**Work Paper PGE3PHVC149**

**Revision 2**

**PTAC/PTHP/Split AC Controller**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**PTAC/PTHP/Split AC Controller**

**Measure Code HA82**

**Ecology Action Programs:** LodgingSavers, CasinoGreen

**Ecology Action/Local Government Partnership Programs:** AMBAG Energy Watch (Hospitality Sector)

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | HA82 |
| **Measure Description** | EMS is installed in guest rooms having in-room PTAC, PTHP or Split HVAC units. EMS optimizes HVAC use during occupied periods and turns off or sets back during unoccupied periods. Source: Ecology Action and Honeywell studies. |
| **Base Case Description** | Existing guest room PTAC, PTHP or Split AC unit of 7k-15k Btuh capacity with no occupancy controls present. Base Case assumes nothing would happen without program. Source: DEER 2016. |
| **Units** | PTAC, PTHP or Split AC unit; assumes one nominal ton of cooling per unit installed (12,000 Btuh). |
| **Energy Savings** | Hotel average: 1,083 kWh/unit and 0.551 kW/unit; Motel average 788 kWh and 0.551 kW/unit (see also references section). |
| **Full Measure Cost ($/unit)** | $335 per unit average installed cost (average of $201 equipment plus $134 labor per unit). Source: Ecology Action. |
| **Incremental Measure Cost ($/unit)** | $335. Measure is an add-on and involves direct installation /retrofit, so incremental measure cost is the full measure cost. |
| **Effective Useful Life** | 5 Years. Source: DEER 2016; value is for EUL\_ID: “HVAC-PTACCtrl” |
| **Measure Installation Type** | Retrofit Add-On (REA) measure, Downstream and Direct Install delivery channel. |
| **Net-to-Gross Ratio** | 0.6 NTG. Source: DEER 2016 “Com-Default>2yrs”. |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 8/28/12 | Chaitanya Sharma, PE, Engineering Director, Ecology Action  Phil Boutelle, Energy Engineer, Ecology Action  Gene Thomas, Senior Energy Analyst, Ecology Action  Tai Voong (PG&E) | Original work paper. |
| 1 | 6/20/14 | Gene Thomas, Senior Energy Analyst, Ecology Action  Phil Boutelle, Energy Engineer, Ecology Action  Tai Voong (PG&E) | Updated to new work paper template; updated NTG; Measure Application Type changed to REA (Retrofit Add-On); noted that PTAC and PTHP measures in DEER 2014 (READI v2.0.1) remain unchanged from DEER 2005 data source; re-ran DEER 05 Hotel/Motel prototypes in eQuest using DEER 2014 (Title 24 2013) weather files; added expanded Study Results Table to Appendix. |
| 2 | 12/15/15 | Sherry Hu (PG&E);  Gene Thomas, Senior Energy Analyst, Ecology Action;  Shawn Liu (ERI) | Updated workpaper template. Updated data spreadsheet to Compliance April Spec template; added DEER measure ID, Energy Impact ID, Measure Cost ID, EUL\_ID. Revised Tech Type to “OccSens” according to DEER 2016. Other applicable DEER references updated to DEER 2016. |
|  |  |  |  |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
| N/A | N/A | N/A | N/A | * N/A | * N/A |

Cal TF website: <http://www.caltf.org/>

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

**Catalog Description** – Installation of Guest Room Energy Management System (GREMS) controls on PTAC, PTHP, or Split HVAC units in hotel and motel guest rooms. The controller must include a passive infrared occupancy sensor or occupancy card key control that turns off or modifies setpoints of the guest room HVAC unit when the room is unoccupied.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | PTAC/PTHP/Split AC Controller |
| Existing Condition | Existing guest room PTAC, PTHP or Split AC unit of 7k-15k Btuh capacity with no occupancy controls present. |
| Code/Standard | Occupancy controls not required by Code for existing guest room HVAC units. Controls are only required for new construction and when new guest room PTAC/PTHP/Split AC units are installed. |
| Industry Standard Practice | Existing guest room PTAC, PTHP or Split AC unit of 7k-15k Btuh capacity with no occupancy controls present. |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
|  |  |  | HA82 | PTAC/PTHP/Split AC Controller |

**Eligibility Requirements and Restrictions**

**Terms and Conditions:** The product must be connected to a guest room PTAC, PTHP or Split AC unit in which the unit’s on/off and setback controls are not currently controlled by an occupancy sensor or occupancy card key.

**Market Applicability:** The measure is an add-on to an uncontrolled guest room PTAC, PTHP or Split AC unit and is applicable to all hotel/motel building types and vintages in all climate zones. The type of transaction for this retrofit measure is Retrofit Add-On (REA) and the Downstream Incentive offered is designed to induce the customer to agree to the installation.

## 1.2 Technical Description

Utilizing a passive infrared occupancy sensor or occupancy card key, the guest room HVAC controller (i.e., Guest Room Energy Management System or “GREMS”) senses whether the guest room is occupied or unoccupied, and then powers down or adjusts the setpoints of the HVAC unit (either PTAC, PTHP or Split) during periods of no occupancy. The controller may be physically located in a separate control box, jointly with an occupancy sensor, or jointly with a thermostat depending on the vendor and existing site parameters. GREMS controllers are most commonly activated by a passive infrared sensor, but some are activated by an occupancy card key. The two approaches operate as follows:

• The passive infrared (PIR) sensor continuously monitors for both body heat and motion to determine whether the room is occupied or vacant; unlike standard motion sensors the infrared technology component eliminates false readings caused by occupants who are sleeping very still. More than one PIR may be needed based on room size and layout. When the PIR detects that the room is unoccupied, the sensor notifies the GREMS controller which (depending on vendor specifics) either turns the room’s HVAC unit off or puts the HVAC unit into energy saving mode.

• An occupancy card key control is triggered by insertion of a special key into a card reader box inside the room (the card key functions for both entry and occupancy status). After unlocking the door with the occupancy card key, a guest enters the room and inserts the card key into a card reader which notes that the room is occupied and signals the GREMS controller to allow the HVAC unit (depending on current temperature) to assume its predetermined setpoint. Upon leaving, the guest removes the occupancy card key which signals the GREMS (based on vendor specifics) to either turn the room’s HVAC unit off or put the HVAC unit into energy saving mode. In addition to controlling in-room HVAC units, some occupancy card key systems may optionally control room lighting and plug loads; however only savings from HVAC runtime reduction are addressed in this work paper.

GREMS using an on/off strategy may achieve higher savings overall but can generate complaints if the temperature is too high or takes too long to recover when guests reenter their rooms. Since Hotel/Motel management is highly sensitive to guest comfort issues, GREMS using setback strategies are generally more acceptable since they result in more tolerable temperature deltas and faster recovery times. While setback approaches and algorithms can vary by vendor, GREMS equipment used herein are pre-set at the factory to an “Unoccupied” status setpoint that is 8-10 degrees above the standard or previously-selected temperature. These program-specific settings are significantly more aggressive than the typical 2-5 degree setbacks that are commonly used. Energy and demand savings results from decreased HVAC runtime (i.e., reduction in EFLH) during these unoccupied periods.

## 1.3 Installation Types and Delivery Mechanisms

Retrofit Add-On (REA). The measure is an add-on control installation to an existing PTAC/PTHP or Split AC unit that lacks such controls, not a modification of or replacement of an existing PTAC/PTHP or split AC unit. As such, per DEER 2016 a single baseline is used for determining lifecycle energy savings and full installed measure costs are required.

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Retrofit Add-on (REA) | Above Customer Existing | N/A | EUL | N/A |

Financial Support is the primary Delivery Mechanism used for this measure. However, the measure may also be delivered through a Partnership mechanism when installed (along with incentives) within a Local Government Partnership program.

**Delivery Method Descriptions**

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Audit/Information/Testing Services | The program performs a free assessment of a customer’s facility and provides the customer with information and guidance on energy efficiency opportunities. |
| **Financial Support** | **The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects.** |
| Innovative Design | The program funds new ideas that meet reasonable scientific scrutiny for potential energy savings. These innovative measures typically have small market penetration (less than 5%) or are targeted toward relatively unreached market segments. |
| New Construction | The program offers financial incentives and/or design assistance to customers involved with new building construction. This is intended is to motivate customer to exceed Title 24 building energy efficiency requirements (residential or nonresidential). |
| **Partnership** | **The program implements projects through a partnership between the utility and an institutional, government, or community-based organization.** |
| Performance Based | The program offers financial incentives that vary based on the energy efficiency performance of specific projects. |
| Up-Stream Programs | See Up-Stream Incentive and Up-Stream Buy Down in the Incentive Method table. |

Direct Install is the primary incentive method for this measure. However, the measure may also be delivered through a Down-Stream Incentive method in some cases due to site-specific existing equipment considerations. In such cases, additional equipment and labor is required to effect the installation and these costs are passed on to the customer.

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| **Direct Install** | **The program implements energy efficiency measures for qualifying customers, at no cost to the customer.** |
| **Down-Stream Incentive** | **The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized.** |
| Mid-Stream Incentive | The program gives a financial incentive to a midstream market actor, such as a retailer or contractor, to encourage the promotion of efficient measures. The incentive may or may not be passed on to the end-use customer. |
| Up-Stream Incentive | The program gives a financial incentive to an upstream market actor, such as a manufacturer or distributor, to encourage the manufacture, provision, or distribution of an efficient measure. The incentive may or may not be passed on to the end-use customer. |
| Up-Stream Buy Down | The program gives a financial incentive to an upstream market actor, such as a manufacturer or distributor, with specific requirements to pass down the incentive to the end use customer. Such an incentive buys-down the cost of an efficient measure for the end-use customer by at least the amount of the financial incentive. |
| Giveaway | The program provides customers with energy efficiency equipment or services for free. |
| Exchange/Replacement | The utility program holds events where customers can trade functional equipment for similar but more energy efficient equipment, free of charge. |
| On-bill Finance/Loan | The program offers financing for the cost an efficient measure as part of the utility bill. This can be an add-on option to an existing program or can serve as an organizing principle for its own program. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

The GREMS measure is not contained in any version of DEER. Information on the base case and measure case is found in the other sub-sections of this work paper.

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | Yes |
| Scaled DEER measure | No |
| DEER Base Case | Yes |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | Yes (Base Case) |
| DEER eQUEST Prototypes | Yes |
| DEER Version | DEER 2016, READI v2.3.0 |
| Reason for Deviation from DEER | DEER does not contain this measure |
| DEER Measure IDs Used | D03-099, D03-101 |

**Net-to-Gross Ratio**

The NTG values were obtained using READI v2.3.0. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| **Com-Default>2yrs** | **All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years** | **Com** | **Any** | **Any** | **0.6** |

**Note:** Direct install measures not identified and documented as hard-to-reach will use the default NTG value.

**Spillage Rate**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The IR values were obtained using READI v2.3.0. The relevant IR values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI tool. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an RET measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| HVAC-PTACCtrl | Package Terminal AC - Controller | Com | HVAC | 15 | 5 |

### 1.4.2 Codes and Standards Analysis

**Title 20:** This measure does not fall under the 2012 Title 20 Appliance Efficiency Regulations. Title 20 covers only the required efficiency levels for new PTACs and PTHPs with integrated controls and does not address retrofits to existing in-room HVAC units. Information on the base and measure case is found in the other sub-sections of this work paper.

**Title 24:** This measure does not fall under 2013 Title 24 of the California Energy Regulations for retrofits to existing in-room HVAC units. Guest room HVAC occupancy controls are required by Title 24 2013 only for new construction and installations of new HVAC units (§120.2(e)4), not for addition of controls to existing units that lack them. This fact has been confirmed by Maziar Shirakh, PE, Title 24 Lead at California Energy Commission in conversations and emails with Ecology Action. Base and measure case information is found in the other sub-sections of this work paper.

**Federal Standards:** This measure does not fall under Federal DOE or EPA Energy Regulations. Information on the base and measure case is found in the other sub-sections of this work paper.

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2013) | Section 120.2(e)4, “Shut-off and Reset Controls for Space-conditioning Systems” | July 1, 2014 |
| Title 20 (2014) | Table X | July 1, 2015 |
| DOE | TBD | TBD |

## 1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

### 1.5.1 Related Empirical Studies

Ecology Action researched available data and reviewed 12 studies and technical papers on Guest Room Energy Management Systems. The studies were published between 2000 and 2011 and variously addressed controls on Package Terminal Air Conditioner (PTAC), Package Terminal Heat Pump (PTHP), Split Package Air Conditioner (Split) and Fan Coil HVAC systems using Occupancy Sensor (combined Passive Infrared and Motion) and Occupancy Card Key approaches. Of the 12 studies reviewed, Ecology Action excluded one as an extreme edge case (Bonneville Power Administration, 2010) and one as not applicable (Title 24 CASE Study, 2011); see the Study Comments document in the Attachments Section of this work paper for details. Table 1 below summarizes the results of the ten remaining studies that were specific to PTACs and PTHPs. For simplicity, studies with multiple sites were averaged into a single row in Table 1. For a full site-by-site listing, see the Attachments section.

**Non-HVAC GREMS Savings.** Some Occupancy Card Key GREMS systems optionally control certain guest room lighting fixtures and/or electrical outlet plug loads. Several of the studies included these GREMS types and provided lighting and/or plug load savings estimates; however our summary herein includes only HVAC study data and excludes any baseline usage and savings related to lighting and/or plug loads. This is because Lighting Controls and Plug Load Controls are separate measures which are each covered under their own work papers. The Study Comments section of this work paper (see Attachments) specifies how the lighting and plug load impacts were excluded from the Summary for these cases.

**DX-based guest room PTAC, PTHP and Split systems** of the same 7-15 kBtuh capacity (typically 12,000 BTUh or one nominal ton of cooling per unit) perform very similarly and thus GREMS on these HVAC systems are grouped as a single measure in this work paper under a single measure code (HA82).

**Fan Coil HVAC systems** differ from DX-based systems in that cooling is supplied by a central chiller and heating by a central boiler, with in-room controls varying the amount of cold or hot water that is brought from the chiller or boiler to the room’s individual fan coil. Unlike PTAC/PTHP and Split Systems, Fan Coil Systems typically also deliver natural gas (Therm) savings along with kWh and peak kW savings and are more complex in design and operation. Accordingly, Fan Coil systems will be treated as separate measure in a future update of this work paper.

The weighted average baseline consumption from the studies for guest room PTAC/PTHP/Split HVAC systems was 2,441 kWh per room, with weighted average GREMS savings of 1,015 kWh (42%) as shown in Table 2 below. We note that these values are very similar to the average baseline consumption and energy savings values found in this work paper. An expanded version of Table 2 showing individual site data from multiple-site studies is shown in the Appendix. See Section 2.2 for peak kW savings.

Table 1: Guest Room Energy Management Systems – Studies Summary



### *1.5.2 Honeywell Energy Solutions Studies*

The studies performed by Honeywell summarize data from 15% of all installations in Honeywell’s Cool Control Plus Program for PG&E customers in California. The Honeywell studies were based on data from in-room monitoring of ten hotel and motel sites over an average period of 464 days and represents the largest available dataset for deriving GREMS energy savings assumptions. Ecology Action has drawn from these findings to develop the methodology in this work paper as detailed below.

**Energy Savings Assumptions (ΔW, ΔTherms):**

No version of DEER includes the GREMS measure; however the DEER 2016 database does include Package Terminal AC and HP replacements (data source in READI v2.3.0 cites DEER 05 v2.01). Machine efficiency varies by vintage but not by Climate Zone. DEER 2016 shows energy savings for PTAC and PTHP replacements; however listed vintages in READI include only “Existing” and “New” and baseline data has been redacted. Since DEER 2016 savings values for PTAC and PTHP replacements remains unchanged from DEER 2005, baseline and vintage values must also have remained unchanged. To view all baselines and vintages one must access the original DEER 05 v2.01 reference source. The EERs and COPs listed for each vintage as well as the baseline data are taken directly from that DEER 2016 data source. “Runtime” as used in this work paper is synonymous with Equivalent Full Load Hours (EFLH) of the HVAC equipment. DEER 2016 does not include EFLH data for PTACs and PTHPs. However, the DEER 2016 data source does include baseline energy consumption for PTACs and PTHPs, and those baseline values must necessarily incorporate estimated operating hours. The estimated weighting of measure vintage is based on the actual weighting found in Ecology Action’s installations of this measure during the 2010-2012 program cycle (see Table 8).

Based on the data collected by Honeywell’s Cool Control Plus in Northern California, Honeywell estimated that 85% of the units visited will have reverse cycle or “heat pump” capabilities and those heat pump units will utilize electric strip heating 50% of all heating runtime. Strip heating is initialized at the start of all heating cycles and is required in colder temperatures. Ecology Action agrees with the finding that 85% of units will have heat pump capabilities based on our LodgingSavers program experience with this measure, but disagrees with Honeywell’s estimated 50-50 split between reverse heating and electric strip heating. Based on our program history Ecology Action believes a more reasonable split for heat pump units is 80% reverse heating and 20% strip heating; we have accordingly made this change in our kW assumptions. The following table summarizes operating performance assumptions used in the calculations:

**Table 2: Operating Performance Assumptions**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Equipment** | **CCP†** | **2013 – 2015** | **Equipment** | | |
| **Legacy Measure ID** | **Vintage** | **to date** | **Estimate** | **EER** | **COP** | **Strip kW** |
| CHtl0575PTHP2 | Before 1978 | 32% | 32% | 6.80 | 2.10 | 3.50 |
| CHtl0585PTHP2 | 1978-1992 | 34% | 34% | 7.80 | 2.40 | 3.50 |
| CHtl0596PTHP2 | 1993-2001 | 22% | 22% | 8.50 | 2.70 | 3.50 |
| CHtl0503PTHP2 | 2002-2005 | 7% | 7% | 8.90 | 2.70 | 3.50 |
| CHtl0505PTHP2 | 2006+ | 6% | 6% | 9.96 | 2.90 | 3.50 |
| **Weighted Average** |  |  |  | 7.82 | 2.42 | 3.50 |
| **Capacity** | btu/h |  |  | 12,000 | 10,800 |  |
| **Power** | kW |  |  | 1.53 | 1.31 | 3.50 |
| ***% Heat Pumps*** | *85%* | ***% Non-Heat Pumps*** | | *15%* |  |  |
| ***Heat Pump Usage\**** | |  |  |  | *80%* | *20%* |
| ***Average Power\*\**** | *kW* |  |  | ***Cooling: 1.53 kW*** |  | ***Heating:***  ***2.01 kW*** |

†*Ecology Action’s LodgingSavers, CasinoGreen and AMBAG Energy Watch Hospitality Programs, 2010-2012*

\**Heat Pumps will call for strip heat at heating start up and on many cold weather days.*

*\*\*”Average Power” is not the weighted average but rather a calculation based on the heat pump COP distribution.*

The following equations illustrate the above table’s assumptions:

kW/ton = 12/EER; for a 1 ton unit, kW = 12/EER. From the table above the average unit EER is 7.82. Hence the corresponding kW = 12/7.82 = 1.53 kW.

kW/ton = 12/3.412/COP; for a 10,800 btuh unit, kW = (12\*(10800/12000))/(3.412\*COP). From the table above the average unit COP is 2.42. Hence the corresponding kW = (12\*0.9)/(3.412\*2.42) = 1.31 kW.

Heating Power: 15% of the units are non-heat pumps that have strip heaters. Their power draw is 3.5 kW. The remaining 85% of the units are heat pumps that run on strip heating an estimated 20% of the time and work as heating units for the remaining 80% of the time. Their power draw = 0.8\*1.31 + 0.2\*3.5 = 1.75 kW. Therefore the average kW for heating power = 0.15\*3.5+0.85\*1.75 = 2.01 kW.

**Table 3: Building Types and Vintages**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Building Type** | **Bldg Vintage** | **Climate Zone** | **Electric Savings Watts** | **Study units** | **Specific study reference** |
| HTL | All | All PG&E | See At-A-Glance Measure List | See At-A-Glance Measure List | Ecology Action & Honeywell Studies |
| MTL | All | All PG&E | See At-A-Glance Measure List | See At-A-Glance Measure List | Ecology Action & Honeywell Studies |

**RUL Electric Savings** **(ΔW):** N/A. The measure is an add-on control installation to an existing PTAC/PTHP or Split AC unit, not a replacement PTAC/PTHP or Split AC unit. As such, a single baseline is used for determining lifecycle energy savings per DEER 2016.

**Comparison of DEER 2015 Source Data (DEER 05 v2.01) PTAC/PTHP Baselines vs. Study Baselines**

Energy simulations were performed using eQuest. The prototype models were extracted from eQuest version 3.54, as they were built to represent the DEER 2005 prototype buildings (as defined in Appendix D of the Statewide Customized Offering Manual, <http://www.aesc-inc.com/download/spc/2013SPCDocs/PGE/App%20D%20Building%20Descriptions.pdf>).

No changes were made to these prototype buildings. For the simulation, the ‘Code Baseline’ model was opened in eQuest version 3.65, and the updated 2013 CA T24 weather file was applied as part of the simulation process.

The results of the simulation were compiled by climate zone, vintage, and hotel/motel building types. DEER 2005 prototype models do not define a quantity of guest rooms, so typical guest room size was calculated by using the values in the 2011 study, “Guest Room Occupancy Controls”, written by the California Utilities Statewide Codes and Standards Team. Link: <http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Nonresidential/Lighting_Controls_Bldg_Power/2013_CASE_NR_Guest_Room_Occupancy_Controls_Oct_2011.pdf>

In the above CASE study, the average room sizes cited are 402 and 322 square feet for Hotels and Motels respectively. With the guest room size and the percentage area allocated to guest rooms in the DEER 2005 prototype models, the simulation baseline results were reduced to a per-room basis, equivalent to a per-unit basis for this work paper.

**Results**

The 2014 weather-updated DEER prototype eQuest baseline outputs are summarized below in Tables 4 (Hotel) and Table 5 (Motel). Actual eQuest output files are available on request. In reviewing the vintage-weighted DEER 2016 PTAC/PTHP baselines for Hotels, Ecology Action notes that they are quite close to the average baseline values shown in the studies.

Table 4: Hotel Baseline Comparison

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Ecology Action LodgingSavers Program 2010-2012 Vintage Distribution** | | | | | | | |  |
|  |  |  |  |  | |  |  |  |
| V1:  < 1978 | V2:  1978-1992 | V3:  1993-2001 | V4:  2002-2005 | V5:  > 2005 | |  |  |  |
| 32% | 34% | 22% | 7% | 6% | |  |  |  |
|  |  |  |  |  | |  |  |  |
|  |  |  |  |  | |  |  |  |
| **DEER Prototype PTAC/PTHP Baseline kWh per Room (using DEER 2014 weather files)** | | | | | | | | |
|  |  |  |  |  |  | |  |  |
| **HOTEL** | Vintage |  |  |  |  | | Wtd Avg | Savings % |
|  | V1 | V2 | V3 | V4 | V5 | | Baseline | *45%* |
| Climate |  |  |  |  |  | |  |  |
| CZ01 | 1709 | 1410 | 1286 | 1036 | 827 | | **1420** | **639** |
| CZ02 | 2828 | 2350 | 2134 | 1439 | 1361 | | **2338** | **1052** |
| CZ03 | 2429 | 1968 | 1783 | 1205 | 1361 | | **1990** | **895** |
| CZ04 | 2930 | 2459 | 2226 | 1537 | 1504 | | **2442** | **1099** |
| CZ05 | 2517 | 1936 | 1757 | 1161 | 1130 | | **1985** | **893** |
| CZ06 | 3109 | 2681 | 2166 | 1806 | 1771 | | **2595** | **1168** |
| CZ07 | 3096 | 2579 | 2070 | 1768 | 1732 | | **2531** | **1139** |
| CZ08 | 3321 | 2801 | 2273 | 1897 | 1860 | | **2738** | **1232** |
| CZ09 | 3490 | 2944 | 2399 | 1979 | 1944 | | **2878** | **1295** |
| CZ10 | 3698 | 3098 | 2804 | 1907 | 1866 | | **3075** | **1384** |
| CZ11 | 3518 | 3273 | 2492 | 2007 | 1971 | | **3022** | **1360** |
| CZ12 | 3255 | 2826 | 2152 | 1736 | 1699 | | **2679** | **1205** |
| CZ13 | 3871 | 3273 | 2519 | 2051 | 2012 | | **3146** | **1416** |
| CZ14 | 3937 | 3298 | 2605 | 2039 | 2004 | | **3193** | **1437** |
| CZ15 | 5437 | 4770 | 3845 | 3093 | 3050 | | **4571** | **2057** |
| CZ16 | 3219 | 2634 | 2181 | 1983 | 1936 | | **2640** | **1188** |
|  |  |  |  |  |  | |  |  |
|  |  |  |  |  | Avg (CA) | | 2703 | 1216 |
|  |  |  |  |  | **Avg (PG&E)** | | **2407** | **1083** |

**Table 5: Motel Baseline Comparison**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Ecology Action LodgingSavers Program 2010-2012 Vintage Distribution** | | | | | | | |  |
|  |  |  |  |  | |  |  |  |
| V1:  < 1978 | V2:  1978-1992 | V3:  1993-2001 | V4:  2002-2005 | V5:  > 2005 | |  |  |  |
| 32% | 34% | 22% | 7% | 6% | |  |  |  |
|  |  |  |  |  | |  |  |  |
|  |  |  |  |  | |  |  |  |
| **DEER Prototype PTAC/PTHP Baseline kWh per Room (using DEER 2014 weather files)** | | | | | | | | |
|  |  |  |  |  |  | |  |  |
| **MOTEL** | Vintage |  |  |  |  | | Wtd Avg | Savings % |
|  | V1 | V2 | V3 | V4 | V5 | | Baseline | *45%* |
| Climate |  |  |  |  |  | |  |  |
| CZ01 | 1331 | 1124 | 1001 | 553 | 517 | | **1091** | **491** |
| CZ02 | 2150 | 1813 | 1617 | 860 | 868 | | **1760** | **792** |
| CZ03 | 1697 | 1437 | 1284 | 656 | 654 | | **1390** | **625** |
| CZ04 | 2075 | 1765 | 1576 | 849 | 847 | | **1709** | **769** |
| CZ05 | 1743 | 1444 | 1294 | 628 | 652 | | **1407** | **633** |
| CZ06 | 2040 | 1797 | 1376 | 979 | 909 | | **1677** | **755** |
| CZ07 | 2005 | 1671 | 1247 | 899 | 915 | | **1590** | **716** |
| CZ08 | 2251 | 1881 | 1457 | 1045 | 1038 | | **1803** | **811** |
| CZ09 | 2386 | 2014 | 1576 | 1091 | 1071 | | **1922** | **865** |
| CZ10 | 2611 | 2171 | 1953 | 1049 | 1039 | | **2124** | **956** |
| CZ11 | 2635 | 2369 | 1658 | 1184 | 1098 | | **2147** | **966** |
| CZ12 | 2431 | 2085 | 1457 | 1037 | 990 | | **1926** | **867** |
| CZ13 | 2786 | 2332 | 1651 | 1195 | 1174 | | **2187** | **984** |
| CZ14 | 2893 | 2376 | 1751 | 1241 | 1203 | | **2262** | **1018** |
| CZ15 | 3707 | 3102 | 2336 | 1664 | 1559 | | **2944** | **1325** |
| CZ16 | 2627 | 2184 | 1756 | 1535 | 1436 | | **2146** | **966** |
|  |  |  |  |  |  | |  |  |
|  |  |  |  |  | Avg (CA) | | 1880 | 846 |
|  |  |  |  |  | **Avg (PG&E)** | | **1751** | **788** |

## 1.6 Data Quality and Future Data Needs

Ecology Action believes this work paper accurately captures GREMS savings for guest room PTAC, PTHP and Split AC units. As previously described, guest room Fan Coil HVAC systems are more complex in design and operation and include Therm impacts. Accordingly, guest room Fan Coil EMS will be treated as separate measure in a future update of this work paper in 2016.

# Section 2. Calculation Methodology

## 2.1 Electric Energy Savings Estimation Methodologies

**GREMS on PTAC/PTHP/Split Units**

DX-based guest room PTAC, PTHP and Split systems of the same 7-15 kBtuh capacity (typically one nominal ton of cooling per unit) perform very similarly and thus GREMS on these HVAC systems are grouped as a single measure in this work paper. Runtime data used in this work paper is based on studies performed in the Honeywell Cool Control Plus program in California, in which runtime data from 15% of all installations was collected for 3-months and 6-months after installation as part of the rigorous quality control process associated with that program. The data points contained in these logs are the following:

• Hours of cooling during occupied periods

• Hours of heating during occupied periods

• Hours of cooling during unoccupied periods

• Hours of heating during unoccupied periods

• Hours of no operation during occupied periods

• Hours of no operation during unoccupied periods

The occupied and unoccupied states were determined by the occupancy sensor installed in the room (movement & thermal detection). Equipment runtime reduction was determined by comparing runtime profiles in occupied states to those during unoccupied periods.

The gross annual energy savings are dependent on climate zone, unit size, building construction, and occupancy patterns. Previous studies estimated an average unit age and size at 7.0 years and 12.0 kBtuh. The runtime reduction was found to be 50% - 68% per Honeywell’s per data gathered from installations of 14,000 GREMS on various hotels and motels throughout California; the ten sites cited in Table 11 below average 55% reduction. Honeywell’s more conservative savings estimate of 45% is used for utility reporting. We note that this value closely approximates and is not significantly different statistically from the various GREMS studies’ weighted average savings of 42%.

**Table 6: Honeywell Study Findings**



The table below shows assumptions used to estimate annual energy savings:

**Table 7: Input Assumptions**

|  |  |
| --- | --- |
| **Category** | **Assumptions** |
| Average HVAC Age (years) | 7.0 |
| Average HVAC Capacity (kBtuh) | 12.0 |
| Unit Operating Efficiency (EER) | 8.8 |
| Runtime (EFLH) Reduction % | 45% |
| Unit Recovery Time | 20 Mins |
| Guest Room Occupancy | 50% - 60% |

Savings estimates are calculated by applying the 45% runtime reduction to the total energy consumption of the PTAC/PTHP units as modeled in eQuest using DEER Hotel and Motel prototypes and DEER 2014 weather files. Estimates of average daily equipment runtime and percentage runtime reduction are based on extensive industry experience and past historical customer evaluations, as referenced in Section 1.5x.

**Annual Electric Savings:**

**Energy Savings [kWh/Unit] = DEER Baseline Energy Consumption x % Runtime Reduction**

The following equations detail the calculation methods used to determine energy savings.

To determine the DEER baseline energy consumption, Ecology Action updated the DEER 2016 source data (DEER 05 v2.01) to incorporate the most recent (DEER 2014) weather files. This was accomplished by opening the original DEER Hotel and Motel prototypes in eQuest and re-running the files using the new weather data. This yielded weather-updated PTAC/PTHP baseline energy consumption data for five (5) vintage types (Before 1978, 1978-1992, 1993-2001, 2002-2005, 2006 and beyond). The individual vintages were then assigned weights based on Ecology Action’s experience in delivering this measure through their LodgingSavers, CasinoGreen and AMBAG Hospitality programs. The weights were assigned based on the kWh energy savings generated within each vintage type. The weights were then used to determine the weighted average baseline PTAC/PTHP energy consumption. Table 8 below shows the vintage distribution derivation:

**Table 8: Ecology Action Historical Hotel/Motel Vintage Distribution**



Equation 1, shown in the figure below, shows the baseline energy consumption as a weighted average of energy consumption data across different vintage types:

****

**Equation 1: Baseline Energy Consumption average across all vintage types (kWh)**

To determine the energy savings, the DEER Baseline Energy Consumption is multiplied with the % runtime reduction metric.

Equation 2, shown in the figure below, shows the energy savings as a product of baseline energy consumption and the % runtime reduction:

****

**Equation 2: Annual Energy Savings (kWh)**

The following example calculation shows the steps taken to find the annual savings in California Climate Zone 12. The pertinent information from Table 1 and Table 5 to complete these calculations is shown below:

Climate Zone 12 (Hotel):

Vintage Type 1 DEER baseline energy consumption: 3,255 kWh/yr

Vintage Type 2 DEER baseline energy consumption: 2,826 kWh/yr

Vintage Type 3 DEER baseline energy consumption: 2,152 kWh/yr

Vintage Type 4 DEER baseline energy consumption: 1,736 kWh/yr

Vintage Type 5 DEER baseline energy consumption: 1,699 kWh/yr

Weights to average across Vintage Types: V1: 32%; V2: 34%; V3: 22%; V4: 7%; V5: 5%

Runtime Reduction: 45%

NOTE: Vintage weights rounded to whole numbers to equal 100%

**Step 1:** Use Equation 1 to calculate the weighted average baseline case energy consumption for PTAC/PTHP units across all vintage types.

Baseline\_PTAC/PTHP = PTAC/PTHP with no EMS

Baseline\_ PTAC/PTHP = {32% \* 3,255 kWh/yr + 34% \* 2,826 kWh/yr + 22% \* 2,152 kWh/yr + 7% \* 1,736 kWh/yr + 5% \* 1,699 kWh/yr}

Baseline\_ PTAC/PTHP = 2,679 kWh/yr

**Step 2:** Use Equation 2 to find the annual energy savings.

Annual\_Energy\_Savings = Baseline\_PTAC/PTHP \* %\_Runtime\_Reduction

Annual\_Energy\_Savings = 2,679 kWh/yr \* 45%

Annual\_Energy\_Savings = 1,205 kWh/yr

The weighted baselines and kWh savings results are summarized in Table 9 below:

Table 9: Summary of PTAC/PTHP Vintage-Weighted Baselines and Savings by Climate Zone

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **HOTEL** | | |  | **MOTEL** | | |
| Climate | Baseline | Savings |  | Climate | Baseline | Savings |
| CZ01 | 1420 | **639** |  | CZ01 | 1091 | **491** |
| CZ02 | 2338 | **1052** |  | CZ02 | 1760 | **792** |
| CZ03 | 1990 | **895** |  | CZ03 | 1390 | **625** |
| CZ04 | 2442 | **1099** |  | CZ04 | 1709 | **769** |
| CZ05 | 1985 | **893** |  | CZ05 | 1407 | **633** |
| CZ06 | 2595 | **1168** |  | CZ06 | 1677 | **755** |
| CZ07 | 2531 | **1139** |  | CZ07 | 1590 | **716** |
| CZ08 | 2738 | **1232** |  | CZ08 | 1803 | **811** |
| CZ09 | 2878 | **1295** |  | CZ09 | 1922 | **865** |
| CZ10 | 3075 | **1384** |  | CZ10 | 2124 | **956** |
| CZ11 | 3022 | **1360** |  | CZ11 | 2147 | **966** |
| CZ12 | 2679 | **1205** |  | CZ12 | 1926 | **867** |
| CZ13 | 3146 | **1416** |  | CZ13 | 2187 | **984** |
| CZ14 | 3193 | **1437** |  | CZ14 | 2262 | **1018** |
| CZ15 | 4571 | **2057** |  | CZ15 | 2944 | **1325** |
| CZ16 | 2640 | **1188** |  | CZ16 | 2146 | **966** |
|  |  |  |  |  |  |  |
| Avg (CA) | 2703 | 1216 |  | Avg (CA) | 1880 | 846 |
| **Avg (PG&E)** | **2407** | **1083** |  | **Avg PG&E)** | **1751** | **788** |

## 2.2 Demand Reduction Estimation

Due to this measure’s dependency on guest room daily occupancy patterns, it is difficult to calculate gross peak demand reduction. California Lighting Technology Center (CTLC) studied three sites and found that the percentage of time a hotel room is actually occupied is as follows:

Table 10: Occupancy Patterns



Honeywell’s work paper cites a 50-60% average occupancy rate (see Table 12 and References section) based on 14,000 GREMS installations, which corresponds well with CLTC’s 58% average occupancy findings shown above. Typical hotel/motel occupancy patterns are reflected in the average 45% runtime reduction used in this work paper.

To calculate peak reduction, this work paper utilizes conservative assumptions of operating duty cycle during the hottest afternoons of the year. The following table shows the assumptions that have been made and the calculated capacity reduction:

Table 11: Peak Period Duty Cycle Reduction Assumptions

|  |  |  |
| --- | --- | --- |
| **Variable** | **Estimate** | **Source** |
| Operating Power | 1.53 kW | See Section 1.5.2 |
| Runtime (EFLH) Reduction | 45% | See Table 7 |
| Base Case Duty Cycle | See below | Conservative assumptions |
| ***Base Case Duty Cycle by Climate Zone*** | | |
| **CZ 01** | **75%** | |
| **CZ 02** | **75%** | |
| **CZ 03** | **50%** | |
| **CZ 04** | **50%** | |
| **CZ 05** | **50%** | |
| **CZ 11** | **80%** | |
| **CZ 12** | **80%** | |
| **CZ 13** | **80%** | |
| **CZ 16** | **75%** | |

The above duty cycles are created using assumption that when the average temperature of a CZ during the DEER peak hours is:

* Between 60 to 70 °F: Duty cycle is 50%
* Between 70 to 80 °F: Duty cycle is 75%
* Above 80 °F: Duty cycle is 80%

The average temperatures of the different CZs during their corresponding DEER peak hours using the most recent DEER weather data (Title 24 2013) is shown below:

**Table 1: DEER Peak Period Temperature Assumptions**



It is assumed that only the cooling cycle will be in operation during peak demand periods, so an operating power of 1.53 kW is used, as outlined in Section 1.5.2.

To calculate peak demand reduction that results from installing a PTAC/PTHP or Split AC unit EMS, find the product of the base case duty cycle, runtime reduction, and operating power, as seen below in Equation 3:

****

Equation : Demand Reduction (kW)

The following example calculation shows the steps taken to find the peak demand reduction in California Climate Zone 12. The pertinent information from Table 11 and Table 12, and the delta wattage assumptions from Section 1.5.2 to complete these calculations, is shown below:

Peak Capacity Reduction: 80%

Runtime Reduction: 45%

Cooling Power: 1.53 kW

Demand Reduction = Peak Capacity Reduction \* Runtime Reduction \* Cooling Power

Demand Reduction = 80% \* 45% \* 1.53 kW

Demand Reduction = 0.551 KW

**Gas Energy Savings Estimation Methodologies**

There are no gas energy savings or HVAC interactive effects associated with this measure.

# Section 3. Load Shapes

The most directly applicable load shape used for this measure is the COMMERCIAL, Commercial EMS load shape. The Table below lists the applicable Building Types and Load Shapes. It is the most directly applicable among choices provided in E3 model (combination of COMMERCIAL Target Sector and Measure Electric End Use Shape choices).

Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| HTL | COMMERCIAL | Commercial EMS |
| MTL | COMMERCIAL | Commercial EMS |

# Section 4. Costs

## 4.1 Base Case Cost

Base Case assumes nothing would happen without program. Measure is a Retrofit Add-On and involves direct installation /retrofit, so not applicable.

## 4.2 Measure Case Cost

The Measure Case Costs are as follows and are based on Ecology Action’s direct field experience with thousands of GREMS installations over the last decade. Vendor quote for installed cost (applicable for add-on/early replacement situation) per guest room, and assumes one nominal ton cooling per unit (hence $/AC unit/room cost is also $/tons cost); value also used in Ecology Action 2006-08 and 2010-2012 LodgingSavers program implementation. All costs are noted as $ per measure unit:

Overall average values:

• Equipment (materials): $201.00 per controller

• Labor: $134.00 per controller

• Total: $335.00 per controller

Gross Measure Cost ($/unit) = $335.00.

Unique materials required for this measure include the following:

• Controller or specialized Thermostat

• Occupancy Sensor

• ~25’ of copper Seven-wire

• ~3’ of copper Three-wire

• Transformer

• Wiring Harness

• Miscellaneous Hardware

Direct laborers required for this measure includes the following:

• Field Installer

• Customer Coordinator

## 4.3 Full and Incremental Measure Cost

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |
| NEW/NC |
| RET/ER | (MEC + MLC) – (BEC + BLC) | MEC + MLC | (MEC + MLC) – (BEC + BLC) |
| REF | (MEC + MLC) – (BEC + BLC) | MEC + MLC | N/A |
| REA | MEC + MLC | MEC + MLC | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

Gross Measure Cost is the cost to install an energy efficient measure per the CPUC calculators. This definition implies a different meaning depending on the Measure Application type.

This Measure Application Type is: **REA.** The measure is an add-on control installation to an existing PTAC/PTHP or Split AC unit machine, not a new PTAC/PTHP or Split AC unit. As such, a single baseline is used for determining lifecycle energy savings per CPUC direction, so the Gross Measure Cost (GMC) is represented by the equation below:

GMC = (Measure Equipment Cost + Measure Labor Cost)

*GMC = $201.00 per controller + $134.00 per controller = $335.00 per controller*

\*Note: Various complicated price fluctuations are not addressed in these equations, such as future costs due to inflation in labor, future costs due to deflation in material cost, and other variables that cannot be accurately described at this time.

Incremental Measure Cost is the premium cost to install an energy efficient measure over a standard efficiency measure or code baseline measure. However in this case, standard efficiency or code baseline is a PTAC/PTHP or Split AC unit with no controller, so the Incremental Measure Cost is equal to the Gross Measure Cost (see above).

**Full and Incremental Costs**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| REA | $335 | $335 | N/A |

# Attachments

**Ecology Action Specific Comments on Guest Room Energy Management Studies**

Ecology Action notes the following specific observations related to the GREMS studies cited herein. See the References Section for additional details.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Utility/Study** | **Sites Studied** | **HVAC Type** | **GREMS Type** | **Ecology Action Comments** |
| SCE Lau Study | Comfort Inn | PTHP | Card Key | Monitored for 196.5 days; extrapolated linearly by Ecology Action to annual since study months included both heating and cooling months over half the year (1107.76 HVAC kWh\*365/196.5 = 898 kWh savings). Study found 12% of room savings on this card key system was from lighting, but only the HVAC baseline and savings are included here. |
| FEMP Case Study | Music Road Hotel | PTAC | PIRS Sensor | No comments noted. |
| ACEEE Emerging Technology Report #A042 | Emerging Technology Report | PTHP | Card Key | Study uses engineering estimates and cites 33% lighting savings, 20% HVAC savings and 25% overall savings. Ecology Action assumes 90% of room load is HVAC and 10% is lighting. The study's baseline of 2,850 kWh per room \* 90% = 2,565 HVAC baseline kWh. The study cites 713 kWh total savings per room with 20% from HVAC; 713 kWh \* 20% = 513 kWh savings from HVAC only. |
| QuEST PTAC Controls Program (PG&E) | Technical Work Paper | PTAC | PIRS Sensor | Tools used to develop savings estimates include "ASHRAE Primary and Secondary HVAC Systems and Equipment Toolkit; DOE-2 based whole building energy simulation software (e.g. eQUEST, VisualDOE); ASHRAE Bin and Modified Bin methods; other public-domain building, system, or equipment modeling software (e.g. EnergyPro, Transys); manufacturer design simulation software (e.g. Trane Trace, Carrier HAP, etc.); engineering calculations and statistical analysis." Work paper notes "Unit is defined as a hotel with 149 rooms and one packaged terminal air conditioning unit per room." Ecology Action derived per-room savings by dividing the work paper unit values by 149. |
| BC Hydro M&V Study | Blue Horizon Hotel | PTAC | PIRS Sensor | The site was monitored for 119 days (6/3 to 9/30 but study claims 139 days); savings shown here have been extrapolated linearly to annual by Ecology Action (251.86 kWh savings/room \* 365/119 = 773 annual kWh savings, and 654.67 baseline kWh \* 365/119 = 2008.011 annual baseline kWh). This is because the study covered the cooling season only and does not include any ventilation (fan only mode) OR heating savings, which should be high for this marine climate zone. This is a conservative extrapolation because PTAC cooling systems are more efficient in providing one unit of conditioning as opposed to heating, so we have scaled up to annual savings using the cooling system savings for 3 months as a proxy for heating and ventilation savings for the missing months. |
| BC Hydro M&V Study | Prince George Hotel | PTAC | PIRS Sensor | Site savings for cooling season only extrapolated linearly to annual by Ecology Action (476 kWh savings/room \* 365/119 = 1,460 annual kWh savings, baseline derived by dividing kWh savings by the 38.47% savings percentage found in the Blue Horizon. This is a conservative extrapolation because the study does not include any ventilation (fan only mode) OR heating savings, and PTAC cooling systems are more efficient in providing one unit of conditioning as opposed to heating, so we have scaled using the cooling system savings for 3 months as a proxy for heating and ventilation savings for the missing months. |
| CLTC Emerging Tech Report (SDG&E) | Hampton Inn | PTHP | PIRS Sensor | The SDG&E Study was analyzed extensively by Ecology Action since it is one of the most extensive GREMS studies we could find (the number of rooms days collected is 440/425 (baseline/test) at the Hampton Inn, 406/460 (baseline/test) at the Navy Lodge. Study mislabeled PTHPs at this site as PTACs (this is common); the fact that the study shows reverse heating values for the units demonstrates that they must be PTHPs. See Section 1.4.4 of this work paper for details. |
| CLTC Emerging Tech Report (SDG&E) | Navy Lodge | PTAC | PIRS Sensor | Extended stay facility, so smaller GREMS savings since occupancy is higher than usual. Study Typo: Heating savings mislabeled as Therms/Rm -- actually is kWh (462). Study mislabeled these PTHPs as PTACs (this is common; see above). See Section 1.4.4 of this work paper for details. |
| PG&E (Honeywell) | 10 Hotel/Motel sites | PTHP | PIRS Sensor | See Section 1.4.4 of this work paper and References section for details. Study mislabeled PTHPs as PTACs (this is common); the fact that the study shows reverse heating values for the units demonstrates that they must be PTHPs. The ten sites cited here average 55% reduction; overall runtime reduction was found to be 50% - 68% per Honeywell’s per data gathered from installations of 14,000 GREMS on various hotels and motels throughout California. Honeywell’s more conservative savings percentage of 45% is used for utility reporting. |
| KEMA Focus On Energy Evaluation, WI | Deemed Savings Manual V1.0 | PTAC | PIRS Sensor | Weighted avg savings of 9k, 12k, 15k btuh units. "Energy savings are estimated at approximately $126/room annually (1800kWh) for electrically heated and cooled spaces (PTAC units)." Study includes PTAC GREMS savings calculator; see Section 1.4.4 of this work paper for details. |
| Bonneville Power Administration, 2010 | Best Western Peppertree | PTHP | PIRS Sensor | **Ruled out as extreme edge case.** The BPA 2010 study was ruled out because in the single site studied, staff operating procedures drastically reduced potential savings (staff turned off HVAC daily after cleaning rooms, even when the rooms were rented); the author noted "If a hotel did not have this procedure then the energy savings would be significantly higher." |
| Title 24 CASE Study, 2011 | Building Modeling | PTHP | PIRS Sensor | **Ruled out as not applicable.** The Title 24 CASE study focused solely on new construction rather than retrofit applications and therefore was not applicable to retrofit projects which comprise the installations covered in this work paper. The study noted that “In a retrofit application, the efficiency of the HVAC and lighting systems is typically lower, leaving more room for improvement in energy efficiency.” The CASE study findings would apply to new PTAC/PTHP/Split systems with built-in GREMS using a shutoff approach installed in new construction hotels/motels; however Ecology Action believes the setback strategy modeled in the study (only 2 degrees) is excessively conservative compared to the 8-10 degree setback GREMS used in our programs and the 4-5 degree setback that is typical in the industry. This work paper, however, does make use of the average Hotel and Motel room sizes cited in the CASE Study (402 and 322 square feet respectively). |

**Study Summary (All Rows)**

The full study summary table below was condensed in Table 1 by averaging the results for each study that included multiple sites (BC Hydro, CLTC/SDG&E and Honeywell/PG&E). The weighted average values shown at the bottom of Table 2 for HVAC Baseline, HVAC Savings and % Savings are the bottom row values in the table below for Baseline – HVAC Only\*, Occupancy-Based HVAC Savings Only\*, and % Savings (HVAC)\*.

\* Any baseline load and savings from lighting and/or plug loads in the studies were removed. See Study Comments above for methodology and additional comments in Section 1.5.1.

**Full Summary of GREMS Study Results**



# References

The following referenced files are available upon request:

Honeywell Energy Solutions’ GREMS work paper, including studies and data from Honeywell’s Cool Control Plus program (PG&E): *Workpaper\_PG&E\_CCP\_090810 – Controller.doc*

H. Lau Study. Field Performance of a Card Key Energy Saving System for Hotel and Motels. *Proceedings of the ACEEE Summer Study 2000.*

FEMP Case Study. The Music Road Hotel, *“Demonstration and Evaluation of HVAC Controller for Lodging Facilities”, July 2002.*

Sachs, H, et. al. 2004. Emerging Energy Saving Technologies and Practices for the Buildings

Sector as of 2004. Report # A042. *American Council for an Energy Efficient Economy, October 2004*.

QuEST PTAC Controls Program, Technical Work Paper (PG&E): *HOSPITALITY – PTAC QUEST).doc*

BC Hydro M&V Study. The Blue Horizon Hotel, *“Two Passive Infrared Motion Sensor Systems for in Room Energy Hotel Management” November 2007*

California Lighting and Technology Center, Western Cooling Efficiency Center, Emerging Technologies Associates, Inc. *Hotel Guest Room Energy Controls. SDG&E, December 2008*

KEMA Focus On Energy Evaluation, WI: *bpdeemedsavingsmanuav10\_evaluationreport.pdf*

DEER data on PTAC/PTHP efficiencies, measure EUL and measure NTG are available at: [www.deeresources.com](http://www.deeresources.com)