy consumption for five primary lighting types for each building types. For each baseline lighting type, a savings factor that represents the percent reduction in consumption that would occur by switching from that equipment type to LED lighting was developed from data ADM has collected through lighting evaluations it has completed. Table 5-6 presents the savings factors utilized in the analysis.

Table 5-6 Estimated Savings Factors for LED Retrofits

Lighting Type	*Savings Factor*
Incandescent / Halogen	66%
Standard Fluorescent	47%
Compact Fluorescent	35%
High-Intensity Discharge	68%
LED	0%

In addition to the savings factors, the calculation of technical potential utilized data on lighting type saturations obtained from the California Statewide Commercial Sector Energy Efficiency Potential Study[11] (for industrial sites) and data collected through a study of SMUD nonresidential customers completed in 2014.[12]

Technical potential for each facility type and lighting replacement was calculated as follows:

> Technical Potential = Lighting Saturation * Savings Factor * Lighting Electricity Consumption

5.5.2 Methodology for Estimating Achievable Market Potential

The inputs utilized to model of achievable market potential were as follows:

- Technical potential estimates;

[10] Itron (2006) California Commercial End-Use Survey. Prepared for California Energy Commission

[11] IBID.

[12] ADM (2014). Commercial Energy Use in the SMUD Service Territory. Prepared for Sacramento Municipal Utility District (SMUD).

- Expected payback based on hours of operation, electricity rates, and project costs; and
- Take-rates given project payback based on participant survey responses.

Each of these inputs is described in greater detail below.

5.5.2.1 Hours of Operation

Average hours of operation for each building type were estimated from lighting energy use intensity (kWh / square foot) as well as total consumption and total square feet of facility type space in SMUD's service territory for each facility type. Because hours of operation vary across buildings within facility types, ADM modeled variability in hours of operation as normally distributed and derived estimates average of operating hours for buildings in each quartile of the distribution. Table 5-7 displays the hours of operation used in the model for each building type.

Table 5-7 Hours of Operation by Facility Type

Building Type	*Average Hours of Operation*	*First Quartile*	*Second Quartile*	*Third Quartile*	*Fourth Quartile*
All Exterior	3,888	6,805	4,544	3,232	971
Warehouse	4,050	7,088	4,733	3,367	1,012
Small Office	3,242	5,674	3,789	3,367	810
School	3,287	5,752	3,841	2,695	821
Retail	4,755	8,323	5,557	2,732	1,188
Restaurant	5,263	8,760	6,150	3,953	1,315
Refrigerated Warehouse	4,129	7,227	4,825	4,375	1,031
Miscellaneous	3,516	6,154	4,109	3,433	878
Lodging	4,334	7,585	5,065	2,923	1,083
Large Office	4,425	7,745	5,171	3,603	1,105
Health	5,860	8,760	6,848	3,679	1,464
Grocery	7,183	8,760	8,394	4,872	1,794
College	2,671	4,675	3,122	5,972	667
Industrial	4,745	8,305	5,545	2,221	1,185

5.5.2.2 LED Lighting Project Costs

LED lighting costs were derived from program data of LED lighting costs from evaluation work ADM has performed in other jurisdictions as well as projected LED. The evaluation data collected included material and labor costs for a variety of LED lighting retrofits completed during the 2012-2013 period. Projected LED costs were taken from a U.S. Department of Energy LED lighting forecast study.[13]

[13] Navigant Consulting (2014). Energy savings forecast of solid-state lighting in general illumination applications. Prepared for the U.S. Department of Energy.

The projected LED costs were used to estimate LED costs during the next 5 years. LED lighting materials costs are estimated to decrease to 70% between 2013 (the year for the cost data) and 2020.[14] ADM assumed that labor costs would increase by 10% over the same period.

5.5.2.3 Customer Electricity Use Charge

Energy use charges were estimated from data collected by the U.S. Energy Information Administration Form 861. The weighted average retail price paid by commercial and industrial customers was calculated to be $0.117/kWh.

5.5.2.4 Take-Rates for Implementing Energy Efficient Lighting

ADM developed "take rates" for implementing efficient lighting retrofits based on customer responses to questions on the likelihood completing lighting retrofits.

Two key financial criteria that businesses typically consider when evaluating efficiency projects, as noted by contractors interviewed for this study, are the projects initial cost and the payback period for the project. Because of the importance of initial cost and payback considerations, take rates were developed based on responses to the likelihood of completing lighting retrofits under three payback and three initial cost scenarios. For the payback scenarios, customers were asked to estimate the likelihood of completing a lighting retrofit if SMUD offered a rebate that reduced the payback period to five, three, and one years. Similarly, customers were asked to estimate the likelihood of installing efficient lighting if the initial cost was equal to $1.00 per square foot, $0.75 per square foot, and $0.50 per square foot.

The reported likelihood of completing a project under the different scenarios is likely an imperfect measure of what customers would actually do under the proposed scenarios. Research on the relationship between attitudes, stated intentions, and behavior has found that while attitudes and intentions predict behavior, the relationship is imperfect.[15] Moreover, research on energy efficiency program participation has found that customers tend to overestimate their likelihood of participating in efficiency programs when their stated likelihoods are compared to their participation rates.[16]

The survey data collected indicated that a number of respondents may have overestimated the likelihood of completing projects based on the project payback. In particular, a large share of respondents (40%) indicated that there was a 10 in 10 likelihood that they would have completed the project if an incentive was provided that reduced payback to five years. This finding is inconsistent other research that has found that businesses typically look for payback periods of 2

[14] The average cost decline for LED lighting was weighted by the lighting types energy usage in the SMUD service territory.

[15] For example, see Armitage, C. J. and Conner, M. (2001). Efficacy of the Theory of Planned Behavior: A meta analytic review. *British Journal of Social Psychology*, 40, 471-499.

[16] EnerNOC Utility Solutions Consulting (2013). Ameren Illinois Energy Efficiency Market Potential Assessment. Report Number 1404. Volume 2: Market Research

to 3 years for lighting projects.[17] Consequently, a decision was made to drop these responses from the analysis.

Additionally, cases were removed if the respondent provided likelihood estimates that decreased when the payback period was shorter or if the cost per square foot decreased. Given that these responses indicate that the respondent would have been more likely to complete projects with higher initial costs and longer payback periods, it was assumed that the respondent misunderstood the question. Based on this criterion, 13 responses were removed for the payback questions and 14 were removed for the cost per square foot questions.

As previously noted, the take-rates were based on surveys of program participants and may not be representative of all SMUD nonresidential customers. As a check on the generalizability of the take-rates, ADM compared the observed take rates those reported in two other sources. The first study (referred to as EnerNOC 2013 hereafter) is a potential study completed in another jurisdiction that developed take-rates from a sample of nonparticipants[18]. The second (referred to as Siemens 2010 hereafter) is a national survey conducted in 2010, of 910 commercial and industrial decision makers. As shown in Table 5-8, ADM take rates were somewhat higher than those found in other research – especially for long payback periods. This is likely due to differences between program participants and nonparticipants. On the other hand, the data from Siemens 2010 show much higher price sensitivity, and very low take rates for long payback periods. This may be influenced by the timing of the survey – 2010 was the beginning of the slow economic recovery from the great recession. In this study, we calculate the achievable potential using each of the three "take rate curves", but use the curve defined by the average of the three curves for our official potential estimate.

Table 5-8 Comparison of Take Rate Curves

Payback Period	*Take-Rate SMUD Participant Survey (2015)*	*Take-Rate EnerNOC Survey (2013)*	*Take-Rate Siemens Survey (2010)*	*Average Take- Rate*
1 Year	66%	60%	76%	68%
3 Years	56%	49%	37%	47%
5 Years	48%	37%	18%	34%

Figure 5-4 Relationship between Payback and Likelihood of Installing Efficient Lighting

5.5.2.5 Calculation of Achievable Potential

Achievable potential for replacement of each baseline equipment type with LED lighting is calculated as a function of the take rate for a given payback and the technical potential for a given replacement type. Specifically,

[17] McKinsey & Company (2012). Lighting the way: Perspectives on the global lighting market.

[18] EnerNOC Utility Solutions Consulting (2013). Ameren Illinois Energy Efficiency Market Potential Assessment. Report Number 1404 Volume 2: Market Research

Project Payback = (Project Cost – Rebate Amount) / Electricity Cost

Where all quantities are in the numerator calculated in units of $/kWh-year, and the denominator is in units of $/kWh.

The Achievable Potential is the portion of the Technical Potential that may be achieved within SMUD territory at a given incentive level, provided that programs to not exhaust funding. The achievable potential is calculated as the product of the technical potential, the take rate discussed above, and the *LED Market Share*.

Achievable Potential = Technical Potential × Take Rate × LED Market Share

The LED Market Share is the fraction of the market that is likely to correspond to LEDs. This fraction is estimated from the Department of Energy market report on solid state lighting[19]. According to this report, between 2016 and 2020, LED lighting's market share will grow linearly from 7.6% to 35.5%, with an average market share of 21.5% for the period.

5.5.1 Market Potential Findings

This section summarizes findings from the findings from the analysis of technical and achievable market potential.

5.5.1.1 Technical Potential

Table 5-9 displays the estimated technical potential for LED lighting retrofits. As shown, replacement of standard fluorescent lighting with LED lighting represents the largest share of LED technical potential. Additionally, exterior lighting, retail buildings, and large offices represent the largest sources of energy savings from implementing LED lighting.

[19] Energy Savings Potential of Solid-State Lighting in General Illumination Applications, January 2012, Tables 7.5, 7.6, 7.7, 7.8, and 7.9.

Table 5-9 Technical Potential for LED Lighting Retrofits by Building Type and Baseline Equipment Type

Facility Type	*Baseline Equipment Type*					*Total*
	Incandescent / Halogen	*Standard Fluorescent*	*Compact Fluorescent*	*High-Intensity Discharge*	*LED*	
All Exterior	9,655	8,275	1,379	104,822	13,792	137,924
Warehouse	86	10,472	1,062	2,165	181	13,966
Small Office	4,789	19,442	3,164	3,637	398	31,430
School	0	28,333	196	0	173	28,701
Retail	2,403	101,967	0	17,889	2,053	124,311
Restaurant	0	16,313	1,714	0	598	18,625
Refrigerated Warehouse	0	2,390	47	0	49	2,486
Miscellaneous	934	50,900	7,626	4,505	1,596	65,562
Lodging	8,522	5,746	1,037	2,466	606	18,376
Large Office	0	93,149	0	0	789	93,937
Health	769	17,523	4,668	1,178	1,905	26,043
Grocery	0	27,138	0	0	71	27,209
College	7,247	9,557	715	0	396	17,915
Industrial	0	38,002	476	28,249	57	66,784
Total	34,404	429,206	22,084	164,911	22,666	673,270

5.5.1.2 Achievable Potential

ADM calculated achievable potential assuming four different incentive levels, specifically, $0.05, $0.15, $0.25, and $0.35 per kWh saved. For each incentive level, we applied four different take rate curves which relate the likelihood of participation to the simple payback period for lighting retrofits. The curves are summarized in Table 5-8 and shown in Figure 5-5 below.

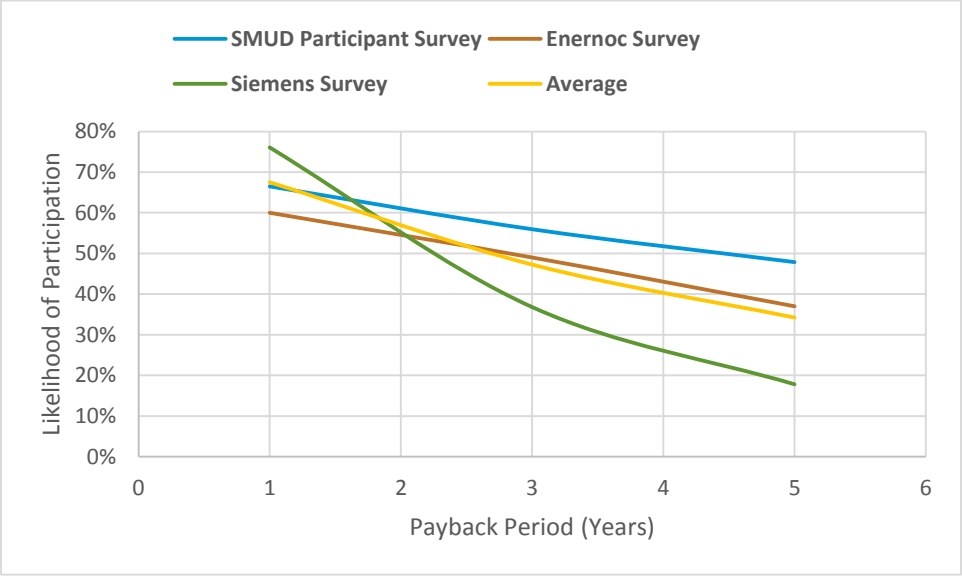


Figure 5-5 Comparison of four "take rate" curves derived from surveys and secondary data.

Table 5-10 summarizes the achievable potential for the four incentive rates. Total achievable potential for 2016 to 2020 ranges from 43,954 MWh to 63,327 MWh. Our best estimate, using the average take rate curve, and the average of the four rebate levels[20] is 51,970 MWh over the five-year period, or an annualized savings of 10,394 MWh. For comparison purposes, the ex post gross savings achieved through the prescriptive lighting program during the 2012-2013 period was approximately 14,000 MWh per year. Of course, the program included all lighting types, not just LEDs.

Table 5-10 Achievable Potential under Different Incentive Scenarios

Rebate Level	*SMUD Participant Survey Take-Rate (MWh)*	*Enernoc Survey Take-Rate (MWh)*	*Siemens Survey Take-Rate (MWh)*	*Average Take-Rate*
$0.05 / kWh	53,311	44,688	27,153	39,383
$0.15 / kWh	60,003	50,954	36,883	47,648
$0.25 / kWh	66,715	57,080	48,639	56,170
$0.35 / kWh	73,277	63,219	63,140	64,677
Average	63,327	53,985	43,954	51,970

5.5.1.2.1 Achievable Potential by Building Operating Hours

Figure 5-6 displays achievable potential for buildings with operating hours in the top, top middle, bottom middle, and bottom quartile of operating hours. As shown, buildings with operating hours in the top quartile account for 63% of the achievable potential.

[20] The average of the four rebate levels is $0.20/kWh, which is similar to the average rebate levels for the 2012 and 2013 programs.

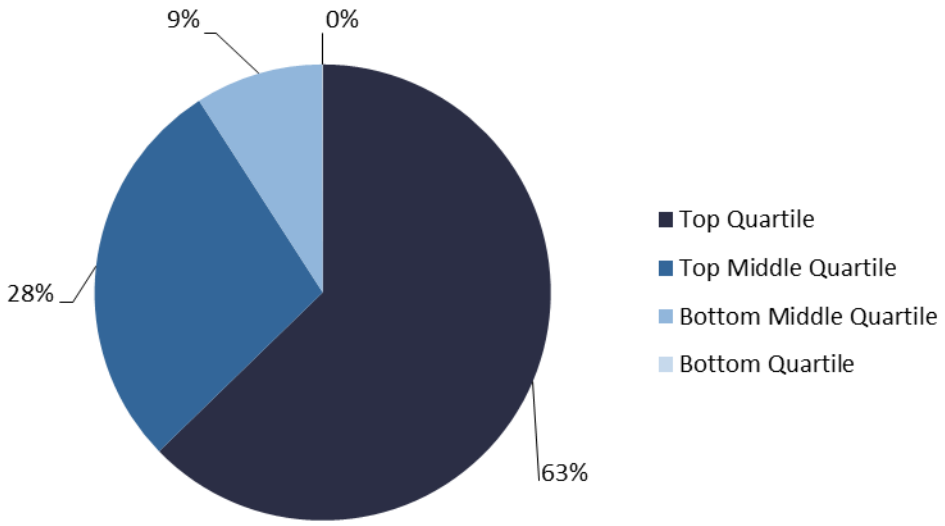


Figure 5-6 Share of Achievable Potential by Operating Hours Quartile (Incentives at $0.15 / kWh)

Achievable potential by hours of operation quartile and incentive level is shown in Figure 5-7. As shown, operating hours has a large impact on total achievable potential than incentive levels.

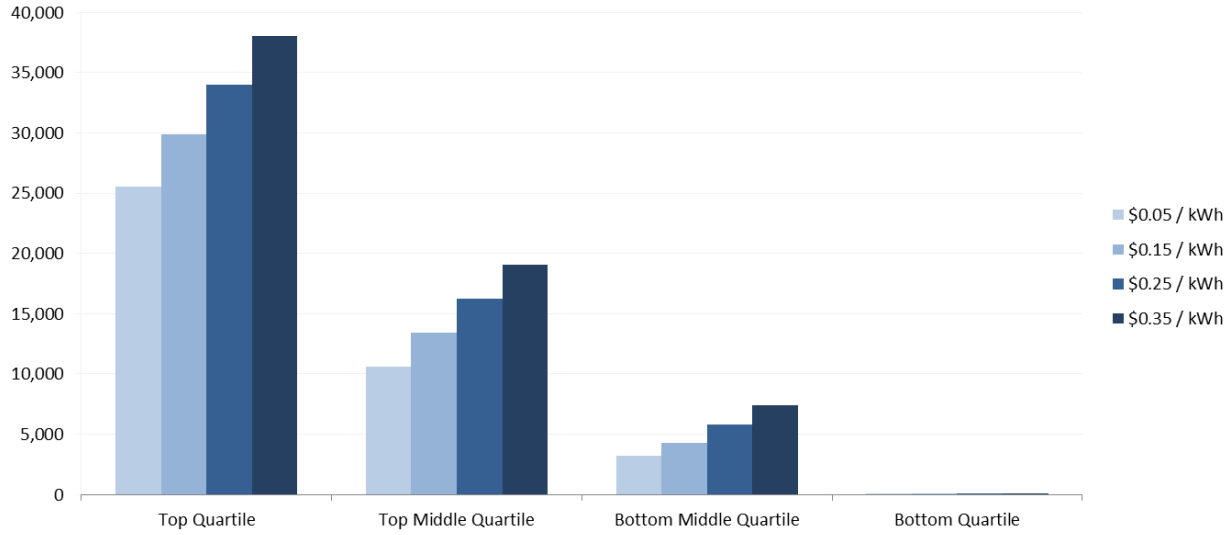


Figure 5-7 Achievable Potential for by Operating Hours Quartile and Incentive Level

5.5.1.2.2 Achievable Potential by Baseline Lighting Equipment Type

The achievable energy saving potential from installing LED lighting is displayed by baseline equipment type. One-half of the energy savings potential for LED lighting comes from replacing

standard fluorescent lighting. A negligible share of potential energy savings comes from replacement of compact fluorescent lamps.

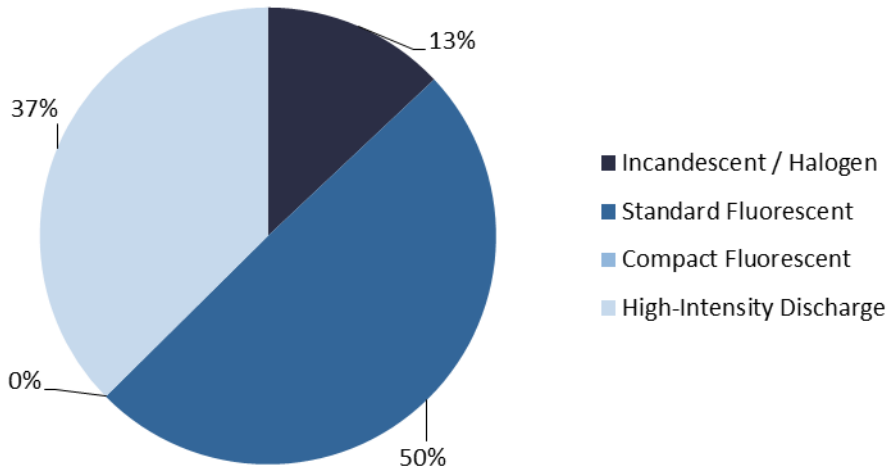


Figure 5-8 Share of Achievable Potential by Baseline Equipment Type (Incentives at $0.15 / kWh)

As shown in Figure 5-9, achievable potential for standard fluorescent lighting replacement increases more rapidly with higher incentives than replacement of incandescent, halogen, and HID lighting. Specifically, the achievable potential under the highest incentive scenario is 82% greater than the under the lowest for standard fluorescent lighting replacements. In comparison, the achievable potential for HID lighting and incandescent / halogen lighting increases by 57% and 23%, respectively.

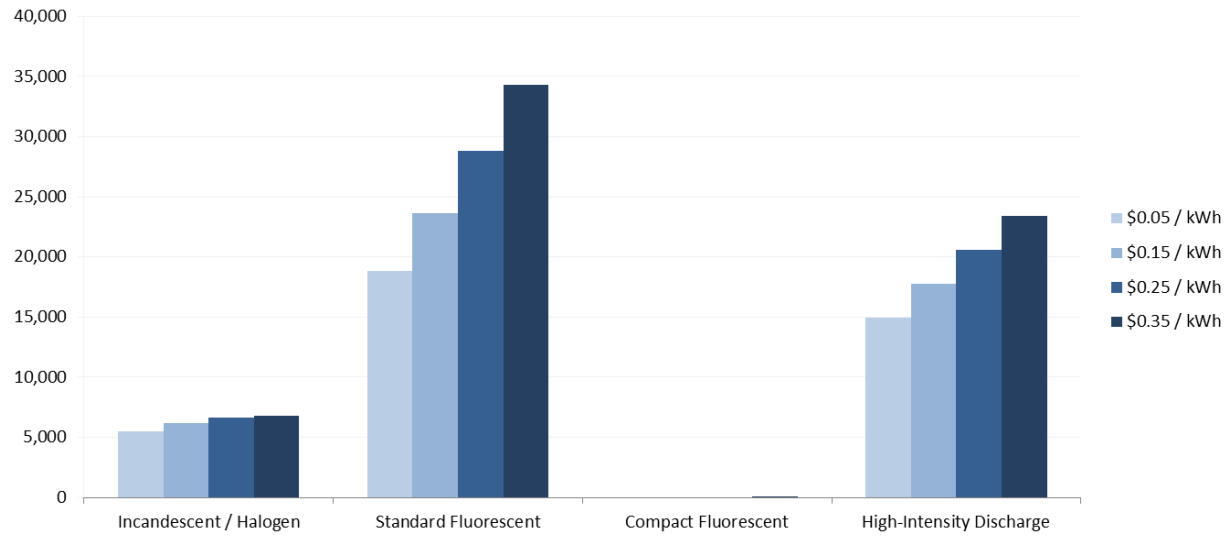


Figure 5-9 Achievable Potential by Baseline Lighting Equipment Type and Incentive Level

5.5.1.2.3 Achievable Potential by Facility Type

Exterior lighting applications and interior lighting in retail, large office, and industrial facilities account for approximately two-thirds of the total achievable potential. The large share of achievable potential for these facility types is largely a function of the available technical potential.

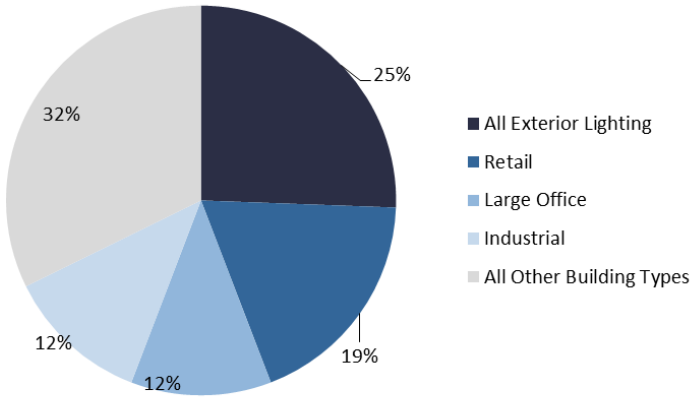


Figure 5-10 Share of Achievable Potential by Facility Type (Incentives at $0.15 / kWh)

Figure 5-11 displays the achievable potential by baseline equipment type for the facility types with the greatest potential electricity savings.

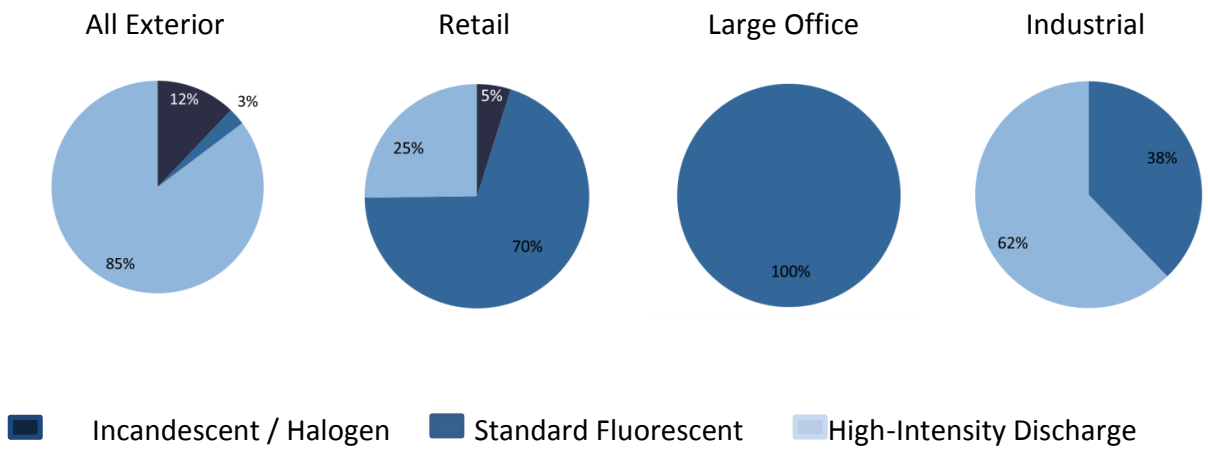


Figure 5-11 Achievable Potential by Baseline Type for Facility Types with Greatest Potential

Figure 5-12 displays achievable potential by building type and incentive level.

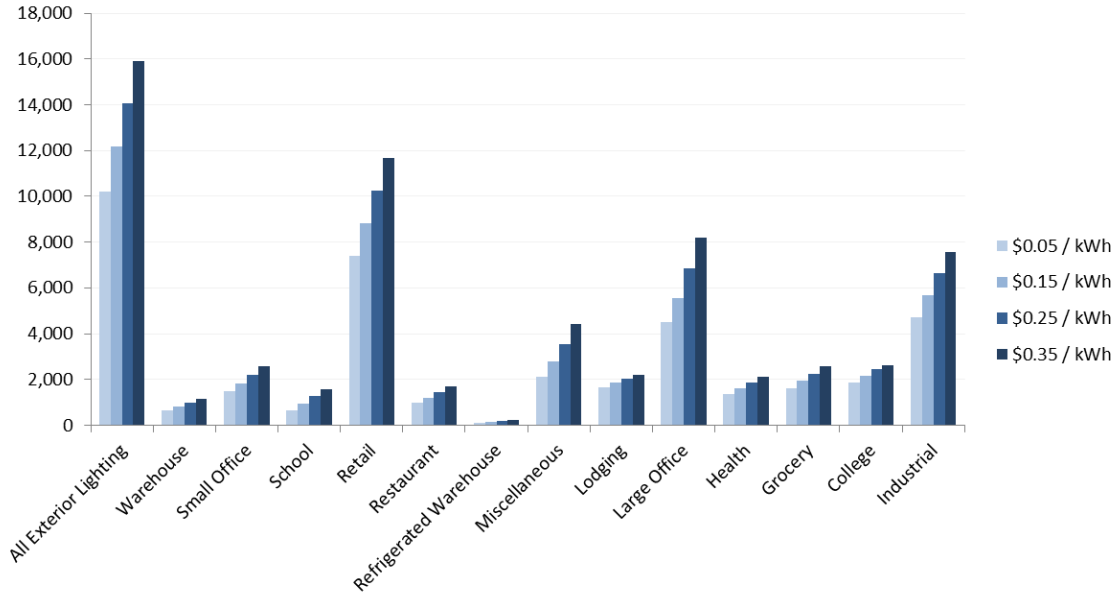


Figure 5-12 Achievable Potential by Facility Type and Incentive Level

5.6 Conclusions and Recommendations

The key findings from the assessment of market potential are summarized below. The study findings are followed by a discussion of program strategy options to maximize energy savings through LED lighting.

5.6.1 Market Potential Findings

The findings from the assessment of market potential for LED lighting are summarized below:

- The estimated technical potential for LED lighting in the nonresidential sector is 673,270 MWh. Depending on the incentive level, achievable potential is estimated to be approximately 8% of technical potential (51,970 MWh).[21] In comparison, two years of operation for the current standard lighting incentive program – *inclusive of all lamp types and not just LEDs* - generated approximately 28,000 MWh of energy savings. Consequently, the analysis indicates that amount energy savings potential from LED lighting applications is greater than what could be funded through the total program budget.
    - The largest share of achievable potential is from replacement of standard fluorescent lighting with LED lighting.
    - The 25% of facilities, within each facility type, with the longest operating hours account for more than one-half of the achievable potential because these buildings have the greatest technical potential and the shortest payback periods for LED lighting retrofits.
    - Exterior applications and retail, large office, and industrial buildings account for approximately two-thirds of the achievable potential. For exterior applications, replacement of high-intensity discharge lighting accounts for most of the potential electricity savings. Replacement of standard fluorescent lighting accounts for the majority of potential energy savings in retail and large office facilities. Standard fluorescent and high-intensity discharge applications account for approximately equal shares of lighting potential in industrial facilities.
- Additional findings support the conclusion that there is significant potential for LED lighting savings.
    - A relatively small share of businesses in SMUDs service territory participated in the program during the 2012-2013 program year (1.3%). Although on par with penetration rates found for other programs, this finding indicates that there are numerous businesses that have not been reached through the existing program and may be induced to complete retrofits.
    - Interviewed contractors reported that there was a high level of interest in LED lighting among their customer base and that they often recommend LED lighting solutions.
- The key challenges faced in achieving energy savings through LED applications are as follows:

[21] Calculated as the average potential for the four incentive scenarios.

- The relatively higher cost of LED lighting presents a barrier to implementation. LED lamps remain more expensive than other technologies and even with recent declines can have longer payback periods, particularly in applications with relatively lower hours of use. Furthermore, contractors noted that payback and initial cost are key criteria that customers use to make decisions about project.
- Contractors noted that while most customers are aware of and interested in LED lighting, some are not aware of all of the benefits such as longer life times and the quality of light.

5.6.2 Options for Maximizing Savings through LED Lighting Applications

SMUD has multiple strategy options for maximizing achieved savings through LED lighting replacements.

- **Provide more aggressive lighting incentives for all LED options.** Higher levels of incentives reduce the first cost and payback period for LED lighting retrofits. Offering incentives of $0.35 per kWh saved, as compared to $0.05 per kWh saved, the program can increase the achievable potential by 64%.
- **Target LED retrofits of standard fluorescent lighting.** Retrofits of standard fluorescent lighting with LED lamps and fixtures accounts for the largest share of achievable savings from the application of LED lighting. Additionally, achievable potential from standard fluorescent lighting replacements is increased to a greater extent through increased incentives than is the case for replacement of incandescent/ halogen or HID lighting. Increasing incentives from $0.10 per kWh saved to $0.25 per kWh saved increases achievable potential for standard fluorescent replacements by 21% as compared to 9% and 16% for incandescent / halogen and HID lighting, respectively. Consequently, providing higher incentives for standard fluorescent replacements than for other LED replacements, along with targeted education and outreach, may be an effective means for maximizing LED lighting potential.
- **Target buildings with longest hours of operations.** Hours of operation have a large impact on both technical and achievable potential. ADM estimates that the 25% of buildings with the longest hours of operation comprise 57% of the total achievable potential. These facilities could be identified through analysis of hourly use data and targeted for special outreach efforts to generate energy savings through the application of LED lighting.
- **Consider alternative program designs to standard rebates.** Survey respondents indicated that they were more likely to participate in midstream discount programs or direct install programs than in a standard mail in rebate program. Midstream programs can be effective means of providing incentives because they take advantage of existing relationships between distributors and contractors, as well as end-users. A recent evaluation of a pilot program offered by Pacific Gas and Electric found that the midstream LED discounts were effective and it was recommended that the program be

continued.[22] Direct install programs for small businesses that offer relatively high incentives are typically effective at reaching these harder to reach customers. Additionally, because of the "high-contact" aspect that typifies these programs, a small business program provides an opportunity to provide enhanced education on the benefits of LED lighting.

- **Target high impact facility types.** Program efforts could target efforts towards exterior applications and retail, large office, and industrial facilities. Targeting could be accomplished through targeted outreach performed by large account representatives, working with contractors that provide services to these facility types, or by offering program designs that are effective for reaching these businesses. For example, midstream discounts may be a particularly effective means of reaching small and large retail customers. An evaluation of a midstream LED lighting discount program found that a disproportionately large share of sales for small and large single story retailers were made through the midstream discount program as compared to the downstream and direct install programs.[23]

[22] Evergreen Economics, Inc. (2015). Pacific Gas and Electric Company's Lighting Innovation Midstream Trial Evaluation. Final Report. Prepared for the Pacific Gas and Electric Company.

[23] IBID.

6. Conclusions and Recommendations

6.1 Conclusions

ADM's conclusions from the persistence study are as follows:

- There was a high variability in the accuracy of the rebate forms. Less than scrupulous contractors inflated installed quantities or exaggerated hours on the forms to increase the rebate amount. Other contractors submitted rebate forms that were accurate to the project as installed at the facility.

ADM's conclusions from the survey of customer satisfaction are as follows:

- Overall, the prescriptive program is operating well for most customers. Customers were largely satisfied with their experience the program and few noted any issues with the participation process. The following points below summarize the key findings from the survey of customer satisfaction:
    - Few customers identified issues with the application process. A clear majority of customers reported that the application process was clear and only one customer noted any difficulty completing or submitting the application.
    - Most customers that had contact with program staff during the course of participating were satisfied with those interactions.
    - Only 3% of customers reported any dissatisfaction with the contractor they worked with.
- Ninety-two percent of customers were satisfied with the program overall. The aspect of the program that the largest share of customers noted any dissatisfaction was the time to receive the rebate. However, only 5% of customers were dissatisfied with this aspect of the program

ADM's conclusions from the assessment of LED lighting market potential are as follows:

- The estimated technical potential for LED lighting in the nonresidential sector is 673,270 MWh. Depending on the incentive level, achievable potential is estimated to be approximately 8% of technical potential (51,970 MWh).[24] In comparison, two years of operation for the current standard lighting incentive program – *inclusive of all lamp types and not just LEDs* - generated approximately 28,000 MWh of energy savings. Consequently, the analysis indicates that amount energy savings potential from LED lighting applications is greater than what could be funded through the total program budget.

[24] Calculated as the average potential for the four incentive scenarios.

  - The largest share of achievable potential is from replacement of standard fluorescent lighting with LED lighting.
  - The 25% of facilities, within each facility type, with the longest operating hours account for more than one-half of the achievable potential because these buildings have the greatest technical potential and the shortest payback periods for LED lighting retrofits.
  - Exterior applications and retail, large office, and industrial buildings account for approximately two-thirds of the achievable potential. For exterior applications, replacement of high-intensity discharge lighting accounts for most of the potential electricity savings. Replacement of standard fluorescent lighting accounts for the majority of potential energy savings in retail and large office facilities. Standard fluorescent and high-intensity discharge applications account for approximately equal shares of lighting potential in industrial facilities.

- Additional findings support the conclusion that there is significant potential for LED lighting savings.
  - A relatively small share of businesses in SMUDs service territory participated in the program during the 2012-2013 program year (1.3%). Although on par with penetration rates found for other programs, this finding indicates that there are numerous businesses that have not been reached through the existing program and may be induced to complete retrofits.
  - Interviewed contractors reported that there was a high level of interest in LED lighting among their customer base and that they often recommend LED lighting solutions.
- The key challenges faced in achieving energy savings through LED applications are as follows:
  - The relatively higher cost of LED lighting presents a barrier to implementation. LED lamps remain more expensive than other technologies and even with recent declines can have longer payback periods, particularly in applications with relatively lower hours of use. Furthermore, contractors noted that payback and initial cost are key criteria that customers use to make decisions about project.
  - Contractors noted that while most customers are aware of and interested in LED lighting, some are not aware of all of the benefits such as longer life times and the quality of light.

6.2 Recommendations

ADM's recommendations based on the persistence study include:

- **Conduct post-inspections for all projects with large savings claims.** Generally the largest projects (expected savings with over 200,000 kWh) were installed as described on the rebate forms. Post-inspections conducted within a few weeks after the project is installed to record actual quantities and installation locations would improve the accuracy of program-wide expected savings estimates. It would also be helpful to future evaluators that will inspect projects several years after their installation.
- **Require invoices of lighting fixtures to be submitted with rebate forms**. There was a high level of uncertainty about quantities and fixture types installed at facilities. Without invoices, the evaluators were unable to match the exact fixture models with what was found as installed on site. Requiring invoices to be submitted along with rebate forms would also help reduce the inflation of quantity of fixtures by contractors on rebate forms.
- **Update rebate form for multiple areas with different hours of use.** The rebate form could include an algorithm for applying different hours of use to different areas. For example, rebate forms for hotels most often used the maximum hours allowed (8,736) in the form. This would be appropriate for lighting retrofits that occurred in hotel common areas. However, ADM verified on-site that most fixtures installed at hotels and motels were located in guest rooms, which have far fewer hours of use. Thus, the rebate forms had inflated hours of use, upping the rebate amount. It would be possible to include a few hours of use inputs on future rebate forms that could be used for installations occurring in different areas of use in a facility.

SMUD has multiple strategy options for maximizing achieved savings through LED lighting replacements.

- **Provide more aggressive lighting incentives for all LED options.** Higher levels of incentives reduce the first cost and payback period for LED lighting retrofits. Offering incentives of $0.35 per kWh saved, as compared to $0.05 per kWh saved, the program can increase the achievable potential by 64%.
- **Target LED retrofits of standard fluorescent lighting.** Retrofits of standard fluorescent lighting with LED lamps and fixtures accounts for the largest share of achievable savings from the application of LED lighting. Additionally, achievable potential from standard fluorescent lighting replacements is increased to a greater extent through increased incentives than is the case for replacement of incandescent/ halogen or HID lighting. Increasing incentives from $0.10 per kWh saved to $0.25 per kWh saved increases achievable potential for standard fluorescent replacements by 21% as compared to 9% and 16% for incandescent / halogen and HID lighting, respectively. Consequently, providing higher incentives for standard fluorescent replacements than for other LED

replacements, along with targeted education and outreach, may be an effective means for maximizing LED lighting potential.

- **Target buildings with longest hours of operations.** Hours of operation have a large impact on both technical and achievable potential. ADM estimates that the 25% of buildings with the longest hours of operation comprise 57% of the total achievable potential. These facilities could be identified through analysis of hourly use data and targeted for special outreach efforts to generate energy savings through the application of LED lighting.
- **Consider alternative program designs to standard rebates.** Survey respondents indicated that they were more likely to participate in midstream discount programs or direct install programs than in a standard mail in rebate program. Midstream programs can be effective means of providing incentives because they take advantage of existing relationships between distributors and contractors, as well as end-users. A recent evaluation of a pilot program offered by Pacific Gas and Electric found that the midstream LED discounts were effective and it was recommended that the program be continued.[25] Direct install programs for small businesses that offer relatively high incentives are typically effective at reaching these harder to reach customers. Additionally, because of the "high-contact" aspect that typifies these programs, a small business program provides an opportunity to provide enhanced education on the benefits of LED lighting.
- **Target high impact facility types.** Program efforts could target efforts towards exterior applications and retail, large office, and industrial facilities. Targeting could be accomplished through targeted outreach performed by large account representatives, working with contractors that provide services to these facility types, or by offering program designs that are effective for reaching these businesses. For example, midstream discounts may be a particularly effective means of reaching small and large retail customers. An evaluation of a midstream LED lighting discount program found that a disproportionately large share of sales for small and large single story retailers were made through the midstream discount program as compared to the downstream and direct install programs.[26]

[25] Evergreen Economics, Inc. (2015). Pacific Gas and Electric Company's Lighting Innovation Midstream Trial Evaluation. Final Report. Prepared for the Pacific Gas and Electric Company.

[26] IBID.

7. Appendix A: Data Collection Form

Commercial Lighting Monitoring Form

Date Installed _____ Time _____

Business Name:_____ Contact Person: _____ ID: _____

Address: _____ City: _____ State: CA _____

LIGHTING LOGGERS:

Logger #	Loggers SN	Area	Conditioned space	Location Of Logger	Fixture Type	Lamps Switched	Removal Date	Removal Time
1								
2								
3								
4								
5								
6								
7								

Notes:

_____

_____

8. Appendix B: Customer Satisfaction Survey Form

RESPONDENT SCREENING

Hello, my name is _____ with _____. I am calling on behalf of SMUD's Commercial Prescriptive Lighting Program that [BUSINESS NAME] participated in.

May I speak with [CONTACT NAME]?

[IF NEEDED: This is regarding your businesses participation in SMUD's Commercial Prescriptive Lighting Program. Your business received a rebate for installing energy efficient lighting equipment through the program.]

[IF NO] Is there someone else who would be better for us to contact?

1 Yes [COLLECT CONTACT INFORMATION AND REPEAT WITH NEW CONTACT]
2 No [TERMINATE]

[WHEN PERSON GETS ON THE LINE] According to our records your business received a rebate for installing energy efficient lighting equipment at a facility located at [ADDRESS] in [YEAR].

I would like to speak with you about your participation and your businesses' decisions about lighting. Is this a good time to talk?

1No [SCHEDULE AND CALL BACK]

2Yes [CONTINUE WITH INTERVIEW]

(IF NEEDED: UTILITY CONTACT

Thomas Adkins

Email: Thomas.Adkins@smud.org

Phone: (916)732-6586)

RESPONDENT BACKGROUND AND FIRMOGRAPHICS

1. Thank you. First, what is your job title?
   1 (Facilities Manager)
   2 (Energy Manager)
   3 (Other facilities management/maintenance position)
   4 (Chief Financial Officer)

5 (Other financial/administrative position)
6 (Proprietor/Owner)
7 (President/CEO)
97 (Other (Specify))
99 (Refused)

2. How did you learn of the SMUD Commercial Prescriptive Lighting Program?
1 (Approached directly by SMUD Staff)
2 (Received an information brochure on the Prescriptive Lighting Program)
3 (Emailed by SMUD)
4 (The SMUD website)
5 (Friends or colleagues (i.e., word of mouth))
6 (An architect, engineer or energy consultant)
7 (An equipment vendor or building contractor)
8 (Internet search or advertisement)
9 (Past experience with the program)
10 (Or some other way) [RECORD VERBATIM]
98 (Don't know)
99 (Refused)

ATTITUDES TOWARD ENERGY EFFICIENCY

3. Now I have some questions about your organization's approach to energy efficiency and energy efficient lighting. Which of the following statements best describes your organizations approach to implementing energy efficiency improvements at this facility?
1 We don't really pay much attention to energy efficiency.
2 We try to watch our energy use, but we haven't done much in terms of replacing equipment with more energy efficient equipment.
3 We have replaced some equipment with more efficient equipment, but we haven't done everything we could to save energy.
4 We have been aggressive in our efforts to make the facility as energy efficient as possible.
98 (Don't know)
99 (Refused)
4. Does your facility have any of the following types of lighting?
[RECORD 1 = Yes, 2 = No, 98 = Don't know, 99 = Refused]
a. Interior fluorescent lighting
b. Interior high intensity discharge lights
c. Refrigerated cases with lighting
d. Exterior lighting

LIGHTING PROJECT PLANS

5. I would like to know if your organization is planning to replace any existing lighting with energy efficient lighting at this location in the next three years, regardless of whether or not there are any rebates available to reduce the cost of equipment. Using a scale of 0 to 10

where 0 is "not at all likely" and 10 is "extremely likely," in the next three years, how likely is your organization to:

[RECORD 0 -10, 98 = Don't know, 99 = Refused]

a. **[ASK IF Q4a = 1]** Replace interior fluorescent lighting with more efficient lighting
b. **[ASK IF Q4b = 1]** Replace interior high intensity discharge lights with more efficient lighting
c. **[ASK IF Q4c = 1]** Install LED refrigerated case lighting
d. **[ASK IF Q4d =1]** Replace exterior lighting with more efficient lighting

LIKELIHOOD OF INSTALLING ENERGY EFFICIENT LIGHTING

6. Using a scale of 0 to 10 where 0 means "not at all important" and 10 means "extremely important," how important are the following considerations to your organization's decisions about upgrading its lighting?

   1 [RECORD 0 – 10]
   98 (Don't Know/Not Applicable)
   99 (Refused)

   a. Initial Project Cost
   b. Project Simple Payback Period or Return on Investment
   c. An improvement in the quality of light provided by the fixtures (such as color rendition or general aesthetics)
   d. Reduction in time and effort required to re-lamp lights that may burn out

7. Now, please assume that SMUD offered a rebate to replace some of your lighting with more energy efficient lighting that would reduce your energy costs. Because this rebate would reduce the initial cost of the lighting, it would take less time for your organization to save enough money on electricity costs to cover the initial cost of installing the efficient lighting.

   Assume that SMUD could provide a rebate that meant your organization would save enough money on electricity costs to pay for the cost of installing energy efficient lighting in **5 years.** Using a scale of 0 to 10 where 0 means "not at all likely" and 10 means "extremely likely," how likely is it that you would replace some of the lighting in this facility?

   1 [RECORD 0 – 10]
   2 (Don't know)
   3 (Refused)

[ASK Q8 if Q7 < 10]

8. Now, assume that SMUD offered a rebate that meant your organization would save enough money on electricity costs to pay for the cost of installing energy efficient lighting in **3 years**. Using the same 0 to 10 scale, how likely is it that you would replace some of the lighting in this facility?

   1 [RECORD 0 – 10]

2 (Don't know)
3 (Refused)

[ASK Q8 if Q7 < 10]

9. Now, assume that SMUD offered a rebate that meant your organization would save enough money on electricity costs to pay for the cost of installing energy efficient lighting in 1 year. Using the same 0 to 10 scale, how likely is it that you would replace some of the lighting in this facility?
   1 [RECORD 0 – 10]
   2 (Don't know)
   3 (Refused)

10. We understand that the initial project cost may matter to decisions about replacing lighting with more efficient lighting. Assume that with a rebate from SMUD the cost of installing the energy efficient lighting was $1.00 per square foot. Using a scale of 0 to 10 where 0 means "not at all likely" and 10 means "extremely likely," how likely is it that you would replace some of the lighting in this facility?
    1 [RECORD 0 – 10]
    2 (Don't know)
    3 (Refused)

[ASK Q11 if Q10< 10]

11. Now assume that with a rebate from SMUD the cost of installing the energy efficient lighting was $0.75 per square foot. Using the same 0 to 10 scale how likely is it that you would replace some of the lighting in this facility?
    1 [RECORD 0 – 10]
    2 (Don't know)
    3 (Refused)

[ASK Q12 if Q11 < 10]

12. Now assume that with a rebate from SMUD the cost of installing the energy efficient lighting was $0.50 per square foot. Using the same 0 to 10 scale how likely is it that you would replace some of the lighting in this facility?
    1 [RECORD 0 – 10]
    2 (Don't know)
    3 (Refused)

13. We know the amount of the rebate provided to you might not be the only thing that matters to decisions about replacing lighting with more efficient lighting. For this reason we would like to understand how other factors might impact your decision to install energy efficient lighting.

First, using the same 0 to 10 point scale, please tell me how likely would be to install energy efficient lighting if you received a rebate and that would save enough energy in 3 years to pay for the cost of installing the energy efficient lighting, under the following program types:

[RECORD 0 – 10, 98 = Don't know, 99 = Refused]

a. The rebate is mailed to you in the form of a check after you submit a rebate application to SMUD
b. The rebate is credited to your utility bill once you submit an application
c. The rebate is an "instant" rebate that is applied as a discount at the time of purchase
d. A program representative would come to your facility and install the lights at no cost to you beyond what it would cost to install standard efficiency lights

14. Thank you for that information. Now I have a few questions about the project you completed through the program. Did a contractor install the lighting equipment that you received a rebate for or did your company self-install the equipment?
    1 Contractor installed the equipment
    2 Self-installed
    98 (Don't know)
    99 (Refused)

15. Had you previously worked with the contractor that installed the equipment?
    1 Yes
    2 No
    98 (Don't know)
    99 (Refused)

16. Did the contractor promote the SMUD rebates?
    1 Yes
    2 No
    98 (Don't know)
    99 (Refused)

17. Did you work on completing the application for the lighting project equipment that you received a rebate for?
    1 Yes
    2 No
    98 (Don't know)
    99 (Refused)

[ASK Q18 IF Q17 = 1]

18. Thinking back to the application process, please rate the clarity of information on how to complete the application using a scale where 1 means not at all clear and 5 means completely clear.
    1. [RECORD 1 – 5]

98 (Don't Know)
99 (Refused)

[ASK Q 18 ONLY IF Q18< 4]

19. What information, including instructions on forms, needs to be further clarified?
1. [RECORD VERBATIM]
1 [RECORD VERBATIM]
98 Don't know
99 Refused

[ASK Q20 IF Q17 = 1]

20. Did you have any difficulty completing or submitting your application?
1 Yes
2 No
98 Don't know
99 Refused

[ASK Q21 IF Q20 = 1]

21. What difficulty did you have with completing the program application?
1 [RECORD VERBATIM]
98 Don't know
99 Refused

[ASK Q22 IF Q17 = 1]

22. Did you have a clear sense of whom you could go to for assistance with the application process?
1 Yes
2 No
98 Don't know
99 Refused

23. How did the incentive amount compare to what you expected? Would you say…
1 It was much less
2 It was somewhat less
3 It was about the amount expected
4 It was somewhat more
5 It was much more
98 (Don't know)
99 (Refused)

24. In the course of doing this project did you have any interactions with program staff?

1 Yes
2 No
98 (Don't Know/Not Applicable)
99 (Refused)

25. Using a scale where 1 means not at all satisfied and 5 means very satisfied, how satisfied are you with:
1 [RECORD 1 – 5]
98 (Don't Know/Not Applicable)
99 (Refused)

a. [ASK IF Q24 = 1] how long it took program staff to address your questions or concerns
b. [ASK IF Q24 = 1] how thoroughly they addressed your question or concern
c. the equipment that was installed
d. [ASK IF Q14= 1] the quality of the installation
e. the energy efficient lighting that was installed through the program
f. the steps you had to take to get through the program
g. the amount of time it took to get your rebate or incentive
h. the range of lighting equipment that qualifies for incentives
i. the program overall

[ASK IF ANY IN Q25 <3]

26. Please describe the ways in which you were dissatisfied with the program/
1 [RECORD VERBATIM]
98 (Don't know)
99 (Refused)

27. What is the total square footage of the interior building space where the lighting project was completed?
1 [RECORD SQUARE FEET]
98 (Don't know)
99 (Refused)

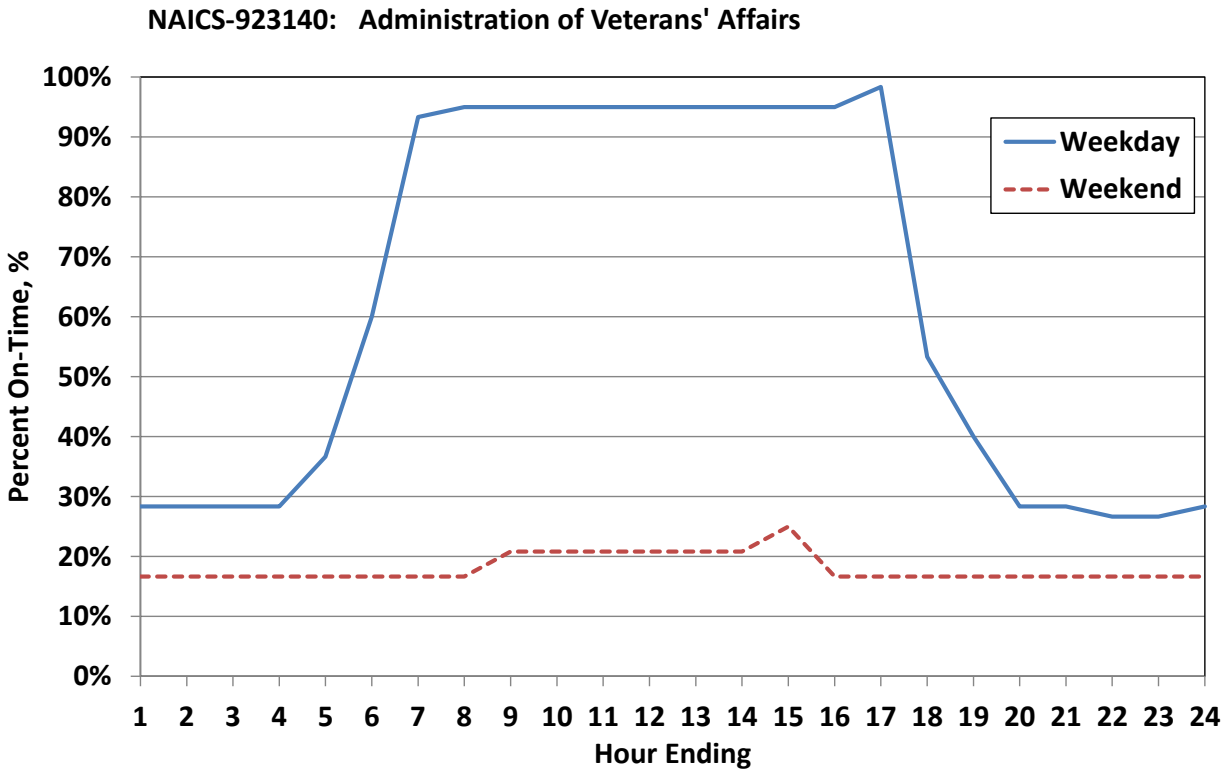
[ASK Q28 IF Q27 = 98]

28. We understand that you are not sure. What is your best guess for how large it is? Would you say…
1 Less than 5,000 square feet
2 Between 5,000 and 25,000 square feet
3 More than 25,000 square feet to 50,000 square feet
4 More than 50,000 square feet to 100,000 square feet
5 More than 100,000 square feet to 500,000 square feet
6 More than 500,000 square feet to 1 million square feet
7 More than 1 million square feet
98 (Don't know)

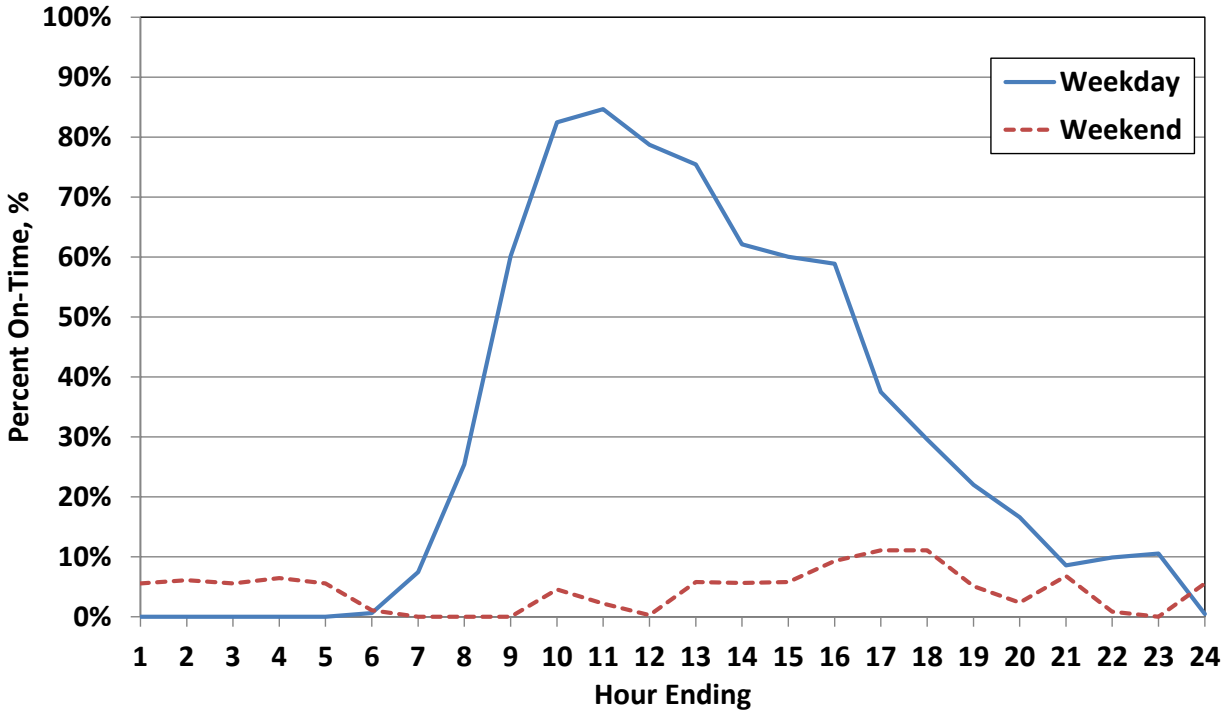
99 (Refused)

29. What is the type of work that your firm or organization does at this facility?
1 (Assisted living or nursing facility)
2 (College/University)
3 (Elementary School)
4 (Grocery)
5 (Healthcare Clinic)
6 (Industrial / Manufacturing)
7 (High School/Middle School)
8 (Hospital)
9 (Lodging/Hotel/Motel)
10 (Medical)
11 (Office)
12 (Public assembly (convention or conference center)
13 (Religious Facility)
14 (Restaurant)
15 (Retail)
16 (Warehouse)
97 (Other) [RECORD VERBATIM]
98 (Don't know)
99 (Refused)

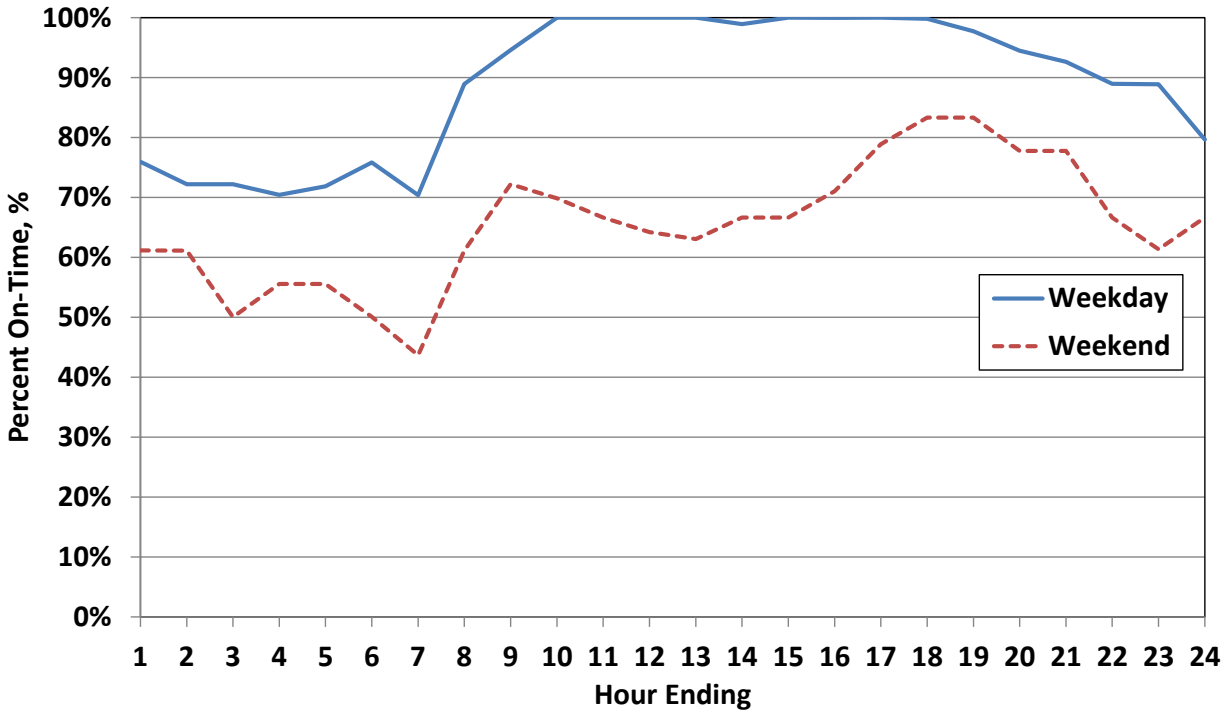
9. Appendix C: Lighting Profiles



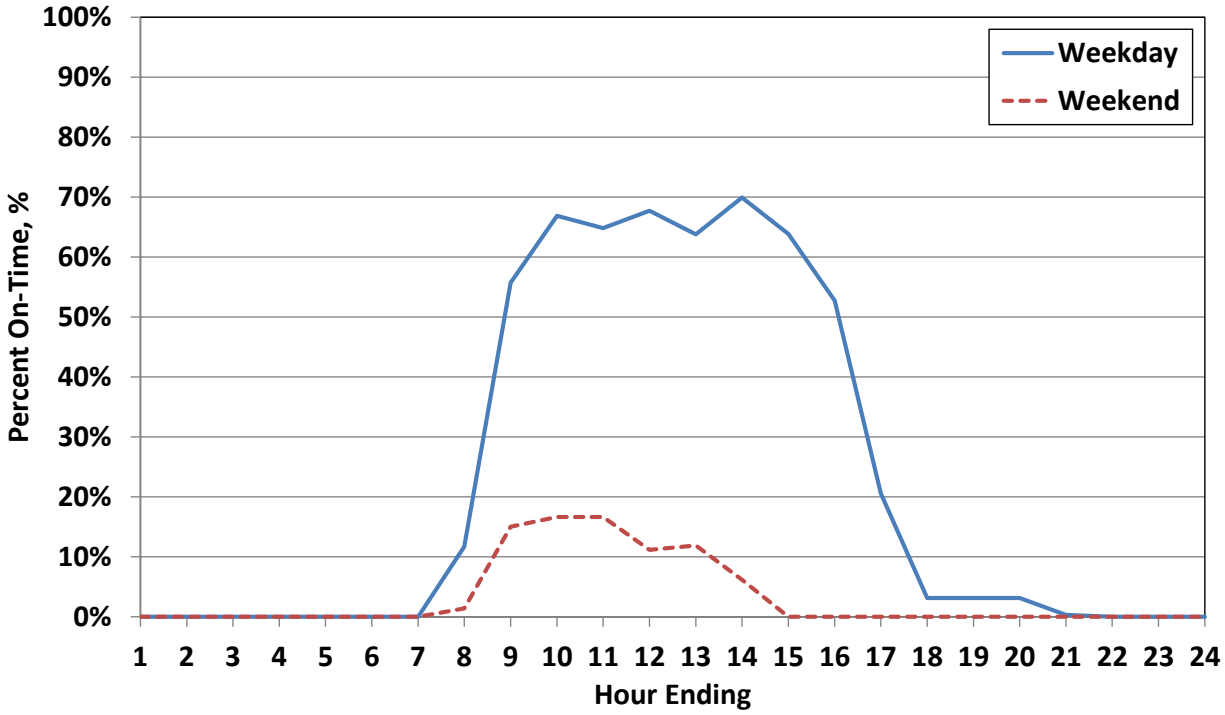
NAICS-813212: Voluntary Health Organizations



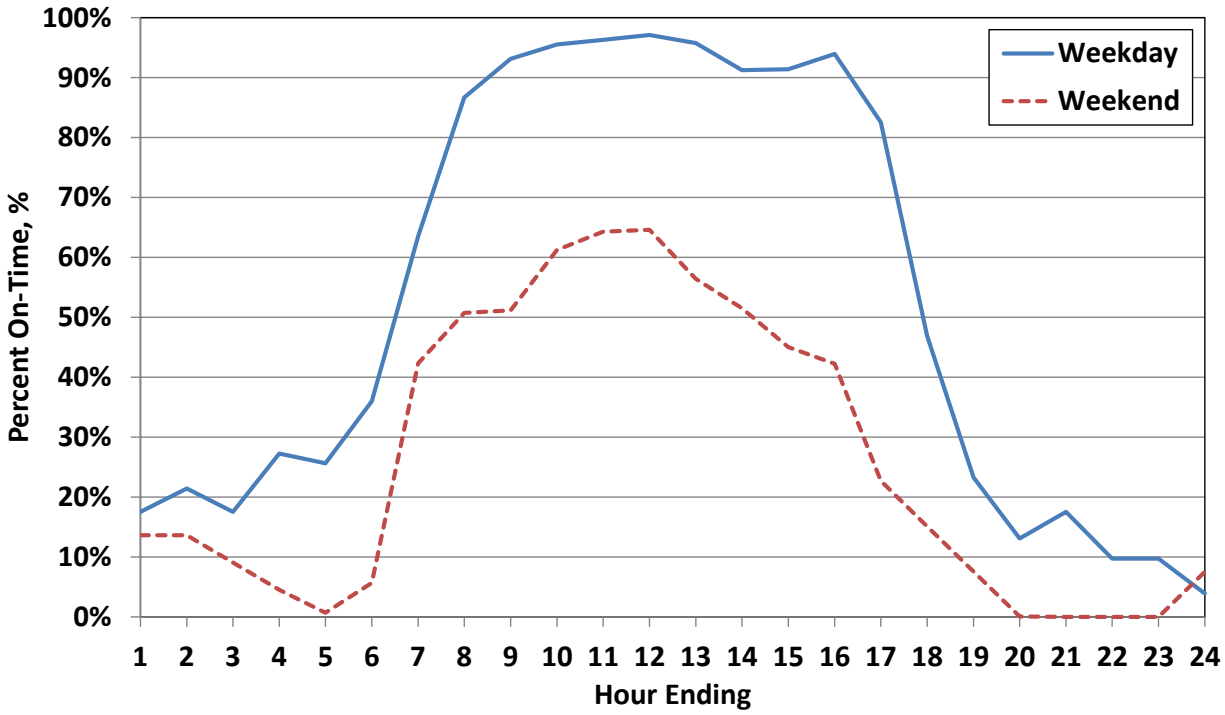
NAICS-812332: Industrial Launderer



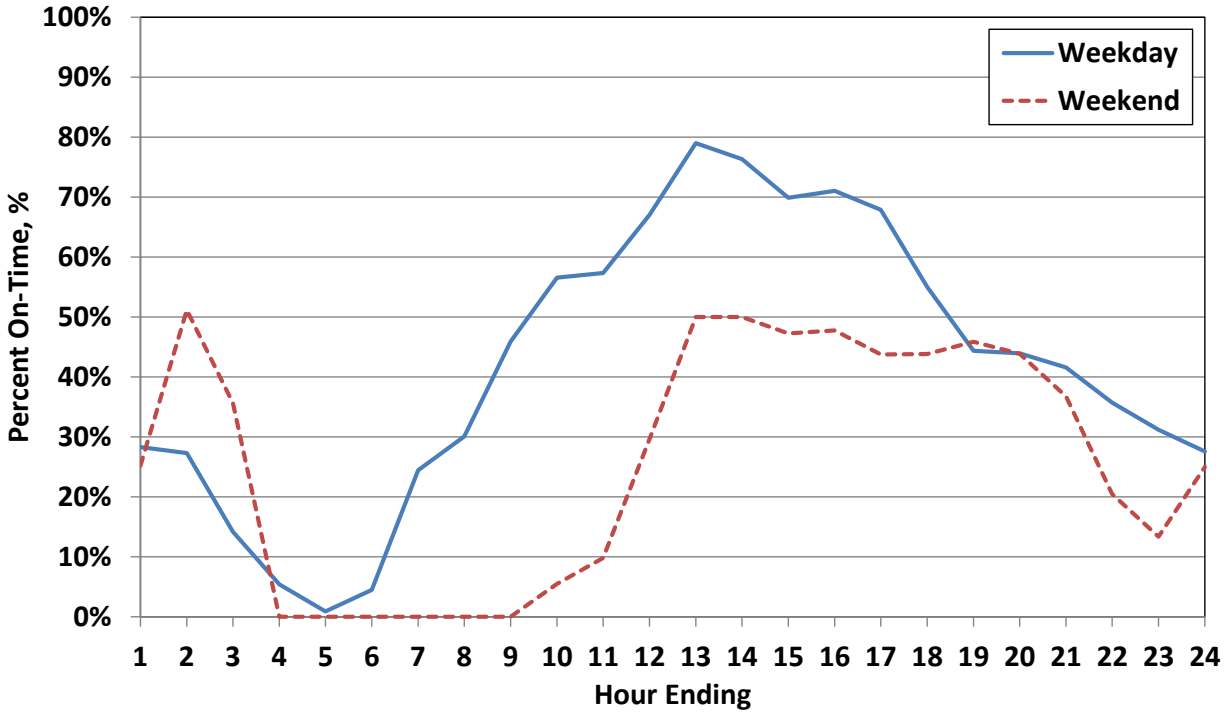
NAICS-812210: Funeral Homes and Funeral Services



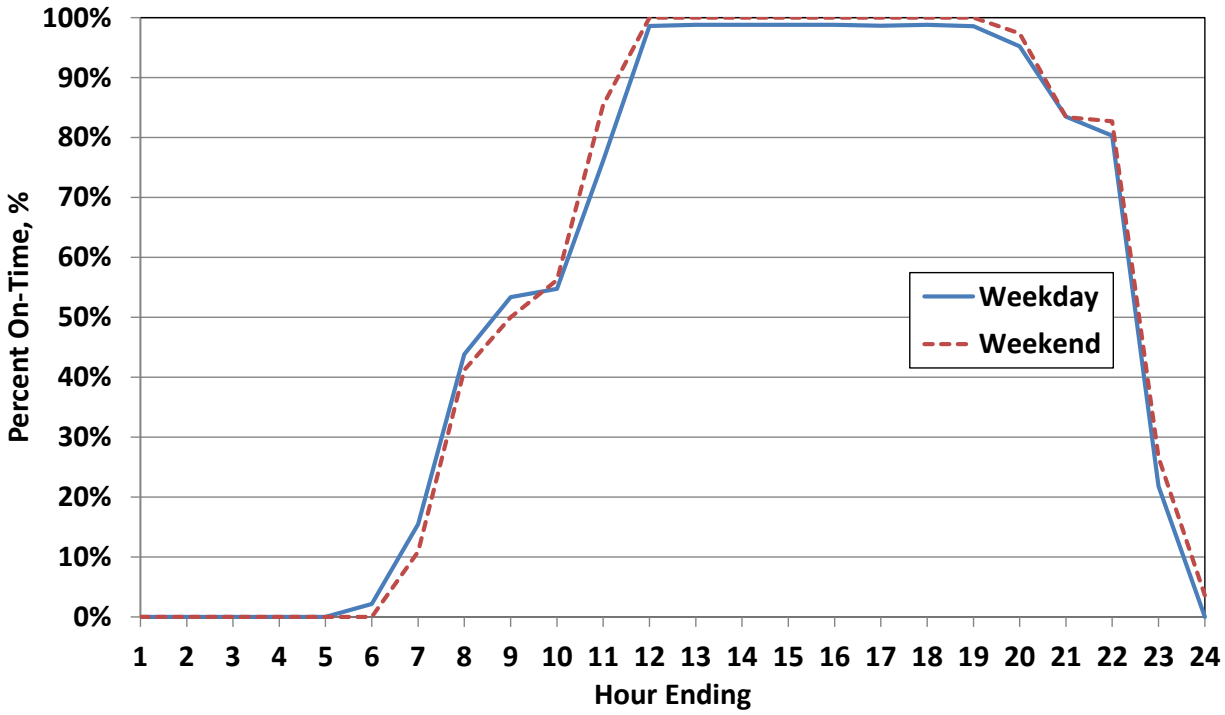
NAICS-811111: General Automotive Repair



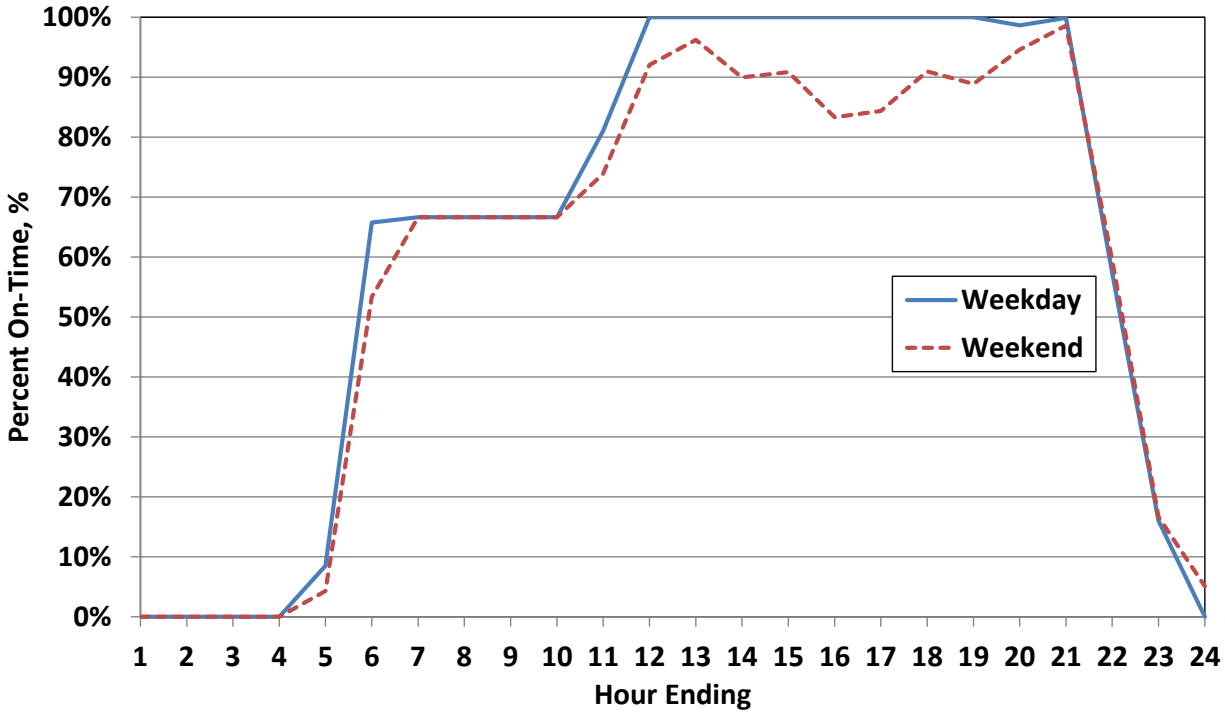
NAICS-722410: Drinking Places (Alcoholic Beverages)



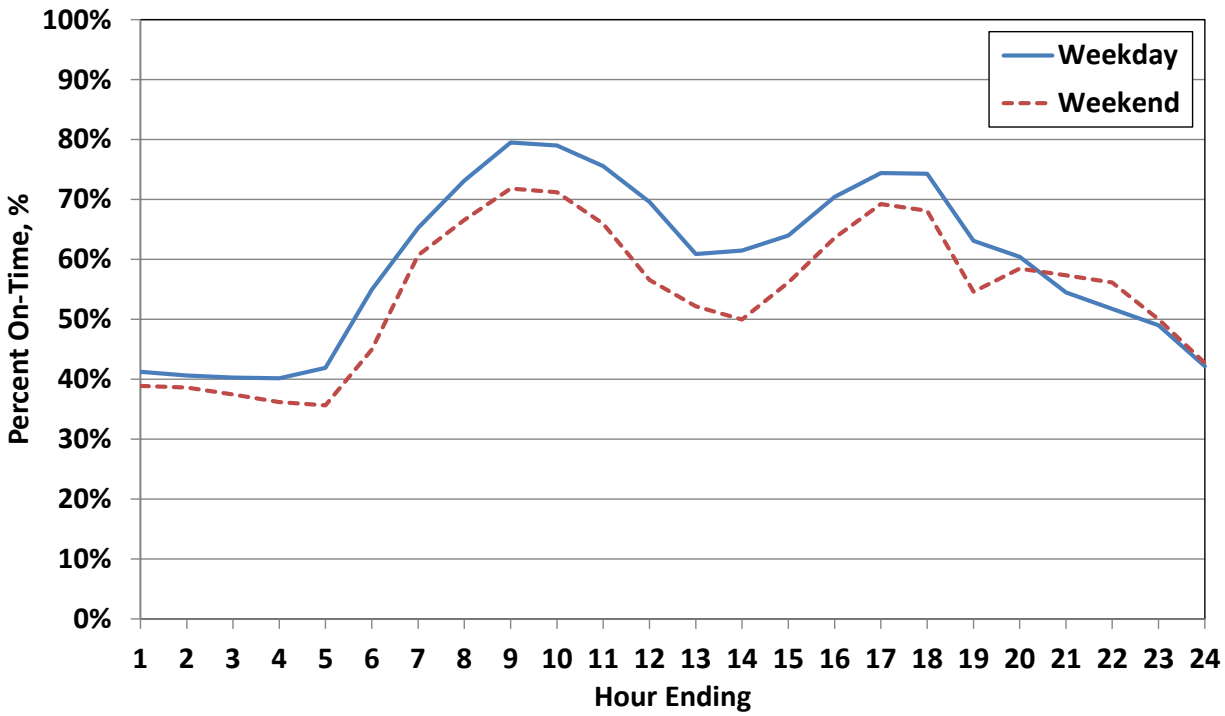
NAICS-722211: Limited-Service Restaurants



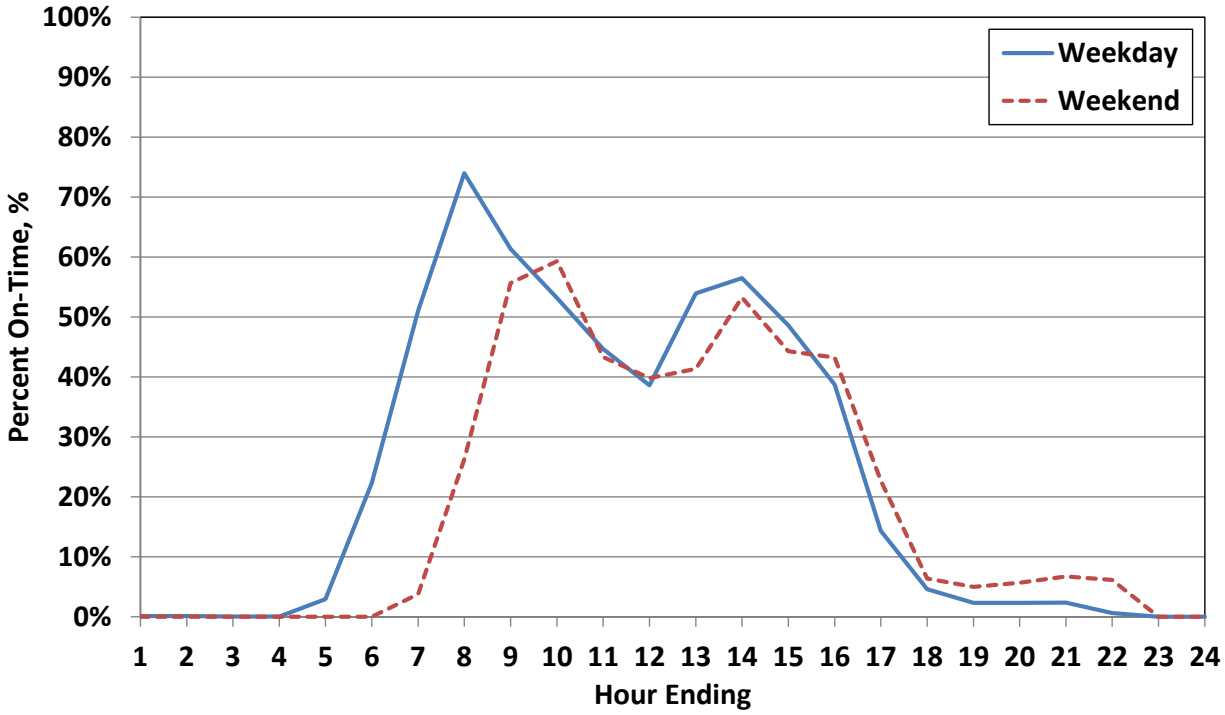
NAICS-722110: Full-Service Restaurants



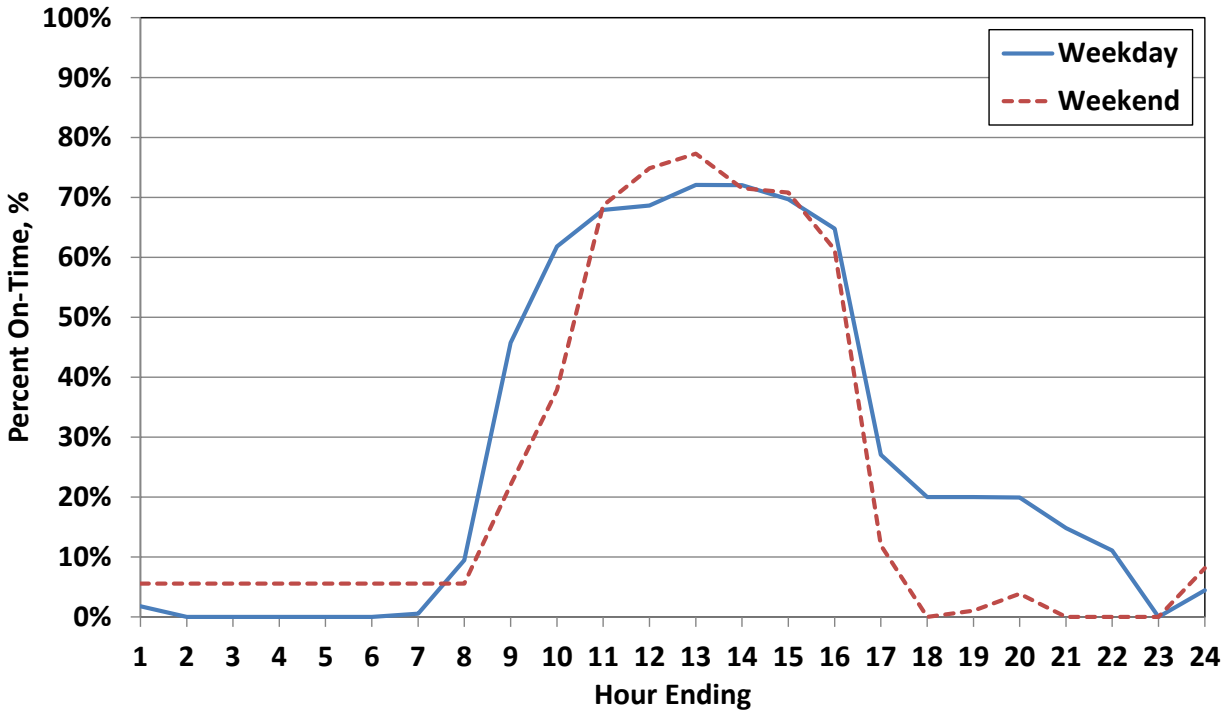
NAICS-721110: Hotels (except Casino Hotels) and Motels

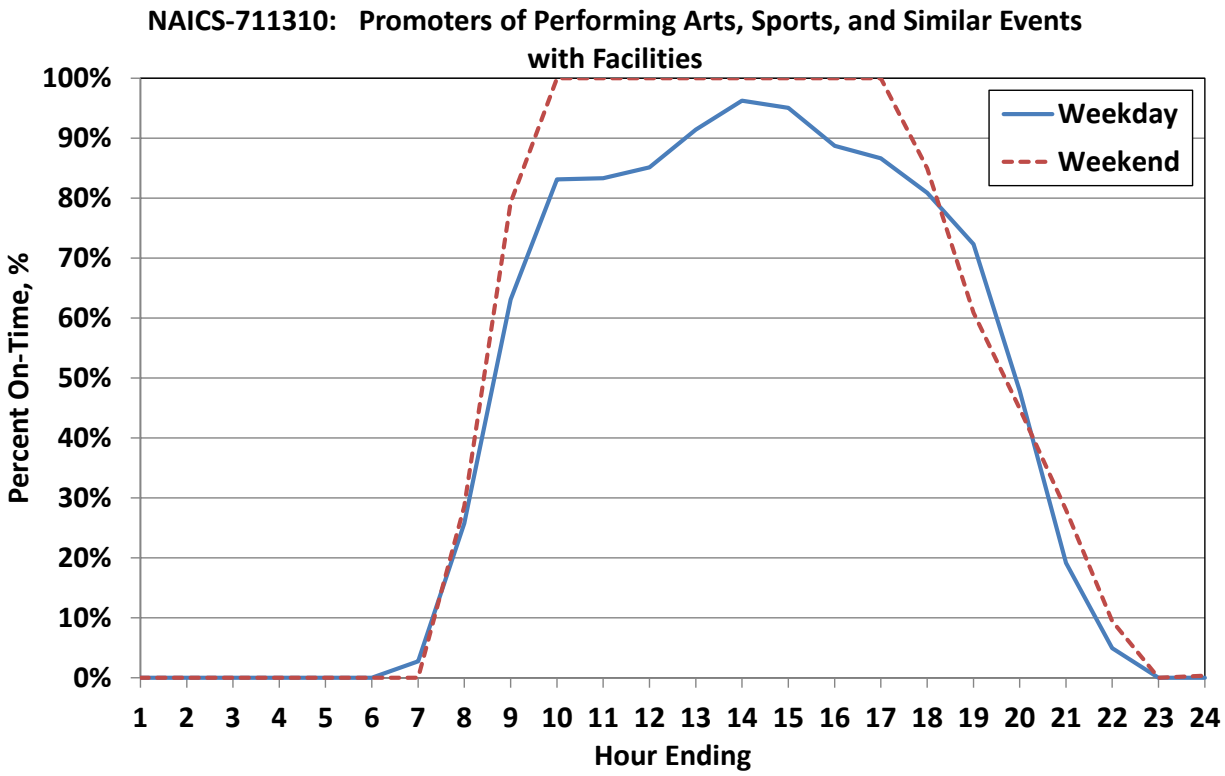


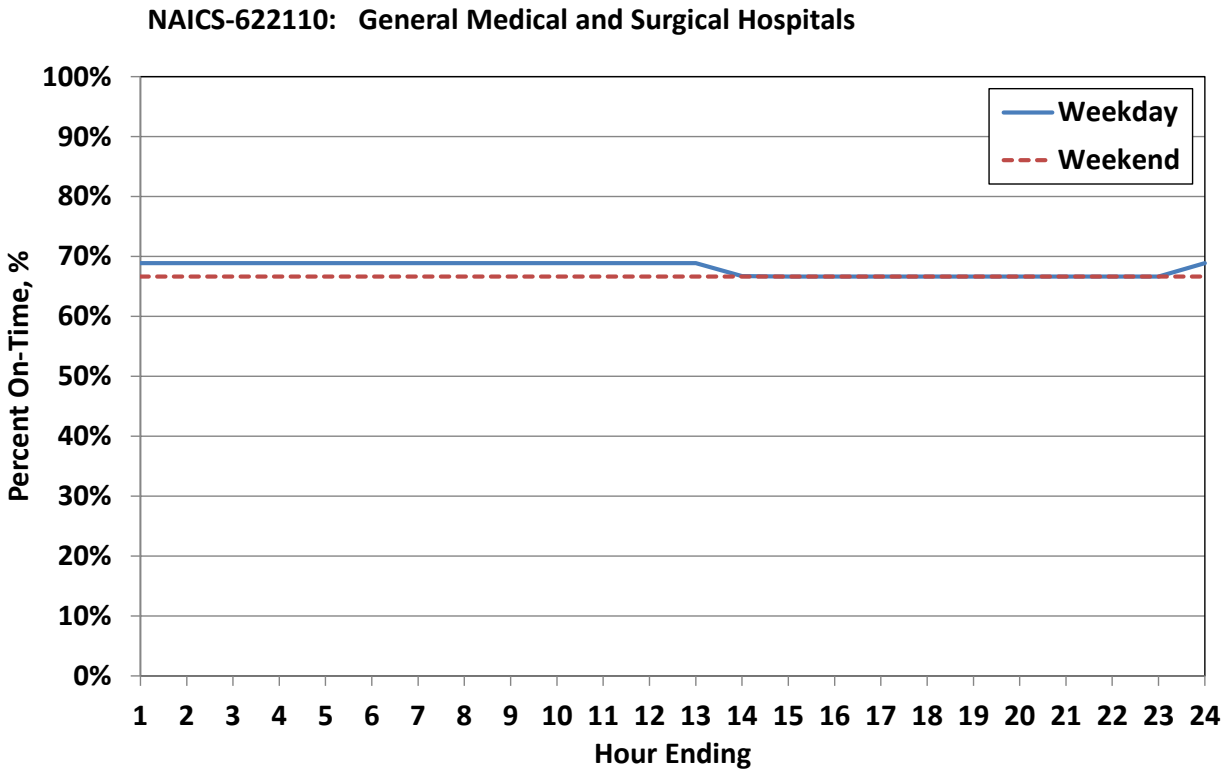
NAICS-712120: Historical Sites



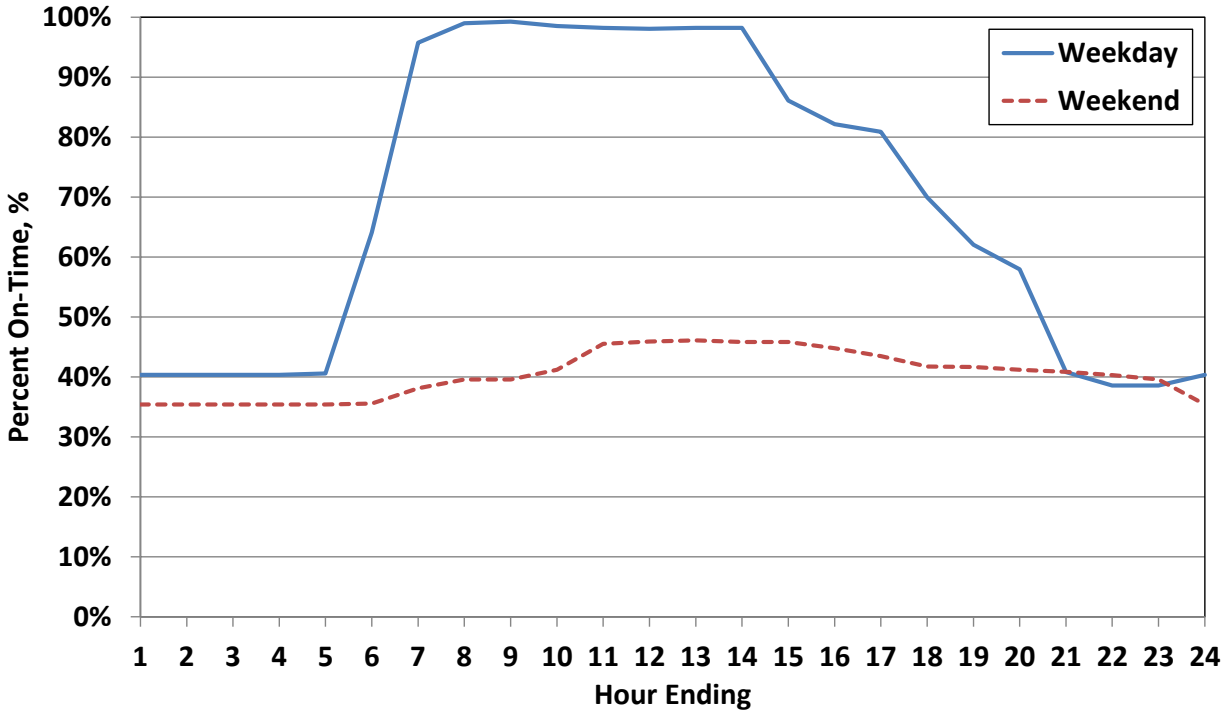
NAICS-712110: Museums



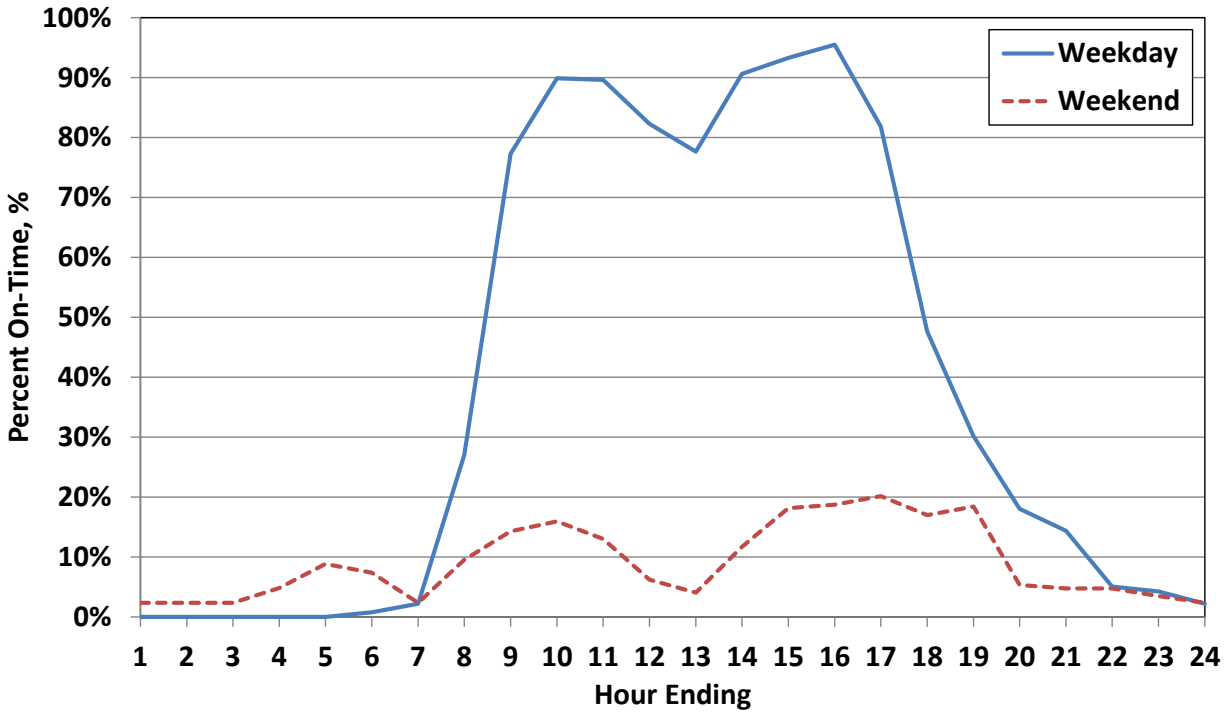

NAICS-711310: Promoters of Performing Arts, Sports, and Similar Events with Facilities
Percent On-Time, %
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending
Weekday
Weekend


NAICS-622110: General Medical and Surgical Hospitals
Percent On-Time, %
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending
Weekday
Weekend

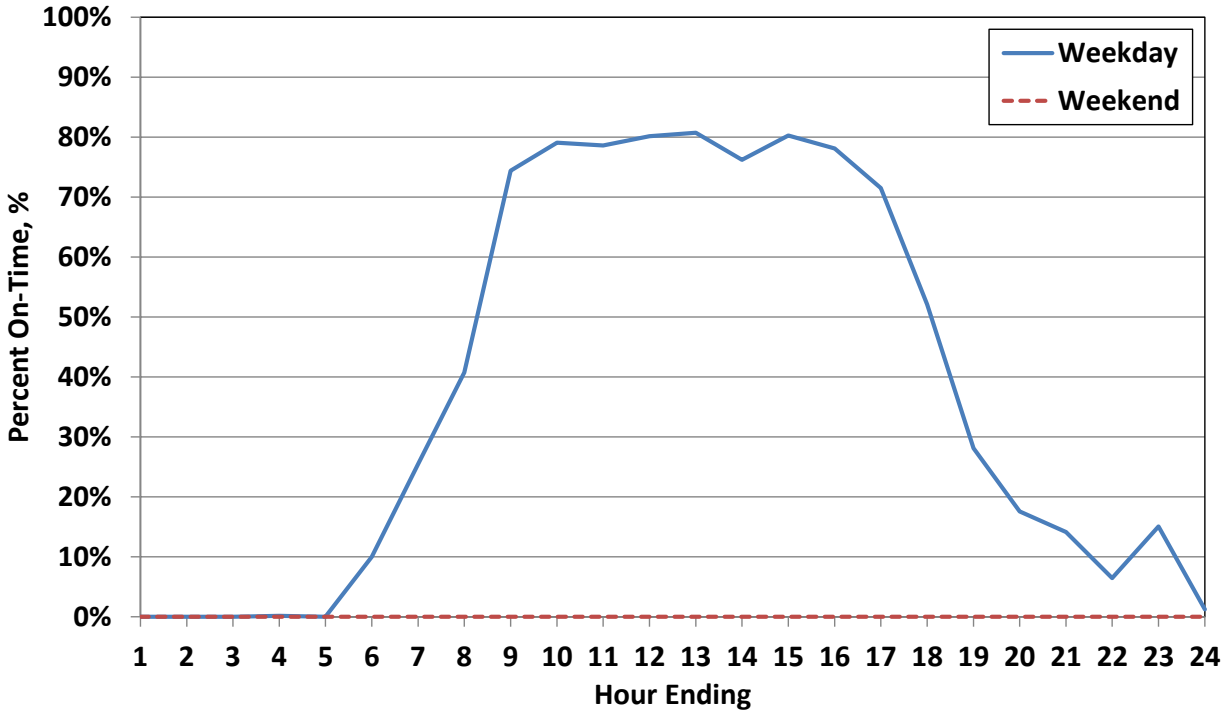
NAICS-621910: Ambulance Services



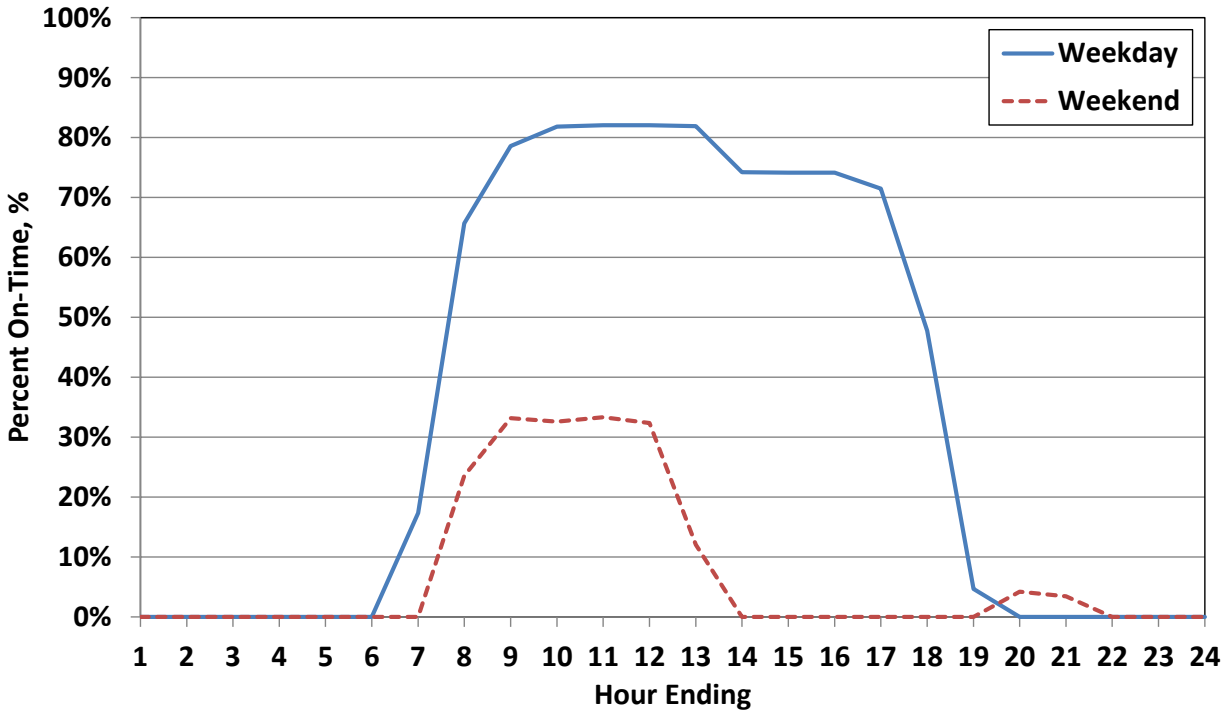
NAICS-621111: Offices of Physicians (except Mental Health Specialists)



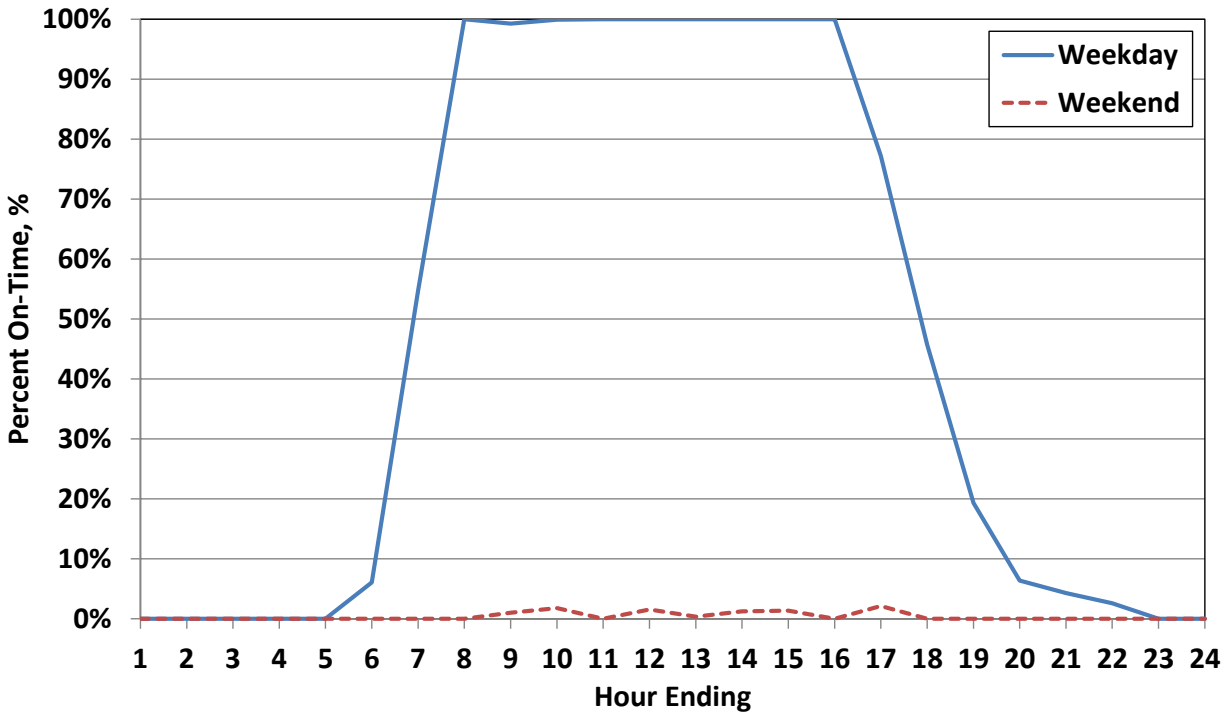
NAICS-611110: Elementary and Secondary Schools



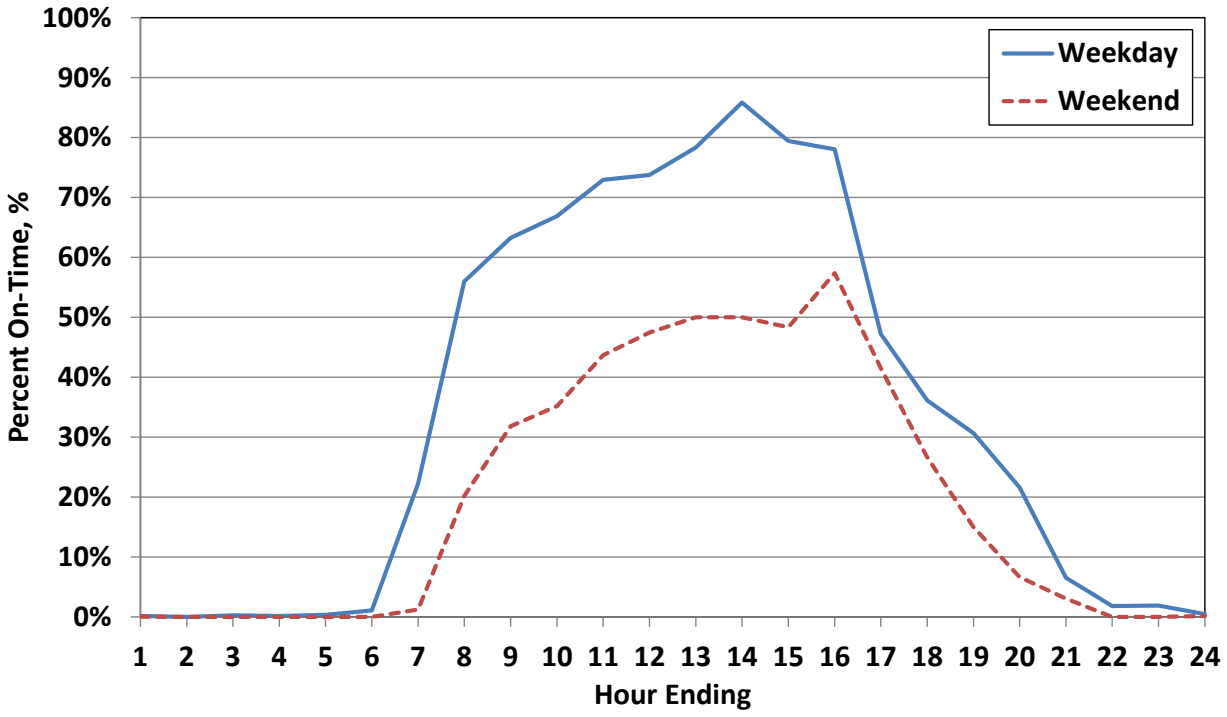
NAICS-541940: Veterinary Services

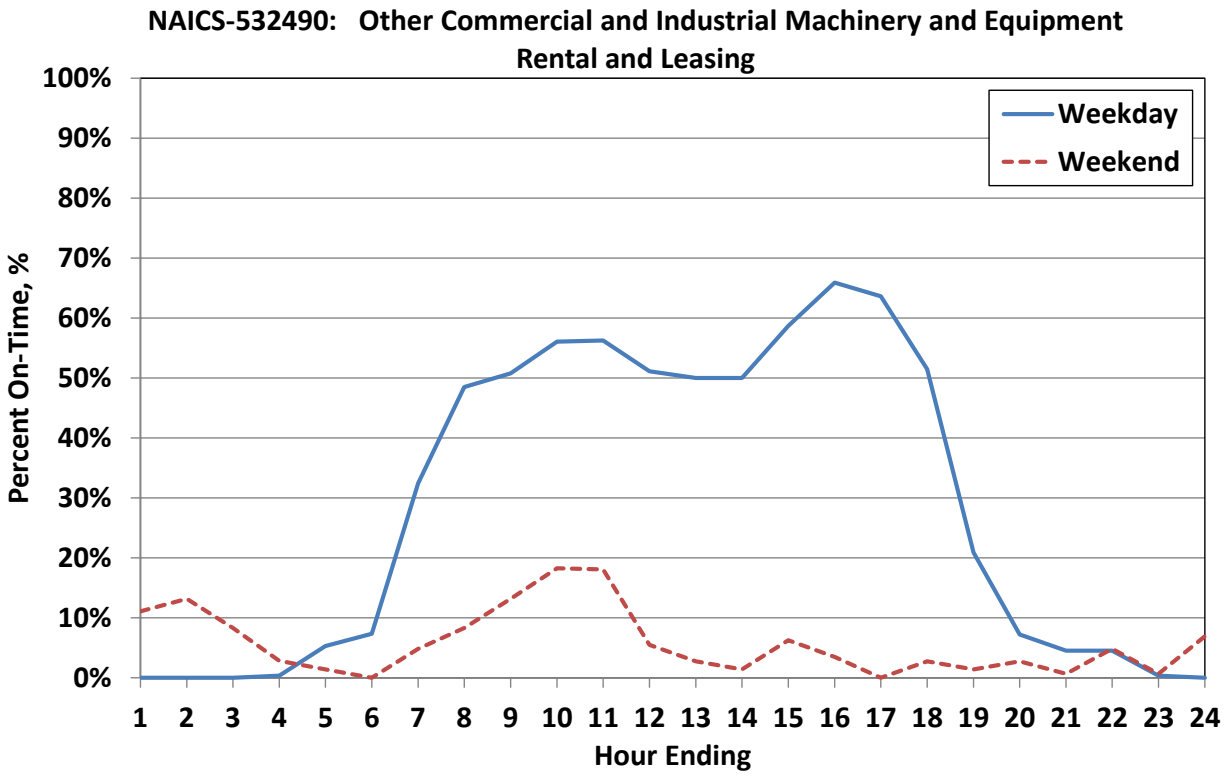


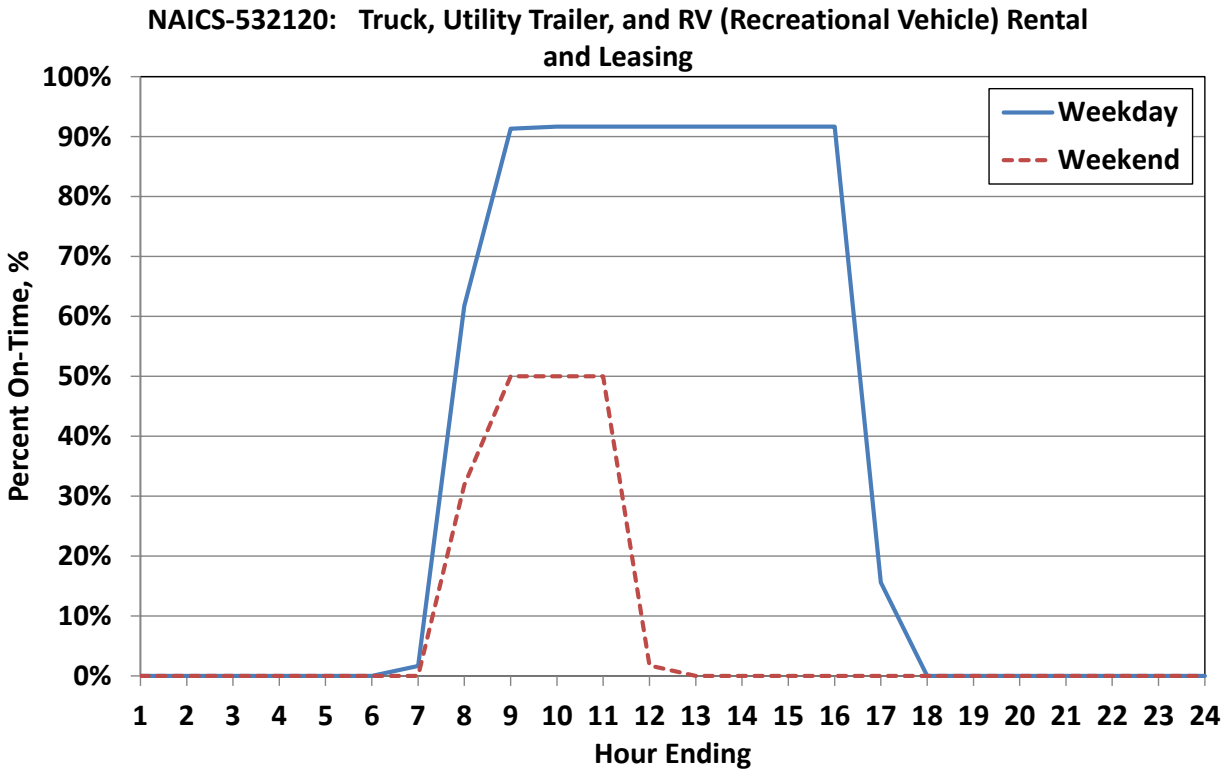
NAICS-541211: Offices of Certified Public Accountants

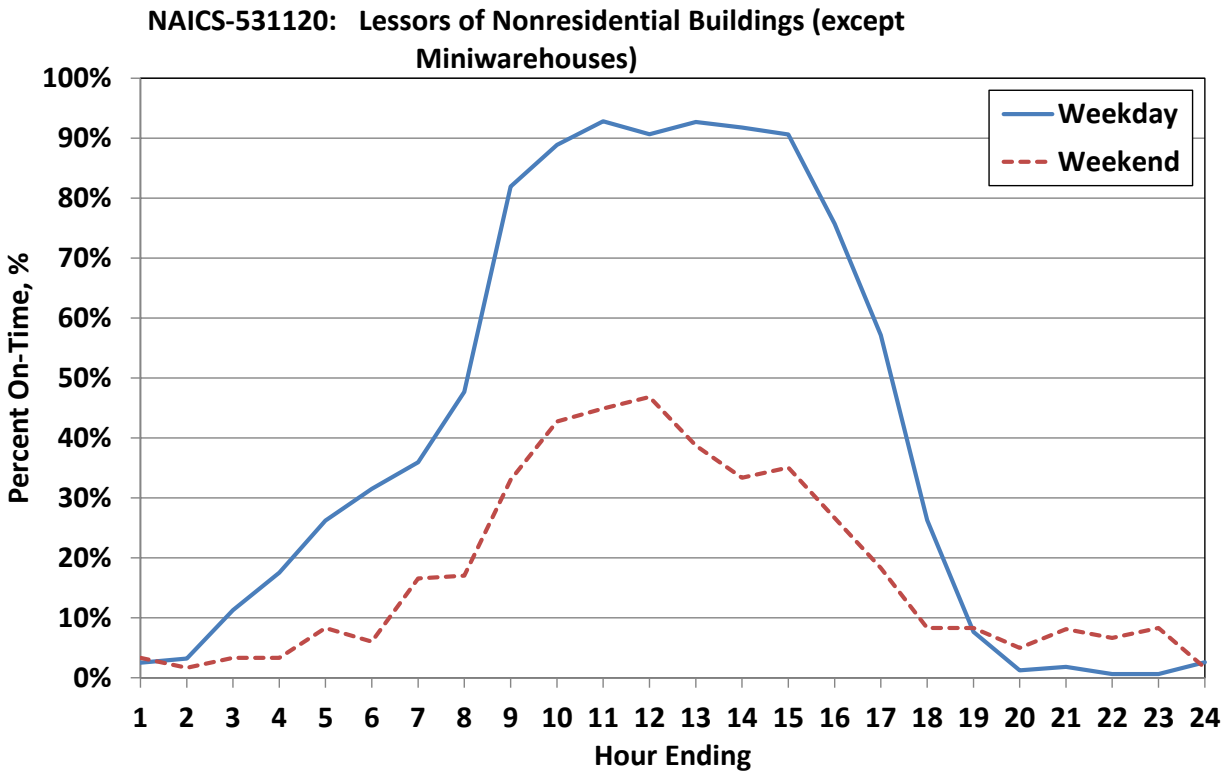


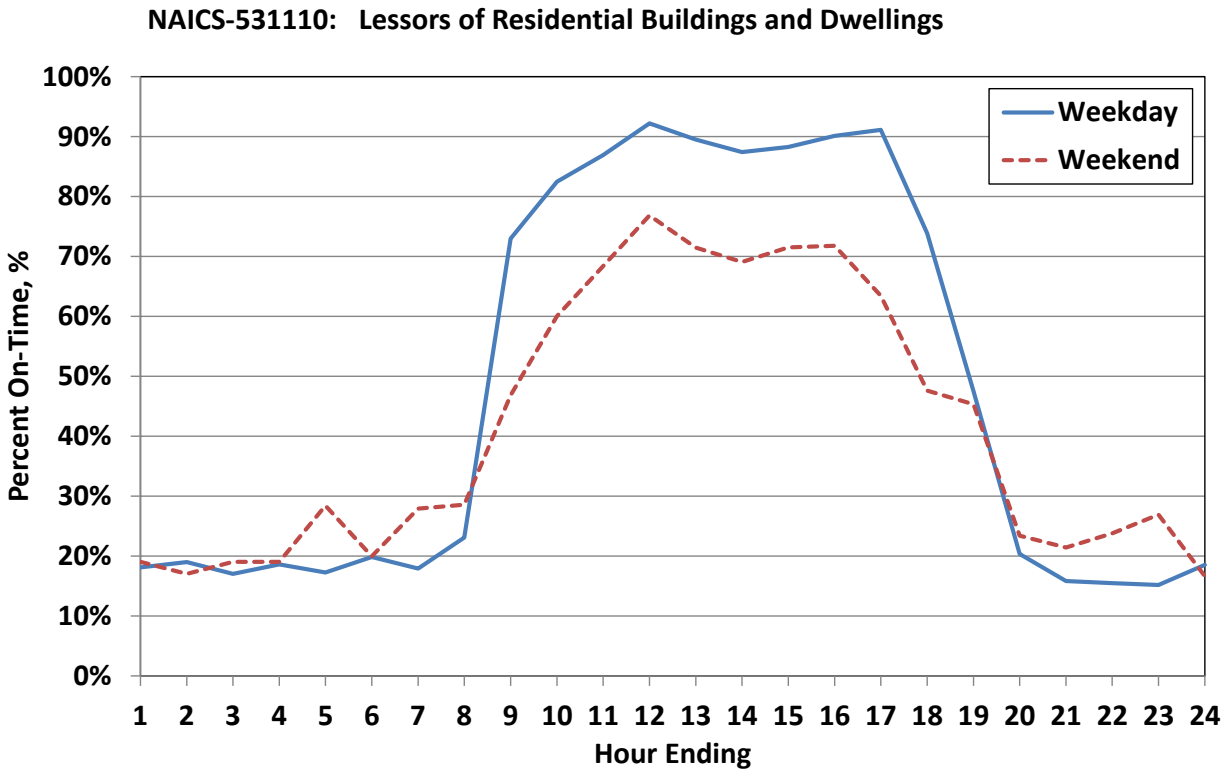
NAICS-541110: Offices of Lawyers



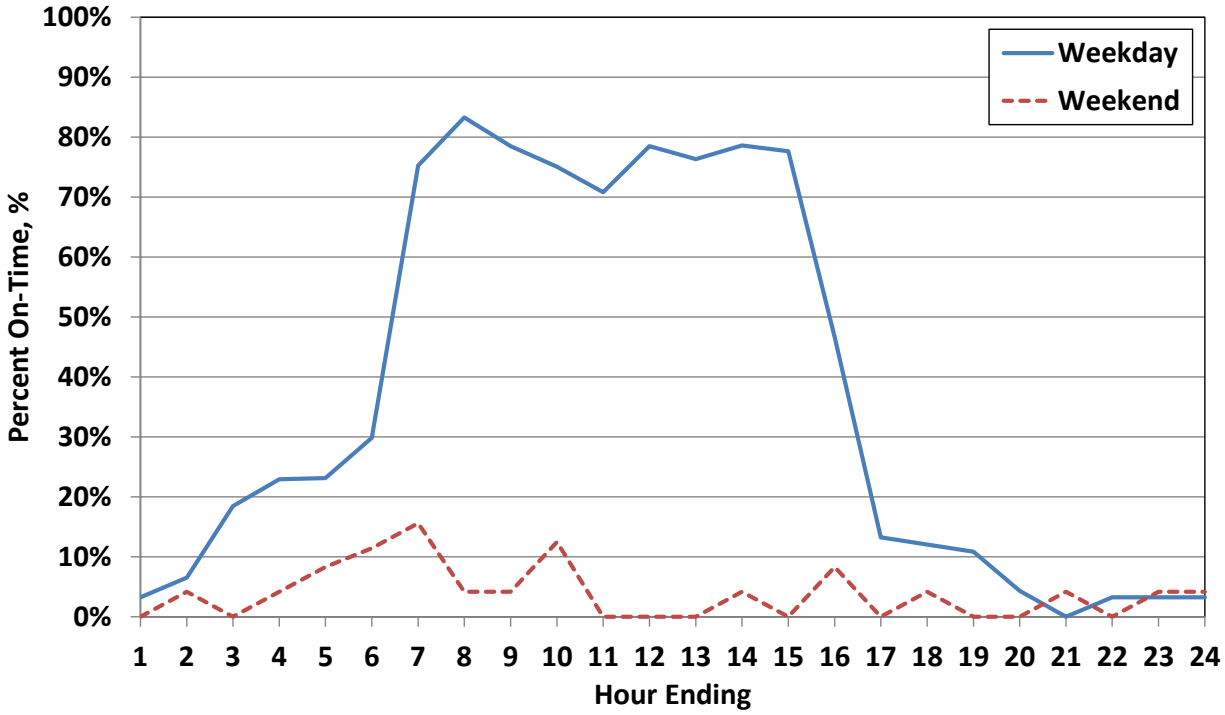

NAICS-532490: Other Commercial and Industrial Machinery and Equipment Rental and Leasing
Weekday
Weekend
Percent On-Time, %
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending


NAICS-532120: Truck, Utility Trailer, and RV (Recreational Vehicle) Rental and Leasing
Weekday
Weekend
Percent On-Time, %
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending

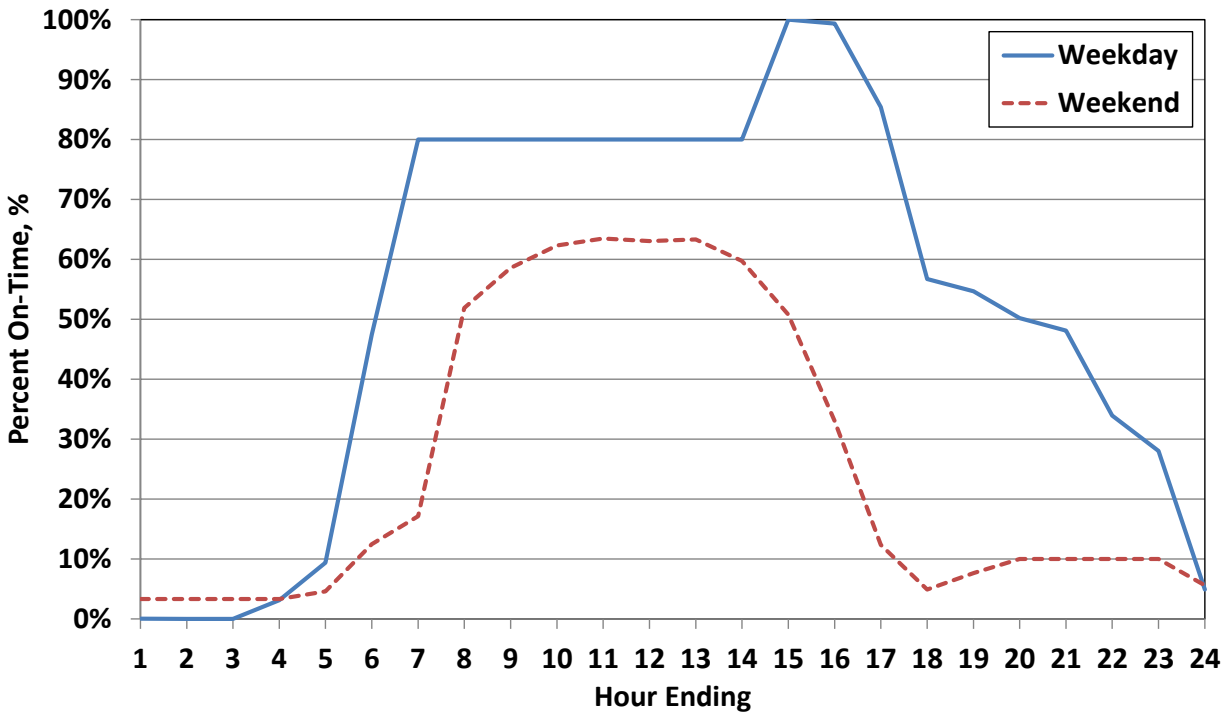

NAICS-531120: Lessors of Nonresidential Buildings (except Miniwarehouses)
Weekday
Weekend
Percent On-Time, %
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending


NAICS-531110: Lessors of Residential Buildings and Dwellings
Weekday
Weekend
Percent On-Time, %
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending

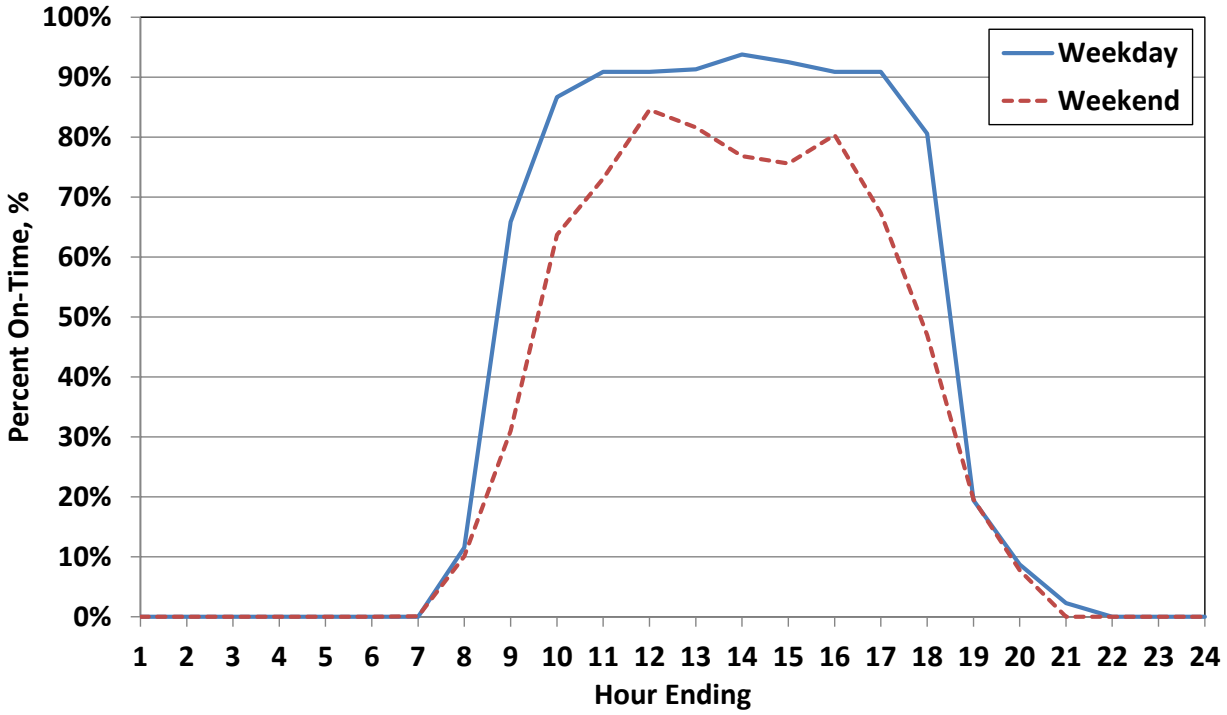
NAICS-493110: General Warehousing and Storage



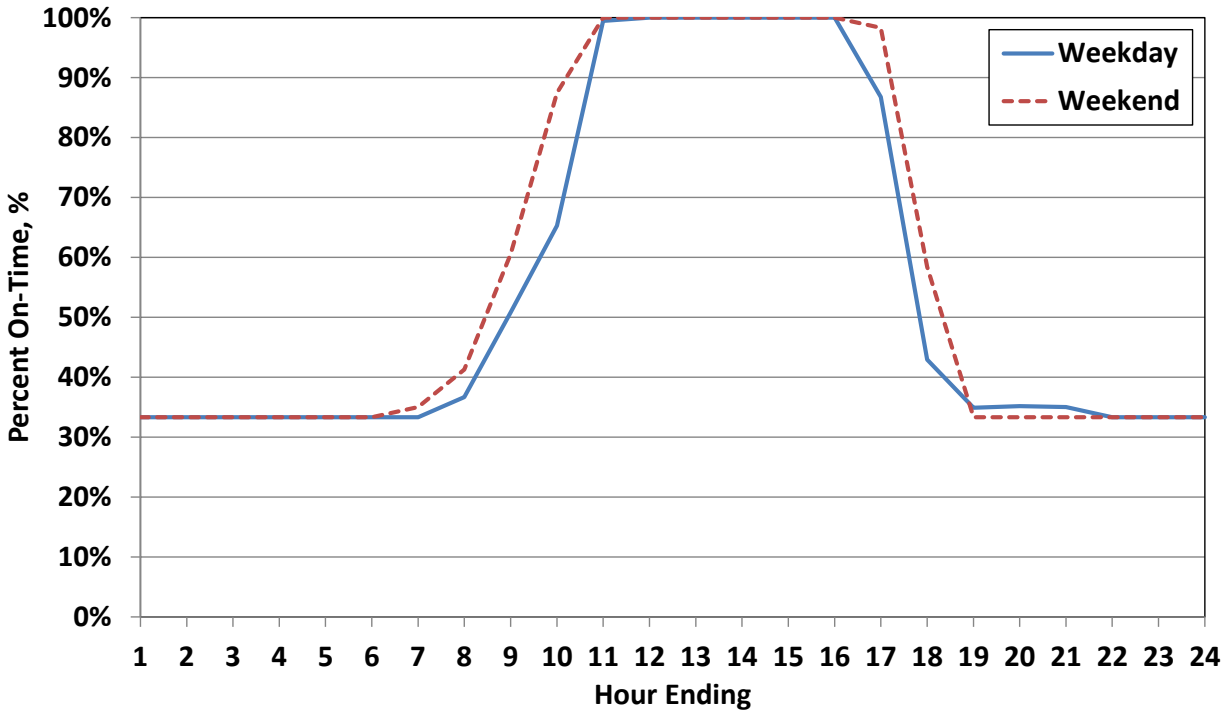
NAICS-488190: Other Support Activities for Air Transportation



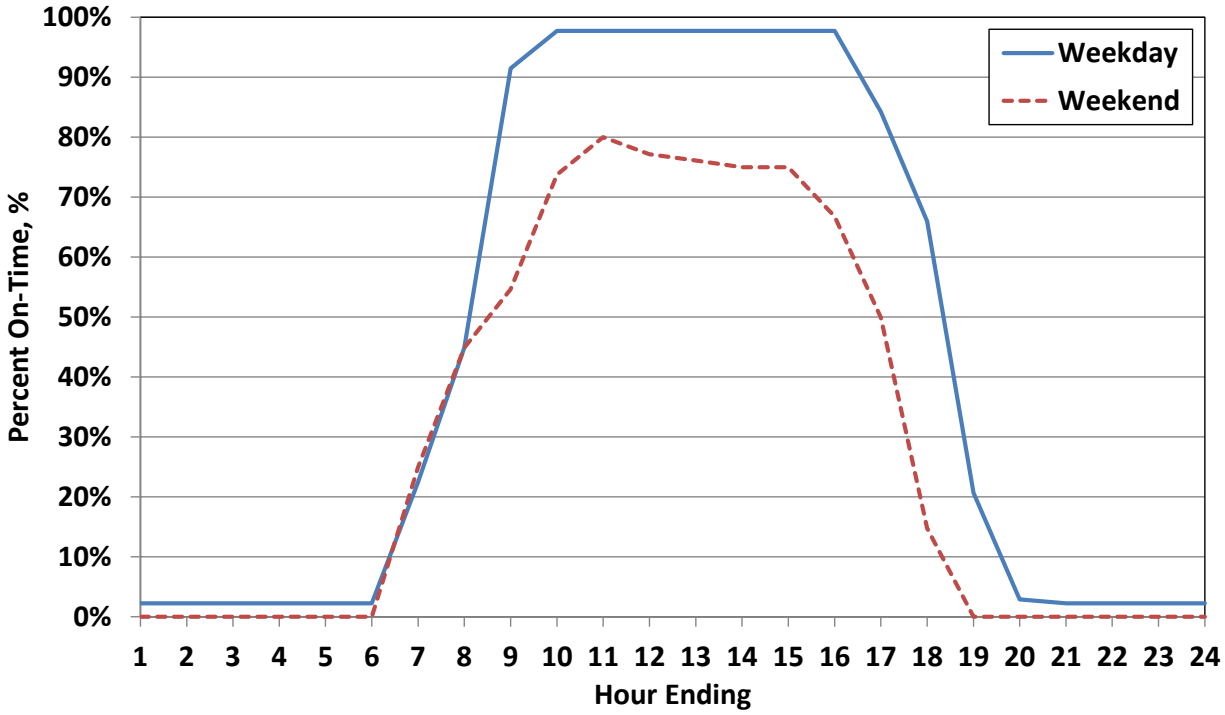
NAICS-453920: Art Dealers



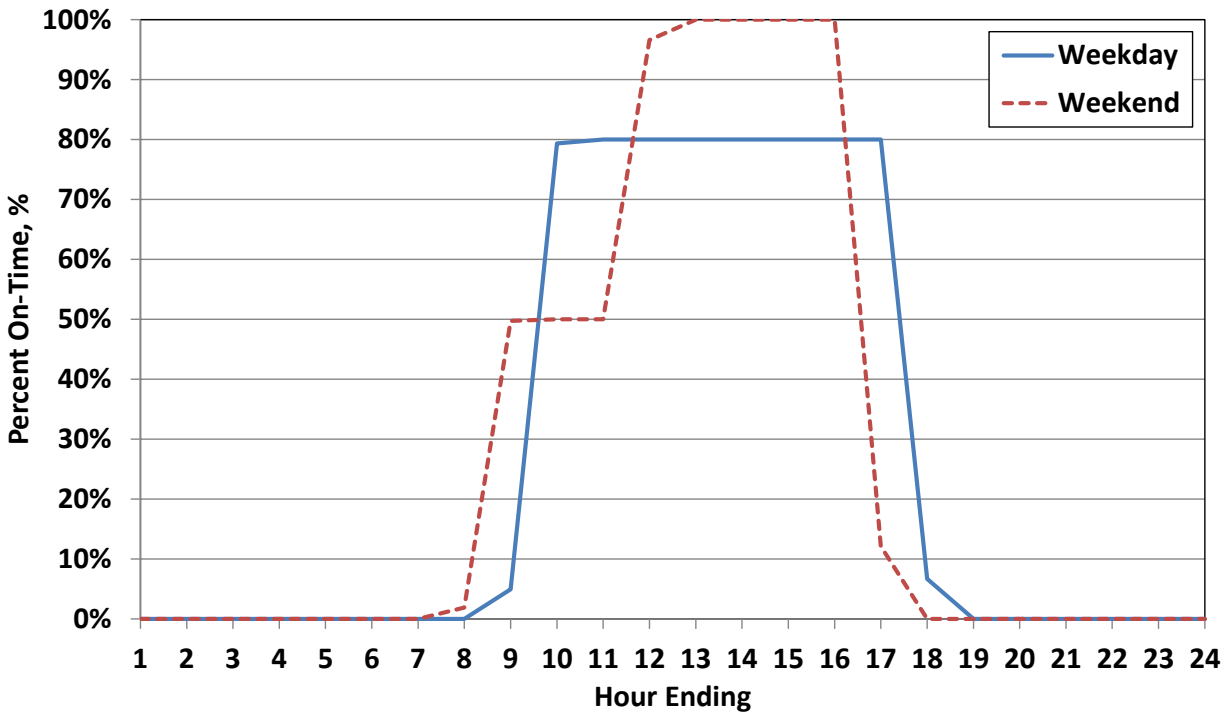
NAICS-453310: Used Merchandise Stores



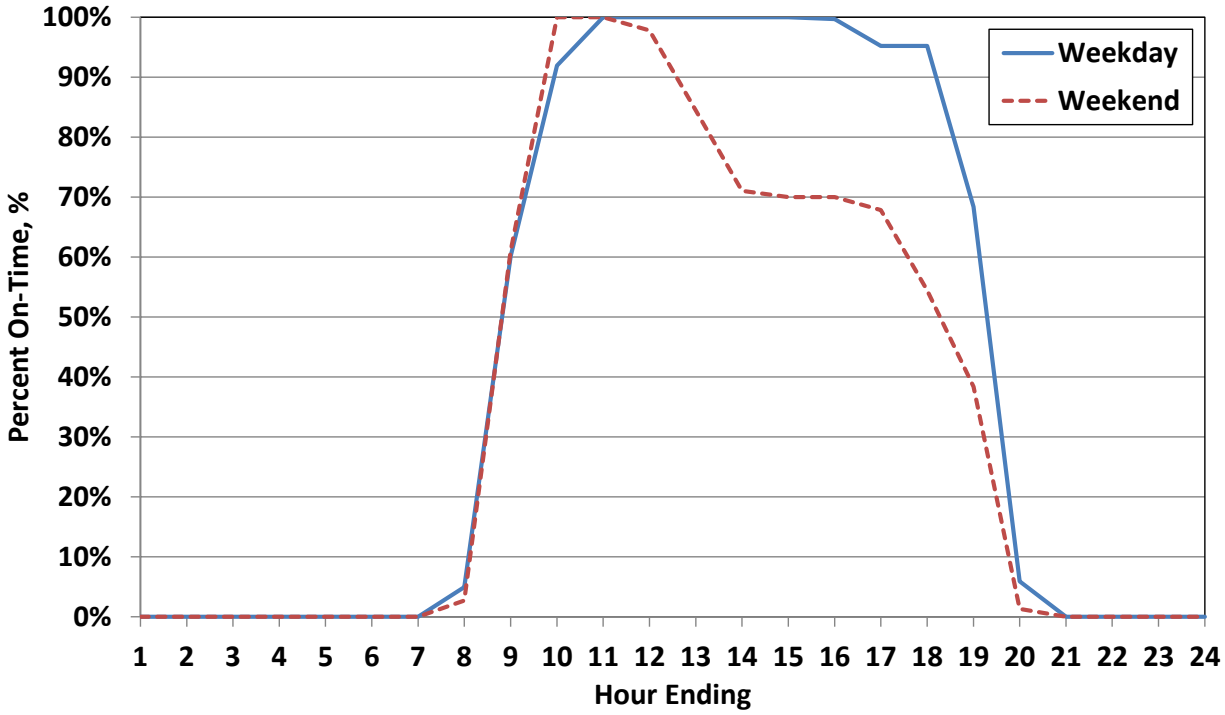
NAICS-453110: Florist



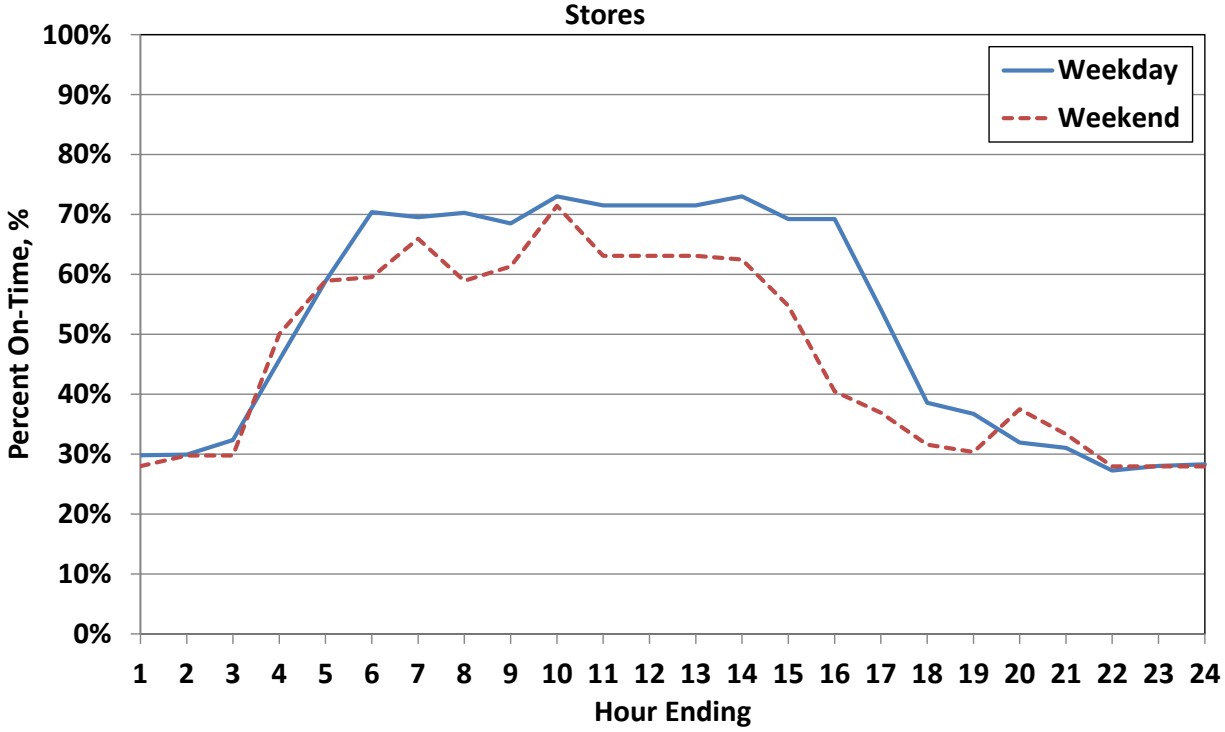
NAICS-451110: Sporting Goods Stores



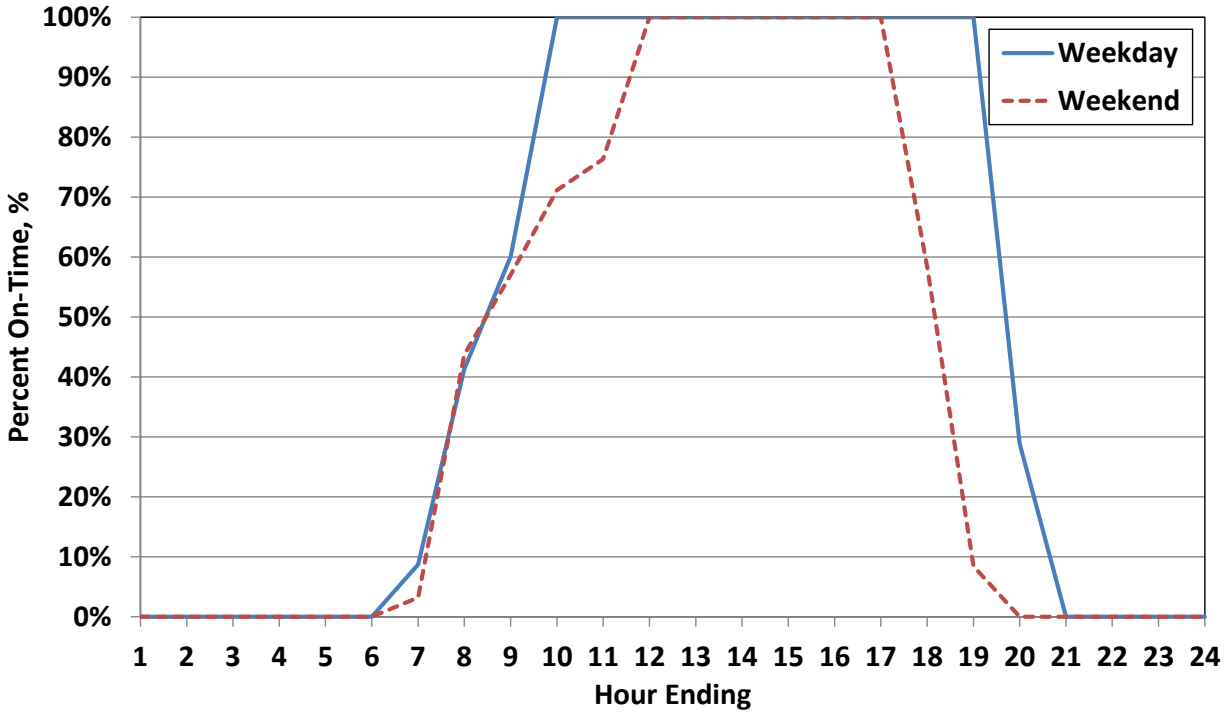
NAICS-448310: Jewelry Stores



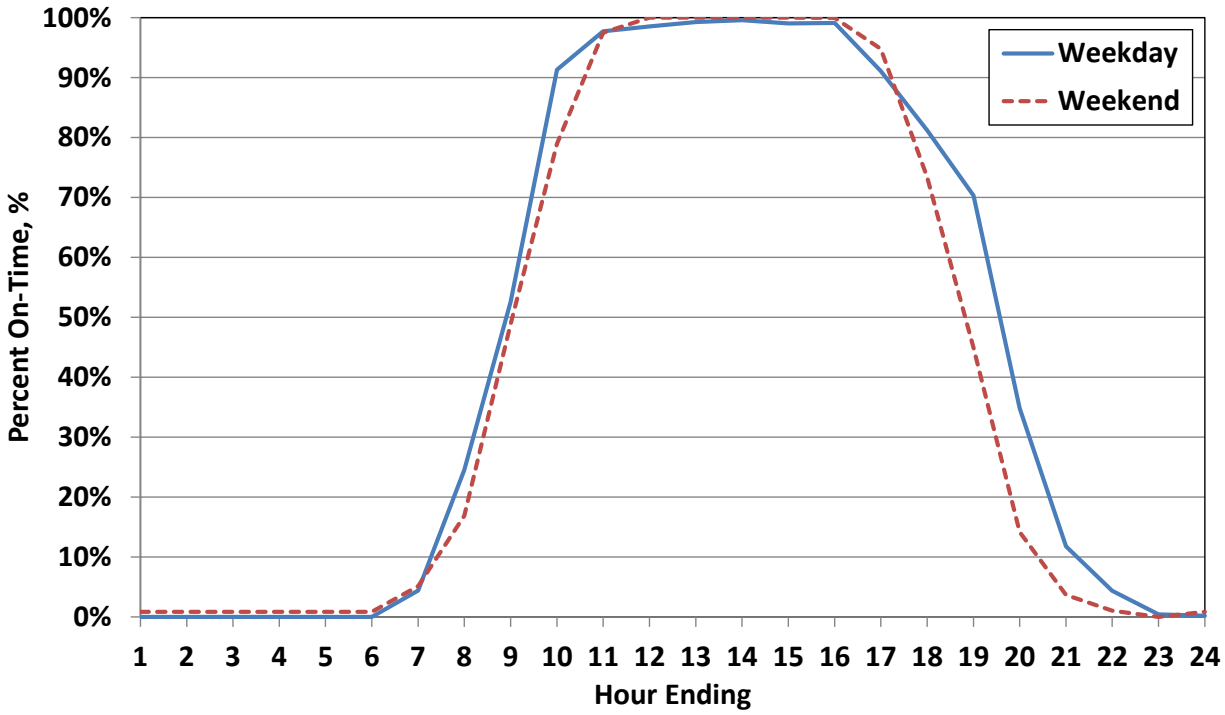
NAICS-445110: Supermarkets and Other Grocery (except Convenience) Stores



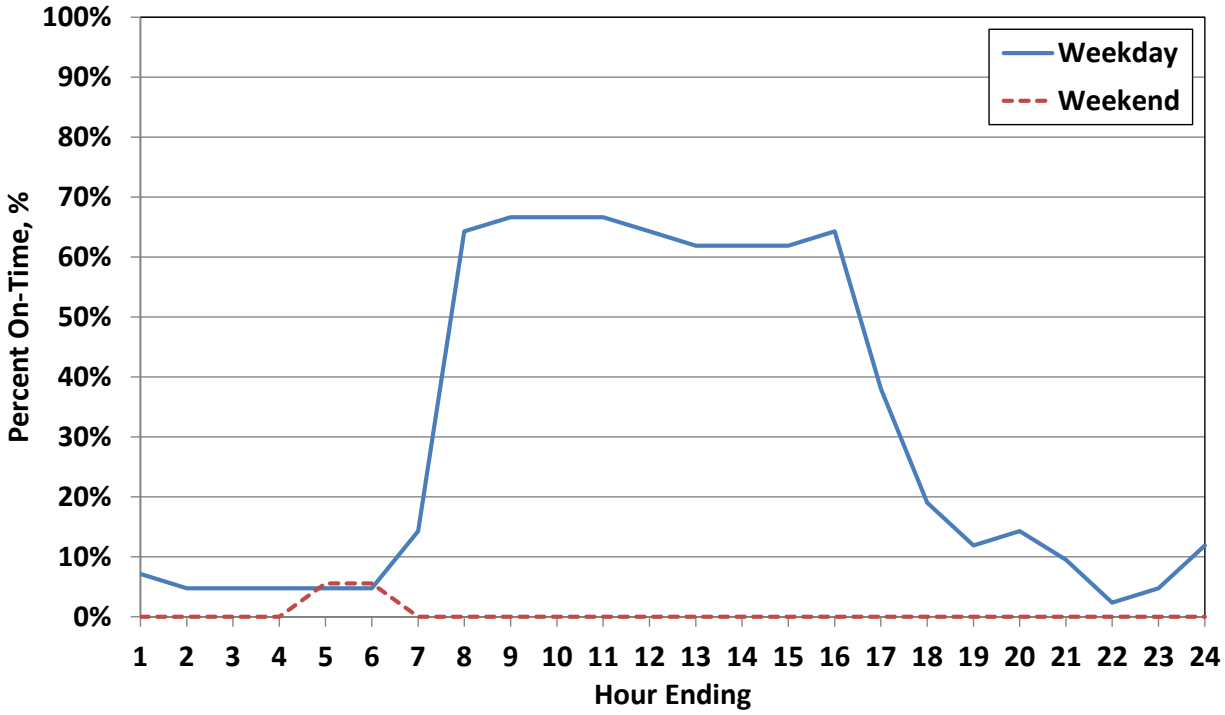
NAICS-443112: Radio, Television, and Other Electronics Stores



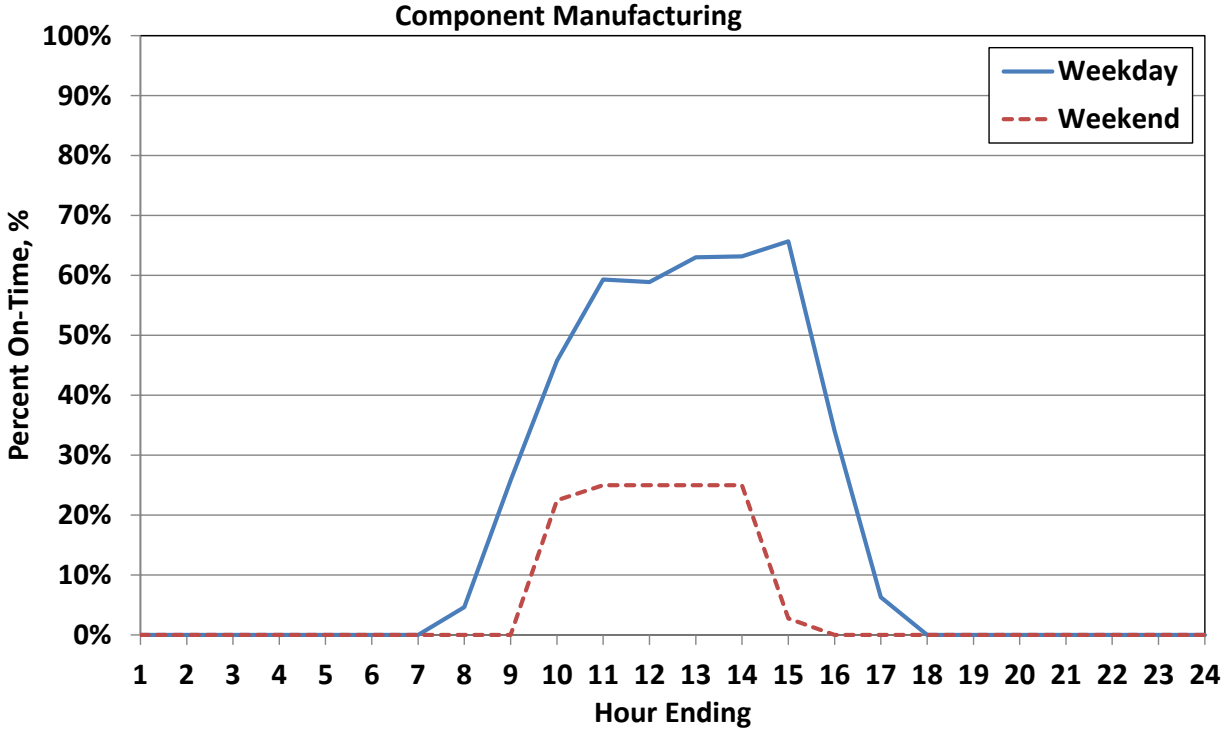
NAICS-442110: Furniture Stores

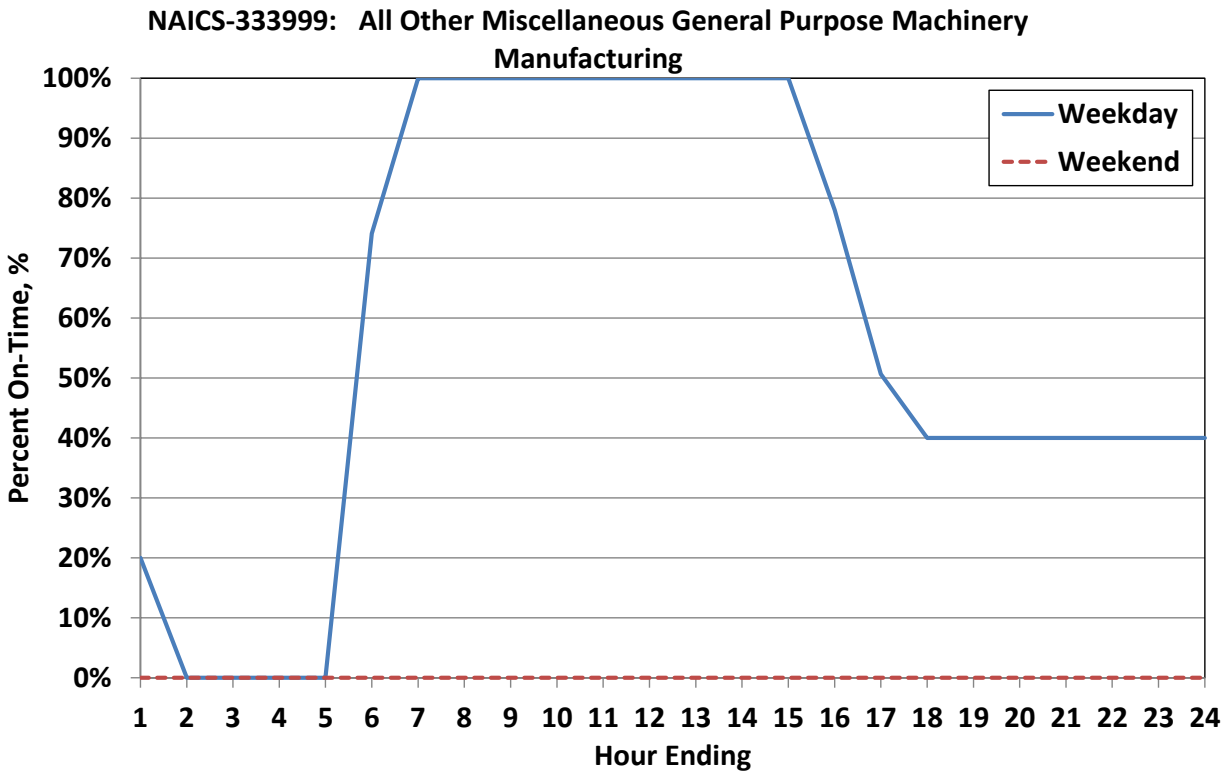


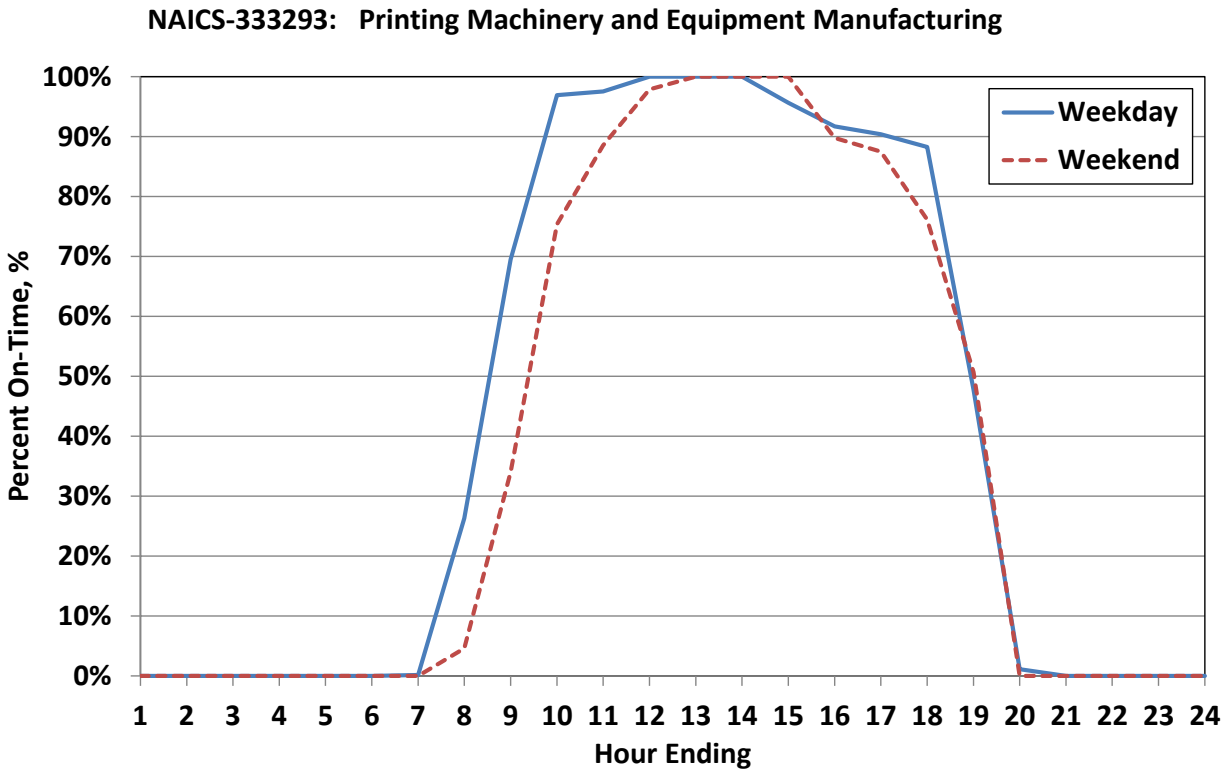
NAICS-423830: Industrial Machinery and Equipment Merchant Wholesalers



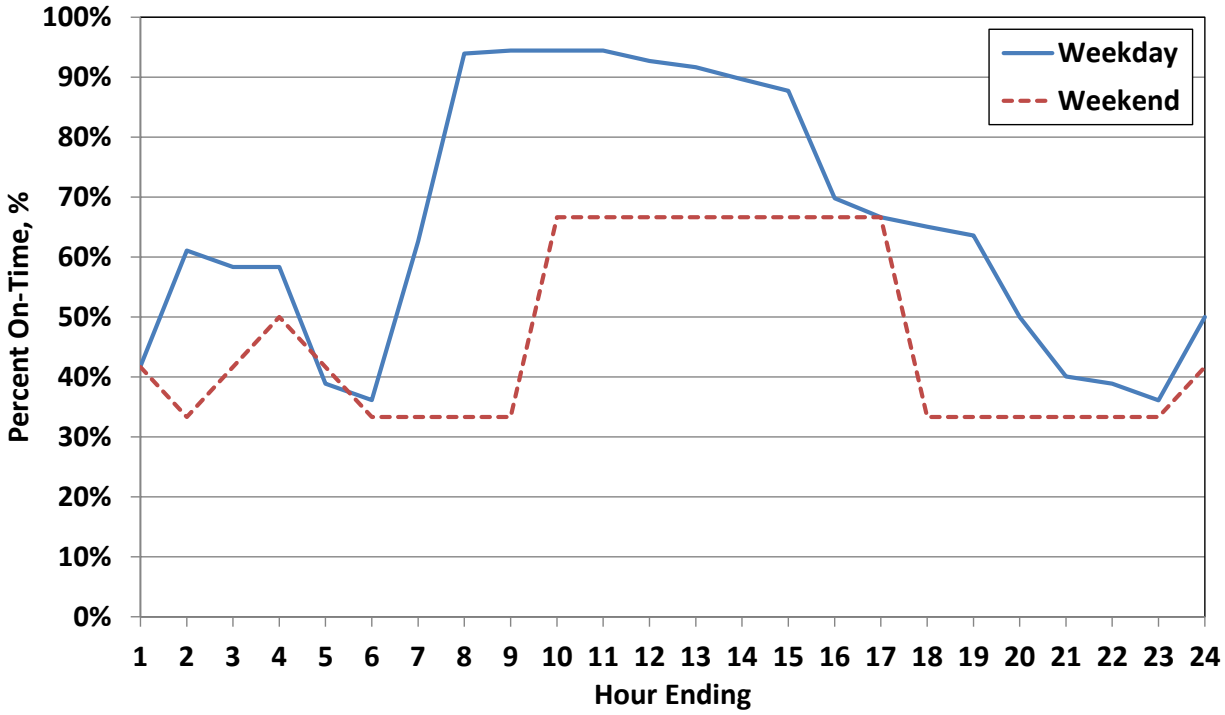
NAICS-335999: All Other Miscellaneous Electrical Equipment and Component Manufacturing



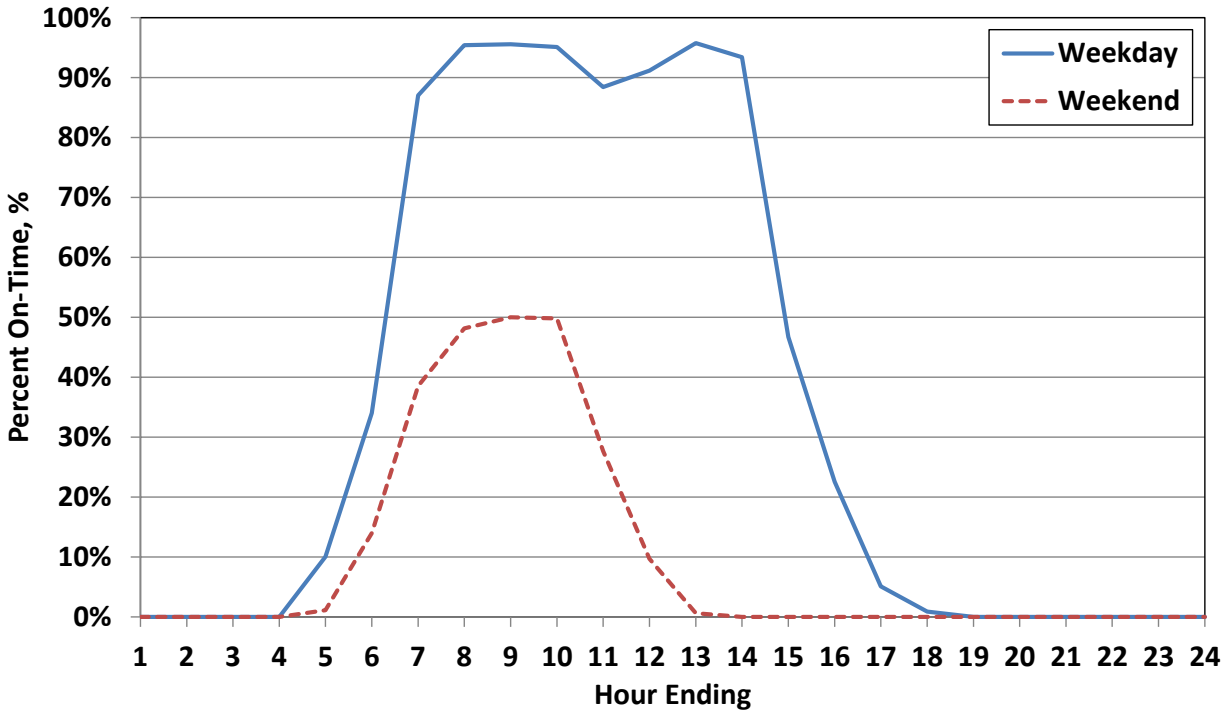

NAICS-333999: All Other Miscellaneous General Purpose Machinery Manufacturing
Percent On-Time, %
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending
Weekday
Weekend


NAICS-333293: Printing Machinery and Equipment Manufacturing
Percent On-Time, %
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending
Weekday
Weekend

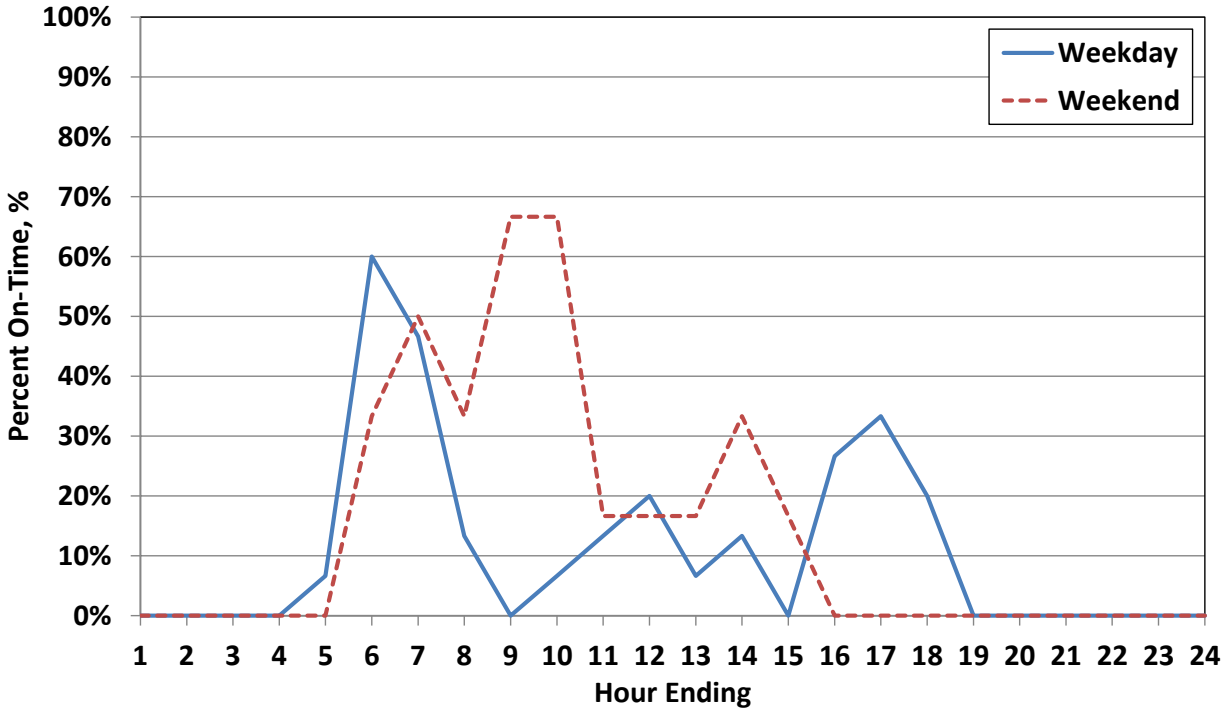
NAICS-322299: All Other Converted Paper Product Manufacturing



NAICS-238990: All Other Specialty Trade Contractors



NAICS-238160: Roofing Contractors



NAICS-922190: Other Justice, Public Order, and Safety Activities