CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Draft Measure Information Template – Guest Room Occupancy Controls

2013 California Building Energy Efficiency Standards

California Utilities Statewide Codes and Standards Team, April 2011

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Guest Room Occupancy Controls

2013 California Building Energy Efficiency Standards

Sempra April 2011

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1. Purpose

Hotel and motel guest room occupancy schedules are highly variable and rooms are frequently conditioned while vacant. Unburdened by the monetary cost of energy, guests often leave space conditioning equipment running and lighting on when they leave the room. Installation of occupancy controls could prevent unnecessary energy consumption in unoccupied guest rooms, while offering additional conveniences to management and staff. The purpose of this CASE report is to show the potential energy savings of occupancy sensors for controlling Packaged Terminal Air Conditioners (PTAC) and lighting in guest rooms. This document is a report template to be used by researchers who are evaluating proposed changes to the 2008 California Building Energy Efficiency Standards. This template sets both the format and content of information needed to completely incorporate a measure into the Standards.

2. Overview

a. Measure Title	Hotel/Motel Guest Room Occupancy Controls for HVAC and lighting systems
b. Description	The proposed measure would require installation of occupancy controls for HVAC and lighting equipment in hotel/motel guest rooms. Guest room occupancy controls will return HVAC equipment to a setback position, and turn off lighting when a hotel or motel room is vacant. An occupancy sensor communicates with a thermostat controlling the HVAC system, as well as with lighting circuits. When the room is occupied, guests have control over the thermostat and lighting, and when the room is vacant, the thermostat returns to default settings and turns off all lighting. The technology is applicable to all HVAC systems types, however, compliance credit should be given only when used with a Packaged Terminal Air Conditioner.
c. Type of Change	Hotel/motel guest room occupancy controls are recommended as compliance option for the 2013 California Building Energy Efficiency Standards. The proposed compliance option does not expand the scope of the standards, nor does it require revision to standards language. The occupancy assumptions for HVAC and lighting systems would change with selection of this compliance credit to more closely resemble actual hotel/motel guest room usage patterns, with return to the setback temperatures when the guest room is unoccupied.

<table>
<tr>
<td>d. Energy Benefits</td>
<td>
Based upon energy analysis conducted using methodology described in the Methodology section of this report and reported in Analysis and Results, this measure is expected to save 7%-25% of annual guest room HVAC energy use, depending on climate zone, HVAC system type and guest occupancy, and 16% of typical lighting energy use in guest rooms with occupancy controls installed. The table below shows the energy savings range possible in kWh and W per guest room and per square foot from combinations of these variables.
Statewide, it is estimated to save 173,639 kWh, assuming 12,459 guest rooms built annually and based on 10% market penetration. This projection takes into consideration the expected distribution across climate zones.
The majority of savings occur during peak hours, between 12pm and 6pm, with a conservative estimated statewide peak load reduction of 18.12 kW. This number is based on a specific occupancy pattern that, for peak demand, is the worst case scenario. It is likely that statewide peak savings would exceed 50kW.
<table>
<tr><th></th><th>Electricity Savings (kWh/yr)</th><th>Demand Savings (W)</th><th>Natural Gas Savings (Therms/yr)</th><th>TDV Electricity Savings</th><th>TDV Gas Savings</th></tr>
<tr><td>Per Hotel/Motel Guest Room</td><td>83 to 226</td><td>1 to 120</td><td>NA</td><td>$289 to $661</td><td>NA</td></tr>
<tr><td>Savings per square foot</td><td>0.21 to 0.70</td><td>0.00 to 0.37</td><td>NA</td><td>$0.72 to $2.05</td><td>NA</td></tr>
</table>
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<tr>
<td>e. Non-Energy Benefits</td>
<td>Occupancy controls reduce daily operating time of HVAC and lighting equipment, thus extending the life of the equipment and reducing the maintenance and replacement costs. Additionally, some occupancy control systems can be centrally wired to allow hotel staff to identify rooms that are unoccupied and deliver more efficient cleaning and maintenance services.</td>
</tr>
</table>

f. Environmental Impact

Installation of guest room occupancy control systems has no known negative impact on the environment, water consumption, or indoor air quality. The materials used in the occupancy sensor and control are small compared to the amount of energy resources they conserve. Components are magnetic or optical decoders, printed circuit boards, logic chips and relays. The environmental impacts of packaging and shipping these small components are insignificant. Aside from reduced CO2 emissions associated with lower energy consumption, longer lasting equipment will reduce the amount of rundown HVAC and lighting equipment needing disposal and replacement.

Material Increase (I), Decrease (D), or No Change (NC): (All units are lbs/year)

	Mercury	Lead	Copper	Steel	Plastic	Others
Per Hotel/Motel Guest Room	NC	NC	NC	NC	NC	NC

Water Consumption:

	On-Site (Not at the Power plant) Water Savings (or Increase) (Gallons/Year)
Per Hotel/Motel Guest Room	NA

Water Quality Impacts:

Comment on the potential increase (I), decrease (D), or no change (NC) in contamination compared to the basecase assumption, including but not limited to: mineralization (calcium, boron, and salts), algae or bacterial buildup, and corrosives as a result of PH change.

	Mineralization (calcium, boron, and salts	Algae or Bacterial Buildup	Corrosives as a Result of PH Change	Others
Impact (I, D, or NC)	NA	NA	NA	NA
Comment on reasons for your impact assessment	NA	NA	NA	NA

Air Quality in lbs/Year, Increase, (Decrease), or No Change (NC)3:

	CO2	CO	PM10	NOx	SOx	VOC
Per Hotel/Motel Guest Room	25.5 to 108.27	.010 to .043	.003 to .014	.007 to .030	.042 to .177	NC

g. Technology Measures	**Measure Availability:** Hotel occupancy controls are currently on the market from a list of manufacturers across the country including Energy Eye, Inc., Amerisafe Industries, Onity, INNCOM International, Inc., LTC Enterprises, LLC, Smart Systems International, Entergize, Energex Inc., Goodman Co., L.P., and Riga Development. Given that, on average, approximately 80 hotel buildings are built each year in California[1], these manufacturers can easily accommodate the demand resulting from the addition of a compliance credit to the 2013 California Building Energy Efficiency Standards for new construction. The majority of these manufacturers use their own team to install the occupancy control systems. Depending on location, the installation work is sometimes performed by local contractors. **Useful Life, Persistence, and Maintenance:** The most common maintenance procedure with occupancy control technologies is battery replacement approximately every two (2) years. Occasionally magnetic sensors need replacement due to wear and tear from guests coming and going frequently, and in rare cases where the occupancy sensor stops communicating with the thermostat, one or more components require replacement. Energy savings related to hotel occupancy sensors are dependent on the type and efficiency of the HVAC and lighting systems used in the hotel guest room. The occupancy control system will result in HVAC and lighting energy savings throughout the product lifetime, assuming the equipment efficiency and average occupancy for a given guest room is also consistent.
h. Performance Verification of the Proposed Measure	Due to the nature of the technology, performance verification will likely be done by the manufacturer and installer of the occupancy control equipment. Many of the systems sold today include warranties and service contracts for follow-up maintenance. No field diagnostic testing is necessary for occupancy controls.

[1] Market Characterization & Program Activity Tracking (MCPAT) Annual reports, 2000-2005.

i. Cost Effectiveness

Cost of equipment and installation vary by technology, system sophistication, geographical region, and hotel size, from approximately $200, up to approximately $500 per hotel guest room. These estimates included equipment, labor, and training of hotel staff.

Based on these costs and a measure life of 15 years, as per 2013 CEC LCC methodology[2], the life cycle cost per guest room ranges from a savings of $251 to an additional cost of $118.

a	b	c		d		e		f	g	
Measure Name	Measure Life (Years)	Additional Costs1– Current Measure Costs (Relative to Basecase) ($)		Additional Cost2– Post-Adoption Measure Costs (Relative to Basecase) ($)		PV of Additional3 Maintenance Costs (Savings) (Relative to Basecase) (PV$)		PV of Energy Cost Savings – Per Proto Building (PV$)	LCC Per Prototype Building ($)	
		Per Unit	Per Proto Building	Per Unit	Per Proto Building	Per Unit	Per Proto Building		(c+e)-f Based on Current Costs	(d+e)-f Based on Post-Adoption Costs
Occupancy Control System	15	$373-$395	$13,428 - $40,290	$373-$395	$13,428 - $40,290	$29	$1,040 - $ 2,946	$18,592 - $38,320	$4,124 – (4,196)	$4,124 – (4,196)

j. Analysis Tools	HVAC energy savings can be quantified using EnergyPro and other compliance software through the adjustment of occupancy schedules to match hotel room usage patterns. Current energy use baselines for HVAC systems in hotel/motel guest rooms assume constant daytime thermostat settings from 6am to 10pm, and constant nighttime settings between10pm and 6am, Monday through Sunday. For a performance-based compliance approach, the current reference methods would need to be updated to include HVAC occupancy schedules that match hotel/motel guest room usage patterns when guest room occupancy control credit is taken. Lighting energy savings were estimated using a combination of occupancy and time-of-use data, as well as energy savings results from similar control strategies.
k. Relationship to Other Measures	The estimated energy savings resulting from other mandatory and prescriptive HVAC system requirements, such as setback thermostats, and lighting efficacy and control requirements would be reduced with the inclusion of guest room occupancy controls, but the measures would not be otherwise influenced. Guest room occupancy controls will only add to the efficiency of other HVAC and lighting measures.

[2] Architectural Energy Corporation, *Life Cycle Cost Methodology 2013 California Building Energy Efficiency Standards,* December 14, 2010.

3. Methodology

This section summarizes the methods we used to collect data for this CASE report, including occupancy control technologies and costs, stakeholder interest and concerns, and energy savings calculations.

3.1 Technology Data and the State of the Market

Through literature review and stakeholder interviews, HMG collected data on the state of the market for occupancy control technologies, including technology types and availability, costs, and consumer satisfaction.

3.1.1 Literature Review

In order to determine energy savings potential and identify technical issues and barriers to code adoption of the measure, HMG reviewed the following field study reports on hotel/motel occupancy controls for both HVAC and lighting:

- Architectural Energy Corporation, Card-Key Guestroom Controls Study (DRAFT), June 2009. Prepared for Pacific Gas & Electric Company.
- California Lighting and Technology Center, Hotel Guest Room Energy Controls, December 4, 2008. Prepared for San Diego Gas & Electric Company.
- California Lighting and Technology Center, Lighting Energy Savings Opportunities in Hotel Guestrooms, October 1999. Prepared for the Office U.S. Department of Energy.
- Honeywell Utility Solutions, Work Paper WPHWLSSC0908: Telkonet PTAC Controller & Thermostat, September 2009. Prepared for Pacific Gas & Electric Company.

The field studies also provided data on guest satisfaction and raw data for determining occupancy schedules.

3.1.2 Stakeholder Interviews

Through interviews with manufacturers and review of product literature, HMG collected information on a wide range of product types and options, including the benefits and limitations of each type, and maintenance issues and technical problems. Manufacturers provided rough cost data for occupancy equipment and installation and confirmed their ability to respond to an increase in demand if the measure is adopted into 2013 California Building Energy Efficiency Standards for new construction. HMG also communicated with industry stakeholders in order to determine acceptance and use of occupancy control technologies. Conversation topics included current use of occupancy sensor technologies, receptiveness to occupancy control installation, variation of system types, common maintenance issues and guest satisfaction. The following questions were asked:

- Do you currently use this technology or a similar technology to control space heating or cooling or lighting? Have you used anything similar in the past?
    - If so, how has it affected everyday hotel operations?
    - How have the guests reacted to the hotel occupancy controls?
    - What kind of heating system is used in your hotel rooms (central, PTAC, hydronic, etc)? What kind of occupancy control system was installed?
    - Have you had any problems with the equipment? If so, how was the problem resolved?

- How does the hotel currently limit or control operation of heating, air conditioning, and lighting in unoccupied guest rooms?
- How do you see your hotels benefitting from this technology?
- How do you see this technology affecting check-in/out and normal operation?
- Are there any issues you'd anticipate following the installation of occupancy controls?

See the Market Conditions section under Analysis and Results for more information on persons interviewed and their responses. HMG also drew upon survey information reported in the AEC field study, mentioned in the Literature Review section of this report, as supplemental data.

3.2 Energy Analysis Prototypes and Assumptions

The baseline condition for this study is a hotel/motel guest room that complies with 2008 California Building Energy Efficiency Standards for hotels, including the use of thermostats with digital temperature display and setback capability.

Projected energy savings from installation of guest room occupancy controls is estimated based on energy simulation runs performed using EnergyPro 5 with weather files developed for the 2013 Building Energy Efficiency Standards. HMG modeled a prototype hotel and a prototype motel with base case thermostat settings to set a baseline energy use. Occupancy patterns documented in the field studies were mimicked in the energy simulation runs to create realistic vacancy schedules. The prototype models were then adjusted to simulate an occupancy control system and the energy use was compared against the baseline. This was repeated in six (6) representative climate zones throughout the California (3, 6, 8, 11, 13 and 16). The data set and energy savings include results from analysis in all six (6) climate zones.

Two prototypes were used in the energy analysis, in order to represent both low rise and high rise building types. The high rise was represented in the hotel prototype and low rise in the motel prototype. Following CEC protocols, the prototype buildings were between 5,000 and 50,000 square feet, with prescribed glazing evenly distributed among the building orientations. Both prototypes deviated slightly from standard CEC methodology to better represent typical hotel and motel building types and construction practices. For instance, motel guest rooms typically have more exterior wall area than would be represented in a rectangular or square building. These deviations are further explained in the Hotel Prototype and Motel Prototype sections.

The prototypes were developed based on an average guest room size. The guest rooms were arranged in building plans with other hotel/motel space types, including lobbies and service areas, in order to determine appropriate orientations and define interior and exterior walls. These other spaces, however, were excluded from the model, so that model outputs would show energy savings from guest room HVAC equipment only, unaffected by the heating and cooling systems used throughout the rest of the building.

Each guest room was modeled with a packaged terminal air conditioner (PTAC) system for heating and cooling. This system type was chosen based on prevalence in the hotel/motel guest room market, as demonstrated by the Commercial Buildings Energy Consumption Survey (CBECS) 2003. The impact on central heating systems would have been difficult to model; simulating central systems would require the model to isolate only the portion of the system serving the guest rooms, which were the focus of this study. Because electric heat was used in the prototype model, no gas savings were accounted for in the primary energy analysis.

3.2.1 Hotel Prototype

The hotel prototype is a 7-story, 102 guest room building of rectangular shape, with metal frame construction and guest rooms on all floors. This prototype is taller than the CEC prototype standard of a one (1) to three (3)-story building, to better represent characteristics of a typical high-rise hotel. The first floor includes a lobby and offices. The core of the building contains elevators, storage, and service spaces. Only the guest rooms were modeled in the software, though the whole building was laid out in order to determine envelope characteristics. Guest rooms are on average 404 square feet (sf), assuming mostly typical 325 sf guest rooms3, as well as some larger suites. Each room has an 8 foot ceiling height, at least one 6'x 4' window, and a PTAC unit for heating and cooling. All guest room entry doors open to a central, conditioned (interior) corridor.
Building characteristics:

- JA4: metal-frame walls, Table 4.3.3
- JA4: metal-frame rafter roof, Table 4.2.2, low slope
- Slab-on-grade, uninsulated floor
- Window to Wall Ratio (WWR) = 15.6%

3.2.2 Motel Prototype

The motel prototype is a 2-story, 36-guest room building, arranged in a U-shape, with parking in the middle and an office at one end of the U. This shape was used—rather than the standard rectangular or square building used in CEC methodology protocols—in order to allow each motel guest room two (2) exterior walls, as is typical of a motel. In order to represent motels of all orientations, the U-shape was closed in the prototype to create a square with a courtyard at the center. This modeling technique allowed for a more realistic averaging of guest rooms savings, accounting for all four (4) cardinal orientations. Because the prescriptive glazing requirements vary by orientation, simply doing a cardinal run of the U-shape would not have provided accurate results. Guest rooms average 322 square feet. Each room has an 8foot ceiling height, one 6' x 4' window, and a PTAC unit for heating and cooling. All guest room entry doors are on exterior building walls.
Building characteristics:

- JA4: wood-frame walls, Table 4.3.1
- JA4: wood-frame rafter roof, Table 4.2.2, low slope
- Slab-on-grade, uninsulated floor
- Window to Wall Ratio (WWR) = 8.6%

Figure 1 summarizes the hotel and motel prototype characteristics.

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3 Yancey, Kitty, Does Size Matter?, USA Today, October 16, 2006. (quote by hotel analyst Bjorn Hansen) http://blogs.usatoday.com/hotelhotsheet/room_size/

	Occupancy type	Total building area (Square Feet)	Average guest room area (Square Feet)	Number of guest rooms	Number of stories	Guest room HVAC system type
Hotel Prototype	Hotel	41,230	404	102	7	PTAC cooling with heat pump in each guest room.
Motel Prototype	Motel	11,592	322	36	2	PTAC cooling with heat pump in each guest room.

Figure 1: Building Prototype Summary Table

3.2.3 HVAC Analysis

In order to simulate temperature settings in guest rooms with occupancy controls, HMG revised the occupancy schedules from the 2008 base case standard, using field data collected by CLTC. The field data indicated whether or not a room was occupied but did not provide data on the number of occupants. Note that the Title 24 occupancy schedule utilized in the energy simulation software relates to occupancy levels as a percent of the rated occupancy of a space, not whether a space is occupied, and thus addresses a different quantity than that measured in the CLTC study. The Title 24 occupancy schedule was not altered as part of the HMG analysis.

For each site, average hourly occupancy was calculated for each of the 24 hours in a day, including all rooms with available occupancy data, for the entire study period. HMG received data from the CLTC on four (4) hotels. One site was dropped from the data set because of limited data. For the other three sites, average overall site room occupancy percentages for each hour of the day, numbered 0 - 23 (beginning with midnight to 1am), were determined as summarized in Figure 2, and graphed in Figure 3.

Hour	Site 1	Site 2	Site 3	Average
0	73%	78%	92%	81%
1	75%	80%	94%	83%
2	76%	81%	94%	83%
3	76%	81%	94%	84%
4	75%	82%	94%	84%
5	75%	82%	93%	83%
6	69%	77%	91%	79%
7	59%	66%	87%	71%
8	49%	50%	80%	60%
9	44%	37%	73%	51%
10	37%	27%	63%	42%
11	35%	23%	53%	37%
12	30%	21%	44%	32%
13	31%	19%	44%	31%
14	34%	21%	45%	33%
15	33%	22%	47%	34%
16	37%	27%	48%	37%
17	39%	31%	51%	40%
18	37%	32%	53%	41%
19	40%	35%	59%	45%
20	45%	43%	67%	52%
21	54%	55%	75%	61%
22	62%	66%	84%	71%

Figure 2: Average Occupancy of Hotel Guest Rooms from CLTC Field Study

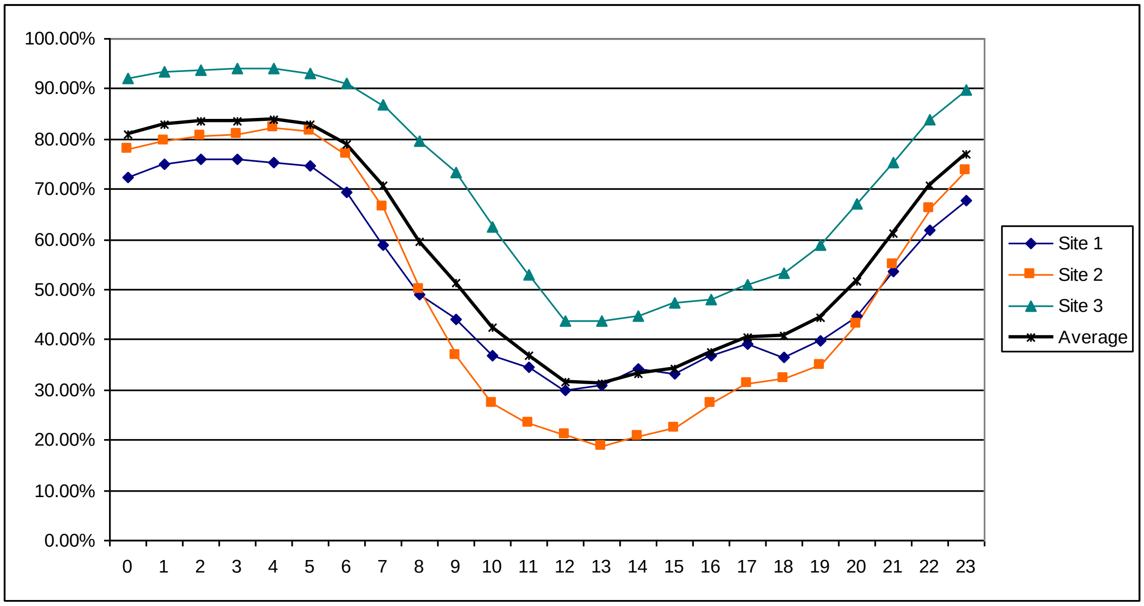

Figure 3: Occupancy Patterns of Hotel Guest Rooms from CLTC Field Study

The site-specific hourly room occupancy averages were then averaged into an overall average room occupancy (in %) for each hour in the day. These results are located in the "Average" column of Figure 2. The hourly occupancy averages for the three sites were equally weighted in this all-site hourly average, which included data for 8, 8, and 9 rooms at hotel sites 1, 2 and 3 respectively. Figure 3 illustrates the similarity of occupancy patterns among the three hotels, showing that averaging the data does not flatten the curve of the occupancy schedule.

In order to enable a range of potential savings to be estimated via the energy simulations, the upper and lower average occupancy percentages were necessary in addition to the overall average. The most and least occupied three rooms for each site were identified based on room occupancy patterns reflected in the CLTC data. The occupancy rates of the three most occupied rooms per site were averaged to develop a site-specific "high" occupancy value. Likewise the occupancy rates for the three least occupied rooms were averaged into a "low" occupancy value. These "high" and "low" values per site were then averaged across the three sites, for each hour in the day, to obtain an overall upper and lower limit of the expected occupancy range. These overall results, in percent occupancy, are located in the "Top3" and "Bottom 3" columns in Figure 4. The upper and lower occupancy averages were weighted equally for each site.

Hour	Top 3	Bottom 3	Average
0	90%	70%	81%
1	92%	71%	83%
2	93%	72%	83%
3	92%	72%	84%
4	93%	72%	84%
5	92%	71%	83%
6	89%	67%	79%
7	82%	58%	71%
8	72%	45%	60%
9	67%	35%	51%
10	62%	26%	42%
11	57%	20%	37%
12	53%	15%	32%
13	51%	16%	31%
14	53%	18%	33%
15	53%	18%	34%
16	56%	21%	37%
17	60%	24%	40%
18	60%	26%	41%
19	62%	31%	45%
20	68%	38%	52%
21	75%	48%	61%
22	83%	58%	71%
23	88%	66%	77%

Figure 4: Table of High and Low Occupancy Schedules from CLTC Data

Energy savings could not be modeled using the developed CASE occupancy percentages directly, since the CASE data is a different metric than Title 24 occupancy schedules. The heating and cooling set point schedules were modified instead. The CASE energy models simulated the effect of the CASE controls by adjusting HVAC system temperature hourly set points corresponding to the percentage of time a room would be unoccupied over the course of each hour.

The upper, average, and lower occupancy percentages described previously were utilized to modify the HVAC system temperature set point schedules. A 4-degree setback (or setup) from the Title 24 (2008) 24-hour heating and cooling set point schedules was assigned to the percentage of time the room was unoccupied. This 4-degree setback/setup acted, in effect, as the "unoccupied room set point." The modified CASE heating and cooling schedules consisted of hourly set points that are weighted averages of the occupied and unoccupied set points. The modeled hourly set points can be summarized as the following:

Tcool(modeled hourly set point) = Tcool(T24 setpt) + (setup * %hour unoccupied)

Theat(modeled hourly set point) = Theat(T24 setpt) - (setback * %hour unoccupied)

This methodology was applied to both heating and cooling schedules for the Top 3, Average, and Bottom 3 occupancy conditions. The resulting hourly schedules, found in Figure 5, were developed for each of the three occupancy cases (high, average, low) in order to determine a range of estimated savings resulting from the CASE controls.

	Title 24 Setpoints						Weighted by Average Occ. %						Weighted by High Occ. %						Weighted by Low Occ. %					
	Heating			Cooling			Heating			Cooling			Heating			Cooling			Heating			Cooling		
Hour	Weekday	Saturday	Sunday	Weekday	Saturday	Sunday	Weekday	Saturday	Sunday	Weekday	Saturday	Sunday	Weekday	Saturday	Sunday	Weekday	Saturday	Sunday	Weekday	Saturday	Sunday	Weekday	Saturday	Sunday
0	60	60	60	78	78	78	59	59	59	79	79	79	60	60	60	78	78	78	59	59	59	79	79	79
1	60	60	60	78	78	78	59	59	59	79	79	79	60	60	60	78	78	78	59	59	59	79	79	79
2	60	60	60	78	78	78	59	59	59	79	79	79	60	60	60	78	78	78	59	59	59	79	79	79
3	60	60	60	78	78	78	59	59	59	79	79	79	60	60	60	78	78	78	59	59	59	79	79	79
4	60	60	60	78	78	78	59	59	59	79	79	79	60	60	60	78	78	78	59	59	59	79	79	79
5	60	60	60	78	78	78	59	59	59	79	79	79	60	60	60	78	78	78	59	59	59	79	79	79
6	68	68	68	78	78	78	67	67	67	79	79	79	68	68	68	78	78	78	67	67	67	79	79	79
7	68	68	68	78	78	78	67	67	67	79	79	79	67	67	67	79	79	79	66	66	66	80	80	80
8	68	68	68	78	78	78	66	66	66	80	80	80	67	67	67	79	79	79	66	66	66	80	80	80
9	68	68	68	78	78	78	66	66	66	80	80	80	67	67	67	79	79	79	65	65	65	81	81	81
10	68	68	68	78	78	78	66	66	66	80	80	80	66	66	66	80	80	80	65	65	65	81	81	81
11	68	68	68	78	78	78	65	65	65	81	81	81	66	66	66	80	80	80	65	65	65	81	81	81
12	68	68	68	78	78	78	65	65	65	81	81	81	66	66	66	80	80	80	65	65	65	81	81	81
13	68	68	68	78	78	78	65	65	65	81	81	81	66	66	66	80	80	80	65	65	65	81	81	81
14	68	68	68	78	78	78	65	65	65	81	81	81	66	66	66	80	80	80	65	65	65	81	81	81
15	68	68	68	78	78	78	65	65	65	81	81	81	66	66	66	80	80	80	65	65	65	81	81	81
16	68	68	68	78	78	78	65	65	65	81	81	81	66	66	66	80	80	80	65	65	65	81	81	81
17	68	68	68	78	78	78	66	66	66	80	80	80	66	66	66	80	80	80	65	65	65	81	81	81
18	68	68	68	78	78	78	66	66	66	80	80	80	66	66	66	80	80	80	65	65	65	81	81	81
19	68	68	68	78	78	78	66	66	66	80	80	80	66	66	66	80	80	80	65	65	65	81	81	81
20	68	68	68	78	78	78	66	66	66	80	80	80	67	67	67	79	79	79	66	66	66	80	80	80
21	68	68	68	78	78	78	66	66	66	80	80	80	67	67	67	79	79	79	66	66	66	80	80	80
22	60	60	60	78	78	78	59	59	59	79	79	79	59	59	59	79	79	79	58	58	58	80	80	80
23	60	60	60	78	78	78	59	59	59	79	79	79	60	60	60	78	78	78	59	59	59	79	79	79

Figure 5: Set Point Schedules for Energy Analysis

The modified HVAC schedules were then input into the energy simulation software. Four simulations were run for each climate zone evaluated. The base case used standard Title 24 24-hour heating and cooling schedules. The three measure cases utilized the heating and cooling set point schedules as described above.

Note that no allowance was made in the energy simulation for the percentage of rooms actually rented or not rented at a given time. All rooms were modeled with the same heating and cooling schedules described above, based on the field data. In addition, since the CLTC field data did not cover multiple seasons, no seasonal adjustments were made to occupancy percentages or the corresponding modified heating and cooling schedules derived from the field data.

3.2.4 Lighting Analysis

The lighting energy savings resulting from installation of guest room occupancy control was analyzed separately from HVAC savings because of the difference in typical use patterns (HVAC setpoints tend to remain constant throughout the day, whereas lighting is turned on or off depending on user needs). In addition, HVAC energy use and savings is heavily dependent on climate, whereas typical lighting energy use and savings is expected to be uniform across the state.

Using the typical guest room lighting layout described in a 1999 California Lighting Technology Center study (CLTC 1999), HMG assumed the following wattages for a typical guest room lighting types:

- Bathroom lighting: 96W (3 @32W, fluorescent or compact fluorescent)
- Bedside lighting: 52W (2 @26W, compact fluorescent)
- Desk lighting: 26W compact fluorescent
- General lighting: 52W (one 26W compact fluorescent downlight at entry, one additional 26W compact fluorescent for general illumination in the room)

The resulting maximum installed wattages is 226W per guest room.

Hotel room occupancy patterns were determined based on data from the CLTC field study, described above in section 3.2.3 (CLTC 2008). Figure 3, above, shows the occupancy pattern results of the CLTC field study.

In addition to typical guest room lighting layouts and occupancy patterns described above, HMG utilized results from the 1999 CLTC study which measured the use of the various lighting types in typical guest rooms. Figure 6, below, illustrates the usage patterns for each lighting type in the guest room (for the purpose of this CASE study, the line in Figure 6 labeled "floor" is considered to represent general (recessed) lighting in the guest room).

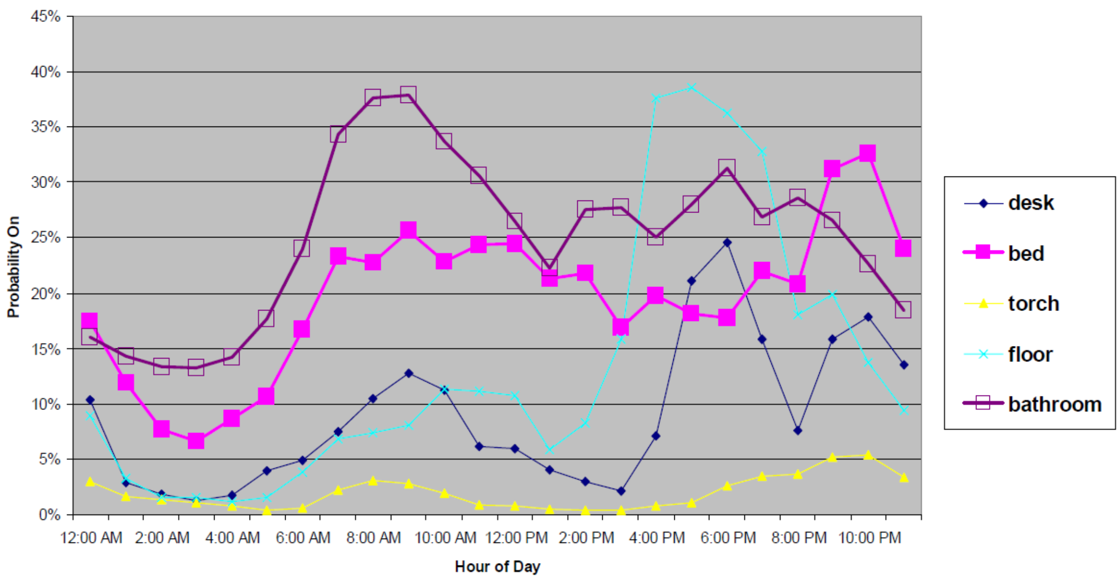

Figure 6: Use Patterns for Guest Room Lighting Types

3.2.5 Statewide Construction Estimates

HMG referenced statewide construction forecast estimates published by the CEC in the Quarterly Fuel and Electricity Report (QFER). The construction estimates are in million square feet and broken down by climate zone. To translate this number into a number of forecasted guest rooms built, HMG used data obtained from Hotel Online (in partnership with Build Central) on hotel new construction activity for 2010.[4] Hotel Online reports the number of guest rooms in each hotel beginning construction in the year 2010, but does not report square footage. HMG divided the CEC 2010 hotel statewide new construction forecast (4.877 million square feet) by the total number of guest rooms built in 2010 (6,679 guest rooms) to find a per guest room square footage that includes non-guest room hotel spaces. The result was 730 square feet of total hotel/motel space per guest room. Because this code change proposal will take effect January 1, 2014, first year statewide energy savings are based on 2014 new construction area of 9.098 million square feet Figure 7 We divided the 2014 CEC new hotel construction forecast, in square feet, by 730 square feet to find the estimated number of guest rooms to be built in 2014. Figure 7 shows the representative climate zone distribution and estimated number of guest rooms built annually in each.

Representative Climate Zone	Actual Climate Zone	2014 Construction Forecast (million sq.ft.)	# of Guest Rooms Forecasted 2014	
3	2	0.2897	397	2738
	3	0.7912	1083	
	4	0.7694	1054	
	5	0.1494	205	
6	6	0.5004	685	1605
	7	0.6718	920	
8	8	0.9430	1291	4292
	9	2.1910	3000	
11	10	0.3304	452	679
	11	0.1656	227	
13	12	1.3375	1832	2827
	13	0.4934	676	
	14	0.1896	260	
	15	0.0436	60	
16	16	0.1977	271	318
	1	0.0345	47	
	TOTAL	**9.0982**	**12,459**	

Figure 7: New Hotel Construction Representative Climate Zones

Using average energy savings calculations for each of the climate zones and estimates of the number of guest rooms built in each climate zone group, HMG estimated the energy savings potential from adoption hotel guest room occupancy controls into the 2013 California Building Energy Efficiency

[4] http://hotels.buildcentral.com/projects/search_result.asp?action=search&searchproduct=18&provider_id=1000&category_id=1050&product_id=1093&subscriptiontype=0&UID={4B4C83F7-3C8C-49E2-AB62-9AD082FFA64F} sourced February 17, 2011

Standards. The rate of construction for hotels and motels is roughly equivalent[5]. HMG therefore averaged the hotel energy savings per guest room with the motel energy savings per guest room in each climate zone to complete the calculation. Statewide energy savings were predicted assuming that a conservative 10% of the hotel guest rooms built in each climate zone would have installed guest room occupancy controls. Results can be found in the Analysis and Results section under the Statewide HVAC Energy Savings heading.

3.3 Cost Effectiveness

HMG determined cost effectiveness through collection of occupancy control system costs for equipment and installation and use of life cycle cost methodology developed for the 2013 California Building Energy Efficiency Standards, prepared for the CEC by AEC.[6] Cost collection and LCC methodology are discussed in this section.

3.3.1 Market Pricing

In preparation for their field study in San Diego, CLTC collected cost data on several occupancy control systems, per guest room. The cost can vary by number of guest rooms (bulk purchasing), so the values collected are rough estimates, and include all equipment and installation costs. Additionally, a hotel-specific estimate was collected from a selected manufacturer for a retrofit application, in order to make a decision between hardwired and wireless systems. All collected costs are shown in Figure 8 and Figure 9 in the Analysis and Results. HMG additionally confirmed the accuracy of these estimates informally through the manufacturers' stakeholder interviews.

Maintenance costs were estimated based on the cost of batteries and replacement thermostats and quoted for the CLTC field study. The maintenance costs assumed battery replacement annually. It is highly likely, however, that reduced maintenance costs for HVAC equipment, due to less running time, would cancel-out the maintenance and replacement costs associated with occupancy control systems. Without more data on reduced HVAC maintenance costs, we are assuming an increased maintenance cost.

3.3.2 Lifecycle Cost (LCC) Analysis

HMG calculated lifecycle cost analysis using methodology explained in the California Energy Commission report Life Cycle Cost Methodology 2013 California Building Energy Efficiency Standards, written by Architectural Energy Corporation, using the following equation:

$$\Delta LCC = \text{Cost Premium} - \text{Present Value of Energy Savings}$$ [7]

$$\Delta LCC = \Delta C - (PVTDV\text{-}E * \Delta TDVE + PVTDV\text{-}G * \Delta TDVG)$$

Where:

ΔLCC change in life-cycle cost

ΔC cost premium associated with the measure, relative to the basecase

[5] http://hotels.buildcentral.com/projects/search_result.asp?action=search&searchproduct=18&provider_id=1000&category_id=1050&product_id=1093&subscriptiontype=0&UID={4B4C83F7-3C8C-49E2-AB62-9AD082FFA64F} sourced February 17, 2011

[6] Architectural Energy Corporation, Life Cycle Cost Methodology 2013 California Building Energy Efficiency Standards, December 14, 2010, 2005.

[7] The Commission uses a 3% discount rate for determining present values for Standards purposes.

PVTDV-E	present value of a TDV unit of electricity
PVTDV-G	present value of a TDV unit of gas
ΔTDVE	TDV of electricity
ΔTDVG	TDV of gas

We used a 15-year lifecycle as per the LCC methodology for nonresidential HVAC measures. LCC calculations were completed for two building prototypes, in all six (6) climate zones analyzed, for high, low, and average occupancies. This provided a range of cost effectiveness to accommodate for varying scenarios.

4. Analysis and Results

Research and analysis of the hotel/motel occupancy controls for guest room HVAC showed market readiness, substantial energy benefit, and marginal cost-effective application in both new construction and retrofit projects. This section discusses HMG's findings in the categories of market conditions, energy savings, and cost-effectiveness.

4.1 Market Conditions

Through product research and stakeholder interviews, HMG has determined that the market is ready for installation of occupancy controls for HVAC and lighting systems in hotel/motel guest rooms. Hotel stakeholders are accepting of the technology. The variety of products and manufacturing companies allow for adaptation to unique HVAC and lighting system types and applications, as well as competition in the market place.

Because of inconclusive cost analysis results, and to ensure a smooth transition for the hotel industry, HMG is proposing this measure as a compliance option in new construction hotel/motel buildings for 2013 California Building Energy Efficiency Standards. A logical progression would suggest reevaluation for possible proposal as a mandatory or prescriptive measure in the code update following 2013. The measure should also be considered for hotel/motel retrofit in future code updates. Many versions of the technology are currently available for retrofit application.

4.1.1 Available Products

This section provides an extensive, though not comprehensive, list of ten (10) occupancy control manufacturers and descriptions of the products they offer. The system capabilities reported by each manufacturing company were neither confirmed by HMG, nor are we recommending any one product over another.

Amerisafe Industries

An infrared sensor and a magnetic switch installed at the front door of the room determine if a guest is inside the guest room or not. Once the guest opens the door and exits the room the Infrared Sensor scans the room to see if another guest is still inside. If not, the System will turn OFF the lights and then follow the preset program, set by the hotel staff, which may be:

- Turn OFF the A/C until the guest returns.
- Turn the A/C intermittently ON and OFF accordingly (For example, 5 minutes ON 15 minutes OFF)
- Keep the temperature at a preset level by observing the "optional" thermostat.

The System will keep the room at a pleasant temperature and at an acceptable relative humidity level. An important feature of this product is the Status Indicator, installed outside of the room door which eliminates guest annoyance, since hotel staff may easily determine if a guest is inside the room or not.

Energy Eye Energy Management Control Systems

Energy Eye produces both a hard wired and wireless occupancy controlled systems.

The hard wired system is for new construction and gut rehabilitation only. Hardwired systems are able to have a secondary control for lighting and do not have the problem of interference present for wireless technology. Although the hardwired system is cheaper on a per unit basis (because the customer does not have to pay for the wireless technology) the cost of the electrician used for the installation can be just as costly if not more so.

The wireless system utilizes a door switch and ceiling mounted passive infrared occupancy sensor. When the door is opened or closed, the system searches for an occupant and determines if the room is occupied. When the room is occupied the PTAC is completely controlled by the user. When the room is unoccupied and the pre-set time delay has passed, the PTAC is shut off unless the room temperature drifts outside of the pre-set temperature range.

The Energy Eye System is capable of detecting whether or not a guest room is occupied through information transmitted to the HVAC Control Module by the company's Passive InfraRed (PIR) Detector and Micro Door Sensor. Energy Eye offers an optional door sensor that will tell an HVAC system to shut off five minutes after a balcony or patio door is left open.

Because of its Advanced Logic technology, the system will not turn off when a guest is sleeping. This is because the PIR detector only needs to see the occupant enter the room the first time.

Entergize

Entergize has a Guest Room Energy Management System that utilizes a key card to control both guest room HVAC energy costs as well as lighting and electrical loads. When a key card is inserted into a master control switch upon entry into the guest room it activates all the power in the room - for lighting, HVAC, TV, etc. As long as the key card remains in the control switch slot, the power remains on. As the guest leaves the room, the key card is removed, which turns the power off.

The system is wireless, using microchip control RF (radio frequency) communication, and average room installation takes less than 30 minutes. The system may be overridden, room by room, at guest request simply by providing an additional key, and significantly reduces guest room lockout caused by key card left in room. The system works with all types of guest room HVAC systems and voltages.

Energex Inc.

Energex offers wired and wireless options that incorporate passive infrared or ultrasonic sensor technology. Like other systems, the sensors power down heating and cooling equipment after guests leave their rooms. Energex also offers a sliding window or door auto shut-off feature to ensure heating and cooling systems do not run when sliding doors or windows are open.

Energex Energy Management System includes an option for a wireless information and communication network using a Palm Pilot or one's own PC. The system allows the building's staff to know whether a room is occupied in real time, to communicate messages to each other, and to provide 'head end control.'

Goodman Co. L.P.

The DigiSmart Control System, an operations management tool to be used with its Amana brand PTACs, employs self-configuring, radio frequency (RF)-based wireless mesh technology. To create the mesh, an antenna is plugged into the control board of each PTAC. With the mesh network, one can control and monitor all PTACs from a single control point. The DigiSmart system includes in-room wireless thermostats and occupancy sensors, and a Web-based control platform. Multiple buildings can be networked together via the Internet.

INNCOM Digital Thermostat (EMCS enabled)

INNCOM offers systems of varying levels of sophistication.

- Simple digital thermostat with a motion sensor incorporated into it.
- Digital thermostat and a door switch
- Thermostats can then be networked for central control and reporting through Inncom's INNcontrol software

The INNCOM e4 can replace virtually any existing thermostat currently in use. It has the ability to directly control almost any HVAC fan coil unit (FCU), packaged terminal air conditioner (PTAC), or other unit types ranging from 24V to 277V, without additional relays or transformers.

With the addition of a passive infrared (PIR) motion sensor and door switch, the e4 becomes the brain of an efficient standalone energy management system. This system utilizes a door switch and ceiling mounted passive infrared occupancy sensor. When the door is opened or closed, the system searches for an occupant and determines if the room is occupied. When the room is occupied the PTAC is completely controlled by the user. When the room is unoccupied and the pre-set time delay has passed, the PTAC is shut off unless the room temperature drifts outside of the pre-set temperature range.

For areas with high labor costs or restrictive electrical codes, installation can be wireless by using INNCOM's patented IR and/or RF technology.

Linking all guest room thermostats with INNCOM's INNcontrolTM provides more powerful energy management and many additional capabilities.

Expansion options include:

- Room occupancy status reporting
- Remote HVAC control
- Guest room HVAC diagnostics
- Peak demand load shedding
- PMS/BMS interface
- Automatic lighting control
- Remote mini-bar access reporting
- Remote smoke detector annunciation

Lodging Technology

Lodging Technology's flagship product is GEM System. GEM System determines the physical presence of guests by detecting infrared body heat. When a guest has left a room for a specified period, the GEM System takes control from the normal thermostat and resets room temperature to energy conserving levels. The system also provides real time information on room occupancy to housekeeping, front desk and security.

The system connects to all HVAC systems including PTACs, heat pumps, split systems and fan coil units of any voltage.

Onity SensorStat Energy Management Control Systems

This system utilizes a door switch and ceiling mounted passive infrared (PIR) occupancy sensor. When the door is opened or closed, the system searches for an occupant and determines if the room is occupied. When the room is occupied the PTAC is completely controlled by the user. When the room is unoccupied and the pre-set time delay has passed, the temperature on the thermostat is set back to a pre-set temperature range. The thermostats can also be networked for central control and reporting.

Onity offers several solutions including the SensorStat DDC, which merges digital temperature control (DDC) with PIR sensing. Onity's SensorStat 2000X utilizes PIR occupancy sensing to reduce energy waste by taking control of the HVAC or thermostat while the room is not occupied and automatically setting the temperature to an optimum energy saving level.

Onity also offers a wireless option. The SensorStat Wireless DDC thermostat control can also network with other thermostats. The wireless network can tie in the HVAC controller, door/window switches, PIR motion sensors, electronic locks, safes, lighting switches, minibars, and any other device operating on the same RF protocol standard. Networking capability allows a hotel to create a central command station that monitors the status and activity of each device in every room.

Riga Development

The WiSuite Environmental Management System allows property owners automate and control the energy efficiency of every room. The WiSuite system automatically self-configures into a wireless mesh network of 'WiStat' digital thermostats, appliances and receivers installed throughout a building. The WiStats and other appliance controls monitor the rooms' environment, reducing energy use in unoccupied rooms, and alerting staff to potential problems.

A WiSuite Control Center, accessible from any Web browser, lets facility managers and front desk hotel staff control the devices wirelessly, monitor their status, and set up custom schedules. To completely automate energy savings, WiSuite connects to a hotel's existing reservation system through the WiSuite Reservations Bridge, enabling it to automatically respond to check-in and check-out dates and times. The WiSuite system does not operate like other technologies that incorporate in-room and/or door sensors, and does not power HVAC systems up or down based on guests entering or leaving a room.

Smart Systems International

The SS1000 uses a wireless radio network to communicate with occupancy sensors. When the guest room is vacant, the SS1000 automatically reduces the energy consumption of the PTAC. In addition, it constantly performs patented scientific calculations to ensure that the comfort temperature is achieved within a specified time frame upon the occupant's return. The SS1000 works with the SS2000 motion/infrared occupancy sensor. It resembles a smoke detector. The SS5000 thermostat is also part of the overall system. Smart Systems can be installed quickly as a retrofit application since the communication link between the sensor and the controller is wireless.

4.1.2 Stakeholder Surveys

Interviews of stakeholders within the hotel industry revealed positive experience with the technology and openness to installation. The main concern among those that had no experience with the technology was guest comfort, while those whose hotels had the technology installed reported few guest complaints. The interviews summarized in this section are representative of the collection of conversations held with hotel stakeholders. Hotel interviewees typically fell into one of two categories: no experience with the guest room occupancy control technology, but interested in exploring the possibility of installation, or they install the technology in every hotel guest room in every hotel. Very few of the hotel stakeholders contacted reported installation of the technology in only a portion of their hotels.

Mondrian Hotel

The Mondrian Hotel does not currently have occupancy control technology installed, but conveyed "support of any system that will conserve energy", so long as guests remain comfortable. The major benefit to the hotel of such a technology would be the energy savings when a guest room has nobody checked into it, suggesting current housekeeping practices do not include shut-off or setback of HVAC equipment upon check-out.

Accor North America, Inc.

The Accor North America hotel group includes Ibis, Motel 6, Novotel, Sofitel, and Studio 6. Within this group, approximately 70 hotels, averaging 110 units per hotel have occupancy control technology installed. The group has installed several types of control systems including hardwired and wireless variations, with various methods of sensing occupancy.

Of the various occupancy sensor types, the door sensor is reported to fail most often, needing replacement due to wear and tear from repeated opening and closing of guest room doors. The sensor associated with the least complaint is completely within the thermostat unit. In order to prevent problems with detecting motion at night – because of the lack of motion and therefore the system shutting down – they have built into the system a failsafe at night. Where an override occurs, and the system stays on all night. Because most of the energy savings occurs in the day, this override has little effect on overall energy savings.

Also mentioned was the convenience offered by systems that can be wired together for monitoring and control from a central point. This would allow hotel staff to know when rooms are vacant, when maintenance is required, and for equipment to be controlled from the facilities department. In his vision of an ideal future, the utility company would be able to send the facilities department a signal to try and reduce energy during a peak period. With central control of individual thermostats, the facilities department could setback all thermostats during this time, saving the hotel money.

Guest complaints have typically been due to hardware failure. Much of this is likely due to bumping of guests and luggage against system components. Very few complaints t couldn't be immediately resolved. Accor North America has generally seen a 2.5 to 3 year return on investment in occupancy control systems. Installation of occupancy control systems is therefore standard in all new hotels in this group.

Guest Survey Results from AEC Card-Key Guest Room Controls Study8

In a field study conducted by AEC, on behalf of PG&E, AEC surveyed guests about satisfaction with room temperatures in guest rooms with active and inactive key-card occupancy controls. Card-key controls in this study shut off (rather than set-back) HVAC equipment when guest rooms were vacant, yielding worst case temperature conditions with use of this technology. Guests were asked a series of questions about satisfactory room temperature upon arrival, during stay, and upon return to the guest room after being out. More than 80% of guests in rooms with active and inactive controls reported that room temperatures were just right upon arrival and 90% of guests were satisfied with room temperature during their stay. Of the guests in rooms with active key-card controls, 70% reported that room temperatures were just right when returning after being out and their HVAC equipment being shut-off for a period of time. In the same pool of guests in rooms with active controls, only 13% of guests reported any change in temperature as inconvenient. Only 4% reported this inconvenience as unacceptable. It should be noted that in guest rooms with inactive controls, 5% of guests reported an unacceptable inconvenience with the temperature change, in rooms whose HVAC equipment had not been shut-off while they were away.

4.1.3 System Pricing

Though most manufacturers were hesitant to quote the price of equipment and installation of occupancy control systems without having an actual hotel project to bid, many informally agreed that the cost varied between $200 and $500 per guest room system controlled. Cost variables included hardwired or wireless system choice, type of occupancy sensor, project location, and system sophistication (e.g. whether the system was wired for central hotel control). Figure 8 shows estimated costs per hotel/motel guest room, as collected by CLTC as part of their occupancy control field study in San Diego.

Occupancy Control Manufacturer/Product	Cost per Guest Room
Onity System - Stand Alone	$270
Onity System - Centrally Controlled	$450
INNCOM System - Stand Alone	$325
INNCOM System - Centrally Controlled	$450
Energy Eye System	$280
Smart Systems	$230
Watt Stopper	$100
Lodging Technology Corp.	$270

Figure 8: Occupancy Control System Cost Estimates (CLTC field study)

Figure 9 shows a comparison of hotel specific quotes for retrofit hardwired and wireless system options. For privacy purposes, the hotel name is not disclosed.

8 Architectural Energy Corporation, Card-Key Guestroom Controls Study (DRAFT), June 2009. Prepared for Pacific Gas & Electric Company.

Description	Quantity	Hardwired System	Estimated Cost	Wireless System	Estimated Cost
Thermostat	139	$142	$19,738	$80	$11,120
Spare thermostat	2	$142	$284	$80	$160
Room control unit	141	-	-	$80	$11,280
Wiring/cable	141	$7	$987	$5	$705
Elec prewire	139	$21	$2,919	-	-
Remote stat kit	141	$50	$7,050	$50	$7,050
Entry door switch	141	$4	$564	$4	$564
Entry door transceiver	141	-	-	$42	$5,922
Sensor stat program kit	1	$650	$650	-	-
Alkaline batteries	880	-	-	$0.40	$352
Installation	139	$98	$13,622	$84	$11,676
Crew travel expenses	2	$600	$1,200	$600	$1,200
System training	1	$600	$600	$650	$650
Hotel Total			$47,614		$50,679
Per Guest room	139	$343		$365	

Figure 9: Quoted Cost Comparison of Hardwired vs. Wireless Systems.

4.2 Energy Savings

Assumptions and analysis methodology for all energy savings reported can be found in the section 3 of this report, under the Energy Analysis Prototypes and Assumptions heading.

4.2.1 Site HVAC Energy Savings

Guest room occupancy controls are estimated to save between 7 and 25% in heating and cooling energy, based on a 4 degree setback when the room is vacant. This equates to 0.11 to 0.58 kWh annual savings per square foot and from 44 to 187 kWh annual savings per guest room, depending on climate zone, room type, and occupancy pattern. The lowest calculated savings occurred in Climate Zone 3, and highest in Climate Zone 13, as illustrated in Figure 10.

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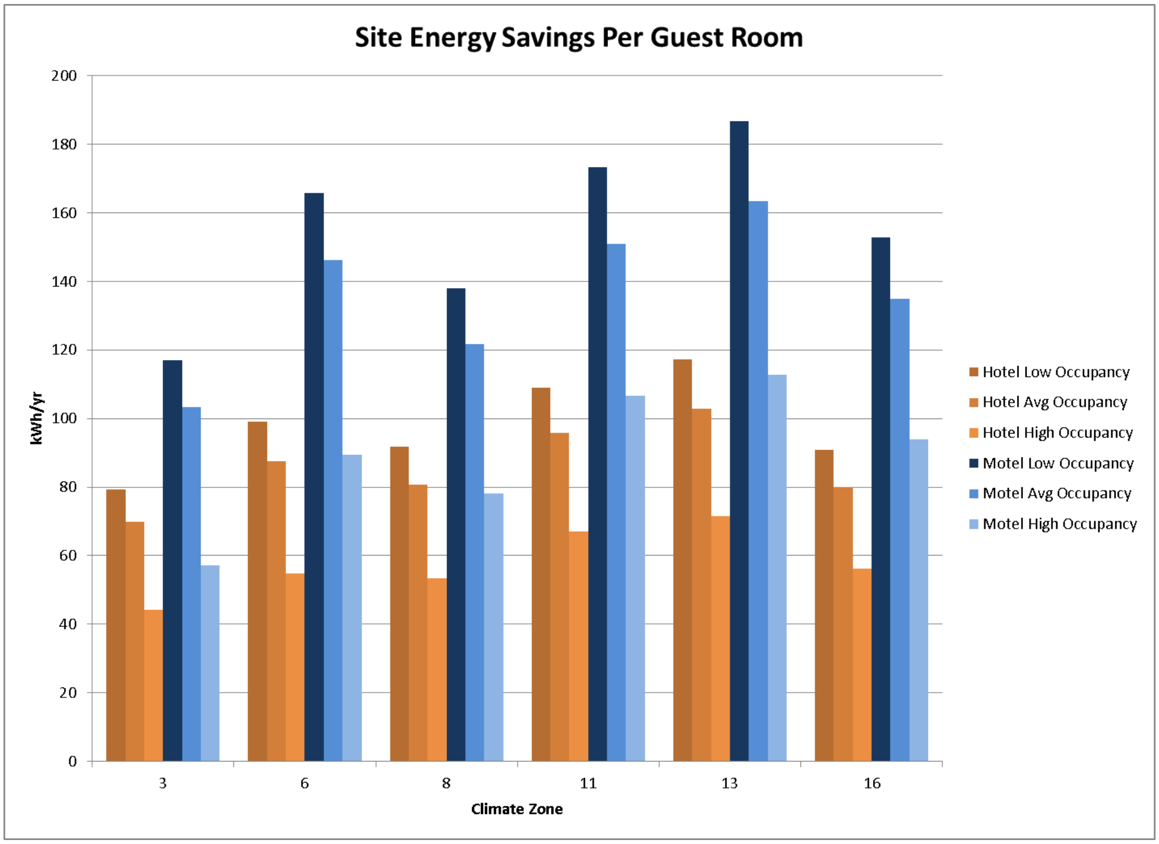

Figure 10: Charted kWh Site HVAC Savings per Guest Room by Climate Zone

The site savings per square foot is shown in
Figure 11. The pattern varies slightly from the per guest room savings due to the difference in floor area from hotel to motel guest room.

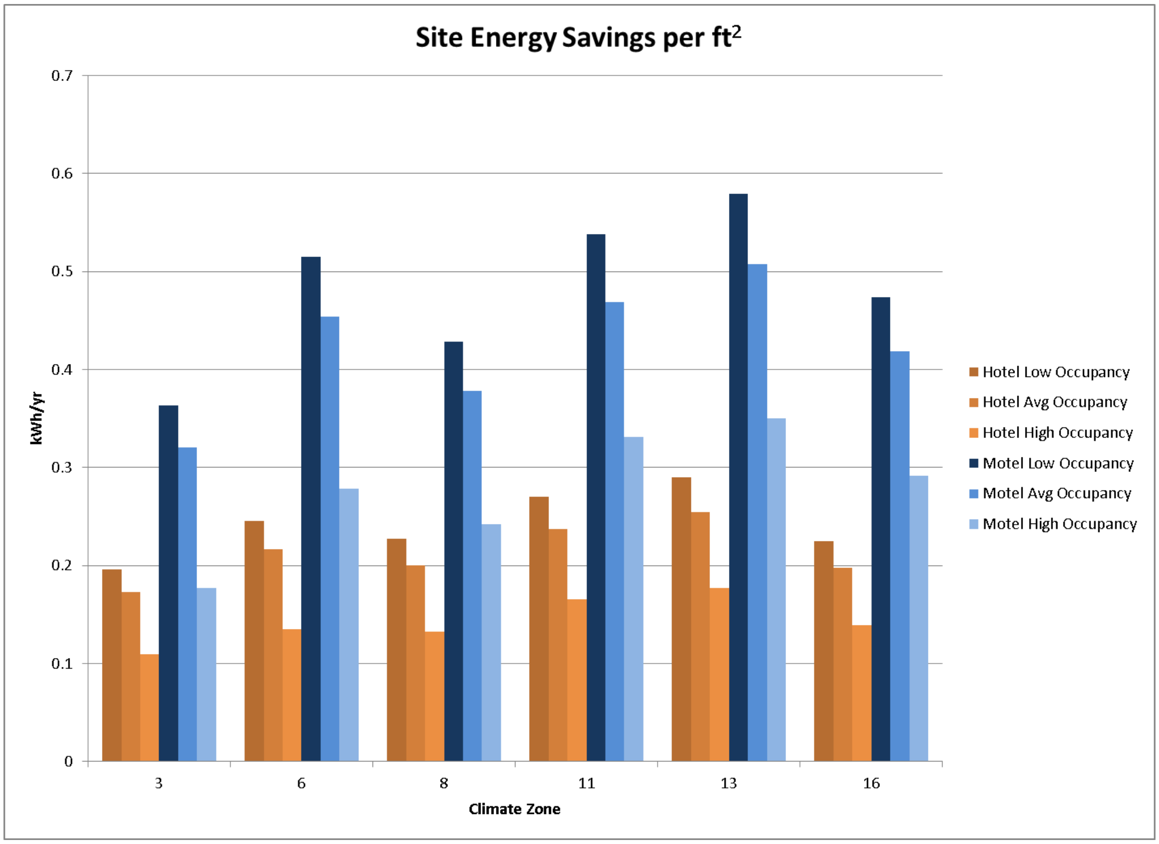

Figure 11: Charted kWh Site HVAC Savings per Square Foot by Climate Zone

A complete set of energy savings outputs for all prototypes, representative climate zones, and occupancy levels can be found in Figure 19 and Figure 20 in the Appendices.

4.2.2 Peak HVAC Energy Savings

HMG estimates a very conservative 18.12 kW kW statewide peak demand reduction with the inclusion of a compliance option for guest room occupancy controls in the 2013 California Building Energy Efficiency Standards. The peak savings were calculated using the worst case scenario of low, average, and high occupancy rooms. These results may be drastically underestimated, since both high and low occupancy rooms yielded higher peak savings than the average occupancy results. Figure 12 illustrates the peak demand savings estimated for each prototype and occupancy level in each representative climate zone, showing that peak demand savings may be as much as five times our conservative estimate.

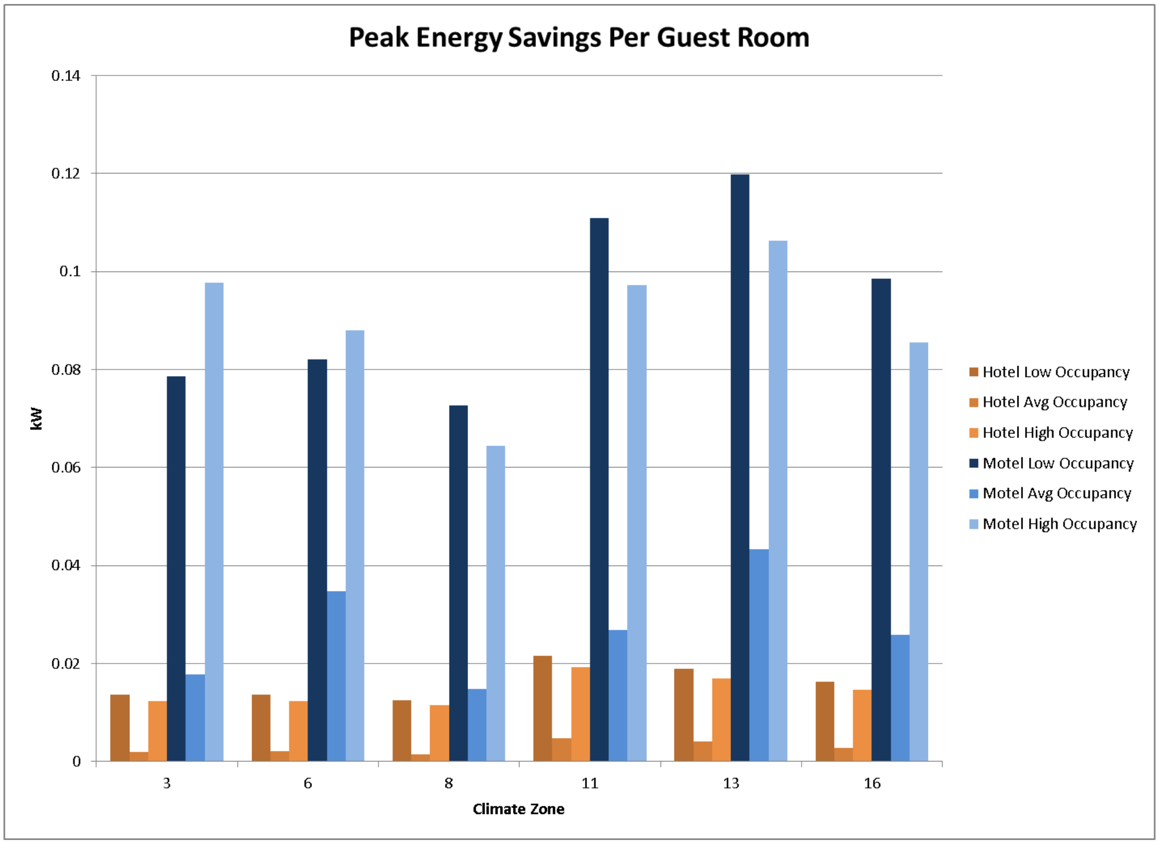

Figure 12: Peak Demand HVAC Savings per Guest Room

Figure 19 and Figure 20 in the Appendices contain a complete data set of peak energy outputs from the energy analysis.

4.2.3 HVAC TDV Savings

The TDV energy savings (in $) were calculated for each of the two prototypes, for high, low, and average occupancies, and in each of the six (6) representative climate zones, using 2013 TDV values. Results ranged from $198 to $566 per guest room and are illustrated in Figure 13. Per square foot TDV savings ranged from $0.49 to $1.76.

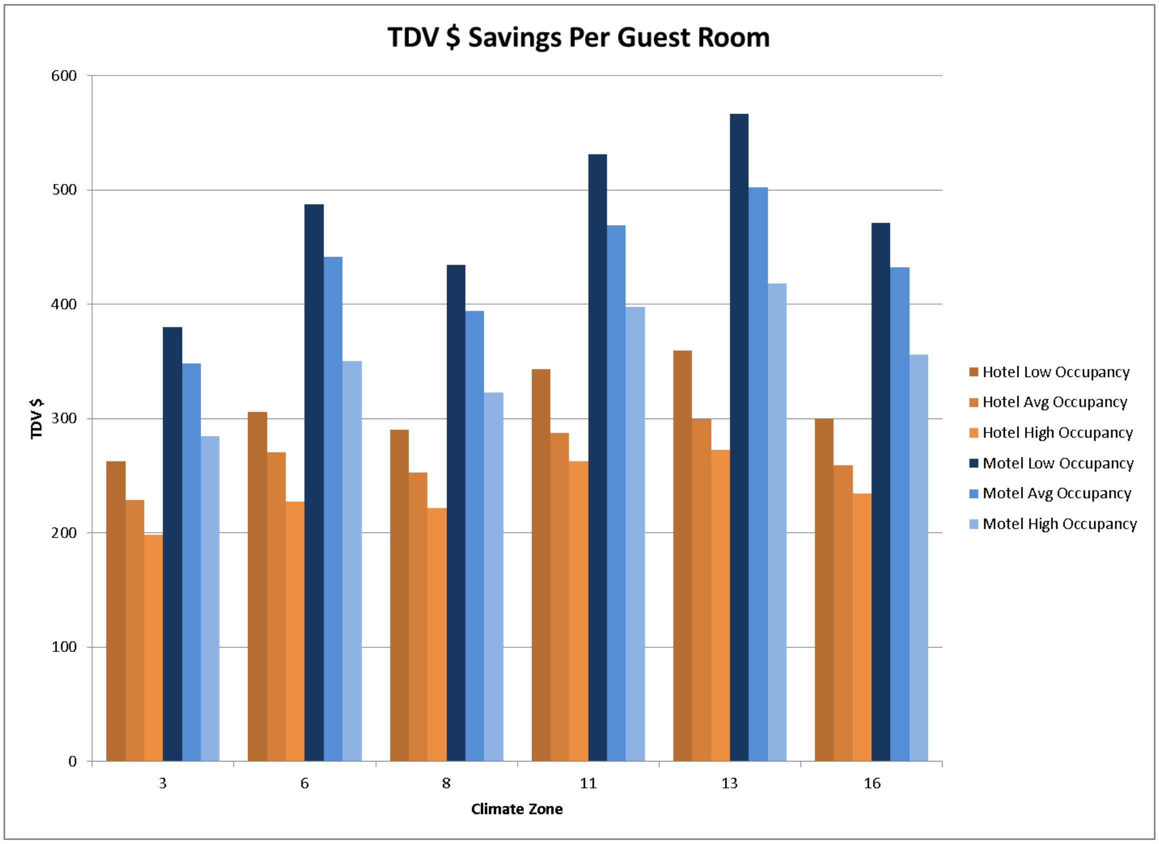

Figure 13: TDV Savings per Guest Room

Figure 21 in the Appendices contain a complete data set of TDV savings values for the 6 climate zones analyzed.

4.2.4 Statewide HVAC Energy Savings

A conservative calculation estimates that adding a compliance credit to the 2013 California Building Energy Efficiency Standards for guest room occupancy controls for PTACs will save 124,796 kWh of site energy annually and reduce peak energy demand by a minimum of 18.12 kW. This is based on calculations and assumptions outlined in the Methodology section of this report, under the 3.2.5 heading.

Figure 14 summarizes the guest room energy savings and 10% market penetration in each climate zone that contribute to the statewide savings estimate.

Climate Zone	Prototype	Site Electric Energy Savings (kWh/sf)	Site Electric Energy Savings (kWh/ guest room)	Peak Demand Savings (watts/sf)	Peak Demand Savings (watts/ guest room)	# of Guest Rooms Estimated to Claim Credit Annually	Total Energy Savings (kwh)	Total Peak Reduction (watts)
03	Hotel	0.17	69.99	0.02	7.82	274	23,739	3,515
	Motel	0.32	103.29	0.64	17.84			
	Average	0.25	86.64	0.33	12.83			
06	Hotel	0.22	87.50	0.02	8.35	161	18,811	3,469
	Motel	0.45	146.17	1.25	34.74			
	Average	0.34	116.84	0.64	21.55			
08	Hotel	0.20	80.81	0.01	5.49	429	43,460	4,358
	Motel	0.38	121.80	0.53	14.83			
	Average	0.29	101.31	0.27	10.16			
11	Hotel	0.24	95.78	0.05	18.86	68	8,389	1,552
	Motel	0.47	150.97	0.96	26.78			
	Average	0.35	123.37	0.51	22.82			
13	Hotel	0.25	102.76	0.04	15.92	283	37,671	8,392
	Motel	0.51	163.46	0.13	43.38			
	Average	0.38	133.11	0.09	29.65			
16	Hotel	0.20	79.95	0.03	11.15	283	30,396	5,227
	Motel	0.42	134.86	0.08	25.79			
	Average	0.31	107.41	0.05	18.47			
Total Statewide Energy Savings							124,796	18,121

Figure 14: Calculation of Statewide HVAC Energy Savings

4.2.5 Retrofit HVAC Savings

Honeywell Utility Solutions has been installing the Smart Systems power controller and optical sensor in California hotels and motels since October 2006 on behalf of Pacific Gas & Electric. Smart Systems International has been collecting data on the systems it has installed since 1994; the originally estimated Controller runtime reduction was 45% per installation when a 20-minute recovery strategy is utilized. Honeywell has completed over 14,000 installations in PG&E's territory, finding that the reduction in Thermostat runtime is 44% of the Air Conditioner unit runtime. Based on 15% random sample of the installations the new Controller runtime reduction is 48%.

Energy Savings

Using runtime reduction data from monitored hotels/motels in California, average operating power estimates for AC cooling power from the DEER database, and estimated duty cycles for various climate zones throughout California, the Honeywell Utility Solutions Work Paper shows power (kW) savings per PTAC unit in California climate zones (1-5, 11-13, 16). 9 The range of power savings is 0.33– 0.52 kW per PTAC unit (or guest room assuming 1 PTAC per room). Based on climate zone operating assumptions published in this work paper this equates to energy consumption values per guest room of 63.0 kWh/yr (CZ3), 340 kWh/yr (CZ11) and 348 kWh/yr (CZ13).

Honeywell Utility Solutions retrofit data show that in hot climates (climates with many cooling degree days) hotel/motel occupancy sensors can achieve large energy savings by cycling off HVAC equipment when appropriate. Projected retrofit energy savings are considerably higher than new construction savings for CZ11 (340 kWh/yr vs. 104 kWh/yr) and CZ13 (348 kWh/yr vs. 117 kWh/yr).

Measure Costs

Measure costs differ between Honeywell's installations as part of a fully operating program and quoted labor and equipment rates collected by HMG. Honeywell's reported equipment cost is lower than costs quoted in Figure 9 ($172/room vs. $232/room); however Honeywell's reported labor rates are higher ($127/room vs. $111/room). The costs reported in the Honeywell Work Paper are derived from full program model costs associated with each installation, not one off installation figures. Though there is discrepancy between Honeywell's Utility Solutions program costs and HMG reported quotes, the overall costs are consistent and the retrofit costs do not affect the measure's cost effectiveness drastically: with total installed cost for a hardwired system of $300/room (Honeywell Utility Solutions) compared to $343/room (Figure 9) the overall cost effectiveness range from $129-($181) to $172-($138).

4.2.6 Lighting Energy Savings

Lighting energy savings from guest room occupancy control systems could be realized any time a guest leaves the room without turning off the lights. Unfortunately, no data are available that explicitly describe the percentage of time for which lighting is left on in unoccupied guest rooms. However, the PIER Hotel Bathroom Lighting Control System case study measured savings resulting from a combination occupancy sensor and nightlight in hotel guest room bathrooms (CEC 2005). While this data is specific to bathroom occupancy, rather than guest room occupancy as a whole, it represents the best available occupancy-based energy savings data for hotel guest rooms. Figure 15, below, shows the reduction in lighting usage measured by the PIER study resulting from the installation of occupancy controls in hotel bathrooms. Savings numbers shown indicate the reduction in time-of-use for each block of time.

9 Honeywell Utility Solutions, Work Paper WPHWLSSC0908: Telkonet PTAC Controller & Thermostat, September 2009. Prepared for Pacific Gas & Electric Company

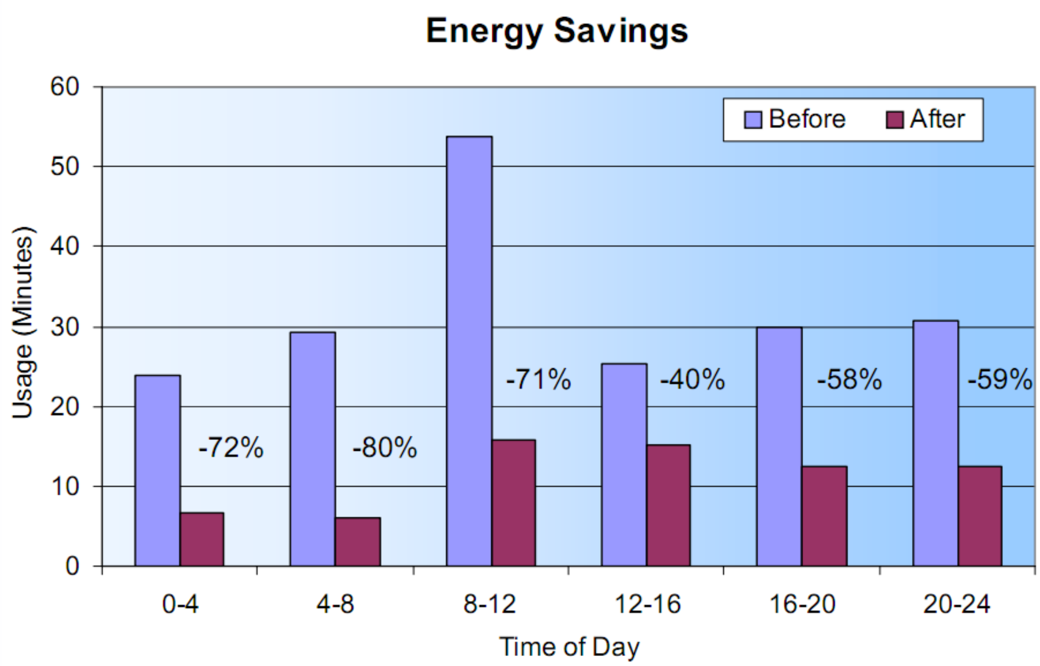

Figure 15: Energy Savings Measured by the PIER Hotel Bathroom Lighting Control Study

As shown in Figure 15, the PIER Study separated savings into six 4-hour periods throughout the day. Much of the savings from this study occur during nighttime hours, when it is likely that the guest room is occupied (while the occupant is sleeping), but there is also considerable savings during daytime hours when the guest room is more likely to be unoccupied.

To create a proxy for potential savings from a guest room occupancy control system, HMG assumed that savings between 11am (check-out time) and 5pm (early evening) were the result of bathroom lighting being left on when the guest room was unoccupied. Hours outside this range were assumed not to have any guest room occupancy control savings due to the higher likelihood that the guest room is occupied.

Claiming all the savings in Figure 15 for the period 11am-5pm assumes that the bathroom savings were due to those rooms being completely unoccupied—this results in a slight overestimate of savings because it's possible that some of the rooms were occupied but the occupants weren't using the bathrooms. However, this overestimate of savings is more than cancelled out by the underestimate that results from assuming no savings at all outside the 11am-5pm period.

We applied these same savings to the other lighting in the room (not just the bathroom lighting) to create a prediction of savings for the whole room.

To estimate potential lighting savings from guest room occupancy controls, time-of-use savings percentages shown in Figure 15 were applied to usage rates for each guest room lighting type, as shown in Figure 6 (section 3.2.4, above), for the daytime hours of 11am to 5pm. Figure 16, below, shows the potential savings from guest room occupancy controls for each lighting type, per guest room.

	Average Savings Between 11am and 5pm	Annual Savings (kWh/year)
Bathroom	16%	32.8
Bedside	15%	13.8
Desk	12%	2.5
General	22%	12.9

Figure 16: Estimated Lighting Savings

Total savings per guest room depends on how much of the lighting is controlled by the guest room occupancy controls. Because many guest room luminaires are plug-load instead of hardwired it may not always be desirable to control those luminaires with guest room occupancy controls (additional special designated outlets would be required, which would increase cost).

Annual savings estimates are calculate based on the typical guest room lighting layout and lighting usage patterns described in section 3.2.4, above, as well as the savings estimates described in this section. Usage patterns described in section 3.2.4 are assumed to represent a daily average for the entire year. Assuming that all bathroom lighting and one of the two general lighting luminaires are hardwired, total lighting savings from guest room occupancy controls would be 39.2 kWh/year per room. If all typical guest room lighting were controlled by guest room occupancy controls would be an average of 61.9 kWh/year per room.

Based on an estimate of 10% adoption (as described in section 3.2.4) and the construction forecast for 2014, statewide energy savings are predicted to range from 48,843 kWh/year to 77,127 kWh/year (depending on how much of the guest room lighting is controlled).

4.3 Cost-effectiveness

4.3.1 HVAC Cost-Effectiveness

Hotel/motel guest room occupancy controls were found to be marginally cost effective, using 2011 LCC methodology. Results ranged from a savings of $213 to an additional cost of $156, and a savings of $0.66 to an additional cost of $0.39 per square foot, showing cost effectiveness in only some climate zone and occupancy scenarios.

Figure 17 shows that the measure is only cost effective in the motel guest room prototype in the low occupancy scenario. Hotel guest rooms are never cost effective, and high occupancy schedules in motels are only cost-effective in CZ 11, 13 and 16 (cooling-dominated climates). Conservative energy savings estimates may have pushed the measure below the line of cost-effectiveness in some climate zones and occupancy scenarios. Because of the marginal cost effectiveness, the measure is proposed as a compliance option, until further research can prove cost-effectiveness.

	CZ 3	CZ 6	CZ 8	CZ 11	CZ 13	CZ 16
Hotel Low Occupancy	$ (91.18)	$ (48.30)	$ (63.80)	$ (10.54)	$ 5.89	$ (53.71)
Hotel Avg Occupancy	$ (125.28)	$ (83.48)	$ (100.76)	$ (66.26)	$ (54.70)	$ (94.54)
Hotel High Occupancy	$ (155.71)	$ (126.39)	$ (132.51)	$ (91.50)	$ (81.47)	$(119.80)
Motel Low Occupancy	$ 25.89	$ 133.36	$ 80.61	$ 177.15	$ 212.51	$ 117.18
Motel Avg Occupancy	$ (5.95)	$ 87.26	$ 40.43	$ 114.96	$ 148.65	$ 78.48
Motel High Occupancy	$ (69.10)	$ (3.72)	$ (31.34)	$ 43.84	$ 64.01	$ 2.06

Figure 17: ΔLCC Savings for HVAC controls per Guest Room by Climate Zone

4.3.2 Lighting Cost-Effectiveness

Based on the lighting energy savings estimates described in section 4.2.6, 15-year TDV savings are estimated to range from $94.79 per room (for hardwired lighting only) to $150.01 (for all guest room lighting). Total statewide TDV savings (based on the 10% adoption rated discussed above) range from $118,000 to $187,000.

The only costs associated with guest room occupancy controlled lighting would be the additional relay or power pack to control lighting, or an additional receiver for wireless systems. The cost of an additional relay to control hardwired lighting in wired control system is assumed to be approximately $30, well below the $94.79 TDV lighting savings estimated above. However, costs could be higher for wireless systems, controlling plug load lighting, or for more complex guest room lighting scenarios. For typical wired systems, lighting savings add approximately $65 to the LCC savings estimated in Figure 17, above, making guest room occupancy controls cost effective in more scenarios.

5. Recommended Code Language

5.1 Building Energy Efficiency Standards

There will be no necessary changes to the standards language for inclusion of guest room occupancy controls as a compliance option.

5.2 ACM Manuals

The ACM Manual Schedule Tables will be updated with the following changes and additions to Section 2.4.3 Schedules:

- Table N2-7 – Schedule Types of Occupancies & Sub-Occupancies will include an additional line for Hotel/Motel Guest Room with Occupancy Controlled Setback Thermostat and Lighting.
- Addition of Table N2-X - Residential Occupancy Schedules (Including Hotel/Motel Guest Rooms) with Occupancy Controlled Setback Thermostat and Lighting

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Heating	(ºF)																							
WD	59	59	59	59	59	59	67	67	66	66	66	65	65	65	65	65	65	66	66	66	66	66	59	59
SAT	59	59	59	59	59	59	67	67	66	66	66	65	65	65	65	65	65	66	66	66	66	66	59	59
Sun	59	59	59	59	59	59	67	67	66	66	66	65	65	65	65	65	65	66	66	66	66	66	59	59
Cooling	(ºF)																							
WD	79	79	79	79	79	79	79	79	80	80	80	81	81	81	81	81	81	80	80	80	80	80	79	79
SAT	79	79	79	79	79	79	79	79	80	80	80	81	81	81	81	81	81	80	80	80	80	80	79	79
Sun	79	79	79	79	79	79	79	79	80	80	80	81	81	81	81	81	81	80	80	80	80	80	79	79
Lights	(%)																							
WD	10	10	10	10	10	30	45	45	45	45	9	18	18	18	18	13	13	30	60	80	90	80	60	30
SAT	10	10	10	10	10	30	45	45	45	45	9	18	18	18	18	13	13	30	60	80	90	80	60	30
Sun	10	10	10	10	10	30	45	45	45	45	9	18	18	18	18	13	13	30	60	80	90	80	60	30
Equipment	(%)																							
WD	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
SAT	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
Sun	10	10	10	10	10	30	45	45	45	45	30	30	30	30	30	30	30	30	60	80	90	80	60	30
Fans	(%)																							
WD	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on
SAT	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on
Sun	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on	on
Infiltration	(%)																							
WD	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
SAT	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Sun	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
People	(%)																							
WD	90	90	90	90	90	90	70	40	40	20	20	20	20	20	20	30	50	50	50	70	70	80	90	90
SAT	90	90	90	90	90	90	70	40	40	20	20	20	20	20	20	30	50	50	50	70	70	80	90	90
Sun	90	90	90	90	90	90	70	40	40	20	20	20	20	20	20	30	50	50	50	70	70	80	90	90
Hot Water	(%)																							
WD	0	0	0	5	5	5	80	70	50	40	25	25	25	25	50	60	70	70	40	25	20	20	5	5
SAT	0	0	0	5	5	5	80	70	50	40	25	25	25	25	50	60	70	70	40	25	20	20	5	5
Sun	0	0	0	5	5	5	80	70	50	40	25	25	25	25	50	60	70	70	40	25	20	20	5	5

Figure 18: ACM Table N2-X - Residential Occupancy Schedules (Including Hotel/Motel Guest Rooms) with Occupancy Controlled Setback Thermostat and Lighting

5.3 Reference Appendices

There will be no necessary adjustments to the Reference Appendices.

6. Bibliography and Other Research

6.1 References

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RLW Analytics, *Savings By Design Program Evaluation*, 2007. Prepared for California Public Utilities Commission

6.2 Personal Communications

John Kriss. Director of Engineering, Mondrian Hotel
Regarding installation of occupancy controls in hotels he oversees. August 2008.

Dan Gilligan, VP of Energy and Environmental Technology, Accor North America, Inc.
Regarding experience with guest room occupancy controls in hotels he oversees. August 2008.

Anna Marie. Energy Eye.
Regarding Energy Eye's occupancy control product specifications and experience. August 2008.

John Tavares, VP of Sales/Marketing, INNCOM International, Inc.
Regarding INNCOM's occupancy control products specifications and experience. August 2008.

Lee Stevens, Energy Products, LLC
Regarding various occupancy control products and experience. June 2008.

7. Appendices

7.1 Energy Analysis Outputs

Figure 19 and Figure 20 contain the output data set and energy analysis calculations for the hotel and motel building prototypes. The average peak demand was calculated by averaging the values for all hours between 12 and 6pm, to demonstrate that the occupancy schedule inputs were operating correctly, but was not used in the peak demand savings reported in this document.

Climate zone	B=base; L=low; A=avg; H=high	**Heating Energy**	**Cooling Energy**	Lighting Energy (0.5 w/sf)	Outdoor Lighting	Process Lighting	Receptacle	**Fan Energy**	Heat Rejection	Pumps	Process	Domestic Hot Water	Total	Peak Demand (kW)	Improvement Over Baseline (kw)	Average Peak Demand (kW)	Total Heating and Cooling Baseline	Total Heating and Cooling Proposed	Improvement over Base Case	% Savings
03	B	0.0	3.0	5.6	0.0	0.0	5.6	1.6	0.0	0.0	0.0	0.0	15.8	51.9		25.3	4.61		kbtu/yr	
	L	0.0	2.6	5.6	0.0	0.0	5.6	1.3	0.0	0.0	0.0	0.0	15.1	46.5	5.5	20.0		3.92	0.69	15.0%
	A	0.0	2.7	5.6	0.0	0.0	5.6	1.3	0.0	0.0	0.0	0.0	15.2	51.1	0.8	20.4		4.00	0.61	13.3%
	H	0.0	2.8	5.6	0.0	0.0	5.6	1.4	0.0	0.0	0.0	0.0	15.4	47.0	5.0	20.3		4.23	0.39	8.4%
06	B	0.0	4.4	5.6	0.0	0.0	5.6	2.1	0.0	0.0	0.0	0.0	17.7	50.0		28.9	6.54			
	L	0.0	3.9	5.6	0.0	0.0	5.6	1.8	0.0	0.0	0.0	0.0	16.9	44.5	5.5	23.2		5.67	0.87	13.2%
	A	0.0	4.0	5.6	0.0	0.0	5.6	1.8	0.0	0.0	0.0	0.0	17.0	49.1	0.9	23.4		5.77	0.76	11.7%
	H	0.0	4.1	5.6	0.0	0.0	5.6	1.9	0.0	0.0	0.0	0.0	17.3	45.0	5.0	23.5		6.06	0.48	7.3%
08	B	0.0	3.6	5.6	0.0	0.0	5.6	1.8	0.0	0.0	0.0	0.0	16.7	46.6		27.5	5.46			
	L	0.0	3.1	5.6	0.0	0.0	5.6	1.5	0.0	0.0	0.0	0.0	15.9	41.6	5.0	22.0		4.66	0.80	14.7%
	A	0.0	3.2	5.6	0.0	0.0	5.6	1.6	0.0	0.0	0.0	0.0	16.0	46.1	0.6	22.3		4.75	0.71	12.9%
	H	0.0	3.3	5.6	0.0	0.0	5.6	1.7	0.0	0.0	0.0	0.0	16.2	42.0	4.6	22.2		4.99	0.47	8.6%
11	B	0.1	4.8	5.6	0.0	0.0	5.6	2.1	0.0	0.0	0.0	0.0	18.3	77.5		36.3	7.05			
	L	0.1	4.2	5.6	0.0	0.0	5.6	1.8	0.0	0.0	0.0	0.0	17.3	68.7	8.7	29.2		6.09	0.95	13.5%
	A	0.1	4.3	5.6	0.0	0.0	5.6	1.8	0.0	0.0	0.0	0.0	17.4	75.5	1.9	29.6		6.21	0.84	11.9%
	H	0.1	4.4	5.6	0.0	0.0	5.6	1.9	0.0	0.0	0.0	0.0	17.7	69.7	7.8	29.7		6.46	0.59	8.3%
13	B	0.1	5.4	5.6	0.0	0.0	5.6	2.3	0.0	0.0	0.0	0.0	19.1	67.1		37.7	7.86			
	L	0.1	4.8	5.6	0.0	0.0	5.6	2.0	0.0	0.0	0.0	0.0	18.0	59.5	7.6	30.5		6.84	1.02	13.0%
	A	0.1	4.8	5.6	0.0	0.0	5.6	2.0	0.0	0.0	0.0	0.0	18.2	65.5	1.6	30.8		6.96	0.90	11.4%
	H	0.1	5.0	5.6	0.0	0.0	5.6	2.2	0.0	0.0	0.0	0.0	18.4	60.3	6.8	30.9		7.23	0.63	8.0%
16	B	0.4	3.3	5.6	0.0	0.0	5.6	1.8	0.0	0.0	0.0	0.0	16.7	64.4		31.6	5.50			
	L	0.3	2.8	5.6	0.0	0.0	5.6	1.5	0.0	0.0	0.0	0.0	15.9	57.8	6.6	25.6		4.71	0.79	14.4%
	A	0.3	2.9	5.6	0.0	0.0	5.6	1.6	0.0	0.0	0.0	0.0	16.0	63.3	1.1	26.0		4.81	0.70	12.7%
	H	0.4	3.0	5.6	0.0	0.0	5.6	1.7	0.0	0.0	0.0	0.0	16.2	58.5	5.9	26.0		5.01	0.49	8.9%

Figure 19: Hotel Prototype Energy Analysis Outputs and Calculations Table

Climate zone	B=base; L=low; A=avg; H=high	**Heating Energy**	**Cooling Energy**	Lighting Energy (0.5 w/sf)	Outdoor Lighting	Process Lighting	Receptacle	**Fan Energy**	Heat Rejection	Pumps	Process	Domestic Hot Water	Total	Peak Demand (kW)	Improvement Over Baseline (kw)	Average Peak Demand (kW)	Total Heating and Cooling Baseline	Total Heating and Cooling Proposed	Improvement over Base Case	% Savings
03	B	0.1	2.0	5.6	0.0	0.0	5.6	1.0	0.0	0.0	0.0	0.0	14.4	24.4		11.5	3.17		kbtu/yr	
	L	0.0	1.6	5.6	0.0	0.0	5.6	0.8	0.0	0.0	0.0	0.0	13.6	21.5	2.8	8.9		2.38	0.79	25.0%
	A	0.0	1.6	5.6	0.0	0.0	5.6	0.8	0.0	0.0	0.0	0.0	13.7	23.7	0.6	9.2		2.47	0.70	22.1%
	H	0.0	1.9	5.6	0.0	0.0	5.6	0.9	0.0	0.0	0.0	0.0	14.0	20.8	3.5	9.1		2.78	0.39	12.2%
06	B	0.0	4.0	5.6	0.0	0.0	5.6	1.9	0.0	0.0	0.0	0.0	17.1	23.8		13.9	5.88			
	L	0.0	3.3	5.6	0.0	0.0	5.6	1.5	0.0	0.0	0.0	0.0	16.0	20.8	3.0	11.0		4.76	1.12	19.1%
	A	0.0	3.4	5.6	0.0	0.0	5.6	1.5	0.0	0.0	0.0	0.0	16.1	23.1	1.3	11.2		4.89	0.99	16.8%
	H	0.0	3.6	5.6	0.0	0.0	5.6	1.7	0.0	0.0	0.0	0.0	16.5	21.2	3.2	11.3		5.27	0.61	10.3%
08	B	0.0	3.0	5.6	0.0	0.0	5.6	1.5	0.0	0.0	0.0	0.0	15.7	21.7		12.8	4.49			
	L	0.0	2.4	5.6	0.0	0.0	5.6	1.1	0.0	0.0	0.0	0.0	14.8	19.1	2.6	10.1		3.56	0.93	20.8%
	A	0.0	2.5	5.6	0.0	0.0	5.6	1.2	0.0	0.0	0.0	0.0	14.9	21.2	0.5	10.2		3.67	0.82	18.4%
	H	0.0	2.7	5.6	0.0	0.0	5.6	1.3	0.0	0.0	0.0	0.0	15.2	19.4	2.3	10.3		3.96	0.53	11.8%
11	B	0.3	4.9	5.6	0.0	0.0	5.6	2.2	0.0	0.0	0.0	0.0	18.7	35.8		18.2	7.48			
	L	0.2	4.3	5.6	0.0	0.0	5.6	1.9	0.0	0.0	0.0	0.0	17.5	31.8	4.0	14.8		6.31	1.17	15.7%
	A	0.2	4.4	5.6	0.0	0.0	5.6	1.9	0.0	0.0	0.0	0.0	17.7	34.9	1.0	15.0		6.46	1.02	13.7%
	H	0.2	4.5	5.6	0.0	0.0	5.6	2.0	0.0	0.0	0.0	0.0	18.0	32.3	3.5	15.1		6.76	0.72	9.6%
13	B	0.4	5.7	5.6	0.0	0.0	5.6	2.6	0.0	0.0	0.0	0.0	19.9	32.8		19.7	8.64			
	L	0.3	5.0	5.6	0.0	0.0	5.6	2.1	0.0	0.0	0.0	0.0	18.6	28.5	4.3	16.1		7.38	1.26	14.6%
	A	0.3	5.1	5.6	0.0	0.0	5.6	2.2	0.0	0.0	0.0	0.0	18.7	31.2	1.6	16.3		7.53	1.11	12.8%
	H	0.3	5.3	5.6	0.0	0.0	5.6	2.3	0.0	0.0	0.0	0.0	19.1	28.9	3.8	16.5		7.88	0.76	8.8%
16	B	1.3	3.1	5.6	0.0	0.0	5.6	1.9	0.0	0.0	0.0	0.0	17.6	30.6		15.2	6.38			
	L	1.1	2.7	5.6	0.0	0.0	5.6	1.6	0.0	0.0	0.0	0.0	16.6	27.1	3.5	12.6		5.34	1.03	16.2%
	A	1.1	2.7	5.6	0.0	0.0	5.6	1.6	0.0	0.0	0.0	0.0	16.7	29.7	0.9	12.7		5.46	0.91	14.3%
	H	1.2	2.8	5.6	0.0	0.0	5.6	1.7	0.0	0.0	0.0	0.0	17.0	27.5	3.1	12.8		5.74	0.64	10.0%

Figure 20: Motel Prototype Energy Analysis Outputs and Calculations Table

		Hotel kWh Savings		Hotel Present Value Savings		Motel kWh Savings		Motel Present Value Savings	
Climate Zone	Occupancy	Per Guest Room	Per Square Foot	Per Guest Room	Per Square Foot	Per Guest Room	Per Square Foot	Per Guest Room	Per Square Foot
3	Low	79.23	0.20	$262.70	$0.65	116.90	0.36	$379.78	$1.18
	Average	69.99	0.17	$228.60	$0.57	103.29	0.32	$347.93	$1.08
	High	44.24	0.11	$198.17	$0.49	57.07	0.18	$284.79	$0.88
6	Low	99.05	0.25	$305.58	$0.76	165.86	0.52	$487.24	$1.51
	Average	87.50	0.22	$270.40	$0.67	146.17	0.45	$441.15	$1.37
	High	54.70	0.14	$227.49	$0.56	89.54	0.28	$350.17	$1.09
8	Low	91.78	0.23	$290.09	$0.72	138.03	0.43	$434.49	$1.35
	Average	80.81	0.20	$253.12	$0.63	121.80	0.38	$394.31	$1.22
	High	53.48	0.13	$221.38	$0.55	78.05	0.24	$322.54	$1.00
11	Low	109.06	0.27	$343.34	$0.85	173.37	0.54	$531.03	$1.65
	Average	95.78	0.24	$287.63	$0.71	150.97	0.47	$468.85	$1.46
	High	67.04	0.17	$262.38	$0.65	106.63	0.33	$397.72	$1.24
13	Low	117.28	0.29	$359.77	$0.89	186.63	0.58	$566.40	$1.76
	Average	102.76	0.25	$299.18	$0.74	163.46	0.51	$502.53	$1.56
	High	71.64	0.18	$272.41	$0.67	112.84	0.35	$417.89	$1.30
16	Low	90.75	0.22	$300.17	$0.74	152.69	0.47	$471.07	$1.46
	Average	79.95	0.20	$259.34	$0.64	134.86	0.42	$432.36	$1.34
	High	56.25	0.14	$234.09	$0.58	93.91	0.29	$355.95	$1.11

Figure 21: TDV Savings Table