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Plug Load Management System Field Study

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Disclaimer

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GSA's GPG program and DOE's High Impact Technology (HIT) Catalyst program enable federal and commercial building owners and operators to make sound investment decisions in next generation building technologies based on their real-world performance.

Executive Summary

As commercial buildings become more efficient and HVAC electrical loads go down, plug load efficiency becomes more relevant to achieving aggressive energy reduction targets.[1] Plug loads consume at least 30% of whole-building energy use,[2] and include all plug-in and hardwired electric loads in a building that are not associated with major heating, ventilating, or air-conditioning equipment; lighting; water heating; or any other major building equipment needed for basic building operation.[3]

This field study assessed a plug load management (PLM) system in two commercial building applications. The Ibis InteliNetwork™ PLM system includes: intelligent socket devices, which plug into existing electrical outlets, collect energy usage information, and provide on-off, schedule-based control of connected devices; a gateway, which manages communication between the intelligent sockets and the PLM cloud service; and a PLM network, which is a cloud-based measurement and control network for the entire system. The PLM enables users to measure and analyze device energy use and identify opportunities for reduction of plug load energy use. A scheduling function can be used to save plug load energy by setting times for individual devices (or groups of devices) to turn off when not in use, rather than left on and in an idle states. The vendor estimates that the PLM solution that was demonstrated could help customers cut energy consumption for individual plug loads by 20%–50%, resulting in an overall energy savings of up to 10% for commercial buildings.

Two stores were selected as field study sites for this PLM solution. Test location A is a pet-oriented retail store located in Chandler, Arizona, and Test Location B is an eyewear manufacturer and retail store in Honolulu, Hawaii. Following site visits to assess each location, 46 devices in Test Location A and 130 devices in Test Location B were identified for monitoring, control, or other efficiency strategies via the PLM system. Plug load equipment at the two sites was comprised of a wide range of devices, including: checkout counter devices, pet grooming equipment, medical equipment, office equipment, and break room devices. Devices that consume low levels of energy or that are not present in large numbers throughout the store, such as pencil sharpeners or clocks, were generally not included in this pilot. Also not included were devices that are required to stay on, such as refrigerators or life safety equipment for maintaining appropriate environmental conditions for animals.

Quantitative and qualitative performance objectives for the PLM field study were developed with input from the vendor and the retailers. The quantitative and qualitative performance objectives for the PLM field study, as well as indicators of whether the success criteria were met, are provided in Table 1. Energy and energy cost savings were calculated by taking the difference between overall plug load energy consumption during a baseline period, and the plug load energy consumption after schedule-based controls were applied. This simple approach was used because that is how building owners typically calculate energy savings.

[1] "Annual Energy Outlook 2018," U.S. Energy Information Administration, accessed December 20, 2018, https://www.eia.gov/outlooks/archive/aeo18/.

[2] Ibid.

[3] "Navigating Cybersecurity Implications of Smart Outlets," ACEEE, 2018 ACEEE Summer Study on Energy Efficiency in Buildings, accessed December 20, 2018, https://aceee.org/files/proceedings/2018/#/paper/event-data/p373.

Table 1: PLM Quantitative and Qualitative Performance Objectives

Metrics & Data		Test Location A	Test Location B	Success Criterion Met
Quantitative Performance Outcomes				
Electricity Savings	Metered electric consumption	1,040 kWh/year $124.80/year[4] 11% savings[5]	2,730 kWh/year $819/year[6] 18% savings[7]	✓
Cost-Effectiveness	Simple payback	59 years	24 years	✗
	Savings to investment ratio (SIR)	0.17	0.41	✗
Deployability	PLM solution has broad applications across the retailer's portfolio of buildings (for a large quantity of devices within each store)	Unfavorable payback and SIR; however, complications during pilot negatively affected outcomes and savings potential	Unfavorable payback and SIR; however, complications during pilot negatively affected outcomes and savings potential	✗
Qualitative Performance Outcomes				
Ease of Installation	Time required to install system at test site	Less than a day to install	9 hours to install	✓
	Time required by vendor to configure and provide online data interface access	2–3 days	2–3 days	✓
	Impact of install on operations	None	None	✓
Operability	Usability of intelligent sockets	Easy and intuitive	Easy and intuitive, but problems encountered with devices not functioning as intended after controls deployed and with staff unplugging sockets	✓ (Location A) ✗ (Location B)
	Usability of online data interface	Did not use enough to provide feedback	Did not utilize online data interface	✗

[4] Assuming a blended electric rate of $0.12/kWh.

[5] Percent savings in measured plug loads.

[6] Assuming a blended electric rate of $0.30/kWh.

[7] Percent savings in measured plug loads.

	Time commitment required for monitoring and management of plug loads	Staff did not have the 1–2 hours needed per week	Staff did not have the 1–2 hours needed per week	✗
Nonenergy Benefits	PLM solution results in increased equipment life, early detection of device failure, awareness of energy use trends resulting in savings not attributed to controls, staff become educated about and engaged in energy management, and other related benefits	None	This pilot was a good way to engage staff about plug load energy use.	✗ (Location A) ✓ (Location B)

The PLM system was found to be effective at reducing plug load energy use, with a projected annual plug load reduction of 11% and 18% in Test Locations A and B, respectively.[8] However, the economics are not favorable at either test site. Test Location A has a simple payback period of 59 years and a SIR of 0.17 (assuming a project lifetime of 10 years[9]). Test Location B has a simple payback period of 24 years and a savings-to-investment ratio (SIR) of 0.41 (assuming a project lifetime of 10 years).

Staff interviewed for this report stated that the PLM hardware was easy to use and intuitive, though there were reports of store employees becoming frustrated with devices being off when they anticipated them being on, and simply unplugging the devices to override controls. In one of the field studies, store employees unplugged more than half of the intellisockets. The online data management system (dashboard), however, was not used by staff at either test location, which was one large limitation of the success of this study. Personnel familiar with the test site need to be engaged in the study and frequently monitor the dashboard to identify potential issues and capitalize on savings opportunities. For example, there were instances at both test locations of intelligent sockets going offline because staff had unplugged devices from the sockets. The dashboard can also be used to capitalize on nonenergy benefits such as monitoring device health over time, which could be indicated by changes or drifts in the energy consumption that are trended and displayed in the dashboard. Minute-level submetered data are available for download via the dashboard. These nonenergy benefits were not realized in this study.

Another limitation of the study (involving educational awareness and how users engaged with the product) was ensuring that staff, including workers from all shifts as well as janitorial and other service providers, were made aware of the installation of the PLM technology and understood what the technology was, the intent of using it, how it worked, and who to contact with questions or issues.

This PLM solution shows promise as an effective means to monitor, control, and reduce plug load energy use. The system is not currently cost effective; however, deployment at a site with a staff member who is able to actively manage the data (to continually find new opportunities for energy savings), monitor the sockets (to ensure they are not being removed), and confirm that the control schedules are being

[8] Percent savings in measured plug loads.

[9] Project lifetime of 10 years accounts for equipment lifetime and SaaS fee structure.

implemented as intended (and not overridden), at regular time intervals, may result in improved economics over those realized at these two test sites.

In addition, these two test sites experienced complications. At one site, a flood forced the remapping of devices and required a second (shorter) baseline and controls period. At the second, staff continually unplugged devices from the intelligent sockets, yielding a much smaller data set than anticipated.

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I. Introduction

A. WHAT WE STUDIED

This field study assessed the Ibis InteliNetwork™ plug load management (PLM) system in two commercial building applications. The system comprises:

- Intelligent sockets, which capture and control device energy
- A gateway, which communicates energy data from the intelligent sockets to a cloud network
- A PLM network, which is a cloud-based measurement and control network for the entire system.

The intelligent socket plugs into a wall electrical outlet, and the metered device plugs into the intelligent socket. The intelligent sockets are available in single or dual socket models, with the dual socket having one controllable socket and one "always-on" socket. The intelligent sockets come in a range of models appropriate for both 120V/15A devices and 240V/20A devices. Two intelligent socket models are shown in Figure 1. Manager cut sheets for all system components are in Appendix A.

Figure 1: Intelligent Sockets

Image: Ibis Networks

The Gateway manages communication between the intelligent sockets and the PLM network. The Gateway collects energy usage data from up to 120 intelligent sockets and conveys the data to the cloud-based PLM network in real time. The Gateway also receives information from the network related to powering devices on or off.

The PLM network is the interface and tool for viewing, analyzing, reporting, and managing plug load data. This cloud-based service utilizes a dashboard that provides reporting, scheduling, data analytics, and system management tools.[10] A screenshot of the PLM network dashboard is in Figure 2.

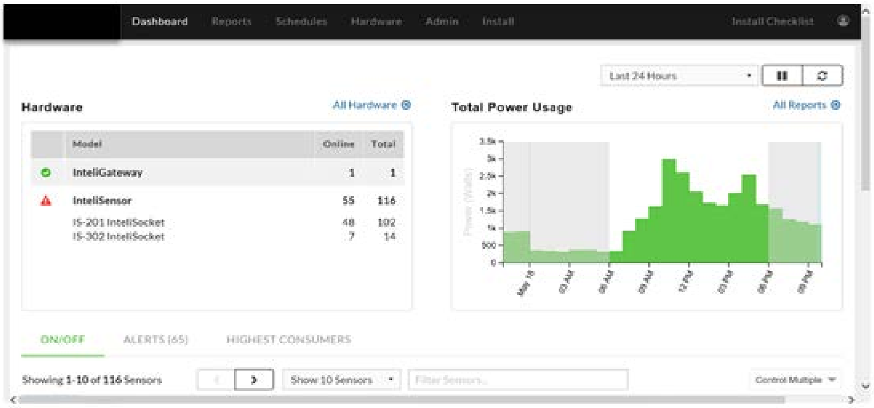


Figure 2: Screenshot of the PLM network dashboard

The vendor estimates that this PLM solution could help customers cut energy consumption for individual plug loads by 20%–50%, resulting in an overall energy savings of up to 10% for commercial buildings.

Two stores—a pet-oriented retail store located in Chandler, Arizona (Test Location A), and an eyewear manufacturer and retail store in Honolulu, Hawaii (Test Location B)—were selected as host sites for the technology. Forty-six devices in Test Location A and 130 devices in Test Location B were identified for monitoring, control, or other efficiency strategies via the PLM system. The two sites included a range of equipment, comprising checkout counter devices, grooming equipment, medical equipment, office equipment, and break room devices. The equipment tested generally did not include devices that consume low levels of energy and are not present in large numbers throughout the store, such as pencil sharpeners or clocks. It also did not include certain devices that the retailer deemed disallowable, such as refrigerators or life safety equipment for maintaining appropriate environmental conditions for animals.

B. WHY WE STUDIED IT

Miscellaneous electric loads (MELs) are electric loads used by appliances and devices outside a building's core functions of heating, ventilation, air conditioning, lighting, water heating, and refrigeration. MELs represent 82% of all miscellaneous electric and gas energy loads for commercial buildings. MELs include plug and process loads (PPLs)—loads plugged into electrical outlets in a building such as computers, coffee makers, etc.—and hard-wired loads, such as fire detectors, escalators, etc.[11] PPLs consume over one third of primary energy in U.S. commercial buildings.[12] As buildings become more efficient, PPL efficiency becomes more relevant to achieving aggressive energy targets.[13] At the building level, MELs account for

[10] "InteliNetwork," Ibis Networks, accessed December 20, 2018, http://ibisnetworks.com/ibissystem/intelinetwork/.

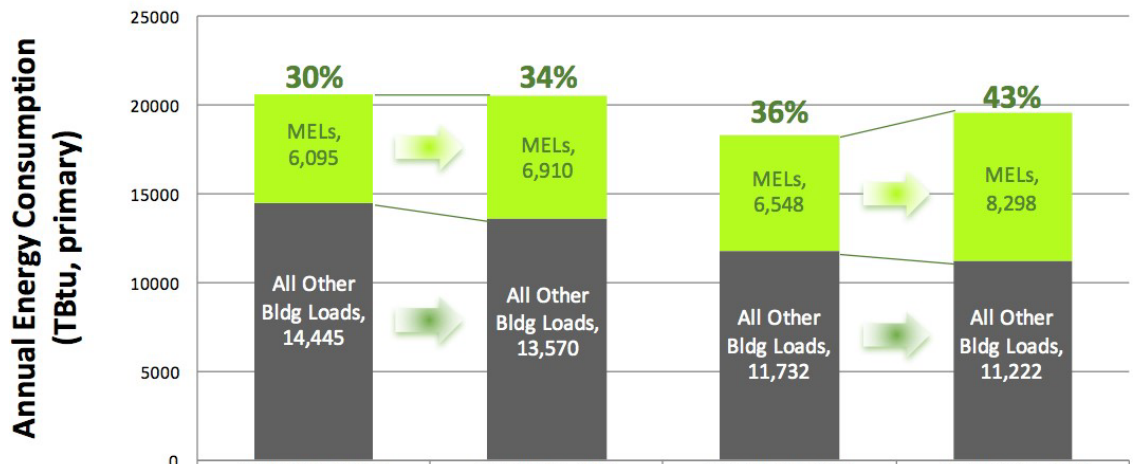
[11] "Miscellaneous Electric Loads: What Are They and Why Should You Care?" U.S. Department of Energy Building Technologies Office article, September 15, 2016, https://www.energy.gov/eere/buildings/articles/miscellaneous-electric-loads-what-are-they-and-why-should-you-care.

[12] "Plug & Process Loads," U.S. Department of Energy Better Buildings, accessed December 20, 2018, https://betterbuildingsinitiative.energy.gov/alliance/technology-solution/plug-process-loads.

[13] Ibid.

approximately 25% of the total electrical load in a minimally code-compliant commercial building and can exceed 50% in an ultra-high efficiency building.[14] Figure 3 demonstrates the increasing percentage of energy use attributed to MELs as buildings become more efficient, projected from 2016 to 2030.

This PLM system is purported to have positive attributes that make it a potentially useful PLM and electricity reduction solution. The system is said to be highly secure, scalable, and affordable. The vendor estimated a reduction up to 10% (based on previous projects they had implemented), in total electricity consumption at both test locations.



	RESIDENTIAL 2016	RESIDENTIAL 2030	COMMERCIAL 2016	COMMERCIAL 2030
MELs	6095	6910	6548	8298
All Other Bldg Loads	14445	13570	11732	11222

Figure 3: Miscellaneous Electric Loads in Buildings (2016 – 2030)

Data From: EIA Annual Energy Outlook 2015 http://www.eia.gov/forecasts/archive/aeo15/;
EIA Residential Energy Consumption Survey https://www.eia.gov/consumption/residential/;
Commercial Buildings Energy Consumption Survey https://www.eia.gov/consumption/commercial/.

[14] Lobato, Chad, Shanti Pless, Michael Sheppy, and Paul Torcellini. 2011. *Reducing Plug and Process Loads for a Large Scale, Low Energy Office Building: NREL's Research Support Facility*. Golden, CO: National Renewable Energy Laboratory. NREL/CP-5500-49002. https://www.nrel.gov/docs/fy11osti/49002.pdf.

II. Evaluation Plan

A. EVALUATION DESIGN

The vendor worked with the two test locations to first identify plug loads to monitor and/or control, and then to install the PLM system, which consisted of intelligent sockets that plugged directly into existing electrical outlets; one or more gateway(s) to manage communication between the intelligent sockets and the PLM cloud service; and the cloud-based PLM network, which is the measurement and control network for the entire system.

An initial baseline period utilizing the intelligent sockets captures data from all monitored devices in each location, facilitating the continual collection of data over that period. The baseline period was 4 weeks and 1 day for Test Location A, and 3 weeks and 6 days for Test Location B. This allowed for measurement and documentation of a wide variety of operational situations (weekday versus weekend operations, business and nonbusiness hour operations, transition times [businesses closed but staff or cleaning crews present]) over several weeks.

After the baseline period, National Renewable Energy Laboratory (NREL) researchers and the vendor jointly studied and analyzed the baseline data to determine an initial energy usage profile by device and device type, the devices with the most potential for savings associated with schedule controls, and potential socket changes (moving a socket from one device to another). These findings were presented to the retail store's energy manager for each test location, and policies for deploying control strategies and communicating them with staff at each test location, control strategies (time on and off per day for each controlled device), and socket changes were then approved by the test locations.

During the control phase, control strategies were applied to approved devices, and data were collected on energy use at the socket level. At the end of the control phase, all data were collected and analyzed, and that analysis is presented here.

B. TEST BED SITES

The vendor and NREL jointly selected two locations for the technology field study: a pet-oriented retail store located in Chandler, Arizona (Test Location A), and an eyewear manufacturer and retail store in Honolulu, Hawaii (Test Location B). The following characteristics were used in the site selection process:

- Required characteristics
    - Commercial building types such as office, multi-tenant office, retail, higher education, hospitality, or other building type with documentation of significant plug loads
    - A building owner open to introducing a wireless network and connectivity through Ethernet cable or access to cell service for data transmission
    - Building owner and occupants willing to participate in a receptacle control field study and provide feedback
    - Building owner and occupants open to a multi-month (3–6 months) field study time
    - Access to an on-site building manager and a staff representative who can act as a liaison between the field study leads and building occupants or tenants.

- Desired characteristics
  - Presence of a building automation system with BACNet IP communication protocols that the vendor technology is allowed to communicate with
    - If a building automation system is not present, access to logs or other measurement and verification records for building systems
  - High-level documentation of general building characteristics
  - High-level approximation of existing plug load types within the building.

TEST LOCATION A

Test Location A is a pet-oriented retail store located in Chandler, Arizona. The store is open from 9:00 a.m. to 9:00 p.m. every day except Sunday, when it is open 9:00 a.m. to 7:00 p.m. In addition to the retail store, there are other services provided such as grooming and veterinary care, which have different operating hours and days. This study used the average annual (blended) electricity rate for this location, which is $0.12/kWh. Note that time-of-use and peak demand charges were not accounted for in this study, but should be accounted for by entities considering this technology, as these charges may impact expected and realized energy savings.

Initially, 46 devices were identified for inclusion in the baseline period. A breakout by device type and a mapping to device category is provided in Table 2.

Table 2: Test Location A—Device Counts by Type and Category

Device Type	Device Count	Device Category
Aquarium	7	Pet Care Equipment
Charger	2	Additional Store Equipment
Computer	1	Office Equipment
Driers	9	Pet Care Equipment
Fan	1	Office Equipment
Floor Scrubber	1	Additional Store Equipment
Pet Food Freezer	2	Pet Care Equipment
Grooming Tables	12	Pet Care Equipment
Microwave	2	Kitchen Equipment

Monitor	3	Office Equipment
Printer	1	Office Equipment
Refrigerator	2	Kitchen Equipment
Vending	3	Kitchen Equipment

A breakout of device counts by device category is provided in Figure 4.

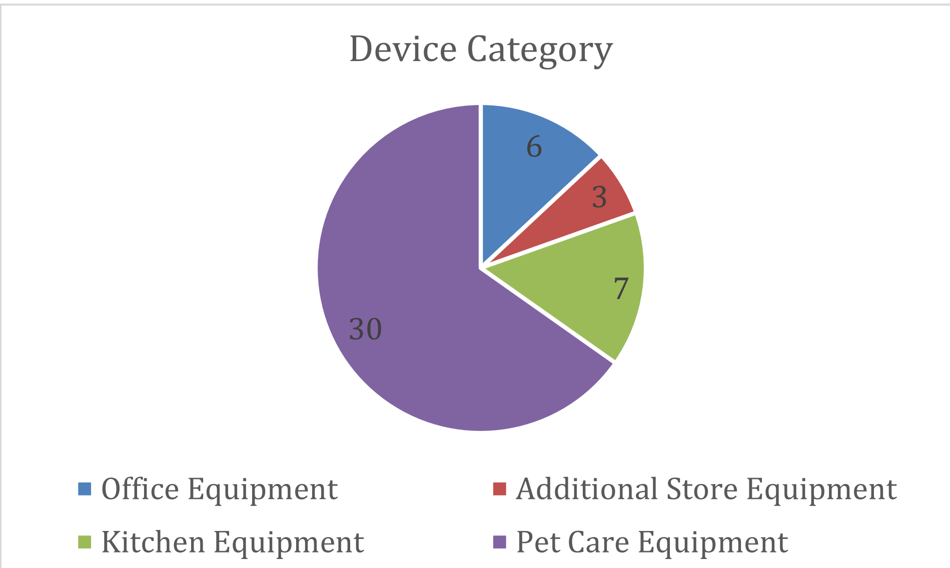


Figure 4: Device Category Counts for Test Location A

TEST LOCATION B

Test Location B is a vision retail store in Honolulu, Hawaii. The store is open from 9:30 a.m. to 9:00 p.m. every day except Sundays, when it is open 10:00 a.m. to 7:00 p.m. The facility also includes optometry services and on-site production of eyewear. The average annual (blended) electricity cost is $0.30/kWh.[15]

Initially, 130 devices were identified for inclusion in the baseline period. A breakout by device and a mapping to the device category are provided in Table 3.

[15] Time-of-use and peak demand charges were not accounted for in this study.

Table 3: Test Location B—Device Counts by Category

Device	Device Count	Device Category
Bicrome Red	4	Optometry Equipment
Cable Box	1	Office/Retail Equipment
Calculator	1	Office/Retail Equipment
Camera	4	Security Equipment
Cash Box	1	Office/Retail Equipment
CD MP3	1	Office/Retail Equipment
Charging Station	1	Office/Retail Equipment
Chiller	1	Optometry Equipment
Chiller Flush Refill	1	Optometry Equipment
Clarifye	1	Optometry Equipment
Clean-n-Coat	4	Optometry Equipment
Computer	17	Office/Retail Equipment
Credit Card Machine	7	Office/Retail Equipment
Equipment Center	1	Optometry Equipment
Exam Machine	5	Optometry Equipment
Exam Table	2	Optometry Equipment
Fan	2	Office/Retail Equipment
Finish Blocker	1	Optometry Equipment
Frame Buffer	1	Optometry Equipment
Gerber Turbo	1	Optometry Equipment

Hilco TempMaster	1	Optometry Equipment
Hilco Ultrasonic Cleaner	1	Optometry Equipment
Hilco TempMaster	1	Optometry Equipment
Hilco Ultrasonic Cleaner	1	Optometry Equipment
Hotfigure	1	Optometry Equipment
Imaging System	1	Optometry Equipment
Ionizing Gun	1	Optometry Equipment
Keeler	1	Optometry Equipment
Lamp	6	Optometry Equipment
Lens Tinting	1	Optometry Equipment
Monitor	13	Office/Retail Equipment
Network Switch	7	Office/Retail Equipment
Optometry Chair	3	Optometry Equipment
Pal ID	1	Optometry Equipment
Phantom Research Lab	1	Optometry Equipment
Phone	2	Office/Retail Equipment
Printer	7	Office/Retail Equipment
Ptronics	3	Optometry Equipment
RayBan Inker	1	Optometry Equipment
Refrigerator	2	Kitchen Equipment
Scan Gun	1	Optometry Equipment
Server	1	Office/Retail Equipment

Shredder	1	Office/Retail Equipment
Stapler	1	Office/Retail Equipment
Surface DeBlock	1	Optometry Equipment
Systech Switch	1	Optometry Equipment
TempMaster	1	Optometry Equipment
TimeClock	1	Office/Retail Equipment
Trans Lenses	1	Optometry Equipment
TV	1	Office/Retail Equipment
UV Trans Meter	1	Optometry Equipment
Vacuum	2	Office/Retail Equipment
Vending Machine	1	Kitchen Equipment
Water Cooler	2	Kitchen Equipment
WECO Finish	1	Optometry Equipment
WelchAllyn	1	Optometry Equipment
Zeiss Machine	2	Optometry Equipment

A breakout of device counts by device category is provided in Figure 5.

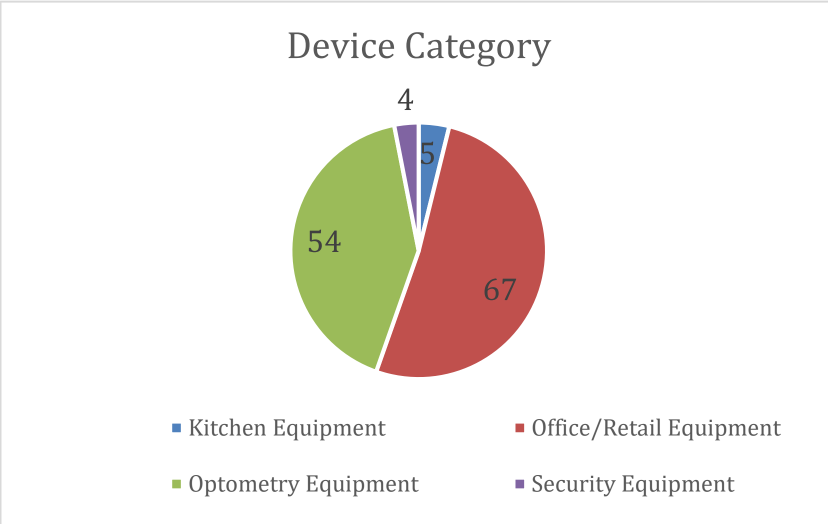


Figure 5: Device Category Counts for Test Location B

C. METHODOLOGY

Quantitative and qualitative performance objectives for the PLM study were developed with input from the vendor and the retailers. The primary objectives of the measurement and verification study are to:

- Verify plug load electricity savings
- Verify cost-effectiveness (payback and savings-to-investment ratio [SIR])
- Evaluate suitability of technology deployment across different building and equipment types
- Evaluate ease of installation, operability, data access, and ability to implement control strategies
- Evaluate nonenergy benefits.

The quantitative and qualitative performance objectives for the PLM study are provided in Table 4.

Table 4: PLM Quantitative and Qualitative Performance Objectives

Objective	Metrics & Data	Success Criterion
Quantitative Objectives		
Electricity Savings	Electricity savings	Electricity savings compared to a baseline period: • At least 10% electricity reduction in measured plug loads
Cost-Effectiveness	Simple payback and SIR	• Simple payback < 10 years • SIR > 1
Deployability	PLM solution has broad applications across the retailer's portfolio of buildings (for a large quantity of devices within each store)	Favorable payback and SIR are achieved in most building and equipment types
Qualitative Objectives		
Ease of Installation	Interview with vendor and retailer representative(s): • Time required to install and configure • Labor associated with install • Impact of install on operations	• < 1 day to install • < 1 week to provide online data access
Operability	Interview with retailer representative(s): • Usability of intelligent sockets • Usability of PLM network • Time commitment required for continual management of plug loads	• No impact to operation and maintenance effort • < 4 hours to understand online data interface
Nonenergy Benefits		At least one non-energy benefit is realized

QUANTITATIVE STUDY DESIGN

The testing protocol for each of the two locations began with an equipment inventory and PLM installation period followed by a baseline period and a controls period. For both locations, the baseline and control periods analyzed were the same length, although they varied between the sites, as shown in Table 5.

Table 5: Baseline and Control Period Lengths

Test Site	Baseline Period	Controls Period
Test Location A	4 weeks 1 day*	4 weeks 1 day*
Test Location B	3 weeks 6 days	3 weeks 6 days

*Note that the baseline and controls period for Test Location A did not occur during the store's flood incident.

After the baseline period, device energy use was analyzed at the device-type and device-category level to identify opportunities for energy reduction via the deployment of control strategies (shutting devices off when not in use). Following this analysis and dialogue with each test site, a subset of devices was selected for control strategies.

At Test Location A, 12 devices were identified for control strategies, and at Test Location B, 63 devices were identified for control strategies. After the control period concluded, data were analyzed to determine realized savings and to quantify projected savings potential (over a longer time period and using a larger data set of devices/sockets). Data for the baseline and control period for Test Location A can be found in Appendix B, and data for the baseline and control period for Test Location B can be found in Appendix C.

QUALITATIVE STUDY DESIGN

The qualitative analysis was based on user input gathered via post-study feedback. It included telephone interviews with the main contacts at each test location, input from the vendor, and firsthand knowledge of the PLM solution gained by the authors of this report.

DATA ANALYSIS

For this analysis, a subset of minute-level data for a given period (baseline or control) was used to calculate an "average week" (average consumption for given device or device category for each hour of the week). The socket sampling interval is every 15 seconds and data was summed to provide minute-level data. Averages were calculated by first summing minute-level data to create hourly data for each week, then averaging weekly data by the hour. Annual numbers were calculated using simple multiplication by 52 weeks; no seasonal variation or holidays were taken into account.

Potential savings were calculated by applying a proposed schedule to baseline data; that is, zeroing out consumption for times when the controls would have turned the device off. Potential savings are calculated by taking the difference between the measured baseline and baseline with the control schedule applied. This does not consider changes in consumption for particular devices when powering up or down, since none of the devices in this study had significant "recovery energy" when turned back on. However, if a study has equipment with significant recovery energy, it should be considered to avoid an overprediction of energy savings. This method was used to calculate savings potential due to large documented inconsistencies between performance and energy use in the baseline versus control periods, the general loss of data sources between baseline and control periods (attributed to staff unplugging the device from the intelligent socket), and the small number of devices that were actually controlled.

The highest confidence in savings potential occurs when the measured savings from the controlled devices are well matched when compared with the potential savings calculated by zeroing out the consumption from the baseline period.

DATA ANALYSIS LABORATORY TEST RESULTS OF INTELLIGENT SOCKETS FOR ACCURACY

The vendor's intelligent sockets were installed in NREL's Energy Systems Integration Facility (ESIF) Systems Performance Laboratory (SPL) to test for metering accuracy. The sockets were tested on the following equipment to get a broad range of power consumers:

- Dishwasher
- Efficient refrigerator
- TV and DVD player
- Small space heater.

Laboratory meters collected data at 1-second intervals and averaged up to 1 minute for the accuracy calculation. To determine the percent difference between the laboratory meters and intelligent sockets, the power was averaged over each "cycle" or appliance test. Table 6 shows the average power values (in watts) for each device and the percent difference. The intelligent meters tend to measure slightly lower than the laboratory power meters, so the percent difference is negative. The results show that the percent difference is small and not of concern, especially for this type of sensor. Additionally, the error does not seem dependent on the size of the load.

Table 6: Average Power per Device and Percent Difference from Lab Meter

Equipment	Average Power–Laboratory Meters (W)	Average Power–Intelligent Sockets (W)	Percent Difference
Dishwasher Cycle	795.5	778.8	-2.1
Refrigerator	33.7	33.1	-2.0
TV/DVD	109.7	105.4	-3.9
Heater	966.5	931.3	-3.6

III. Results

Quantitative and qualitative findings from the pilots at each of the two test sites are provided below. The findings are summarized in Table 7.

Table 7: Plug Load Management Quantitative and Qualitative Performance at Two Pilot Sites

Metrics & Data		Test Location A	Test Location B	Success Criterion Met
Quantitative Performance Outcomes				
Electricity Savings	Metered electric consumption	1,040 kWh/year $124.80/year[16] 11% savings[17]	2,730 kWh/year $819/year[18] 18% savings[19]	✓
Cost-Effectiveness	Simple payback	59 years	24 years	✗
	Savings to investment ratio (SIR)	0.17	0.41	✗
Deployability	PLM solution has broad applications across the retailer's portfolio of buildings (for a large quantity of devices within each store)	Unfavorable payback and SIR; however, complications during pilot negatively affected outcomes and savings potential	Unfavorable payback and SIR; however, complications during pilot negatively affected outcomes and savings potential	✗
Qualitative Performance Outcomes				
Ease of Installation	Time required to install system at test site	Less than a day to install	More than a day to install	✓ (Location A) ✗ (Location B)
	Time required by vendor to configure and provide online data interface access	2–3 days	2–3 days	✓
	Impact of install on operations	None	None	✓

[16] Assuming a blended electric rate of $0.12/kWh.

[17] Percent savings in measured plug loads.

[18] Assuming a blended electric rate of $0.30/kWh.

[19] Percent savings in measured plug loads.

Operability	Usability of intelligent sockets	Easy and intuitive	Easy and intuitive, but problems encountered with devices not functioning as intended after controls deployed and with staff unplugging sockets	✓ (Location A) ✗ (Location B)
	Usability of online data interface	Did not use enough to provide feedback	Did not utilize online data interface	✗
	Time commitment required for monitoring and management of plug loads	Staff did not have the 1–2 hours needed per week	Staff did not have the 1–2 hours needed per week	✗
Nonenergy Benefits	PLM solution results in increased equipment life, early detection of device failure, awareness of energy use trends resulting in savings not attributed to controls, staff become educated about and engaged in energy management, and other related benefits	None	This pilot was a good way to engage staff about plug load energy use.	✗ (Location A) ✓ (Location B)

A. QUANTITATIVE RESULTS

The quantitative findings for both of the test locations are summarized in Table 8.

Table 8: Quantitative Results

Site	Baseline Performance (annual energy use, all monitored devices)	Technology Performance (potential annual energy savings)	% Savings Compared to Baseline
Test Location A	9,673 kWh/year	1,040 kWh/year	11%
Test Location B	15,215 kWh/year	2,730 kWh/year	18%
Average	12,444 kWh/year	1,885 kWh/year	15%

Not all devices with potential for savings via control strategies were included in the control period due to a number of factors—the test site opted a particular device type or device category out of control for functional purposes or operational considerations (they were concerned about not having reliable access to that device or about the impact of having to restart a device); staff at the test site unplugged the device from the intelligent socket, thus disabling the ability to control that device; the device was no longer in use in the store after the baseline period (and therefore could not be controlled); and, in the case of Test

Location A, a flood after the baseline period impacted which sockets and devices were functional and capable of being controlled.

The subsections below discuss the quantitative results in more detail.

TEST LOCATION A

Test Location A experienced a flood that affected the store following the initial baseline period, necessitating a second baseline period (all data in this report are from the second baseline period). As a result of the flood, store operations as well as electrical sockets and devices were impacted. Some intelligent sockets and equipment were destroyed, and some intelligent sockets had to be moved to other devices and the data management system remapped to account for these socket moves. After the remapping, a second baseline period was necessary to accurately capture device energy use and savings potential based on a smaller subset of devices that were included in the second baseline period. Therefore, the opportunities for savings associated with control strategies were also reduced.

After the second baseline period, the collected data were analyzed and control opportunities identified for a subset of devices. Out of the 46 devices included in the baseline period, 11 were identified as being intended for control (see "Devices Intended for Control" in Table 9), and only five devices of those 11 devices yielded a full data set for the entire control period (see "Controlled Device Count" in Table 9). The other six were either unplugged by staff and/or suffered large losses of data and could not be included in this analysis.

Annual energy use, based on summing energy use for all device counts in the baseline period, as well as device counts, controlled device counts, and devices intended for control are provided in Table 9.

Table 9: Annual Energy Use by Device Type for Test Location A

Device	Baseline Device Count	Baseline Electricity Use[20,21] (kWh/year)	Controlled Device Count	Devices Intended for Control
Aquarium	7	1,280	0	0
Charger	2	184	0	0
Computer	1	46	0	0
Driers	9	3,335	0	0
Fan	1	14	1	1

[20] Summing measured electricity use for all monitored devices for each device type (aquarium, charger, computer, etc.).

[21] A subset of data from the baseline period was used to calculate an "average week," which was multiplied by 52 to attain annual energy use by device, as further described in Section II-Data Analysis.

Floor Scrubber	1	327	1	1
Grooming Table	12	89	1	6
Microwave	2	64	0	0
Monitor	3	208	0	0
Pet Food Freezer	2	597	0	0
Printer	1	77	1	1
Refrigerator	2	957	0	0
Vending Machine	3	2,495	1	2
TOTAL	**46**	**9,673**	**5**	**11**

A breakout of device energy use by device category, as measured by the intelligent sockets during the baseline period, is provided in Figure 6.

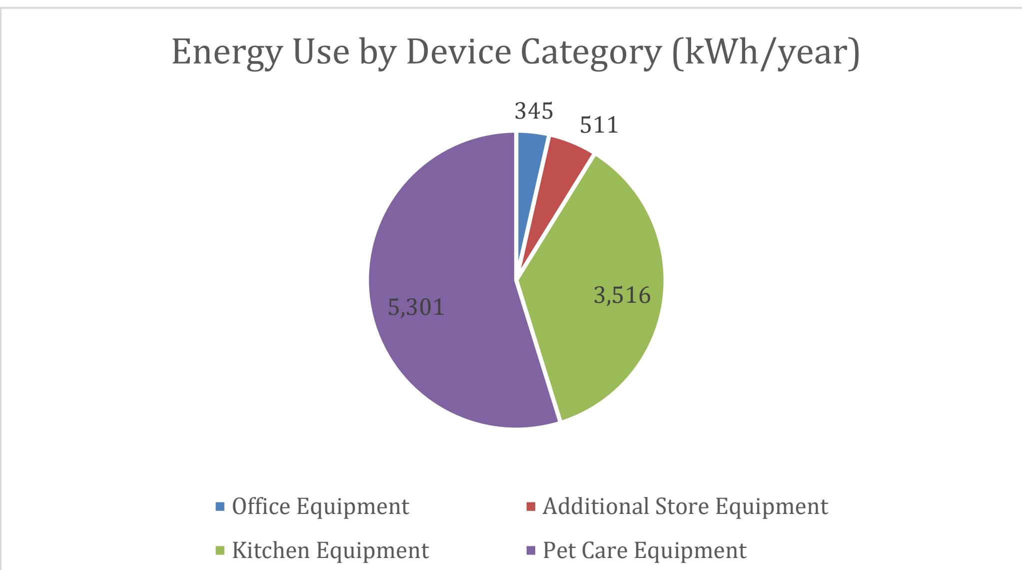


Figure 6: Energy Use by Device Category

Realized and projected energy savings data for the five controlled devices are provided in Table 10. The measured energy use for all 46 devices during the baseline period, averaged and projected for a full year, was 9,673 kWh/year.[22] When testing the five controlled devices by applying schedules during the controls

[22] Method further explained in Section II-Data Analysis.

period, the realized savings were 429 kWh/year. Applying controls to the baseline data by zeroing out that data during the control periods for all of the devices that were intended to be controlled is estimated to have potential savings of about 1,040 kWh/year—approximately 11% savings over the baseline data. Some external variables could not be controlled between the baseline and control periods, so the higher-than-projected savings may be attributed to varying consumption patterns (less use of a device during the control period than the baseline period).

As previously mentioned, potential savings were calculated by applying a proposed schedule to baseline data; that is, zeroing out consumption for times when the controls would have turned the device off. Potential savings are calculated by taking the difference between the measured baseline and baseline with the control schedule applied. This method was used to calculate savings potential due to large documented inconsistencies between performance and energy use in the baseline versus control periods, the general loss of data sources between baseline and control periods (attributed to staff unplugging the device from the intelligent socket), and the small number of devices that were actually controlled.

Table 10: Realized and Projected Energy Savings for Controlled Devices for Test Location A

Device	Control Period Device Count	Control Period Realized Savings (kWh/year)	Devices Intended for Control Count	Potential Savings, Estimated from Baseline for all Devices Intended for Control (kWh/year)
Fan	1	7.43	1	4.82
Floor Scrubber	1	318.81	1	73.41
Grooming Table	1	2.77	6	2.53
Printer	1	7.18	1	10.23
Vending Machine	1	93.25	2	949.43
TOTAL	**5**	**429.44**	**11**	**1,040.42**

Devices with control period realized savings (during the control period) larger than potential savings calculated from baseline (such as the fan and the floor scrubber) or smaller (vending machine) show very different consumption patterns from the baseline period to the control period. The usage patterns of these devices were unpredictable.

TEST LOCATION B

Out of the 130 devices included in the baseline period for Test Location B, 54 were identified as being intended for control (see “Devices Intended for Control” in Table 11), and only 19 devices of those 54 devices yielded a full data set for the entire control period (see “Controlled Device Count” in Table 11). At the initiation of the control period, all identified devices (54) were controlled, but during the several weeks that controls were activated, staff unplugged many of the intelligent sockets, thus yielding an incomplete data set. Only devices that were controlled for the full control period (3 weeks and 6 days for Test Location B) are included in this analysis.

Annual energy use, based on summing energy use for all device counts in the baseline period, as well as monitored device counts, controlled device counts, and devices intended for control, are provided in Table 11.

Table 11: Annual Energy Use by Device for Test Location B

Device	Baseline Device Count	Baseline Electricity Use[23, 24] (kWh/year)	Controlled Device Count	Devices Intended for Control
Bicrome Red	4	218	1	4
Calculator	1	9	0	1
Camera	4	12	1	4
Cash Box	1	5	0	1
CD MP3	1	13	0	0
Chiller	1	3,275	0	1
Chiller Flush Refill	1	16	0	0
Credit Card Machine	7	87	0	6
Finish Blocker	1	19	1	1
Frame Buffer	1	4	0	0
Gerber Turbo	1	422	0	1
Hilco TempMaster	1	20	0	0
Hilco Ultrasonic Cleaner	1	0	0	0

[23] Summing measured electricity use for all monitored devices for each device type (aquarium, charger, computer, etc.).

[24] A subset of data from the baseline period was used to calculate an "average week," which was multiplied by 52 to attain annual energy use by device, as further described in Section II-Data Analysis.

Hotfigure	1	0	0	0
Ionizing Gun	1	12	0	1
Lamp	6	16	5	6
Lens Tinting	1	16	1	1
Monitor	13	4,212	2	8
Pal ID	1	16	0	0
Phantom Research Lab	1	630	1	1
Printer	7	479	1	4
Ptronics	3	928	0	3
Refrigerator	2	967	0	1
Scan Gun	1	16	1	1
Stapler	1	8	0	1
Surface DeBlock	1	0	0	0
TempMaster	1	306	0	0
Trans Lenses	1	19	1	1
TV	1	5	1	1
UV Trans Meter	1	21	0	1
Vacuum	2	562	1	2
Vending Machine	1	2,083	1	1
Water Cooler	2	777	1	1
WECO Finish	1	42	0	1
TOTAL	**74**	**15,215**	**19**	**54**

A breakout of device energy use by device category, as measured by the intelligent sockets during the baseline period, is provided in Figure 7.

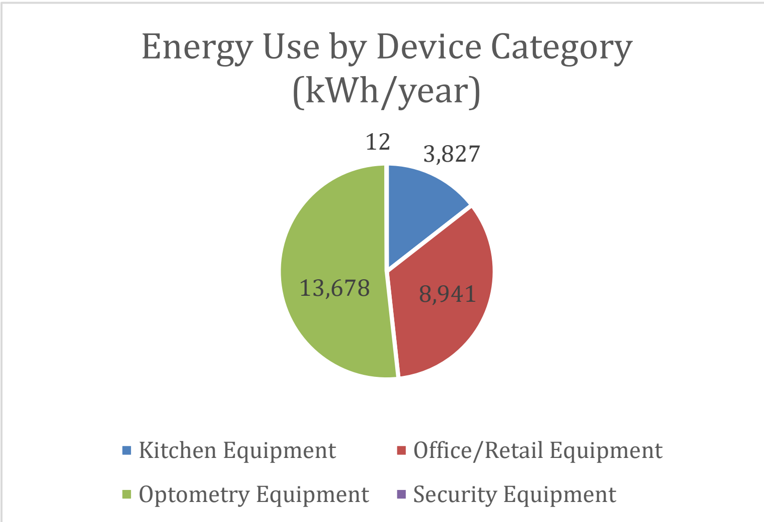


Figure 7: Energy Use by Device Category for Site B

Actual and projected energy savings data for the 19 controlled devices are provided in Table 12. The measured energy use for all 130 devices during the baseline period, averaged and projected for a full year, was 15,215 kWh/year.[25] Application of controls to the 19 controlled devices resulted in realized savings of 1,088 kWh/year. Applying controls to the baseline data by zeroing out that data during the control periods for all of the devices that were intended to be controlled is estimated to have resulted in potential savings of about 2,730 kWh/year—approximately 18% savings over the baseline data.

Some external variables could not be controlled between the baseline and control periods, so the higher-than-projected savings may be attributed to varying consumption patterns (less use of a device during the control period than the baseline period). Conversely, lower-than-projected savings may be attributed to an increase in use of a device during the control period versus the baseline period.

[25] Method further explained in Section II-Data Analysis.

Table 12: Realized and Projected Energy Savings for Controlled Devices for Test Location B

Device	Control Period Device Count	Control Period Realized Savings (kWh/year)	Devices Intended for Control	Potential Savings, Estimated from Baseline for All Devices Intended for Control (kWh/year)
Bicrome Red	1	16.25	4	29.47
Calculator	0	0	1	4.59
Camera	1	2.56	4	5.36
Cash Box	0	0	1	2.63
Chiller	0	0	1	650.20
Credit Card Machine	0	0	6	30.47
Finish Blocker	1	(0.83)	1	0.06
Gerber Turbo	0	0	1	4.35
Ionizing Gun	0	0	1	5.38
Lamp	5	(36.34)	6	0.09
Lens Tinting	1	15.61	1	7.07
Monitor	2	79.68	8	187.88
Phantom Research Lab	1	132.46	1	30.83
Printer	1	63.24	4	76.95
Ptronics	0	0	3	36.30
Refrigerator	0	0	1	388.81
Scan Gun	1	3.56	1	7.52
Stapler	0	0	1	3.77
Trans Lenses	1	8.57	1	9.22

TV	1	(37.08)	1	2.38
UVTrans Meter	0	0	1	0.13
Vacuum	1	1.75	2	16.33
Vending Machine	1	762.12	1	1,001.80
Water Cooler	1	142.02	1	192.80
WECO Finish	0	0	1	35.54
TOTAL	**19**	**1,087.73**	**54**	**2,729.93**

B. QUALITATIVE RESULTS

Qualitative results, including feedback from staff associated with both of the test locations and the NREL authors of this study, are provided below.

TEST LOCATION A

Data were collected from the company's lead contact for this pilot project via email. She indicated that she was not present for the installation—the person who was present has since left the company—but she indicated that it took less than a full day. She's not aware of any impacts associated with the installation.

She indicated that the intelligent sockets are very intuitive and easy to use, and the label on them is very clear. She did use the online dashboard a few times, but not frequently. She indicated that if she had more time to dedicate to the project, she would've used it more often, but with her limited use, she isn't able to speak to its usability.

She identified the biggest issue associated with this pilot as a lack of dedicated staff time to manage plug loads based on feedback from the energy usage data measured by the intelligent sockets. She indicated that they ended up just measuring plug load energy use, rather than proactively using the data to effectively manage the loads.

Additional feedback indicated that this pilot project experienced many issues, some of which were self-imposed and others pure bad luck. A monsoon storm caused a roof leak, which flooded portions of the store, damaging the building, sockets, and some equipment. One socket went missing during the project, presumably removed by an associate. And the highest energy-using device—a piece of equipment used to make tags for dogs and cats—is poorly designed, and any interruption of power damages the internal central processing unit (CPU).

She felt this system required a lot of effort and oversight to keep it running and to monitor it frequently, and that this system is likely not a good fit for broader deployment at other stores. She indicated that associates tampered with the system, and that, combined with varying operational schedules and usage patterns, made it difficult to effectively manage the system. She felt that without adequate time to monitor the data and make changes in schedules, the benefits of the system are not realized. She said that for their specific store, plug loads are very small compared to heating, ventilating, air-conditioning, and lighting loads, and she felt that focusing on reducing those loads would be a better use of time and resources.

TEST LOCATION B

A phone interview was conducted with staff familiar with the project at Test Location B—a store manager and the company's lead contact for this pilot project. They indicated that the system took approximately three hours to install at the Honolulu store, and the impact of the installation on operations was minimal; vendor staff began the installation before operating hours and finished it approximately one hour after the store had opened.

The staff interviewed stated that the intelligent sockets were easy to use, and that instructional material provided with the system very clearly explained how to reset the sockets, if needed. However, there were significant issues at this store associated with staff unplugging devices from the intelligent sockets and removing the sockets. This was in response to a couple pieces of equipment that froze or did not work as expected or when expected. Staff stated that they tried to reset the devices but that was ineffective at solving some of the problems. They did not look at the online dashboard or consult with NREL or Ibis Networks to further troubleshoot the problem, and eventually resorted to unplugging a large number of the sockets.

Neither of the two people interviewed used the online dashboard. They didn't see a need to monitor the performance of the measured devices as they believed that was happening through the vendor and NREL.

Both staff members interviewed were open to continued or expanded use of the technology in the future. However, additional methods to reach all store staff would need to be identified. In a retail setting with two to three or even more shifts, it is difficult to inform everyone of a pilot like this, including what the technology is, what the intent of using the technology is, how it works, and who to contact with questions or issues. All of this information was communicated to the store manager directly, and signage was placed throughout the store. However, it seems to have been insufficient.

NREL STAFF EVALUATION

PLM System Ease of Use:

At both test sites, the PLM system was installed and configured by vendor staff. However, the PLM system is simple to install and set up. Each socket needs to be configured and labeled with the individual device that is plugged into it. This is done via the online dashboard, using a ZigBee-based dongle to communicate with the gateway (via ZigBee wireless communication protocols) to recognize each socket. The gateway can be preconfigured by the vendor offsite or configured on site by anyone with an installation kit (a vendor is not required to be on site). The gateways require a wired Ethernet connection, which can be achieved with a mobile hotspot and WiFi-to-Ethernet adapter. The intelligent sockets are available in the following configurations:

1. Dual socket model with one controllable socket and one always-on socket. Both sockets have metering capabilities, for 120V/15A devices
2. Single socket model with meter and control capabilities, for 120V/15A devices
3. Power socket model with meter and control capabilities, for 240V/20A devices.

The PLM online dashboard has a number of useful features, as well as some that could be improved upon:

- Data are easy to read and device energy is easily comparable.
- Schedule-based controls are moderately easy to set up and activate, although the controls must be activated manually through the online dashboard (i.e., if you want the controls to start at 2am on a specific day, then the user must activate the controls via the online dashboard at 2am on that specific day).
- Online dashboard features could be improved through:
    - Graphing capabilities that are more intuitive
    - Interval data that are easier to download. One-minute data is available, but the user must request one-minute data from Ibis Networks directly for time periods greater than 12 hours.
    - Control activation start times that could be set up ahead of the actual activation time, so controls would automatically be implemented at the specified time and date.

The PLM system triggers alerts—sent via email or SMS to a defined user—when an intelligent socket goes offline, and again when it comes back online. The sockets often go offline for short periods of time (sometimes one second), but then come back online. Data are not lost during these short interruptions due to the socket and gateway's ability to hold data for short periods of time and push them to the cloud after reconnecting. (For example, in a system of 50 sockets, a gateway can cache data for up to 8 hours.[26]) However, these short interruptions trigger alerts—sometimes many alerts—and it can be challenging to identify critical alerts among so many noncritical alerts.

Education and Communication:

It is very important that all occupants interacting with the PLM system:

1. Are aware of why the intelligent sockets have been installed
2. Understand how they work, the on/off equipment schedules, and how to override controls if need be (otherwise, personnel are likely to unplug the sockets)
3. Have a point of contact to call if any issues arise or changes to the system need to be made
4. Know to contact the point of contact if equipment is moved from one socket to another.

[26] "Hardware FAQ." Ibis Networks, accessed December 20, 2018, http://docs.ibis.io/HardwareFAQ.pdf.

C. COST-EFFECTIVENESS

The vendor provided cost estimates for the systems as deployed in each of the two test locations. The vendor also charges a software-as-a-service (SaaS) fee of $6 per intelligent socket per year deployed. The SaaS fee was applied to all sockets that were identified for control during the baseline period (for the assumed 10-year project lifetime).

TEST LOCATION A

Test Location A had 46 intelligent sockets and one gateway deployed. The vendor provided an estimated cost for this hardware of $4,545, which included labor associated with site walkthrough, device inventory creation, installation, and as-needed support and may also have been discounted by the vendor.[27]

The SaaS fee is assumed to be:

SaaS fee = 10 years * 46 sockets * $6/socket/year = $2,760

Annual electricity savings at Test Location A were estimated to be 1,040 kWh/year. Using the site's annual average electricity rate of $0.12/kWh, the annual cost savings would be $124.80/year.

The simple payback period and the SIR over the assumed project lifetime of 10 years are 58.53 years and 0.17, respectively.

TEST LOCATION B

Test Location B had 130 intelligent sockets and one gateway deployed. The vendor provided an estimated cost for this hardware of $12,063, which included labor associated with site walkthrough, device inventory creation, installation, and as-needed support and may also have been discounted by the vendor.

The SaaS fee is assumed to be:

SaaS fee = 10 years * 130 sockets * $6/socket/year = $7,800

Annual electricity savings at Test Location B were estimated to be 2,730 kWh/year. Using the site's annual average electricity rate of $0.30/kWh, the annual cost savings would be $819/year.

The simple payback period and the SIR over the assumed project lifetime of 10 years are 24.25 years and 0.41, respectively.

[27] Hardware costs broken down by component can be provided by the vendor.

IV. Summary Findings and Conclusions

A. OVERALL TECHNOLOGY ASSESSMENT BASED ON FIELD STUDY

A PLM system was tested in two stores—a pet-oriented retail store located in Chandler, Arizona (Test Location A), and an eyewear manufacturer and retail store in Honolulu, Hawaii (Test Location B). The PLM system was found to be effective at reducing plug load energy use, with a projected annual plug load reduction of 11% and 18% in Test Locations A and B, respectively. However, the economics were not favorable at either test site, with Test Location A having a simple payback period of 59 years and a SIR of 0.17 (assuming a project lifetime of 10 years). Test Location B had a simple payback period of 24 years and a SIR of 0.41 (assuming a project lifetime of 10 years).

However, both test sites experienced complications that negatively affected outcomes and savings potential. Staff at both locations unplugged devices from intelligent sockets, causing a disruption in data collection and limiting realized savings. One site experienced a flood, and the baseline and controls periods were shortened. Lastly, neither site closely monitored energy data on the dashboard, which is important for continually finding opportunities for energy savings and for identifying issues soon after they arise (such as unplugged sockets).

This PLM solution shows promise as an effective means to monitor, control, and reduce plug load energy use. The economics of the system are not currently cost effective; however, deployment at a site with a staff member who is able to actively manage the data, the sockets, and the control schedules by dedicating at least one to two hours per week to this effort may result in improved economics over those realized at these two test sites.

B. LESSONS LEARNED AND BEST PRACTICES

This PLM solution, although easy to use and seemingly low maintenance, requires regular interaction with both the online data management system and with building occupants to bring awareness on how to use the system effectively, for successful PLM and savings achievement. Personnel familiar with the test site, the operations at the site, and the devices being monitored need to be engaged in the study and regularly monitor the dashboard to assess alerts, identify potential issues, and capitalize on savings opportunities. They also must regularly engage with and remind building occupants of how the system works and its importance, and of protocols for moving devices and overriding controls if necessary. For example, there were instances at both test locations of staff unplugging devices from the sockets that could have been avoided or remedied quickly with more diligent monitoring of the system and better communication with staff about operational protocols. The dashboard can also be used to capitalize on nonenergy benefits, such as monitoring device health, which could be indicated by declining performance as measured and displayed in the dashboard. For example, researchers were able to identify an old refrigerator at one of the sites, due to the fact that the energy usage was very high, and the usage pattern did not show regular compressor cycles that are typically seen in newer, efficient models. However, these nonenergy benefits were not realized in this study.

Another important takeaway from this pilot is the importance of communicating well and often with all staff at the site where the PLM solution is installed. All staff, including workers from all shifts as well as janitorial and other service providers, must be made aware of the installation of the PLM technology, understand what the technology is, be clear about the intent of using the technology, know how it works, and know who to contact with questions or issues. Depending on the type of building the PLM technology is deployed in (retailer, office, etc.), staff may be limited in their time and motivation to learn about and interact with the system.

C. FIELD STUDY RECOMMENDATION

This PLM solution will be most cost effective when used in areas with high utility rates and/or in applications with a large percentage of plug loads. An organization with many facilities might find success in investing in this PLM solution for one site, using it to monitor and control loads, and then moving some of the sockets (perhaps from devices deemed not appropriate for controls) to another site for monitoring and control strategies. Additionally, buildings that have multiple high-energy loads—such as hotels with mini-refrigerators and ice machines, or schools with window-box air conditioners—can leverage this technology to monitor the health of these devices and remotely turn off the devices when they are not in use.

V. Appendices

A. MANUFACTURER CUT SHEETS

Ibis NETWORKS

IG-302
InteliGateway™

FEATURES

- ZigBee Pro Coordinator
- 128 bit AES Security
- 17dBm RF Power
- RoHS Comliant

DESCRIPTION

The IG-302 is a standalone InteliGateway which implements Ibis' Plover profile. It connects the ZigBee mesh to an Ethernet port, providing connectivity to the InteliNetwork™.

PERFORMANCE

Parameter	Symbol	Min	Typ	Max	Units
RF Range			50		m
RF Transmit Power			17		dBm
Sockets per Network				120	
ZigBee Channels		11		26	
ZigBee Hive		0x3000		0x3FFF	
Size		4.4 x 2.3 x 1.3			inches

COMPLIANCE

Agency	File
ZigBee Profile (Plover)	0x114B
FCC	

ENVIRONMENTAL

Parameter	Symbol	Min	Typ	Max	Units
Operating Temperature	T_O	0	25	40	C
Storage Temperature	T_S	-40		100	C
Relative Humidity	RH	0		95	%

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02/24/16

FCC

This equipment has been tested and found to comply with the limits for a class B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

The user is cautioned that changes and modifications made to the equipment without the approval of manufacturer could void the user's authority to operate this equipment.

To satisfy RF exposure requirements, this device and its antenna must operate with a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

IS-201
InteliSocket™

FEATURES

- 120V 15A
- UL Certification
- ZigBee Pro
- 128 bit AES Security
- 20dBm RF Power
- Surge Protected
- RoHS Compliant

DESCRIPTION

The IS-201 is a smart socket which meters plug load energy usage and provides device on/off capability. It works with other InteliSockets™ to form a secure wireless mesh network for control and reporting of data. Each network has an InteliGateway™ base station providing connectivity to the InteliNetwork™, a cloud-based data collection and analysis application. InteliSockets can be configured to operate on any of the 15 ZigBee channels. In addition, the hive (PANID) has over 4000 possible settings, preventing nearby systems from interfering with each other.

PERFORMANCE

Parameter	Symbol	Min	Typ	Max	Units
Input Voltage (RMS)	V_{IN}	108	120	132	V
Input Frequency			60		Hz
Output Current (RMS)	I_{OUT}			15	A
Output Power	P_{OUT}			1800	W
Power Consumption			1		W
Reporting Interval		1	15	255	s
Accuracy (Energy)				0.5	%
Accuracy (Voltage)				2	%
Accuracy (Interval)				1	ms
Resolution			1		W-s
RF Range			50		m
RF Transmit Power		0		20	dBm
Sockets per Network				120	
ZigBee Channels		11		25	
ZigBee Hive		0x3000		0x3FFF	
Size		4.1 x 2.2 x 1.7			inches

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12/03/15

COMPLIANCE

Agency	File
UL916 – Energy Management Equipment	E470522
ZigBee Profile (Plover)	0x114B
FCC	2AECN200

ENVIRONMENTAL

Parameter	Symbol	Min	Typ	Max	Units
Operating Temperature	T_O	0	25	40	C
Storage Temperature	T_S	-40		100	C
Relative Humidity	RH	0		95	%

InteliSockets are for indoor use only.

PROTOCOL

InteliSockets use the Ibis custom Plover profile for commands, acknowledgements, and reporting of data.

DATA

InteliSockets report data typically every 15 seconds. Each report packet is comprised of socket type, ZigBee channel, ZigBee hive (PANID), interval (seconds), voltage (RMS), frequency (Hz), energy (watt-seconds), and power factor (fraction). From these data we can calculate instantaneous power (watts) and current (amps).

The InteliGateway appends additional information (IP, timestamp, location, etc.) before uploading to the InteliNetwork. This allows any socket in the world to be located and addressed individually.

PUSHBUTTON

The small pushbutton provides addition control features. First and foremost, it is a manual override for turning the outlet on (green) and off (red). If pressed and held for at least three seconds it causes a reboot of the socket. If held in for ten seconds (two reboots) it reverts back into factory mode settings. This is a useful feature for maintenance purposes or when a socket gets moved from one location to another.

LED

The LED on the front indicates the state of the socket. When red the outlet is off; green is outlet is on. If LED is blinking, the socket has not yet associated with a mesh network. During a reboot, the LED will flash yellow for a second.

FCC

This equipment has been tested and found to comply with the limits for a class B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

The user is cautioned that changes and modifications made to the equipment without the approval of manufacturer could void the user's authority to operate this equipment.

To satisfy RF exposure requirements, this device and its antenna must operate with a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

IS-301

Single InteliSocket™

FEATURES

- 120V 15A
- UL Certification
- ZigBee Pro
- 17dBm RF Power
- Surge Protected
- RoHS Compliant

DESCRIPTION

The IS-301 is a smart socket which meters plug load energy usage and provides device on/off capability. It works with other InteliSockets™ to form a secure wireless mesh network for control and reporting of data. Each network is anchored by an InteliGateway™ base station providing connectivity to the InteliNetwork™, a cloud-based data collection and analysis application.

PERFORMANCE

Parameter	Symbol	Min	Typ	Max	Units
Input Voltage (RMS)	V_{IN}	108	120	132	V
Input Frequency			60		Hz
Output Current (RMS)	I_{OUT}			15	A
Output Power	P_{OUT}			1800	W
Power Consumption			1.2		W
Reporting Interval		1	15	255	s
Accuracy (Energy)				0.5	%
Accuracy (Voltage)				1	%
Accuracy (Interval)				1	ms
Resolution			1		W-s
RF Range			50		m
RF Transmit Power			17		dBm
Sockets per Network				120	
ZigBee Channels		11		26*	
ZigBee Hive		0x3000		0x3FFF	
Size		3.0 x 1.5 x 1.4			inches

* Channel 26 limited to 3dBm

COMPLIANCE

Agency	File
UL916 – Energy Management Equipment	
ZigBee Profile (Plover)	0x114B
FCC	

ENVIRONMENTAL

Parameter	Symbol	Min	Typ	Max	Units
Operating Temperature	T_O	0	25	40	C
Storage Temperature	T_S	-40		100	C
Relative Humidity	RH	0		95	%

InteliSockets are for indoor use only.

PROTOCOL

InteliSockets use Ibis' custom Plover profile for commands, acknowledgements, and reporting of data.

DATA

InteliSockets report data typically every 15 seconds. Each report packet is comprised of socket type, ZigBee channel, ZigBee hive (PANID), interval (seconds), voltage (RMS), frequency (Hz), energy (watt-seconds), and power factor (fraction). From these data we can calculate instantaneous power (watts) and current (amps).

The InteliGateway appends additional information (IP, timestamp, location, etc.) before uploading to the InteliNetwork. This allows any socket in the world to be located and addressed individually.

PUSHBUTTON

The illuminated pushbutton provides addition control features. First and foremost, it is a manual override for turning the outlet on (green) and off (red). If pressed and held for at least three seconds it causes a reboot of the socket. If held in for ten seconds (two reboots) it reverts back into factory mode settings. This is a useful feature for maintenance purposes or when a socket gets moved from one location to another. A blinking backlight indicates the socket has not associated with a mesh network yet.

FCC

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a class B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

The user is cautioned that changes and modifications made to the equipment without the approval of manufacturer could void the user's authority to operate this equipment.

To satisfy RF exposure requirements, this device and its antenna must operate with a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

IS-302
Dual InteliSocket™

FEATURES

- 120V 12A
- UL Certification
- ZigBee Pro
- Surge Protected
- RoHS
- Title 24 Part 6 Compliant

DESCRIPTION

The IS-302 is a dual smart socket which meters plug load energy usage and provides device on/off capability. It works with other InteliSockets™ to form a secure wireless mesh network for control and reporting of data. Each network is anchored by an InteliGateway™ base station providing connectivity to the InteliNetwork™, a cloud-based data collection and analysis application.

PERFORMANCE

Parameter	Symbol	Min	Typ	Max	Units
Input Voltage (RMS)	V_{IN}	108	120	132	V
Input Frequency			60		Hz
Output Current (RMS)	I_{OUT}			12	A
Power Consumption			1.2		W
Reporting Interval		4	15	60	s
Accuracy (Energy)				0.5	%
Accuracy (Voltage)				1	%
RF Range			50		m
Resolution		1			W-s
RF Transmit Power			11		dBm
ZigBee Channels		11		26*	
ZigBee Hive		0x3000		0x3FFF	
Size		4.5 x 2.75 x 1.4			inches

* Channel 26 limited to 3dBm

COMPLIANCE

Agency	File
UL916 – Energy Management Equipment	E470522
ZigBee Profile (Plover)	0x114B
FCC	2AECN302

ENVIRONMENTAL

Parameter	Symbol	Min	Typ	Max	Units
Operating Temperature	T_O	0	25	40	C
Storage Temperature	T_S	-40		100	C
Relative Humidity	RH	0		95	%

* InteliSockets are for indoor use only.

PUSHBUTTON / LED

Action	Result
Press (no hold)	Toggle outlet state (on/off).
Pressed while plugging in	Ignored.
Press and hold 3+ seconds	Soft reset. Re-start socket. Similar to plugging in.
Press and hold 8+ seconds	Hard reset. All conditions are set to default. Normally this sets socket back to FACTORY channel and hive. However, if socket has been deployed on CUSTOMER channel and hive, a hard reset will then toggle between FACTORY and CUSTOMER settings. This is a useful feature to correct a socket that has been accidentally reset to FACTORY. It also provides a quick method to perform a manual self-heal. If on FACTORY, LED will be red, CUSTOMER green.

Color	Meaning
Black	Socket has no power.
Yellow	Boot-up sequence in effect. Typically ½ second duration.
Flashing Red or Green	Socket is attempting to join mesh network.
Red	Outlet is off.
Green	Outlet is on.

DUAL OUTLETS

Outlets on the IS-302 are metered separately, although only one of them can be turned off. The "always on" outlet is meant to be used for monitoring a device such as a computer or lamp, providing an indication of a user's presence (occupancy detection), which then automatically turns on the "controlled outlet (having set an appropriate power threshold). Such behavioral control can potentially lead to greater savings than fixed time schedules.

TITLE 24

The IS-302 is Title24 compliant.

FCC

This equipment has been tested and found to comply with the limits for a class B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

The user is cautioned that changes and modifications made to the equipment without the approval of manufacturer could void the user's authority to operate this equipment.

To satisfy RF exposure requirements, this device and its antenna must operate with a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

B. TEST LOCATION A DATA

BASELINE DATA

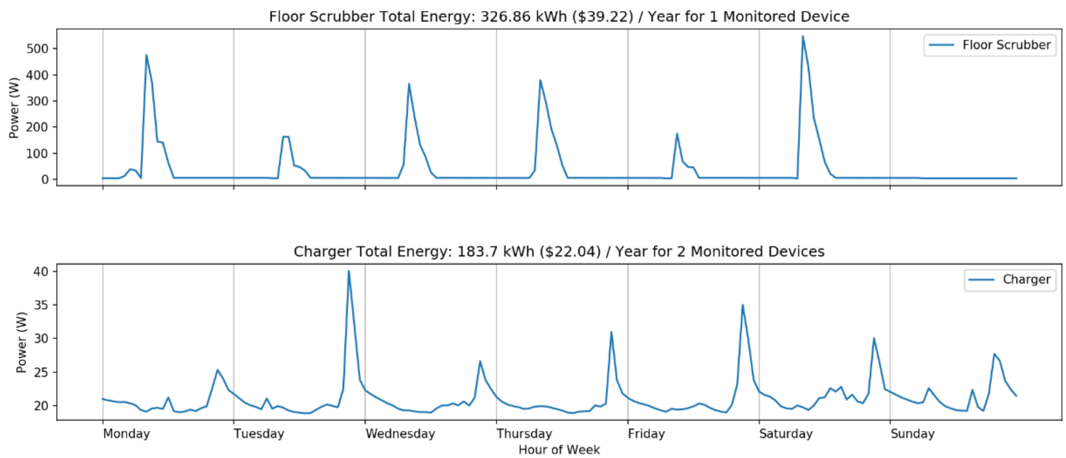

Figure 8: Additional Store Equipment - Total Energy: 510.56 kWh ($61.27) / Year

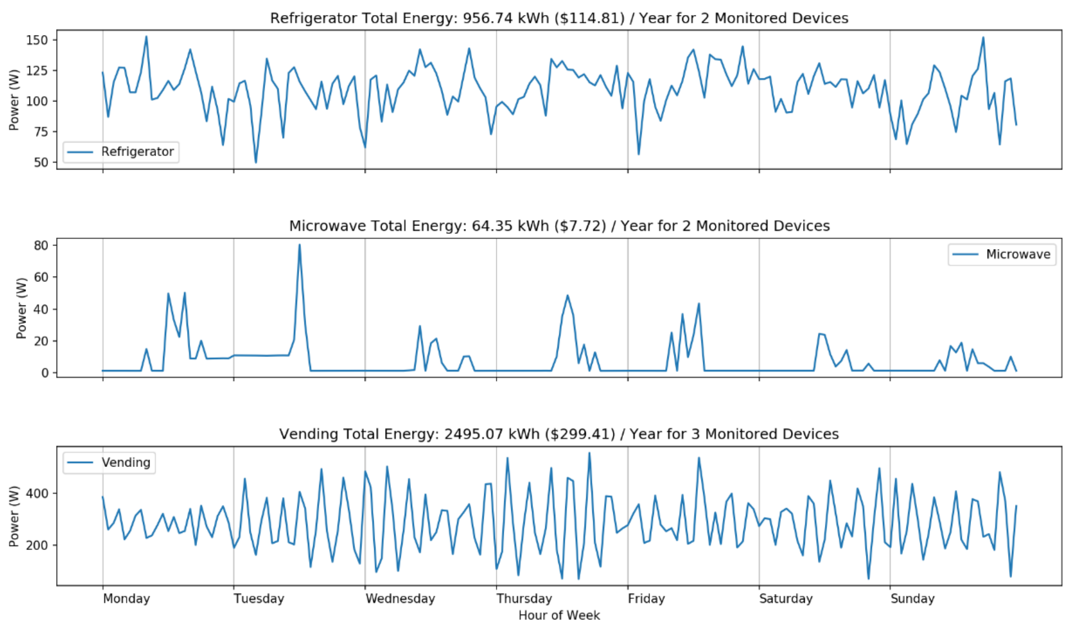

Figure 9: Kitchen Equipment - Total Energy: 3,516.16 kWh ($421.94) / Year

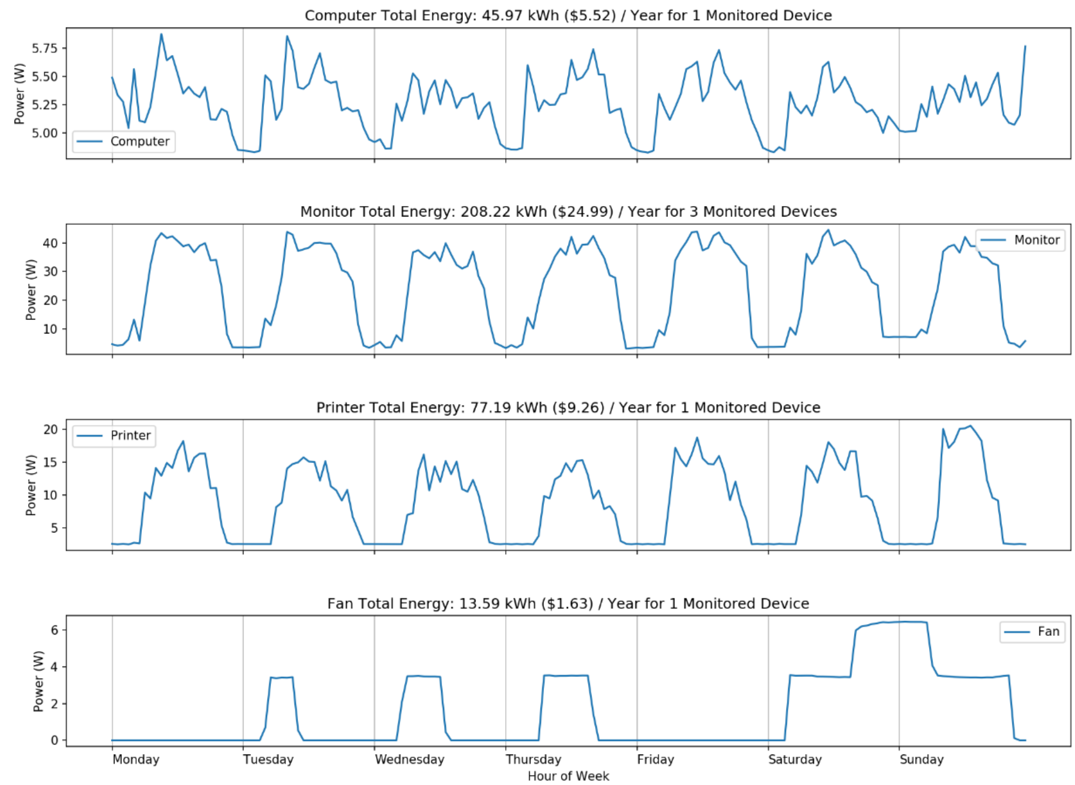

Figure 10: Office Equipment - Total Energy: 344.98 kWh ($41.40) / Year

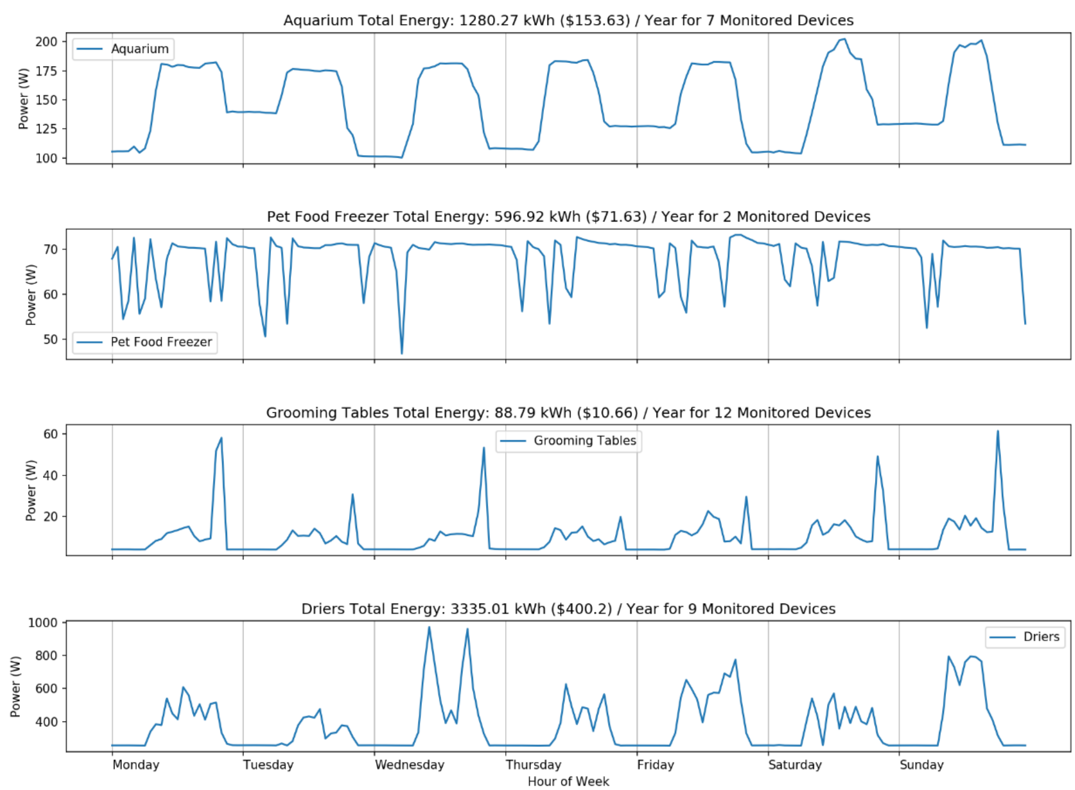

Figure 11: Pet Equipment - Total Energy: 5,300.99 kWh ($636.12) / Year

CONTROL DATA

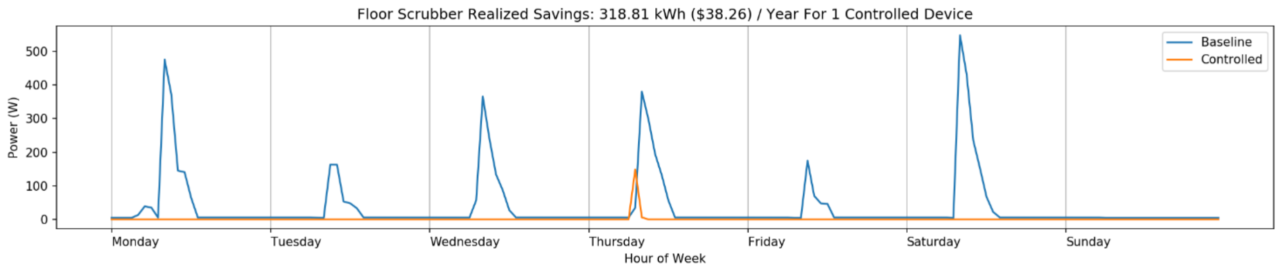

Figure 12: Additional Store Equipment - Realized Savings: 318.81 kWh ($38.26) / Year

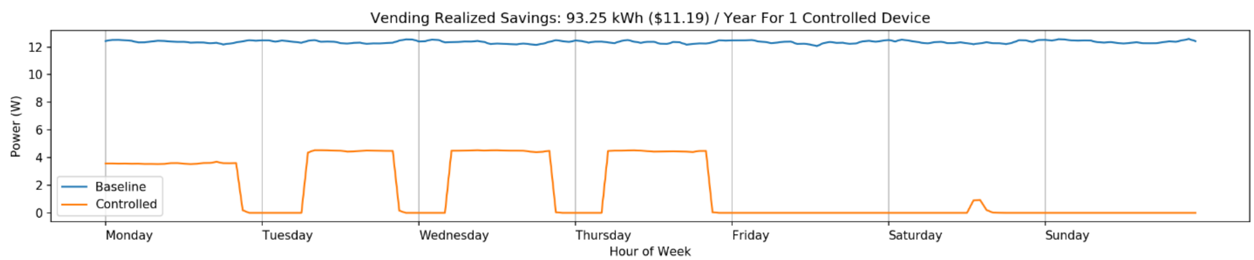

Figure 13: Kitchen Equipment - Realized Savings: 93.25 kWh ($11.19) / Year

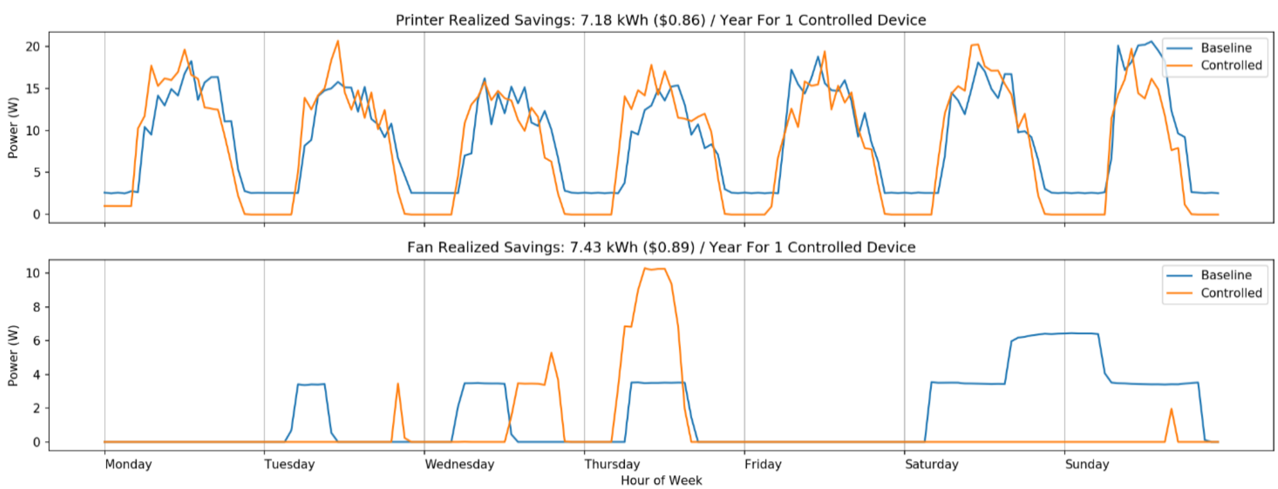

Figure 14: Office Equipment - Realized Savings: 14.61 kWh ($1.75) / Year

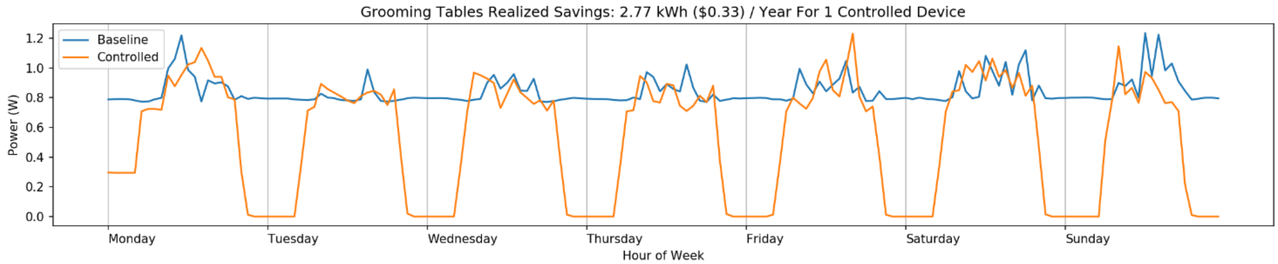

Figure 15: Pet Equipment - Realized Savings: 2.77 kWh ($0.33) / Year

PROJECTED SAVINGS FOR ALL INTENDED TO BE CONTROLLED DEVICES

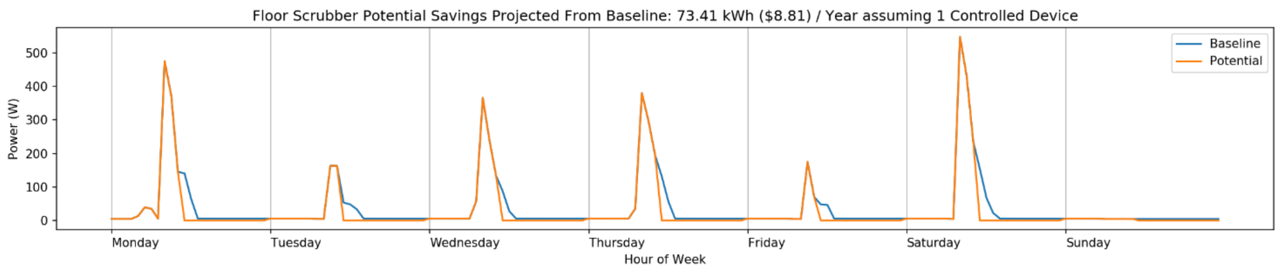

Figure 16: Additional Store Equipment - Potential Savings Projected from Baseline: 73.41 kWh ($8.81) / Year

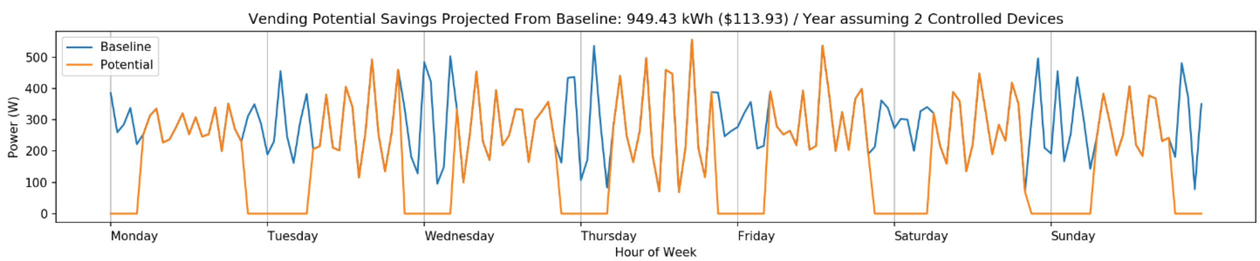

Figure 17: Kitchen Equipment - Potential Savings Projected from Baseline: 949.43 kWh ($113.93) / Year

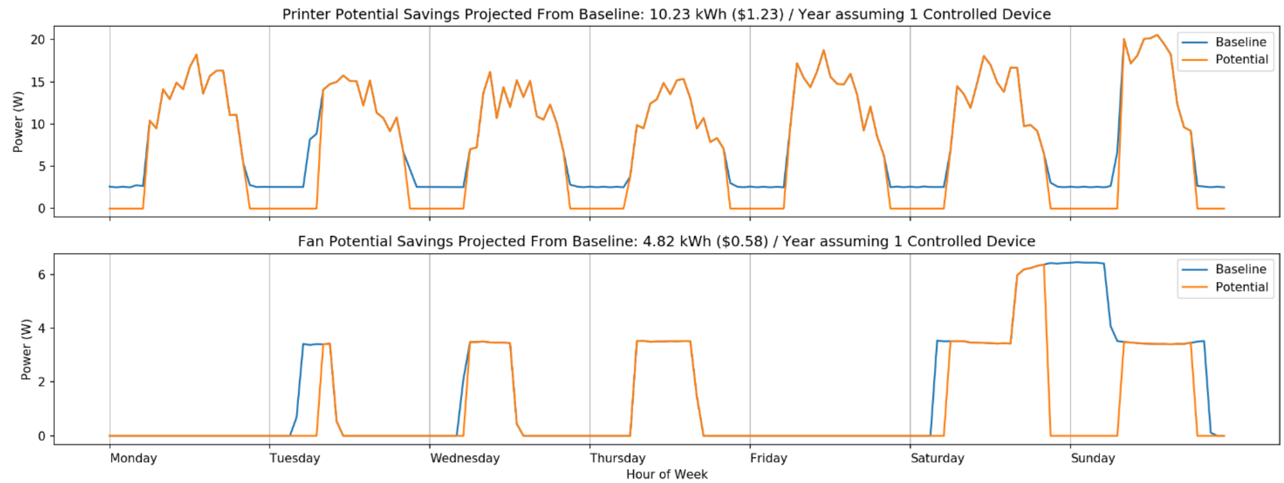

Figure 18: Office Equipment - Potential Savings Projected from Baseline: 15.05 kWh ($1.81) / Year

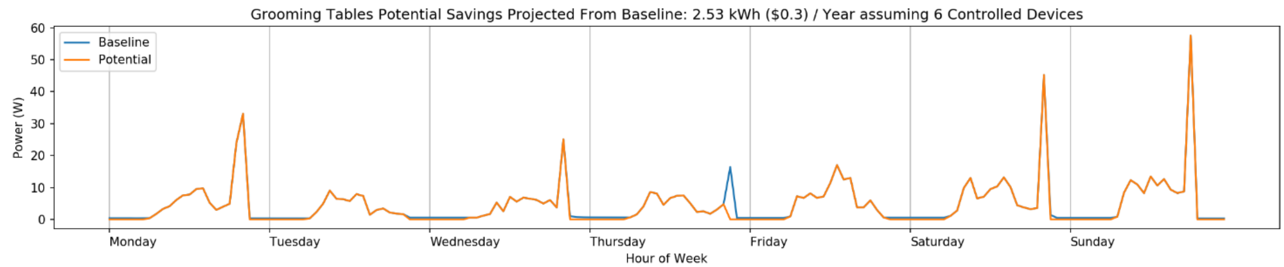

Figure 19: Pet Equipment - Potential Savings Projected from Baseline: 2.53 kWh ($0.30) / Year

C. TEST LOCATION B DATA

BASELINE DATA

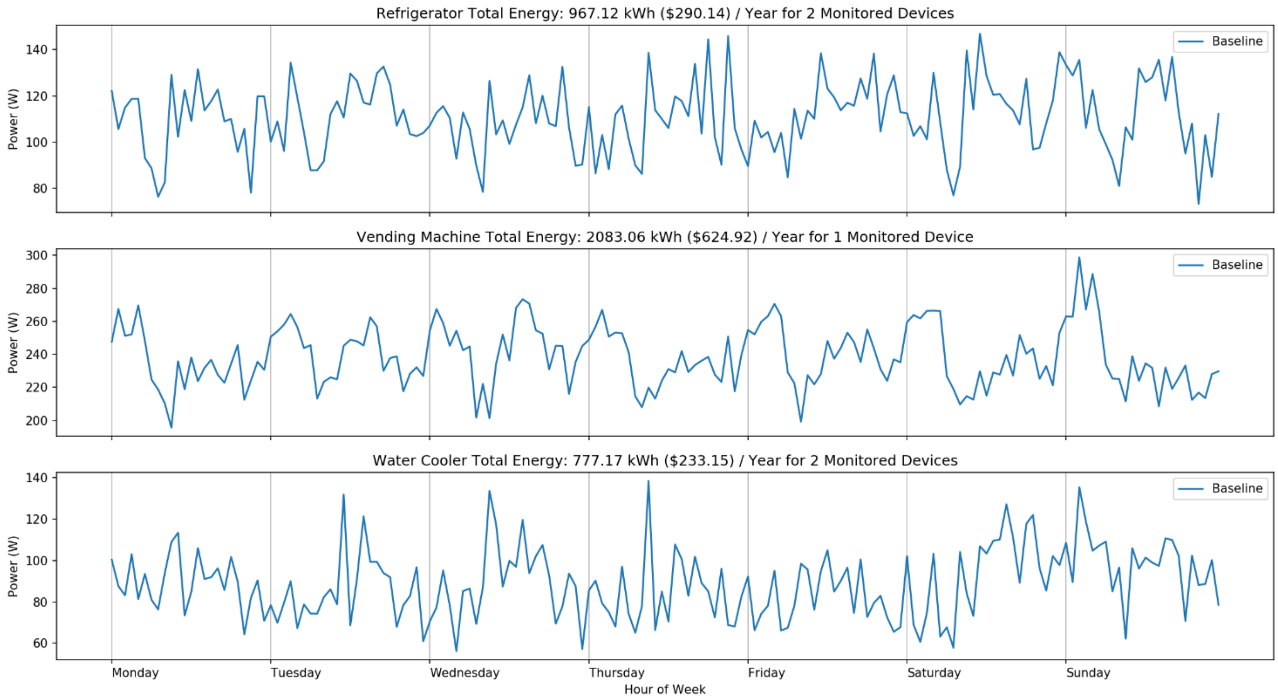

Figure 20: Kitchen Equipment - Total Energy: 3,827.35 ($1,148.21) / Year

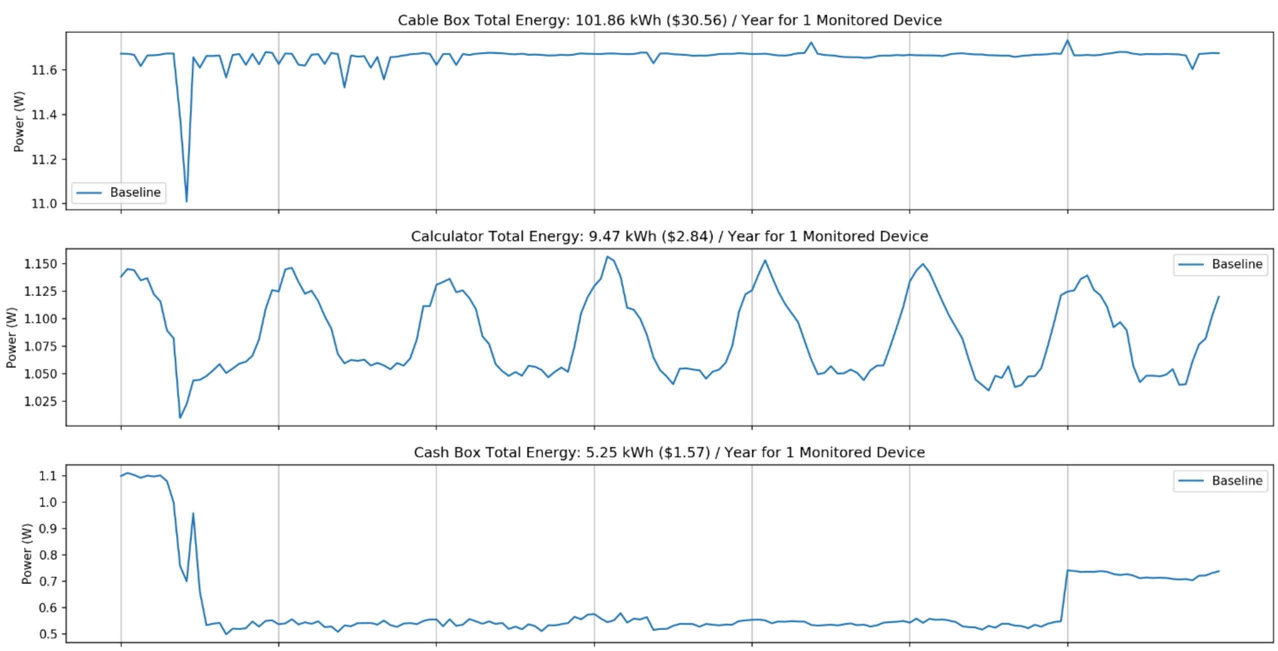

Figure 21: Office/Retail Equipment - Total Energy 8,941.23 kWh ($2,682.37) / Year

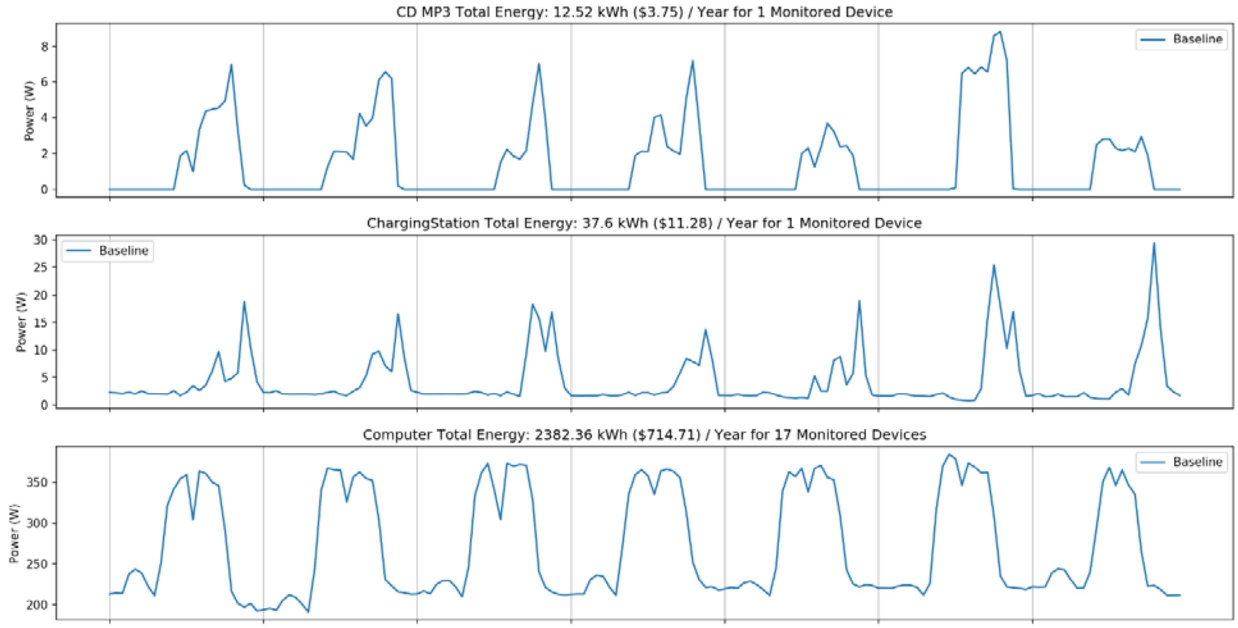

Figure 21 (continued): Office/Retail Equipment - Total Energy 8,941.23 kWh ($2,682.37) / Year

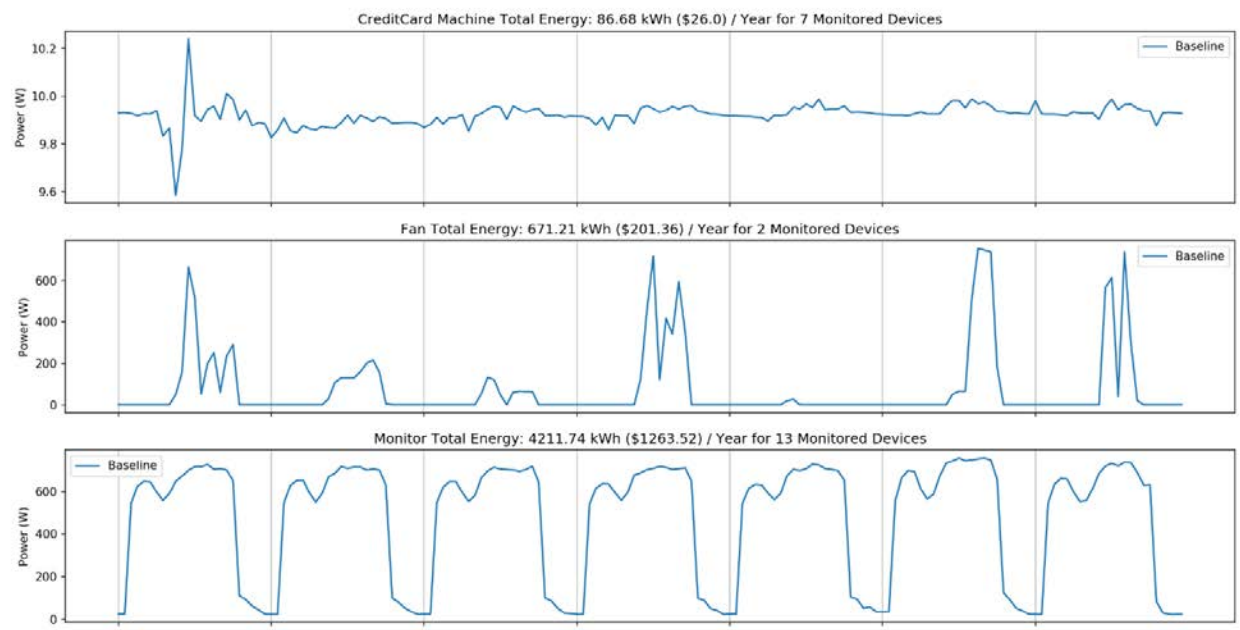

Figure 21 (continued): Office/Retail Equipment - Total Energy 8,941.23 kWh ($2,682.37) / Year

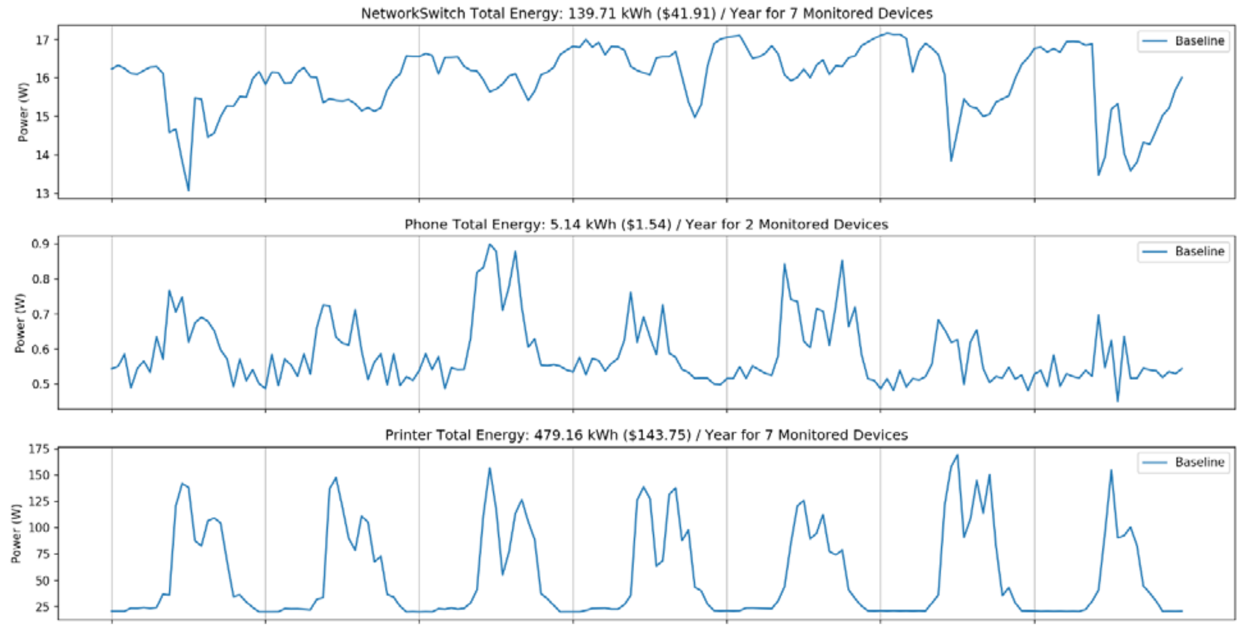

Figure 21 (continued): Office/Retail Equipment - Total Energy 8,941.23 kWh ($2,682.37) / Year

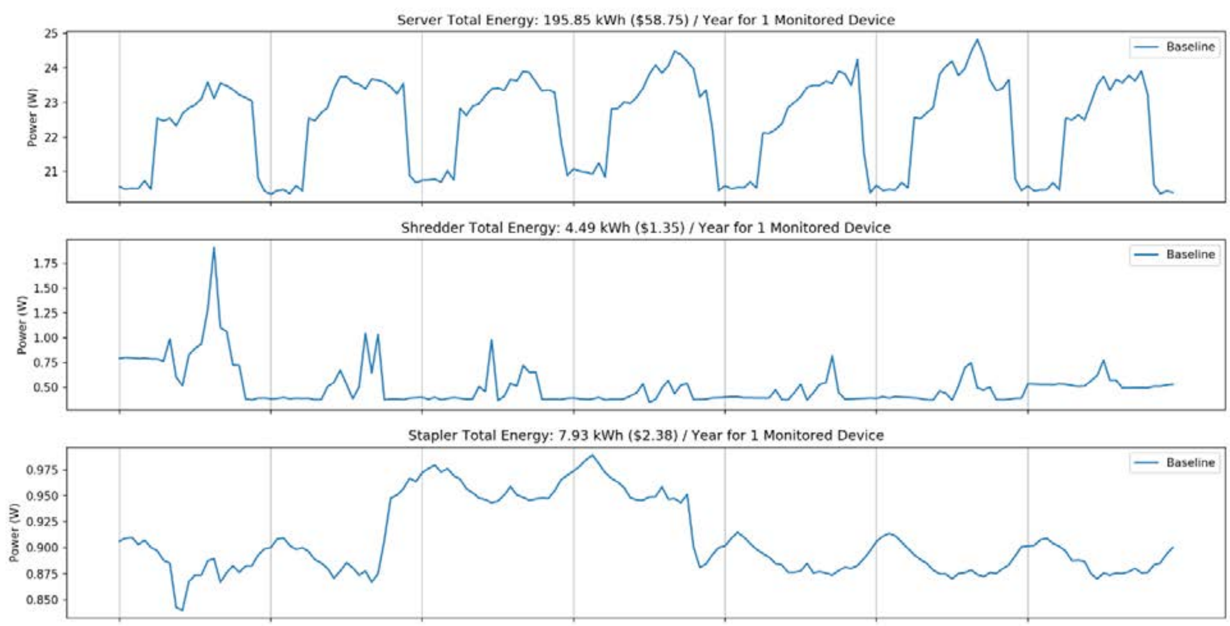

Figure 21 (continued): Office/Retail Equipment - Total Energy 8,941.23 kWh ($2,682.37) / Year

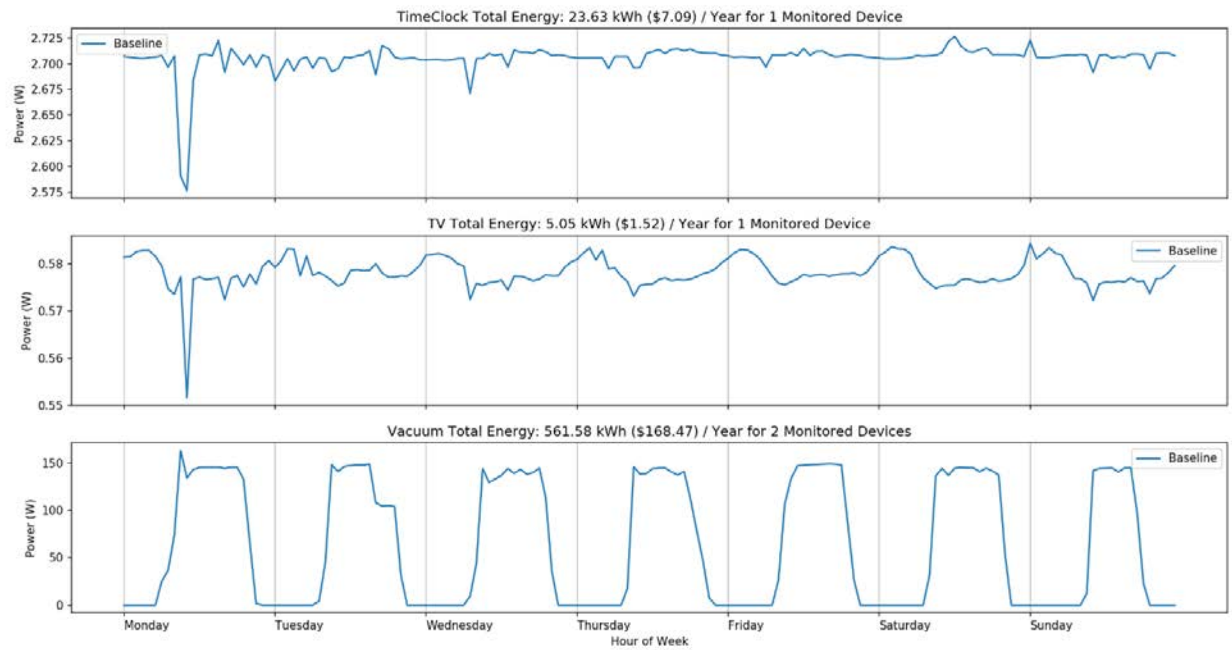

Figure 21 (continued): Office/Retail Equipment - Total Energy 8,941.23 kWh ($2,682.37) / Year

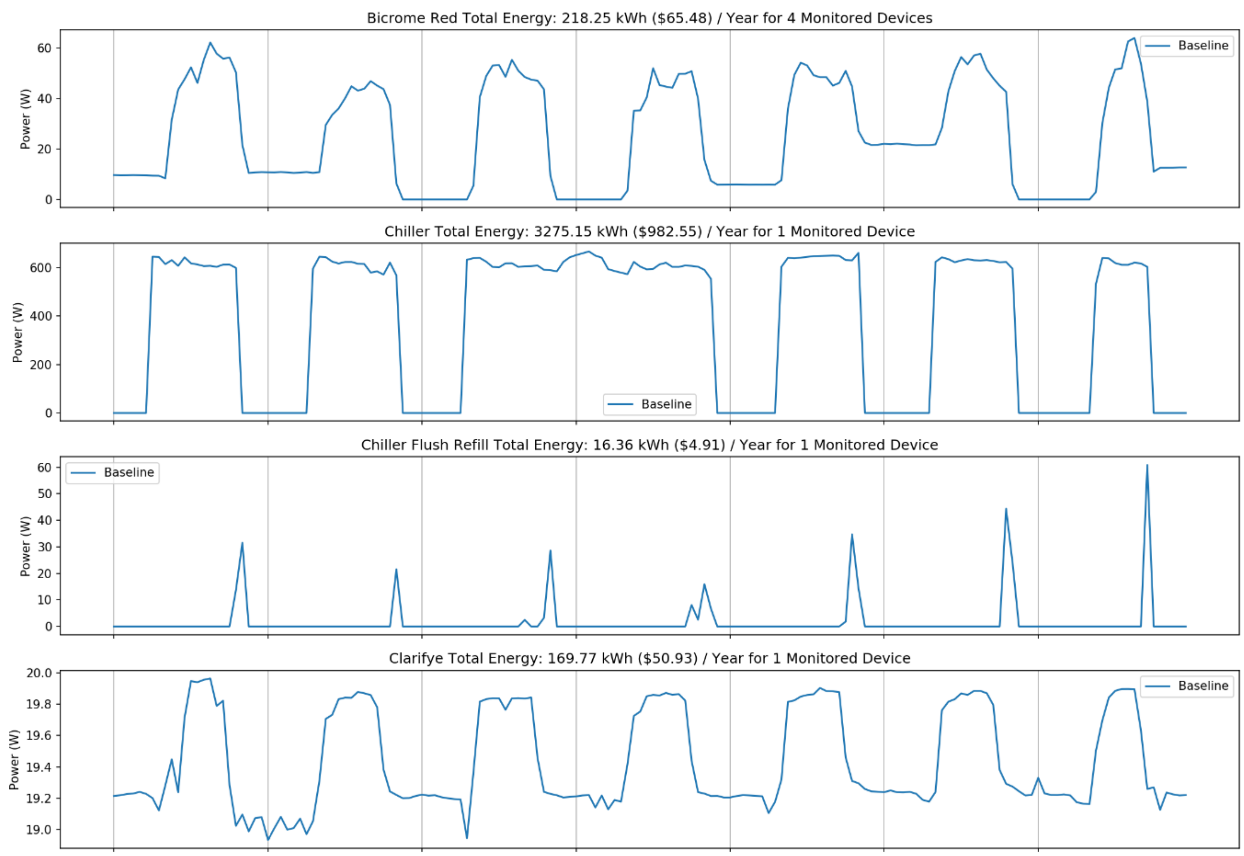

Figure 22: Optometry Equipment - Total Energy 13,677.5 kWh ($4,103.25) / Year

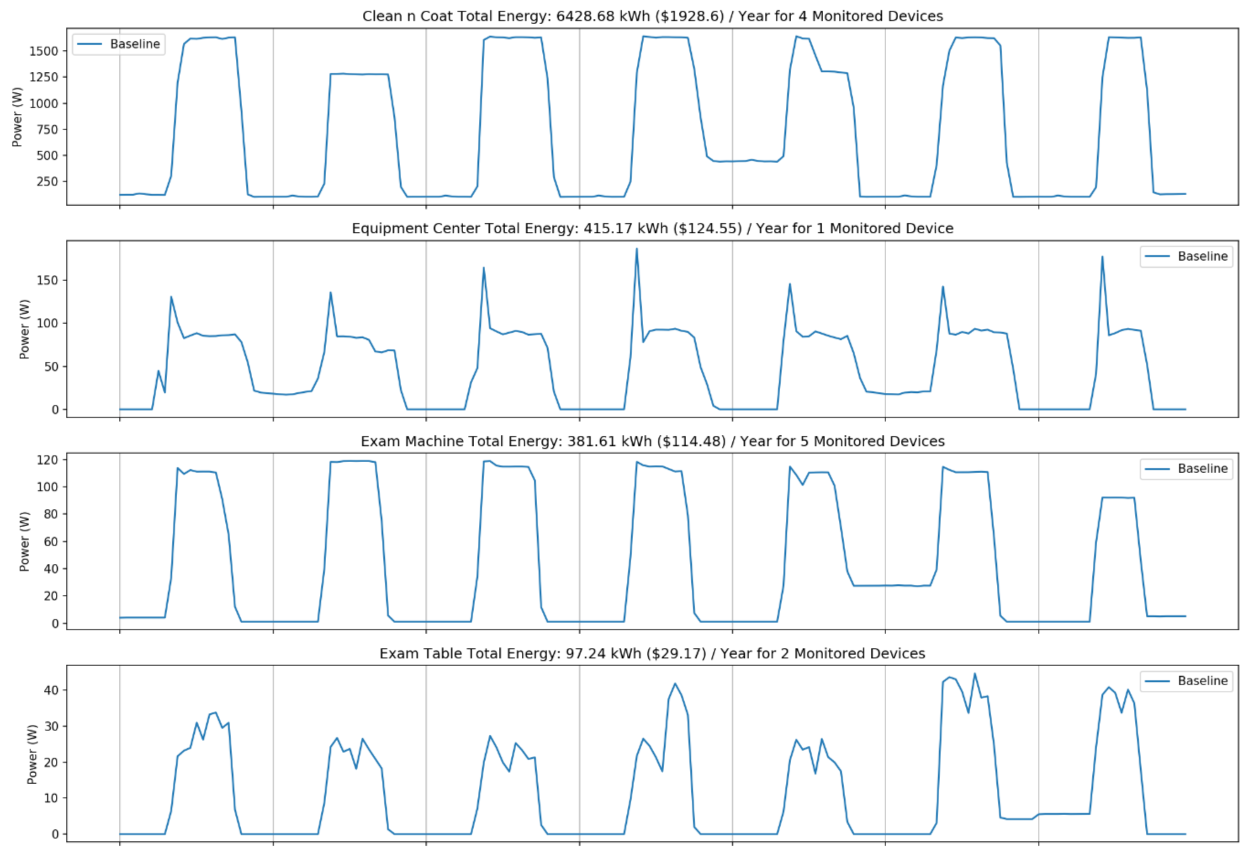

Figure 22 (continued): Optometry Equipment - Total Energy 13,677.5 kWh ($4,103.25) / Year

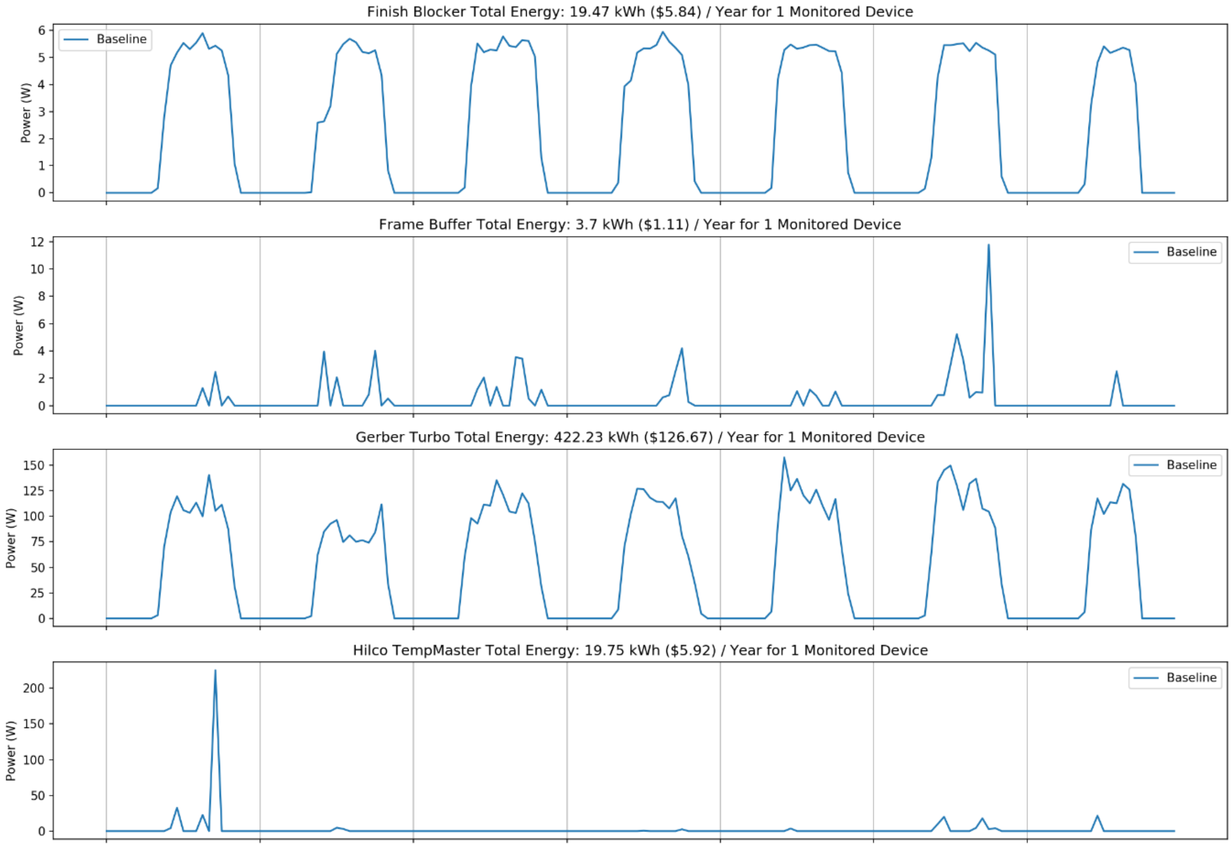

Figure 22 (continued): Optometry Equipment - Total Energy 13,677.5 kWh ($4,103.25) / Year

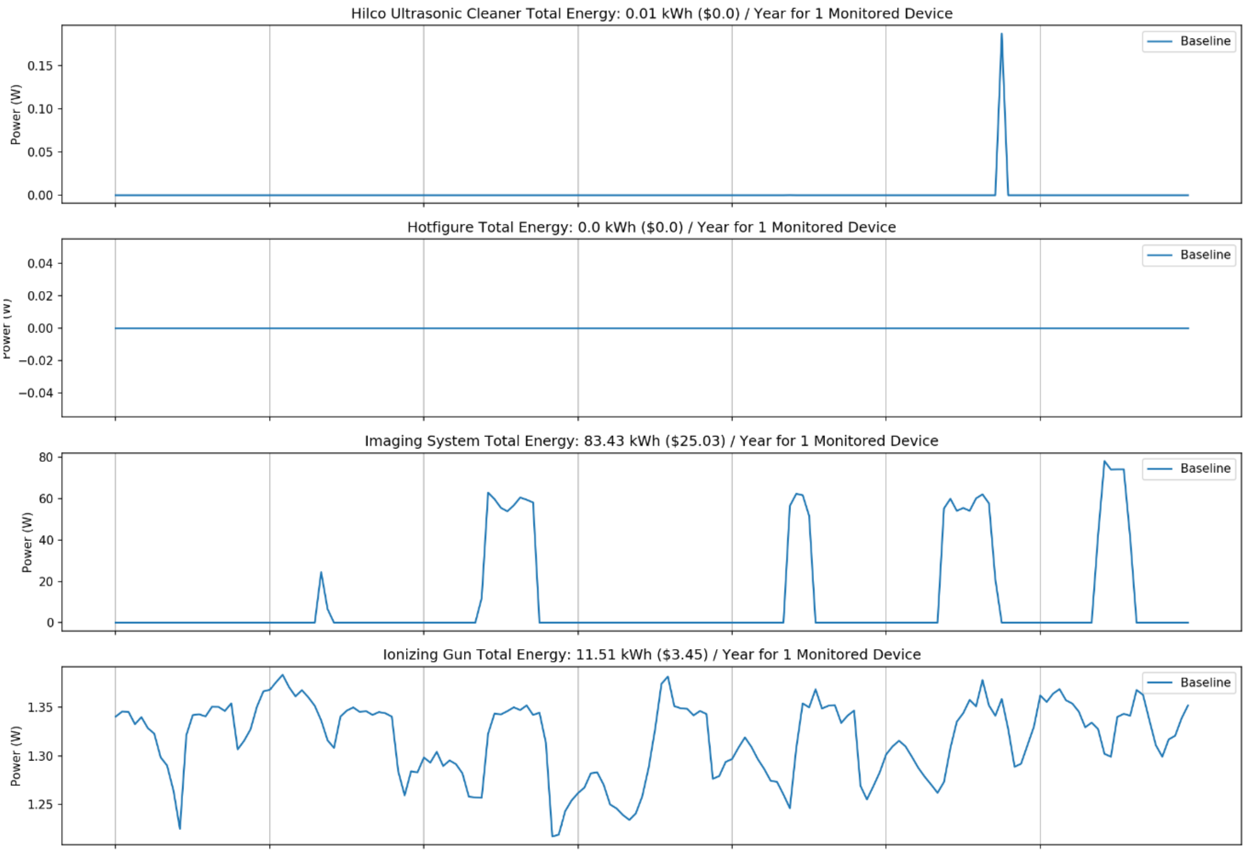

Figure 22 (continued): Optometry Equipment - Total Energy 13,677.5 kWh ($4,103.25) / Year

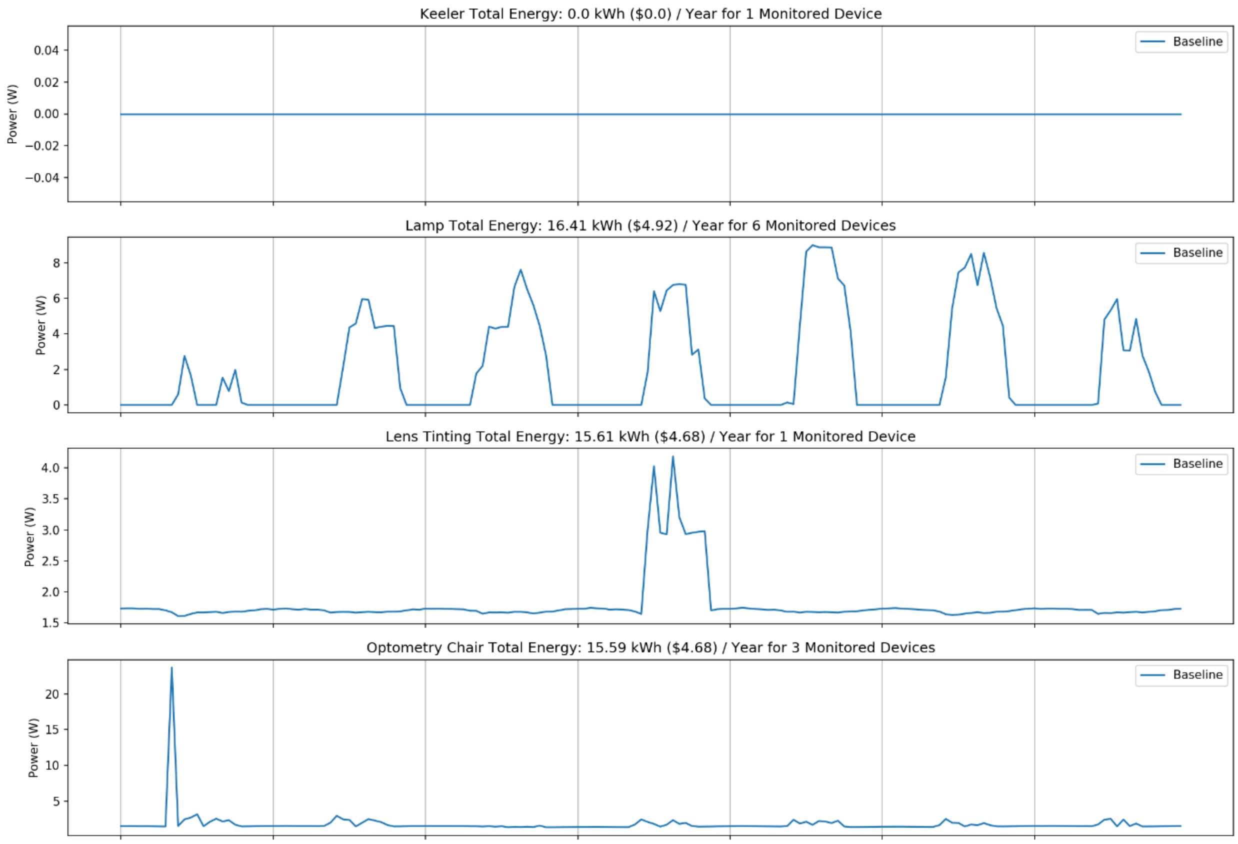

Figure 22 (continued): Optometry Equipment - Total Energy 13,677.5 kWh ($4,103.25) / Year

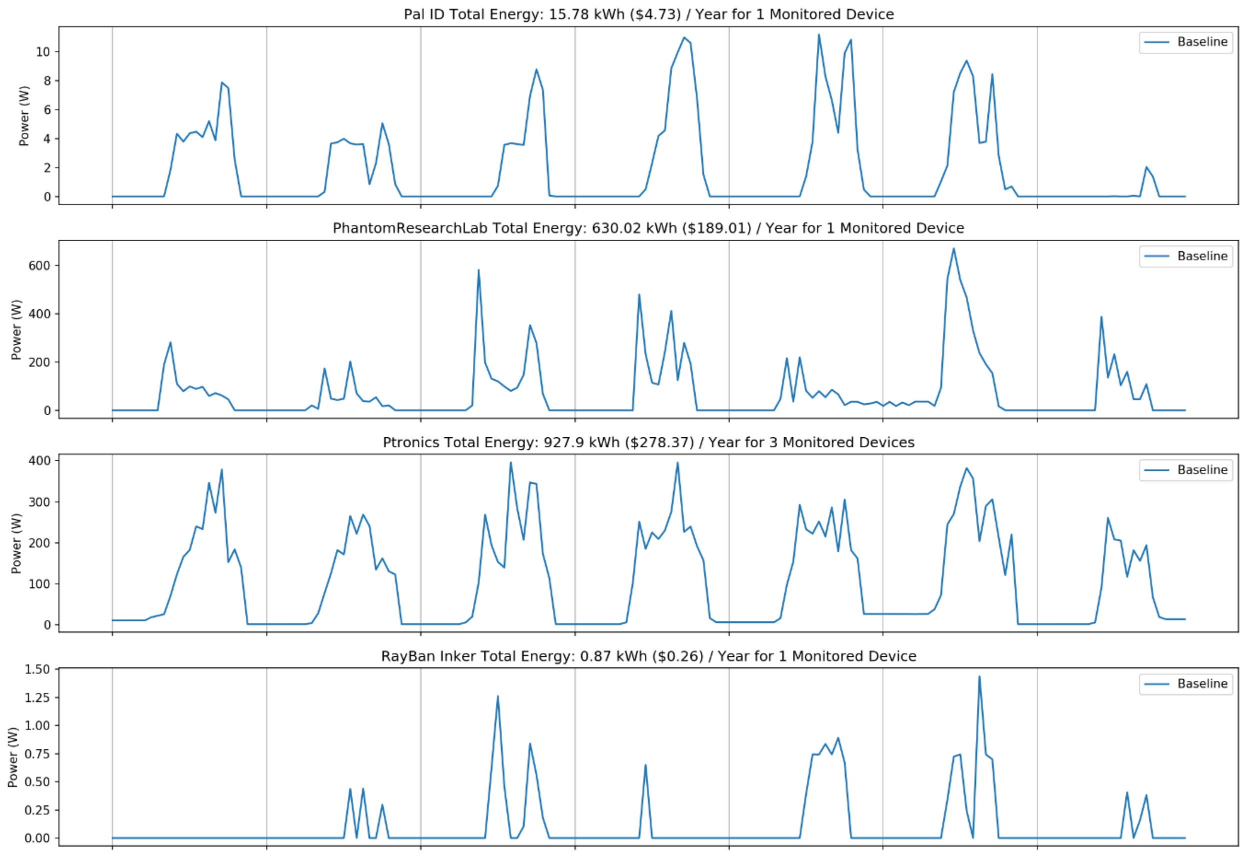

Figure 22 (continued): Optometry Equipment - Total Energy 13,677.5 kWh ($4,103.25) / Year

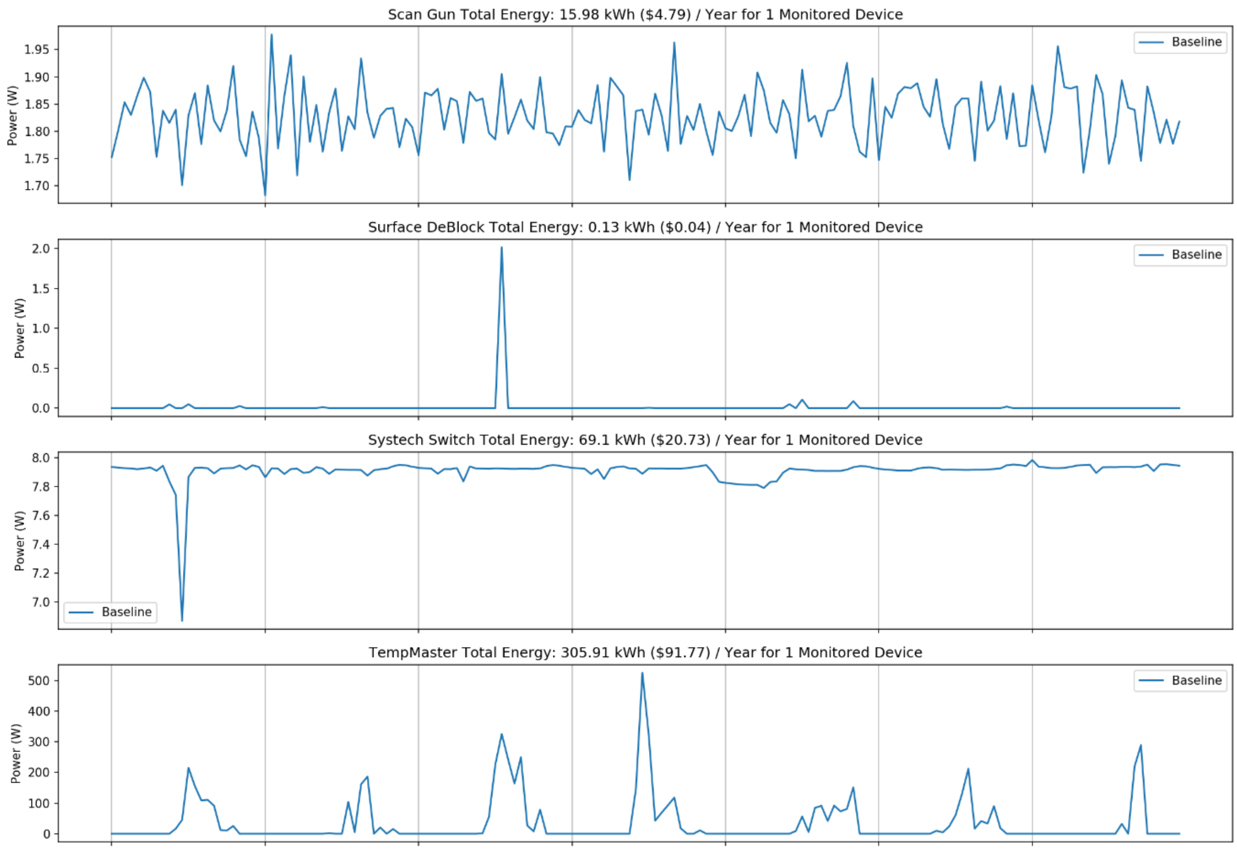

Figure 22 (continued): Optometry Equipment - Total Energy 13,677.5 kWh ($4,103.25) / Year

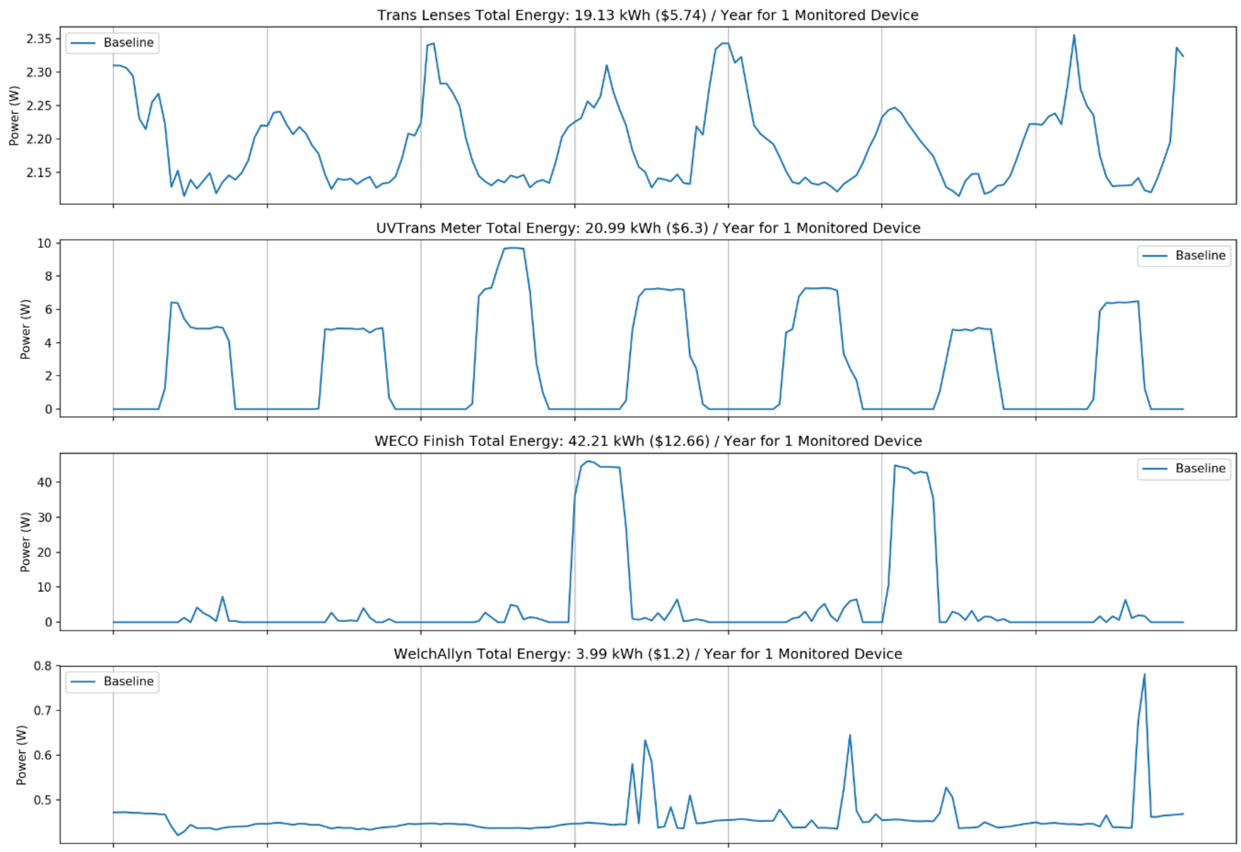

Figure 22 (continued): Optometry Equipment - Total Energy 13,677.5 kWh ($4,103.25) / Year

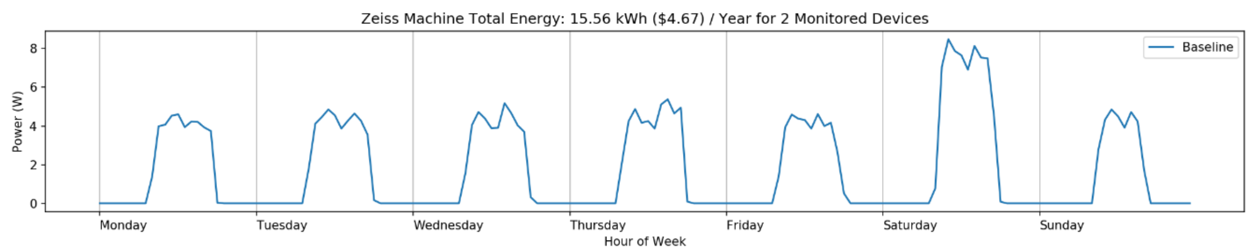

Figure 22 (continued): Optometry Equipment - Total Energy 13,677.5 kWh ($4,103.25) / Year

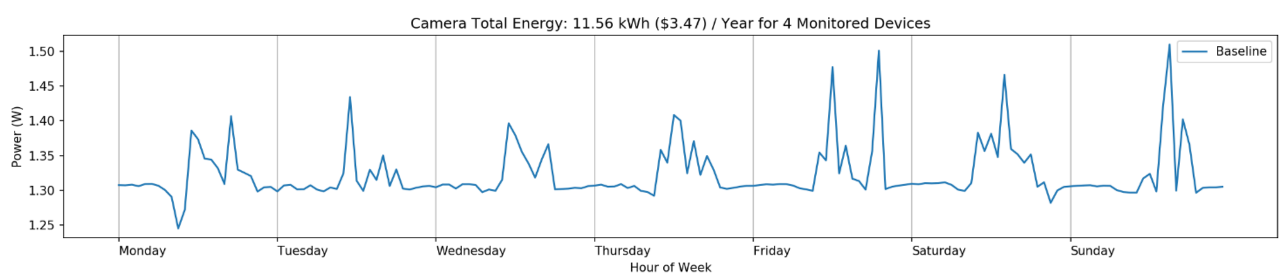

Figure 23: Security Equipment - Total Energy: 11.56 kWh ($3.47) / Year

CONTROL DATA

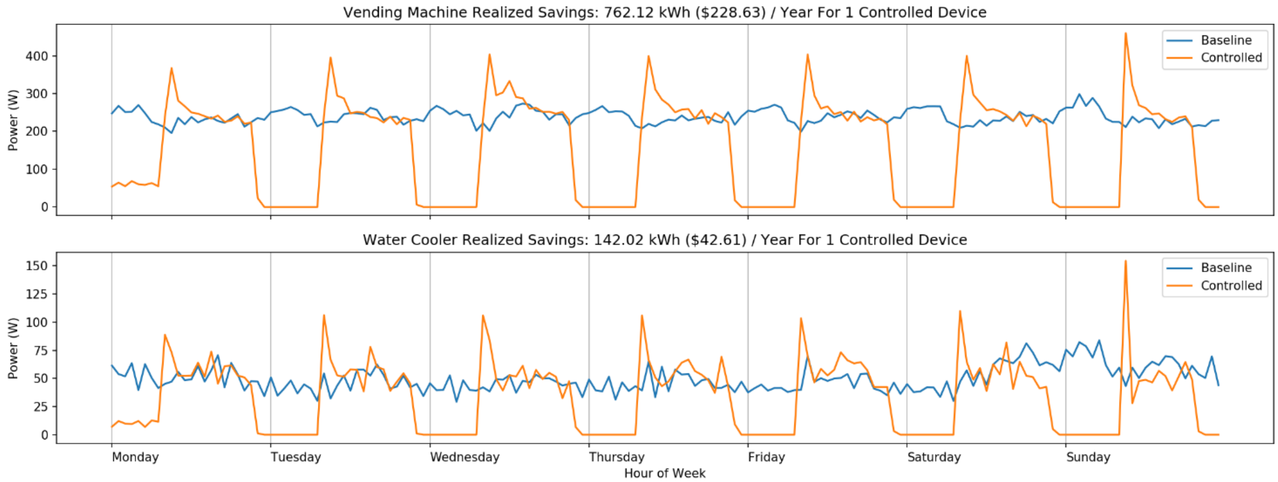

Figure 24: Kitchen Equipment - Realized Savings: 904.14 kWh ($271.24) / Year

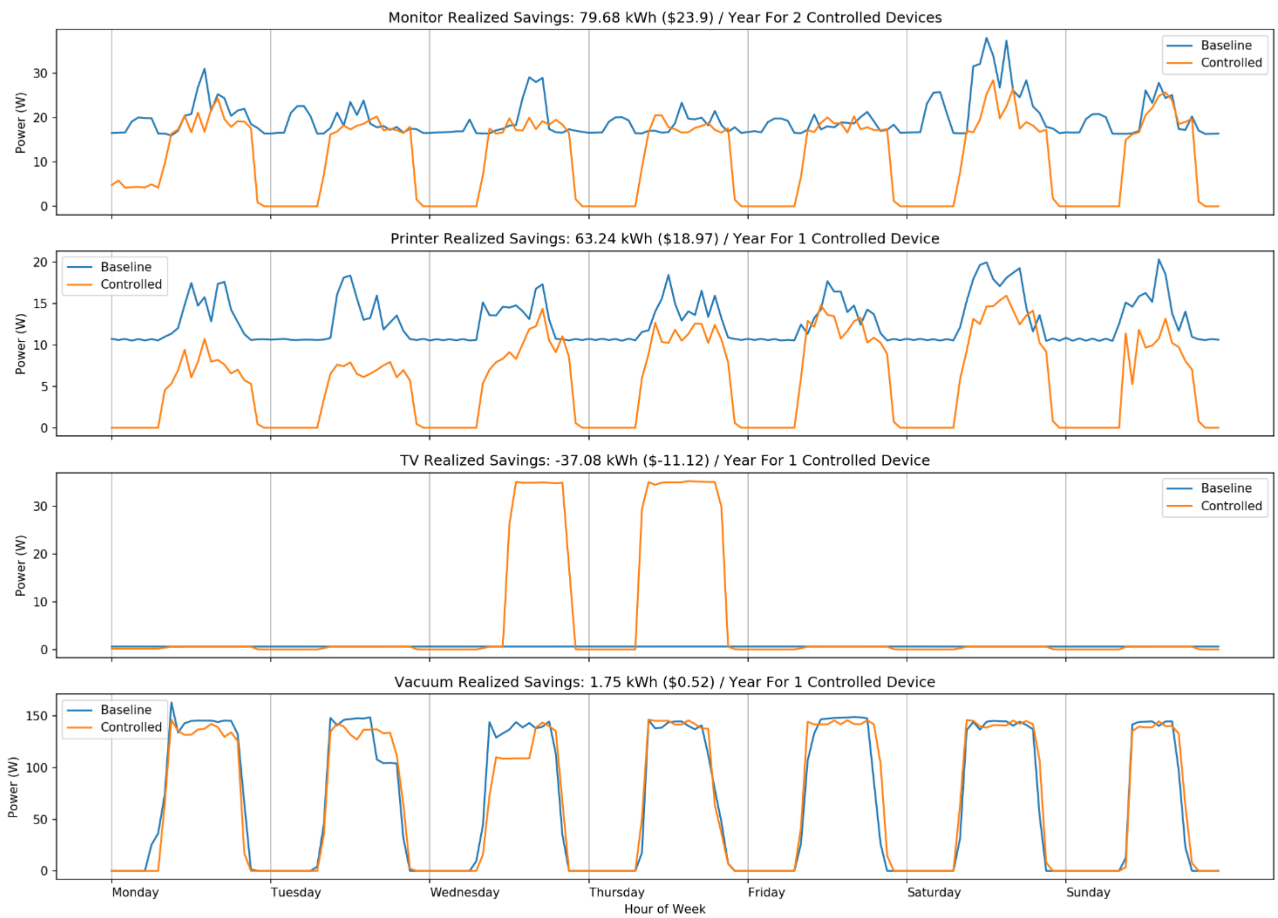

Figure 25: Office/Retail Equipment - Realized Savings: 107.59 kWh ($32.27) / Year

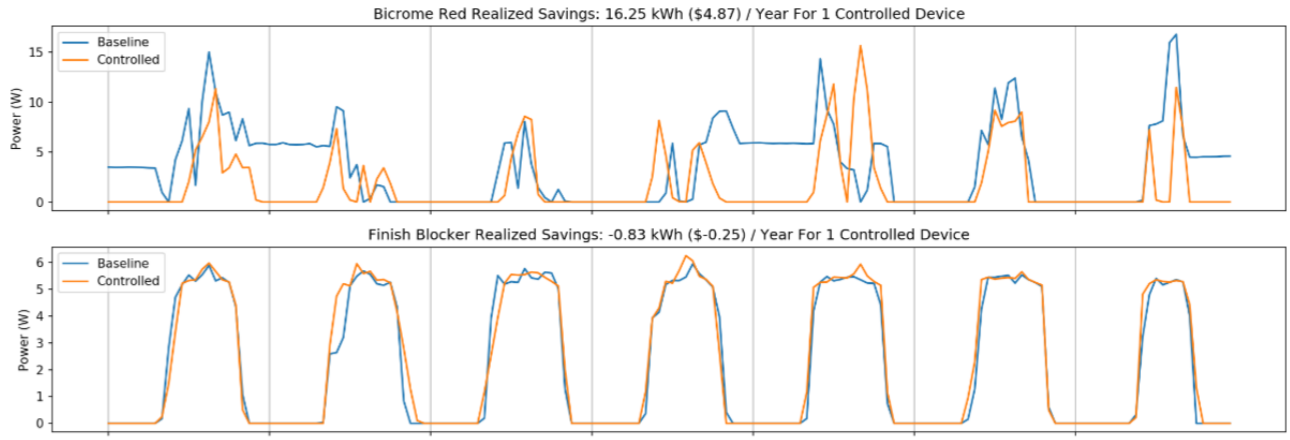

Figure 26: Optometry Equipment - Realized Savings: 139.27 kWh ($41.78) / Year

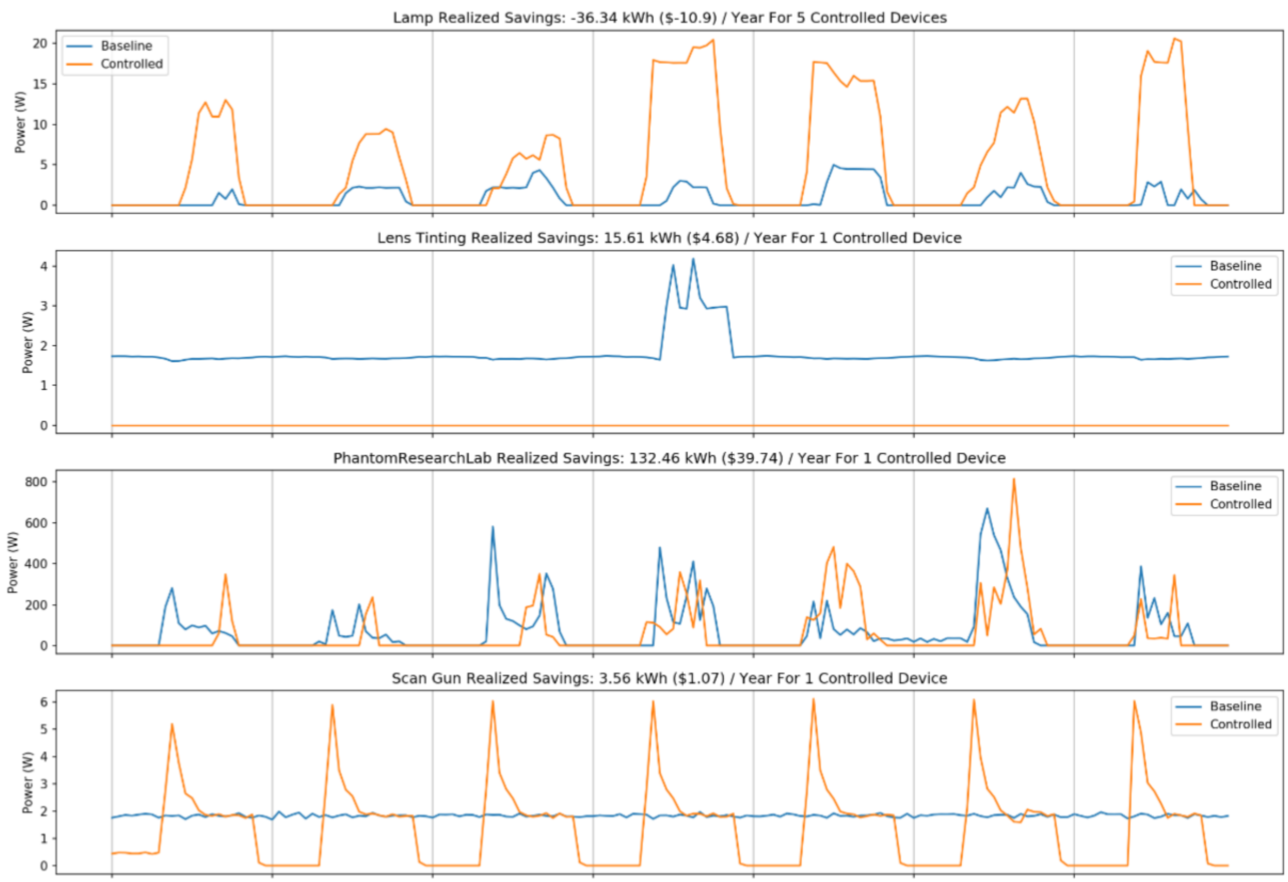

Figure 26 (continued): Optometry Equipment - Realized Savings: 139.27 kWh ($41.78) / Year

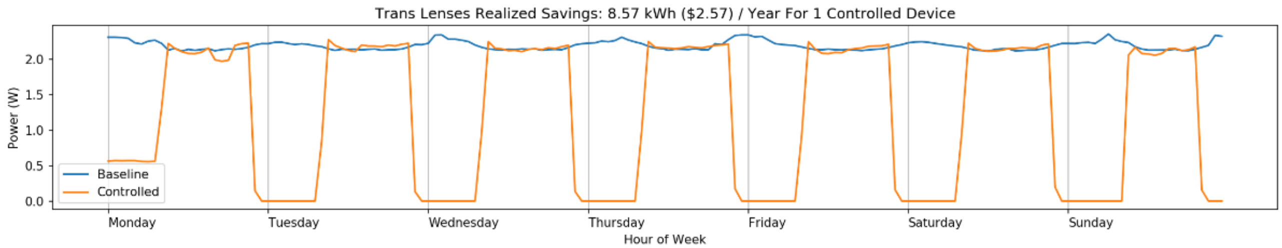

Figure 26 (continued): Optometry Equipment - Realized Savings: 139.27 kWh ($41.78) / Year

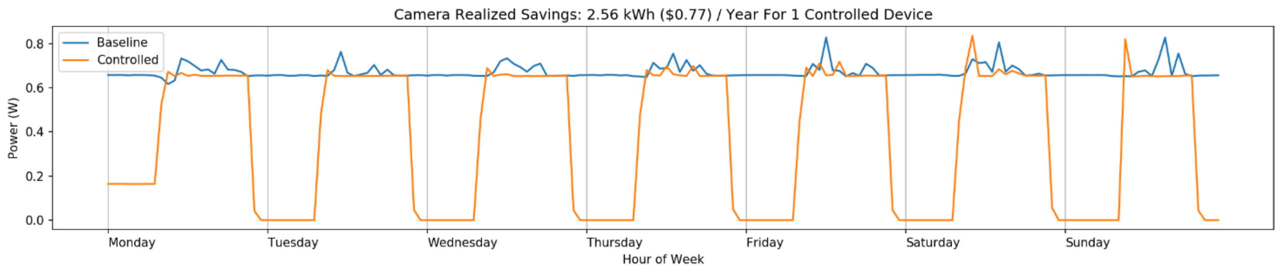

Figure 27: Security Equipment - Realized Savings: 2.56 kWh ($0.77) / Year

PROJECTED SAVINGS FOR ALL INTENDED TO BE CONTROLLED DEVICES

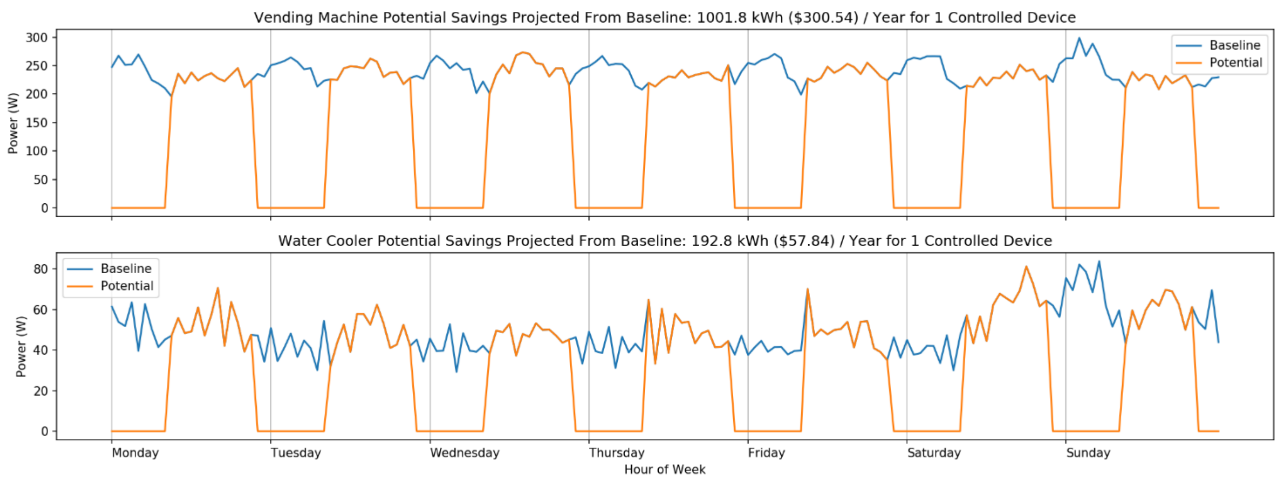

Figure 28: Kitchen Equipment - Potential Savings from Baseline: 1,194.6 kWh ($358.38) / Year

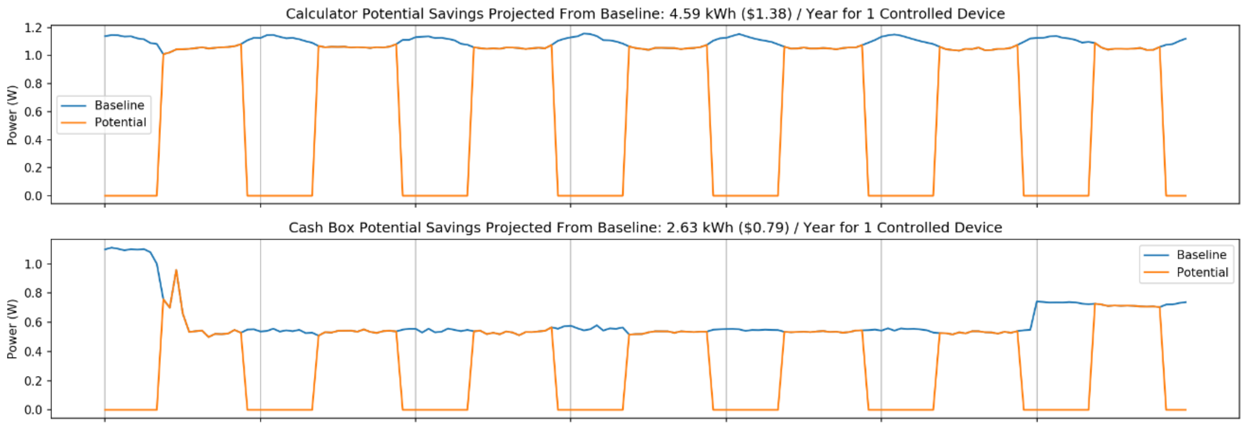

Figure 29: Office/Retail Equipment - Potential Savings Projected from Baseline: 325 kWh ($97.5) / Year

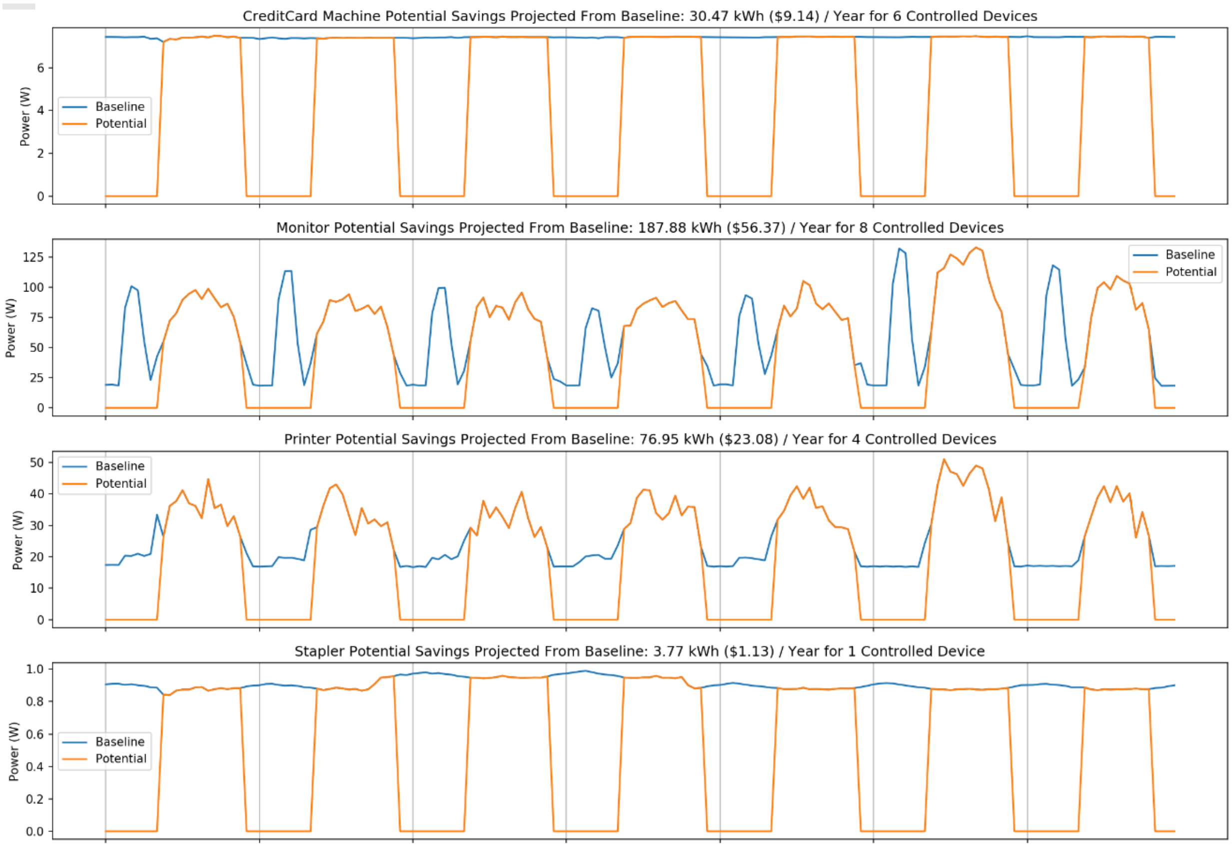

Figure 29 (continued): Office/Retail Equipment - Potential Savings Projected from Baseline: 325 kWh ($97.5) / Year

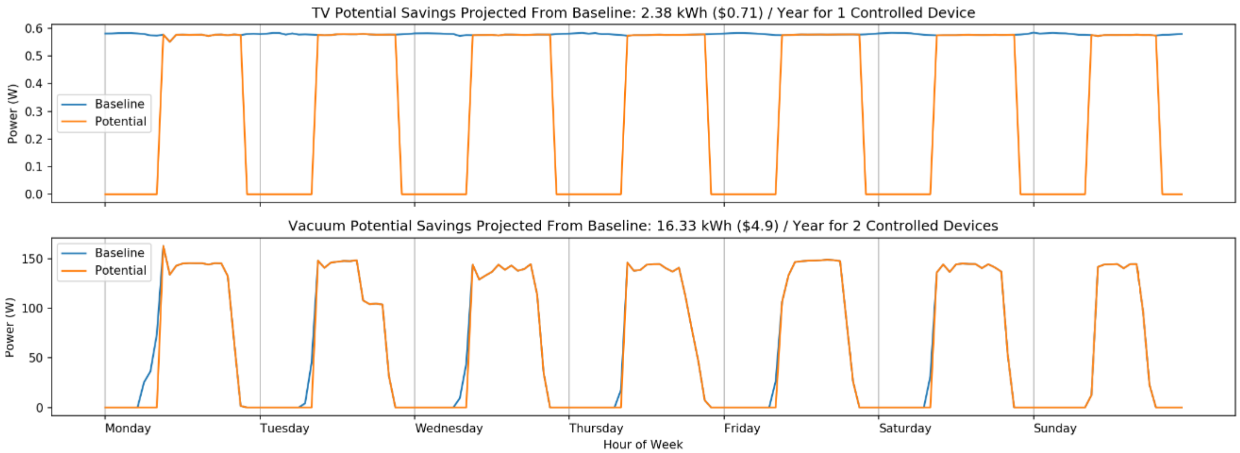

Figure 29 (continued): Office/Retail Equipment - Potential Savings Projected from Baseline: 325 kWh ($97.5) / Year

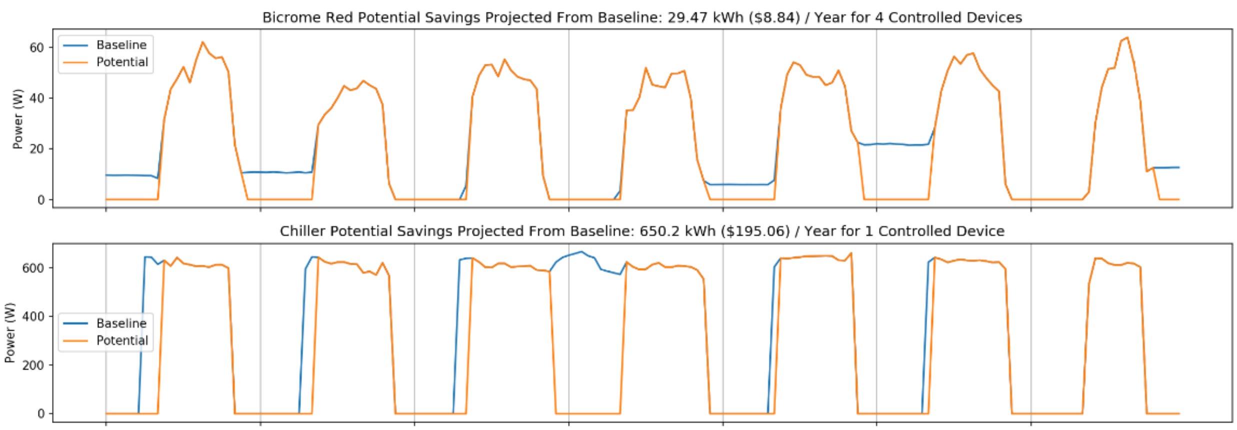

Figure 30: Optometry Equipment - Potential Savings Projected from Baseline: 816.16 kWh ($244.85) / Year

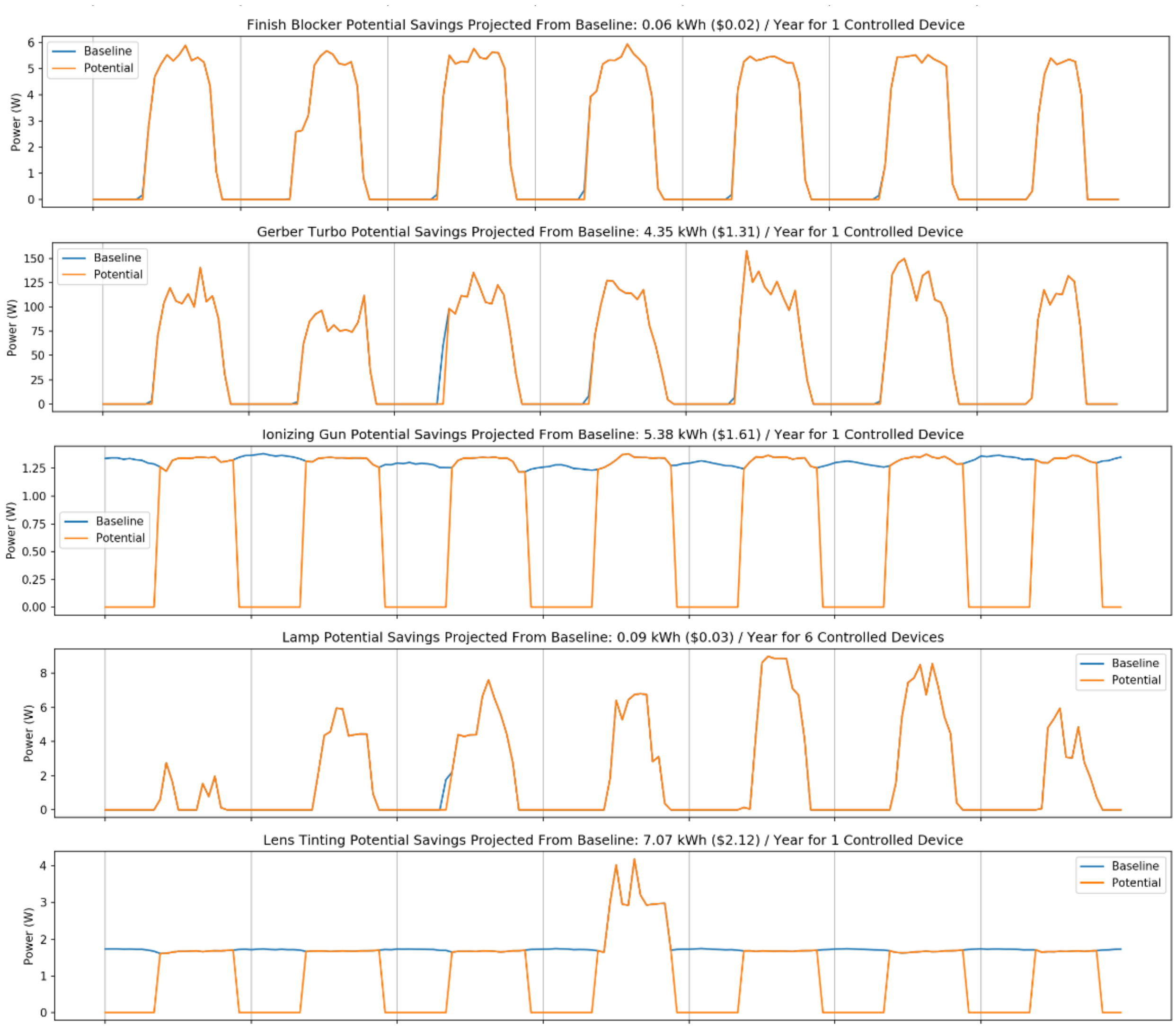

Figure 30 (continued): Optometry Equipment - Potential Savings Projected from Baseline: 816.16 kWh ($244.85) / Year

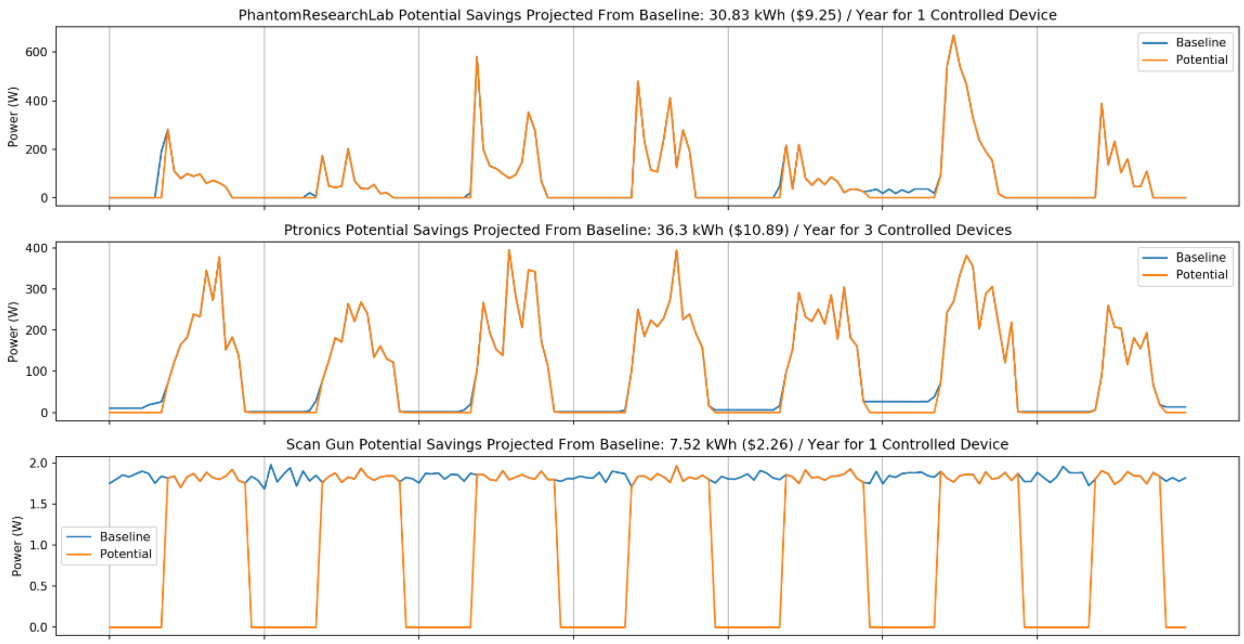

Figure 30 (continued): Optometry Equipment - Potential Savings Projected from Baseline: 816.16 kWh ($244.85) / Year

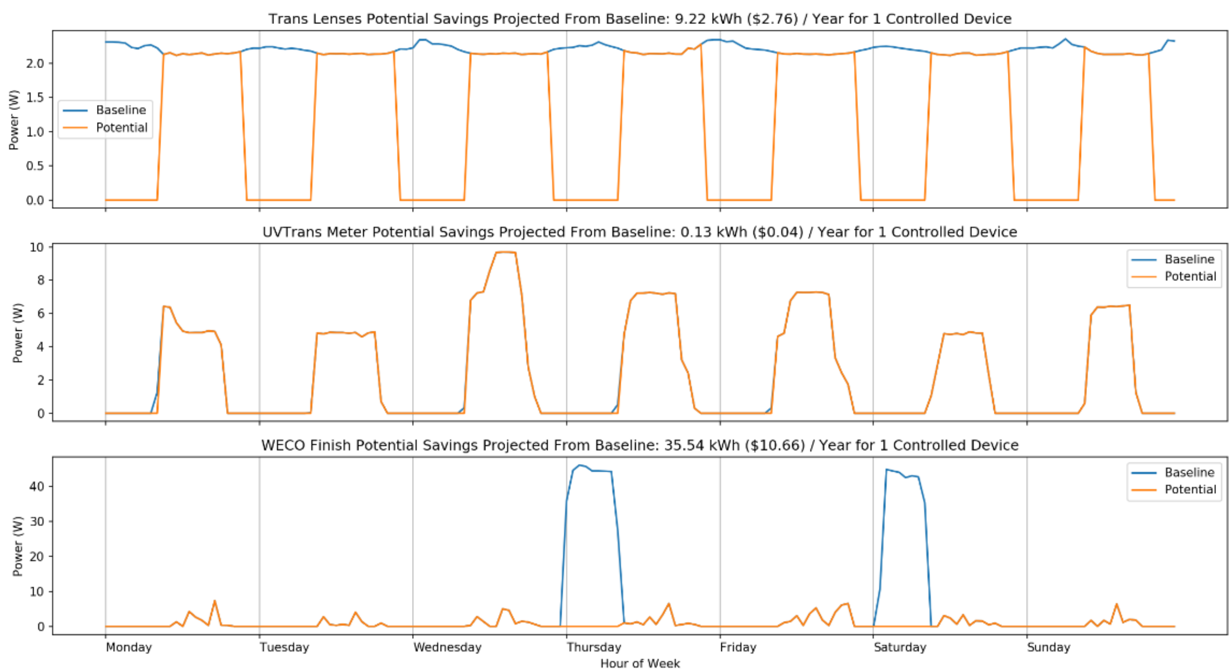

Figure 30 (continued): Optometry Equipment - Potential Savings Projected from Baseline: 816.16 kWh ($244.85) / Year

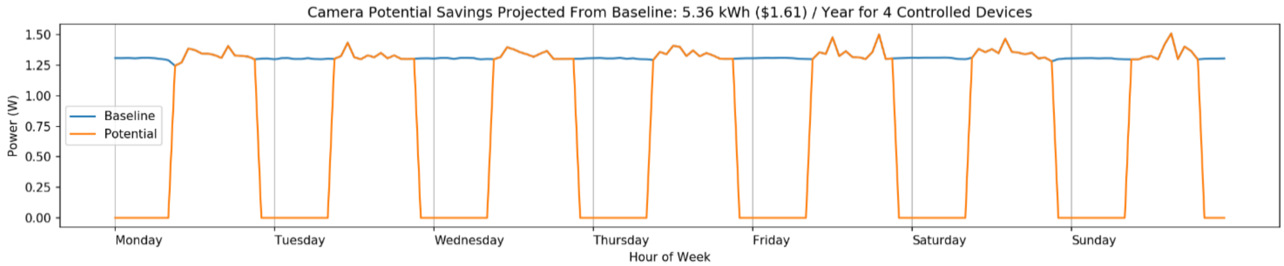

Figure 31: Security Equipment - Potential Savings Projected from Baseline: 5.36 kWh ($1.61) / Year