Codes and Standards Enhancement (CASE) Initiative

National Model Building Codes Technical and Advocacy Support

Automatic Controlled Receptacles – National Data Collection

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SURVEY FINDINGS

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

This report was prepared by the California Statewide Codes and Standards Enhancement (CASE) Program that is funded, in part, by California utility customers under the auspices of the California Public Utilities Commission.

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1. Background

Both ASHRAE/IES 90.1-2016 (Section 8.4.3) and Title 24, Part 6 (Section 130.5(d)) include requirements for automatic controlled receptacles. There are discussions underway regarding potential updates to both requirements. On the national level, some stakeholders have expressed concern about the ability to comply with the ASHRAE/IES 90.1 requirements.

The ASHRAE/IES 90.1 lighting subcommittee was tasked with exploring these concerns and determining if the requirements need to be modified to make it easier for builders to comply, potentially by providing an alternative compliance pathway.

In California, the California Energy Alliance (CEA) is considering submitting a code change proposal to the California Energy Commission that would modify the Title 24, Part 6 requirements for the 2022 code cycle, which may result in an expansion of the existing requirements for controlled receptacles.

Energy Solutions was asked to conduct stakeholder outreach and collect perspectives to help inform decisions to potentially modify requirements for controlled receptacles. The goal of this information gathering exercise was to understand the market's experience with and barriers to implementing automatic controlled receptacles.

Since the initial development of this report in October 2019, the International Code Council (ICC) approved new provisions for automatic controlled receptacles for the 2021 International Energy Conservation Code (IECC), with will align IECC and ASHRAE/IES. It is important to note this change as the misalignment was a recurring topic in conversations with survey participants and addressed in Section 3.9.2.

2. Approach and Methodology

Information was gathered predominantly through stakeholder interviews. The following groups of stakeholders were contacted:

- Controlled Receptacle Manufacturers
- Designers
- Sales Representatives
- Facilities Managers
- Modular Furniture Manufacturers

2.1 Survey Design

Participants were asked to participate in an anonymous survey to provide information that would be used to inform future code change proposals. They were asked to provide background on their experience and familiarity with automatic controlled receptacles and to answer a series of open-ended questions on:

- Product availability
- Market trends
- Current design practices
- User acceptance
- Technical feasibility of meeting and exceed code minimum requirements
- Market barriers to meeting and exceed code minimum requirements

- Applications for applying controlled receptacles beyond minimum code requirements
- Energy savings

Some questions were tailored for specific stakeholder groups. Interviews were conducted in a conversational setting and participants were encouraged to recount firsthand experiences and their honest opinions. The complete questionnaire is included in Appendix A: Data Collection Form.

2.2 Stakeholder Outreach

Potential participants were identified by leveraging industry connections through the ASHRAE/IES 90.1 lighting subcommittee and previous code change work and by contacting individuals within organizations whose mission offered access to relevant perspectives.

The research team contacted 147 individuals by email. Follow up emails and phone calls were made to individuals that were personally referred to the research team or who responded to initial email outreach. Of the twenty-two individuals that responded, sixteen agreed to be interviewed and fourteen successfully completed the survey.

With the exception of one respondent that opted to provide written responses, individuals completed the survey by participating in a phone interview during that typically lasted forty-five to fifty minutes. The interviews were not recorded. Participants were provided with written notes taken during the interview and allowed to provide clarifications and edits.

Table 1: Summary of Outreach Results

Stakeholder Group	Contacted	Responded	Interviewed
Controlled Receptacle Manufacturer	15	3	2
Designers	14	8	7
Sales Representatives	6	3	1
Facilities Managers	109	6	2
Modular Furniture Manufacturer	3	2	2
Technology End Users Contractors / Builders	Not contacted		
Total:	147	22	14

A brief description of each stakeholder group is provided below.

2.2.1 Not Contacted: Technology End Users and Contractors / Builders

Technology End Users and Contractors / Builders represent two stakeholder perspectives that the research team identified during the study but did not successfully capture.

Technology end users are individuals, namely building occupants in newly constructed or renovated office spaces, that interact with controlled receptacles daily. The research team believed that facilities managers represented the best chance of identifying and connecting with occupants of buildings where controlled receptacles are installed. For this reason, significant effort was made to reach facilities managers. In addition, survey participants were asked to help reach this stakeholder group at the end of each interview. The facility managers and participants that declined requests for referral to end uses did so for the following reasons, listed in order of frequency:

1. They did not believe end users had any awareness of the technology.

2. They were involved in project planning and did not have any connection to the building owner or occupants.
3. They had a company policy against sending surveys to their sites.

The research team determined that the effort required to effectively locate and recruit these individuals by researching electrical permits and cold calling was not within the scope of this project.

Recommendations discussed later in this memo include a more comprehensive data collection effort to understand the end user experience.

Builders / Contractors work with designers, manufacturers, and building owners to execute specified building plans. It was initially assumed that contractors do not deviate from written specifications based on designers' interpretations of the code requirements. Therefore, outreach to this group was prioritized less than other groups. However, later responses call this assumption into question and indicate that the role of builders / contractors in interpreting code requirements may be more influential than initially thought. Recommendations discussed later in this memo include outreach to this stakeholder group and research on variations in code interpretation between local jurisdictions.

2.2.2 Controlled Receptacle Manufacturers

Controlled Receptacle Manufacturers refer to organizations that design, produce, and distribute controlled receptacles. These consist primarily of wired or wireless solutions that are powered on or off depending on occupancy or schedule. Major manufacturers include:

- Acuity
- Hubbell
- Lutron
- Legrand / WattStopper
- Leviton
- Eaton
- Enerlites
- Gordon Electric
- General Electric / Daintree
- Wavelength

2.2.3 Designers

Designers refer to building systems designers who may be part of larger architecture, engineering, or facilities management firms. These individuals primarily deal with controlled receptacles at the project conception and planning phase. They are often electrical or mechanical engineers and may focus more on system design, code compliance, or energy / sustainability. The individuals included in this survey represented a broad range of organizations, including:

- Small to mid-size engineering firms
- Large, global architecture design firms
- A small sustainability practice
- A large, global facilities management firm

2.2.4 Sales Representatives

Lighting Sales Representatives provide technical sales support to contractors and lighting designers, normally within a defined geographic region, and represent specific technology manufacturers. They are often designers who consult on technical specifications and code compliance.

2.2.5 Facilities Managers

Facilities Managers are building engineers and maintenance staff responsible for maintaining installed equipment. Extra effort was made to reach this group of individuals in hopes of contacting end users and to better understand the challenges of managing controlled receptacle technology, including common complaints from building occupants and owners. Providers of these services include:

- CBRE
- Cushman & Wakefield
- Prologis
- Colliers International
- BMS Building Maintenance Service
- The General Services Administration (GSA)

2.2.6 Modular Furniture Manufacturers

Early feedback from Designers indicated that working with modular furniture providers to accommodate controlled receptacle specifications in open plan offices added a layer of additional work to projects. The research team decided to include modular furniture manufacturers in outreach efforts in order to understand the market and potential barriers to incorporating controlled receptacles in modular solutions.

Major manufactures include:

- Herman Miller
- Steelcase
- Knoll
- HON

2.2.7 Researchers

When it became clear that respondents were not able to answer the key question: "What devices do people typically favor or avoid plugging into controlled receptacles?" the research team reached out to plug load researchers to ask if previous studies sought to answer this question. The research team conducted informal interviews with individuals at the California Plug Load Research Center (CALPlug) and the National Renewable Energy Laboratory (NREL) Commercial Buildings Research Group.

3. Survey Findings

The goal of this survey is to understand the barriers to meeting or exceeding minimum code requirements for controlled receptacles. The survey was initiated in response to industry stakeholder concern that the current requirements were already too difficult to comply with and that additional stringency would create insurmountable barriers.

3.1 Cost

Respondents did not cite cost as a barrier to code compliance. However, several respondents noted that cost was the primary motivation for bypassing code requirements and for organized efforts by contractors and designers to roll back existing controlled receptacle requirements. Several respondents confirmed that code compliance results in additional equipment and installation costs and that these costs are high enough to prevent building owners from complying with them in projects.

- "(An) owner would not do it voluntarily. Cost is the driver. It's requiring a lot of a building owner in terms of first construction cost."

- "Owners are not interested in implementing additional code features because they represent additional cost and they don't see a reasonable payback. They want a payback of 2 years. "
- "Within the receptacle, you have to bring in 4 wires instead of 3 which would be more costly."
- "If no one (i.e., the building inspector) is going to check it, it's not worth the cost. Perception that it takes more time/effort, can be difficult to convince installers that it's worth it."
- "Contractors are choosing not to install plug load controls in retrofits – the engineer may specify, but contractors choose not to do the install to reduce equipment cost. Justify by calling the payback into question."
- "Costs have come down, but because of the initial high cost in 2013 (when the requirements were first introduced), people are still avoiding them. It's difficult to prove payback."

3.2 Product Availability

Respondents did not cite product availability as a barrier to code compliance. There were no respondents who felt that code compliant technologies were unavailable. Most designers expressed a preference for a particular type of controlled receptacle solutions, but those preferences varied with hardwired occupancy-based solutions being the most common, wifi-enabled occupancy-based solutions having a few strong proponents, and one individual advocating for schedule-based controlled receptacles. None of the respondents had heard of integrating controlled receptacles with alarm or security systems nor felt that it was a viable concept.

One designer pointed out that open offices are becoming more the norm and that modular furniture manufacturers do not offer out-of-the-box solutions for controlled receptacles. However, one modular furniture manufacturer surveyed has offered an integrated solution since 2015, in which the controls (circuit controls, controlled receptacles, and occupancy sensor) are contained entirely within the furniture. The manufacturer stated that none had been sold because it "has no return on investment, (it) costs $3000 and the occupancy sensor is $900."

3.3 Technical Feasibility

Respondents did not cite technical feasibility as a barrier to code compliance.

Respondents noted that additional wiring and coordination increases the level of effort necessary on projects with controlled receptacles; however, they did not view this as an insurmountable barrier. Groups that require additional project communication / coordination include:

- Building owner representatives who want to understand the increased equipment cost.
- Interior designers who want to reduce the number of receptacles for aesthetic purposes.
- Modular furniture manufacturers who need to ensure the products ordered include room for extra wiring.

When asked "Are there applications or types of building spaces where it is not technically feasible to install controlled receptacles?" respondents offered edge cases, but generally agreed that controlled

receptacles are feasible in most building spaces where safety was not an issue[1]. As one designer summarized: "(There are) some unique applications that might not make sense, but they're not technically infeasible." Applications that respondents cited include:

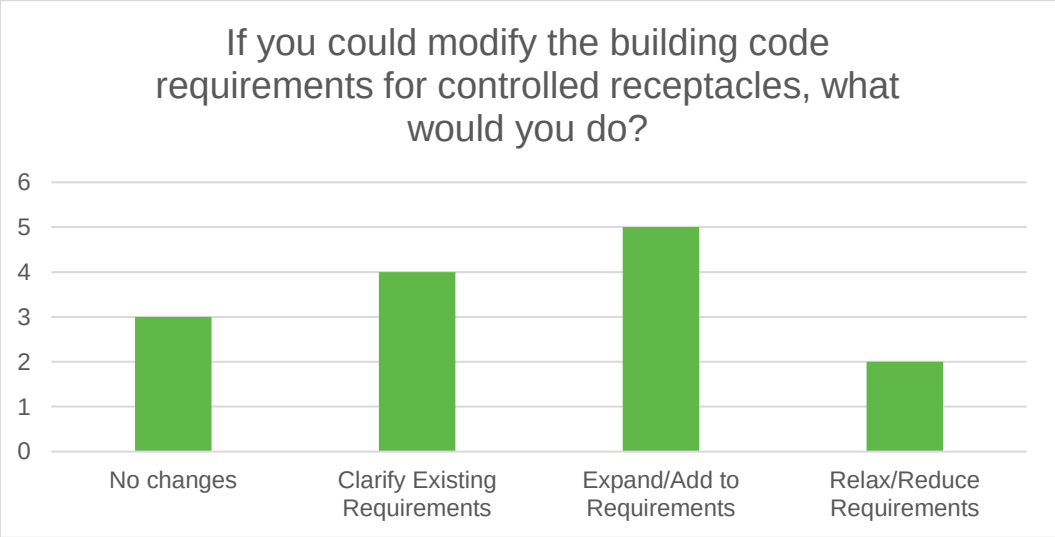
- Some spaces within healthcare facilities.
    - "Operating room, anywhere where safety is an issue."
- Research spaces in universities.
    - "A lot of lab buildings… have huge plug loads, so there is a big push to make those plugs controlled, but there is pushback because there is sensitive equipment that needs to be run all the time. Labs are ~50% office space. Concept sounds good but application has issues."
- Spaces with intermittent or continuous usage.
    - "Anything where you don't have a regular group of people coming in and out every day: labs, courthouses, churches."
    - "Anything that runs 24/7, like a call center, you don't want to touch it. Same issues for trading centers because when people show up to work a few seconds is worth money to them, so they don't want to shut things off."
    - "Depends on who is using the office space. Like a call center or trading floor that works on a 24/7 schedule.
    - "Anything with potential loss of goods (refrigerators)."
- Industrial spaces with standby equipment.
    - "Manufacturing (except for the offices), data centers, warehouses"
- One designer noted, "Some remodels. If they're not planning to touch the walls or outlets in a remodel (it) doesn't make sense."
- One designer noted, "You would have said that (it was unfeasible in) open offices 5-years ago but now it's fine. Furniture vendors have put themselves ahead of the curve and have wired the systems to work properly and integrate occupancy sensors."

[1] Exceptions to Section 8.4.2, part 2 exempts "*Spaces* where an *automatic control* would endanger the safety or security of the room or *building* occupants."

3.4 Recommended Code Changes

Most respondents offered some code change recommendation. Answers to this open-ended question can be roughly categorized into the four areas below.

Table 2: Summary of Responses - Code Changes



Stakeholder Group	No changes	Clarify Existing Requirements	Expand/Add to Requirements	Relax/Reduce Requirements
Controlled Receptacle Manufacturer			2	
Designer	1	3	1	2
Sales Rep			1	
Facilities Manager	1		1	
Modular Furniture Manufacturer	1	1		
Total	**3**	**4**	**5**	**2**

3.4.1 Clarify Existing Requirements

Most respondents did not feel that code requirement language was unclear or difficult to interpret. However, a few respondents pointed to potential confusion when jurisdictions have different interpretations of where the requirements are applicable. Related feedback regarding Overlapping Jurisdictions is discussed later in this document.

- A design consultant that works on projects across the country explained, "Jurisdiction varies, it's not always clear where it applies. When the code first came out it applied to all projects. In 2016 it was only applicable when there were changes to the building electrical. What does that mean exactly? In 90.1 there are no statements to that effect."
- A technical sales representative that primarily works where 2016 ASHRAE/IES 90.1 applies suggested that code writers "define when it's NOT applicable, rather than letting interpretation dictate what the exceptions are."

Several respondents also pointed to potential clarification for the number of minimum required receptacles.

- Potential conflict with electrical codes: "Align with electrical code for the number of receptacles; do not try to dictate the number of receptacles in the energy code."
- Exemptions for small projects: "Would try to figure out a minimum acceptable number of receptacles that you can exempt in small projects. Because installing only one receptacle creates enough additional costs that it won't pay for itself."
- Need for guidance for complying with the 50% minimum: "As written, it's vague and confusing. What if you have an odd number of receptacles? The onus is on the electrical designer, but the code isn't very clear for the ones complying (contractor) or reviewing (building inspector)."

One respondent said that more guidance on which receptacles should be controlled could increase confidence in savings:

- "More specifications on which receptacles and their use. For example, a switched receptacle that is rarely used isn't getting much savings."

3.4.2 Expand or Add to Existing Requirements

Most of the respondents that recommended expanding or adding to the existing requirements called for compliance enforcement.

- "Compliance enforcement. There's no standardized penalty."
- "A method for enforcement. Include it in the lighting compliance test - everyone has a lighting system. Otherwise, I don't see (controlled receptacle installation) happening. "
- "Certificate of occupancy should require occupant education on … compliant systems."

In addition, one respondent recommended expanding the requirements to include controlled receptacles to include existing building alterations.

3.4.3 Relax or Reduce Existing Requirements

A few respondents advocated for relaxing or walking back the existing requirements:

- One designer whose main exposure to the requirement was through LEED said, "There should be a tradeoff, it should be an optional strategy. You should be able to make it up by doing something else (that saves energy)."
- Another designer working mostly in a jurisdiction that is stricter than ASHRAE/IES 90.1 expressed frustration with the technology and questioned its effectiveness: "(The) code is ridiculous. Owners say they're never going to use this (and) we're installing a bunch more controls and circuiting where ninety percent of people are not using them."

3.5 Overlapping Jurisdictions

Several respondents indicated that jurisdictions where both ASHRAE/IES and IECC apply do not install controlled receptacles.

- "Controlled receptacles seem to be one of the only areas where the two codes differ."
- A respondent explained: "Projects start with the question: what codes are applicable? Some are IECC only. Sometimes ASHRAE supersedes, (for example) if there's mechanical. For example, Houston recognizes both – sometimes there is a clear cost reason to use ASHRAE**.** *If IECC is the only requirement, they're unlikely to adopt ASHRAE.* Or if there are exceptions. For example, Michigan is ASHRAE, but auto-controlled receptacles are not required.

- Another respondent working nationally said that they don't specify controlled receptacles often because "it's seen as an inconvenience and cost-adder." When asked to attempt to quantify the ratio of controlled to uncontrolled receptacle projects they said "Eighty percent use IECC, in twenty percent the client will tolerate (controlled receptacles)"
- A respondent noted that local jurisdictions implement the controlled receptacle requirements differently. They cited San Francisco, where code enforcement officials define a remodel as any building space with an existing electrical panel. As a result, newly constructed spaces with new sets of outlets are not subject to new construction requirements if they use existing electrical panels.
- A respondent cited New York as an example of a local jurisdiction that chose to exempt the controlled receptacle requirement when adopting 2016 ASHRAE/IES 90.1.

As noted previously, since the initial development of this report, the ICC approved automatic controlled receptacle requirements for the next version of IECC, which will align IECC with ASHRAE/IES and help to alleviate confusion regarding competing jurisdictions.

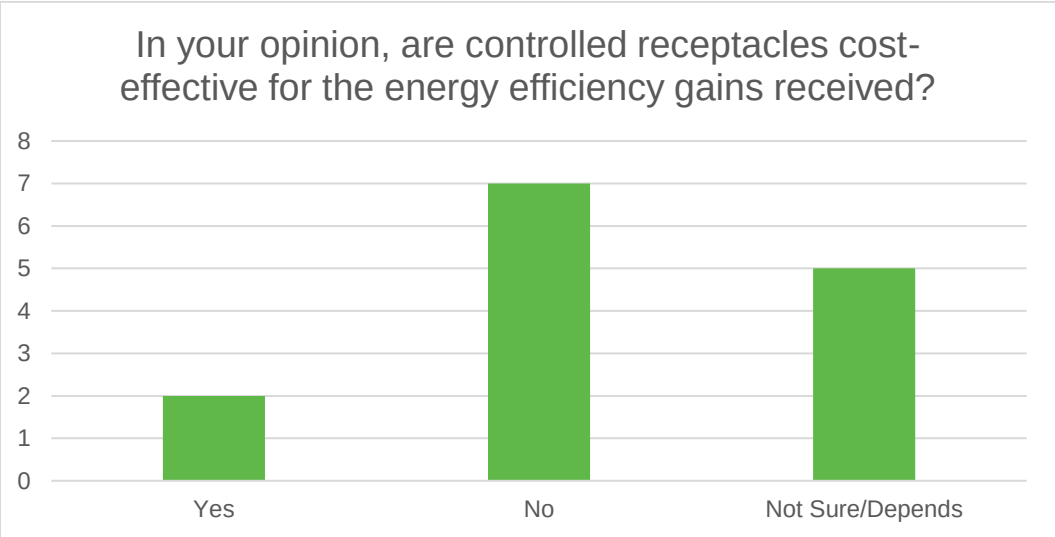
3.6 Perceived Value

Respondents said that a lack of perceived value was the primary barrier for and source of pushback against controlled receptacle requirements. Across the spectrum, both self-described supporters and detractors of the technology pointed to the difficulty in demonstrating cost and energy savings and the lack of usage by end users as primary factors in the technology's failure.

3.6.1 Cost Effectiveness

The majority of respondents did not believe or were not sure that controlled receptacles were cost-effective for the energy efficiency gain received.

Table 3: Summary of Responses - Cost Effectiveness



Stakeholder Group	Yes	No	Not Sure / Depends
Controlled Receptacle Manufacturer	1		1
Designer	1	3	3
Sales Representative		1	
Facilities Managers		2	
Modular Furniture Manufacturer		1	1
Total	**2**	**7**	**5**

"Yes" respondents cited personal experience and pre/post-installation analyses that are not common practice for most projects.

- "Based on my experience, they are efficient."
- "Yes. In installed project data (pre/post projects), we can see that they pay for themselves in under a year. Occupant interaction is where they become not effective."

Most "No" and "Not Sure" respondents qualified their responses by pointing out that the difficulty measuring savings and the uncertainty around end user behavior lower confidence in savings estimates.

- "You need a name plate rating, how much are things charging, how much energy is used, and then you have to do a value proposition (to determine cost effectiveness). Unless you have numbers on how much things run, it's hard to determine the payback time. Typically, the payback is not that great."
- "Energy savings are never seen on the utility side where a building manager would see payback on their utility bill."
- "This is a really complicated energy conservation measure that does not have good payback. Maybe in aggregate it saves some energy, but not at any given end point. And you have a lot of tenant impact. If things are not turning on it gets people really unhappy."
- "No – They're difficult to use properly or to know if they're being used properly, (for example,) if switched receptacles are mostly used for the vacuum."

- "No, but they could be (if they were used). … I've never seen anybody use (them)."

3.6.2 Real or Perceived Lack of Information and Transparency

Another smaller contingent voiced their lack of confidence in existing studies, which they felt were biased, missing important information, or outdated.

- "I am personally very skeptical that if someone did a more thorough case study, from an unbiased organization, not just one building with a bunch of space heaters, I would be surprised if they found energy savings."
- "Most devices have sleep mode already, so how much savings are the receptacles saving? "

3.7 Building Occupant Acceptance

Several attempts were made to reach building occupants via facility managers, building operators, and project engineers. This proved to be a very difficult perspective to capture for two reasons:

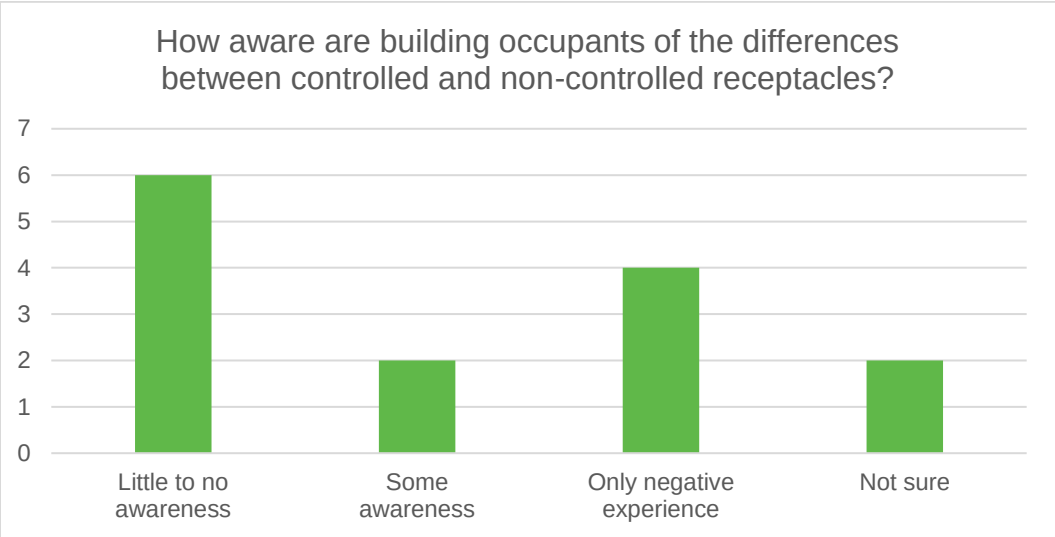
1) Stakeholders are protective of their customers' time and reluctant to be a burden, particularly to ask questions about a technology they believe customers have little awareness of.
2) The general public has very little awareness of the technology. When building occupants did respond, they rarely recognized the technology being referred to.

When outreach for interviews failed, the research team reviewed or assessed studies with commercial end use information at the plug level. Reviewing the literature and reaching out to NREL and CALPlug uncovered several advanced power strip studies containing relevant information, which is discussed in section 3.8 Other Data Sources.

3.7.1 Building Occupant Awareness

Nearly all respondents expressed a belief that most building occupants had very little awareness of controlled receptacles. Two respondents pointed to a few very sustainably-oriented companies that were aware of plug load controls. Several respondents said that building occupants only became aware of controlled receptacles through negative encounters, such as failing to have mobile phone charging, or a desktop computer update overnight.

Table 4: Summary of Responses - Building Occupant Awareness



Stakeholder Group	Little to no awareness	Some awareness	Only negative awareness	Not sure
Controlled Receptacle Manuf.	1			1
Designer	4	1	2	
Sales Rep		1		
Facilities Manager			2	
Modular Furniture Manuf.	1			1
Total	6	2	4	2

3.7.2 End-Use Technologies

When asked, "What devices do people typically favor or avoid plugging into controlled receptacles?" few of the respondents were able to confidently provide answers. The most commonly mentioned "favored devices" were computer monitors. Less common devices were task lighting, AV equipment in conference rooms, and coffee makers in kitchens. However, these responses were mostly speculative and had not been personally observed by respondents.

A few respondents pointed out that power strips have become common in office spaces and the staff at CALPlug reported observing power strips plugged into controlled receptacles during an advanced power strip study (see section 3.7.3 Confusing or Inconsistent User Interface Design).

The most common response was that end users actively avoid the controlled receptacles altogether. Several respondents mentioned that IT equipment requiring or required for remote updates, such as desktop computers, routers, phones, and printers, would be avoided.

All respondents noted the impact that end-use technologies would have on attributable savings and the lack of visibility into this variable:

- "In an office study, I think it was a 40k square foot office, they clamped an average office workstation for a couple days and found the type of monitor and printer makes a big difference."
- "We need good data on current, up-to-date technologies in work spaces to understand the savings. We need this info to begin educating people."

3.7.3 Confusing or Inconsistent User Interface Design

Several respondents expressed a need for more end user education in order to increase usage and mitigate negative first impressions that would cause future avoidance.

- "Customers are not aware… They have a little information on the base of a panel, but there is typically no indication on the receptacle itself."

A researcher at CALPlug pointed to the lack of information available to guide end users as well as the prevalence of confusing or inconsistent user interface designs. They observed that if discerning controlled from uncontrolled receptacles was a difficult task for professional plug load researchers, it must be even more difficult for the general public, who are generally unaware of the technology's existence. To illustrate, the following images were provided by CALPlug. These were collected during preparation for an advanced power strip study.

Figure 1: Example of a controlled outlet ("two dots plus odd symbol in middle")

Figure 2: Similar version in same building ("four dots")

Figure 3: Example of a controlled outlet ("power icon")

3.8 Other Data Sources

Failing to gather information from respondents about what plug load technologies are being used with controlled receptacles, the research team sought out existing studies that could provide insight. We found that most comprehensive plug load surveys, such as the Commercial End-Use Survey (CEUS), are over ten years old. Other plug load surveys are more recent, but do not disaggregate plug load technologies or otherwise distinguish controllable and uncontrollable plug loads.

The research team could not locate any recent in-building studies specifically on controlled receptacles. A handful of studies have been done on plug load use and reduction strategies that may have relevant information current plug technologies and building occupant behavior.

A 2016 plug load reduction study[i] commissioned by the Minnesota Department of Commerce found that building occupants reported higher levels of satisfaction with plug load reduction strategies that were

transparent, and that they could control. In the study, participants were given one of four plug load reduction strategies:

1. A schedule-controlled advanced power strip (APS) that occupants could also power down using a foot pedal.
2. The same schedule-controlled APS and foot pedal, plus a behavior change program.
3. An occupancy-controlled APS.
4. A computer power management software system.

The advanced power strip with the foot pedal received the highest levels of participant satisfaction. "Specific respondent comments suggest that participants preferred the foot pedal because it let them … decide when they would shut things down, rather than relying on an automated or timed shut down (CPM and APS with occupancy sensor) which might shut down equipment prematurely, interrupting their productivity, or not soon enough." Although controlled receptacles were not one of the included strategies, this suggests that one barrier to building occupant acceptance may be the lack of transparency and control.

The study also included a baseline plug load survey of eight Minnesota offices which showed that:

- The average workstation used 332 kWh per year. Slightly over half consumed by the computer (laptop or desktop) and the remainder by monitors, electronics, and peripherals.
- Common area equipment used similar amounts of energy as did each workstation, from 67 kWh per year for televisions to 352 kWh for medium-sized multi-function devices (MFDs), to 548 kWh for coffeemakers.
- Server closets can use energy "on a similar order of magnitude to the workstations," but with greater variability between buildings.
- Modern high-performance office buildings tend to have a total building plug load usage of between 5 – 15kBtu/sqft (including kitchen equipment, etc.). As much as fifty-five percent of energy usage in some buildings.

A 2014 advanced power strip study by NREL was conducted in an 18,818 square foot Department of Defense building[ii] and also included the following plug load survey:

Plug Load	Count
Monitors	129
Phones and Accessories	95
Audio	91
Miscellaneous	51
Hard Drives	46
Desktop Computers	43
Printers/Copiers/Scanners	37
Laptops	35
AC Units (plug in)	32
Docking Stations	32
Task Lights	31
Fans	20
Pencil Sharpeners	17
Microwaves	11
Clocks	6
Refrigerators	5
Coffee Machines	4
Drinking Fountains	2
Vending Machines	2
Total	**689**

Figure 4: 2014 NREL Plug Load Survey.

A 2012 study conducted by NREL on plug load control and behavior change[iii] included the following plug-load inventory of eight office buildings located in the Mid-Atlantic Region (Pennsylvania, New Jersey, Maryland, and Virginia).

Edward A. Garmatz U.S. Courthouse		Cohen Complex		Clarkson S. Fisher Federal Building and U.S. Courthouse		Veteran Administration Building	
Laptop	7	Laptop	10	Laptop	4	Laptop	9
Monitor	8	Monitor	11	Monitor	3	Monitor	10
Printer	4	Printer	4	Printer	3	Printer	5
Undercabinet Light	4	Undercabinet Light	10	Undercabinet Light	4	Undercabinet Light	3
Coffee Maker	2	Desktop	1	Paper Shredder	1	Stereo Speakers	2
Fax Machine	1	Desktop Fan	1	Stereo Speakers	2	Electric Stapler	1
Desktop Fan	2	Stereo Speakers	3	Radio	1	Radio	1
Pencil Sharpener	1	Electric Stapler	1			Wireless Mouse	1
Fax Machine	1	Radio	1			Cell Phone Charger	1
Clock	1	Other Peripheral	1				
Plotter	1						
Water Cooler	1						
Video/Teleconference	2						
Total Devices	**35**	**Total Devices**	**43**	**Total Devices**	**18**	**Total Devices**	**33**
William J. Green Jr. Federal Building		**Robinson & Merhige Courthouse**		**William S. Moorhead Federal Building**		**Robert C. Byrd Federal Building and U.S. Courthouse**	
Laptop	8	Laptop	9	Laptop	9	Laptop	10
Monitor	15	Monitor	10	Monitor	14	Monitor	15
Printer	2	Printer	9	Printer	5	Printer	5
Undercabinet Light	10	Undercabinet Light	4	Undercabinet Light	3	Undercabinet Light	5
Desktop	1	Desktop	1	Space Heater	3	Electric Stapler	1
Desktop Fan	1	Plotter	1	Radio	1	Space Heater	1
Space Heater	2	Stereo Speakers	4	Stereo Speakers	2	Paper Shredder	1
Coffee Maker	2	Walkie Talkie	1	Paper Shredder	1		
Cell Phone Charger	1	Pencil Sharpener	1	Electric Stapler	3		
Other Peripheral	1	Calculator	1	Electric Typewriter	1		
		Cell Phone Charger	1				
		Other Peripheral	1				
Total Devices	**43**	**Total Devices**	**43**	**Total Devices**	**42**	**Total Devices**	**38**

Figure 5: 2012 NREL plug load survey.

3.9 Recommended Next Steps

In this section, the research team has attempted to summarize areas worthy of further study and exploration, based on the feedback and recommendations of the individuals we spoke with.

3.9.1 Code Language

- Address potential confusion with existing code language by providing a formal interpretation of how to interpret the "at least 50%" requirement (ASHRAE/IES 90.1 2019 8.4.2a), particularly in small alterations or when there are an odd number of existing receptacles.
- Increase confidence in savings by developing compliance enforcement strategies, for example:
    - Guidance to help code enforcement officials better recognize and value properly installed controlled receptacles.
    - Add automatic receptacle control functional testing requirements to ensure installation and operation as intended.
    - Review guidance provided in the ASHRAE/IES User Manual.
- Increase potential savings and help prevent inconsistent application of the code, as in the example of San Francisco cited on section 3.5 Overlapping Jurisdictions, by expanding the requirements to include additions or alterations.

3.9.2 Code Alignment

There is an opportunity for IECC and ASHRAE/IES to align controlled receptacle requirements and ensure more consistent application of the codes. Leverage ongoing collaboration efforts to ensure savings are not exclusive to jurisdictions or project teams that choose one code over the other.

3.9.3 The Role of Contractors and Builders

Several respondents indicated that contractors remove or negotiate out controlled receptacles from final building plans. Additional data collection is needed to understand the motivation for and extent to which this is occurring.

3.9.4 End User Experience

Every respondent in the survey agreed that the efficacy of controlled receptacles relies completely on usage; however, there is limited understanding of the end user experience, even among researchers and technology experts on plug loads. Consider partnership or advocacy opportunities to create focus groups that answer:

- How aware are building occupants of controlled receptacles, their purpose, how to use them, and their benefits?
- What are building occupants impressions or opinions of controlled receptacles? How much of a lasting impact do negative first experiences have on future behavior?
- How are building occupants using controlled and non-controlled receptacles? What are the associated energy savings? Are there design choices that manufacturers and designers can make to improve usability?

3.9.5 Savings Uncertainty

In addition to a lack of specific controlled receptacle user experience studies, most plug load surveys are over ten years old and limited to narrow geographic regions. Meanwhile, technologies and usage habits continue to rapidly evolve. Steps can be taken to help technology stakeholders feel more confident in controlled receptacle savings:

- Support or commission updated plug load assumptions that distinguish controllable and non-controllable load.
- Broadcast the use of cost-effectiveness calculations based on “unbiased” third party studies and measurements taken from real-world scenarios.

3.9.6 Education

Several respondents advocated for more education to address the disconnect between potential and realized energy savings. Leverage educational resources within ASHRAE/IES and its partner groups, such as the National Electrical Manufacturers Association (NEMA), the Building Owners and Managers Association (BOMA), and the National Electrical Contractors Association (NECA), to develop educational strategies and materials for:

- Building compliance officials.
- Key building management groups, namely building maintenance and IT staff, who are most likely to receive calls when building occupants struggle with controlled receptacles.
- Building occupants / technology end users.

Appendix A: Data Collection Form

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Data Collection to Inform Energy Code Requirements for Controlled Receptacles

STAKEHOLDER OUTREACH

Prepared by: Energy Solutions | May 2019

Interviewer notes: *[Background info on the interviewee goes here (e.g. location, title, background, etc.)]*

1. Introduction

[note for reviewers: Energy Solutions will use this content when reaching out to people to interview so they have information about the effort and can make decisions about participating. We will reiterate this information at the beginning of interviews]

Thank you for your time.

The California Statewide Utility Codes and Standards Team is supporting a data collection effort on controlled receptacle application and use as well as to comply with some national model energy codes. Energy Solutions is conducting the outreach on behalf of the Statewide Utility Codes and Standards Team. We are gathering information on:

- Product availability
- Market trends
- Current design practices
- User acceptance
- Technical feasibility of meeting and exceed code minimum requirements
- Market barriers to meeting and exceed code minimum requirements
- Applications for applying controlled receptacles beyond minimum code requirements
- Energy savings

We are reaching out to the following groups of stakeholders:

- Manufacturer
- Distributors
- Designers
- Builders
- Building managers / occupants

Information we collect will be anonymized and compiled into a report that will be made available to energy efficiency code teams.

Would you be willing to participate in this important (anonymous?) survey? It should take no longer than 45 minutes.

2. Survey Questions

2.1 Background

1. Can you tell us a little bit about your background with controlled receptacles?
2. Where are you located and where are the projects you work on located?
    a. Are controlled receptacles mandated by code in these areas?

2.2 Product Availability

The questions in this section will be tailored based on the market actor.

2.2.1 Manufacturers

1. We have reviewed the controlled receptacles products that are available on your website. Are we looking at the full list of available products, or are their other products that we should be aware of that are not posted?
2. What are the major differences between your controlled receptacle products?
3. How are controlled receptacles programmed out of the box?
    a. What are the default schedules?
    b. What are default settings for occupancy sensor controls (time unoccupied before shut-off)?
4. Do you offer products that can communicate with the building alarm system or the energy management control system?
5. What percentage of receptacles sales are controllable receptacles?
6. Where are controlled receptacles being purchases?
7. What are customers typically looking for in a controlled receptacle?
8. Can you explain the typical supply chain between you, the manufacturer, and the builder (specialty distributor, direct from manufacturer)?

2.2.2 Distributors

1. Which controlled receptacle products do you distribute?
2. What are the major differences between the controlled receptacle products you distribute?
3. Do you typically discuss the default control strategies with contractors (scheduling, occupancy sensing, ability to communicate with building control system or alarm system)?
4. What is your market territory for your products, and do you distribute controlled receptacles throughout your territories?
5. Can you explain the typical supply chain between a manufacturer and the user (specialty distributor, direct from manufacturer)?
6. What percentage of receptacles sold are controllable?
7. Where are controlled receptacles being purchased?
8. What are your customers typically looking for in a controlled receptacle?

2.2.3 Designers

1. In which geographic regions does your company operate?
2. What is your role in the building design process (electrical engineer, controls specialist, architect, project manager)?
3. Do building codes require controlled receptacles in any regions where you operate?
4. How often do you specify or have owner requests for controlled receptacles in buildings where they are not required by code?
5. What receptacle control products are you able to find that meet your needs? Roughly how many manufacturers would you say offer receptacle control products?
6. When developing specifications, do you tend to request any specific features for the controlled receptacles?

2.2.4 Builders

1. In which geographic regions does your company operate?
2. Do building codes require controlled receptacles in any regions where you operate?
3. Do you install controlled receptacles in buildings where they are not required by code?
4. How often do you encounter building projects where controlled receptacles are specified/required?
5. What receptacle control products are you able to find that meet your needs? Roughly how many manufacturers would you say offer receptacle control products?
6. How are receptacles sourced for projects?
7. How are receptacles purchased/installed?

2.2.5 Building Occupants / Managers

1. In which geographic regions does your company operate?
2. Do building codes require controlled receptacles in any regions where you operate?

3. Do you purchase or direct your maintenance staff to purchase controlled receptacles for buildings where they are not required by code?
4. Do you commission or program the controlled receptacles installed in your buildings?

Market Trends

1. How aware are customers of the differences between controlled/non-controlled receptacles?
2. How do you expect the size of the market for controlled receptacles to change in the future?
3. What is driving changes in the market for controlled receptacles?
4. Are controlled receptacles being installed more, less, or about same today as five years ago?
5. Some building codes require controlled receptacles in newly constructed building spaces such as offices, breakrooms, classroom, print/copy room, and in workstation furniture. Have you seen controlled receptacles used in other building areas?
    a. If yes, which type of areas?
    b. Are you seeing controlled receptacles installed in tenant improvements / alterations?
6. Which control strategies are most common today (scheduling, occupancy sensors, control through building management control system or alarm system)?

Current Design Practices

1. Are specifications for design receptacles included in building plans?
    a. If yes, please describe what information you provide/are being provided and the level of detail.
    b. How much do specifications vary between buildings where controlled receptacles are required and ones where they are not required?
2. Who are the specifications intended for (e.g. contractor, building inspector)?
3. Is it more difficult to design a building with controlled receptacles than one without?
    a. If yes, please describe the primary challenges and associated costs (e.g. time, money).
4. What factors determine controlled receptacle placement?
5. What percentage of receptacles are controlled vs non-controlled in:
    a. Designs
    b. Practice
6. What are the benefits/drawbacks of controlled vs. non-controlled receptacles for:
    a. Designers
    b. Installers
    c. Building Occupants
7. Are there any design considerations to ensure occupancy sensors used in conjunction with controlled receptacles sense occupancy correctly?

Building Occupant Acceptance

1. How aware are building occupants of the differences between controlled and non-controlled receptacles?
2. What are some common questions from people who are plugging devices into controlled receptacles?
3. What devices do people typically favor or avoid plugging into controlled receptacles?
4. Do building occupants use controlled receptacles as intended? How do we know?
5. Occupant education: Is there any occupant education happening? Who provides it? How much education is needed before people understand how to use controlled receptacles effectively?
6. Is it common for building occupants to override or circumvent the use of controlled receptacles?
7. How common is it for people to request control strategies that differ from the default strategies?
8. How difficult is it to operate or make changes to controlled receptacles controls?

Technical Feasibility

1. What are some common challenges associated with designing, installing, commissioning and using controlled receptacles?
2. Are there applications or types of building spaces where it is not technically feasible to install controlled receptacles?
3. Do controlled receptacles require additional programming / commissioning, or can they just be installed and work as intended?
4. How often do you experience technical challenges associated with the use of controlled receptacles?
5. In your opinion are controlled receptacles cost effective for the energy efficiency gains received?

Code Compliance and Recommended Code Changes

1. Have you heard of people experiencing challenges complying with the code?
    a. How would you categorize these challenges (e.g., availability of product, technical feasibility, design challenges, cost, other)?
2. Have you personally experienced challenges in complying with the code?
    a. Please describe if different from above.
3. If you could modify the building code requirements for controlled receptacles, what would you do?
    a. Make sure to leave time for this question. Leave at least 5 minutes.

3. Conclusion

Notes for concluding portion of interview. Leave 5 minutes for this portion of the call.

1. Thank you for your time.
2. Any other comments that we have not covered already?
3. For manufacturers and distributors: Would you be willing to put us in contact with designers, builders, or building managers who have experience working with controlled receptacles?
4. Thank you again for your time.

Send a follow-up email to thank interviewee.

4. Excerpts of Code Language Pertaining to Controlled Receptacles

4.1 ASHRAE/IES 90.1-2016

8.4.2 Automatic Receptacle Control

The following shall be automatically controlled:

a. At least 50% of all 125 V, 15 and 20 amp receptacles in all private offices, conference rooms, rooms used primarily for printing and/or copying functions, break rooms, classrooms, and individual workstations.
b. At least 25% of *branch circuit* feeders installed for modular furniture not shown on the *construction documents*.

This *control* shall function on

a. a scheduled basis using a time-of-day operated *control device* that turns receptacles off at specific programmed times—an independent program schedule shall be provided for controlled areas of no more than 5000 ft^2 and not more than one *floor* (the occupant shall be able to manually override the *control device* for up to two hours);
b. an *occupant sensor* that shall turn receptacles off within 20 minutes of all occupants leaving a *space*; or
c. an automated signal from another *control* or alarm *system* that shall turn receptacles off within 20 minutes after determining that the area is unoccupied.

All controlled receptacles shall be permanently marked to visually differentiate them from uncontrolled receptacles and are to be uniformly distributed throughout the *space*. Plug-in devices shall not be used to comply with Section 8.4.2.

Exceptions to Section 8.4.2

Receptacles for the following shall not require an *automatic control device*:

1. Receptacles specifically designated for *equipment* requiring continuous operation (24/day, 365 days/year).
2. *Spaces* where an *automatic control* would endanger the safety or security of the room or *building* occupants.

4.2 California Energy Code

SECTION 130.5 –ELECTRICAL POWER DISTRIBUTION SYSTEMS

Nonresidential, high-rise residential and hotel/motel buildings shall comply with the applicable requirements of Sections 130.5(a) through 130.5(e).

(d) **Circuit Controls for 120-Volt Receptacles and Controlled Receptacles**. In all buildings, both controlled and uncontrolled 120 volt receptacles shall be provided in office areas, lobbies, conference rooms, kitchen areas in office spaces, and copy rooms. Additionally, hotel/motel guest rooms shall comply with Section 130.5(d)4. Controlled receptacles shall meet the following requirements, as applicable:

1. Install a control capable of automatically shutting OFF the controlled receptacles when the space is typically unoccupied, either at the receptacle or circuit level. When an automatic time switch control is installed it shall incorporate an override control that allows the controlled receptacle to remain ON for no more than 2 hours when an override is initiated and an automatic holiday "shut-OFF" feature that turns OFF all loads for at least 24 hours and then resumes the normally scheduled operation. Countdown timer switches shall not be used to comply with the automatic time switch control requirements; and
2. Install at least one controlled receptacle within 6 feet from each uncontrolled receptacle, or install a splitwired receptacle with at least one controlled and one uncontrolled receptacle. Where receptacles are installed in modular furniture in open office areas, at least one controlled receptacle shall be installed at each workstation; and
3. Provide a permanent and durable marking for controlled receptacles or circuits to differentiate them from uncontrolled receptacles or circuits; and
4. For hotel and motel guest rooms, install controlled receptacles for at least one-half of the 120-volt receptacles in each guestroom. Electric circuits serving controlled receptacles in guestrooms shall have captive card key controls, occupancy sensing controls, or automatic controls so the power is switched off no longer than 30 minutes after the guestroom has been vacated.

NOTE: A hardwired power strip controlled by an occupant sensing control may be used to comply with Section 130.5(d). Plug-in strips and other plug-in devices shall not be used to comply with the requirements of this Section.

EXCEPTION 1 to Section 130.5(d): Receptacles that are only for the following purposes:

i. Receptacles specifically for refrigerators and water dispensers in kitchen areas.

ii. Receptacles located a minimum of six feet above the floor that are specifically for clocks.

iii. Receptacles for network copiers, fax machines, A/V and data equipment other than personal computers in copy rooms.

iv. Receptacles on circuits rated more than 20 amperes.

v. Receptacles connected to an uninterruptible power supply (UPS) that are intended to be in continuous use, 24 hours per day/365 days per year, and are marked to differentiate them from other uncontrolled receptacles or circuits.

4.3 International Energy Conservation Code (IECC)

IECC does not include controlled receptacle requirements.

4.4 Voluntary Rating Programs

Per LEED Interpretation ID# 10462, proposed projects that do not comply with the ASHRAE/IES 90.1 controlled receptacle requirement must either model increased receptacle power density or

demonstrate efficiency projects that will achieve equal or greater reduction receptacle energy consumption.[2]

- Path 1: Projects Using Option 1. Whole Building Energy Simulation may model a penalty in the Proposed model for the spaces where mandatory ASHRAE/IES 90.1 receptacle controls are not implemented…. The Proposed model shall include either a 20% increase in the receptacle power density for these spaces OR a 20% increase in the scheduled receptacle Equivalent Full Load Hours of Operation versus the Baseline model.
- Path 2: Projects must demonstrate that the project has implemented efficiency measures that will achieve an equal or greater reduction in receptacle energy consumption and will persist for a similar timeframe to those achieved by ASHRAE/IES 90.1-2010 Section 8.4.2.

[2] https://www.usgbc.org/leedaddenda/10462.

Appendix B: Outreach Communications

I received your contact information from [ ], who said you might be able to help with an important research project. Energy Solutions is collecting data to better understand the impacts that effect compliance with controlled receptacle installation requirements (Title 24 and ASHRAE/IES 90.1). We are looking to speak with individuals who understand how the market interacts with this technology and/or can speak to the different challenges of controlled vs. standard receptacles.

Any help is greatly appreciated. Is there a time I can call to discuss for a few minutes?

I am hoping you can help with an important research project. Energy Solutions is conducting interviews to understand the impacts and challenges of using controlled receptacles, also called control-switched electrical outlets, which are required in some building codes (e.g. California Title 24 Part 6 and ASHRAE/IES Standard 90.1). We are looking to speak with individuals who have experience managing buildings where this technology is installed. We are working on behalf of on behalf of the PG&E Codes and Standards Team. The feedback will be anonymized and used to inform future building code considerations.

Questions we are interested in asking include:

- In your opinion are controlled receptacles cost effective for the energy efficiency gains received?
- Do you purchase or direct your maintenance staff to purchase controlled receptacles for buildings where they are not required by code?
- Do you commission or program the controlled receptacles installed in your buildings?

I would appreciate if you could forward this email to any individuals interested in providing their perspective to contribute to future building energy codes. Please let me know if you have any questions.

Energy Solutions is conducting interviews to understand the impacts and challenges of using controlled receptacles, also called control-switched electrical outlets, which are required in some building codes (e.g. California Title 24 Part 6 and ASHRAE/IES Standard 90.1). We are looking to speak with individuals who have experience managing buildings where this technology is installed. The interviews are anonymous and typically take about 40 minutes. We are interested in any sites where controlled receptacles are installed, they do no need to be in California.

Questions we are interested in asking include:

- In your opinion are controlled receptacles cost effective for the energy efficiency gains received?
- Do you purchase or direct your maintenance staff to purchase controlled receptacles for buildings where they are not required by code?
- Do you commission or program the controlled receptacles installed in your buildings?

Please let me know if you have any questions,

Appendix C: Footnotes

[i] S. Hackel et all, "Impacts of Office Plug Load Reduction Strategies", Seventhwave

[ii] M. Sheppy, I. Metzger, D. Cutler, and G. Holland, A. Hanada, "Reducing Plug Loads in Office Spaces Hawaii and Guam Energy Improvement Technology Demonstration Project", National Renewable Energy Laboratory

[iii] I. Metzger, D. Cutler, M. Sheppy, "Plug-Load Control and Behavioral Change Research in GSA Office Buildings", National Renewable Energy Laboratory