**Work Paper WPSCNRLG0016**

**Revision 2**

**San Diego Gas & Electric**

**Energy Efficiency Engineering**

**Occupancy Sensors: Wall or Ceiling Mounted**

# At a Glance Summary

|  |  |
| --- | --- |
| **Measure Name** | **Occupancy Sensors:** **1-Wall or Ceiling Mounted****2-Fixture Integrated**  |
| **Savings Impacts Common Units** | Sensor |
| **Customer Base Case Description** | No Occupancy Sensor |
| **Code Base Case Description** | If the measure is affected by code, then the energy and demand savings can not be claimed |
| **Costs Common Units** | Same as Savings Impacts |
| **Building Vintage** | All |
| **Climate Zone** | Varies |
| **Measure Equipment Cost ($/unit)** | Varies |
| **Measure Incremental Cost ($/unit)** | Varies |
| **Measure Installed Cost ($/unit)** | Varies |
| **Measure Load Shape** | Indoor Lighting |
| **Effective Useful Life (EUL) in years** | 8 Years |
| **Program Type** | Retrofit (RET) |
| **Time of use (TOU) AC Adjustment** | 0% |
| **Net-to-Gross Ratio** | .6 |
| **Important Comments** | See WPSDGENRLG0999 |

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **.** |  |
| Revision 0 | N/A | Original work paper from June 2005 or March 2007 short form | Unknown |
| Revision1 | April 2010 | * Format was updated to reflect new statewide template
* NTG was updated to reflect Deer 08 updated
* Saving calculation was redone to account for negative therm
* Cost was updated to reflect deer 08 proposed cost
* Basecase was changed to reflect SDGE service territory data.
 | * Lucie Sidibe/SDGE
 |
| Revision 2 | June 5, 2012 | * Revised NTGR to .6 for 2011 DEER
* Removed Product Code J11 and J21 from 2005 DEER savings. Added controlled fixtures from 2003 work paper info
* Revised Product Code L-J31 for dual baseline fixtures
* Revised Product Code L-J41 and L-J51 Baseline fixture wattages
* Added references to WPSDGENRLG0999
 | * Charles Harmstead/SDGE
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**Note:** The information provided in this Work Paper was developed using the best available technical resources at the time this document was prepared.

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[The Controlled wattage is the same as described above in the base case description section. Interactive Effects and Peak Coincidence Factor are derived from the DEER 2008 Miser tool. For a summary of savings values, refer to embedded excel calculation sheet. 7](#_Toc328485820)

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# Section 1. General Measure and Baseline Data

## 1.1 Measure Description and Background

This work paper documents the E3 calculator input values used to forecast the impacts of either wall / ceiling mounted occupancy sensors or fixture integrated occupancy sensor higher or lower than 12 foot. The measures assume the following:

1. Wall-box lighting sensor (Product Code L-J11) and Ceiling Mounted Occupancy sensor <500 Watts (Product Code L-J21) were initially deemed in 2003 lighting work papers. Three 4’ 2-lamp fixtures with 34Watt T12 lamps were controlled. The measure has been revised for the more current T-8 electronic ballast fixture consuming 60 watts per fixture or 180 watts for the total measure.
2. For the wall or ceiling mounted occupancy sensor > 500 watts (Product Code L-J31) the occupancy sensors control eight fixtures. To satisfy dual baseline considerations for the lamps, one third of the fixtures are considered two lamp 48” T-12 linear fluorescent energy saver lamps with energy saving magnetic ballasts and 2/3 of the fixtures are considered 48” T8 linear fluorescent lamps with electronic ballasts. This estimation is due to the fact that T-12s will be in existence for the 2013-2014 transition period utilizing the DEER default of 1/3RUL and 2/3 EUL lacking any additional specific information. The wattages for the baseline and proposed fixtures were obtained from the SPC Table of Standard Fixture Wattages.
3. For the fixture integrated occupancy sensors, (Product Code J41) each occupancy sensor is assumed to be integral to one high bay linear fluorescent fixture containing programmed rapid start ballast equipped with four T5HO lamps with total wattage equal to 234 W. For the fixture integrated occupancy sensors, (Product code J51) each occupancy sensor is assumed to be integral to one three lamp linear fluorescent fixture containing programmed rapid start ballast equipped with three F32T8-STD lamps with total wattage equal to 93 W

***Program Catalog Description***

**L-J11-31. Wall or Ceiling Occupancy Sensors**

Self-Contained Wall-Switch (Wall-Box) Lighting Sensors – *line voltage units that are designed to replace a standard wall switch without additional switch/relay packs*

**Requirements**:

* Only hardwired passive infrared and/or ultrasonic detectors that control interior lighting fixtures are eligible
* **Must not** exceed the maximum Controlled wattage requirements, Listed in table 19 below

**Exclusions**:

* Sensors for exterior installations do not qualify

**Application Process**:

* Please be sure that the product qualifies under this category and not under the Bi-level Stairwell/Hall/Garage Fixtures category
	+ New fixtures equipped with fixture-integrated sensors used in stairwells, halls, or garages sometimes qualify through the Bi-level category and not the Occupancy Sensor category depending on specifications.

Table 19

|  |  |  |
| --- | --- | --- |
| **Product code** | **Description** | **Rebate/Unit Measure** |
| L-J11 | Wall-box lighting Sensor | $20.00/Sensor |
| L-J21 | Wall- or ceiling Mounted Lighting Sensor <500 Watts | $35.00/Sensor |
| L-J31 | Wall or Ceiling Mounted Lighting Sensor ≥ 500 Watts | $55.00/Sensor |

**L-J41& 51 FIXTURE INTEGRATED OCCUPANCY SENSORS**

Fixture-Integrated Sensors – *occupancy sensors that are factory or field-installed in a lighting fixture intended to control the lamps within that fixture*

**Requirements**:

* Only hardwired passive infrared and/or ultrasonic detectors that control interior lighting fixtures qualify
* Sensors must control all lamps in the fixture
* Must be inline with wattage controlled requirements listed in Table 20
* Must be compatible with installed ballast

**Application Process**:

* New fixtures equipped with fixture-integrated sensors used in stairwells, halls, or garages may qualify through the Bi-level Fixture category.
* Applications filed under Bi-level fixture category are not eligible for additional rebates through T8/T5 Lamp and Ballast, Occupancy Sensor or Linear Fluorescent Fixture categories

**Additional Details**:

* **When used in conjunction with both T8 and T5 lamps:** Program start ballasts are designed to provide maximum lamp life in frequent lamp staring applications such as in areas where occupancy sensor controls are used
* **When used in conjunction with T8 lamps:** Instant-start electronic ballasts are the most popular type of electronic ballast today because they provide maximum energy savings and start lamps without delay

**Table 20**

|  |  |  |  |
| --- | --- | --- | --- |
| **Product Code** | **Occupancy Sensor Type** | **Wattage controlled** | **Rebate/Unit** |
| L-J41 | Fixture-Integrated; Installations higher than 12'  | >150 Watts | $40.00/sensor |
| L-J51 | Fixture-Integrated; Installations 12' or under | <150 Watts | $15.00/sensor |

## 1.2 DEER Differences Analysis

Database for Energy Efficient Resources no longer lists lighting occupancy sensors. The savings calculations follow DEER methodologies with READI tool interactive effects.

## 1.3 Codes and Standards Requirements Analysis

***Title 20:*** This measure does not fall under Title 20 of the California Energy Regulations.

***Title 24:****.* Under this regulation, the following is required

Title 24 requires automatic controls that include occupancy sensors. Figure 1. **Title 24, Section 5.2.1.2 Area Controls, Shut-Off Controls §131(d)** shows Section 5.2.1.2 Area Controls, Shut-Off Controls §131(d).

The Standards require that lights on each floor of a building be controlled by a separate automatic control device (or control point with multiple point control systems).

The areas exempted from automatic shut-off are:

* Areas that must be continuously lit, such as hotel lobbies and 24-hour, 365 day per year grocery stores where lights are never turned off.
* Security or emergency egress lighting that must be continuously on, provided it does not exceed 0.5 W/ft2 and the area is controlled by switches accessible only to authorized personnel (the security or egress area must be documented on the plans).
* Corridors, guest rooms, and lodging quarters of high-rise residential buildings or hotel/motels.

The shut-off control need not be a single control, but may include automatic time switches, occupancy sensors, or other automatic controls (see Sections 5.2.1.1 A. Automatic Time Switches and B. Occupant-Sensors).

When an occupant-sensing device is used to meet the automatic shut-off requirement, it must be installed in accordance with manufacturer's instructions with regard to placement of the sensors.

Figure . Title 24, Section 5.2.1.2 Area Controls, Shut-Off Controls §131(d)

If an occupancy sensor is used to comply with this section of the code, then it cannot be used to claim energy and demand savings.

New additions to existing spaces require automatic controls which include occupancy sensors. shows selected text from Section 5.14 Additions and Alterations, §149.

***5.14 Additions and Alterations***

New additions must meet the all mandatory measures for both the prescriptive and performance method of compliance. Prescriptive requirements, including the lighting power densities must be met if prescriptive method of compliance is used. If performance approach is used, the lighting power densities may be traded-off against other prescriptive building features.

***5.14.1 Mandatory Measures – Additions and Alterations***

New additions and lighting systems that are installed for the first time in an existing space must comply with mandatory requirements of §119, §130, §131, and §132.

***5.14.2 Prescriptive Measures – Additions***

All additions must comply with the prescriptive requirements of

* §143 (c) – Minimum Skylight Area for Large Enclosed Spaces in Lowrise Buildings, and
* §146 – Prescriptive Requirements for Indoor Lighting

Additions must also meet the mandatory requirements discussed in Section 5.12.1 above. For more information on these requirements, refer to Section 5.2.2 Prescriptive Approach.

Figure . Title 24, Section 5.14, Selections Pertaining to Additions

If the occupancy sensor is used for either the mandatory, prescriptive, or performance compliance, then it cannot be used to claim energy and demand savings.

Alterations to existing spaces require automatic controls which include occupancy sensors. Figure 3. **Title 24, Section 5.14, Selections Pertaining to Alterations** shows selected text from Section 5.14 Additions and Alterations, §149.

***5.14 Additions and Alterations***

Altered lighting components must also meet applicable mandatory measures described below. Prescriptive requirements apply if in a permitted space (The Basis for the Alteration Area is discussed in Section 5.12.3, Prescriptive Measure – Alterations below) more than 50% of the fixtures are replaced, or if the connected lighting load is increased. These requirements are discussed in the following sections.

Lighting alterations generally refers to replacing the entire luminaire, which includes the housing, lamps, ballasts, and louvers or lenses. Simply replacing the lamps and ballasts in an existing fixture is not considered a lighting alteration. Replacing or installing new wiring that connects the luminaires to switches, relays, branch circuits, and other control devices represents a lighting alteration and therefore must meet the applicable mandatory requirements as described below.

***5.14.1 Mandatory Measures – Additions and Alterations***

All “altered” lighting components in alterations must comply with applicable mandatory requirements of §119, §130, §131, and §132. Although these mandatory requirements apply only to altered lighting components, it is recommended that mandatory measures be considered for the entire space to achieve maximum energy savings.

* All altered luminaires in a space must meet the automatic shut-off controls requirements of §131 (d).

For lighting alterations purposes, rewiring refers to replacement or installation of new wires that serve the circuit between the switches, relays, branch circuits, other control devices, and rewired luminaire(s). In the case where only the wiring in a circuit that connects the switch and the luminaire(s) is being replaced without any alterations to the luminaire(s), the wiring system itself is considered the altered component and must therefore meet the lighting control requirements.

***5.14.3 Prescriptive Measures – Alterations***

Alterations that involve the following must comply with §146:

* Replacing more than 50% of the luminaires, or
* An increase in the connected lighting load.

When it is necessary to calculate the existing wattage to demonstrate that the alteration does not result in an increased lighting level, use the same methodology used for new lighting installations found in this chapter.

Figure . Title 24, Section 5.14, Selections Pertaining to Alterations

If the occupancy sensor is required by or used to comply with any of the above codes, then the occupancy sensor cannot be used to claim energy and demand savings.

***Federal Standards:*** This measure does not fall under Federal DOE or EPA Energy Regulations.

1.4Measure Effective Useful Life

See WPSDGENRLG0999 for additional and updated information. The effective useful life was updated form the updated deer table and is assumed to be 8 years[[1]](#endnote-1).

## 1.5 Base Case for Savings Estimates: Existing and Above Code

1. **For Wall or Ceiling mounted Occupancy Sensors**
2. L-J21 and L-J21: The base case assumption is three T8 fixtures of two lamps.
3. L-J31: The base case assumption is an existing eight fixtures of two lamps. To satisfy dual baseline considerations for the lamps, one third of the fixtures are considered two lamp 48” T-12 linear fluorescent energy saver lamps with energy saving magnetic ballasts and 2/3 of the fixtures are considered 48” T8 linear fluorescent lamps with electronic ballasts. The wattages for the baseline and proposed fixtures were obtained from the SPC Table of Standard Fixture Wattages.[[2]](#endnote-2)

48” T-12 linear fluorescent energy saver lamps with energy saving magnetic ballasts and no occupancy sensor. The wattage of the baseline fluorescent fixture is 72 watts \* 1/3 +60 Watts \*2/3)=64 watts (72 Watts fixture code: F42EE) and (60 watts Fixture code F42LL)1 The occupancy sensor controls a total of eight fixtures, or 512 Watts.

1. **For Fixture Integrated Occupancy Sensors**
2. L-J41: For the fixture integrated occupancy sensors, each occupancy sensor is assumed to be integral to one high bay linear fluorescent fixture containing programmed rapid start ballast equipped with four T5HO lamps with total wattage equal to 234 watts per fixture. Fixture code is F44PHL/2
3. L-J51:In this scenario, the existing base case assumed for the occupancy sensor is assumed to control 3 lamp T8 32 Watt Rapid Start Ballast Fixture ( SPC Fixture code: F43LL) equal to 93 watts per fixture.

Note that in each case, the energy savings and demand reduction is calculated from no occupancy sensor to having an occupancy sensor. If the occupancy sensor was used to comply with code, then the above code energy and demand savings from the occupancy sensor is zero.

If the occupancy sensor was not used to meet code, and the code was met by other means, such as automatic time clocks, then the base case would be, in this case, automatic time clocks. It is assumed that the automatic time clock would be set to turn on and off at the beginning and end of the day, respectively. If this is the case, then the incremental energy savings would be relatively small, due to inactivity or vacancy only during lunch and break periods, which may not perfectly coincide. Therefore, above code savings are assumed to be zero.

## Hours of operation

See WPSDGENRLG0999. The hours of operation match the non-CFL lighting operating hours for each building type provided by Paul Reeves in an email to Pacific Gas and Electric Company on 11/19/2008, The table below shows a summary of it.

##

##

## 1.6 Net-to-Gross Ratio for Different Program Strategies

Net-to-Gross (NTG) Ratios are used to estimate free-ridership occurring in energy efficiency programs. Free riders are program participants who would have undertaken an activity whether or not there was an energy efficiency program promoting that activity. An NTG Ratio is a factor that represents the net program load impact divided by the gross program load impact. This factor is applied to gross program savings to determine the program's net impact.

The recommended Net-to-Gross Ratio (NTGR) for these measures are from DEER 2011 “NonRes-sAll-mOccSens” Table 6 below specifies the NTG ratio to be used for these measures[[3]](#endnote-3).

Table Net-to-Gross Ratios

|  |  |
| --- | --- |
| **Program Approach** | **NTG** |
| Lighting Control | 0.6 |

# Section 2. Calculation Methods

## 2.1 Energy Savings Estimation Methodologies

The occupancy sensor savings estimation calculation uses a 20% time off value for spaces which are assumed to have higher occupancy and a 50% time off value for spaces which are assumed to have lower occupancy.

The annual energy savings per occupancy sensor is the product of the controlled wattage, annual hours of use, energy interactive effects (EIE), and occupancy sensor percent time off (PTO). The calculation is shown in Equation 1.

 [Eq. 1]

## The Controlled wattage is the same as described above in the base case description section. Interactive Effects and Peak Coincidence Factor are derived from the DEER 2008 Miser tool. For a summary of savings values, refer to embedded excel calculation sheet[[4]](#endnote-4).

## 2.2 Demand Reduction Estimation Methodologies

As discussed in Section 2.1, the occupancy demand reduction estimation calculation uses a 20% time off value for spaces which are assumed to have higher occupancy and a 50% time off value for spaces which are assumed to have lower occupancy.

The demand reduction per occupancy sensor is the product of the controlled wattage, coincident diversity factor (CDF), demand interactive effects (DIE), and occupancy sensor percent time off (PTO). The calculation is shown in Equation 3.

 [Eq. 3]

## For a summary of savings values, refer to embedded excel calculation sheet.

**2.3 Gas Energy Saving Estimation**

Only losses in Gas savings are associated with these measures

*Gas Savings = (∆Watts/unit) x (annual hours* of use) x (3.413 BTU/Watt hours) x Interactive Effects [**Equation 3]**

 100,000 (BTU/Therm)

## For a summary of savings values, refer to both the embedded excel calculation sheet and to WPSDGENRLG0999 for individual results. WPSDGENRLG0999 shall have precedence over this workpaper.

# Section 3. Load Shapes

Load Shapes are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year. Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure’s load shape. The measure’s load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A time of use (TOU) load shape indicates what fraction occurs within five broad TOU periods, typically defined by a specific utility rate tariff. Formally, a load shape is set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure’s Total Resource Cost (TRC) benefit.

## 3.1 Base Case Load Shapes

The base case indoor lighting system demand is expected to follow a typical non-residential indoor lighting end use load shape for each market sector as shown in the E3 Calculator.

## 3.2 Measure Load Shapes

For purposes of the net benefits estimates in the E3 Calculator, what is required is the demand load shape that ideally represents the difference between the base equipment and the installed energy efficiency measure. This difference load profile is what is called the Measure Load Shape and would be the preferred load shape for use in the net benefits calculations. For the occupancy sensor measure, the base case is no occupancy sensor, so the Measure Load Shape is the same as that of the installed energy efficiency measure load shape. The occupancy sensor controls would alter each typical commercial indoor lighting hourly demand profile differently, making it difficult to select any single demand profile to represent the entire category.

The Load Shape Update Initiative Study determined that for load-following measures, the end-use load shape can be substituted for the measure shape:

“It can be argued that for measures that are roughly load-following (have a similar pattern to the end-use itself), substituting the end-use load shape for the measure shape is a reasonable simplification. Errors introduced by this substitution may be minor compared to other uncertainties in the savings valuation process. Distinguishing measure shape from end-use shape may be an unnecessary complication except for measures that are not load-following. This perspective was suggested by some workshop participants and interviewees.”

The E3 Calculator contains a fixed set of load shapes selections that are the combination of the hourly avoided costs and whatever load shape data were available at the time of the tool’s creation. In of the case of the Southern California Edison E3 Calculator, the majority of the load shape data at the time were TOU End Use load shapes and not Hourly Measure load shapes. and represent the TOU End Use Energy and Peak Demand factors for indoor lighting measures that are embedded within the E3 Calculator.



Figure . TOU Energy Factors for the Lighting End Use



Figure . TOU Demand Factors for the Lighting End Use

In the E3 Calculator, for the “Measure Electric End Use Shape” selection, the “Indoor Lighting” (IndoorLT) load shape is the only appropriate selection for the Integrated Occupancy Sensor for High Bays measure category. The “Indoor Lighting” selection is enabled for most of the nonresidential Target Sectors in Version 3c3-2000 of the E3 Calculator.

The exceptions are:

* Grocery Store, select Food Store to enable the IndoorLT load shape
* Fast Food Restaurant, select Restaurant to enable the IndoorLT load shape
* Sit Down Restaurant, select Restaurant to enable the IndoorLT load shape
* Storage Building, select Non-Refrigerated Warehouse to enable the IndoorLT load shape
* School, select K-12 School to enable the IndoorLT load shape
* Assembly, select Miscellaneous Commercial to enable the IndoorLT load shape.

# Section 4. Base Case and Measure Costs

## 4.1 Base Case Costs

The measure assumes that the base case has no occupancy sensor. The base case cost is zero.

## 4.2 Measure Costs

The measure cost for the occupancy sensor was obtained from the updated DEER cost Table 6 shows data from the DEER Cost Data spreadsheet.4

Table . DEER Cost Data for Large Area Lighting Sensor Control

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Measure Code** | **Cost Case Description** | **Cost Case ID** | **Program Delivery Strategies** | **Material Cost** | **Installation Man Hours - Retrofit** | **Installation Labor Cost - Retrofit** | **Normalizing Unit** | **IMC** |
| L-J41, L-J51 | Assume control 3 single fixture | D08-NE-ILtg-OccSens | Downstream Prescriptive Rebates/Incentives | 47.1459166666667 | 0.65 | $44.12 | Sensor | $91.27 |
| L- J11, L-J21,L-J31 | D03-856 | CALC00AVOCC01 | Downstream Prescriptive Rebates/Incentives | $42.2833 | N/A | $35.00 | Sensor | $77.2833 |

## 4.3 Incremental and Full Measure Costs

Refer to WPSDGENRLG0999 for specific incremental measure costs. The incremental and full measure cost is the same as that of the measure cost

**Attachments**

1. **References**

 WPSDGENRLG0999 contains a listing of all lighting measures used in developing the SDG&E forecast. Data and information in WPSDGENRLG0999 supersedes that contained in this workpaper. [↑](#endnote-ref-1)
2. 2 2008 Database for Energy-Efficient Resources, December 2008.

 [↑](#endnote-ref-2)
3. *DEER 2011 NTGR*

 [↑](#endnote-ref-3)
4. *Product Code Energy Savings Matrix*

 [↑](#endnote-ref-4)