CALIFORNIA ENERGY COMMISSION

Energy Research and Development Division

FINAL PROJECT REPORT

Advanced Plug Load Management in the Educational Environment

Emerging Energy Efficient Technology Demonstration

Gavin Newsom, Governor
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PREFACE

The California Energy Commission's (CEC) Energy Research and Development Division supports energy research and development programs to spur innovation in energy efficiency, renewable energy and advanced clean generation, energy-related environmental protection, energy transmission and distribution and transportation.

In 2012, the Electric Program Investment Charge (EPIC) was established by the California Public Utilities Commission (CPUC) to fund public investments in research to create and advance new energy solutions, foster regional innovation, and bring ideas from the lab to the marketplace. The CEC and the state's three largest investor-owned utilities—Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E) and Southern California Edison (SCE) Company—were selected to administer the EPIC funds and advance novel technologies, tools, and strategies that provide benefits to their electric ratepayers.

The CEC is committed to ensuring public participation in its research and development programs that promote greater reliability, lower costs, and increase safety for the California electric ratepayer and include:

- Providing societal benefits.
- Reducing greenhouse gas emission in the electricity sector at the lowest possible cost.
- Supporting California's loading order to meet energy needs first with energy efficiency and demand response, next with renewable energy (distributed generation and utility scale), and finally with clean, conventional electricity supply.
- Supporting low-emission vehicles and transportation.
- Providing economic development.
- Using ratepayer funds efficiently.

Advanced Plug Load Management in the Educational Environment is the final report for the Emerging Energy Efficient Technology Demonstration project (Contract Number: EPC-17-014) conducted by Willdan Energy Solutions. The information from this project contributes to the Energy Research and Development Division's EPIC Program.

For more information about the Energy Research and Development Division, please visit the CEC's research website (www.energy.ca.gov/research/) or contact the CEC at ERDD@energy.ca.gov.

ABSTRACT

This project installed and evaluated advanced plug load management devices across multiple California community college district campuses in investor-owned utility service territories.

Approximately 15 years ago, products were developed allowing for plug-load energy use reduction around computer workstations, such as individual offices and computer labs. These efforts targeted devices like computer monitors, speakers, desk lamps, printers, scanners, copiers, and space heaters, implemented with Tier 1 advanced-power strips. Because of the issues that emerged with these advanced power strip devices, research and industry groups worked to develop a next generation of advanced plug load management devices or Tier 2 devices.

Advanced plug load management device technology as advanced power strip products or others have not been widely adopted by the California commercial building market.

This project used advanced plug load management technology with about 3,500 devices at 13 California community college campuses and focused on integrating the technology with facility operations to ensure that they met the needs of the sites and staff. The project showed that when properly installed and configured, advanced plug load management devices provide, on average, between 50 and 115 kilowatt-hours per year savings per unit, depending on specific device type or roughly 14.1 percent electric energy savings systemwide.

Recent technology advances have enabled advanced plug load management device technology companies to apply "Internet of things" principles to create low-cost sensors that can be installed on every electrical plug load management device. The devices allow building owners to obtain real-time data and analytics on plug load equipment and apply control strategies to significantly cut plug load energy use.

Keywords: California Energy Commission, advanced plug load management devices, energy efficiency, plug loads

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EXECUTIVE SUMMARY

Introduction

Plug loads or electricity used by equipment plugged into outlets such as computers, televisions, and printers, are growing sources of overall energy consumption in buildings. Other energy consuming systems like heating, ventilation, and air conditioning (HVAC) and lighting have become more energy efficient as the energy-efficiency industry continues to focus on greater efficiency and more sophisticated controls for these systems. Meanwhile, plug load control has remained largely unaddressed, and the number of individual plug load devices has increased as their cost has decreased. In 2007, the Lawrence Berkeley National Laboratory found plug loads to be 11 percent or 19 percent of total building energy use in commercial buildings. In October 2015, Stanford University estimated that plug loads make up 32 percent of total educational market campus-wide energy use. If, as expected, plug loads continue to represent significant portions of building energy consumption, their control cannot continue to be ignored if California is to meet its aggressive energy efficiency goals.

Past plug load control technologies used between 2005-2007 attempted to control computer workstation devices using simple occupancy sensing controller switches. Users of these Tier 1 advanced power strip devices generally reported dissatisfaction with items such as occupancy sensor misplacement or misalignment, premature device shut offs and vandalism of sensors, and many of the units were reportedly taken out of service.

In response to the problems with the Tier 1 advanced power strip devices, research and industry groups are developing the next generation of advanced plug load management devices. Key features of this new generation of devices include advanced power monitoring of workstations, peripherals (devices connected to a computer to provide communication), and other plug load devices, and more sophisticated methods to shut off plug loads when not in use. These new plug load control technologies also communicate data continuously with the Cloud, giving building facilities and information technology staff real time monitoring and control capabilities.

The project focused on monitoring and controlling personal-computer and other plug-load equipment in an education environment, in office and laboratory settings, with advanced plug-load management devices.

Project Purpose

This *Advanced Plug Load Management in the Educational Environment* project helps address the gap in existing research by focusing on the savings potential of using advanced plug load management devices that control the loads of personal computers, peripheral computer devices, and other plug load equipment in offices and laboratories (for example, liquid crystal display screens, refrigerators, water coolers, printers, and so on) at California community college campuses.

Previously conducted demonstration projects were only implemented on a small scale (fewer than 100 units) and at a limited number of test sites. This large-scale demonstration and evaluation offered significant opportunities for cost effective market transformation for this technology. The project is considered “large-scale” using about 3,500 units, making it 35 times bigger than previous projects and includes 65 buildings and 13 college campuses.

By demonstrating the capabilities of new technologies this project aimed to encourage the adoption of advanced plug load management devices as an energy efficiency measure in California that can be deployed on a large scale to help meet California’s aggressive energy efficiency goals, including the doubling of energy efficiency as required by Senate Bill 350 (de León, Chapter 547, 2015).

Project Approach

The primary contractor, Willdan Energy Solutions, conducted initial outreach with many California community college districts to spread awareness of the technology and this research project opportunity. Partners Embertec and Ibis Networks supplied equipment and provided technical support. Interested college staff met with representatives from these equipment vendors and discussing system and plug load surveys were conducted in targeted buildings selected by the campuses.

A unique feature of this project was using members of the California Conservation Corps on-the-job training program to receive technology education and install 3,500 devices, including 1,315 on computer stations. Once devices were installed and cloud data communication was established, the systems were left to operate in a monitoring-only mode for at least two weeks per site to establish baseline energy consumption behavior of the connected plug load devices. Care was taken to ensure that these baseline periods did not overlap holidays or other non-standard operational periods at the sites. Once the baseline period had elapsed, the energy savings functionality of the systems was enabled, and the resulting energy savings could be estimated by comparing the post-baseline period energy consumption to that of the baseline periods at the individual device level.

Table ES-1 and Table ES-2 summarize how gaps in existing research were addressed under this project.

Table ES-1: Barriers and How they Were Addressed

Barrier	Project Approach to Address
Lack of broad market awareness of the technologies and their capabilities	Increased outreach to multiple community college district facilities and information technology staff and facilitated communication with vendors
Unknown validity of savings metrics for mass deployments across multiple buildings and campuses	Evaluated device savings at installations across 13 campuses and 65 buildings
Logistics required for mass deployment across multiple buildings and campuses are unknown	Developed mass deployment approaches with vendors and California Conservation Corps installers
Unknown ongoing requirements for facility staff and end-user effort for successful large-	Monitored and provided support for post installation system operation with individual site staff.

Barrier	Project Approach to Address
scale advanced plug load management devices operation	

Source: Willdan Group

Table ES-2: Challenges Encountered and Actions Taken

Challenges Encountered	Actions Taken
Detailed plug load surveys are time and labor intensive	Survey format and approach were streamlined for later demonstration sites
Low savings from some plug load device types (small printers, fans, coffee makers, lightly used personal computer workstations)	Later installation scopes focused on devices with higher savings potential
Resistance to adoption and cooperation from campus information technology staff	For later demonstration sites, information staff was brought into the decision making and project planning process at earlier stages. Provided ongoing technical support as issues arose. At one of the final demonstration sites, project "champions" were more clearly identified
End-user confusion about systems functionality and purpose	Additional end-user education materials (such as flyers and information cards) were produced and distributed. Later installations were limited to locations not accessible by the public. Project "champions" also assisted with end-user education.

Source: Willdan

The project gathered and analyzed a wide range of energy savings data from vendor platforms, performed measurement and verification of installed devices, and compared results and device performance with those of previous studies. This data can guide future large, advanced plug load management devices use for maximum energy savings, and future plug load research projects.

Finally, the products from two vendor partners were demonstrated and evaluated in a wide variety of real-world applications and environments. This includes demonstration of real-world large scale installation costs and requirements and ongoing operational needs when implemented over a broad range of end-use scenarios. These observations have been documented so that they can provide direction to product manufacturers for future product improvements that can ultimately increase market uptake of the technology.

A technical advisory committee was formed including various representatives from education, research, state government, and utility organizations. The committee was brought in after the demonstration site installations were complete to provide advice and direction on the final project evaluation and focus of the final investigation.

Project Results

Key results achieved by the project:

- A detailed product characteristic comparison matrix has been created, which also identifies optimal product characteristics that can be incorporated into future product updates or new offerings.

- The project team compared the advantages and disadvantages of the different vendors energy information offerings, which is included in the product characteristic comparison matrix, as well as recommendations for system improvements.
- Provided significant immediate and ongoing energy and cost savings to the California IOU customers included in the study. The installed advanced plug load management devices are currently controlling approximately 832,500 kilowatt-hours (kWh) (one year duration) of annual baseline plug loads across all the installation sites. The systems are reducing the controlled plug-loads by approximately 14.1 percent, or 117,000 kWh per year.
- Trained members from the California Conservation Corps, an organization providing vocational training for volunteers in the areas of environmental and energy project installations.
- Utility representatives will use the results from this study to develop codes and standards for this technology.

Technology/Knowledge Transfer/Market Adoption (Advancing the Research to Market)

Willdan Group's approach to building market adoption of advanced plug-load management devices was to disseminate the project's results and recommendations as widely as possible throughout California's higher education target market. Activities included working with the project's technical advisory committee, delivering presentations at key conferences, coordinating with utility energy efficiency program implementers, and developing a public facing website (http://willdan.com/markets/k12-and-higher-education.aspx).

The project's data and conclusions will be most useful to higher education facility and energy managers, technology vendors, and utility program implementers. Each of these groups will be able to leverage the project's research to develop and install more effective plug-load control strategies, technologies, and programs.

The near-term (beachhead) market for this technology was the initial sample of the 13 participating California community college districts, which is roughly 18 percent of the total number of districts. This study revealed the savings potential and challenges of expanding advanced plug-load management device deployments in the broader mid-term market of the entire California community college system, which includes 72 districts and more than 240 campuses. The long-term target market for this technology involves expansion beyond the community college system to the entire California higher education sector.

The project's technical advisory committee also played a key role in the project's technology transfer strategy. The committee included representatives from Willdan, the California Energy Commission, Pacific Gas and Electric Company (PG&E), the California Conservation Corps, the Electric Power Research Institute, the California Technical Forum, and community colleges. The committee's input led to invitations for Willdan Group to present the study data and conclusions to the California community colleges facility officers at their quarterly meetings, as well as commitments from the utilities, particularly PG&E, to incorporate the data into filings for future Title 24 Part VI code cycle; this will facilitate the project's findings to core and third-party program implementers. The committee also recommended developing a matrix of best practices and ideal technology features to serve as a template for successful use strategies, which was subsequently developed and included in the project's final report and other presentations.

Willdan Group has presented these project findings at two community-college facilities conferences, the Northern California community college facilities officers' meeting on November 6, 2020, and the Southern California community college facilities officers' meeting on December 9, 2020. Willdan Group will also host a web page where those interested can learn more about the technology, deployment approach, and expected costs and savings.

As a result of this study, California community colleges are now using 3,500 advanced plug-load management devices to control 832,500 kWh of annual baseline plug loads, saving 117,000 kWh per year. These savings represent approximately 5 percent of the total potential savings for advanced plug-load management devices deployments across the entire California community college system. The results of the study have provided Willdan Group and the participating technology vendors with critical data and insights about how to better serve this market and optimize deployments in the future. Following the conclusion of this study, vendors have continued to support the devices used at the participating districts, and Willdan continues to identify and pursue opportunities for advanced plug load management devices through direct work with California community college districts and as a third-party energy efficiency utility program implementer serving the public sector.

Benefits to California

General Benefits

Significant electricity use reductions and cost savings were delivered to the participating community college districts by the advanced plug-load management device technology. These savings began to accrue as the devices were used in a phased approach and were fully achieved once this project was complete. The systems will continue to provide savings throughout their 8-year expected useful life.

If the technologies were implemented at all California public higher education institutions (including the 245 community college campuses, the 23 California State University campuses, and the 10 University of California campuses), the overall savings are estimated to be approximately 9,700,000 kWh/yr. This estimate assumes controls would be implemented at 48,500 computer workstation peripherals, plus 84,300 individual, larger plug-load devices. This would generate $15,300,000 in cost savings over the life of the equipment that community colleges could then reinvest in their core missions. It would cost $194,000 for materials and labor installation.

This information was incorporated into promotional materials and outreach activities to ensure broad dissemination of project results and deployment of advanced plug-load management device technology in other institutional and commercial market sectors throughout investor-owned utility service territories in California.

Specific Benefits

- **Lower Utility Costs:** Each individual device has an average net present value of electricity savings of approximately $110 over its expected useful life. The combined net present value across the total deployment across all community college districts is approximately $185,000 in immediate and ongoing annual savings over the expected life of the equipment.

- **Environmental benefits:** Future benefit opportunities include participating in utility demand response programs.
- **California Workforce Development:** Successfully provided on-the-job training and work on environmental projects for California Conservation Corp members. The project team conducted multiple training sessions at the Corps' northern and southern California training centers. At each of the 13 campus installations a crew of 10 to 20 Corps members were used to install the advanced plug load management device units, with support from Willdan Group and vendor staff.
- **COVID Response:** Willdan Group took advantage of the statewide shelter-in-place order and worked with the San Mateo District to shut off more than 400 plug load devices on campus through the cloud-based platform, with no on-site coordination from staff required. Due to this control intervention, the baseload of the plug load devices was reduced from approximately 2,500 Watts to 300 Watts across the district. Electric savings are approximately 32,000 kWh annually, or $6,400.

CHAPTER 1: Introduction

Studies from more than a decade ago estimated that office equipment and other miscellaneous plug loads represented up to 20 percent of total building energy use intensity (EUI) in California office settings,[1,2] and up to 32 percent of total educational market campus-wide energy usage[3]. More recent data from the 2018 U.S. Energy Information Administration's (EIA's) *Annual Energy Outlook*[4] estimates that plug loads consume at least 30 percent of whole-building energy use, a fraction that is expected to grow significantly in the residential and commercial sectors by 2040. More recent studies have also projected the actual level of plug-load consumption as 30 percent of whole-building energy use.[5,6]

This increase in plug loads as a share of whole building energy use is likely attributable to energy efficiency measures reducing overall major heating, cooling, and air conditioning (HVAC) and lighting loads, while plug loads have been largely overlooked. To-date, statewide efforts to reduce electricity consumption and greenhouse gas (GHG) emissions in California buildings have primarily focused on the end-use categories of lighting, HVAC, commercial kitchen equipment, major server-side computing equipment, and to some extent cogeneration and renewable self-generation. From a building owner's/facility manager's perspective, efforts to reduce electricity use in the plug-load end-use category have been mainly limited to purchasing the proper equipment in the first place.

Stanford's plug load equipment inventory conducted in 2015 studied 220 buildings on its campus, with an average square footage of 40,500 pre-building. The study identified 110,529 plug-load devices, or about 500 devices per building. The project team installed advanced

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[1] Lawrence Berkeley National Laboratories. Space Heaters, Computers, Cell Phone Chargers: How Plugged In Are Commercial Buildings, February 2007.

[2] New Buildings Institute. *Office Plug Load Field Monitoring Report,* 2008. Laura Moorefield, Brooke Frazer, and Paul Bendt, PhD. https://newbuildings.org/sites/default/files/Ecos-Office-Plug-Load-Report_14Jul2009_DRAFT.pdf.

[3] Stanford University. Inventorying Plug Load Equipment and Assessing Plug Load Reduction Solutions on a University Campus, October 2015.

[4] EIA Annual Energy Outlook, 2018. https://www.eia.gov/outlooks/aeo/. U.S. Energy Information Administration, accessed August 2020.

[5] National Renewable Energy Laboratory. *Plug Load Management System Field Study,* February 2019. Alicen Kandt and Rois Langner. https://www.nrel.gov/docs/fy19osti/72028.pdf.

[6] National Renewable Energy Laboratory. *Navigating Cybersecurity Implications of Smart Outlets*, 2018 ACEEE Summer Study. Rois Langner and Dane Christensen. https://www.aceee.org/files/proceedings/2018/#/paper/event-data/p373.

plug-load management device (APMD) systems in 65 buildings at 13 campuses, with an average square footage of 48,000 each. The project team screened for plug load devices that were predicted contribute appreciable savings by being shut down during off hours via the APMDs. Through this screening process, the project team found approximately 50 devices of this type per building. Comparing the results of the Stanford plug-load inventory and the project findings, it appears that a good rule-of-thumb estimate is that roughly 10 percent of overall plug loads are controllable in a typical campus building.

Project Objectives

This project generated a large, complex, and diverse dataset to:

1. Investigate new issues that emerge when the APMD technology is deployed at a mass scale, and across multiple customers and sites (qualifying California community college campuses identified in the targeted service area).
2. Provide significant savings to the California investor-owned utilities (IOU) customers included in the study, including providing relief to the supply side systems in the Aliso Canyon Service Territory.
3. Compare and contrast multiple vendor offerings and technology features in the commercial APMD market. Prior studies focused only on single commercial manufacturers.
4. Evaluate whether the findings of the prior studies hold up in the case of mass deployment of the APMD technology.
5. Investigate plug load management and control approaches beyond those applicable to the typical computer workstation, such as loads found in copy rooms, kitchenettes, and other devices.
6. Evaluate California Workforce training and employment opportunities associated with deployment of the APMD technology under this study and beyond.
7. Investigate energy information system capabilities associated with the APMD technologies either not yet developed at the time of prior studies or were not the focus of the evaluations, or both.
8. Provide a comprehensive and well documented summary of findings that will serve to inform future utility programs program offerings and large-scale deployments of APMD technologies.

Achieving these objectives was a key step in contributing to a growing body of data on plug load management, facilitating the spread of knowledge about the identified technologies' capabilities, and fostering more widespread adoption of Tier 2 APMD applications in general.

CHAPTER 2: Project Approach

Efforts to reduce energy consumption and GHG emissions at California community colleges (CCC) have historically focused on more easily identified HVAC and lighting loads. However, given the high volume of plug loads on CCC campuses, Willdan Group (Willdan) determined that the CCC system represented a significant opportunity to serve as an emerging technology pilot setting for assessing the capabilities and savings potential of recent developments in APMD technologies. Successful implementation of this project required the coordination of a variety of stakeholders and partners, including technology partners, installation personnel, facility managers, IT departments, and decision-makers across the CCC system.

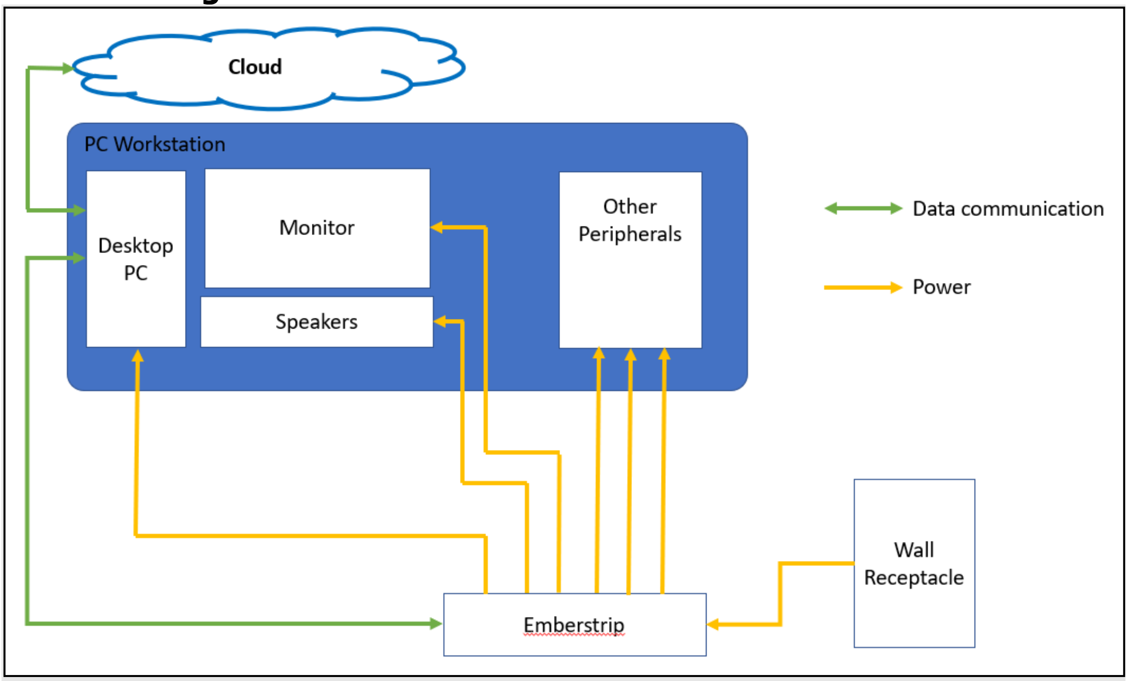
Willdan served as the principal investigator and project manager for this effort. Willdan was ultimately responsible for all coordination between project stakeholders and oversaw execution of all tasks. Willdan's responsibilities included site screening, measurement, and evaluation (M&V) activities, stakeholder satisfaction outreach and surveys, implementation best-practice evaluation, characteristic evaluation across manufacturers, overall data analysis, and project reporting. Regular meetings were held with relevant stakeholders at critical decision points during implementation, and meeting minutes were recorded and maintained. Willdan created and maintained a project implementation schedule and, as project manager, was the primary point of contact for any issues requiring resolution.

Partners

Technology Partners

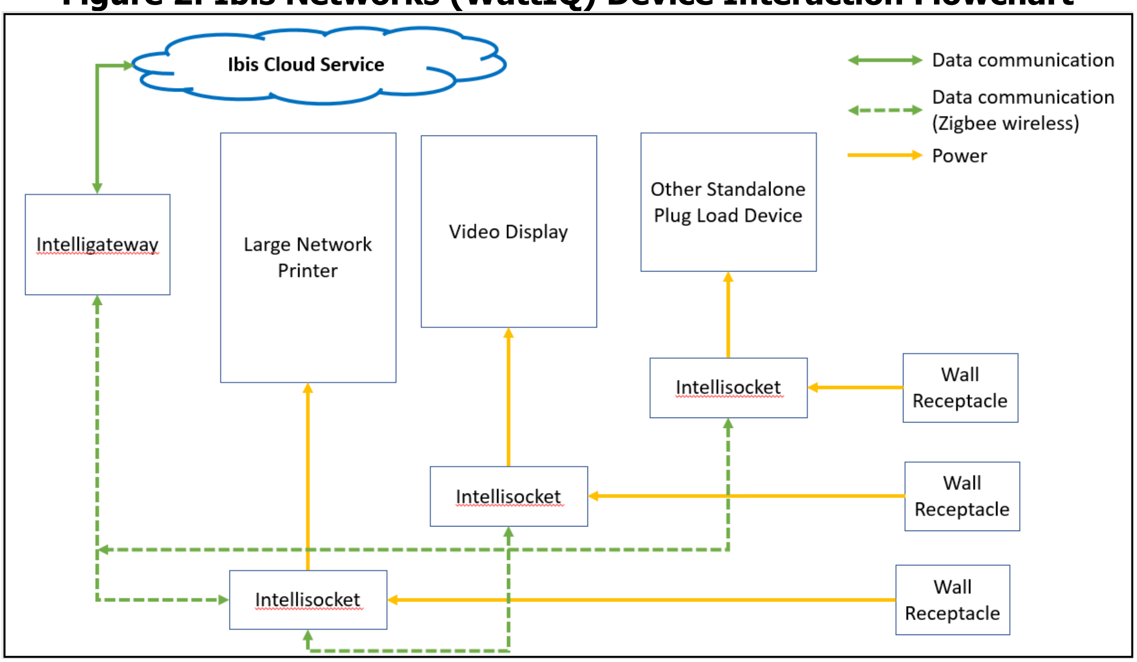
Willdan identified two technology partners, Embertec and Ibis Networks (now WattIQ), both with different APMD offerings that incorporated recent advancements in internet of things (IOT) capabilities and an interest in determining the market potential for their products in California's educational sector. Both firms had also previously participated in smaller-scale emerging technology studies incorporating their products. The applications identified for analysis in this study were the Embertec Emberstrip 8PC+ Unit (Emberstrip), the Ibis Networks Single and Dual Intellisocket, and Intelligateway System. Flowcharts showing how each device interacts with connected plug loads are provided in Figure 1 and Figure 2.

Figure 1: Embertec Device Interaction Flowchart



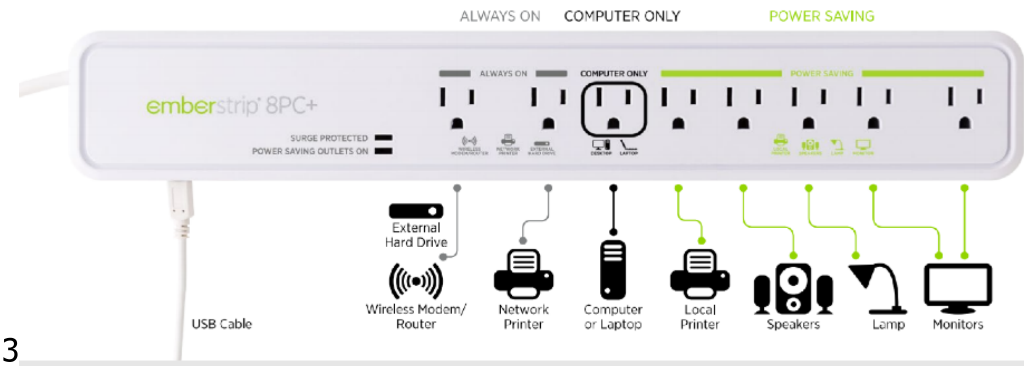
Source: Willdan

Figure 2: Ibis Networks (WattIQ) Device Interaction Flowchart



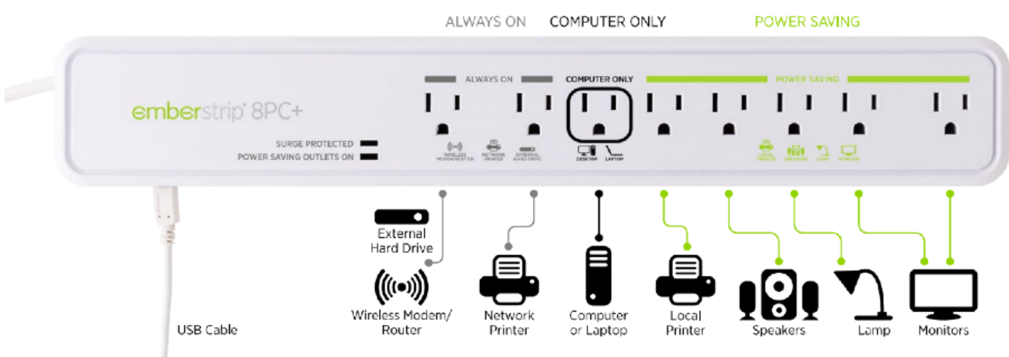
Source: Willdan

Embertec

The Embertec Emberstrip 8PC+ is an APMD that automatically powers down personal computers (PCs) and their peripheral devices. This includes monitors, lamps, printers, speakers, and scanners. The cost of this device is about $100 per strip. Emberstrip units, as shown in Figure 3 

, were only installed at PC workstations. These units qualify as "Tier 2 APS Devices," as defined by the U.S. Department of Energy[7] and elsewhere. Data collected from these devices is stored internally on the Emberstrip. The strip comes equipped with a universal serial bus (USB) cord that connects to a user's computer. Once the Embertec software is installed on the user's computer, the usage data is uploaded through the computer's network connection to the Embertec portal. The device controls consist of power-saving mode ports, where the software puts the user's computer to sleep and cuts the power to the peripheral loads after 15 minutes of user inactivity. The Emberstrip registers user activity via keystrokes and mouse movement, and by tracking the connected computer's power signature. Peripheral loads controlled include monitors, lamps, fans, personal space heaters, and non-networked personal printers. The device has ports where the power is never cut and is appropriate for devices such as routers and networked printers that should always remain on.

Figure 3: Embertec Emberstrip 8PC+ Unit



Source: Willdan

Ibis Networks (WattIQ)

The Ibis Networks Single Intellisocket contains an outlet for a single plug load to be controlled and the Dual Intellisocket contains one outlet for a plug load to be controlled and one outlet for a plug load that will not be controlled. This is applicable in situations such as a refrigerator or coffee maker that are plugged into a double receptable where the refrigerator should not be controlled. At the time of this agreement, the Dual Intellisocket cost $61.80 per unit. The Ibis Networks Single and Dual Intellisocket and Intelligateway System shown in Figure 4 was

[7] https://betterbuildingssolutioncenter.energy.gov/beat-blog/a-tale-two-tiers-advanced-power-strips-commercial-buildings.

installed on various individual plug load devices such as networked printers, watercoolers, vending machines, liquid crystal displays (LCDs), among others. System components include the Single Socket (IS-301), the Double Socket (IS-302), and the Ibis Gateway (IG-301). Each Ibis socket communicates data to each other via a ZigBee mesh network[8]. The mesh includes the Ibis gateway with an ethernet connection, enabling data to upload to the Cloud. Schedules are set via the online Ibis portal. Schedules can be set on individual connected devices or on groups of devices. Typical controlled loads controlled include networked printers, water coolers, dispensers and fountains, coffee machines, vending machines (containing non-perishables) and display monitors.

Figure 4: Ibis Networks Single and Dual Intellisocket and Intelligateway System

Source: Willdan

California Conservation Corps

To cost-effectively facilitate the large-scale installation of APMDs across multiple campuses within a compressed timeframe and meet the objective of evaluating California workforce training and employment opportunities associated with the APMD technology, Willdan partnered with the California Conservation Corps (CaCC). The CaCC is a department within the California Natural Resources Agency that provides young adults 18 - 25 years old a year of paid service to the State of California. During their year of service, corps members work on environmental projects and respond to natural and man-made disasters. Through this work, they gain skills and experience that lead to employment and careers. For this project, the CaCC provided a group of entry-level installation employees trained and sent to the targeted campuses to install the APMD technologies on previously identified plug load devices (Figure 5).

[8] A ZigBee mesh network is primarily used for short-range communication between a sensor and a control system.

Figure 5: California Conservation Corps Training Session

Source: Willdan

California Community College System Partners

Willdan leveraged long-term relationships with the California community colleges to identify and secure the participation of eight districts, with APMD deployments planned and installed at 13 college campuses. Each district played a critical role in the project, committing time and resources to identifying specific sites, coordinating installations and integration with information technology (IT) operations, assisting with M&V, and providing valuable end-user feedback. Facilities department staff at each campus provided installation scheduling support and site access, while IT department staff identified local area network (LAN) connection points for Ibis gateways and pushing Embertec software installations to Embertec-connected PCs. Participating sites are shown in Table 1.

Table 1: Installation Sites

Site Name	# Of Buildings Included	District
Chaffey College	3	Chaffey District
Cypress College	11	North Orange District
Citrus College	5	Citrus District
Merritt College	8	Peralta District
Peralta District Office	2	Peralta District
Berkeley City College	1	Peralta District
Sierra College	6	Sierra District
Mira Costa College	5	Mira Costa District
Mira Costa San Elijo Campus	3	Mira Costa District
Los Angeles Southwest College	6	LA District
Canada College	3	San Mateo District
College of San Mateo and San Mateo District Office	5	San Mateo District
Skyline College	7	San Mateo District
Total	**65**	

Source: Willdan

COVID-19 Impacts

Project activities for this study began in December 2017. The project was nearing its final phase when the consequences of the COVID-19 pandemic began to impact the activities of Willdan and its partners in April 2020. Most on-campus activities at California community colleges shut down at this time. The shutdown of on-campus activities resulted in extreme changes in campus energy use, with significant ramifications for the operation of APMDs and their associated energy savings data.

Willdan reached out to its community college partners to help remotely shutting off connected plug loads following the widespread unplanned school closures after the state implemented shelter-in-place orders in March 2020. This only applied to Ibis connected devices. San Mateo Community College District was one district that opted to participate in this emergency device shutoff program so researchers were able to switch off more than 400 devices at their three campuses, reducing the total load of Ibis-monitored devices by 1 MW and saving over 12,450 kWh. With the Cloud-based control systems already installed and configured, shutoffs were easily coordinated via email communication and implemented from home-offices over the internet. This not only reduced energy consumption to provide additional cost savings, but it also helped mitigate fire risks from unattended appliances. This effort added an unexpected beneficial aspect to this demonstration project that could also apply to sites subject to other kinds of emergency evacuations.

Deployment Process Design and Execution

The deployment process for this project was developed and implemented to incorporate the greatest number of applicable devices possible across the CCC campuses. Willdan identified the following factors as critical to the project success:

- Willdan leveraged its long working history and established level of trust with CaCC districts to encourage participation in the program. The districts also had a history of working with project partner CaCC and an established level of trust.
- The scope of this project required a significant installation effort, which was the first of its kind with this APMD technology in California. To meet this scale of installation, the project team leveraged its partnership with the CaCC to train and equip its Corps members with best practices for installation. The CaCC had a track record of quickly training and mobilizing large teams of installers for similar projects. Multiple CaCC operations centers were already located in the target area and were committed to working within the time frame required.
- Willdan, CaCC, Ibis and Embertec provided full education and training, installation, verification, and functionality support for the project from the pre- through post-implementation phases, right up to project hand off. Funding was made available to participating districts to compensate for staff time used for implementation assistance.
- Willdan conducted intensive outreach and education with site staff and end-users, providing information about the improved operation and capabilities of the advanced devices currently on offer and contrasting them to past devices where necessary.
- Sites were offered a choice between two APMD equipment manufacturers, with varying capabilities and characteristics that could be tailored to the site's concerns.
- APMD installation at individual sites was phased in, including a pilot group, that gave the site staff and a sample of end-users a chance to evaluate the product before full-site roll-out.
- Buy-in and comfort with technology were necessary from the site facility staff, IT department and device end-users. IT staff were pivotal to installing the software associated with the technology and interfacing with the data collected from the devices.

- The selected APMD technologies incorporated power-consumption data collection native to the devices and included Web-enabled data-collection and visualization tools. These capabilities and tools were used for measurement and verification (M&V) and were independently verified with parallel data collection devices.

Willdan's deployment process was broken into six key activities, as shown in Figure 6.

Figure 6: Project Deployment Process

Source: Willdan

- **Initial Outreach:** Willdan provided outreach and individual education programs to the districts, with a focus on district facilities and IT staff and building occupants. Willdan staff and manufacturer representatives provided information about the various benefits and features of the available APMD products. This outreach consisted of initial introductory e-mails to solicit interest from eligible districts, which were then followed up with in-person meetings with facilities and IT staff.
- **Site Audits:** Willdan evaluated district sites for inclusion in the program, to optimize the energy savings goals and evaluation potential. These audits included requesting floor plans and escort detail, coordinating with the CaCC and district representatives, and determining the type and number of Ibis or Embertec devices to be ordered or both. In addition, to facilitate ease of adoption and installation, Willdan conducted pre-installation end-user education with the participating site staff, including the production of education resource materials (such as quick information sheets, tip-sheets). Willdan was also on site and available by phone as a point of contact to address and coordinate resolution of issues that arose at a particular installation site. In addition, for early adopter districts, Willdan implemented smaller pilot installations that allowed end-users and other IT staff to further familiarize themselves with the products and processes.
- **Memoranda of Understanding (MOUs) With Districts:** Willdan established MOUs with the individual districts, that were signed by the district representative, IT staff representative, and Willdan staff, before implementation on any campus. Willdan developed a template MOU that could be used for each district. Many MOUs, however, required customization to satisfy individual district's needs. Some examples follow:
  - Los Angeles Community College District's legal department required several additional clauses to be added into the final MOU including indemnity, governing law, nondiscrimination, and attorney fees.
  - As the researchers developed the MOU process with the various districts, it became apparent that certificates of insurance were required by the districts along with MOUs before work could begin.
  - In addition to the MOU, one district required a professional services agreement (PSA) prior to performing site audit work. While this was not common, and most districts viewed this stage as a "site walk" not requiring a formal agreement, entities replicating this process should be aware that some sites may require it.

    - Willdan provided a phased installation for several districts and each phase required its own MOU.
- **Hardware Installation:** Willdan provided coordination between the equipment manufacturers, installers (CaCC), and district staff. Willdan established contracts with the manufacturers to purchase the APMD equipment, and the CaCC for installation and logistical support. Hardware installations included coordinating with all stakeholders to develop a deployment plan, noting locations for installation, and naming conventions for devices, and addressing any site-specific installation challenges. Phased installations were generally adopted by individual districts to allow for course corrections if required to maximize project success.
- **Embertec Software Installation:** Willdan facilitated meetings between Embertec representatives and campus IT staff to use software.
- **Data Collection and Device Scheduling:** Willdan created baseline data monitoring time frames with individual districts and subsequent scheduling based on campus activities.

Following these steps, Willdan conducted M&V activities pre- and post-APMD implementation at the selected district sites, following guidelines established by the International Performance Measurement and Verification Protocol (IPMVP) and CalPlug. A minimum of two weeks of pre- and post-implementation performance data were analyzed at each site.

Willdan also gathered stakeholder satisfaction information from district facilities and IT staff, and from APMD end-users through interviews and surveys.

Deployment and Overall Scope

Campus Outreach

Willdan attended conferences such as the Community College Facility Coalition's Northern California facilities Summit to spread broad awareness of the project. In addition, Willdan staff also reached out to individual districts to encourage their participation. Campuses were provided incentives to participate by receiving free APMD equipment paid for by the grant, free installation, and access to a small discretionary fund for district use. Even with these incentives for the district, Willdan staff conducted a significant amount of outreach before districts decided to join the project.

Willdan focused the outreach efforts on two different departments at the community colleges: the facilities departments and IT departments. Wherever possible, Willdan scheduled a meeting with both departments simultaneously, though there were several occasions where Willdan met with these groups separately. Facilities departments were key stakeholder since they were often responsible for maintaining campus equipment and escorting Willdan staff during site audits and installations. The IT departments were also key stakeholders since connected devices could be tracked and managed online. IT departments were also instrumental in pushing out Embertec software to connected devices.

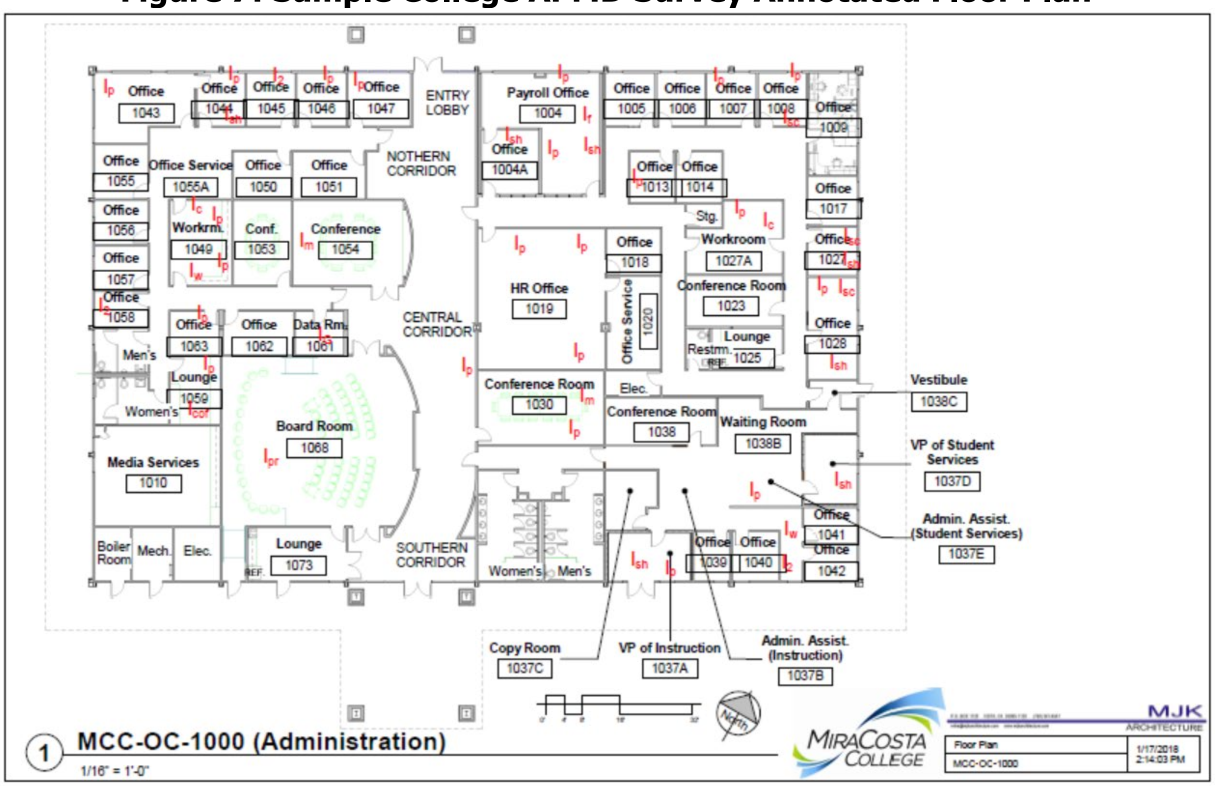
Outreach meetings also allowed Willdan to review processes for the rest of the project and address district staff concerns. For example, IT departments commonly brought up privacy and security concerns related to the devices. As a result, Willdan facilitated additional meetings between the IT departments and technology vendors. To further ease concerns, Willdan provided districts with a few demonstration units of the devices for IT staff to test and further evaluate. Two districts decided to not participate in the project following their demonstration reviews. Two of the eight districts that participated in the program decided to only install only one instead of both technology options.

Willdan also obtained stakeholder buy-in from district financial services departments, which coordinated consulting agreements and insurance requirements as necessary.

Site Audit and MOUs: Plug Load Field Surveys

Following campus commitments to the project, Willdan sent engineering staff out to perform site audits. Several districts preferred a phased-in approach to the project. In those cases, Willdan consulted with district facilities and IT staff to identify one or two buildings with high densities of plug loads to serve as a pilot installation. This typically included administrative buildings with multiple offices as opposed to classrooms. If districts were impressed with the project after the pilot installation, Willdan surveyed most of the rest of the campus for additional potential plug loads. District facilities staff escorted Willdan throughout campus buildings and Willdan catalogued building floor plans by device type, location and the plug load control device required, as shown in Figure 7. A large building with a high density of plug loads could take several hours to fully audit. Smaller buildings with a lower densities of plug loads were often surveyed in less than an hour.

Figure 7: Sample College APMD Survey Annotated Floor Plan



Source: Willdan

Willdan reviewed the survey with the technology vendors to ensure that devices were appropriate for controls. Willdan then refined future surveys based on this feedback. For example, personal printers were designated for control by Embertec while networked printers were designated to be controlled by Ibis. Willdan stopped including high amperage devices such as space heaters from Ibis surveys, since they exceeded Ibis's rated limits. Ibis depends on a stable mesh within the building to function properly. If a building had less than 10 potential Ibis plug loads, a stable mesh could not form so it would be removed from the potential installation. Willdan then prepared a final summary table, (Table 2), to be incorporated into the MOUs.

Table 2: Sample Pilot APMD Survey Summary Table (LA Southwest College)

Building Name	Sq footage	Emberstrip	Ibis - 301	Ibis - 302	Total Ibis Sockets	Ibis - Gateway
Cox	133,212	35	0	76	76	1
SSB	67,299	76	0	88	88	1
Totals	**200,511**	**111**	**0**	**164**	**164**	**2**

Source: Willdan

In some cases, Willdan was unable to audit campus spaces due to privacy concerns. These included spaces containing sensitive or private data, including business or finance offices, labs with hazardous materials, and sites hosting counseling and family services. These facilities were therefore generally excluded from the project.

Full copies of the MOU and field data form templates are in Appendix B.

Hardware Installation: APMD System Deployments

Throughout the process of APMD deployments, Willdan acted as the project manager. Willdan coordinated logistics, labor, lodging, and supervised product installation. Facilities department staff acted as the project's advocates during the installations, assisting installers and explaining the project goals to end-users. Crew from the CaCC were the installers.

Figure 8: California Conservation Installation Crew at LA Southwest College

Source: Willdan

On installation days, Willdan met with campus representatives from the IT and facilities departments and vendor representatives (Embertec and Ibis technicians) to discuss logistics. This provided an opportunity to inform the IT department about the project details, and to clarify what areas to avoid during installations. Willdan provided the CaCC a list of rooms with the devices slated to receive one of the APMD technologies. Embertec documents included how many controlled plug loads would be on each device. Ibis documents included the plug load equipment description. Willdan also conducted a brief refresher training for AMPD technologies.

As the project progressed, it was clear that the staff from campus' facilities departments were crucial for the project's smooth installation since they represented the campus and reduced end-users worries about privacy and security.

Embertec

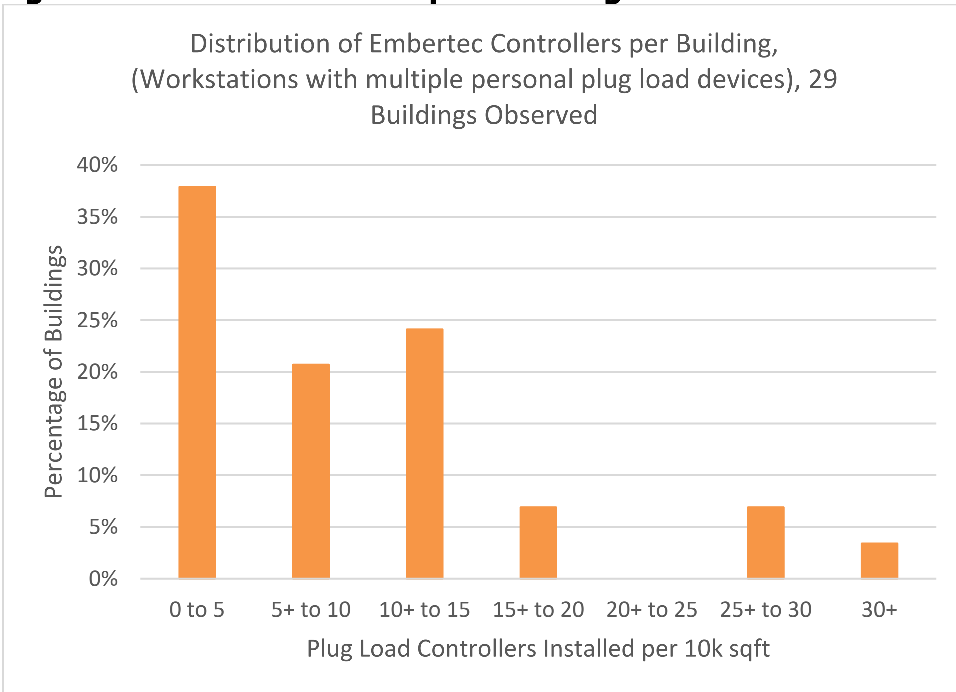
Prior to installation, Willdan worked with IT staff to hold demonstration installations of the Embertec device on a few workstations of their choice. Willdan also coordinated with facilities and IT before installation so that the campus would know when projects would take place. Campus staff in the IT or facilities departments also sent notices to all participating users informing them that if the end-users were going to be present during installations, they would have to save their work and shutdown their machines. More importantly, if they weren't going to be there, they would have to make sure their computers did not have any unsaved work that could be lost when they were powered down during installation. Since computers must be unplugged prior to installing the Embertec device, if a computer was left on and there was unsaved work on the screen, the installation crew skipped that workstation.

Installing the Embertec device required access to a USB port. Workstations with all USB ports occupied could not be retrofitted with this device. The smart strip had clearly labeled positions showing where to plug in the computer, as well as two power sockets for "always on" power, and five sockets that could be controlled off. Installers switched plug loads from the original power strip to the new strip, then left an informational brochure on their desk upon completion. The brochure informed users of the new power strip and its functionalities.

The following steps were followed to install the Embertec devices:

- CaCC members travelled in groups of two or three to install the Emberstrips.
- The installers checked that the computer was turned off. If it was left on, and the user was not in the area, it was skipped and noted for later. Installers were instructed not to power down computers without the user present so that no un-saved work would be lost.
- If a computer was turned off, installers unplugged the computer and other devices from the existing power strip and plugged them into the new Emberstrip.
- Installers plugged the USB cable from the Emberstrip into the desktop, ideally in a more hidden USB port that was less likely to be tampered with.
- Each Emberstrip took 5-10 minutes to install, though it took longer for situations where there were multiple tangled cables by the workstation (Figure 9).
- By the end of the project, a total of 1,313 devices were installed at 10 campuses in 30 buildings.

Figure 9: Installation Rate per Building for Embertec Devices



Source: Willdan

Ibis

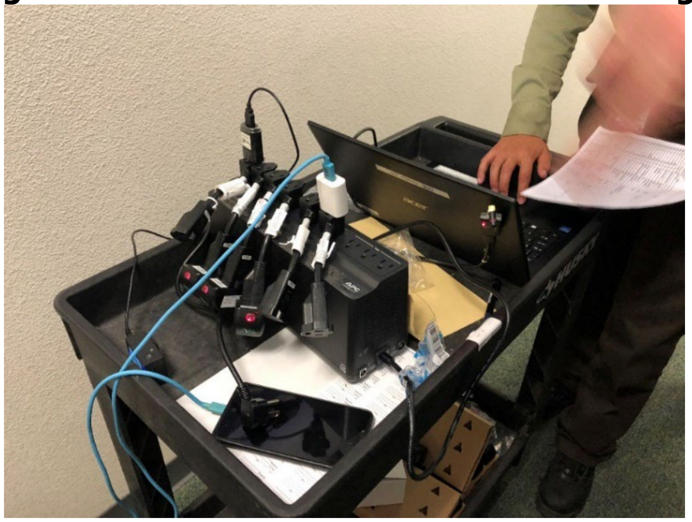
Prior to installation days, Willdan coordinated installation of gateways between IT staff and Ibis technicians. The gateways were installed in centrally located IT rooms within the buildings. The gateway acts as a central link between the Cloud and the mesh formed by the individual Ibis devices. If this could not be coordinated in advance of the installation, the gateway was installed first before any Ibis sockets.

During installation, installers set up individual sockets on the Ibis website to designate the device type and location. The device power plug was then removed from the existing socket and reconnected via the Ibis device. The double socket devices still monitored energy use for the uncontrolled plug loads, which provided valuable data from their plug loads. Two IS-301 devices could not fit on a double electrical outlet, so an IS-302 device was used to control two plug loads at the same outlet. In those situations, Willdan selected the device that was more likely to deliver higher savings to be controlled. In some instances, it was difficult to install an Ibis socket between the device and a wall outlet, such as behind vending machines and monitors. A short extension cord was used to connect plug loads more easily to the Ibis devices.

The following steps were followed to install the Ibis devices:

1. The Ibis vendor installed a gateway in each building where Ibis sockets were to be installed in.
2. CaCC members travelled with a cart that included Ibis sockets to be installed, a laptop to program the Ibis socket, and pigtail extension cords, as shown in Figure 10.

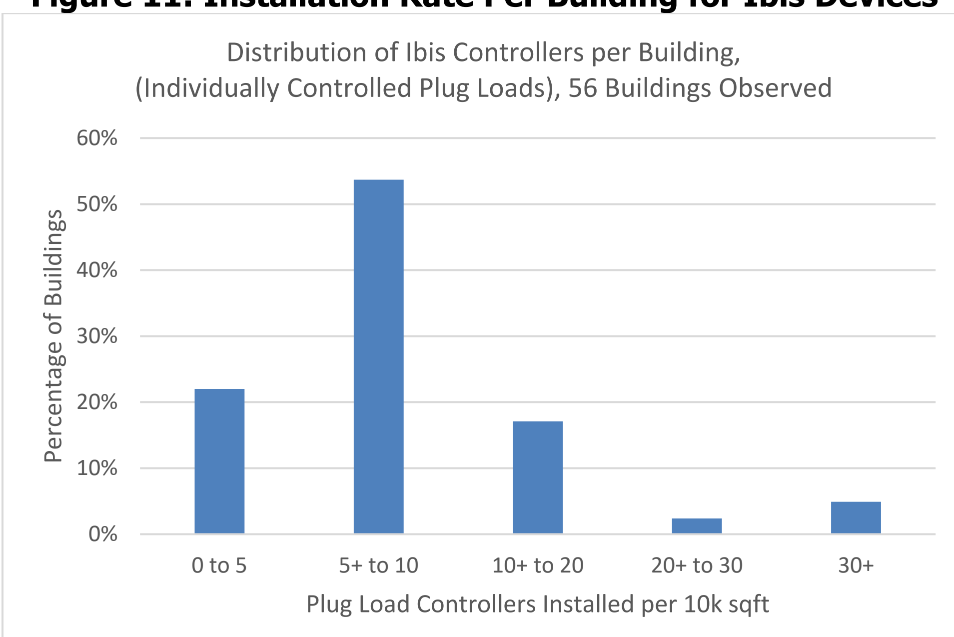
Figure 10: Installation Cart for Merritt College



Source: Willdan

3. CaCC members plugged in an Ibis socket into an empty outlet and programmed it with the plug load device information including building, room number, device type, and device model number.
4. The Ibis socket then automatically connected to the ZigBee mesh network.
5. Once connected, the Ibis socket was then moved and plugged into the electrical outlet with the plug load. The plug load to be controlled was plugged into the "controlled" outlet. Other devices were plugged into the uncontrolled outlet, if applicable.
6. Each Ibis socket takes about 10-15 minutes to program and install (Figure 11).

Figure 11: Installation Rate Per Building for Ibis Devices



Source: Willdan

By the end of the project, a total of 2,186 Ibis devices were installed at 13 campuses and 45 different buildings.

Software Installation and Device Scheduling

Embertec

When the software is not installed, the Emberstrip functions as a normal power strip. However, if power is not drawn through the socket designated as “PC-only” on the strip, power is cut to all devices connected to the “Power Saving” sockets. When the software is installed, the energy use of the computer and the peripherals is monitored. After two weeks of monitoring, the strip automatically switches to a “Normal” operation mode. In this mode, the slots on the power strip labeled “Power Saving” switch off when it detects that the computer is asleep.

Operation of the strip without software deployment caused confusion among end-users, due to power being cut to “Power Saving” sockets when no power was flowing to the “PC-only” socket. Due to this confusion, it is recommended that software be used as soon as possible after the Embertec hardware has been installed.

Ibis

After a few weeks of data logging, Willdan engineering staff analyzed the trend data per device type and drafted a schedule for the IT and facilities departments. The schedules were then approved by the heads of the IT or facilities departments and subsequently Willdan implemented them.

CHAPTER 3:
Project Results

Cloud Data System Functionality

Embertec

The Embertec website allows users to download raw data in .csv format. Data is stored in the Cloud following installation of the Embertec software on the workstations. As shown in Figure 12, individual devices were identified by their device ID, device name, campus, department, and department ID. Embertec's web portal also displays energy parameters for each connected device, including wattage of connected devices and estimated annual energy consumption (Figure 13).

Figure 12: Sample Screenshot of the Embertec Portal at Berkeley City College

embertec Home Reports Admin Willdan_BCC

Berkeley City College Devices

Show 100 entries Search:

	Device ID	External Device ID	Device Name	Enterprise ID	Department	Department ID
	002BEC10	337SHK43	BA542ZWDA01L	Berkeley City College	FACULTY - FACULTY	FACULTY
	004D2DE2	332U7UH7	BA347ZWIN01L	Berkeley City College	VETERANS - VETERANS	VETERANS
	004D31BE	332U14SH	BA344ZWDA01L	Berkeley City College	EOPS - EOPS	EOPS
	004D33B0	332U11S3	BA124BWDA01L	Berkeley City College	LRC - LRC	LRC
	004D34C6	332U12K5	BA153ZWDA03L	Berkeley City College	CASHIER - CASHIER	CASHIER

Source: Willdan

Figure 13: Sample Screenshot of Embertec Portal Showing Measured Energy-Related Results by Device

Timestamp (ACST)	Time Since Reset (Seconds)	Time Since Reset (Hrs:Mins:Sec)	PC Power (W)	Peripheral Power (W)	Accumulated Energy Used Since Reset (Wh)	Annualised Projected Used (kWh)	PC On Time	Mode
2016/Dec/21 07:44:42	515283	143:08:03	34.6	54.3	2575	158	96725	Normal
2016/Dec/21 07:39:35	514976	143:02:56	35.4	55.0	2567	157	96418	Normal

Source: Willdan

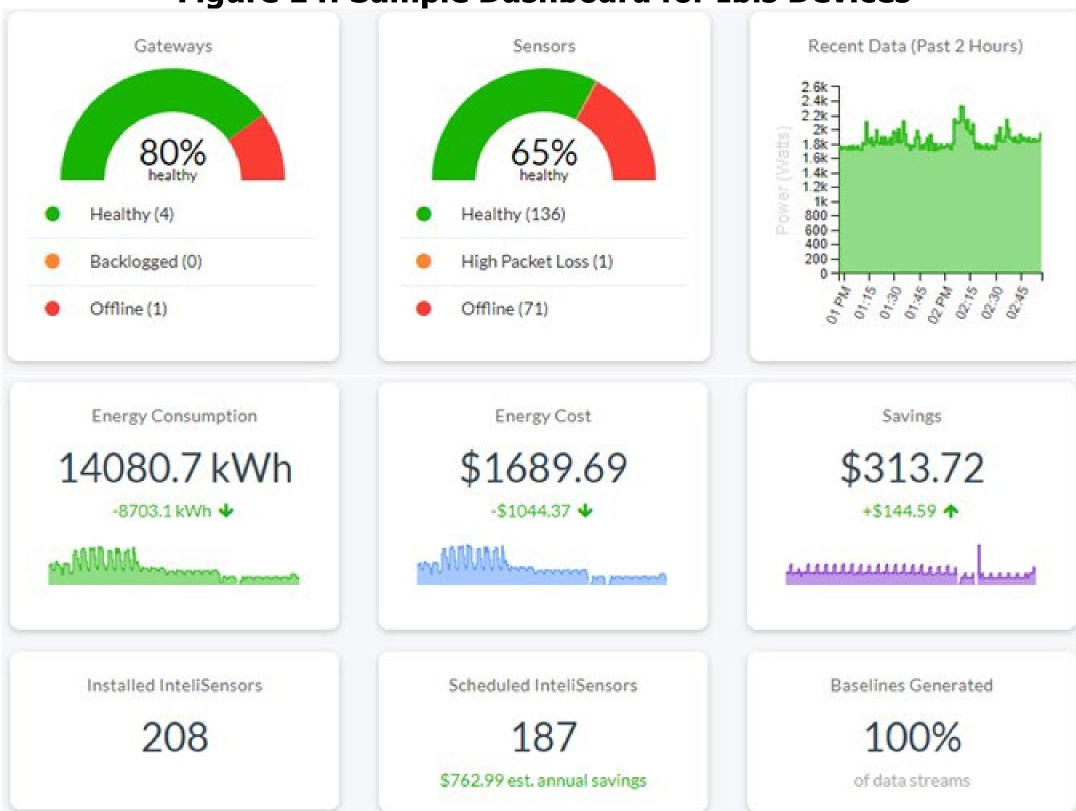
The Embertec software installed on individual workstations allowed college IT departments to monitor the status of the power strips, group units together by building and department, measure energy saving characteristics such as baseline and reduced energy use levels for these groups, and view and download detailed time-series usage data from individual units. The software does not allow users to download data in bulk. When analysis of bulk data is required, it can be requested directly from Embertec.

Ibis

The Ibis website features a dashboard that displays metrics such as offline devices, power trends, energy savings and maximum device temperature. An administrator can schedule the devices to power on or off through the website, and users can either develop customized schedules for individual devices, or develop schedules by groupings, such as by building or device type (for example TV, projectors, and vending machines)

Figure 14 shows the dashboard Ibis provides for its devices. Healthy devices are devices that are connected to the internet and are sending and receiving data from the Cloud. Backlogged gateways are ones that are not consistently connected to the Internet so are thus storing a backlog of data from the Ibis sensors that are not being uploaded quickly enough. Sensors with high packet loss mean they are experiencing a connectivity issue with the gateway and cannot transmit more than 20 percent of the sensor data. Off-line sensors have lost connection to the gateway entirely.

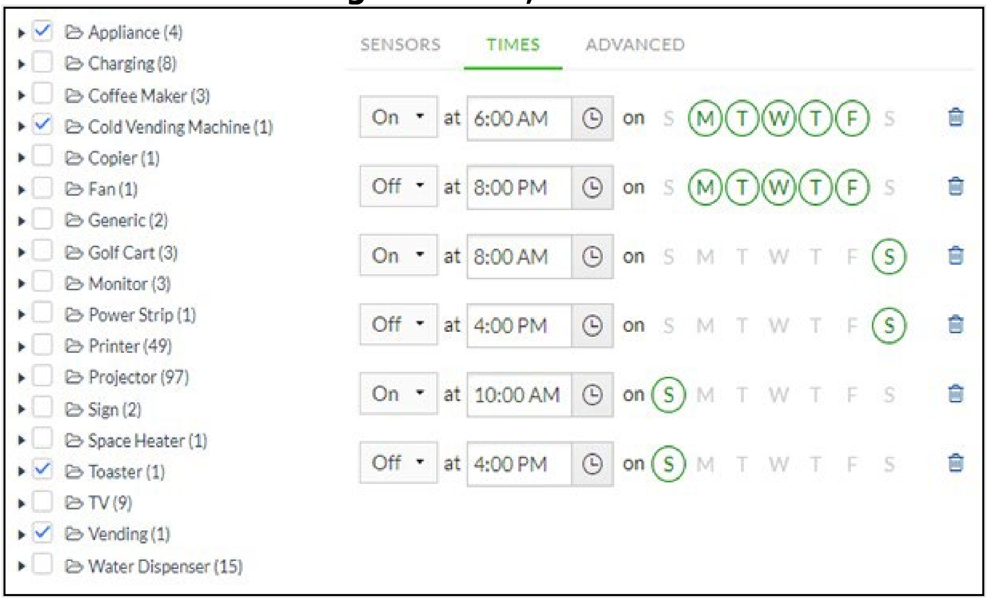
Figure 14: Sample Dashboard for Ibis Devices



Source: Willdan

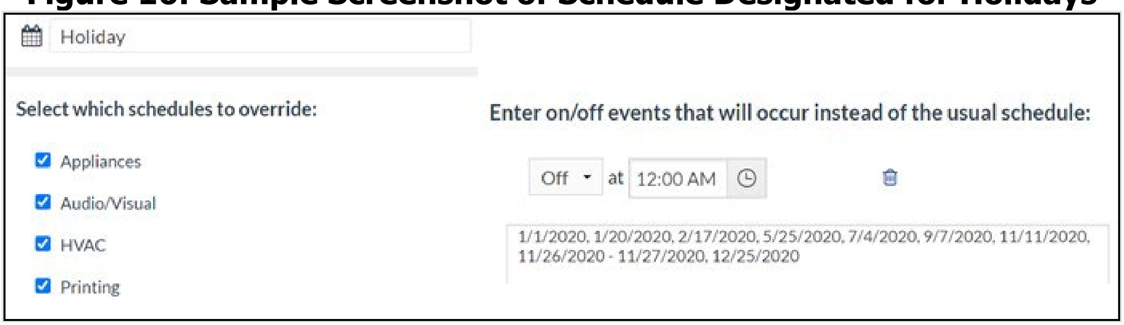
Schedules can be tailored to each day of the week, and users can specify special schedules, such as for holidays and breaks between school terms. A sample schedule is shown in Figure 15. For this sample campus, the Ibis sockets control appliances, vending machines, and a toaster to turn on between 6 a.m. to 8 p.m. on weekdays, 8 a.m. to 4 p.m. on Saturday, and 10AM to 4 p.m. on Sunday. The devices are turned off during all other hours. Exception schedules can be set for multiple groups of devices as well, as shown in Figure 16. In the sample case shown, appliances, audio/visual equipment, and HVAC and printing devices are scheduled to turn off at 12 a.m. on holidays. They will remain off until the software turns them on the next day (Figure 16).

Figure 15: Scheduling Tool for a Group of Devices Consisting of Appliances, Vending Machines, and Toasters



Source: Willdan

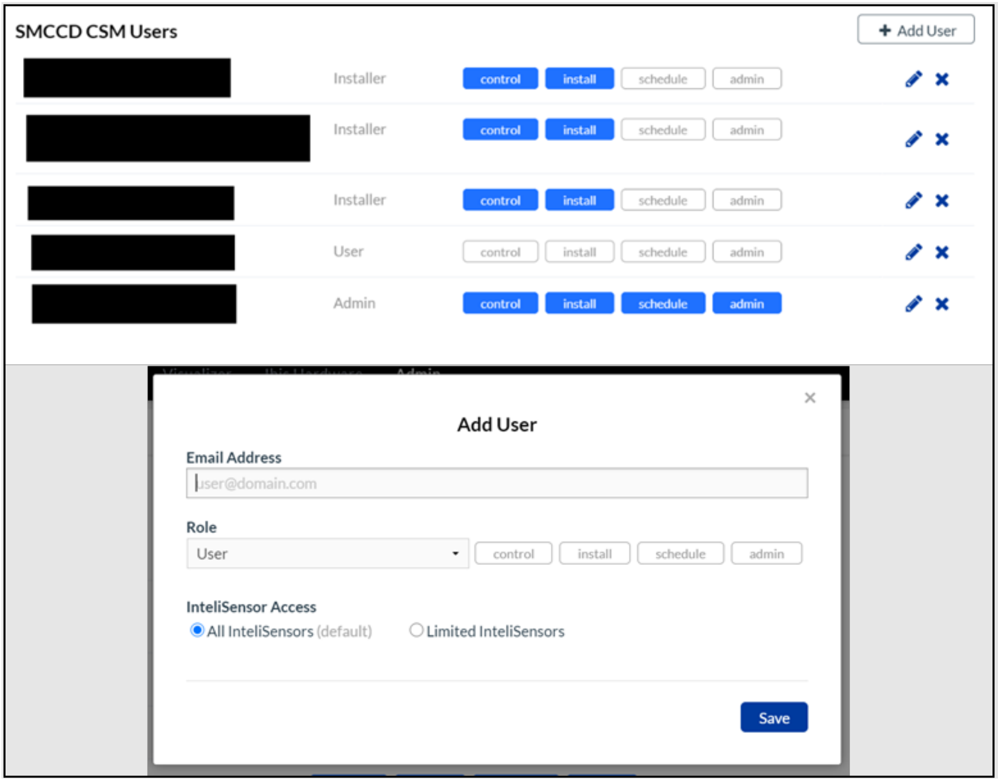
Figure 16: Sample Screenshot of Schedule Designated for Holidays



Source: Willdan

Multiple administrators can be added for each campus on the Ibis website. Administrators can include IT departments, facilities departments, sustainability departments, and third-party consultants. Each administrator can be given a different level of access such as viewing devices or having the ability to schedule devices. New users can be added by email, and can be designated as Admin, Installer, Manager or User (Figure 17).

Figure 17: Sample Users and Their Privileges at College of San Mateo

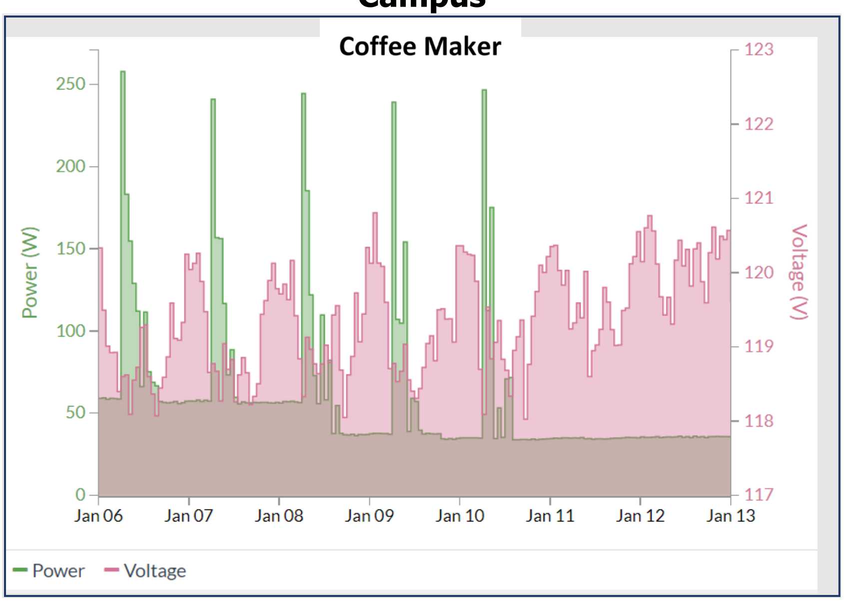


Names of users redacted for privacy.

Source: Willdan

To visualize results, Ibis allows users to create customizable graphs based on metrics captured for each socket – power, baseline power, energy, voltage, and current – as shown in Figure 18. Graphs can then be saved and shared directly from the website.

Figure 18: Screenshots of Power and Voltage Trends for Coffee Makers at a Sample Campus



Source: Willdan

Measurement and Verification

Embertec

Emberstrips monitor power use from the computer and connected peripherals. They also monitor the amount of time that a workstation is turned on and calculate an annualized energy use for the workstation. For the first two weeks after the power strip software is installed, it stays in "Log" mode to capture baseline conditions such as energy use. During this 2-week period, the Embertec device will not control either the computer or peripheral devices. After two weeks, the power strip switches to a "Normal" mode and starts turning off the computer and its peripherals when the computer is not in use. The software will produce a pop-up notification that the Embertec software will put the computer to sleep within a predetermined period. The software then uses the difference in energy consumption between the "Log" and "Normal" modes to calculate annual energy savings.

Energy savings calculated by the Embertec software are calibrated to baseline behavior. If the use pattern during the baselining period is not representative of regular use, (such as low use during holidays or school breaks), this can impact estimated annual energy savings for the rest of the Emberstrip's lifetime. For this reason, Willdan coordinated with IT departments to install the Embertec software when there would be at least four weeks of normal operation to provide a buffer in capturing representative baseline data. If a non-representative baseline was created during the 2-week baselining period, the administrator can manually delete and reinstall the Embertec software to re-baseline the workstation.

Even though the Emberstrips might report non-representative energy savings values from baselining errors, they will still save energy during the operational period since they will proactively turn power off when a workstation is idle.

Ibis

Ibis devices monitor power, energy, current, voltage, temperature, signal strength, on/off state, and packet loss. Once installed, each individual smart plug begins recording data. Ibis recommends waiting for 2-4 weeks after installation to have enough time to accurately establish the following baselines:

- An average weekday, using data from Monday – Friday
- An average weekend day, using data from Saturday – Sunday
- An average holiday
- Individual baselines for each day of the week: Monday through Sunday

Like Embertec, if the use pattern of the connected device during the baseline period is abnormal, the annual energy savings calculations are impacted. The impacts to calculated savings are expected to be less severe than Embertec savings, however, given the variability in usage between the typical types of devices controlled by each of the APMD technologies. For example, the use variability for a public, Ibis-controlled device such as a printer or vending machine is much less than the use variability for a private Embertec-controlled device such as a workstation.

Independent Verification of Native APMD Power Readings

Willdan performed a comparison of the power measurements produced by the two APMD technologies with an independent measurement. Power measurements generated by the APMD devices were compared with measurements taken independently, using Onset HOBO plug load meters.

Description of HOBO Device

Plug load power measurements were collected independently of the APMD devices using an Onset HOBO UX120-018 Data Logger device (Figure 19). This is a highly accurate, easy to use data logger that measures and records the power and energy consumption of 120-volt plug loads. The Underwriters Laboratories (UL)-certified logger provides 0.5 percent measurement accuracy with a measurement resolution of 1 watt. The unit uses Onset's HOBOware software to view, transfer, and export data.

Figure 19: HOBO Data Logger

Source: Willdan

Comparison Approach

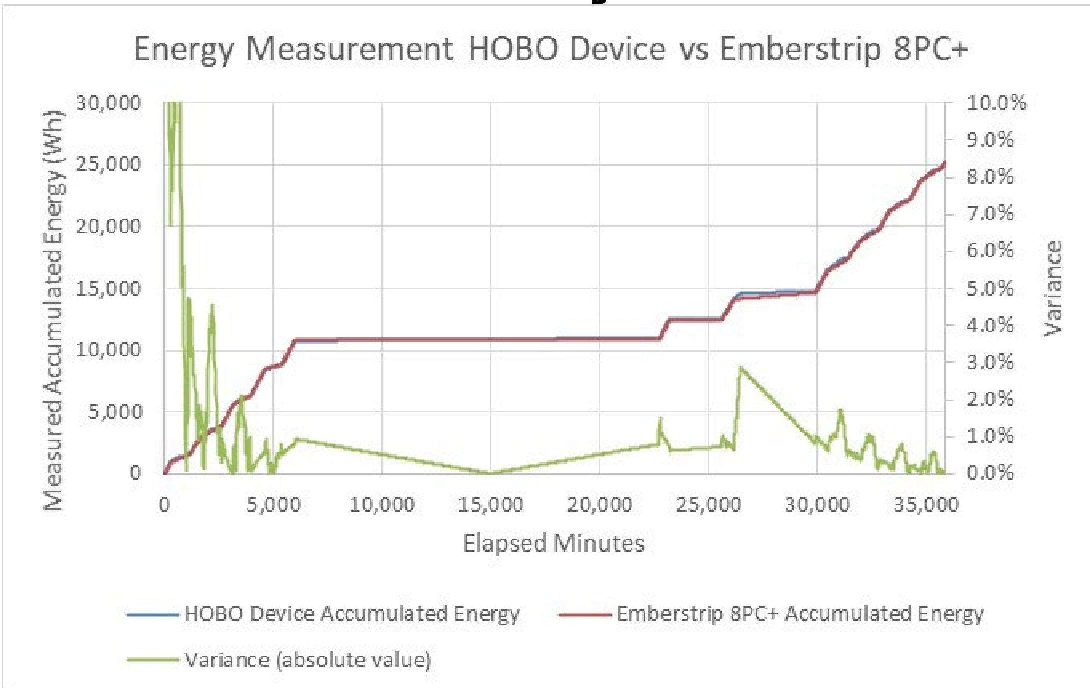
Power measurement comparisons were set up as follows:

- Emberstrip 8PC+: HOBO unit connected between wall outlet and Emberstrip, Emberstrip running in normal mode with PC plugged into appropriate socket, with peripheral lamp plugged into controlled socket and left switched on overnight.
- Intellisocket: HOBO unit connected between wall outlet and Intellisocket; refrigerator connected at unscheduled Intellisocket

Results and Conclusions

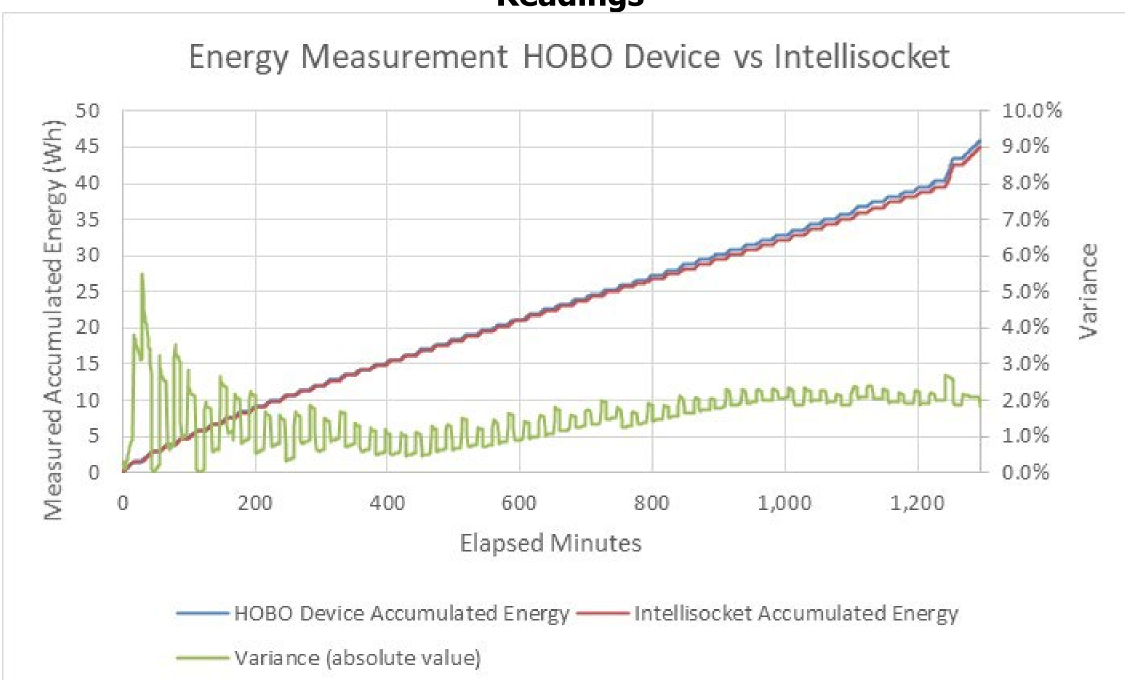
The results of accumulated energy comparisons for both devices are presented in Figure 20 and Figure 21.

Figure 20: Comparison of HOBO Device and Emberstrip Accumulated Energy Readings



Source: Willdan

Figure 21: Comparison of HOBO Device and Intellisocket Accumulated Energy Readings



Source: Willdan

Accumulated energy measurements produced by the Emberstrip and the Intellisocket are shown to compare well with the measurements produced by the HOBO device. The variance in measurements for both devices is large for small, elapsed time periods but later settle down, due to the small amount of energy accumulated, which is the denominator of the variance formula. After sufficient time has elapsed, both devices consistently exhibit energy measurement variances of less than 3 percent against the HOBO measurement consistently. The Intellisocket consistently has a small higher/lower power reading than the HOBO device. This is likely due to the Intellisocket's built in LED light, which is not included in the onboard power measurement readings.

Plug Load Dataset

Embertec

Willdan installed approximately 1,400 Emberstrips across 10 community college campuses, more than 500 of those campuses provide energy savings to their respective sites, as shown in Table 3. Emberstrips log data in 5-minute intervals and capture the following information: time since reset, PC power, peripheral power, accumulated energy used since reset, PC on time, and mode).

Table 3: Summary of Embertec Installations

Power Strips Installed	Online as of report writing	Successful Strips (Saving Energy)	Successful Deployment Rate (Successful Strips/Installed Strips)
1,404	1,046	524	37%

Source: Willdan

In addition to the Emberstrips that contained errors as shown in Table 4, 108 Emberstrips at Los Angeles Southwest College did not have their control software installed because the strips were installed too close to March 2020 when shelter-in-place orders were issued. The total of 1,046 online units includes the 414 Emberstrips in error, and the 524 successful Emberstrips saving energy.

Table 4: Failure Analysis for Emberstrips

Error	Count	Percentage of Installed Units	Corrective Action
Discrepancy in usage between log and normal datasets[a]	101	10%	Install the Embertec software before a 2-week period that the most users are expected to be at their workstations. For example, this can be during the middle of a semester. This way, the baseline will be created when most workstations are powered on regularly, with fewer users on vacation.
No Log mode data	100	10%	IT department to check whether any workstation was missing the software after the initial software rollout.
Negative Savings[a]	88	8%	
Less than 2 weeks of Log data	53	5%	1) Software error – not easily resolved. 2) Workstation was not powered during the entire 2-week baseline period – avoid installing Emberstrip in unfrequently used workstations
Less than 2 weeks of Normal data	31	3%	Avoid installing Emberstrip in unfrequently used workstations -workstation was not powered for more than 2 weeks after baseline period.
No Normal mode data	23	2%	Avoid installing Emberstrip in unfrequently used workstations – workstation was not powered beyond baseline period.
Emberstrip forced to stay on 100%	13	1%	Better deployment coordination with IT department to select more applicable users to installed Emberstrip on – a college campus requested all Emberstrip functionality be removed due to user complaints.
No Log or Normal mode data recorded	5	0%	1) Software error – not easily resolved. 2) Workstation was not powered at all after installation – avoid installing Emberstrip in unfrequently used workstations
Total Error	**414**	**40%**	

[a] Emberstrips with Discrepancy in Usage measured a higher workstation utilization rate after the baseline period, this is abnormal because the Emberstrip is supposed to reduce the time that the workstation is powered on. The user might have been using the workstation less than normal during the baseline period and reverted to normal afterwards. There was difficulty of installing software and getting IT to agree was the biggest barrier to a successful deployment. Also, there is multiple colleges so it is working many different people. It not as easy as plug and start saving. There's a bit of education and software in-order to make this technology work. This would underestimate energy consumption during the baselining period, therefore measuring a negative saving value. Emberstrips with Negative Savings simply mean that despite workstation utilization being reduced after the baseline period, those strips were still recording higher usage after baseline period.

Source: Willdan

Ibis

Willdan installed nearly 2,200 Ibis sockets across 13 community college campuses. More than three quarters of the installed devices provide energy savings to their respective campuses, as shown in Table 5. Ibis devices log data in 1-minute intervals and collect the following data: location, device type, current power, baseline power, energy, packet loss, voltage, current, on/offline, on/off state.

Table 5: Summary of Ibis Installations

Intellisockets Installed	Online as of report writing	Successful Deployment Rate (Online/Installed)
2,185	1,679	77%

Source: Willdan

Table 6: Failure Analysis for Ibis Intellisockets

Error	Count	% Of Installed Units	Corrective Action
Offline Units	506	23%	Units become offline because of 3 reasons. 1) Unplugged by users. 2) Gateway is powered off. 3) Mesh failure. 1) Plugs for small devices such as small printers and coffee makers are most easily unplugged by users. The two main reasons are because they don't know how to override the "off" schedule, and because a user has moved out of an office and unplugged all devices. It is therefore recommended to put a small notice next to all Intellisockets pointing to the manual override, and notify the user in case of moving offices, to leave the Intellisocket with the IT department. Another solution is to place Intellisockets in hard-to-reach locations so they cannot be interfered with. 2) Intellisockets receive instructions to control devices from the cloud through the gateways. If a gateway is powered off, all Intellisockets connected to it default to a non-interference mode and would appear offline in the web portal. It is recommended to place a notice next to gateways to discourage people from unplugging the device, and to put the gateway in a hard-to-reach location. 3) Intellisockets far from a gateway depend on the mesh that Intellisockets form to communicate to the gateway. If critical Intellisockets are removed in a mesh, it is possible to cut off connection to a now-islanded group of Intellisockets. It is recommended to install enough Intellisockets in a building to ensure redundancy in the mesh. If there are not enough devices to install Intellisockets on, it is possible to install Intellisockets as a repeater – with no devices attached.

Source: Willdan

Combined

The installed devices collectively record a massive amount of data. From the 2,725 online devices, this project logs more than 3 million data points per day, as shown in Table 7. This provides a massive amount of incoming data from which researchers analyze energy use from different plug load types, climate zones, and room types.

Table 7: Summary of Daily APMD Data Collection

Device Type	Online as of report writing	Energy usage Data points per device per day	Total Energy Usage Data Points per Day
Embertec strip	1,046	576	602,496
Ibis Intellisocket	1,679	1440	2,417,760
Total	**2,725**		**3,020,256**

Source: Willdan

Usage and Savings Data

Embertec

Willdan developed an analysis of the data collected from the Emberstrips installed at 10 campuses in California (Table 8). At two locations – Los Angeles Southwest College and Peralta Community College District, the Emberstrips were installed close to March 2020 when shelter-in-place orders were issued. Since the software had to be installed when the workstations were in normal operation, the decision was made to delay software installation at those sites, resulting in a lack of data from them.

Table 8: Number of Embertec Units Deployed and Average Savings Per Successfully Operating Unit at Each Campus

Campus	Installed Units	Online Units (As of 5/2020)	Successful Units	Baseline Annual Usage (kWh)	New Annual Usage (kWh)	Savings[a] (kWh)
Berkeley	117	105	62	164	69	95
Chaffey	135	130	107	254	115	138
Citrus	249	176	47	224	86	138
Cypress	308	295	173	340	249	90
LASC[b]	151	108	– [b]	– [b]	– [b]	– [b]
Merritt	173	77	55	168	48	120
Mt SAC	15	13	9	405	132	273
Peralta DO[b]	99	– [b]	– [b]	– [b]	– [b]	– [b]
San Mateo	70	65	41	263	97	166
Sierra	87	77	30	181	139	42
Systemwide	**1,404**	**1,046**	**524**	**259**	**145**	**114**

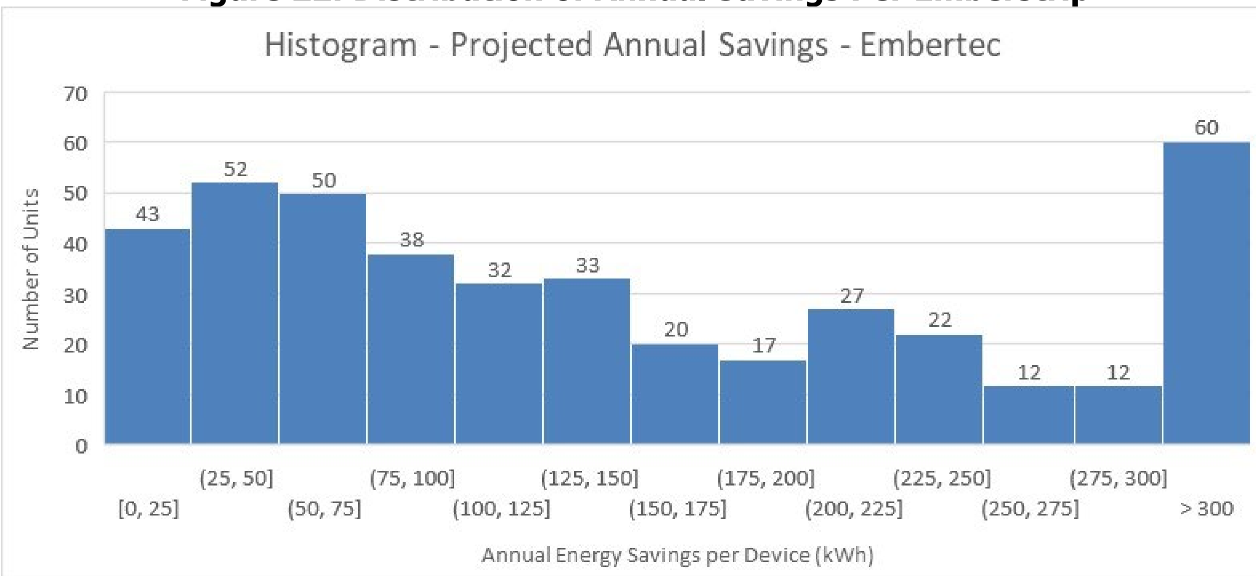
[a] Savings are only calculated for Emberstrips that successfully save energy.

[b] Embertec software was not installed at this campus.

Source: Willdan

The installed Emberstrips control a wide variety of workstations and peripherals, leading to a large spread in annual energy savings, as shown in Figure 22.

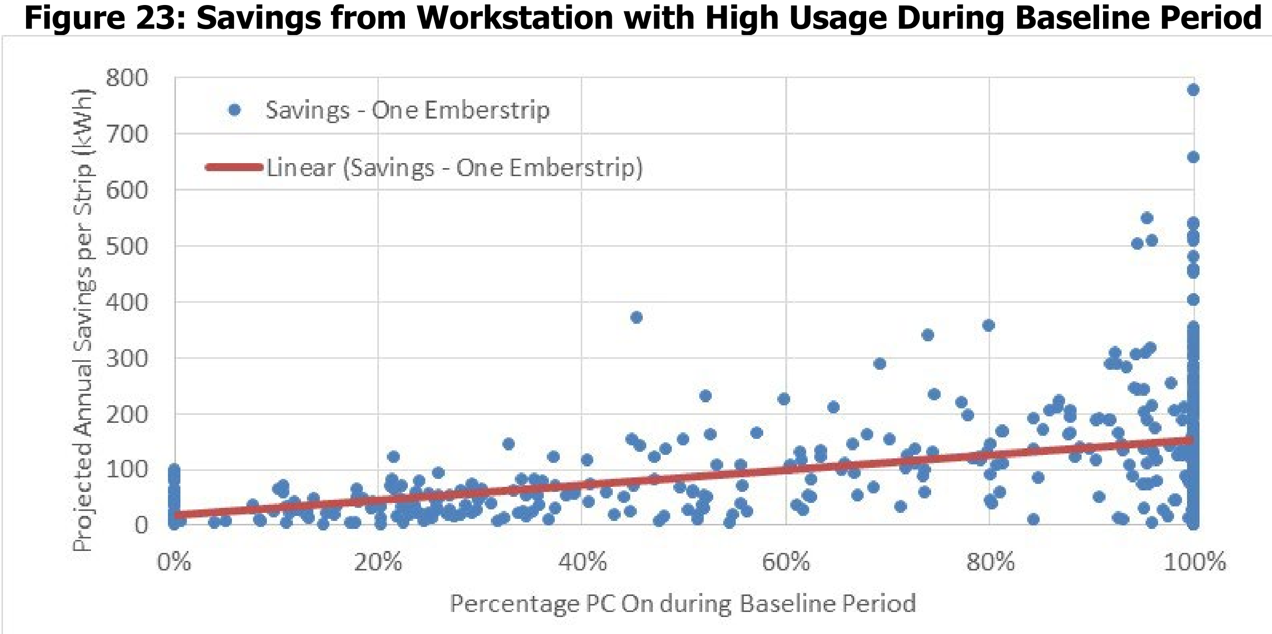
Figure 22: Distribution of Annual Savings Per Emberstrip



Source: Willdan

Willdan discovered two optimal scenarios for higher annual energy savings. The first scenario was when a PC was left on most of the time during baseline conditions. In this scenario, an Emberstrip has more opportunities to turn off any peripherals and put the computer to sleep to generate greater energy savings. Figure 23 shows a workstation that was on for the whole day during the baseline period. After that period, the Emberstrip was able to shut down the workstation outside of work hours, saving 640 kWh in that case.

Figure 23: Savings from Workstation with High Usage During Baseline Period

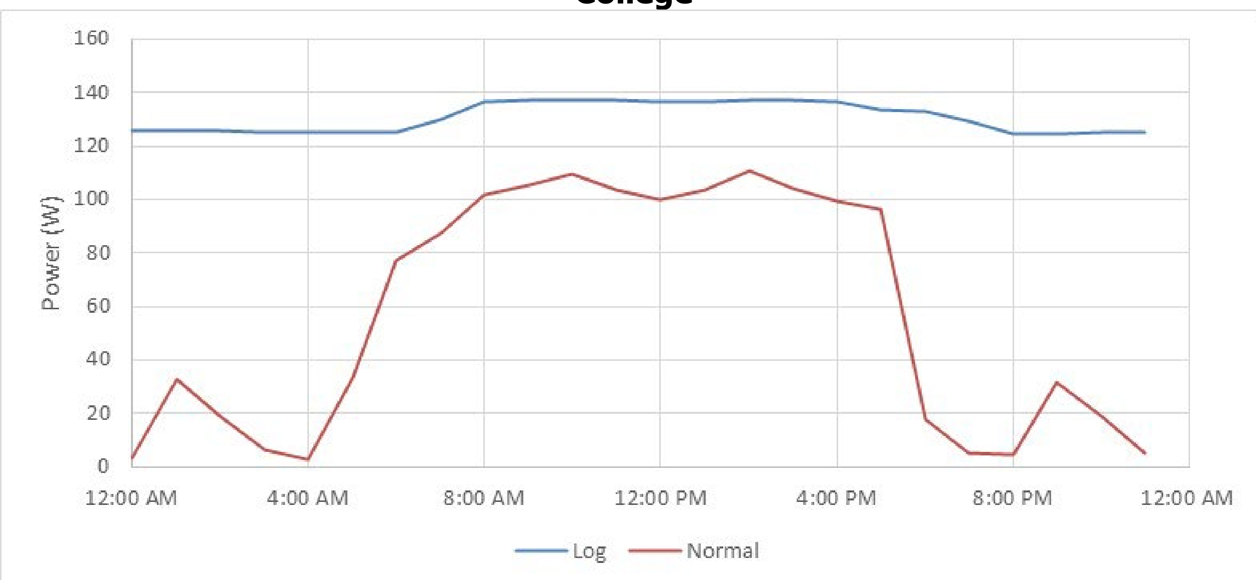


Source: Willdan

Figure 24, shows that the Emberstrip was able to reduce power consumption to almost zero outside of business hours. For this user, typical business hours are from 6 a.m. to 5 p.m. There is a dip in energy use around noon when employees typically take their lunch breaks. There is also an elevated use around 9 p.m. and 1 a.m., that could be attributed to updates or programs that run overnight for this workstation. In the *normal* power mode, the power use during business hours is lower than in *log* mode. Since the normal graph is generated from the average hourly power consumption of all collected data, that reduction can be attributed to the holidays and weekends when the Emberstrip shut down the workstation.

For the example the Emberstrip installation at Chaffey college (Figure 24), showed energy savings and utility bill savings. In many utilities in California, the peak use hours are from 4 p.m. to 9 p.m. Energy costs are typically 2-3 times higher during these hours than other hours. If a college campus installs Emberstrips at these actively used workstations, there would be a large reduction in peak-hour consumption, leading to sizeable utility-bill savings.

Figure 24: Average Power Usage Trends Logged by an Emberstrip at Chaffey College

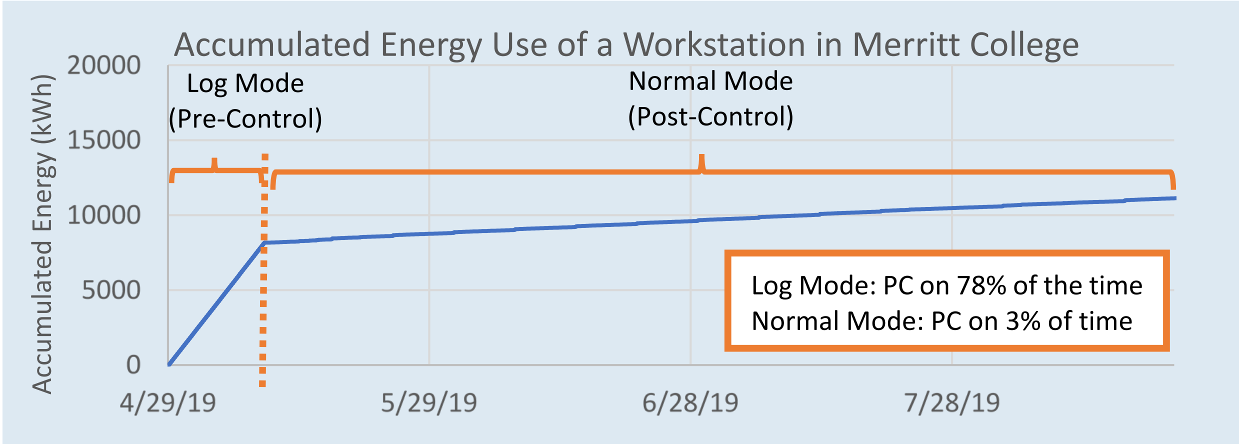


Source: Willdan

The second optimal energy saving scenario is when a workstation either has multiple peripherals or has peripherals with a high peripheral power draw. In this scenario, even if the baseline computer usage is lower, any time the computer goes to sleep, large energy savings are generated by cutting power to peripherals any time a computer goes to sleep.

The accumulated energy measured by a power strip in Merritt College, (Figure 25), indicates the overall effect of the power strip in reducing energy consumption over time. The data displayed represents strip-level information available through the Embertec Partner Portal. Note the decrease in the line's slope in *normal/controlled* mode as the strip consumes less power. For the first two weeks in the *log* mode, 8,160 kWh were consumed. For comparison, 438 kWh were used during the first two weeks at the start of the *normal* mode.

Figure 25: Accumulated Energy Use of One Emberstrip Plotted in Log and Normal Modes



Source: Willdan

Ibis

Willdan also developed an analysis of the Ibis Intellisockets installed at 13 campuses in California (Table 9). At three locations – Cañada College, San Mateo College and Skyline College – an energy savings schedule was implemented on March 26, 2020. This date is after the COVID-19 shelter-in-place order was mandated, so energy-savings results generated by the time this report was written would not have been representative of typical operation. At Los Angeles Southwest College and Peralta Community College district office the Intellisockets were installed close to March 2020. Since the baselining period should be when the devices are in normal operation, the decision was made to delay baselining and schedule implementation at those sites so there is no energy savings data for these five sites.

Table 9: Number of Ibis Units Deployed and Average Savings Per Successfully Operating Unit at Each Campus

Campus[a]	All Units	Successful Units	Online as of May 2020	Average Annual Savings (kWh)
Berkeley	168	158	137	36.63
Cañada	119	– [b]	45	– [b]
Chaffey	76	72	65	78.34
Citrus	124	96	85	48.11
Cypress	472	379	345	81.82
Los Angeles Southwest	172	– [c]	151	– [c]
Merritt	209	176	184	35.80
Mira Costa	170	147	115	17.62
Peralta DO	91	– [c]	73	– [c]
San Elijo	34	13	19	18.60
San Mateo	224	– [b]	206	– [b]
Sierra	119	97	56	61.56
Skyline	213	– [b]	198	– [b]
Systemwide	**2,191**	**1,138**	**1,679**	**50.17**

[a] **A successful unit is defined as one that recorded positive saving over a 23-week period from which the energy saving values were calculated. The 23-week period is taken right after the energy saving schedule is set. It is possible for the number of online units to be fewer than the number of successful units because the Intellisockets might have become unplugged in the months following deployment. Ibis would be the easier pathway to scale up as it does not involve software installation into individual computers. This would replace a plug receptacle. It would not target computers or computer workstation equipment**

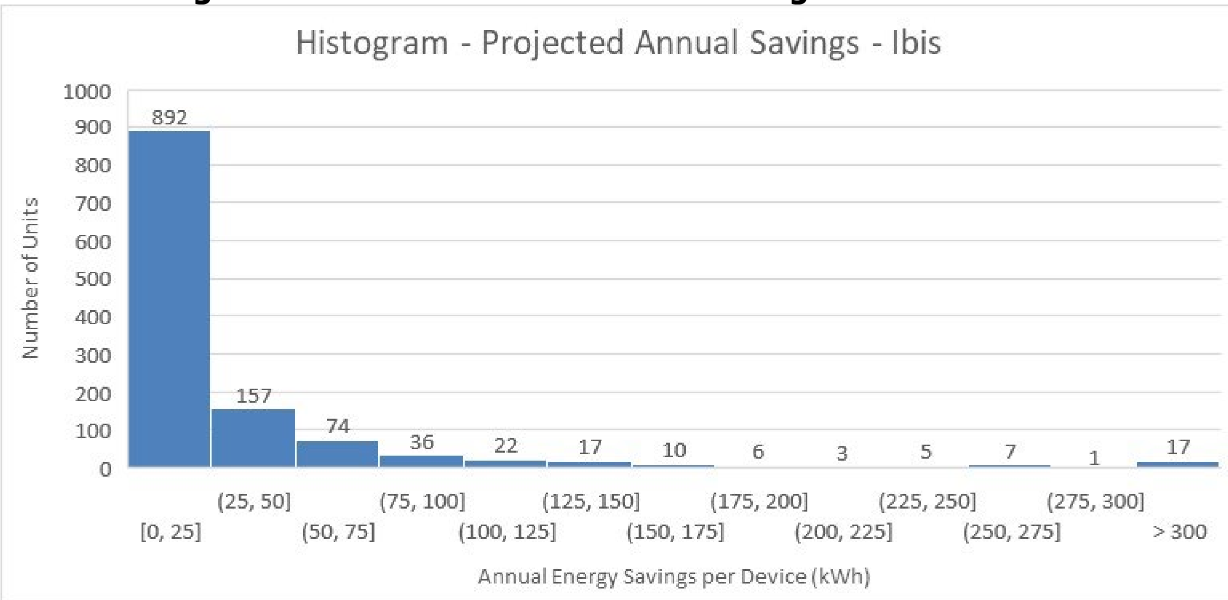
[b] **Energy saving schedule was implemented after shelter-in-place orders were issued. Nonrepresentative data.**

[c] **No energy saving schedule was implemented at this campus at the time of writing.**

Source: Willdan

When considering the data in Figure 26, it should be noted that campuses in this study often schedule their devices very conservatively, as seen in Table 10. Most devices are scheduled to turn off between 9 p.m. and 11 p.m. on weekday nights. Devices are mostly unused from 7 p.m. onwards. Savings from the Ibis devices could be increased by implementing more aggressive schedules.

Figure 26: Distribution of Annual Savings Per Ibis Device



Source: Willdan

Table 10: Ibis Schedules at Sample Colleges

		Cypress	Berkeley	Citrus	Chaffey
Appliances	Weekdays	6AM to 10PM	7AM to 11PM		
	Weekends	8AM to 3PM	7AM to 6PM		
AV	Weekdays	6AM to 10PM	7AM to 11PM	7AM to 9PM	
	Weekends	8AM to 3PM	7AM to 6PM	Off	
Printing	Weekdays	6AM to 10PM	7AM to 11PM	6AM to 10PM	6AM to 11PM
	Weekends	8AM to 3PM	7AM to 6PM	Off	6AM to 4PM
Multimedia	Weekdays	6AM to 10PM			
	Weekends	8AM to 3PM			
Water Dispenser	Weekdays	8AM to 9PM		8AM to 8PM	6AM to 7PM
	Weekends	8AM to 9PM		Off	6AM to 7PM

Source: Willdan

Aside from energy savings, another benefit of mass use of smart sockets is the ability to access energy use patterns by device type. As seen in Figure 27, there is a distinct difference in the baseline use for each appliance type.

Figure 27: Baseline Power and Voltage Measured for Four Device Types

Source: Willdan

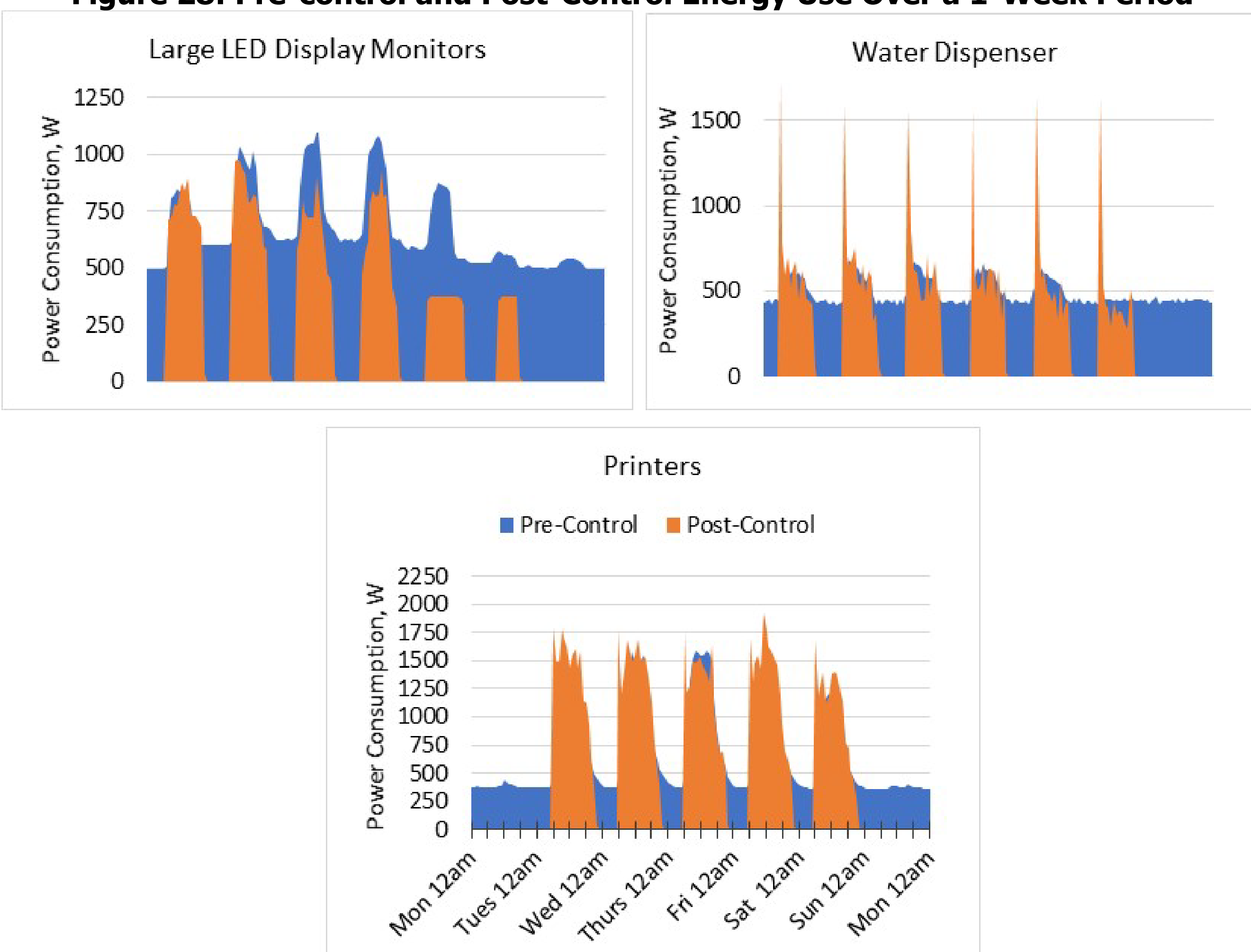
Appliances such as printers, coffee makers and projectors have variable loads. They can idle at lower-power consumption and only use higher power when they are being actively used. As expected, coffee makers have high-use spike at 6 a.m. to 8 a.m. as people arrive at work; there is also a smaller spike again at 1 p.m. to 3 p.m. as people finish their lunch. The post-lunch spike is smaller on Friday afternoons as perhaps more people take Friday afternoons off. Printers are used consistently from 8 a.m. to 5 p.m. on weekdays, with slightly lower use on Fridays. Projectors have high use from 8 a.m. to 1p.m. on all weekdays, and considerable use again from 5 p.m. to 9 p.m. night classes are held. This contrasts with water dispensers, which have a consistent power consumption regardless of the time.

The Ibis website performs its own analysis that calculates savings by comparing baseline energy use to the use under imposed schedules. Since the smart plugs can only turn devices on or off, the savings consider only periods when the devices are scheduled off – reductions in energy use at other times are not due to the smart plug.

Cost savings are then calculated based on the selected utility tariff. Ibis displays estimated annual bill and energy savings. They also display the savings from inception of the project, including emissions, cost, and energy.

LED screens have high savings potential. They are often left on at all hours in public spaces as signage. Ibis devices installed at LED screen frequently save 400-600 kWh per year. Water dispensers also have high savings potential; they are left on at all hours though use is confined mostly to hours when a campus is open (Figure 28). Ibis devices installed at water dispensers on average save 100 kWh per year. Printers are found to have very little savings, potential. Power consumption from 68 printers, adds up to only about 300 watts, compared to roughly 500 watts for 20 LED screens, or nine water dispensers. This means that the Ibis Intellisockets have very limited potential to save energy for printers, especially given that their idle power is so low.

Figure 28: Pre-control and Post-Control Energy Use Over a 1-Week Period

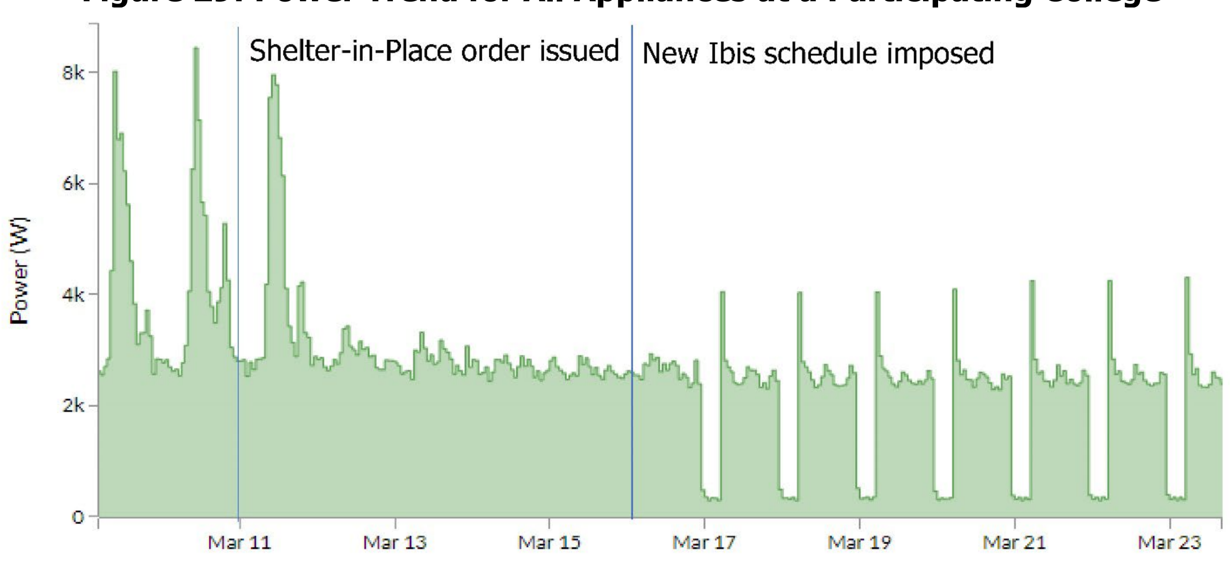


Source: Willdan

Another item to note is the use pattern for water dispensers. During the first few minutes of startup there is 1.5 kW spike in power demand. The demand spike therefore causes demand to be higher than levels before the control was implemented. This is because water cooling has warmed up overnight. This can be easily amended by staging the water dispenser start-up times. Water dispensers can be scheduled for example in groups five minutes apart, which would flatten the demand curve, with little impact on user convenience.

During the COVID-19 shelter-in-place order, additional savings were achieved by turning devices off at participating campuses. A schedule was put in place to shut off most devices from 11 p.m. to 5 a.m. as seen in Figure 29.

Figure 29: Power Trend for All Appliances at a Participating College



Source: Willdan

As shown, the Ibis-controlled devices at this campus reduced energy use from roughly 2,500 watts of baseline energy to 300 Watt. The devices controlled were printers, vending machines, and projectors, and were not expected to be used during mandated shelter-in-place time. With very little effort from the campus staff, significant energy savings were achieved. In fact, this specific campus was essentially closed the whole time, so even more energy could have been saved if plug loads had been switched off the entire time. To avoid user inconvenience, the plug loads were switched back on during work hours.

The bubble size in Figure 30 represents the number of devices were installed. Device types are ranked by decreasing average energy savings from left to right. Devices that are most cost effective to control with APMDs are shown on the left side of the chart. These include vending machines[9], water dispensers and TVs. These devices usually have a higher power draw and are always left on in a business-as-usual environment, providing ample opportunity to save energy. On the other end of the spectrum, a sizable number of Intellisockets were installed at projectors and printers, which had some of the lowest savings. These devices have low savings since they are typically newer devices that switch themselves off when not in use, so the marginal savings from adding an on/off schedule are minimal.

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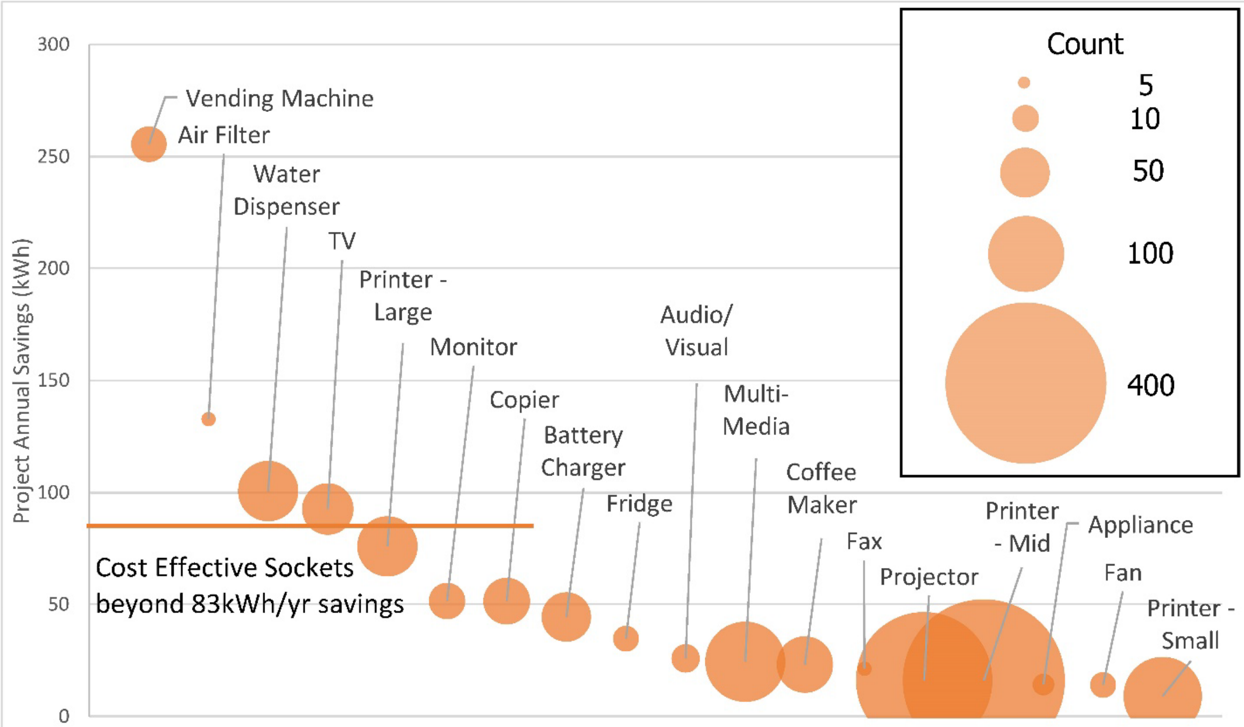
[9] Note that vending machines containing perishable (e.g., dairy, meats) should not be scheduled off using APMDs. However, most vending machines in operation in campus environments contain only non-perishable items.

Figure 30: Ibis Projected Annual Savings Per Device Type



Source: Willdan

These results show that smart socket devices should target vending machines, water dispensers, TVs, and large printers. Air filters could potentially return high savings, but the sample size of three air filters wasn't large enough to draw conclusions.

Stakeholder Feedback

Facilities and Information Technology Staff

Feedback from facilities and IT staff at the participating campus was solicited through online surveys and in-depth e-mail interviews. Of the 35 personnel contacted, roughly 20 percent responded, 67 percent of the participating districts provided feedback.

Data from the online survey indicated that overall end-user satisfaction with the project was mixed. Responses were evenly split between "satisfied" and "somewhat unsatisfied" when asked about satisfaction with the APMD program overall, with one outlier returning a "not at all" satisfied response. Similarly, answers were evenly split between "somewhat likely" and "not likely" when respondents were asked if they would recommend installation of APMDs to other educational facility managers.

Satisfaction with the energy savings features of the technologies rated slightly higher. In terms of ease of use, many respondents indicated that the APMD technologies were either "easy" or "neither easy nor difficult," with an outlying minority (1 in 5) indicating that they were "difficult." Incorporating the APMD technologies into facility and IT operations was rated less favorably, with 3 out of 4 indicating this was "somewhat difficult," and 1 in 4 indicating this was "very difficult."

Online survey respondents also indicated that their satisfaction with the level of energy savings achieved was also evenly split, with half the respondents indicating they were "satisfied" and the other half indicating they were either "somewhat satisfied" or "not at all satisfied." Satisfaction with the ease of accessing and reviewing utilization data for the installed devices was similarly mixed.

In-depth interviews conducted via e-mail provided a greater degree of insight into specific end users' experiences. Takeaways from these interviews included: the following highlights.

- High level of interest exists in technology applications that can accurately identify plug loads and related savings opportunities, including devices that do not need to be running 24/7, devices with high power loads, or devices that are running out of specifications (such as high-amperage draw).
- Challenges identified included working with large devices (which required the assistance of facilities personnel), and signal loss in areas with high voltage devices running.
- Coordination between facilities departments and IT departments was challenging. While IT departments are often responsible for power management, they are not typically concerned with energy savings.
- Specific issues with Embertec included lack of remote reset capabilities and a lack of proper device identification through the Embertec interface.
- No issues with Ibis devices were identified.

Technical Advisory Committee

Willdan held two technical advisory committee (TAC) meetings during this project, one on December 18, 2019, and another on August 28, 2020. In both meetings the committee included representatives from Willdan, CEC, PG&E, CaCC, Electric Power Research Institute (EPRI), California Technical Forum (Cal TF), and some of the community colleges. The TAC committee received guidance on the project's direction, reviewed the products and provided recommendations for future improvements, evaluated the benefits of the devices studied, and provided recommendations to disseminate information to stakeholders and the public. Willdan reviewed the data and preliminary results with TAC members and discussed some of the challenges faced in the project.

At the end of the initial presentation Willdan held an open forum with TAC members. The need for end-user education was brought up to ensure that devices are used to their maximum potential. There was discussion about how this can impact future building and energy codes in the future. Building codes for new construction already require that plugs loads be placed on separate circuits but do not require further controls. TAC members also noted that Ibis devices may be used as asset management tools.

The second TAC meeting was held following the conclusion of the installation and M&V phases of the project and served to disseminate and review the Willdan team's findings, conclusions, and recommendations. The presentation focused on the large and detailed dataset that was compiled over the two years of the study, including detailed load shapes and savings for various controlled plug load device types. The team stressed that the size and scope of the dataset vastly outstrips those of previous studies, and will be an excellent asset for researchers, analysts, vendors and facilities and IT staff at any building.

The presentation also addressed the unanticipated impacts of the COVID pandemic on the study. This included an opportunity to work with the College of San Mateo on implementing an aggressive energy saving mode during shelter in place and turning off devices for extended durations. This allowed the campus to reduce about 75 percent of its energy use.

Coordination with utility program offerings, vendor activities, and technology transfer strategies were discussed to ensure that the project's data and recommendations will be widely disseminated.

The committee's feedback included recommendations to present study data and conclusions to the wider California community colleges audience of facilities officers in northern and southern California at their upcoming quarterly meetings; also discussed was the potential for utilities, in particular PG&E, to cite the data set for the upcoming Title 24 Part VI code cycle. The committee further discussed the potential for integrating data into utility program offerings including upcoming third-party new construction programs as well as smaller "core" programs run by the utilities such as the appliance standards program. The committee recommended the development of a matrix of best practices and ideal technology features to serve as a template for successful deployment strategies.

Following the study's conclusion, installed devices will continue to save energy, and WattIQ and Embertec have committed to continuing to serve the California's community college market. Streamlining their product offerings to simplify deployment will likely to be a critical factor in the future participation of campus facility managers.

CHAPTER 4: Technology/Knowledge/Market Transfer Activities

Website

Willdan has developed a public-facing website to highlight the project's reporting, conclusions, and data analysis. This website hosted by Willdan (http://willdan.com/markets/k12-and-higher-education.aspx), will serve as a public repository of project data and include contact information for the various stakeholders should viewers want further information.

Utility Program Coordination

Integrating APMD applications into energy efficiency program efforts throughout the state represents a significant opportunity. Willdan has reached out on several fronts to ensure that the project's dataset and conclusions are available to energy efficiency program implementers. Energy-efficiency programs are currently in a state of flux given their recent regulatory and contracting requirements, where program design and implementation that has traditionally been performed by the state's IOUs are shifting to third parties. As a result, many programs are in the process of being designed and initiated by third-party implementers, while the utilities' roles and priorities have shifted.

On the utility side, PG&E has committed to incorporating this study's data set into the upcoming Title 24 Part VI code cycle, which includes a nonresidential plug load modeling component[10]. As an energy efficiency program implanter, Willdan is also continuing to work with APMD technology vendors to identify potential opportunities for program integration, including in Los Angeles Department of Water and Power (LADWP) territory where Willdan delivers a direct install energy efficiency program services to small businesses and public sector clients.

Conference Presentations

Willdan presented project findings and recommendations at the California community colleges' Northern California meeting on November 6, 2020, and at the Southern California facilities officers meeting on December 9, 2020. These regional, quarterly meetings are attended by the facilities managers and supporting staff of local community-college districts and represent a key audience for technology transfer. Personnel from districts in each region that participated in the study shared their feedback and discussed lessons learned for the benefit of the non-participating districts in their regions. These presentations addressed the specific opportunities, challenges, and potential benefits of the APMD technologies for California's community colleges.

Market Impact

[10] https://title24stakeholders.com/measures/looking-forward/nonresidential-plug-load-modeling/.

Impacts on Future Uptake

Widespread availability of the project's dataset and conclusions will be the most effective driver of market transformation. The unprecedented scope and detail of the dataset will be useful in assisting facility managers in targeting APMD deployments and for guiding vendors' improvements to product offerings. Willdan anticipates modest gains in the higher-education market based on continued efforts to publicize the technologies' potential and will continue to work with districts following the presentations and outreach efforts.

Participating vendors in this study have also shifted their customer engagement practices and product offerings based on lessons learned from this study. These strategies reflect the attempt to improve their product offerings, better serve their target markets, and increase the overall energy savings impact from APMDs. Embertec's lessons learned include a greater understanding of the importance of reaching key decision makers that are invested in energy savings and improved operations. Ibis Networks' (now WattIQ) noted that the project revealed two key areas of development for the higher-education market. The first is leveraging existing network infrastructure, since equipment is highly distributed on a campus and not all plug loads are good candidates for their APMDs. The second is that installations must be a self-serve model to minimize deployment costs and improve overall return on investment (ROI). Based on the challenges Ibis encountered meeting an acceptable ROI, the vendors shifted their primary solution focus to asset use and condition monitoring using electrical consumption data. However, due to these ROI challenges, Ibis does not currently foresee plug-load management alone as a viable business model. For Ibis, plug-load management is a great secondary offering even though a three-year ROI business model is not yet attractive to investors given current electricity prices.

The potential energy savings from APMD installations across the state's community college system are estimated to be at 3,000,000 kWh/yr. However, further adoption of APMDs in the California community college system beyond the demonstration sites will likely depend on the ability of vendors to deliver streamlined solutions and proactive engagement by college facility managers. Streamlining this process at the CCCs will improve the ROI and potentially make the technology more attractive to campus facility managers. Willdan and the APMD vendors participating in this project are committed to continuing to support APMD deployments at the CCCs.

While there is substantial savings potential from controlling plug loads in the broader higher-education target market as well as in wider commercial and institutional markets, widespread adoption of this technology is likely to be dependent on how well and how quickly vendors can improve their product offerings.

CHAPTER 5: Conclusions and Recommendations

Objectives

As shown in Table 11, Willdan's study achieved the objectives as outlined in Chapter 1. Willdan's findings in relation to these objectives are discussed in detail this chapter.

Table 11: Achievement of Objectives

Objective	Outcome
Identifying and investigating issues with mass deployment of APMDs across multiple customers and sites	Developed approach for multi-building, multi-campus large-scale deployment in higher ed market sector
Achievement of energy savings for California IOU customers included in the study	Delivered 117,000 kWh/yr in energy savings, reducing plug loads by 14.1% for customers spanning all four IOU territories
Comparison of multiple vendor offerings and technology features in the commercial APMD market	Deployed two different APMD technologies and evaluated their performance
Comparison of current study's findings with those of prior studies	Determined that savings potential was roughly in line with prior studies
Evaluation of California Workforce training and employment opportunities associated with deployment of the APMD technology	Successfully trained California Conservation Corps members to deploy APMDs
Investigating energy information system capabilities of APMDs that were not yet developed or addressed in prior studies	Compiled large amount of data from APMD monitoring systems

Source: Willdan

General Deployment Challenges

Coordination Between Interested Parties

The coordination and logistics of the installation of the APMD devices were handled primarily between Willdan and the facilities departments of the community colleges. The facilities department would then act as the project manager within the campus, coordinating with IT and the users receiving the APMDs. The coordination between all interested parties was essential for the success of the project and for buy-in of the technology. Decision-making can be slow in large, complex organizations that go through multiple levels of approvals. This lengthy approval process can adversely affect stakeholder engagement and hinder timely and cost-effective project implementation. There were also instances where the communication between these departments was lacking, leading to misunderstandings and conflicts. Many IT departments, for example, resisted the project unless they were included in the initial conversations between Willdan and the facilities department, so in later installations IT departments were brought into the process earlier; however, the level of involvement for IT departments isn't always clear. In some cases, IT departments may ultimately manage the devices long term, adding to their workload.

Software Coordination

Coordination of software installation and configuration was a major barrier to successful use of APMD systems at the community college sites.

The Embertec Emberstrip 8PC+ system requires that software be installed on the individual PC associated with each workstation. This software installation can be performed at the PC itself or pushed out through a typical network installation using standard Windows network tools. For large deployments like the ones included in this report, the network level installation is required to save time, but requires the support and time commitment of knowledgeable IT staff.

During the evaluation, a few of the sites required Emberstrip 8PC+ units to conduct baseline energy measurements a second time. This was typical because the initial baseline period occurred during a time of atypically low use (such as holiday or other high levels of staff leave). Since the Emberstrip 8PC+ units can only be commanded to run baseline measurements during the software installation process, this meant that IT staff must be re-enlisted to perform a second software installation for these units. This was burdensome on staff's limited availability and was found to significantly slow down successful system deployment. It is recommended that re-establishing future baseline modes for a set period be incorporated into the online Cloud system controls in future iterations.

Generally, IT related issues like software installations or IT related equipment scheduling contributed to significant delays in system deployment due to the inability of IT staff to find time to provide support. The focus of the project was energy savings, and IT departments are generally given incentives for that result. Future approaches should be optimized to minimize the need for IT staff involvement and focus on issues that are more important to them, such as equipment remote monitoring, improved overall uptime, and reduction in service calls.

End User Training

For Ibis and Embertec devices, educating the end users on how to properly use the devices is critical to sustained energy savings.

Embertec strips have specific plug ports for specific devices. If the user does not plug the computer into the proper port the device will not work and may turn off the computer while it is in use. Additionally, the Emberstrip must be connected to the computer via the USB cord. Most installations do not review these requirements with end users which may lead to poor performance and low user satisfaction.

Ibis units do not require as much interaction with the users, but if devices are moved, the Ibis sockets may get lost in the transition. Even if the sockets are kept with the devices if they are moved to an area that is not connected to the mesh they will not function properly.

Challenges Specific to California Community Colleges and California's Higher-Education Sector

Community colleges in California operate under a complex system of governance reaching from the state level down to individual operating departments at local districts and colleges. Implementing energy-efficiency upgrades at community colleges requires an understanding of this system. A summary of this governance system is provided here in the interest of assisting in future energy efficiency project implementations, APMD related and otherwise.

The California community college system is made up of 72 individual college districts, with 116 individual college campuses. Every geographic region of California is covered by one of these community college districts.

Each community college district is governed by a locally elected board of trustees. In addition to trustees elected by the local community, boards include student representatives elected by the colleges' local student bodies.

In combination with leadership provided by the districts' individual local boards of trustees, the Board of Governors (BOG) oversees the statewide community college system. The BOG is responsible for policy and regulations and interactions with state and federal entities; it also appoints the system Chancellor. Individual seats on the BOG are assigned by the governor, district trustees, college faculty, and students.

The Chancellor's Office is the main administrative unit for California's community colleges at the state level. One of its administrative functions is allocation of state funding to the individual districts. State funding contributes to districts' capital and operating budgets, which in turn affects their abilities to implement energy efficiency projects.

The Chancellor's Office also represents the statewide community college system in its interactions with other state agencies, including the California Energy Commission. For this project, the Chancellor's Office endorsed the project at the statewide level.

At the individual district and campus level, each APMD system deployed in the project had to coordinate with financial services, facilities, and IT departments on a case-by-case basis. Any consideration of energy-efficiency projects at California community colleges should also include the input of college faculties. College faculty input into this decision-making process was established through the state's shared-governance law (Assembly Bill 1725 [Author, Chapter, Statutes]).

Table 12 provides an overview of these entities and their responsibilities as they relate to the operation of community colleges and energy-efficiency projects in general, as well as how they affected this APMD project.

Table 12: California Community College Controlling Entities

Entities	General Responsibilities	Interaction with CEC EPIC APMD Project
California Community College Board of Governors (BOG)	• Statewide policy and regulations • Interactions at state and federal Level • Establishes Chancellor	N/A
California Community College Chancellor's Office	• Primary administrative unit at the statewide level • Allocates state funding to districts • Represents statewide system in interactions at state and federal level	Endorsed the project at the statewide level
Local District Boards of Trustees	• Local district planning and policymaking • Determination of district capital and operations budgets, including funding through local taxes and bond measures • Management and control of district property • Assignment of district personnel	N/A
District Financial Services Departments	• District budgets • Purchasing • General business interactions	Coordinated consulting agreements and insurance requirements where required
District Facilities Departments	• Design standards • Construction projects and retrofits • Facilities operations and maintenance	Established MOUs describing campus AMPD system scopes and responsibilities. Coordinated schedules, staging, and other APMD deployment activities. Organized IT Department interactions.
District Information Technology Departments	• Network services and infrastructure • Individual computers and other network connected devices • Technology training	Coordinated network requirements and software deployment of APMD systems. Participated in APMD system operation training.
District Faculty	• Faculty input in community college decision-making is guaranteed through the shared governance process, established through state law AB 1725.	Interactions at campus deployment survey stage and input on suitability of APMD devices in specific locations.

Source: Willdan

CHAPTER 6: Benefits to Ratepayers

Summary and Analysis of Achieved Savings

Energy Consumption Data by Device Type and Observed Device Efficiency Gains

A detailed discussion of the observed energy consumption of non-residential plug load equipment is presented in Chapter 3 of this report. The energy consumption data for typical devices can be compared with a similar study conducted by Stanford University in 2015, as shown in Table 13.

Table 13: Energy Consumption of Typical Non-Residential Plug Load Devices, Current Study versus Stanford 2015 Study

Device Category	Estimated Average Annual Energy Consumption, Uncontrolled (kWh)		Stanford 2015 Study Device Quantity	Comments
	Current Study	Stanford 2015 Study[11]		
Vending Machine	980	2,375	81	
TV / LCD Screen	506 and 287	175	1,734	Current study separated TV and Monitor categories
Refrigerator	419	761	919	
Large Networked Copier/Printer	378 and 344	799	520	Current study separated Copier and Large Printer categories
Water Cooler	292	203 and 221	486 and 79	Stanford study separated Water Cooler/Heater, and Water Cooler/Filter categories
Fan	41	84	1,865	
Air Filter	271			Stanford did not include an Air Filter category
Projector, Overhead Projector	195	175	759	

[11] https://sustainable.stanford.edu/resources/library/plug-load-inventory-white-paper

Device Category	Estimated Average Annual Energy Consumption, Uncontrolled (kWh)		Stanford 2015 Study Device Quantity	Comments
	Current Study	Stanford 2015 Study[11]		
Medium Printer	75			Stanford study did not include a medium printer category
Small Printer	46	111 and 287	2,037 and 3,582	Stanford study separated Small Networked Printer, and Personal Printer
Fax Machine	46	54	378	
Coffee Maker	66	472	1,022	

Source: Willdan

Average energy consumption for almost all categories of typical plug load devices has decreased in the time since the Stanford study was conducted This is the result of plug load devices becoming more efficient overall and incorporating improved reductions in phantom loads during standby operation. Much of this can be credited to programs like Energy Star labeling and the marketplace advantages of comparatively energy efficient devices.

Exceptions can be seen in average plug-load device consumption for audio/visual equipment like TV/LCD screens and projectors. This is likely due to increasing size, resolution, and brightness associated with newer devices of this type which are outpacing efficiency improvements.

The Stanford study was meant to be a comprehensive inventory of all plug-load devices on their campus. Assuming the plug-load device quantities are still accurate, Table 14 shows what the overall impact on campus energy would be if plug-load device efficiency improvements observed under the current study were applied to the devices observed at Stanford in 2015.

Table 14: Estimated Overall Plug Load Device Energy Consumption at Stanford with Efficiency Levels Observed in 2015 and Currently

Estimated Usage in 2015	Estimated Usage with Current Equipment	Estimated Reduction
3,772,000 kWh per year	2,072,000 kWh per year	45%

Source: Willdan

The estimated reduction shown is significant and encouraging for efficiency gains achieved for typical plug load devices. However, this does diminish the savings that can be achieved through external power consumption control of these same devices.

Savings and Ranges Compared with Other Studies

A detailed discussion of APMD savings is presented in Chapter 3 of this report. To summarize, the APMD systems successfully installed in this project yielded an average annual savings of 70 kWh per control unit as shown in Table 15.

Table 15: APMD Savings Evaluation Summary

APMD Device Type	Successfully Operating Units Included in Savings Evaluation	Range of Avg Annual Savings per Campus (kWh per unit)	Systemwide Average Annual Savings (kWh per unit)
Embertech Emberstrip 8PC+	524	42 to 273	114
Ibis Intellisocket	1,138	19 to 82	50
All Units in Savings Evaluation	1,662	19 to 273	70

Source: Willdan

These results can be compared with other similar studies. Other studies have been conducted to evaluate Tier 2 APS savings potential, but many have focused solely on residential applications. Northeast Energy Efficiency Partnership's (NEEP) Report, *APS Tier 2 Case Study, April 2015,*[12] summarizes the scope and results of many of these individual studies. The individual studies summarized in the NEEP report show residential application APMD annual savings ranging from 79 kWh to 386 kWh.

The scope of this project more directly relates to non-residential applications of APMDs. The most relevant evaluations of savings for these types of applications are shown in Table 16.

The savings observed at the APMD systems installed under the current study are within range of the two studies described. Discrepancies are attributed to the following factors:

- The Southern California Edison work paper focuses on Tier 2 APS devices (like the Emberstrip 8PC+) while the PG&E Emerging Technologies Program report focuses on single-socket plug- load controllers (like the Intellisocket). This study includes both types of devices.
- The two evaluations listed observed a lower number of devices (12,199) at a limited number of individual locations compared with the current study's evaluation of savings (1,666 units).
- Typical non-residential plug-load devices are rapidly becoming more efficient overall and during standby modes. This reduces the ability of external plug-load controllers to save energy. The applicability of the SCE 2016 work paper (based on 2012 evaluation data) is probably by this trend.

[12] https://neep.org/aps-tier-2-case-study.

Studies such as San Diego Gas & Electric's Emerging Technologies Program's *Tier 2 Advanced Power Strips in Residential and Commercial Applications, April 2015*, produced savings evaluations for non-residential APMDs in office workstations and computer labs in the range of 336 to 371 kWh/yr per unit. In retrospect these results are out of range with the current study as well as those shown in Table 16. It is assumed that this significant discrepancy is primarily due to the third factor previously listed.

Table 16: Similar Non-Residential APMD Savings Evaluations

Study/Program	Document	Date	Non-residential APMD Unit Savings Established (kWh/yr)	APMD Units Observed	APMD Type Evaluated
Southern California Edison, CPUC	*Workpaper SCE13CS002 Revision 3, Smart Power Strips*[13]	January 25, 2016	163	121[14]	Tier 2 APS
Pacific Gas & Electric Emerging Technologies Program	*ET18PGE8241, Wi-Fi-Connected, Controllable Plug Load Controller Evaluation Report*	July 23, 2019	44	99	Single Socket Plug Load Controllers

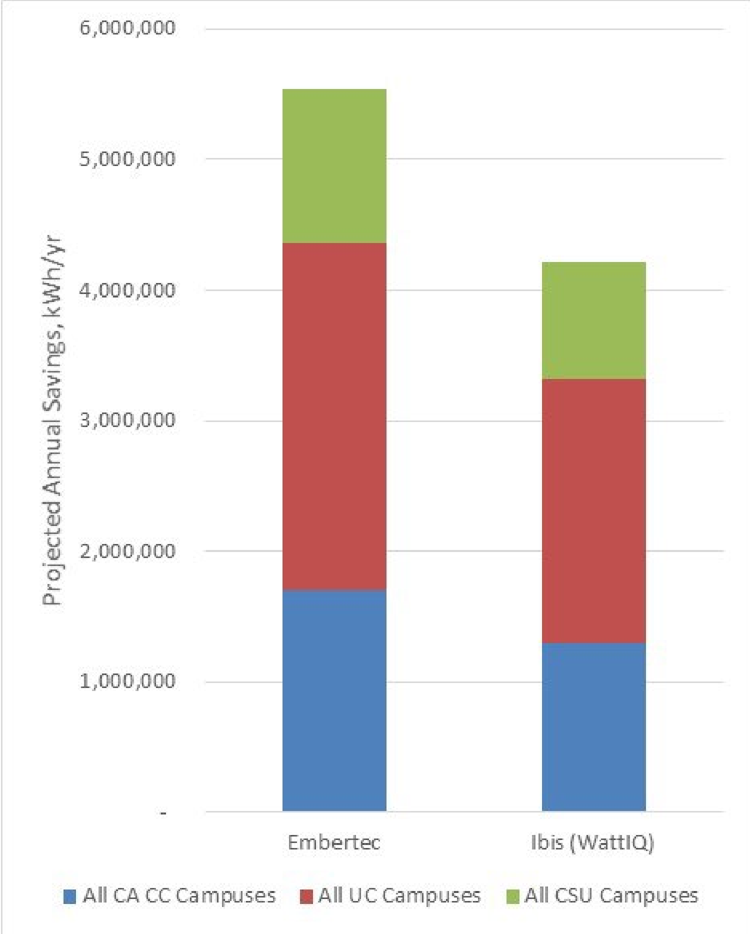
Source: Willdan

This savings data can be extrapolated to develop an estimate for potential savings from statewide deployment of evaluated APMD technologies across the state's higher-education system. Willdan estimates that full market penetration of these technologies would require the installation of 48,500 Emberstrip Units and 84,300 Ibis (WattIQ), saving roughly 9,700,000 kWh/yr, with associated cost savings of $1,940,000/yr (Figure 31).

[13] http://www.deeresources.net/workpapers

[14] Based on observations from prior study, *Office Space Plug Load Profiles and Energy Saving Interventions*, Brad Acker, Carlos Duarte and Kevin Van Den Wymelenberg, University of Idaho, 2012.

Figure 31: Estimated Impact for Total California Public Higher Education Penetration



Source: Willdan

Direct Energy Savings Cost Effectiveness at Time of Study

This project implemented plug-load monitoring and control of 832,500 kWh of annual baseline plug loads across all installation sites. Final data shows that the APMD systems reduced the controlled plug-loads by approximately 14.1 percent, or 117,000 kWh/yr.

As shown in Table 17, when accounting for matching funds and installation costs, the simple payback period (SPB) for installed devices was 4.9 years. Without either matching funds or the installation costs provided by this study, the SPB would be 7.4 years. Keeping installation costs low and streamlining the deployment process will be key factors in making these technologies more cost effective.

Table 17: Cost-Effectiveness

	Total Project Cost	Total Project Cost per Unit	Estimated Annual Savings (kWh)	Average Energy Cost	Estimated Annual Energy Cost Savings	SPB	SPB without installation costs
With matching funds, using $0.20/kWh	$114,535	$68.75	117,000	$0.2000	$23,400	4.9	4.0
Without matching funds, using $0.20/kWh	$193,908	$116.39	117,000	$0.2000	$23,400	8.3	7.4

Source: Willdan

The currently calculated net present value (NPV) of savings to all the districts combined is approximately $185,000, over the expected life of the equipment. This was calculated using current rules for the California's Proposition 39 energy savings program covering rate escalation and does not cover maintenance savings or other non-energy benefits. An Expected Useful Life (EUL) of eight years[15] was used for this analysis.

The overall cost of the successful APMD installations in this project is an estimated $115,000, including materials and labor. This estimate includes the matching funds from vendors involved with the project to buy down unit costs. Without matching funds, the total installation costs would be $194,000 including materials and labor. For sites that can self-install using in-house labor (at no marginal labor cost), these costs could be reduced by an estimated $21,000.

These savings are occurring at installations at 13 sites: Mira Costa College, Mira Costa San Elijo Campus, LA Southwest College, Chaffey College, Cypress College, Citrus College, Merritt College, Peralta District Headquarters, Berkeley City College, Sierra College, Canada College, College of San Mateo (including the College of San Mateo District Office), and Skyline College.

The 20 percent reduction from baseline energy use is comparable to the 43 percent reduction evaluated in the National Renewable Energy Laboratory (NREL) document, *Assessing and Reducing Plug and Process Loads in Office Buildings, 2013*[16]. The greater reduction in energy use from baseline in the National Renewable Energy Laboratory (NREL) study may be from a more comprehensive approach to plug- load management that included many behavioral approaches. These behavioral approaches were outside of the scope of this study, which

[15] DEER READI tool, EUL ID: *Plug-OccSens.*

[16] https://www.nrel.gov/docs/fy13osti/54175.pdf.

focused on the technologies, but they are recommended for anyone considering implementing a plug-load project to improve overall energy performance and cost effectiveness. A few of the NREL study's recommendations were to:

- Establish a plug-load champion.
- Institutionalize plug-load measures.
- Identify occupants' true needs.
- Promote occupant awareness.

Summary of Non-Energy Benefits

The project's primary goals were to evaluate the energy savings and related cost effectiveness of the emerging technologies, to investigate deployment approaches for the APMD systems, and to promote awareness and public acceptance.

In addition to its primary goals, the project achieved additional non-energy benefits that could impact the California community college system and the broader California workforce and are described.

- **California Workforce Development With the California Conservation Corps (CaCC):** The CaCC was established in 1976 and provides young adults 18 to 25 years old a year of on-the-job training and employment on the state's environmental projects. The project team worked with the CaCC staff and leadership to train Corps members in the basics of plug-load technology and the specifics of APMD system installation and operation. In addition to gaining first-hand knowledge of this emerging technology, members also gained valuable experience working with the AMPD vendor companies and staff. The project team conducted multiple training sessions at the CaCC's northern and southern California training centers. At each of the 14 campus installations a crew of 10 to 20 corps members installed the hardware, with support from others involved in the project.
- **COVID response With Cloud-Based APMD System Control at San Mateo Community College District:** The COVID pandemic began during the program, at a point where system deployments had just been completed. Due to this timing, the researchers were able to reach out to districts to offer additional support facilities operators. The Cloud-based plug- load monitoring capabilities allowed the researchers to directly observe plug load consumption reductions at the districts as the campuses emptied of staff and students during the shelter-in-place mandates. Campus representatives were asked if they would like to further reduce their energy loads and reduce device malfunctions by adapting the plug-load scheduling to the pandemic's occupancy patterns. San Mateo District accepted this offer and worked with the project team to shut off roughly 400 plug load devices. This modification was coordinated between the parties remotely, with no face-to-face meeting or site visits. The effectiveness of the scheduling changes was immediately demonstrated in the Cloud-based monitoring platform.

Technology-Specific Findings

Optimal Product Applications

Willdan's conclusions regarding the optimal characteristics of APMD appear in Table 18. This table provides an overview of the characteristics of the APMD technologies deployed in the study, as well as Willdan's conclusions. These characteristics are broken down into the following categories.

- **General Application:** Describes the overall plug unit control strategy. Both technologies used in this study were determined to be appropriate to the types of devices controlled, so either strategy could be integrated into successful deployment.
- **Scheduling Control and Savings Algorithm:** Addresses the different methods employed to control the energy use of connected devices. Embertec's units control device use based on an algorithm, while the Ibis's system is based on active scheduling by system users. The Embertec approach allows the APMDs to begin saving energy immediately after they are configured and enabled in energy-savings mode. Because the schedules are based on workstation user activity the APMDs operate continuously according to their schedules. The Ibis approach requires facilities and IT staff to decide and implement operating schedules once the system is configured. Likewise, any changes to building operation require that the schedules be updated for maximum savings. Embertec's approach to continuously adapt to day-to-day changes in plug-load scheduling (by monitoring PC user behavior) is preferable, but this type of control is appropriate only for smaller desk-based devices. It may not be feasible for the large plug-load devices that are typically controlled by the Ibis units. Both systems incorporate a user override functionality.
- **Hardware and Form Factor:** Describes the physical characteristics of the APMD technologies. Embertec's are like standard power strips, while Ibis's units are like standard wall-socket power units and router/modems. In general, the less obtrusive and less visible the hardware is to the end-user, the better. This increases the physical security of the devices, making them less susceptible to theft, vandalism, or other activities that could render them inoperable. Fewer physical connections (cords) besides plug-load power connections are easier for end-users and installers to manage. New construction applications (which were not within the scope of this study) should consider solutions that are located either behind or within a wall or integrated into a socket.
- **Data Communication:** Describes the method in which the APMDs handle plug-load data from connected devices. Embertec's devices use the Internet connection of connected PCs, while Intellisockets form a Zigbee mesh network that connects back to the Intelligateway(s). Each Intelligateway communicates with the Cloud through a dedicated ethernet connection.
- **System Deployment (hardware and software):** Addresses the steps required to install APMDs and enable their functionality. Embertec and Ibis's units required a combination of hardware installation and software configuration. An optimal scenario would simplify these steps as much as possible.
- **User Interface:** Defines the platform through which users can access data related to APMD functionality. Both technologies in this study employed Web portals for this

purpose, which served as a robust solution. Optimal deployments could also include native smart-phone applications.

- **Data Monitoring:** Describes the type and level of detail of energy use data available to the end-user. Embertec and Ibis provide visualizations of energy consumption and savings data. Willdan has determined that graphic data visualization is best. Powerful data customization tools are useful but need to be balanced so that beginners and power-users can benefit, as well as keep software costs manageable.
- **End-User Interactions:** Defines the type and degree of end-user actions required or enabled for each APMD technology. Embertec units may be interacted with through PC functionality, while the Ibis Intellisockets can be manually overridden by an LED button on the sockets. As in other categories, simple and straightforward functionality is best.

Table 18: Product Comparison and Optimal Applications

APMD System Characteristics	Embertec Emberstrip 8PC+ System	Ibis Intellesocket/ IntelligatewaySystem	Optimal System Features[a]
General Application	• Each unit pairs with PC workstation and associated peripheral devices (up to five per unit) • Example controlled devices: PC monitors, speakers, headsets, personal printers, task lighting, and other desktop devices	• Each unit controls a single plug load device • Example controlled devices: Large shared office printers, water coolers, common area display monitors, vending machines, other large plug load devices	Units that are specifically designed for the different types of plug loads controlled
Scheduling Control / Savings Algorithm	• Algorithm monitors PC usage • Puts PCs in sleep mode and shuts off peripherals' when devices are not in active use • Users opt-out/override enabled through device application	• Web-based user interface enables users to set schedules • User override enabled via button on unit	Straightforward configuration that minimizes engagement from end-users, IT departments and facility personnel
Hardware/Form Factor	• Standard power strip/surge protectors with the USB connection to end-user PC	• Intellisockets cover a typical 120V wall receptacle 100% (two socket units) or 50% (single socket units) • Intelligateways are smaller than a standard router/modem and require an ethernet connection and an external power supply	Minimization of obtrusive hardware and installation in secure and/or non-public spaces
Data Communication	• PC internet connection	• Intelligateway dedicated ethernet connection	Secure data communication protocol that does not interfere with normal facility or IT operations

APMD System Characteristics	Embertec Emberstrip 8PC+ System	Ibis Intellesocket/ IntelligatewaySystem	Optimal System Features[a]
System Deployment (hardware and software)	• Hardware – Connected to end-users' PC workstations and peripherals • Software – installed on end-users' PCs following hardware installation • Following preset "Log Mode" period, software automatically switches units to "Normal Mode"	• Individual Intellisockets are configured using an installation laptop with a dongle attached to allow communication through a Zigbee mesh network • Energy saving schedules are then established through the cloud interface for all devices or groups of devices	Simplified "plug-and-play" approach that minimizes the requirements for IT staff involvement
User Interface	• Web browser	• Web browser	Web browser
Data Monitoring	• Energy consumption and savings data is available through a cloud-based interface	• Full suite of data visualization tools in cloud-based platform	Graphic data visualization that conveys savings and usage information simply and effectively
End-User Interactions	• End-users notified via pop-up window of impending device shut-down following period of inactivity • End-user engaging with devices following a period of inactivity results in all devices powering back on	• Devices are powered up and down based on preset schedules • End-user can manually override schedules and power on devices as desired	Simple, intuitive functionality requiring a minimum of training

[a] Note that the term "Optimal System" is used here with the primary consideration given to maximizing energy savings and operational benefits to Facilities and IT departments and system end-users. Manufacturing feasibility and economics are secondary.

Source: Willdan

Issues Identified

The installation approach employed for this study required a high level of coordination between implementers, vendors, installers, facilities and IT departments' staff, and end-users. The following issues were identified during implementation and provide some guidance on how best to improve the performance of APMDs in the broader marketplace.

Up-front site surveys were required as part of this study to identify suitable opportunities for deployment. A direct-install approach, an approach where contractors install pre-approved technologies commonly used in utility energy efficiency programs, could eliminate this need for up-front surveys. This approach was not appropriate for an emerging technology demonstration project but would offer a more streamlined delivery model in the general marketplace.

Navigating the priorities of campus IT departments also revealed the need for a process that streamlines and minimizes the need for IT staff involvement. IT staffs are generally not provided incentives to consider energy efficiency, so it is often low on their lists of priorities.

A related but distinct issue involving IT departments was the range of technical and software challenges presented by integrating the APMDs into existing operations. Local software installations slowed down the process and prevented IT departments from supporting the project. Individual PC configurations can hinder smooth software installations, and PCs with problems (viruses, Trojan, and other operating system problems) present a potential weak link. In addition, IT staffs were generally wary of wireless devices interfering with the wireless networks they already maintain, even when entirely separate networks were used. However, no ill effects were observed with network interference at any of the demonstration installations.

SYSTEM DEPLOYMENT IMPROVEMENTS INFLUENCED BY DEMONSTRATION PROJECT

The experience gained during this demonstration project led one of the APMD vendors (Ibis Networks dba WattIQ) to develop an alternative, streamlined deployment process to overcome the staff and IT-specific-technology coordination barriers that are described here. The key aspects of the streamlined approach are as follows:

- APMDs (sockets and gateways) are shipped to the site, pre-configured and individually labeled. Labels indicate which plug load devices are to be attached and their locations.
- Pre-configuration and labeling allow site staff to self-install the units, without the need for field configuration via laptop and knowledge of the configuration process.
- Gateways are shipped with cellular hotspot devices to connect to the cloud service, without the need for an ethernet connection to the site's network.

Pre-configured devices and out of the box cloud connection allow for a "plug-and-play" installation. This vendor is currently using this approach for smaller pilot installations. These pilots allow the sites to familiarize themselves with the systems before full adoption and expansion to additional plug load devices, at which time the cloud connection can be transferred to their networks.

The California community college system's shared governance model, which requires end-user and other stakeholder participation in decision-making processes, required considerable outreach and engagement with each of the identified stakeholders gain project buy-in. In many cases, frequent communications with end-users were required to ease deployment concerns. Markets and customers with a more hierarchical decision-making structures are likely to implement projects more efficiently, and with a greater degree of success. End-user concerns about APMDs and their functionality included privacy concerns about the devices' monitoring capabilities, which were addressed by emphasizing that APMDs only monitor energy use, and that normal workplace IT network systems already collect user-activity data far beyond what APMD functions collect.

Maintaining the physical security of the devices was also an issue. The devices are small and easy to move, and many plug-load devices are in areas that are accessible to the public and not closely monitored. These devices could attract vandalism or theft. Physically securing the devices to permanent space fixtures (such as walls, desks) were explored but none were found to be satisfactory (for example too expensive, did not provide adequate security). Effective solutions included limiting installations to areas that are already secure such as private offices or offices that are only open to the public during supervised periods. In cases where devices are deployed in unsupervised public areas (such as lobbies, common areas), locating the plug-load devices in inaccessible locations (like behind large plug load equipment, or otherwise out of human reach) would increase their security. APMD units may be inadvertently moved, which would also affect their operation. This can be overcome by better educating of building occupants of the existence of APMD systems. The project team helped campuses and districts create email communications for this purpose and created informational flyers for display in common areas (Figure 32).

Willdan also identified issues with overall project economics. The overall cost-effectiveness of plug-load control systems has been diminished by energy-efficiency advances elsewhere (most prominently in advancements in the energy consumption of the devices themselves), but also the ability to schedule up-and-down times to maximize energy savings. For example, an older cathode ray tube (CRT) PC workstation monitor consumes an average of roughly 60W, while a current Energy Star rated LCD monitor uses only 7.9W in "on mode" and 0.3W in "sleep. mode"[17]). Similarly, systems that showed a short economic payback five years ago (Chapter 5) now have longer payback periods due in large part to the control of more efficient plug-load devices.

[17] https://www.energystar.gov/productfinder/product/certified-displays/details/2348867.

Figure 32: Sample Informational Flyer

YOUR NEW ENERGY SAVING DEVICE

WHAT?

- Your District is participating in an emerging technology study funded by the California Energy Commission to test advanced plug load control systems.
- Devices and appliances plugged into wall sockets and power strips can use energy **even when they are not turned on or in use.**
- Your new plug load controllers **help to save energy and reduce greenhouse gas emissions** by turning your devices off when they are not in use.

HOW?

IBIS INTELISOCKET

The Ibis InteliSocket allows facility owners to control and optimize plug load device schedules across sites from a central monitoring dashboard. They are typically installed on non-critical devices, which run 24/7 (i.e. vending machines, water dispensers, copiers, and coffee machines).

IMPORTANT INFO:

- System components include InteliSockets (pictured above) and an InteliGateway which handles communication from (and control of) the sockets.
- You can override the schedule by pressing the button on top; scheduling resumes the next day; please inform us if you do this.

EMBERSTRIP 8PC+

The Emberstrip 8PC+ manages the power draw of the PC and peripheral devices based on detection of user activity. A software application running in the background on the PC controls the power saving features of the system. Emberstrip 8PC+ monitors PC activity through wattage draw of the CPU.

IMPORTANT INFO:

- **The device does not collect personal information nor keep a log of what the user is doing.**
- The power saving system is comprised of a smart power strip and a USB cable that plugs into your computer (**do not remove**).
- A pop-up screen will notify you if the PC is “going to sleep”; move the mouse or press any key to keep your PC on (pictured on the right).

SUPPORT

Please direct all questions or comments to plugloadcontrols@willdan.com

Thanks for helping your campus save energy!

WILLDAN

Source: Willdan

Challenges Moving Forward

The greatest challenges to commercially advancing this emerging technology follow.

First, deployment processes must be streamlined and condensed, including all steps from initial plug-load surveys, site coordination, and installation, to final training and hand off. To move past the early-adopter customers, deployment of the systems must be easier and faster from a site's perspective. Direct-install approaches could minimize the need for surveys and extensive site coordination. Deployment innovations by vendors may also play a key role. SaaS (software as a service) and EEaaS (energy efficiency as a service) models could minimize the extent of final training required during hand off. This is currently the preferred model for Ibis. Some institutional customers (like California community colleges) are reluctant to sign up for these types of contracts and prefer to pay up-front for projects. However, these attitudes may change in the future as these types of services become more prevalent.

Secondly, deployments must reduce their dependence on client IT involvement. Reliance on local software should be minimized, with Cloud-based solutions employed wherever possible. In addition, IT departments and other end-users must be reassured that the deployments are secure and will minimally affect existing IT infrastructure.

Third, the overall project economics of APMD deployments must be improved, possibly by reducing implementation costs (including material and software-system cost reductions through manufacturing and development progress and economies of scale) as well as optimizing deployment strategies. Quantifying the benefits of asset management and demand response capabilities through further research and development will also change important perceptions of the technologies' overall cost-effectiveness.

Lastly, the market perception of APMD systems needs to be improved. Prior to this study, the California higher-education market sector had a generally poor perception of the technology as the result of experiences with Tier 1 APS products alone. These perceptions were carried over to current technologies at the beginning of the project. As shown in Chapter 5, there has been some improvement of this previously poor perception because of this project. The details and benefits of successful projects should continue to be disseminated as widely as possible to improve public understanding of the full potential of these technologies.

California Community Colleges

Considering these challenges, Willdan identified several criteria that, when met, increased the likelihood of success for APMD deployments at California's community colleges. These criteria can be used to construct the ideal scenario for deploying the current technology community colleges going forward.

First, the campus should have an engaged energy-sustainability manager or IT department representative or both, preferably who work closely together on shared energy-efficiency goals. Current APMD solutions require that responsible party to engage with the systems to realize full benefits, monitor data to note and adapt to plug-load changes (including strange patterns or units that are offline), and fine-tune schedules. Secondly, the campus should be sophisticated enough to value the non-energy benefits (such as asset management and operations and maintenance improvements). Campuses where energy management is a small subset of facility management staff's work, or where IT departments are overloaded with basic system maintenance tasks, are less likely to successfully deploy current APMD solutions and achieve desired results.

Embertec

Willdan identified the following factors for consideration in improving future deployments of Embertec Emberstrip 8PC+.

- The product's automated energy savings algorithm is its biggest advantage. While the Emberstrip has the capability to manually set up device schedules, the automatic savings feature makes it relatively easy to achieve savings with minimal user engagement.
- Of the two solutions evaluated in this study, the Emberstrip had the lowest cost and highest average savings, but also had fewer features and was the least flexible.
- Emberstrips are best suited to commercial offices with many more uniform PC workstations (standard work routines, and standardized equipment and software packages). In contrast, community college PC workstation areas tend to be more non-uniform in use and layouts. At community colleges, there is a high degree of variability among workstation usage patterns, configuration, and software.
- Allowing the 8PC+ units to communicate directly with the Cloud would be a great improvement and eliminate the need for individual PC software installations.
- Embertec's current cloud data visualization features could be improved, although this would likely increase system costs, as the cloud service is currently free.

Ibis (WattIQ)

Willdan identified the following factors to consider in terms of future deployments of WattIQ's Intellisocket / Intelligateway / Intellinetwork system.

- Watt IQ's powerful Cloud data visualization and control are the product's biggest advantage and can be highly useful for facilities and IT management beyond its capacity for increasing energy efficiency.
- WattIQ's solution is more expensive and more sophisticated than other product offerings. WattIQ currently prefers a SaaS model, which requires a certain level of customer sophistication to deliver full benefits.
- While difficult to develop, incorporating automated savings algorithms would potentially be a big improvement, since it would mitigate the time-consuming challenge of maintaining effective schedules.

Alternative Uses

Demand Response

This capability would result in what is referred to as non-direct energy savings as described in Chapter 6, *Benefits to Ratepayers*. It is recognized that electric demand and electric energy are separate measurements; they are however closely related and typically considered together by electric utilities, including how they contribute to customers utility bills.

California electric utilities currently focus on the time-of-use aspects of energy consumption. Discussing the reasons for this is outside the parameters of this report. This emphasis does lead, however, to the need for customers and utilities to manage the time, duration, and magnitude of peak electric demand.

Although this capability was not pursued in this study, APMD technologies can effectively control demand-response measures.

- Scheduling changes can be sent out quickly to controlled devices. These changes can be made within a 15-minute window that most utilities would consider instantaneous. This does not account for time required for human decision making, which would be the limiting factor in this scenario.
- Automated demand response (ADR) could be implemented by applying programming interfaces (APIs) to the APMD system software. These functions are not currently in the devices included in this study, but the approach seems feasible. Ibis Networks software is already BACnet compatible which would lend itself to integration with an ADR system.
- Critical plug loads could easily be excluded from a demand-response shut off since APMD systems identify and control each device at the individual level. Plug loads that were eligible for demand-response shut off could easily be marked or grouped as such within the software.

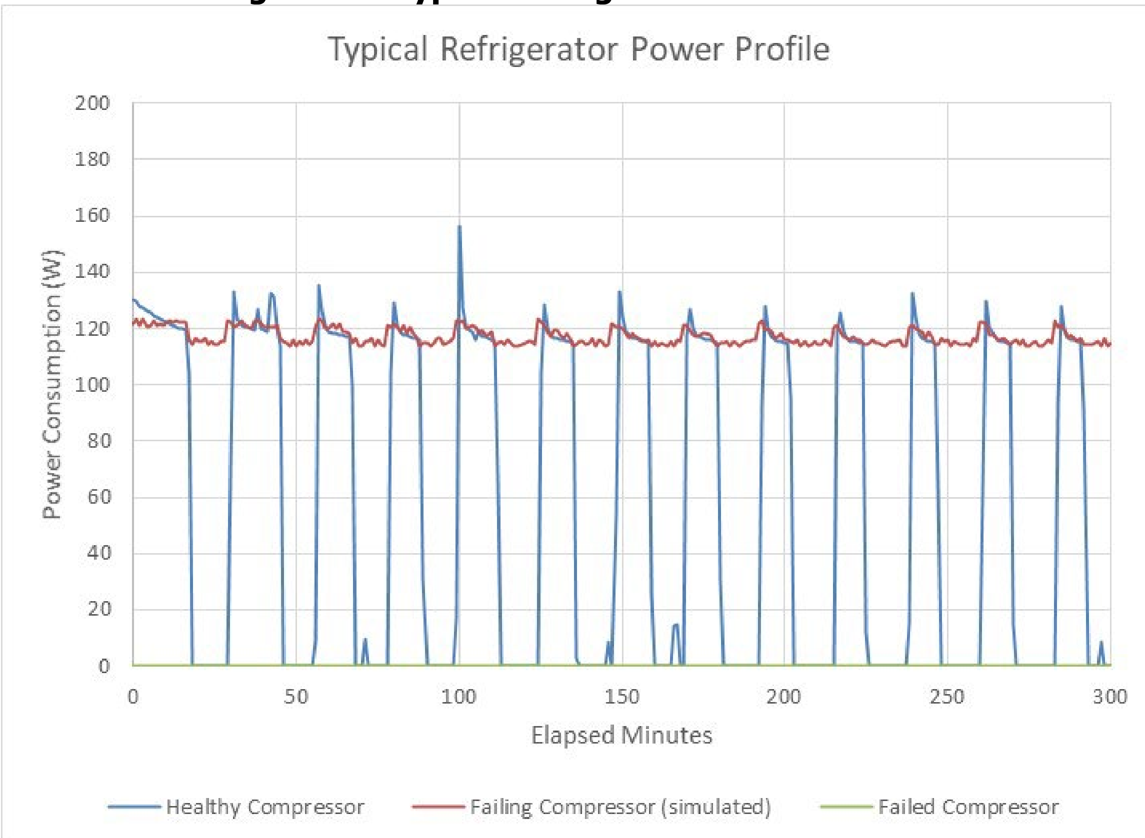
Asset Management

Advanced plug-load management equipment monitoring functions can be leveraged as asset management tools. They can provide intelligence into individual device use along with location and device condition. These functions can also identify equipment that is near failure (preventing unexpected service outages) and reduce energy overconsumption associated with malfunctioning devices. This level of information and organization of plug-load devices can also lead to increased asset sharing across a site, which can lead to energy savings and reduced capital costs from fewer under-used devices.

In an asset management role APMDs can improve efficiency of site maintenance operations. For example, if a maintenance request is submitted for a particular plug-load device, it can be useful for staff to observe the recent power consumption patterns of the device before going out to conduct diagnostics or repairs or both in the field. It could also be useful to know if a malfunctioning device has not consumed power for a given recent duration (as with an overall power outage or other problem with electric infrastructure) or exhibited other nonstandard power consumption patterns (such as non-standard power cycling or changes in power consumption aligning temporally with other known events within in the building). Given this prior knowledge of device operation, maintenance departments could be able to reduce costs, by reducing the frequency and time spent in the field.

As an example of APMDs being used as asset management tools, consider a refrigerator or freezer being monitored by the system. A refrigerator with a properly functioning compressor has a recognizable power consumption profile. Power consumption cycles regularly as it maintains its desired storage temperature. Cycling increases if a refrigerator is frequently opened but will generally maintains this recognizable pattern. As a refrigerator’s compressor fails, it will stop cycling as its cooling capacity is reduced and it is unable to maintain the desired temperature. Eventually, the compressor may fail altogether and stop consuming power. These behaviors are illustrated in Figure 33.

Figure 33: Typical Refrigerator Power Profile



Source: Willdan

The failing refrigerator consumes more power, since it never cycles off, and cannot maintain its cooling temperature, which can lead to food spoilage or to even greater losses for valuable research items such like sensitive laboratory samples that require constant refrigeration.

As an example of increased asset sharing, consider printers in a typical office environment. In the individual department offices at community colleges, the project team observed a wide variety of printers during plug load surveys. Individual staff offices all had personal printers. At the same time, large, networked printers were in the common areas of the same offices or otherwise nearby. Through monitoring these printers and their use with the APMD systems, facilities and IT departments can encourage individual departments to consolidate their printing requirements to a smaller number of centralized printer devices; this would reduce overall energy use, by reducing the standby loads of the many small devices, since larger printers tend to be more energy efficient. Similar situations were observed with personal mini refrigerators located in individual offices where larger shared refrigerators were in nearby kitchenettes. Facilities staffs could make the case for device consolidation with comprehensive energy-consumption data provided by the APMDs. Consolidation and sharing of these types of devices also reduces the operational carrying costs of the under-used assets.

COVID-19 and Emergency Shutdowns

COVID-19 is demonstrated how remotely controlling building systems can benefit to facility and IT operators. In California and the Western US in particular, the recent prevalence of emergency evacuations of large areas due to wildfires also demonstrates this benefit.

The APMD systems studied under this project lend themselves to the remote-control benefits of plug-load devices. This study coincided with the pandemic-related shutdowns of community college campuses across California. Because of this coincidence, the research team was able to explore these capabilities at multiple San Mateo community college campuses. The results of the evaluation are further discussed in Chapter 2.

LIST OF ACRONYMS

Term	Definition
ADR	Automated demand response
API	Application programming interface
APMD	Advanced plug load management device
APS	Advanced power strips
BACnet	Communication protocol for Building Automation and Control networks that leverage the ASHRAE, ANSI, and ISO 16484-5 standard protocol
BOG	Board of Governors
CaCC	California Conservation Corps
Cal TF	California Technical Forum
CCC	California Community College
CEC	California Energy Commission
CO2	Carbon dioxide
COVID-19	Coronavirus
CPUC	California Public Utilities Commission
CRT	Cathode ray tube
EEaaS	Energy efficiency as a service
EIA	Energy Information Administration
EPIC	Electric Program Investment Charge
EPRI	Electric Power Research Institute
EUI	Energy use intensity
EUL	Expected useful life
IOT	Internet of Things
IOU	Investor-owned utility
IPMVP	International Performance Measurement and Verification Protocol
IT	Information Technology
kWh	Kilowatt-hour
LCD	Liquid crystal display
LED	Light emitting diode

Term	Definition
M&V	Measurement and verification
MOU	Memorandum of Understanding
MW	Megawatt
NEEP	Northeast Energy Efficiency Partnership
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
PC	Personal computer
PG&E	Pacific Gas & Electric
PSA	Professional Services Agreement
ROI	Return on Investment
SaaS	Software as a service
SB	Senate Bill
SCE	Southern California Edison
TAC	Technical Advisory Committee
th	Therm
Title 24 Part VI	California Building Code
UL	Underwriter Laboratories
USB	Universal serial bus

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APPENDICES

Appendix A: Product Specifications and Appendix B: Project Tools and Templates are available under separate cover (Publication Number CEC-500-2021-XXX-APA-B) by contacting Felix Villanueva at Felix.Villanueva@energy.ca.gov.