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Emerging Technologies Program

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Hotel Bathroom Lighting Controls
San Francisco, CA

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Hotel Bathroom Lighting Controls Evaluation Report
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This evaluation report is a supplement to Report #0609, *Marketable Technologies for the Hospitality Segment*. The full list of supplements follows:

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Preface

The San Francisco office of Architectural Energy Corporation (AEC), an energy and environmental research, development, and design consulting firm headquartered in Boulder, Colorado, prepared this document for PG&E. The report was contributed to by John J. Arent, and reviewed for technical quality and responsiveness by Erik Kolderup and Donald Frey. Wayne Krill of PG&E provided guidance and input as project manager.

Please note that product and manufacturer names used in this report are proprietary and may be trademarked and copyrighted.

Acknowledgements

This project would not have been possible without the ongoing assistance of Steve Hutchison, PG&E's Hospitality Segment Program Manager and of Sharon Harris, Account Services Manager for major hotels.

The assistance of Jerry Eaton at the California Lighting Technology Center is most gratefully acknowledged.

0.0 Executive Summary

A recent Public Interest Energy Research (PIER) study observed that **a significant number of guests leave bathroom lighting on throughout the night**. Consequently, **controlling bathroom lighting has the potential for significant energy savings.**

Products are available that combine the functions of an occupancy sensor and a bathroom nightlight. One such product installs in a standard wall switch electrical box. It uses an infrared sensor to determine occupancy and has a low-wattage LED nightlight. The occupancy sensor has a configurable timeout, with an adjustable value between 15 minutes and two hours. The default timeout setting is one hour. The LED consumes less than 1W of power.

The study found that **the most significant energy savings occurred in leisure hotels and motels**.

Estimates of simple payback for two types of bathroom lighting control products are shown in Table 0-1. Paybacks are calculated for bathroom lighting loads ranging from 62W to 400W. **Energy savings will be greatest in hotels and motels with high lighting loads,** particularly ones that use incandescent luminaires in guest bathrooms. The cost of the wall switch occupancy sensor / nightlight is approximately $38, with an estimated additional $30 for installation. A PG&E rebate of $16.50 per switch is available for this product.

Table 0-1: Typical Simple Payback Estimate for Bathroom Lighting Controls

			WN-100 Wall Switch		HN-300 Fixture Mount Controller with LED	
Fixture Load	**Annual Savings (leisure)**	**Annual Savings @ $0.13 kWh**	**Simple Payback (before incentive)**	**Simple Payback with incentive**	**Simple Payback (before Incentive)**	**Simple Payback with incentive**
62 W	49.3 kWh	$6.41	10.6 yrs	8.0 yrs	14.8 yrs	11.7 yrs
90 W	74.3 kWh	$9.66	7.0 yrs	5.3 yrs	9.8 yrs	7.8 yrs
140 W	118.8 kWh	$15.44	4.4 yrs	3.3 yrs	6.2 yrs	4.9 yrs
180 W	154.4 kWh	$20.07	3.4 yrs	2.6 yrs	4.7 yrs	3.7 yrs
240 W	207.8 kWh	$27.01	2.5 yrs	1.9 yrs	3.5 yrs	2.8 yrs
400 W	350.3 kWh	$45.54	1.5 yrs	1.1 yrs	2.1 yrs	1.6 yrs

Notes: savings are for leisure hotels. Energy savings for business hotels may be significantly lower

Other product variations include a fixture-mount LED nightlight, which can be purchased either as a retrofit to an existing luminaire or as a replacement luminaire. One manufacturer's fixture-mount luminaire includes an integrated nightlight, and also includes a 9V battery backup. This costs $50 as a volume purchase, and an estimated $45 labor cost to install. A $20 incentive is available from PG&E for fixture-mount controllers.

The occupancy sensors used in the wall switch nightlight have a typical coverage area of 300 ft^2, suitable for most bathrooms. The wall switch nightlight has been used in several installations in hotels, motels, and school dormitories, with generally positive occupant feedback. The fixture-mount controller is a comparatively new product from Watt Stopper, and currently has a rebate

from PG&E of $20. The fixture-mount controller will carry a slightly longer payback than the wall switch, since it is a more costly option with similar energy savings.

1.0 Evaluation Summary

Hotel bathroom lighting controls have moderate payback. The shortest paybacks will be in hotels and motels where the existing bathroom lighting load is high. These tend to be leisure hotels and motels. Since these products are new, the number of installations is small. The feedback from hotel and motel managers has been positive. Since bathroom lights will be on for fewer hours, they will be replaced less often. Therefore, an additional benefit of bathroom lighting controls is less frequent lamp replacement, resulting in O&M savings.

Table 1-1: Evaluation Summary

Criteria	Score (1 = poor, 10 = excellent)	Notes
Speed of Implementation	6	Installation is straightforward and requires no more than 30 minutes per switch.
Focus on Products	8	Product is well-defined and benefits are readily understood.
Demand Reduction	3	Limited demand reduction; no demand response.
Cost Effectiveness	7	Significant initial cost but short payback time.
Persistence	9	Savings should persist over the product's life.
Customer Satisfaction	6	Potential risk for dissatisfaction.
Supply	3	One manufacturer; other manufacturers could make similar product.
Market Size	8	Applicable to the majority of hotels. Applicable to both CFL and incandescent fixtures.
Magnitude of Energy Savings	7	75-150 kWh annually per unit (30-60 MWh/y per 400-room hotel, or 0.1-0.2 kWh/ft2-y).
PG&E Program	6	Savings are well-defined and technology is a mature product.
Existing Installations	8	Sensors have been installed in several hotels and motels, as well as dormitories and assisted-living facilities.

2.0 Technology Overview

This report summarizes the status and potential market benefits of bathroom lighting control products. The ones reviewed have occupancy sensors and integrated LED nightlights. These products are one of many energy efficiency opportunities in hotel and motel lighting. Other lighting energy efficiency products for hotels and motels include a stairwell bi-level fixture, an improved compact fluorescent (CF) desk lamp (the "Berkeley lamp"), cold-cathode compact fluorescent lamps and LED exit signs.

Bathroom lights in many hotels and motels operate more hours than necessary. They are left on during unoccupied periods and are left on all night, because guests use them as nightlights. As a result electricity is wasted and the frequency at which lamps must be replaced is higher than necessary. Hotel and motel bathroom lighting consumes a great deal of electricity. Monitoring of a southern California hotel revealed that on average, bathroom lighting is on nearly 8 hours a day. With four 60 W lamps, that amounts to 600 kWh of electricity a year – for each guestroom.

Historically, hotel managers have been reluctant to use occupancy sensors to control guest bathroom lighting, since occupancy sensors often have shorter timeout periods than are appropriate for bathrooms. The timeout period is the amount of time from when the device no longer recognizes that someone is in the room until it turns off the lights. Managers have been concerned that lights could turn off when bathrooms are occupied, compromising guest satisfaction. One product that has been designed especially to control hotel bathroom lighting is the Watt Stopper WN-100 Motion Sensor Nightlight. The product features an adjustable timeout period and a nightlight that is automatically activated when the light is switched off. Researchers at Lawrence Berkeley National Laboratory (LBNL) found that a timeout period of 1 hour provided good energy savings, while minimizing the risk of turning off the lights when the bathroom is occupied.

2.1 Technology Description

The bathroom lighting control technology has been implemented by the Watt Stopper in two products: the WN-100 Wall Switch and the HN Fixture Mount Nightlight Controller.

2.1.1 Wall Switch with Occupancy Sensor

The WN-100 bathroom night light consists of an LED night light and an occupancy sensor built into a wall switch. It is designed to replace existing wall switches and can be easily retrofitted into existing hotels and motels.

Product Features:

- Designed specifically for hotel and motel bathrooms
- Bright LED nightlight consumes less than 1W of power
- Nightlight integrated with occupancy sensor
- Adjustable timeout period from 15 minutes to two hours (one hour recommended)
- 180 degree sensing window

- Manual ON option
- Impact-resistant lens
- Five-year warranty; UL and CUL listed

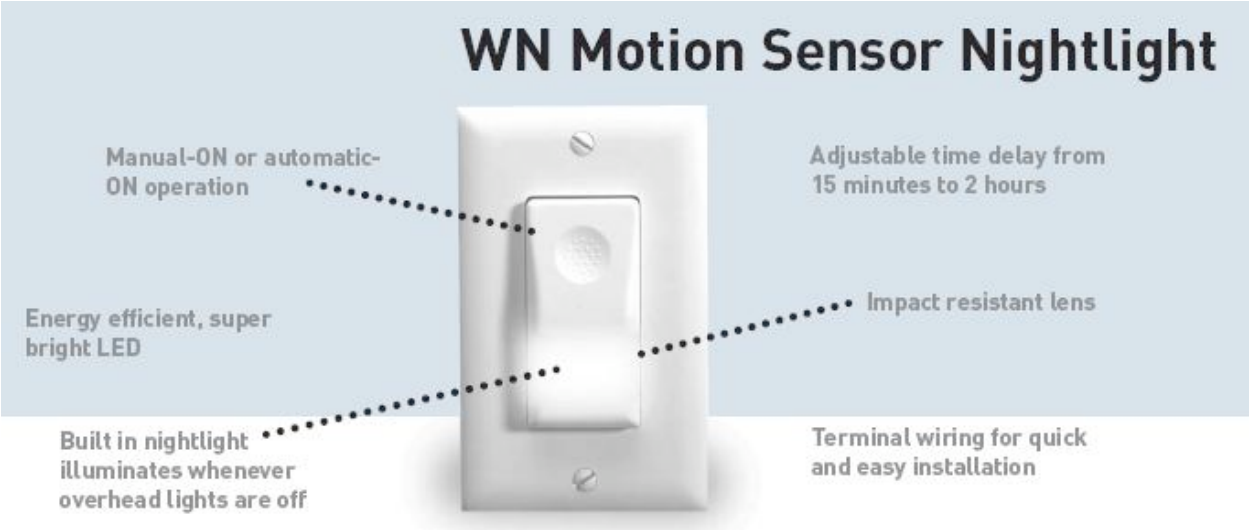

Figure 2-1: Wall Mount Occupancy Sensor / Nightlight (Courtesy: Watt Stopper, Inc.)

2.1.2 Fixture Mount Nightlight Controller

The Fixture Mount Nightlight Controller (Watt Stopper series HN system) is an energy-saving lighting control solution for bathroom vanity lighting fixtures. The HN-200 consists of a fixture mounted occupancy sensor, controller, momentary wall switch, and 9 Volt battery backup. The HN-300 system includes the same, plus an LED nightlight assembly. The HN series products are available as retrofit kits for existing fixtures. They are also being sold to fixture manufacturers, to be integrated with vanity lights for new installations and major remodels. The controller can be used with a variety of linear fluorescent fixtures of different lengths and loads. The product has the following features:

- Occupancy-based control of light fixture with fixture mounted occupancy sensor
- 9V battery for back-up power of LED nightlight for safety
- Optional LED nightlight system has adjustable light pattern

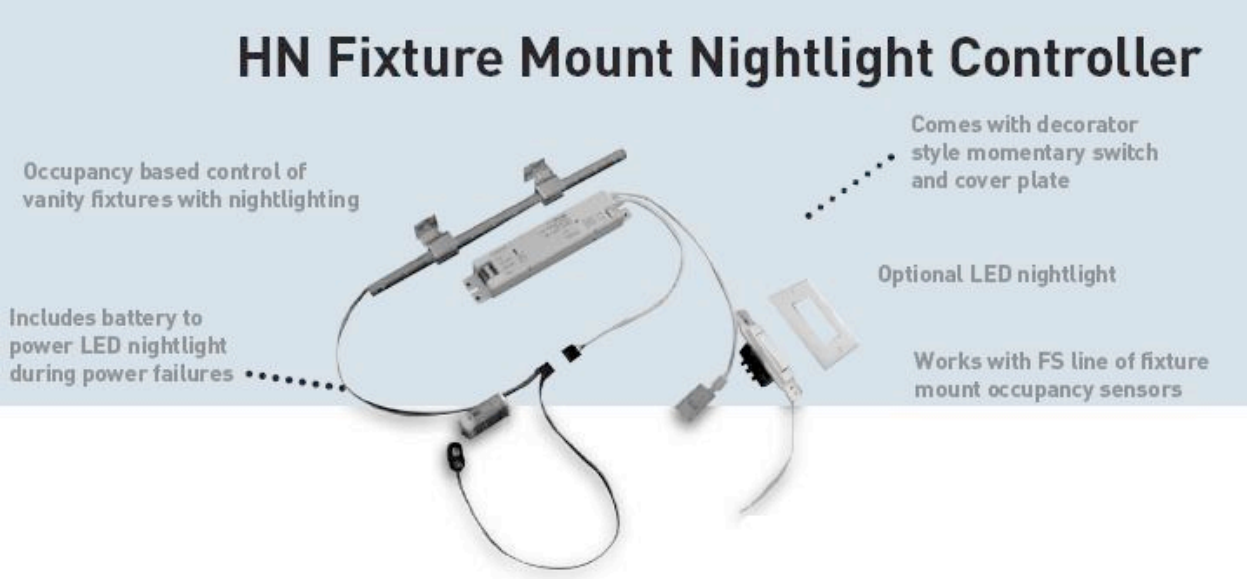

Figure 2-2: Fixture-Mount Nightlight Controller (for retrofits)

Speclight has integrated the HN controller into one of their linear fluorescent fixtures and developed a product called the Smart Vanity Light. Speclight's Smart Vanity Light is applicable to new construction and major remodels.

Figure 2-3: Speclight Smart Vanity Light

The Speclight vanity fixture incorporates an occupancy sensor and nightlight LED that also serves as an emergency light due to the battery backup feature.

2.2 Where Hotel Bathroom Lighting Controls are Applicable

Products with bathroom lighting controls are applicable in all hotel and motel guestroom bathrooms. Energy savings will be greatest in applications with the greatest number of hours of bathroom usage. As explained later in this report, energy savings are greatest in leisure hotels and motels, because guestrooms are occupied for longer periods of time than hotels and motels with other types of occupancy, such as business travelers.

The Fixture Mount Nightlight Controller is available directly to hotels and motels for retrofit applications. For new hotels and motels and major remodels, the controller is sold to fixture manufacturers for integration into bathroom linear fluorescent fixtures. The Smart Vanity Light by Speclight is one example of the controller integrated with a bathroom fixture. In addition to hotels and motels, the bathroom lighting control is also well-suited for dormitories, and assisted living and healthcare facilities.

2.3 Market Readiness (Current Status)

Bathroom lighting controls are mature products and are being used in a number of hotels and motels. The WN-100 Wall Switch was first installed in a hotel in Sacramento as part of a research program conducted by the Sacramento Municipal Utility District (SMUD). One of the findings of the program is that the magnitude of energy savings depends upon the bathroom lighting load and how the lighting is used.

The fixture mount nightlight controller (model HN-300) was introduced in early 2006, and has been installed in college dormitories at the University of California at Davis and Sonoma State University. It has also been installed at assisted living facilities. The nightlight feature of the product is attractive to assisted living facilities because it increases safety. Multiple fixture manufacturers are developing new products that will utilize either the HN-200 or HN-300.

The primary market barrier is the perceived impact on occupant satisfaction. Typical occupancy sensors have timeouts of 5–15 minutes, which is deemed too short for bathroom use. The products discussed in this report all have timeout periods or at least one hour and can be adjusted to have longer timeout periods.

2.4 Comparison to Related Technologies

Many manufacturers offer wall mounted passive infrared occupancy sensor switches. However, earlier products lacked two features of the Watt Stopper WN-100. First, they had a shorter timeout period, which makes them less suitable for hotel bathrooms. Second, the Watt Stopper product includes an LED nightlight designed for bathroom use. The technologies used for this product are well-established and could be implemented by a number of manufacturers.

Other manufacturers have copied the idea of the nightlight / occupancy sensor and have produced similar products. One example is SensorLite™ by Sensor Switch, which includes a low-power LED nightlight and a configurable time delay of up to 2 hours.

3.0 Market Opportunity, Benefits, and Cost Effectiveness

3.1 Market Opportunity

The MN-100 Motion Sensor Nightlight can be implemented in the majority of guestroom bathrooms. The switch is available in 120V and 277V and is compatible with a variety of lamp output sizes. It easily installs in place of the existing light switch.

3.2 Average System Energy and Demand Savings

Energy savings for the MN-100 Motion Sensor Nightlight are estimated at 50% of bathroom lighting use. Annually, this amounts to approximately 148 kWh per installation, for a bathroom luminaire with fluorescent lamps having a connected load of 64W. The annual savings would be approximately $20 per fixture. A similar analysis for incandescent fixtures shows a savings of nearly $40 per fixture per year, assuming two 60W lamps.

A secondary benefit results from having to replace lamps less frequently. This O&M benefit will further increase annual savings.

Research funded by the California Energy Commission's PIER program has investigated the energy reduction in rooms occupied for leisure and business purposes. Researchers found that people traveling for leisure occupy their hotel and motel guestrooms more throughout the day than people traveling for business purposes. Thus, the potential energy savings is much greater in hotels and motels occupied mostly for leisure than business. Expected annual energy savings is between 76 kWh and 154 kWh. Energy savings will be lower for lower wattage bathroom vanity fixtures.

Table 3-1: Estimated Energy Savings from Existing Case Studies

	Business Hotel	Source	Leisure Hotel	Source
Lighting load (W)	180	Sac hotel	180	Assumption
Baseline energy use (hr/day)	4.42	PIER Case Study	8	LBNL research
Energy use with occupancy sensor (hr/day)	2.37	PIER Case Study	4	Estimated 46%-56% savings (LBNL)
Occupancy sensor nightlight load (W)	0.75	Watt Stopper	0.75	Watt Stopper
Lighting use reduction (hr/day)	2.05		4	
Guestroom annual occupancy rate (%)	61%	Selwitz 2004	61%	Selwitz 2004
Increased hours lighting is off (hr/yr)	456.4		890.6	
Gross energy savings per guestroom (kWh/yr)	82.2	0.180 kW*hrs off	160.3	0.180 kW*hrs off
Nightlight consumption during occupied days (kWh/yr)	3.6	Calculation	3.3	Calculation
Nightlight energy consumption during unoccupied days (kWh/yr)	2.6	Calculation	2.6	Calculation
Net energy savings per guestroom (kWh/yr)	**76.0**	Calculation	**154.4**	Calculation

* As a conservative assumption, it is assumed that the standard (baseline) hotel bathroom light would be off at all times when no guest is checked in the hotel guestroom. If the light were left on, there could be additional savings.

Results of a lighting research program funded by the PIER program (AEC 2001) reported an average reduction in electrical demand of 7.1%. In an average guestroom with 180 W of bathroom lighting, this results in a peak demand reduction of 12.8 W per sensor.

Annual energy savings estimates resulting from the MN-100 Motion Sensor Nightlight for bathroom fixtures with a range of lighting loads are presented in Table 3-2. Savings for hotels and motels occupied by both business and leisure travelers are presented.

Table 3-2: Annual Savings Estimate for Different Fixtures

Fixture Load (W)	Annual Savings, Business (kWh)	Annual Savings, Leisure (kWh)
62	22.1	49.3
90	34.9	74.3
140	57.7	118.8
180	76	154.4
240	103.4	207.8
400	176.4	350.3

3.2.1 Other System Benefits

In a field study, some guests reported positive feedback about the nightlight features of the product.

3.2.2 Demand Response Capability

While there is a potential for reduced peak demand through a reduction of daytime lighting use, this product has no demand response capability.

3.3 Cost Effectiveness

Estimated costs for the WN-100 motion sensor are $68 each ($38/unit for a large-volume purchase and $30 at $60/hr for installation). With estimated savings of $8 to $20 annually per unit, the sensors have a simple payback of 3 to 8 years for retrofit applications. Expected useful life of the sensor is 8 to 10 years.

Sensors installed in new construction would have lower costs, since there would be little or no increase in labor time for installation.

The savings for the fixture mount controller would essentially match those of the wall switch. The volume prices for the fixture mount controller are $30 for the HN-200 (without the nightlight) and $50 for the HN-300 (with the LED nightlight).

Table 3-3: Payback Summary – Bathroom Occupancy Sensors

	Wall Switch (WN-100)	Fixture Mount Controller / LED (HN-300)
Annual savings (kWh)	76 kWh – 155 kWh (note 1)	76 kWh – 155 kWh (note 1)
Installed cost ($)	$68	$95
Simple payback (without incentives) (years)	3.5–7 years	4.7 – 9.5 years
Expected product life (years)	8 years	8 years

1- This savings estimate assumes a 180W fixture is controlled. Energy savings are roughly proportional to the existing load.

3.3.1 Factors Affecting Cost Effectiveness

Although this measure is cost effective, there are several project-specific factors that will impact energy savings.

- Hotel and motel type – leisure hotel and motel guestrooms typically have longer periods of occupancy than business hotels and motels. The potential savings of the bathroom lighting controls is greatest in leisure hotels and motels.
- Bathroom fixture type and load – savings are roughly proportional to the electrical loads of bathroom lighting fixtures. The greater the electrical load, the greater the savings. The motion sensor nightlight is generally economical for use in most leisure hotels and motels where the bathroom lighting loads are 200W or less. For business hotels and motels where bathroom lighting loads are 200W or greater, the product will provide a good payback.
- Occupancy rate – the cost analysis in this report assumes an average occupancy rate of 65%. Increased occupancy rates will increase the magnitude of the energy savings.

4.0 Design Considerations

For retrofit applications, manufacturers provide a wall mounted switch with occupancy sensor and lighting controller that can replace the existing switch. Most occupancy sensors are passive infrared (PIR) sensors that detect heat from occupants. These sensors are limited to direct line-of-sight applications. They are not able to "see" around corners or through objects that block infrared radiation. A typical PIR sensor can detect movement at a distance of 10 to 20 feet.

The WN-100 has a coverage range of 300 ft^2 and is designed for hotel guestroom bathrooms. The sensor must have a clear line of sight to the occupant in the bathroom to operate properly.

4.1 Implementation Issues

For PIR sensors, avoid placing the sensor in contact with sunlight (as under a skylight) where it may trigger false positive readings. Also, verify that the sensor does not trigger from occupant motion in adjacent areas of the guestroom. This may simply involve covering the section of the sensor that has a line of sight to the adjacent space. After an occupancy sensor is installed, it should be tested to verify coverage and sensitivity.

4.2 System Persistence Risks

The primary risk involves increased customer complaints due to "false negatives" – the light turning off when the bathroom is in use. When the timeout period is set sufficiently long (1 hour), complaints should be minimized, while still ensuring significant energy savings. Shorter timeout durations may increase the frequency of false negatives, leading to increased customer complaints.

5.0 Energy Savings Opportunity in PG&E's Territory

The opportunity for energy savings can be estimated based on average system energy savings and estimates of new construction and retrofits. Impacts have been estimated by both PIER (HMG 2001) and SMUD (Bisbee 1999, ACEEE 2004). A potential market impact is shown in Table 5-1, for an assumed 10% market penetration in PG&E territory. The overall potential is estimated to be 254 MWh per year and 32 kW per year. The CBECS database[1] shows that during 1990-2000, approximately 80 million square feet of lodging was built in the U.S. per year. Assuming that the fraction of lodging built in California is proportional to its population (may be higher, due to level of tourism in California), this amounts to 9.252 million square feet of new lodging construction in California per year.

Table 5-1: Potential Market Impact, Hotel Bathroom Occupancy Sensor

National hotel construction estimate (nationwide)	80,000,000	ft^2 per year	CBECS database, table B9, 1990-2000[2]
California hotel construction estimate	3,809,524	ft^2 per year	Assumption that PG&E territory per capita construction rate same as national rate
Guestroom construction estimate	2,857,142	ft^2 per year	Assumption that 75% of floor space is guestrooms
Guestroom size	450	ft^2 per year	Assumption used in PIER evaluation for hotel bathroom lighting control[3]
Annual guestrooms added	6,349	rooms / yr	
Retrofit market	12,698	rooms / yr	Assumption (retrofit market twice new construction)
Market penetration	10%		Assumption
Incentive program length	2	years	
Market size	2,540	rooms	
Per room savings	100	kWh	Assuming mix of business and leisure hotels
Per room demand savings	12.8	W	
Annual PG&E energy savings	254.0	MWh/yr	
Annual PG&E demand savings	32.51	kW /yr	

[1] 1 US Energy Information Administration, 1999 Commercial Buildings Energy Consumption Survey: Detailed Tables, table B9.

[2] 2 US Energy Information Administration, 1999 Commercial Buildings Energy Consumption Survey: Detailed Tables, table B9.

[3] 3 Siminovitch, M. 2003. Performance Analysis of Hotel Lighting Control System. PIER Lighting Research Program. Deliverable 4.2.1b. Contract 500-01-041. California Energy Commission. Aug. 2003.

6.0 References

Case Studies: Sacramento DoubleTree hotel installed the Watt Stopper WN-100 in 448 guest bathrooms, and reduced bathroom energy use by an average of 46%. They saved 66,500 kWh in electricity annually, resulting in a simple payback of 2.5 years. Savings were largest between 10PM and 3AM and between 7AM and 1PM.

Bisbee, Dave, 2003. “Light Emitting Diode (LED) Lighting Control Systems”, Sacramento Municipal Utilities District, Customer Advanced Technologies Program, August 2003.

Mahone, Doug 2004. “Prioritzed R&D / Standards Connections”, PIER Lighting Research Program, Deliverable 6.3.5.b, Contract 500-01-041, California Energy Commission, Nov. 2004.

Page, Erik, et. al. 1999. “Lighting Energy Savings Opportunities in Hotel Guestrooms”, LBNL 1999.

This study of a Redondo Beach hotel provided insight on lighting usage patterns in hotel guestrooms. One of the greatest energy savings opportunities was found in hotel bathrooms, where lights are often left on for a period of four hours or longer.

Siminovitch, Michael, 2003. “Performance Analysis of Hotel Lighting Control System”, PIER Lighting Research Program, Deliverable 4.2.1b, Contract 500-01-041, California Energy Commission, Aug. 2003.