Starting Time	The time needed after switching on for the la fully and remain lighted, shall be an average
Color Quality	Color Rendering Index >80
Starting Temperature	Lamp package must declare the minimum st temperatures or geographical zone of use ar conditions (e.g., use in enclosed luminaire) fo starting to meet the starting time requiremen C78.5, Clause 4.7.
Run-up Time	Per ANSI C78.5, Clause 3.11 and 4.8, shall r minutes.
Correlated Color Temperature	If a product has a color temperature that doe between 2700K and 3000K, the packaging sh describe the color of the product (cool or war the intended use for the product.
Electrical Requirements	**ENERGY STAR Specification**
Input Voltage and Frequency	120 volts, 60 Hz
Power Factor	>0.5
Electromagnetic Interference	Compliance with FCC 47 CFR Part 18 requir consumer limits
Operating Frequency	>40 kHz
Transient Protection	Per ANSI/IEEE C62.41, Category A, 7 strikes
Base	Medium screw E26/24
Compatibility with Controls	Lamp package shall clearly state any known incompatibility with photo controls, dimmers, devices.
Durability	**ENERGY STAR Specification**
Average Rated Lamp Life	6,000 hours, or greater as declared by the m
Warranty (applicable to normal residential use)	Either 12 months from date of purchase, or a such as an "800" number or address for cons complaint resolution.
Labeling	In English, or English with additional languag

Table 2
Key Product Criteria for ENERGY STAR Qualified Compact Fluorescent Lamps

Performance Characteristic	Test Procedure
Lumen Output and Efficacy	Compact Fluorescent (see note below): IESNA-LM66 Circle De LM9
Lumen Depreciation and Life	Compact Fluorescent: IESNA-LM65 & ANSI-C78.5 Circle Design: IESNA-LM40
Color Rendering Index	CIE Publication 13.3
Transient Protection	ANSI/IEEE C62.41, Category A, 7 strikes
Electromagnetic Interference	FCC 47 CFR Part 18 for consumer limits

Note: Testing with a reference ballast shall not apply to integrally ballasted compact fluorescer These lamps shall be measured with their integral ballasts at 120 volts and 60 Hz.

Self-ballasted Compact Fluorescent Lamp: A compact fluorescent lamp unit that incorporates, enclosed, all elements that are necessary for the starting and stable operation of the lamp, anc not include any replaceable or interchangeable parts.

Rated Voltage: The voltage marked on the lamp.

Rated Wattage: The wattage marked on the lamp.

Rated Supply Frequency: The frequency marked on the lamp.

Initial Performance Values: The photometric and electrical characteristics at the end of the 1(period. The lamp operating position shall be base-up when measuring the initial performance v otherwise specified by the manufacturer.

Rated Luminous Flux: Initial lumen rating declared by the manufacturer.

Lumen Maintenance: The luminous flux at a given time in the life of the lamp and expressed a percentage of the initial luminous flux. The mean lumens are the value at 40% of rated life.

Average Rated Lamp Life: The length of time declared by the manufacturer during which 50% number of lamps reach the end of their individual lives.

Lamp Color: The color characteristics of a lamp as defined by the color appearance and the c

Color Appearance: The actual color of the lamp is called the color appearance and is defined the spectral tri-stimulus values (color coordinates) according to the recommendations of the CI No. 13.3-1995. For color coordinates near the black body loci, the correlated color temperature be used to define color appearance.

Color Rendition: The effect that the spectral characteristics of the light emitted by the lamp ha appearance of the objects illuminated by it is called color rendition. The color-rendering index i terms of a comparison of the spectral tri-stimulus values of the objects under test illumination a illumination according to the recommendations of CIE Publication No. 13.2.

Starting Time: The time needed after switching on for the lamp to start fully and remain lighte(

Run-up Time: The time needed after switching on the supply for the lamp to reach 80% of its : luminous flux.

Starting Temperature: The minimum and maximum temperatures at which the lamp will reliat

Power Factor: The active power divided by the apparent power (i.e., product of the rms input ' rms input current of a ballast).

Scope: The ENERGY STAR compact fluorescent light bulb specification covers the requireme based compact fluorescent light bulbs and lamp systems, comprising:

(A) Single based compact fluorescent light bulb with twin tube, triple tube, quad tube, square, (limb configurations and having integral electronic ballasts.

(B) Circle and square lamps with a maximum diameter of 9 inches or a maximum side length o having electronic ballast adapters that are packaged with the lamp.

(C) Single based compact fluorescent lamps with integral electronic ballasts and which have a cover over the bare fluorescent tube. The cover may be globe, bullet, pear, or other shape.

(D) Single based compact fluorescent light bulbs with integral electronic ballasts and which ha\ that may be open or enclosed. The lamp shall be primarily intended to replace wide beam inca reflector lamps.

ENERGY STAR® Program Requirement for Residential Light Fixtures

Eligibility Criteria – Version 3.2

Table of Contents

P. APLAC: Asia Pacific Laboratory Accreditation Cooperation (NVLAP MRA Signatory).

Q. NACLA: National Cooperation for Laboratory Accreditation (NVLAP MRA Signatory).

R. OSHA: Occupational Safety & Health Administration.

S. NRTL: Nationally Recognized Testing Laboratory Program, which is a part of OSHA's Directorate of Technical Support.

T. ANSI: American National Standards Institute.

U. IESNA: Illuminating Engineering Society of North America.

V. CIE: Commission Internationale de l'Eclairage.

W. IEC: International Electrotechnical Commission.

X. UL: Underwriters Laboratories.

Y. NEMA: National Electrical Manufacturers Association.

Z. ALA: American Lighting Association.

AA. Recessed downlight retrofit kit: A non-linear lighting unit consisting of lamp(s), ballasting, optics, trim, and power supply connection designed to convert an incandescent or halogen type Insulated Ceiling (IC) or non-I.C. recessed downlight into an "air-tight" (AT) fixture that uses an energy-efficient source.

BB. Optics – Include reflectors, baffles, lenses and/or diffusers, all which control the light distribution and the appearance of the lighted fixture.

CC. Trim – Trim is the part of the downlight that covers the ragged edge of the ceiling cut-out. The trim may be a separate ring, or trim ring, or it may be integrated with the optics (i.e., a self-flanged reflector). Airtight or non-airtight.

DD. Pigtail – A short piece of cable with two connectors on each end for converting between one connector type and another; also referred to as a screw-based adapter and socket adapter.

2) Qualifying Products: The ENERGY STAR Residential Light Fixture specification covers the requirements for indoor and outdoor light fixtures and recessed downlight retrofit kits, as defined in Section 1A and 1Z above, and intended primarily for residential type applications. For the purposes of this ENERGY STAR specification, residential applications include single-family and multi-family dwellings (such as houses and apartments), dormitories, public or military housing, assisted-living facilities, motels and hotels, and some light commercial applications.

3) Energy-Efficiency Specifications for Qualifying Products: Only those products listed in Section 2 that meet the criteria below may qualify as ENERGY STAR. Specifications for qualifying **indoor fixtures** can be found in Table 1. Specifications for qualifying **Recessed Downlight Retrofit Kits** can be found in Table 1A. Specifications for qualifying **outdoor fixtures** can be found in either Table 2A – Outdoor Fixtures: Compliance Through Efficient Light Source or Table 2B – Outdoor Fixtures: Compliance Through Reduced Operating Time.

Correlated Color Temperature	For fixtures that are shipped with a lamp, and do not have a *rated* color temperature of 2700K or 3000K (*actual measured* CCT of 2700 to 3000K $\pm$ 200K), the packaging should clearly describe the color of the product (cool or warm) and state its intended use. For fixtures that do not ship with a lamp, a list of lamp types must be provided that would result in the fixture complying with the specification. This list must be clearly visible to the consumer on the fixture packaging. Manufacturers are not required to provide specific lamp manufacturer names and model numbers on the packaging. Rather, generic lamp listings, such as the NEMA or ANSI generic descriptions, such as F32T8/830 or CFQ26W/G24q/827, will suffice.
Noise	Class A sound rating for electromagnetic and electronic ballasts, outside the fixture. Not to exceed a measured level of 24 dBA when measured in a room with ambient noise no greater than 20 dBA.
Fixture Warranty	A written warranty must be included in fixture packaging at the time of shipment, which covers repair or replacement of defective parts of the fixture housing, optics, trim and electronics (excluding the lamp) for two years from the date of purchase.
Dimming	Torchiere style portable fixtures shall be dimmable from 100% to 30%, or less, of maximum light output, or be switchable to three levels of brightness, not including the off position. Other fixture types that utilize dimmable ballasts shall be dimmable from 100% to 30%, or less, of maximum light output, or be switchable to three levels of brightness, not including the off position.
<u>Durability:</u>	
All lamps must utilize an ANSI Standardized lamp base configuration	Lamp bases shall meet C81.61.
ANSI-IEC Standardized Lamps	Lamps shall meet ANSI C78.901-2001 or C78.81-2001 as appropriate.
Non ANSI-IEC Standardized Lamps	For fixtures using non-ANSI-IEC standardized lamps, supply a manufacturer lamp specification sheet as appropriate. (Use ANSI lamp data sheets found in ANSI C78.901 or C78.81 and C81.61. Note: Specific lamp and lamp base characteristics that should be included in the lamp specification sheet are detailed in Table 3.
ANSI Standardized Ballast	See "Performance Characteristics For Electronic and Magnetic Ballasts" presented later in this table.

End of Life Protection	Required for all T5 and smaller lamps. Manufacturer must submit laboratory data or an engineering description outlining the scheme that is used to achieve the end of life function within the ballast. [Tests for these protection circuits are under development by ANSI subcommittee C82-1 for inclusion in C82.11. ENERGY STAR may require further documentation when standard is adopted.]
Performance Characteristics for Magnetic Fluorescent Ballasts:	
General	Per ANSI C82.1 Section 5 except paragraph 5.3.1 and 5.3.2.1.
Power Factor	$\geq$ 0.5
Lamp Current Crest Factor	$\leq$ 1.7
Maximum Ballast Operating Case Temperature for Optimal Performance	$\leq$ 90° C or not to exceed ballast manufacturer recommendation, whichever is lower. **Note:** all qualified fixtures are expected to meet the Maximum Ballast Operating Case Temperature for Optimal Performance requirements. This includes every qualified fixture including linear, suspended, close-to-ceiling, IC, ICAT and Non-IC recessed canisters, etc. as well as those fixtures that may be exempt from UL1598.
Electromagnetic and Radio Frequency Interference	Not Applicable
Ballast Frequency	60 Hz
Transient Protection	Not Applicable
End of Life Protection	Not Applicable

Table 2A - Outdoor Fixtures: Compliance Through Efficient Light Source

Performance Characteristic	ENERGY STAR Specification
Maximum Input Power	150 watts
System Efficacy	≥ 40 Lumens Per Watt, for fixtures up to 70 listed lamp watts. ≥ 50 Lumens Per Watt, for fixtures from 70 to 150 listed lamp watts.
Lamp Socket Compatibility	Lamp socket can accept, but shall not operate, any lamp that either exceeds the input power range of the fixture or is a lamp type not intended for use in the fixture (i.e. metal halide lamp in a mogul base CFL fixture). **Note:** Fixtures that utilize self-ballasted compact fluorescent lamps, regardless of base type (mogul, medium, etc), are not eligible to earn the ENERGY STAR under the requirements set forth in this table.
Lamp Life	For fixtures that are shipped with a lamp, the average rated life of the lamp must be ≥ 10,000 hours. For fixtures that are not shipped with lamps, a list of lamp types must be provided that would result in the fixture complying with the specification. This list must be clearly visible to the consumer on the fixture packaging. Manufacturers are not required to provide specific lamp manufacturer names and model numbers on the packaging. Rather, generic lamp listings, such as the NEMA or ANSI generic descriptions, such as F32T8/830 or CFQ26W/G24q/827, will suffice.
Electromagnetic and Radio Frequency Interference	Ballast must be FCC rated for consumer use (FCC 47 CFR Part 18 Class B for EMI & RFI Consumer Limits).
Controls: Time of Day	 Fixture must contain an integrated daylight threshold sensor that automatically prevents operation during daylight hours. The sensor must automatically reset to sensing mode within 24 hours of a manual override or testing operation. If the daylight threshold sensor can be adjusted such that the fixture can operate during full daylight, the fixture package must provide a range of settings that will result in the fixture complying with the specification.
Fixture Warranty	A written warranty must be included in fixture packaging at shipment, which covers repair or replacement of defective parts of the fixture housing or electronics (excluding the lamp) for two years from the date of purchase.
Safety	Fixtures must be compliant with NFPA 70, the National Electrical Code (NEC), including requirements for wet locations (Articles 410-4a and Article 100).

4) Qualification Process, Acceptable Testing Facilities, Testing Standards & Required Documentation: The following section describes the steps required to qualify residential light fixtures as ENERGY STAR, provides information about acceptable testing facilities, and states the testing standards and documentation required for each performance characteristic.

Steps for Partners to Qualify Residential Light Fixtures for ENERGY STAR
To qualify a residential lighting fixture as ENERGY STAR, it must be tested according to the protocol outlined below. **Note: EPA reserves the right to require additional documentation, at any time, in order to determine compliance with all performance characteristics.**

A. Partner must test qualifying products and obtain required documentation to meet the performance characteristics listed in Section 3 of this specification. Refer to Table 3, below, to determine the reference standard and required documentation applicable to each performance characteristic.

The following stipulations apply:

- For performance characteristics that require testing, the minimum required sample size is three units for each lamp/ballast combination.
- For multiple fixture models that use the same lamp/ballast combination, only one set of test results is required. For example, two fixtures that use the same lamp and ballast combination, but have different trim, lens and/or chasse need only be tested once.
- For fixture models that may use different ballasts (either in terms of the type of ballast or manufacturer), each lamp/ballast combination must undergo testing and the test results must be submitted for qualification. For example, if a residential light fixture partner plans to use ballasts from several manufacturers in any one fixture, the fixture must be tested with each manufacturer's ballast.
- For fixture models with one ballast type that can work with multiple lamp types, the fixtures need only be tested with one lamp type. The lamp type must either be the one supplied with the fixture at shipment or, if a lamp is not supplied, one of the lamp types listed on the packaging. Please note that EPA expects all lamps listed on the packaging to comply with the specification when operating on the fixture's ballast. To ease the burden on the manufacturer, however, test data need be submitted for only one lamp type operating on the fixture's ballast.

B. Submit a signed and completed copy of the ENERGY STAR Residential Light Fixture Qualified Product Information (QPI) form along with required documentation. To obtain the current version of the form, visit the "Lighting" section of the ENERGY STAR Web site at www.energystar.gov/partners and click on "Product Specifications."

Explanation of Acceptable Testing Facilities:

- To ensure quality product in the marketplace, ENERGY STAR requires test data from a laboratory accredited by one of the following: NVLAP, a laboratory accredited through one of NVLAP's MRA signatory partners (ILAC, APLEC, NACLA), or, when appropriate, from an OSHA NRTL or a laboratory accredited by an OSHA NRTL (see Table 3 for specific requirements).

  Please note that the required laboratory data for lumen output, CRI, CCT, and lamp life must come from a NVLAP accredited laboratory whose scope of accreditation includes the specific reference standards that are listed in Table 3 of this specification. Partner should obtain from the laboratory both its certificate of accreditation and its scope of accreditation and submit them to ENERGY STAR. Documentation for safety requirements must come from an OSHA NRTL. All other documentation may come from one of the accredited laboratories mentioned in the previous paragraph.

Table 3 – Reference Standards and Required Documentation

Performance Characteristic (refer to Tables 1, 1A, 2A or 2B as appropriate)	Methods of Measurement Reference Standards	Required Documentation (to be attached to QPI Form)
System Efficacy: Light Output Input Power (Tables 1, 1A, 2A)	 IESNA LM-9; LM-66 IESNA LM-9; LM-66; ANSI C82.2	Laboratory test results must come from the generic lamp and specific ballast combination that will operate in the fixture. Provide a test report from a laboratory: 1. accredited by NVLAP; or 2. supply an EPA approved Platform Letter of Qualification that lists the lamp/ballast combination used in the fixture and the test result for this performance characteristic. **Note:** The laboratory used for this test must be accredited by NVLAP *and* have a scope of accreditation that includes the method of measurement reference standard for this performance characteristic.
Reflectors (Table 1A)	N/A	Record the reflector type in the appropriate space on the Qualified Product Information (QPI) Form.
Lamp Start Time (Tables 1, 1A)	ANSI C82.11-5.2	Laboratory test results must come from the lamp and ballast combination that is shipped with the fixture. Provide a test report from: 1. a laboratory accredited by NVLAP; or 2. a laboratory accredited by one of its MRA signatories; or 3. a laboratory accredited by an OSHA NRTL; or 4. supply an EPA approved Platform Letter of Qualification that lists the lamp/ballast combination used in the fixture and the test result for this performance characteristic.
Lamp Life (Tables 1, 1A)	IESNA LM-40; LM-65	Laboratory test results are not required for ENERGY STAR qualification. However, a test report from a laboratory accredited by NVLAP must be submitted upon EPA request. **Note:** The laboratory used for this test must be accredited by NVLAP *and* have a scope of accreditation that includes the method of measurement reference standard for this performance characteristic.

Dimming (Tables 1, 1A)	No Standard Available (Use manufacturer protocol)	A laboratory report is NOT required to be attached at the time of product submittal. However, it should be stated on the QPI form if the ballast is dimmable. **Note:** A laboratory test report proving the fixture is dimmable from 100% to 30% must be submitted upon EPA request.
<u>Durability</u>: (Tables 1, 1A) ANSI Standardized Lamps	 ANSI C78.901-2001; ANSI C78.81-2001; ANSI C81.61	 Specify applicable ANSI or ANSI-IEC Standard Data Sheet Number and ANSI designated base type on the QPI Form.
Non ANSI Standardized Lamps	ANSI C78.901-2001; ANSI C78.81 (as reference) ANSI C81.61	For fixtures using non-ANSI standardized lamps, supply a manufacturer lamp specification sheet that describes the electrical and dimensional information including the following as appropriate. (Use ANSI lamp data sheets found in ANSI C78.901 and C78.81 as reference): o Lamp Description: - Lamp Abbreviation - Nominal Wattage - Nominal Dimension (OAL, Width, Depth) - Bulb Designation - Circuit Application o Physical Characteristics - Dimensional Characteristics - Base Specifications (must be standardized, reference ANSI C81.61) o Operating Position o Cathode Characteristics - Type o Radio Interference Suppression Capacitor - Minimum (uF) (at 60Hz) - Maximum (uF) (at 60Hz) o Lamp Starting Time o Reference Ballast Characteristics - Rated input voltage (V) - Reference Current (A) - Impedance (ohms) o Thermal Conditions - Base temperature rise (K max.)

Safety: Outdoor (Tables 2A & 2B)	NFPA 70, the National Electrical Code (NEC), including requirements for wet locations when applicable (Articles 410-4a and Article 100)	Provide the cover page of a safety test report or a general coverage statement from an OSHA NRTL. Including evidence of the Rain Test for Wet Location when applicable.
Power Factor (Tables 1, 1A)	ANSI C82.11-3.3.1	Supply manufacturer or lab data. Note: A laboratory test report must be submitted upon EPA request.
Lamp Current Crest Factor (Tables 1, 1A)	ANSI C82.11-3.3.3 and 5.6 ANSI C82.1-5.6.1	Laboratory testing must be completed using the ballast that is shipped with the fixture. Provide a test report from: 1. a laboratory accredited by NVLAP; or 2. a laboratory accredited by one of its MRA signatories; or, 3. a laboratory accredited by an OSHA NRTL; or 4. supply an EPA approved Platform Letter of Qualification that lists the lamp/ballast combination used in the fixture and the test result for this performance characteristic.
Maximum Ballast Operating Case Temperature for Optimal Performance (Tables 1, 1A)	UL 1598, Section 11 (Acceptable when the thermocouple is placed at the hot-spot location indicated by the ballast manufacturer for performance.) Lighting Research Center (LRC) "Proposed Durability Testing Method: Temperature". **Note:** All qualified fixtures are expected to meet the Maximum Ballast Operating Case Temperature for Optimal Performance requirements. This includes every qualified fixture including linear, suspended, close-to-ceiling, IC, ICAT and Non-IC recessed canisters, etc. as well as those fixtures that may be exempt from UL1598.	Supply manufacturer or lab data. **Note:** A laboratory test report must be submitted upon EPA request. The test report should show that the temperature of the ballast case, when installed in the fixture and after being in operation for at least 7.5 hours, does not exceed the manufacturer's maximum ballast case temperature for performance. The temperature of the ballast case should be taken at the "hot-spot" locations for performance as indicated by the ballast manufacturer. If the maximum ballast operating case temperature and hot-spot locations cannot be obtained from the ballast manufacturer, measurements should be completed in accordance with the LRC's "Proposed Durability Testing Method: Temperature". The laboratory test report may come from one of the following: 1) "In-house" fixture manufacturer laboratory; 2) lamp or ballast manufacturer laboratory; 3) third party independent laboratory.

Indoor Product Packaging Requirements: (Tables 1A) • Recessed Downlight Retrofit Kit	No Standards Available	Provide a written copy or a PDF graphic of the language that will be displayed on product packaging and provide the appropriate installation instructions
Outdoor Product Packaging Requirements: (Tables, 2A, 2A Special Applications, and 2B): • Time of Day Control • Shut-Off • Motion Control	No Standards Available	Provide a written copy or a PDF graphic of the language that will be displayed on product packaging.
Lamp Socket Compatibility (Table 2A)	N/A	Provide a written description about the physical characteristics and the operation of the lamp socket indicating that the lamp holder could accept but shall NOT operate any lamp that either exceeds the input power range of the fixture, or is a lamp type not intended to be used in that particular fixture. Note: A copy or photograph of the "relamp" marking on the fixture, which designates the intended lamp type and wattage, is acceptable documentation.
Time of Day Control (Tables 2A & 2B)	N/A	Supply manufacturer or lab data. Note: A laboratory test report must be submitted upon EPA request.
Motion Control (Table 2B)	N/A	Supply manufacturer or lab data. Note: A laboratory test report must be submitted upon EPA request.
Shut-off (Table 2A)	N/A	Supply manufacturer or lab data. Note: A laboratory test report must be submitted upon EPA request.

5) Effective Date: The date that manufacturers may begin to qualify products as ENERGY STAR will be defined as the *effective date* of the agreement. The ENERGY STAR Version 3.2 Specification for Residential Light Fixtures shall go into effect on **September 19, 2003**. Any previously executed agreement on the subject of ENERGY STAR qualified residential light fixtures, shall be terminated effective September 19, 2003.

   A. Qualifying and Labeling Products under the Version 3.2 Specification: All products, including models originally qualified under Version 3.1 with a **date of manufacture** after **September 19, 2003**, must

California Home CPUC Home Thursday, December 4, 2003

Established Cost-Effectiveness Inputs

Certain inputs to the cost-effectiveness tests identified in the SPM have already been established by the Commission. Parties should use these inputs presenting their cost-effectiveness analysis to the Commission in their program proposals. These established inputs, along with their sources, are given below. All of the values given below represent the best-available data at the time of adoption of this manual. The Commission will update these assumptions periodically.

Effective Useful Lives of Energy Efficiency Measures

Standard values for effective useful lives (EULs) or measures are the standard assumptions used to determine the life-cycle savings associated with certain common energy efficiency measures. The EUL is generally an estimate of the median number of years that the measures installed under a given program are still in place and operable.[5] If a program proposal involves any of the measures listed below, the standard assumption should be used. If a proposed program involves a measure not listed below, the applicant should propose an appropriate assumption for the EUL, citing any relevant studies or other data sources. In order to minimize uncertainty, EULs will be limited to a maximum of 20 years, even if particular devices may be expected to survive longer.

Table 4.1. Effective Useful Lives of Energy Efficiency Measures

Measure	Lifetime	Measure	Lifetime
Lighting		UNPROVEN **HVAC**	
Ballast - Dimmable	16	Air Conditioners - High Efficiency	15
Ballast - Electronic	16	Boiler - High Efficiency	20
CF- Screw-in Replaceable Lamp (Modular)	8	Bypass/Delay Timer TOO HIGH	15
Compact Fluorescent Hardware Fixture	16	Chiller - High Efficiency	20
Delamping/Fixture Modifications/Removal	16	Chiller - Variable Speed Drive	20
Exit Sign - CF Hardware Kid/LED/ Electro-Luminescent	16	Cooling Towers/Evaporative Condenser	15
Fluorescent Fixture - T8	16	Furnace - High Efficiency	20
Halogen Lamp	0.6	Glazing - High Shade Coefficient	20
HID Fixture	16	Heat Pump - Packaged	15
Occupancy Sensor	8	HVAC/Space Heating/ Efficiency (Gas)	15
Photocell	8	Insulation	20
T8 Fixtures - 17 Watt Lamp, 2ft or 32-watt Lamp, 4ft	16	Reflective Window Film/ Windows	10
Time Clock - Lighting	8	Set-Back Thermostat	11
Fixture: T8 Lamp & Electronic Ballast	16	Timeclock	10
High Efficiency Lighting	16	Heat Pump - Split System	15
High Output T5 Fixture	16	AC Packaged Terminal Units	15
Induction Lamps	2	Adjustable Speed Drive	15
Induction Fixture	16	Ground Source Heat Pump	15
Indoor or Outdoor System Modification	16	Heat Pump with Integrated Water Heating	15

Lighting Controls	16	Packaged HVAC Systems	15
Daylighting Controls	16	Water Cooled Chillers	20
Lighting Power Density	16	Insulation Package	20
Refrigeration		Energy Management System	15
Auto Closer for Cooler/Freezer	8	Reduce Internal Load	15
Door Gaskets	4	Evaporative Coolers	15
Floating Head Pressure	16	HVAC/Refrigeration - SPC	20
Heatless Door	16	Nonresidential Gas - AC	20
Humidistat Control for Anti-Sweat Heater	12	**Hot Water**	
Insulation on Refrigeration Suction Line	11	Water Heater - Gas	15
Night Covers for Display Cases	5	Horizontal Clothes Washer	10

Table 4.1 (continued). Effective Useful Lives of Energy Efficiency Measures

Measure	Lifetime	Measure	Lifetime
PSC Evaporator Motor - Walk-in/Display	16	Efficient Dishwashing	5
Refrigeration Case Doors - Glass/Acrylic	12	Water Heater Controls	15
Refrigerator Case with Doors	16	Domestic Hot Water Boiler	20
Refrigerator Condensate Evaporator - Elec/Non Elec	8	**Miscellaneous**	
Strip Curtains for Walk-Ins	4	Cooking Equipment	12
Ballast: Electronic, for display case	16	High Efficiency Engine	15
Defrost	16	Kiln/Oven/Furnace	20
FHP & EFF Conditioner	16	Thermal Night Curtains	5
High-efficiency Liquid Suction Heat Exchangers	16	Custom Measures - SPC	15
Night Shields on Refrigerator and Freezer Cases	16	Local Government Initiatives	11
Refrigerator: Evaporative Fan Controller	5	Extrusion Equipment	15
Supermarket Systems	14	Audits	3
		Plug Load Sensor	10
		Information	1
		High Efficiency Motors	15
		Variable Frequency Drives	15
		Process Overhaul	20
		Pump Test	15
		System Controls	15

Net-to-Gross Ratios

Net-to-gross ratios (NTGRs) are used to estimate free-ridership occurring in energy efficiency programs. Free riders are program participants who would have undertaken an activity, regardless of whether there was an energy efficiency program promoting that activity or not. An NTGR 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.[6] This factor is important in determining actual energy savings attributable to a particular program, as distinct from energy efficiency occurring naturally (in the absence of a program).

Applicants should refer to the SPM to determine the appropriate manner in which to use NTGRs in submitting program cost-effectiveness information.

Program proposals should use the applicable NTGRs listed below. If a program is not listed below, or if a proposed program design deviates substantially from past design of related programs, program proposals may utilize a default NTGR of 0.8 until such time as a new, more appropriate, value is determined in the course of program evaluation. All existing programs not listed below shall also use a default value of 0.8.

Table 4.2. Net-to-Gross Ratios

Program Area/Program	Net-to-Gross Ratio
Residential	
Appliance early retirement and replacement	0.80
California Home Energy Efficiency Rating System (CHEERS)	0.72
Residential Audits	0.72
Refrigerator Recycling	0.80
Residential Contractor Program	0.89
Emerging Technologies	0.83
All other residential programs	0.80
Nonresidential	
Advanced water heating systems	1.00
Agricultural and Dairy Incentives	0.75
Coin Laundry and Dry Cleaner Education	0.70
Commercial and agricultural information, tools, or design assistance services	0.83
Comprehensive Space Conditioning	1.00
Lodging Education	0.70
Express Efficiency (rebates)	0.96
Energy Management Services, including audits (for small and medium customers)	0.83
Food Services Equipment Retrofit	1.00
Industrial Information and Services	0.74
Large Standard Performance Contract	0.53
All other nonresidential programs	0.80
New Construction	
Industrial and Agricultural Process	0.94
Industrial new construction incentives	0.62
Savings by Design	0.62
All other new construction programs	0.80

Discount Rate

In evaluating all energy efficiency program proposals, the Commission shall use a pre-established discount rate of 8.15%. This standard assumption, used as the default in recent years, may be updated in the future. The discount rate is used simply to translate potential benefits in future years into current year terms.

Avoided Costs

In order to estimate the value of the energy efficiency occurring as a result of program activities, parties will need to be able to estimate the "avoided cost" of the provision of that supply of energy. Avoided costs represent the value of the electricity or natural gas that, in the absence of a program, would need to be procured and delivered to an individual consumer. When an energy efficiency programs creates a reduction in demand for electricity or natural gas, costs are avoided from the perspective of the consumer, the utility, and society. The Commission will continue to use six sets of avoided cost streams, which should be used on a statewide basis to apply to all program proposals:

Electric

- Avoided generation costs
- Avoided transmission and distribution costs
- Environmental externalities

Gas

- Commodity procurement costs
- Transmission and distribution costs
- Environmental externalities

Not all of the above avoided cost streams are necessary for all cost-effectiveness tests described in the Standard Practices Manual. Refer to that manual for more details on how to use the avoided cost streams.

Table 4.3 gives the Commission's avoided cost assumptions. Sources of each stream of values are given below the table. These estimates will be updated in the coming year for use during the 2003 funding cycle. Any new avoided costs will be utilized on a prospective basis for future program planning, and not applied retroactively to evaluate existing programs that were developed based on an earlier set of avoided cost assumptions.

Table 4.3. Electric and Gas Avoided Costs

	Electric ($ per MWh)				Gas ($ per therm)			
Year	Generation	Trans. & Dist.	Env. Ext.	Total Electric	Commodity	Trans. & Dist.	Env. Ext.	Total Gas
2002	$99.05	$5.25	$6.55	$110.85	$0.49	$0.03	$0.06	$0.58
2003	$56.71	$5.50	$6.80	$69.01	$0.37	$0.03	$0.06	$0.47
2004	$53.41	$5.74	$7.04	$66.19	$0.34	$0.03	$0.06	$0.43
2005	$54.51	$6.00	$7.20	$67.71	$0.35	$0.03	$0.06	$0.45
2006	$49.61	$6.20	$7.40	$63.21	$0.37	$0.03	$0.07	$0.47
2007	$51.55	$6.50	$7.60	$65.65	$0.39	$0.03	$0.07	$0.49
2008	$53.25	$6.75	$7.85	$67.85	$0.40	$0.04	$0.07	$0.51
2009	$55.10	$7.04	$8.14	$70.28	$0.42	$0.04	$0.07	$0.53
2010	$57.08	$7.34	$8.34	$72.76	$0.44	$0.04	$0.07	$0.55
2011	$58.96	$7.60	$8.60	$75.16	$0.38	$0.04	$0.08	$0.49
2012	$61.38	$7.94	$8.84	$78.16	$0.40	$0.04	$0.08	$0.51
2013	$63.99	$8.30	$9.10	$81.39	$0.42	$0.04	$0.08	$0.53
2014	$66.76	$8.60	$9.40	$84.76	$0.43	$0.04	$0.08	$0.56

2015	$69.76	$9.00	$9.70	$88.46	$0.45	$0.04	$0.09	$0.58
2016	$73.00	$9.34	$9.94	$92.28	$0.48	$0.04	$0.09	$0.61
2017	$76.49	$9.74	$10.24	$96.47	$0.50	$0.04	$0.09	$0.63
2018	$80.23	$10.14	$10.54	$100.91	$0.52	$0.05	$0.09	$0.66
2019	$84.28	$10.55	$10.81	$105.64	$0.54	$0.05	$0.10	$0.68
2020	$88.44	$10.59	$11.08	$110.11	$0.57	$0.05	$0.10	$0.71
2021	$92.87	$11.12	$11.36	$115.34	$0.59	$0.05	$0.10	$0.74

Data Sources

Electric

1. Avoided Costs of Generation. These values are based on an August 2000 California Energy Commission forecast of market clearing prices using the MULTISYM model. Values for certain years were updated based on direction given in an October 25, 2000 ALJ Ruling on PY2001 planning in A.99-09-049, subsequently adopted by the Commission in D.01-01-060. Modifications to the CEC forecast were as follows:

Table 4.4. Assumptions for Electric Generation Costs

Program Years	Basis
2002	Historical market clearing price data from the Power Exchange (October 1999 to September 2000)
2003-2010	CEC market clearing price forecast, plus 20%
2011-2020	CEC market clearing price forecast
2021	CEC market clearing price escalated by growth rate over previous five years

In addition, the values reflected in Table 4.3 incorporate an "on-peak" multiplier, as ordered in the ALJ ruling of October 25, 2000 to account for the system value of reduced load on reducing market clearing prices, pursuant to AB970, Section 7, Table B, Paragraph 8, and the September 14, 2000 and October 25, 2000 ALJ rulings in A.99-09-049. The on-peak multipliers are described in Table 4.5.

Table 4.5. On-Peak Multipliers

Program Years	Multiplier
2002	5.0X
2003-2005	2.0X
2006-2021	1.5X

2. Electric Transmission and Distribution Avoided Costs. The T&D avoided cost value-stream is calculated based upon a statewide average of weighted forecasts of avoided T&D costs across utility service territories. This forecast was based upon 1996 sales for each utility, and converted from $/kW to $/MWh by assuming a 0.6 load factor. These values were adopted by the Commission in Resolution E-3592.

3. Electric Environmental Externalities. These values were adopted by the Commission in Resolution E-3592.

4. Gas Avoided Commodity Costs. Gas procurement costs are based on the CEC's August 2000 base case price forecast for electric generation.

5. Gas Transmission and Distribution Avoided Costs. These values represent a weighted average of gas T&D

costs in PG&E, SDG&E, and SoCalGas territories, as represented by each utility in their PY2000 annual reports.

6. Gas Environmental Externalities. These values were recommended by the CBEE and adopted by the Commission in Resolution E-3592.

[5] Source: *Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand Side Management (DSM) Programs (MA&E Protocols).* See also p. 26 of September 25, 2000 CALMAC report prepared pursuant to Ordering Paragraph 9 of D.00-07-017. [6] Source: p. 26 of September 25, 2000 CALMAC report, referencing D.00-07-017 ordering paragraph 9.

Previous Page | Top of Page | Next Page | First Page

Technology

Occupancy Sensors

Estimated Energy Savings – kWh

Savings estimates vary by type of space and connected load. We are suggesting a two tier incentive based on square footage controlled. Larger square footages controlled will likely result in higher costs for multiple sensors, additional wiring, etc. We are not specifying savings or incentives by type of space assuming a natural mix in actual applications.

Industry Estimates of potential energy savings for occupancy sensors (%)

Space Type	CEC	Esource	EPRI	Novitas	Watt Stopper
Private office	25-50	13-50	30	40-55	15-70
Open office	20-25	20-28	15	30-35	5-25
Classroom	-	40-46	20-35	30-40	10-75
Conference	45-65	22-65	35	45-65	20-65
Restroom	30-75	30-90	40	45-65	30-75
Warehouses	50-75	-	55	70-90	50-75
Storage	45-65	45-80	-	-	45-65

Assumed 3,956 annual hours of operation (average of all commercial and industrial customers), a 30% reduction in operating hours and 1.2 watts/square foot of lighting controlled.

Under 500 ft^2 $\dfrac{300\ ft^2 \text{ average} \times 1.2\ watt/ft^2 \times 3956 \text{ hours} \times 30\%}{1000 \text{ watts/kWh}} = 427$ kWh

Over 500 ft^2 $\dfrac{750\ ft^2 \text{ average} \times 1.2\ watt/ft^2 \times 3956 \text{ hours} \times 30\%}{1000 \text{ watts/kWh}} = 1068$ kWh

Summer Peak Savings

None – occupancy sensors may reduce load at peak but not for most applications.

Measure Life

8-15 years

Initial One-Time Cost

Prices vary depending on sensor capability. Range from approximately $40 for low end or residential model to $200, not including installation. Assume $100 to $400/unit installed.

Any Recurring Costs

None.

Suggested Incentive

Under 500 ft^2 - $20/unit
Over 500 ft^2 - $40/unit

Incentive could be structured on wattage controlled or at a single incentive level for all installations.

Requirements

For Application –

Care should be taken when specifying occupancy sensors to ensure occupant satisfaction. Two main technologies used for occupancy sensors are passive infrared (PIR) and ultrasonic. PIR sensors react to body heat and sense occupancy by detecting the difference in heat from a body and the background. Ultrasonic sensors use volumetric detectors and broadcast sounds above the range of human hearing, then measure the time it takes the waves to return and can detect persons behind obstructions.

Both types of sensors feature a delay adjustment which sets the time that lights are on after no occupancy is detected and a sensitivity adjustment which makes the unit either more or less sensitive to motion. Delays should not be set for less than 10 minutes so that lamp life is not affected or make sure that programmed start ballasts are specified with fluorescent lamps.

Ultrasonic sensors are sensitive to air movement from HVAC diffusers and should be adjusted to a point at which they are not sensing air movement.

Existing Energy Standards

There are currently no Energy Star standards for this technology.

Source of Info

FEMP, LRC; Green Seal Report, manufacturer's web sites Novitas, Leviton, Watt Stopper, Pass & Seymour Legrand

An analysis of the energy and cost savings potential of occupancy sensors for commercial lighting systems

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An Analysis of the Energy and Cost Savings Potential

of Occupancy Sensors for Commercial Lighting Systems

Introduction

Since their introduction more than 20 years ago, occupancy sensor controls for lighting systems have promised significant energy and dollar savings potential in a variety of commercial lighting applications. By automatically controlling lighting to turn lights off when spaces are unoccupied, occupancy sensors controls compliment connected load reductions accomplished by lamp and ballast retrofits, giving building owners and operators additional opportunities to improve energy savings without compromising lighting service to building occupants. With typical estimated energy savings potential in from ¼ to more than ½ of lighting energy (Audin, 1993, EPRI 1992), occupancy sensors have frequently been promoted as one of the most cost effective technologies available for retrofitting commercial lighting systems. Both national and many state new construction codes also recognize the contribution of occupancy sensors to meet the power density allowances for designing interior lighting systems.

Despite widespread promotion of these benefits, occupancy sensors have relatively poor market development compared to other lighting technologies. In addition to confronting the typical market barriers facing all new lighting technologies (high first cost, no uniform performance standards or measurement methodology, difficulty in specifying and commissioning, interaction with other system components, long term persistence due to user interference, etc), occupancy sensors also suffer from the difficulty of definitively predicting and demonstrating savings. Unlike technologies that reduce connected load where savings can be readily measured, occupancy sensor performance is dependent on the user occupancy, lighting control patterns, sensor selection and commissioning. Consequently even within generic space uses categories, industry savings estimates range by a factor of two to three as shown in Table 1.

These savings estimates have also been criticized as being overly optimistic, given that energy saved during utility off-peak hours is typically less valuable than energy saved during utility shoulder or peak periods. These performance uncertainties make it difficult to predict the economic benefit, and create significant additional specification risks beyond those borne by demand limiting measures.

Previous Work

Little objective, independent and detailed research information is available on occupancy and lighting patterns. Single building case studies have also reported a range of savings in a variety of applications. Savings of 10% to 19% have been reported for classrooms (Floyd, et al., 1995; Rundquist, 1996), and of 27% to 43% in private offices (Jennings et al., 1999; Maniccia et al., 1999; Seattle City Light, 1992). Richman, et al. (1996) reports potential energy savings of between 45% and 3% for private offices and between 86% and 73% for restrooms.

The primary objective of the present study was to investigate lighting operation and workspace occupancy patterns across numerous commercial buildings to better quantify the performance estimates of occupancy sensors across typical space types. By examining how occupants occupy their spaces and manually control their lighting, and comparing these baselines to modeled occupancy sensor control scenarios, energy and dollars savings potentials are investigated. Note that the system economics of evaluating energy savings against lamp maintenance costs for these same control scenarios are evaluated in an associated paper, *The Effects of Changes Occupancy Sensor Timeout Setting on Energy Savings, Lamp Cycling, and Maintenance Costs.*

Methodology

Sixty organizations were chosen for study from active participants in the US. Environmental Protection Agency's Green Lights Program. The study buildings were located in twenty-four states, and occupied by profit, not-for profit, service and manufacturing companies, healthcare organizations, primary and secondary education, and local, state, and federal government entities. The diversity of age, size, efficiency, ownership and occupancy types for these buildings was intended to represent a typical cross section of the country's commercial building stock.

Rooms for study were identified by on-site facilities management staff as representative of space types within that building, both in their floorplan, occupancy, and lighting system . All spaces contained manual controls for the lighting systems, with a minimum connected lighting load of at least 150 watts. A two-week monitoring period between February and September 1997 was chosen to represent a typical lighting and occupancy schedule. Data for 180 rooms were originally collected; after eliminating records with inconsistent or incomplete data, the study database contained 158 rooms categorized by primary occupancy type into 42 restrooms, 37 private offices, 35 classrooms, 33 conference rooms, and 11 break rooms. Rooms were surveyed for occupancy type, dimensions and lighting system specification. Occupancy and lighting operation data was collected using Wattstopper InteliTimer Pro® IT100 data loggers. The logger device recorded the time and state of the light and/or occupancy condition. Each time occupancy or the lighting condition changed, the logger documented the time of day and the change in condition. An algorithm was developed to convert the data recorded from the Watt Stopper InteliTimer Pro device into one-minute increments for the 14-day monitoring period. There were cases when the lights were turned on and off, but no occupant was detected in the space. This was considered a detection error, and was corrected by modifying the data set to switch the occupancy condition from unoccupied to occupied for those instances. This occurred for:

- six of the break rooms with detection errors ranging between one and 181 events (0% to 1% of the total events)
- 17 of the classrooms with detection errors ranging between one and 2,677 events (0% to 13% of the total events)
- 16 of the conference rooms with detection errors ranging between one and 1,681 events (0% to 8% of the total events)
- 17 of the private offices with detection errors ranging between one and 5,686 events (0% to 28% of the total events)
- seven of the restrooms with detection errors ranging between one and 275 events (0% to 1% of the total events).

Descriptive statistics were calculated and cost analyses were performed for weekdays, weekends, and for the total 14-day monitoring period. Data also were analyzed by separating 24-hour periods into one 12-hour day shift (Day) and one 12-hour evening shift (Night). Day and night shifts were analyzed from 06:00 to 18:00 and 18:00 to 06:00, respectively. Data presented for weekdays were averaged over the 10 weekdays, and for weekends were averaged over the four weekend days in the monitoring period. Data presented for the total period were averaged over the 14-day monitoring period. Baseline occupant switching and occupancy patterns were established using the collected data on occupancy and light usage. The baseline occupancy and light usage data were then used for modeling the effects of installing occupancy sensors with 5-, 10-, 15-, and 20-minute time delay periods.

Statistical analyses also were conducted to investigate whether there were significant differences between the energy use for shift (day or night), time of week (weekday or weekend), and timeout setting, or any interactions between shift and timeout settings and time of week and timeout settings. These analyses were used to provide evidence of which differences were real and which occurred by chance. Within-subjects analyses of variance using repeated measures (ANOVR) were used for the analyes. One analysis compared day and night periods to the baseline and the four timeout settings. A second analysis compared the weekday and weekend data for a 24-hour period to the baseline and the four timeout settings. Follow-up tests were conducted using pairwise comparison t-tests.

For the energy calculations, the total load for each room was used to determine lighting energy use and waste. Lighting energy use was calculated by multiplying the total lighting load by the time that the lights were on and the room was occupied. Lighting energy waste was calculated by multiplying the total load by the time that the lights were on and the room was unoccupied. Total energy savings was determined by applying a flat $0.08/kWh rate to the modeled energy savings under each control scenario.

Findings – Baseline data

Total energy savings potential

Determining the basic energy savings potential across applications requires establishing a baseline of observed occupancy and lighting conditions. Lighting and occupancy use in any space will always fall into one of the following four conditions:

1. Occupied with the lights on
2. Occupied with the lights off
3. Unoccupied with the lights on
4. Unoccupied with the lights off

Of the four conditions, the first three are of particular interest. Condition one is of interest for garnering information about how frequently occupants use these types of spaces with the lights on. Conditions two and three are of interest when considering lighting controls. If occupants frequently occupy a space with the lights off (condition two), then a manual lighting control device that allows occupants to turn lights off when needed should be provided. Condition three represents wasted lighting energy by having lights on when spaces are unoccupied. This condition is of primary importance when considering using automatic occupancy sensor control. Table 2 lists the average percentage of time each application was in each of the first three occupancy and lighting conditions.

Table 2 illustrates that spaces were infrequently occupied, with the daily percentage of total occupied time with lights on and off never exceeding 24%. Also, occupants did not diligently turn lights off when they vacated spaces, with the lighting system in classrooms, conference rooms, and restrooms operating more often when the occupants were out of the room than in the room. This is intuitively understandable in common area applications (such as restrooms and conference rooms), where occupants do not feel that the lighting is "theirs" to control. The split, however, is still fairly even in private offices, indicating that even in personal spaces, occupants were not diligent about controlling their lighting use. The data shown for condition 2 indicates that occupants rarely occupied spaces with the lights off, indicating that for these spaces there may be a small potential benefit of installing manual controls. Note that since the presence of daylight availability was not documented in this study, however, it is difficult to compare these results to other studies which have found higher savings potentials from installing manual controls (Maniccia et al., 1999).

Time of day/week impacts on energy savings

Determining the applicability of occupancy sensors as a control strategy suitable to obtain these savings requires an examination of when those savings present themselves. As an automatic control strategy, occupancy sensors work best in areas where occupancy is intermittent and unpredictable. Where the lighting is inadvertently left on overnight by cleaning, security, or occupants, a more cost effective control strategy may be an education campaign, or the installation of a simple timeclock. For these reasons, the savings estimates are examined over four defined periods - weekday days, weekday evenings, weekend days, and weekend evenings.

As expected, Table 3 demonstrates that the majority of energy use (76-88%) occurs for all space types during the weekdays, with 55-85% of total energy use occurring during the day. Likewise, the majority of energy waste (between 70-87%) occurs during the weekdays, not on the weekends. For all space types except restrooms, the majority energy waste also occurs during the daytime (53-70%) rather than in the evenings. This indicates that occupants controlled their lighting poorly during the workday, but were more diligent about turning the lights off after hours and over weekends. This is particularly true for personal spaces such as private offices, where occupants feel a high degree of control over their lighting, and less true in common area spaces, such as classrooms and restrooms, where a high percentages of waste occurred over weekends and after hours. This indicates that time-based controls (timers, timeclocks) could eliminate a significant amount of energy waste in common areas by controlling runaway operation after hours and on weekends, however occupancy-based controls would be more effective given they save not only after hours but also at capturing savings during business hours.

Coincidence of savings with peak demand

Central to defining the economic benefits of occupancy sensors is understanding when the savings opportunities occur. Most commercial and industrial facilities pay a considerable portion (as high as 40%) of their electric energy bill for the peak demand created by the electric loads. Lighting is the second largest contributor to summer peak demand in commercial facilities, and rivals heating as the largest contributor to a commercial building's winter peak. As such, reductions in lighting demand can significantly impact the energy bill.

Occupancy sensors have been criticized in their ability to reduce this peak demand, saving cheaper kilowatts in the utility's off-peak billing hours rather than during the peak demand billing period. Although the value of this savings is highly dependent on how the utility billing rate is structured (time-of-use, annual peak, ratcheted, etc), it is useful to examine when the potential savings occur to understand how occupancy sensors may contribute to reducing a building's peak demand, and reducing demand during peak utility periods. To evaluate this, Figures 1-5 illustrate the time of day profiles for when the spaces were lighted and occupied, and lighted and unoccupied for all weekdays..

Figures 1-5 indicate that the control's largest contributions to potential savings are not coincident with a building's peak occupancy. This is intuitive; when occupancy rises, occupancy-based savings opportunities diminishes. Although the majority of energy savings from sensors occur during weekdays, the sensors largest contribution to savings (with the exception of conference rooms and offices) is generally not coincident with a building's peak load (10 a.m. to 4 p.m.) or with a utility's peak billing periods (early afternoon hours). This would indicate that while sensors can reduce a buildings peak load, they may not be a reliable method of achieving of peak savings due to the diversity of savings profiles observed among these different space types.

Findings – Occupancy Sensor Simulations

Impact of time-out period on energy savings

Most occupancy sensors are equipped with a variable time delay feature to adjust the time interval between the last detected motion and the switching off of the lamps. This allows the sensor to be customized to the application to reduce the chance of lamps switching off when a room is occupied but minor motions are not detected. Adjusting the time delay creates a tradeoff between saving energy and avoiding occupant complaints. Longer time delays reduce the incidence of occupant complaints. Shorter time delays increase energy savings (particularly in rooms that are infrequently and briefly occupied), but also reduces lamp life from more frequent lamp cycling. Manufacturers report time delay setting ranging from several seconds to more than 30 minutes.

To examine the impact of time delay on energy savings, control scenarios for 5-, 10-, 15-, and 20-minute time delays were modeled for each application. Statistical analyses were also conducted to investigate the impact of time of day, time of week, and timeout setting on energy use. Note that the impact of frequent switching on lamp and maintenance costs for these same control scenarios are evaluated in an associated paper, *The Effects of Changes Occupancy Sensor Timeout Setting on Energy Savings, Lamp Cycling, and Maintenance Costs*.

Statistical Analysis Findings

As discussed in the "Methodology" section, statistical analyses of the energy use data were conducted to investigate whether there were significant differences between the energy use for Shift (day or night), time of week (weekday or weekend), and timeout setting, or any interactions between shift and timeout settings and time of week and timeout settings. The energy use data for each Shift were compared to the baseline and the timeout settings for one analysis. A second analysis compared the weekday and weekend data for a 24-hour period to the baseline and the timeout settings.

The statistical analyses addressed the following questions:

- Is there a significant energy use difference between the shifts for the total monitoring period?
- Is there a significant energy use difference between the baseline and each timeout setting?
- Is there a significant energy use difference between weekdays and weekends?

Shift verses timeout settings

There were no significant interactions between the energy use for each shift and for the timeout settings for the break rooms or for the classrooms. For both applications, differences between the main effects (Shifts 1 and 2) were significant ($p < 0.01$ for the break rooms, and $p < 0.001$ for the classrooms). Differences between the timeout setting main effects were also significant for both of these applications ($p < 0.01$ for the break rooms, and $p < 0.01$

for the classrooms). Figures 6 through 9 illustrate the results of the main effects tests for the break rooms and classrooms, respectively.

Significant interactions occurred between energy use for each shift and timeout settings for the conference rooms ($p < 0.05$), private offices ($p < 0.001$), and restrooms ($p < 0.01$). Follow-up tests illustrated that differences between the shifts at each timeout setting and the baseline condition were all significant ($p < 0.001$) for all three applications. Differences between the baseline condition and each timeout setting were all significant for Shift 1 for all three applications ($p < 0.001$). Differences between the baseline condition and each timeout setting also were significant for Shift 2 for all three applications (the conference rooms and private offices [$p < 0.01$] and restrooms [$p < 0.001$]). Figures 10 through 12 illustrate the results of the follow-up tests with the 95% confidence intervals.

Figures 6 through 12 illustrate that more energy is used during the day than at night, which would be expected of these types of applications. They also show that installing occupancy sensors decreases baseline energy use, and that energy use increases as the timeout setting increases because lights remain on for longer periods of time.

Time of week verses timeout settings

There were significant interactions between the energy use for time of week and timeout settings for all five applications ($p < 0.05$ for the break rooms and $p < 0.001$ for the classrooms, conference rooms, private offices, and restrooms). Follow-up tests illustrated that differences between the energy use values for the weekdays and weekends at each timeout setting and the baseline were significant for all of the applications ($p < 0.01$ for the break rooms, and $p < 0.001$ for the classrooms, conference rooms, private offices, and restrooms). Differences between the energy use values for the baseline and each timeout setting for the weekdays also were significant for each application ($p < 0.01$ for the break rooms and classrooms, and $p < 0.001$ for the conference rooms, private offices, and restrooms). Differences between the energy use values for the baseline and each timeout setting for the weekends were not significant for the break rooms, classrooms, and conference rooms. However, these differences were significant for the private offices ($p < 0.05$) and restrooms ($p < 0.001$). These results are illustrated in Figures 13 through 17.

The two main points that can be taken away from this analysis are:

- the differences between the energy use for each timeout setting and the baseline for each application were all significant for each shift. This indicates that energy savings can be achieved during the day and at night using occupancy sensors.
- the differences between the energy use for each timeout setting and the baseline for each application were all significant for the weekdays, but varied by application for the weekends. This indicates that energy savings can be achieved during the week for all applications, and during the weekend for private offices and restrooms.

Effects of Time Delay on Energy and Cost Savings

As demonstrated in Table 4, the savings estimates were considerable across all space types (ranging from 17-60%), and consistent with the ranges of industry estimates provided in Table 1. Table 4 illustrates that both application and time delay selection significantly impacts the quantity of available savings. For this data set, restrooms showed the highest overall savings, followed by classrooms, conference rooms, and private offices. Break rooms showed the lowest overall savings. The range of savings between the shortest and longest time out setting varied with application as well because of the occupancy pattern differences among the applications. Classrooms had the smallest savings difference between the 5- and 20-minute time out settings (6%) and restrooms had the largest difference (13%).

Figures 18-22 illustrate the load profiles for the baseline energy use and modeled energy use under 5 and 20 minute simulated delay conditions. These figures graphically depict the differences found in the energy savings captured between the longest and shortest time delays. These figures also confirm the observations found from the baseline occupancy and lighting conditions depicted in Figures 1-5; although the majority of energy savings from sensors occur during weekdays, the sensors largest contribution to savings (with the exception of conference rooms and offices) is generally not coincident with a building's peak load or with a utility's peak billing periods. This suggests that while sensors can reduce a buildings peak load, sensors may not be a reliable method of achieving peak savings in buildings with a diversity of space types.

Conclusions/Recommendations for Future Work

People do not occupy spaces for a large percentage of time, and are not diligent about controlling the lighting in their spaces both during the workday, and after hours and weekends. This applies to both public spaces as well as personal spaces. The majority of this energy waste occurs during the weekdays, not during the weeknights or over the weekends. This pattern of energy waste is particularly suited to control by occupancy sensors, which not only prevent runaway operation after typical business hours, but also capture savings during the business day. Although the majority of observed savings opportunities occurred during the weekday, the peak savings contributions from occupancy sensors for several space types did not fall within the typical peak utility billing periods (early afternoon) or peak commercial building demand periods (10 a.m. to 4 p.m.). This suggests that while sensors may help to save expensive kilowatt-hours, they would have a variable effect at reducing a building's peak demand, given their variable performance in when they provide high levels of savings among the various space types. This would be a useful topic of additional research, where assigning specific kilowatt-hour rates to each kilowatt-hour saved would yield more accurate indication of the economic benefits of installing sensors within these various space types.

Finally, modeling control scenarios with 5- to 20-minute time delay periods indicated savings potentials that were within the ranges suggested by the industry estimates. The time delay settings used for these analyses showed that energy savings can range from between 6% and 13% depending on the application and on which time out setting is used. In addition, the highest savings were obtained in the restroom application (47% to 60%), and the lowest in the break rooms (17% to 29%). Thus, the time delay selection can greatly impact energy savings. Although these savings are significant they do not consider the increased maintenance lamp and labor replacement costs that could result due to more frequent lamp switching. This is evaluated in a related paper entitled *The Effects of Changes Occupancy Sensor Timeout Setting on Energy Savings, Lamp Cycling, and Maintenance Costs.*

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Table 1. Industry estimates of potential energy savings for occupancy sensors (in %)

Space type	CEC	Esource	EPRI	Novitas	Watt Stopper
Private office	25-50	13-50	30	40-55	15-70
Open office	20-25	20-28	15	30-35	5-25
Classroom	-	40-46	20-35	30-40	10-75
Conference	45-65	22-65	35	45-65	20-65
Restroom	30-75	30-90	40	45-65	30-75
Warehouses	50-75	-	55	70-90	50-75
Storage	45-65	45-80		-	45-65

Table 2. Average percentage of time each application was occupied with lights on and off, and unoccupied with lights on.

	Occupied with lights on			Occupied with lights off			Unoccupied with lights on		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Break room	36%	7%	21%	4%	2%	3%	17%	11%	14%
Classroom	22%	3%	13%	4%	2%	3%	20%	17%	19%
Conference	16%	2%	9%	4%	1%	2%	15%	7%	11%
Private office	32%	2%	17%	1%	1%	1%	23%	9%	16%
Restroom	32%	7%	19%	1%	1%	1%	44%	51%	48%

Table 3. Percentage of energy use and waste for weekdays, weekends, and for the total monitoring period for each application.

	Energy Use (%)								
	Weekdays			Weekends			Total monitoring period		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Break room	69%	19%	88%	8%	5%	12%	77%	23%	100%
Classroom	55%	26%	82%	11%	7%	18%	66%	34%	100%
Conference	65%	19%	83%	11%	6%	17%	76%	24%	100%
Private office	74%	12%	86%	11%	3%	14%	85%	15%	100%
Restroom	43%	33%	76%	12%	12%	24%	55%	45%	100%

	Energy Waste (%)								
	Weekdays			Weekends			Total monitoring period		
	Day	Night	Total	Day	Night	Total	Day	Night	Total
Break room	50%	29%	79%	12%	8%	21%	63%	37%	100%
Classroom	40%	36%	76%	13%	11%	24%	53%	47%	100%
Conference	55%	24%	80%	12%	9%	20%	67%	33%	100%
Private office	67%	21%	87%	8%	5%	13%	75%	25%	100%
Restroom	29%	41%	70%	14%	16%	30%	42%	58%	100%

Table 4. The effects of time delay on energy and cost savings for the total monitoring period.

	Total daily energy use (kWh)	Energy saved compared to baseline	Annual energy cost ($)	Annual energy cost reduction ($)	Total daily energy use (kWh)	Energy saved compared to baseline	Annual energy cost ($)	Annual energy cost reduction ($)	Total daily energy use (kWh)	Energy saved compared to baseline	Annual energy cost ($)	Annual energy cost reduction ($)
Break Room		Day				Night				Total		
Baseline	5.53	---	161.48	-	1.67	---	48.76	-	7.20	---	210.24	-
5-minute	4.33	22%	126.44	35.04	0.78	53%	22.78	25.99	5.11	29%	149.21	61.03
10-minute	4.64	16%	135.49	25.99	0.89	47%	25.99	22.78	5.53	23%	161.48	48.76
15-minute	4.83	13%	141.04	20.44	0.97	42%	28.32	20.44	5.80	19%	169.36	40.88
20-minute	4.97	10%	145.12	16.35	1.03	38%	30.08	18.69	6.00	17%	175.20	35.04
Classroom		Day				Night				Total		
Baseline	11.37	---	332.00	-	5.84	---	170.53	-	17.21	---	502.53	-
5-minute	6.21	45%	181.33	150.67	0.94	84%	27.45	143.08	7.15	58%	208.78	293.75
10-minute	6.60	42%	192.72	139.28	1.03	82%	30.08	140.45	7.63	56%	222.80	279.74
15-minute	6.88	39%	200.90	131.11	1.11	81%	32.41	138.12	7.99	54%	233.31	269.22
20-minute	7.12	37%	207.90	124.10	1.18	80%	34.46	136.07	8.30	52%	242.36	260.17
Conference room		Day				Night				Total		
Baseline	3.09	---	90.23	-	0.99	---	28.91	-	4.08	---	119.14	-
5-minute	1.76	43%	51.39	38.84	0.27	73%	7.88	21.02	2.03	50%	59.28	59.86
10-minute	1.91	38%	55.77	34.46	0.31	69%	9.05	19.86	2.22	46%	64.82	54.31
15-minute	2.02	35%	58.98	31.24	0.35	65%	10.22	18.69	2.37	42%	69.20	49.93
20-minute	2.11	32%	61.61	28.62	0.38	62%	11.10	17.81	2.49	39%	72.71	46.43
Private office		Day				Night				Total		
Baseline	2.83	---	82.64	-	0.51	---	14.89	-	3.34	---	97.53	-
5-minute	1.92	32%	56.06	26.57	0.14	73%	4.09	10.80	2.06	38%	60.15	37.38
10-minute	2.05	28%	59.86	22.78	0.16	69%	4.67	10.22	2.21	34%	64.53	33.00
15-minute	2.14	24%	62.49	20.15	0.17	67%	4.96	9.93	2.31	31%	67.45	30.08
20-minute	2.21	22%	64.53	18.10	0.18	65%	5.26	9.64	2.39	28%	69.79	27.74
Restroom		Day				Night				Total		
Baseline	3.10	---	90.52	-	2.50	---	73.00	-	5.60	---	163.52	-
5-minute	1.83	41%	53.44	37.08	0.42	83%	12.26	60.74	2.25	60%	65.70	97.82
10-minute	2.04	34%	59.57	30.95	0.52	79%	15.18	57.82	2.56	54%	74.75	88.77
15-minute	2.19	29%	63.95	26.57	0.60	76%	17.52	55.48	2.79	50%	81.47	82.05
20-minute	2.29	26%	66.87	23.65	0.68	73%	19.86	53.14	2.97	47%	86.72	76.80

Figures

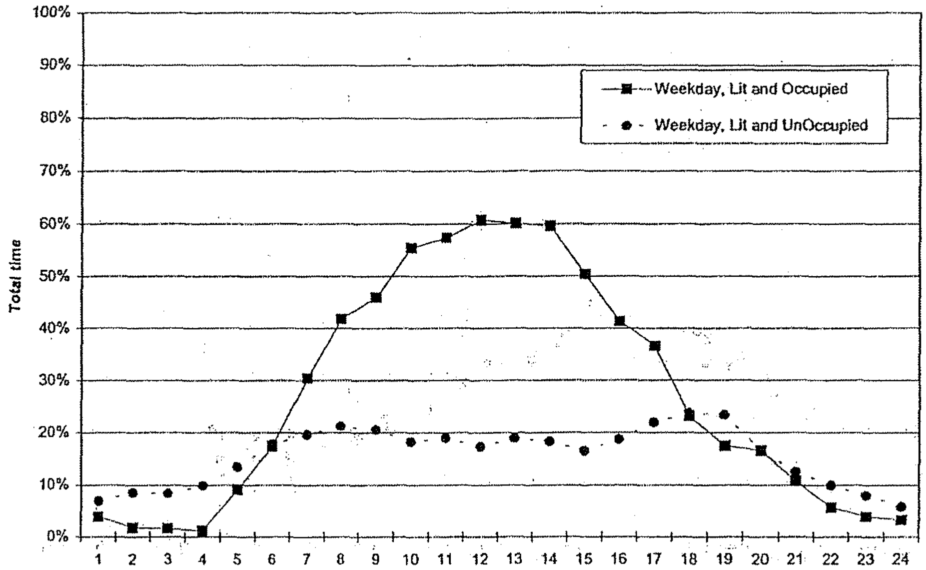


Figure 1. Break room average hourly lighting condition profile for the percentage of time when spaces were lighted during occupied and unoccupied periods for the weekdays.

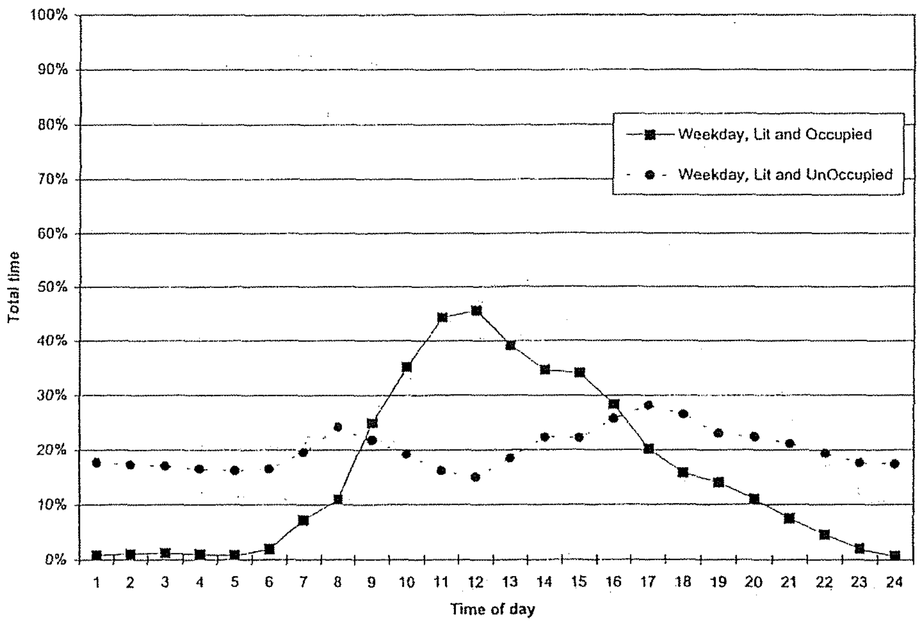


Figure 2. Classroom average hourly lighting condition profile for the percentage of time when spaces were lighted during occupied and unoccupied periods for the weekdays.

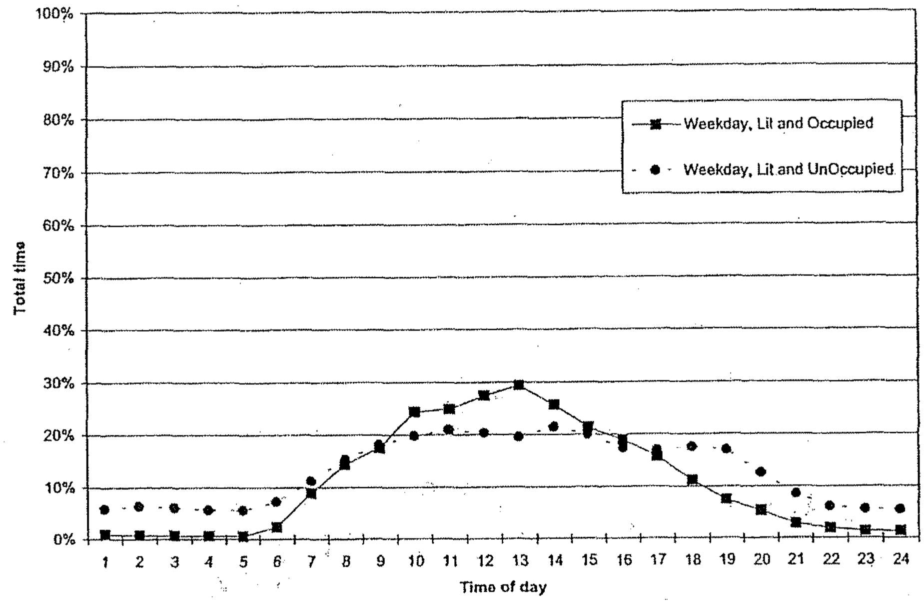


Figure 3. Conference room average hourly lighting condition profile for the percentage of time when spaces were lighted during occupied and unoccupied periods for the weekdays.

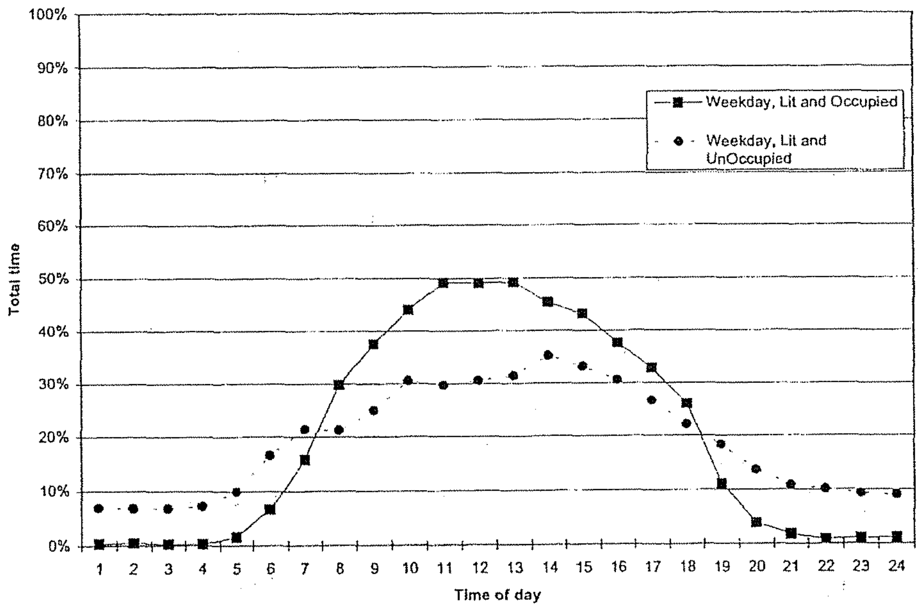


Figure 4. Private office average hourly lighting condition profile for the percentage of time when spaces were lighted during occupied and unoccupied periods for the weekdays.

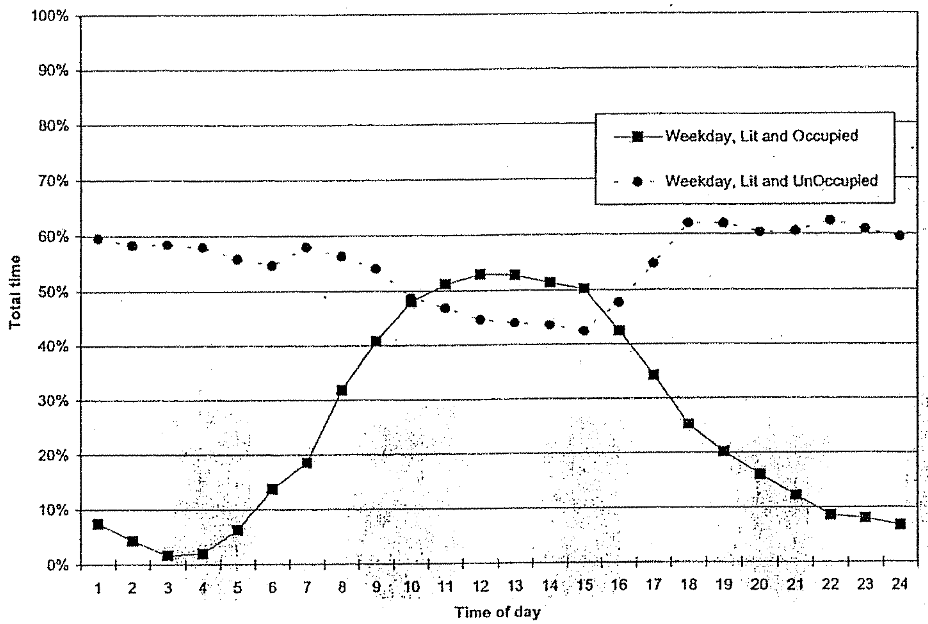


Figure 5. Restroom average hourly lighting condition profile for the percentage of time when spaces were lighted during occupied and unoccupied periods for the weekdays.

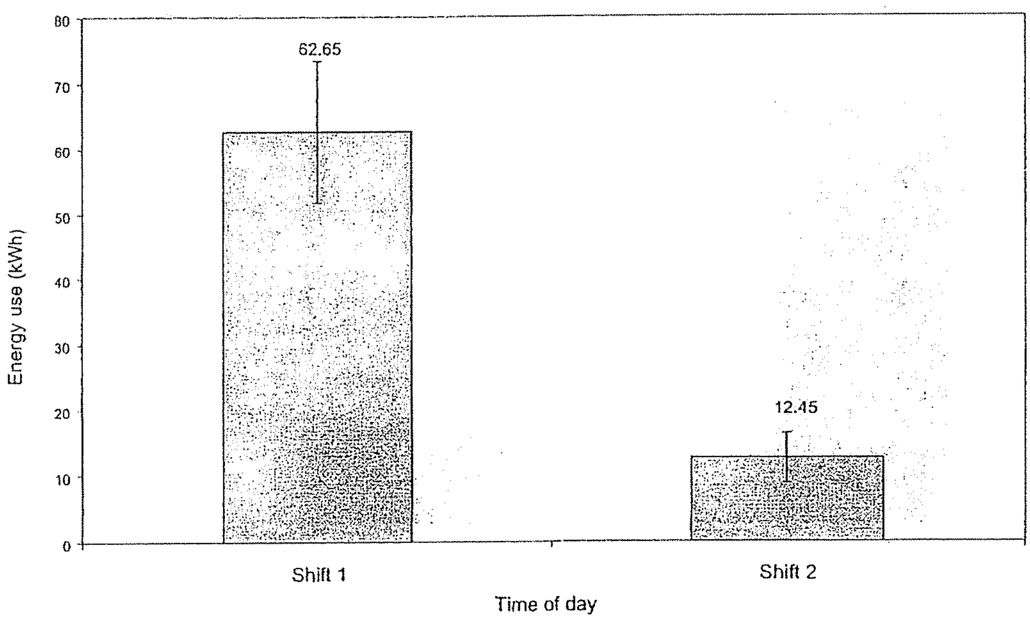


Figure 6. Break room main effects, Shift 1 and Shift 2 comparisons.

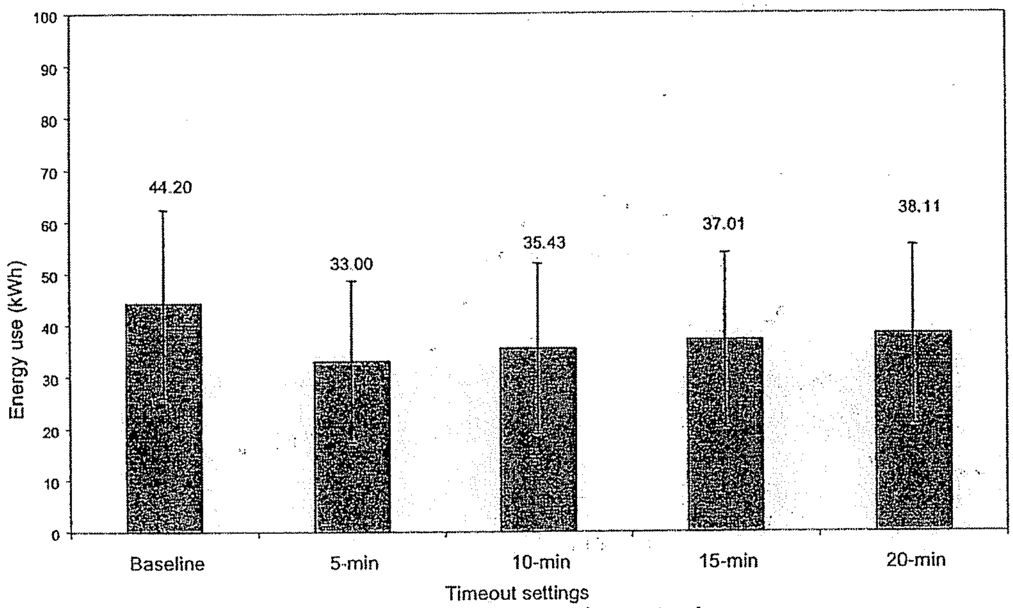


Figure 7. Break room main effects, baseline and timeout setting comparisons.

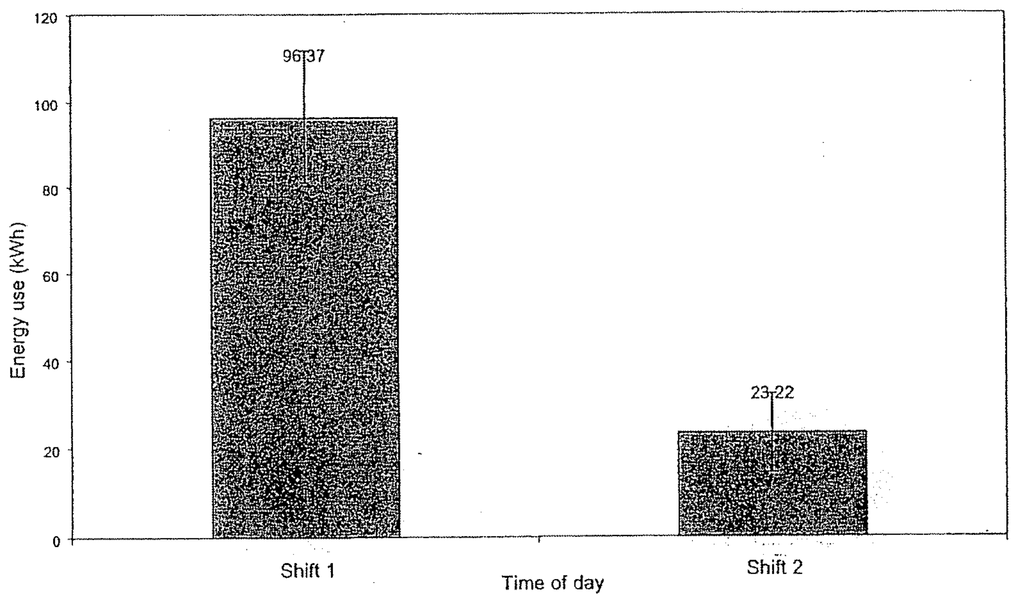


Figure 8. Class room main effects, Shift 1 and Shift 2 comparisons.

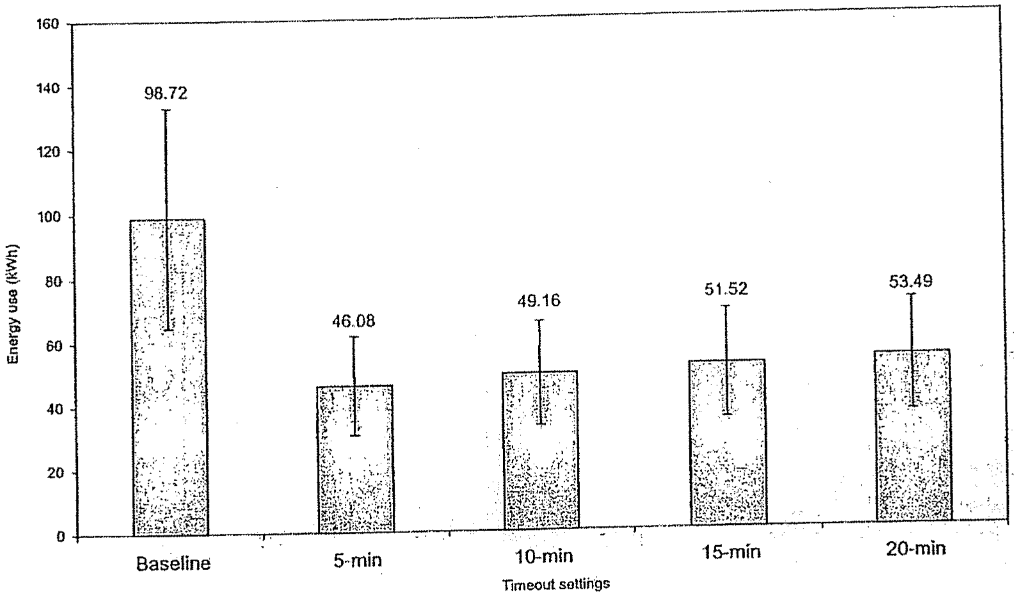


Figure 9. Classroom main effects, baseline and timeout setting comparison

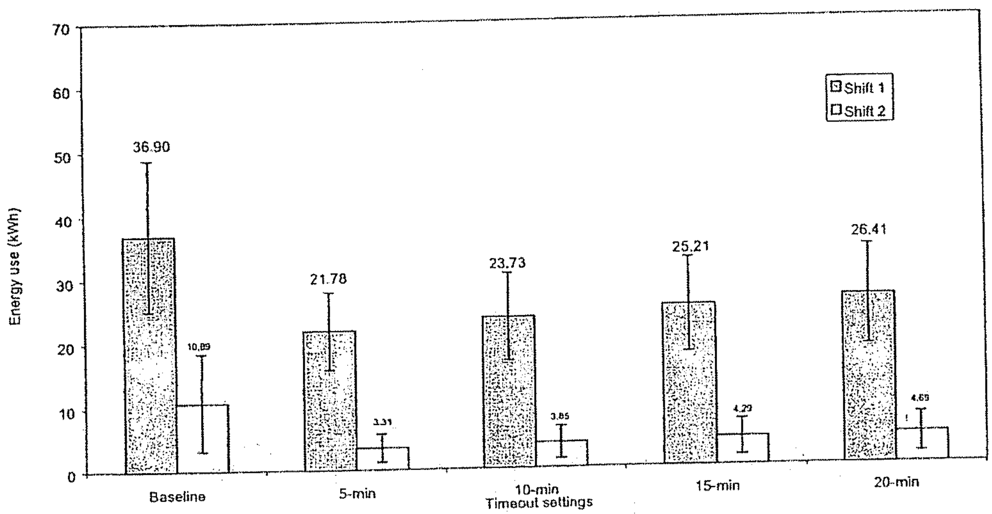


Figure 10. Conference room post hoc comparisons for each shift for the baseline and each timeout setting with the 95% confidence intervals.

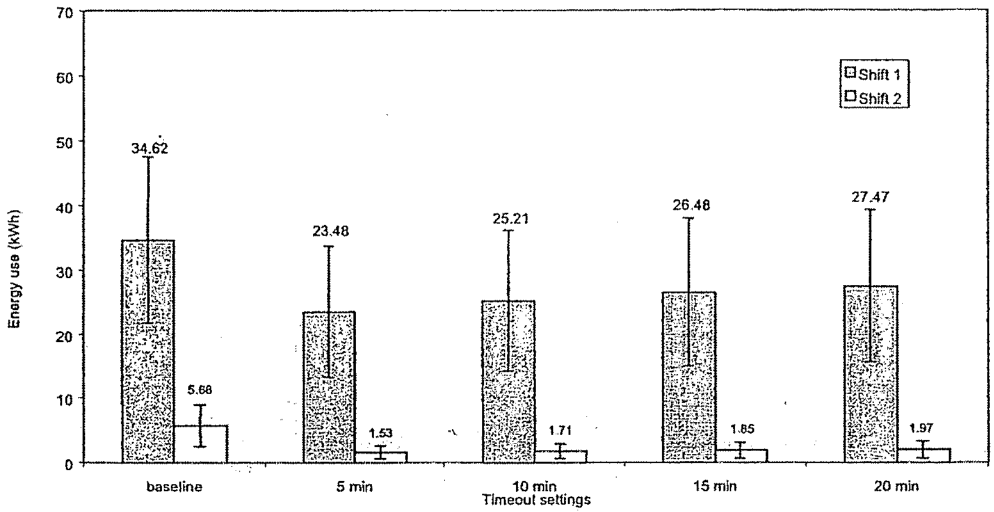


Figure 11. Private office post hoc comparisons for each shift for the baseline and each timeout setting with the 95% confidence intervals.

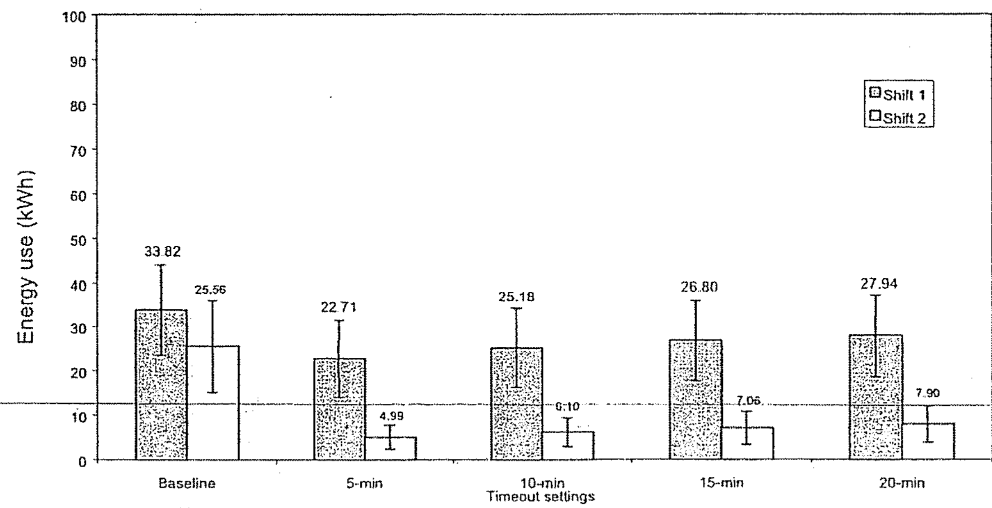


Figure 12. Restroom post hoc comparisons for each shift for the baseline and each timeout setting with the 95% confidence intervals

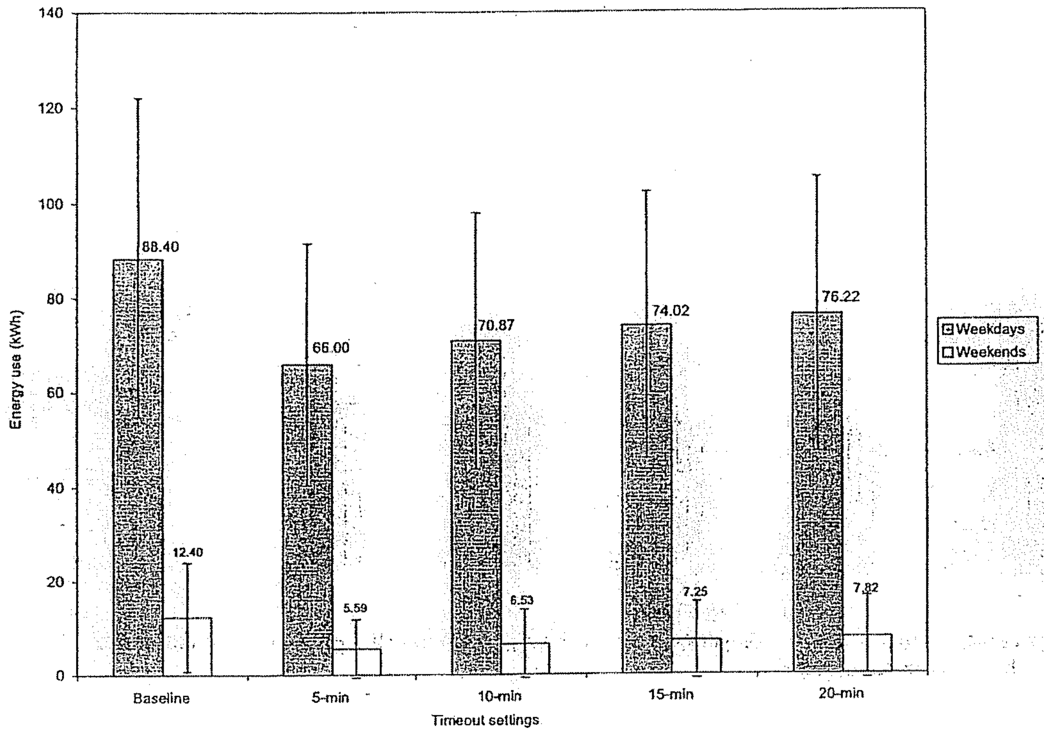


Figure 13. Break room post hoc comparisons for weekdays and weekends for the baseline and each timeout setting with the 95% confidence intervals.

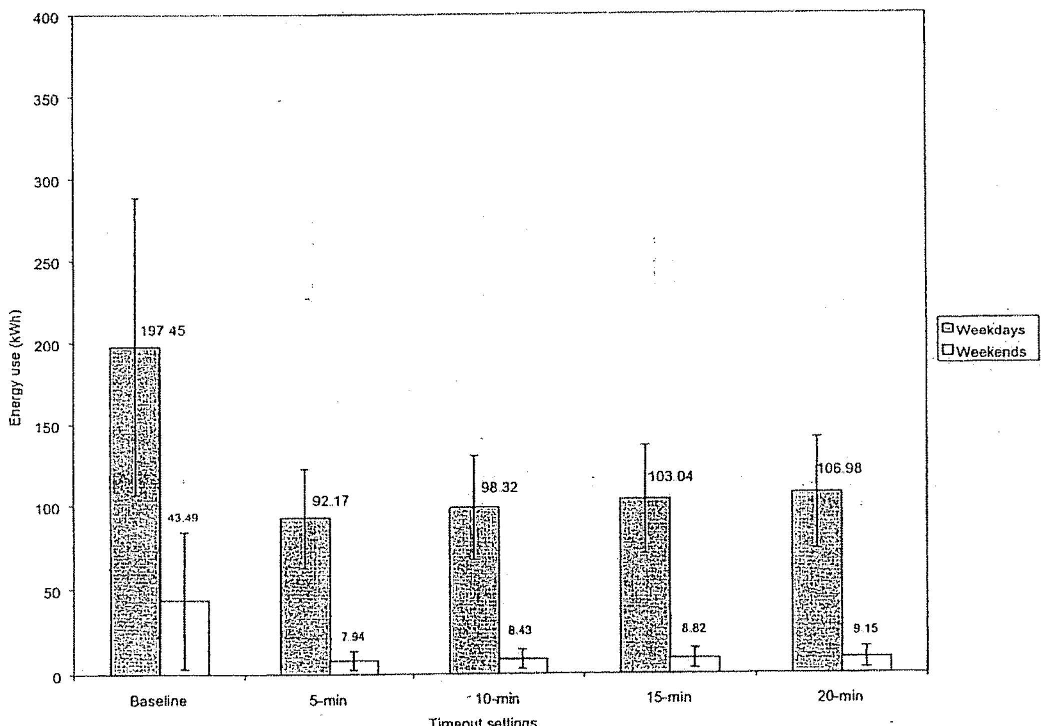


Figure 14. Classroom post hoc comparisons for weekdays and weekends for the baseline and each timeout setting with the 95% confidence intervals.

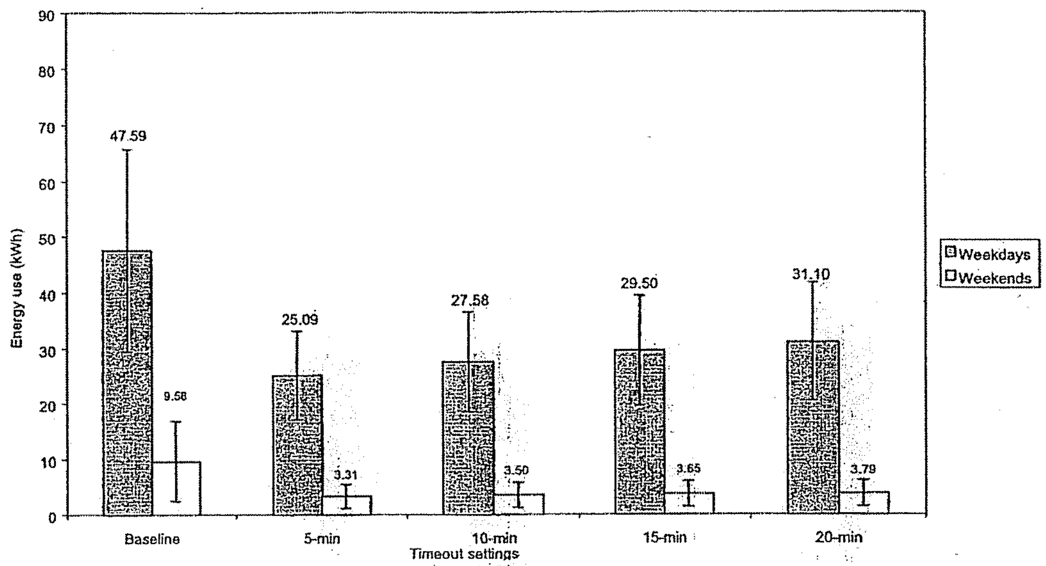


Figure 15. Conference room post hoc comparisons for weekdays and weekends for the baseline and each timeout setting with the 95% confidence intervals.

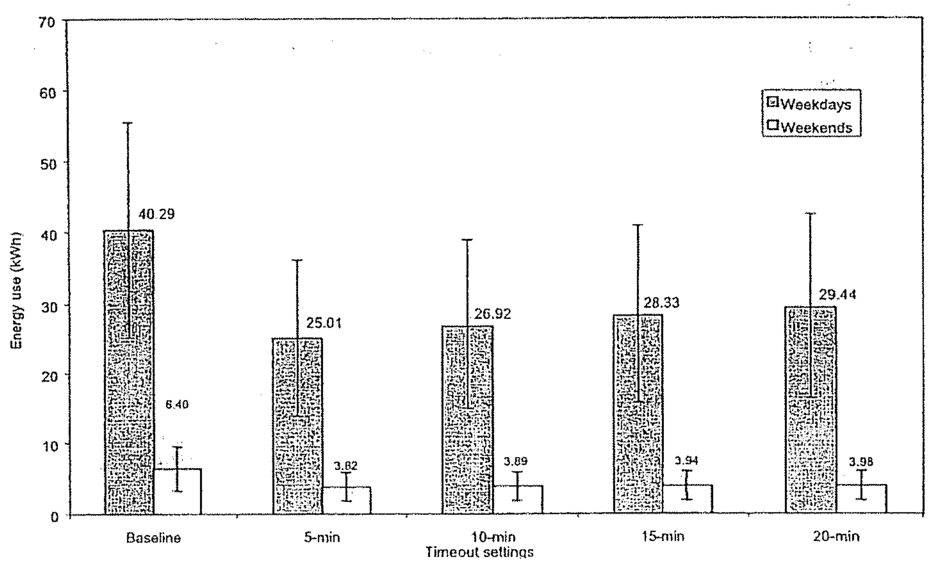


Figure 16. Private office post hoc comparisons for weekdays and weekends for the baseline and each timeout setting with the 95% confidence intervals.

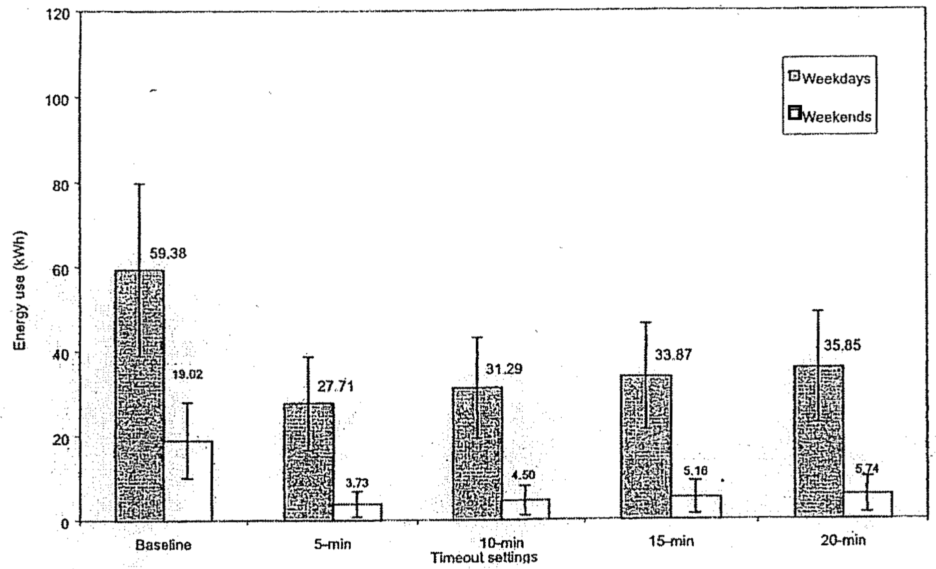
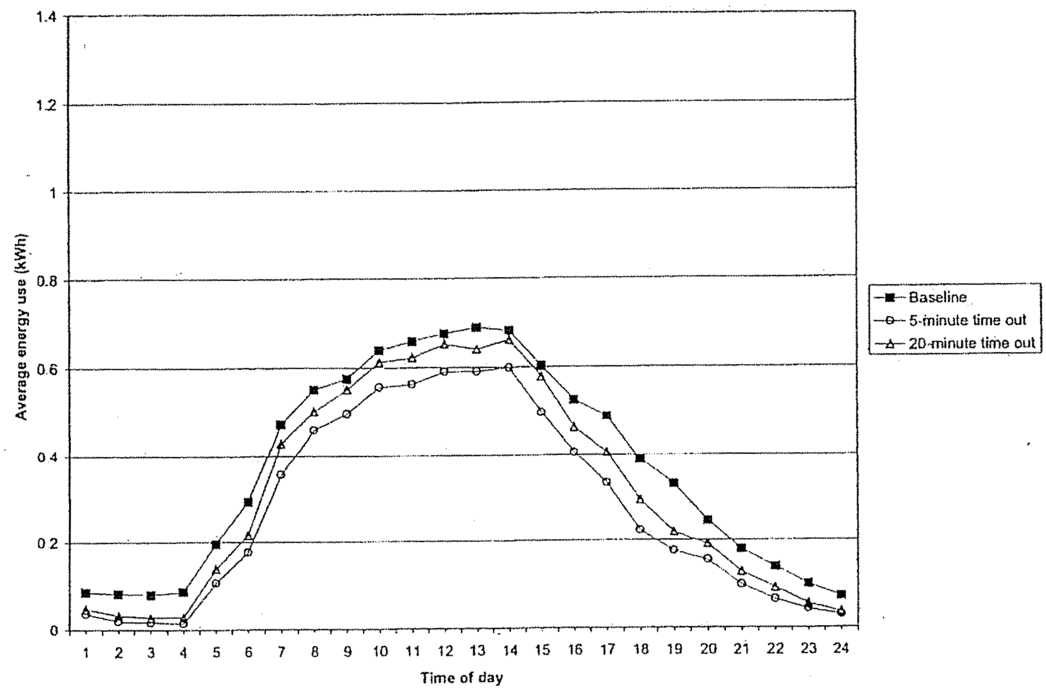
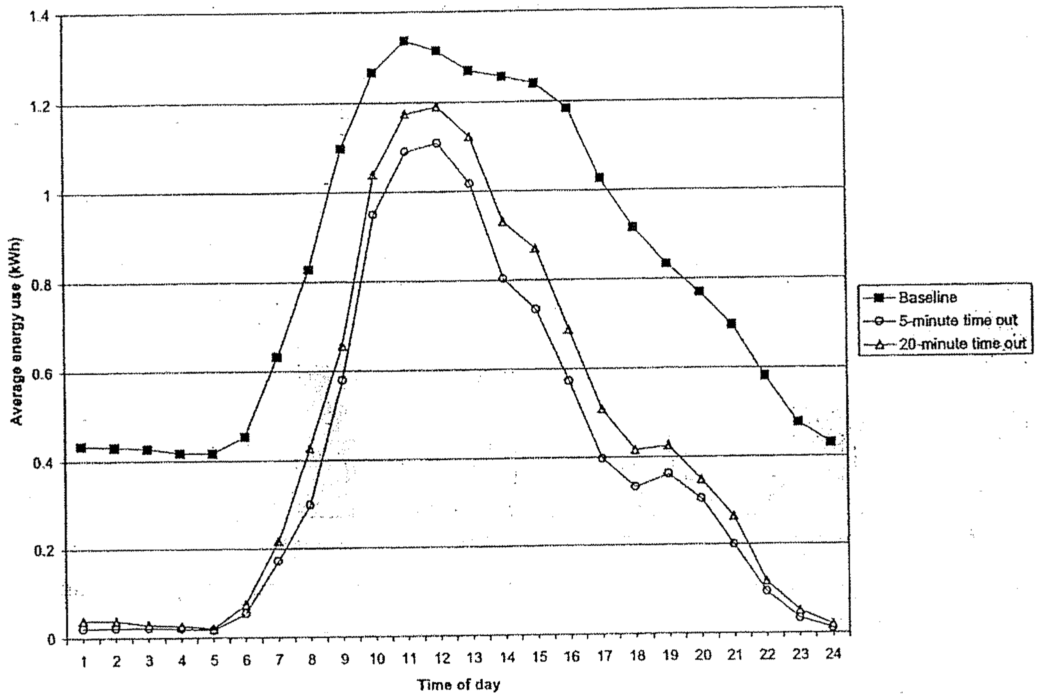


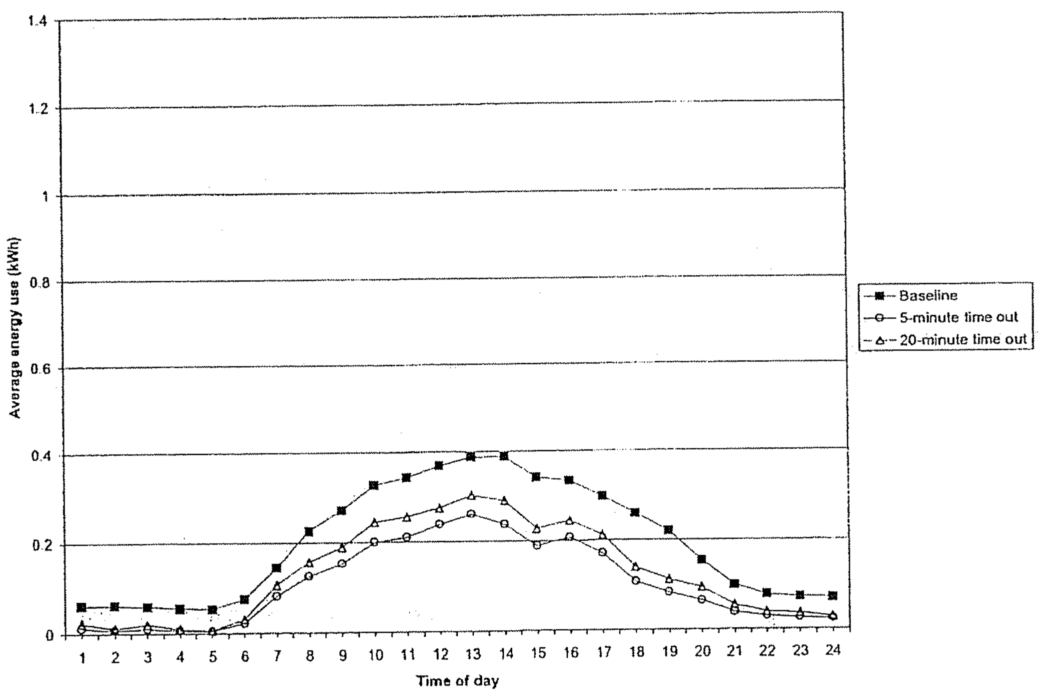
Figure 17. Restroom post hoc comparisons for weekdays and weekends for the baseline and each timeout setting with the 95% confidence intervals.



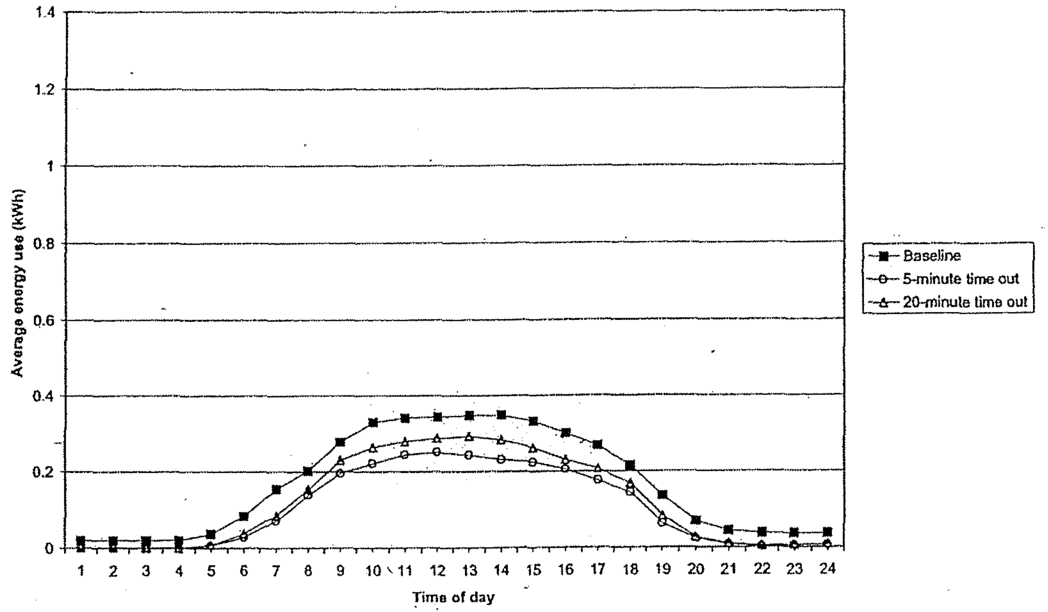
Figures 18. Break room weekday load profiles for the baseline and for the shortest and longest time delay settings.



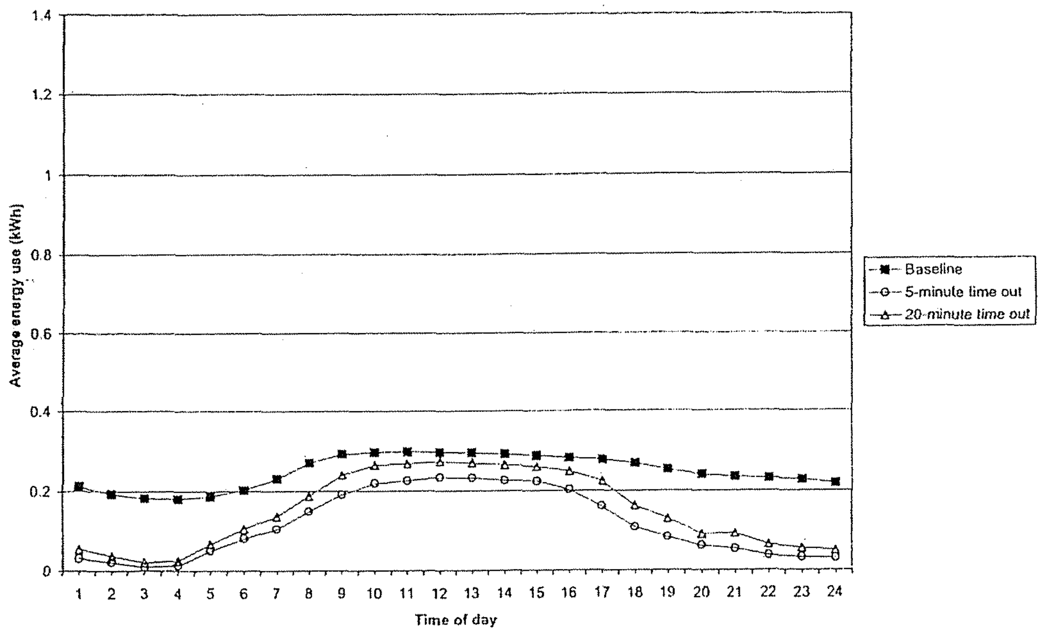
Figures 19. Class room weekday load profiles for the baseline and for the shortest and longest time delay settings.



Figures 20. Conference room weekday load profiles for the baseline and for the shortest and longest time delay settings.



Figures 21. Private office weekday load profiles for the baseline and for the shortest and longest time delay settings.



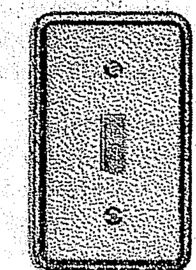
Figures 22. Restroom weekday load profiles for the baseline and for the shortest and longest time delay settings.

GREEN SEAL'S Choose GREEN REPORT

FEBRUARY 1997

OCCUPANCY SENSORS

One of the most overlooked energy-saving tools in the work place is the light switch. Lighting accounts for 30 to 50% of a building's energy use, or about 17% of total annual US electricity consumption. Simply turning off unneeded lights can reduce direct lighting energy consumption up to 45%. Reducing lighting electricity usage reduces your energy cost and lessens the environmental impacts associated with electricity generation.



In this report, we discuss one approach to reducing office lighting energy consumption: occupancy sensors. These are inexpensive and effective devices that can quickly and easily be installed on a wall or ceiling. A list of features to look for when you shop for these devices is included. We have gathered information from the major sensor manufacturers and identified a number of devices that satisfy these criteria. We also explore other options for turning off unused lights and other equipment.

Making Sense of Sensors

Occupancy or motion sensors are devices that turn lights and other equipment on or off in response to the presence (or absence) of people in a defined area. Some sensors also control lighting based on the amount of daylight available in their coverage area. Most available sensors are designed to function independently or in parallel with other sensors for large areas.

> *A complete sensor unit consists of a motion sensor, an electronic control unit, and a controllable switch/relay*

Originally developed for use with security systems, occupancy sensors have been refined and enhanced to control lighting and HVAC in commercial and residential spaces. More sophisticated sensor units now offer users a variety of adjustment capabilities; manufacturers have

continued on page 2

Making Sense of Sensors
continued from page 1

also introduced sensors that can be integrated into a building's automation and control system.

Sensors have become more widely used in the last five years as the devices have become more reliable and as building automation and energy savings have become more prominent. Where there are utility rebates available, sensors can pay for themselves in less than one year, but most pay for themselves in two to three years without rebates.

Units are available in wall-mounted switch configuration for use in offices or other small areas and in ceiling- and wall-mounted configurations for large, open areas. There are also sensors specifically designed for bathrooms, stairwells and hallways.

Although they are commonly referred to as "sensors", a complete sensor unit consists of a motion sensor, an electronic control unit, and a controllable switch/relay. Some units also incorporate an optional daylight (or light level) sensor. The motion detector senses motion and determines the occupancy status of an area. It also has a timer which signals the electronic control unit after a set period of inactivity. The control unit uses the signal from the sensor unit and other inputs, (for example, input from a light level sensor), as the basis on which to activate the switch/relay to turn on or off the lights and/or other equipment.

Where Should Sensors Sense?

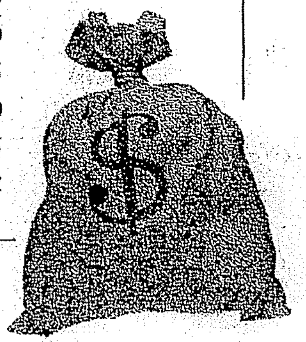
Generally, the most effective areas for sensors are areas that are not frequently used, areas with irregular use patterns or areas where lights are inadvertently left on, *e.g.*, conference rooms or reading rooms. Other targets include places where users are not often in control of the lighting/equipment or where the controls are not visible, such as copier rooms, bathrooms or storage areas. In commercial settings, individual offices, hotel and office conference rooms, library stacks, warehouses, store rooms and bathrooms tend to have the most unoccupied periods. The lights in these spaces are also more likely to be left on overnight.

To identify other potential areas for sensors, start where lights are often on, but where there is no continuous or permanent user presence. A rule of thumb is that areas with incandescent lighting usually yield more significant reductions and a faster payback.

Can you really save with sensors?

Here's an example: In Green Seal's building, lights are left on in the bathrooms on every floor for 24 hours a day. If sensors were installed, the on-time would be reduced by at least 12 hours, a 50% savings. At an estimated 500 watts per bathroom and 5 cents per kWh, the annual savings works out to be $219, or enough to buy 7 more sensors. The chart below shows the possible reduction in on-time gathered by MyTech Corp. in a survey of a large corporate headquarters.

Area type	**% Reduction**
Locker room	65
Large work room	55
Rest room	50
File room	45
Small work room	40
Corridors	25
Small offices	22



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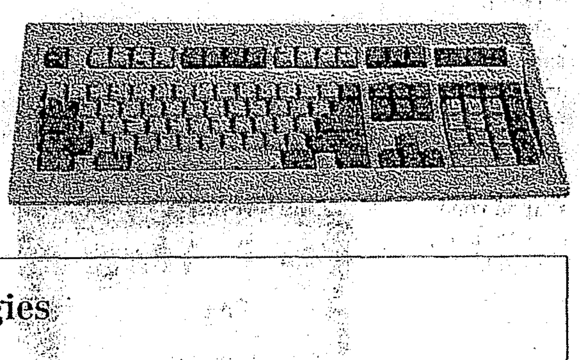
What Kind of Sensors Should You Use?

Device sensitivity/accuracy and capability for multiple adjustments are the two most important characteristics to look for in a sensor. Selection should be a function of the type of activity(ies) in the sensing area. Distinct types of motion that occupancy sensors typically key on are: desktop-type motion such as page turning or mouse and keyboard motion, torso motion such as reaching for objects, and whole body-type motion, such as walking. Depending on type and sensitivity setting, sensors can also respond to false signals (or "false triggering"), such as air movements from HVAC vents, or motion on the desktop due to HVAC flows, or the movement of warm air in front of a sunny window.

Selection should be a function of the type of activities in the sensing area.

Keep in mind that studies have shown that lighting controls work only when they are appropriate and unobtrusive. Occupants have disabled or defeated lighting controls when they interfered with their daily routine, and there are specific areas such as hallways or stairs that should not be controlled by sensors.



Available Types of Sensor Technologies

■ Infrared or Passive Infrared (PIR)

These sensors are tuned to detect infrared radiation (heat) from humans. A lens divides its coverage areas into pie-shaped segments and positive detection occurs when the sensor "sees" the motion of infrared radiation from one wedge to the next. IR devices are considered "passive" because they only detect radiation.

Advantages: highly resistant to false triggering, quite inexpensive, do not emit ultrasound or microwaves.

But: they are strictly line-of-sight devices, cannot "see" over partitions; range for small motion is dependent on the lens' focal length. At longer distances, the lens requires larger movements in order to register occupancy.

Recommendations: an excellent choice for areas with little or no obstructions, like library stacks, hallways and smaller offices and conference rooms.

■ Ultrasonic or Ultra Sound (US)

These sensors contain both an ultrasound generator and receiver. The ultrasound generator emits sound waves and any motion towards or away from the sensor causes a change in the reflected frequency.

Advantages: sensitive to almost all types of motion, no coverage gaps, and can detect movements that are not in their line-of sight.

But: they tend to be more expensive than PIR sensors; and are more prone to false signals; obstructions can reduce their effectiveness. Care must be taken to avoid overlapping sensors. There have been reports that sensors operating in the 25 to 27 kHz range may interfere with hearing aids.

Recommendations: an excellent choice for larger areas, open offices, hallways, conference rooms, bathrooms and unusually shaped areas.

■ Microwave

These sensors contains both a microwave generator and receiver. Sensors emit microwaves and detect movements through changes in the reflected frequency (most automatic door openers are microwave-operated).

Advantages: quite sensitive and usually have good coverage.

But: very little data currently exist on their reliability or operating cost.

Recommendations: specialized applications only.

■ Audio

These sensors contain a microphone that "listens" for sounds made by occupants or operating equipment.

Advantages: can be activated by voice, fairly inexpensive, do not emit sound or microwaves; they are not defeated by partitions.

But: they may mistake external sounds such as door closing, people walking, or even phone ringing as signs of occupancy.

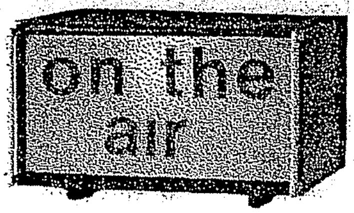
Recommendations: a good choice in unusually shaped areas.

Choosing Sensors

For most average-sized offices, wall switch-type PIR or US sensors will perform well. However, care should be taken in cases of unusual shaped rooms where the switch location does not provide the sensor with a good field-of-view (an "L" shaped room, for example); especially where the sensor can be easily obscured. For larger spaces such as an open office area, conference rooms or library stacks, wall or ceiling mounted PIR, ultrasonic or combination sensors should be considered, and more than one sensor unit may be necessary. The sensor/switches combinations generally offer better coverage areas as well as ability to handle larger electrical loads.

Sensors must have an indicator to alert occupants when they are on or about to switch off.

Use the criteria below to select sensors. For use in small individual offices, the coverage area is not as important as the feature requirements.



■ **Compatibility:** Wall switch sensors and control units must be able to switch electronically-ballasted fluorescent lamps. (If you plan to upgrade or install building automation in the near future, look for sensors with outputs that are compatible with building automation systems).

■ **Daylight-Level Equipped Sensors:** Daylight or light level equipped sensors should offer users override capabilities.

■ **Failure Mode:** Sensors must be designed so that the equipment they control remains on in case of sensor failure.

■ **Indicators:** Sensors must be equipped with an audio or visual indicator to alert occupants whenever sensors are on, and provide warning prior to switching off.

continued on page 6

Available Types of Sensor Products

■ **Hybrid or Combination Sensors**

Units combine two or more technologies to minimize false detection, usually PIR and ultrasonic, or PIR and audio.

Advantages: can be very foolproof, allowing wide coverage and applications.

But: they can be more expensive (for small area applications), and may require more adjustments since sensors contain more than one sensing unit.

Recommendations: a good choice for large open areas and areas with unusual occupancy patterns or work requirements.

■ **Integrated Daylight Sensors**

A combination of PIR or ultrasonic sensors with a light-level sensor.

Advantages: can be wired to a dimming circuit to control room lighting based on available light and occupancy.

But: they can be difficult to adjust and require a dimming ballast or special wiring.

Recommendations: good for areas that receive large amounts of daylight.

■ **Wall Switch Sensors**

A PIR, ultrasonic or combination/hybrid sensor and control circuitry packaged into one unit, sized to fit in a standard wall box.

Advantages: small, inexpensive and easy to install.

But: their range can be limited, and depending on the location of the switch, they can easily be obscured.

Recommendations: good for smaller meeting rooms, individual offices and store rooms.

■ **Wall or Ceiling-Mounted Sensors**

PIR, ultrasonic or hybrid sensors designed to be mounted separately from the control unit(s), usually in high locations.

Advantages: can cover wide areas effectively; switching units can control a variety of equipment.

But: they tend to be more expensive and often necessitate rewiring.

Recommendations: a good choice for large areas.

■ **Specialized Sensors**

PIR or ultrasonic sensors designed specifically for bathrooms, hallways and stairwells.

Advantages: specifically designed for these spaces.

But: rewiring may be necessary if certain lights need to stay on.

Recommendations: excellent for these areas.

Recommended Products

Based on manufacturers' provided information, and the criteria listed above, Green Seal selected the following products as "Green buys." These were selected solely on information provided to Green Seal by their manufacturers. Green Seal has not tested or otherwise verified these claims.

COMPANY	MODEL #	TECH	COV. AREA (SQ FT)	WARRANTY (YRS)	LIST PRICE* ($)
SMALL AREA WALL SWITCHES					
MyTech Corp 512-450-1100	LP-2	PIR	900	5	N/A
Novitas, Inc. 310-568-9600	01-200	PIR	300	5	57.00
Sensor Switch 203-265-2842	WSDx	PIR	800	5	47.60
Technology Design Center, Inc. 610-539-4210	LO300WS	US	800	3	55.00
Unenco 510-337-1000	SOM-500	PIR	1000	5	73.00
The WattStopper 408-988-5331	Wx-277	PIR	900	5	65.00
LARGE AREA WALL SWITCHES AND SENSORS					
Leviton MFG 800-323-8920	6775x	PIR	2700	5	92.00
Novitas, Inc. 310-568-9600	01-083	US	2100	5	122.00
MyTech Corp. 512-450-1100	LAS-2200SF	US	2200	5	N/A
Sensor Switch 203-265-2842	WV-PDT	PIR	2000	5	77.00
Unenco 510-337-1000	C-500-2000	US	2000	5	99.00
The WattStopper 408-988-5331	W-2000x	US	2000	5	100.00

* For large area sensors, sensor prices may not include price of switching units.

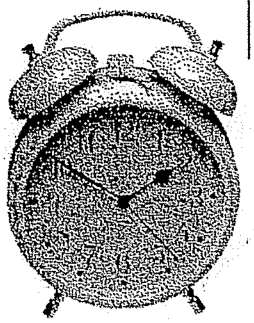
Choosing Sensors continued from page 4

■ **Manual Controls:** Look for wall switches with manual control capabilities.

■ **Minimum Load:** Sensors must be rated for 120, 240 or 277 volts operation, and have a minimum load rating of 600 W @ 120 V, or 1200 W @ 277 V.

■ **Timer Settings:** Look for an adjustable time delay period. At a minimum, the unit should have time delay periods from 30 seconds to 15 minutes.

Look for a sensor with an adjustable time delay period.



Coverage for Large Areas

SENSOR TYPE/CATEGORY	TYPICAL MOUNTING HEIGHT (ft.)	MINIMUM COVERAGE AREA (ft^2)
Wall Switches	3.5	300
Wall Mount	8	900
Ceiling Mount	8 to 10	1500
Hallway	8 to 10	100 linear ft
Combination - Wall Mount	8 to 10	1200
Combination - Ceiling Mount	8 to 10	1800

■ **Warranty:** Look for a repair or replacement warranty covering a minimum period of three years after installation.

■ **Coverage:** For applications other than small, individual offices, bathrooms or store rooms, you should look for the coverage in the chart above.

Other Things to Consider

Your savings will vary depending on the area size, type of lighting and occupancy pattern. Manufacturers claim that in some applications, savings can approach 75%. The California Energy Commission estimates that typical savings range from 35% to 45%.

continued on page 7

SUCCESS STORY

(From Lighting Management & Maintenance, February 1996 — Reprinted with author's permission)

In 1991, the State of Connecticut began an energy-efficiency program for state-owned office buildings in partnership with Northeast Utilities. One of the buildings selected for this program was #55 Elm St. in Hartford. This 188,000 square foot building houses the offices of the State's Attorney General, Treasurer and Comptroller. About 2/3 of the building is open office space and its lights often stayed on for 14 to 16 hours a day, shut off only when the building was totally empty.

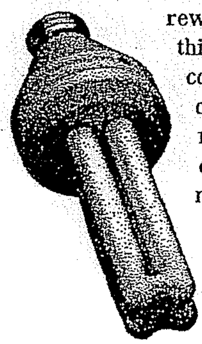
The State used a contractor to outfit the building with hybrid occupancy sensors (dual technology PIR/microphonic). The installation was carried out over a six-week period. All lights not intended for 24 hour use were wired to be controlled by occupancy sensors. Because of the building's open space, sensors were selected over other control methods such as computer-control or timed systems.

With a reported annual savings of $24,000 in direct electricity cost, the project paid for its $51,000 cost in just over two years. Just as important is the fact that the sensors were readily accepted by the building's occupants — high level lawyers and executives — without complaints.

For more information, contact the Connecticut Department of Public Works.

Other Things to Consider
continued from page 6

However, savings can be achieved without the use of sensors. If the occupancy pattern in an area is regular and predictable, a more effective choice is a timer system to turn lights and other equipment on and off at predetermined times. Also, the installation of sensors may not provide a payback if extensive rewiring is required. In this case, more effective conservation may come from lighting retrofits or other conservation measures.



Two important issues in the use of sensors with fluorescent lamps are ballast compatibility and the possibility of reduced lamp life. While all switching units are compatible with incandescent loads, some units are not compatible with electronic ballasts — check with manufacturers about the particular model(s) you have selected. Regarding reduced lamp life, the issue is not so clear-cut. Under most applications, the switching actions are long enough (>15 minutes) so that this is not a serious issue. But under certain situations, the useful life of compact fluorescent lamps and certain lamp-ballast combinations can be shortened by frequent on-off cycles.

Other Resources

California Energy Commission
916-654-5200

Lighting Research Center/RPI
518-276-8716

Rocky Mountain Institute/E Source 303-440-8500

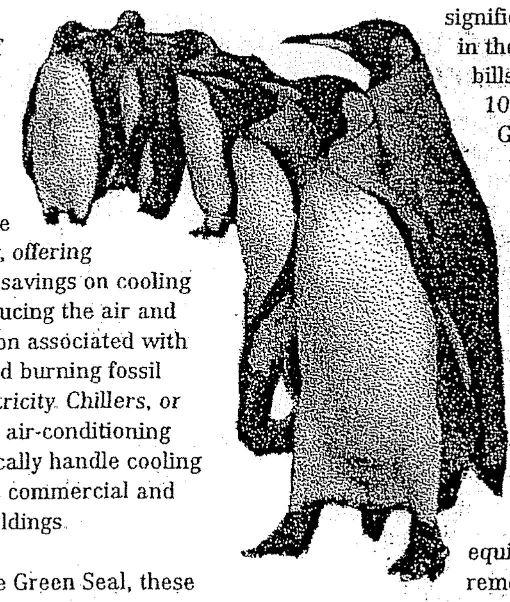
US EPA Green Lights Program
202-775-6650

The development of total building control systems may affect your installation of sensors. These computerized systems use sensors and actuators to monitor entire buildings and regulate their lighting, HVAC and other equipment. Standardized software and control/sensor modules are now being developed for use with these control systems. If your building is scheduled for automation, it may be necessary to use sensors that can be integrated into the proposed system. Additionally, the upcoming revision of ASHRAE standard 90.1, which will include requirements for building lighting and equipment controls, will affect new and retrofit buildings.

ANNOUNCEMENT

Trane Chillers Earn the Green Seal of Approval

Green Seal has certified the Earth•Wise™ CenTraVac® chillers, available in 300–1400 tons capacity, made by The Trane Company. These electric chillers are the first to receive the Green Seal of Approval. They are among the most energy efficient chillers on the market today, offering considerable savings on cooling bills, and reducing the air and water pollution associated with extracting and burning fossil fuels for electricity. Chillers, or chilled-water air-conditioning systems, typically handle cooling tasks in large commercial and industrial buildings.



To earn the Green Seal, these Earth•Wise™ CenTraVac® chillers had to meet Green Seal's rigorous environmental standard for electric chillers. Central to the standard are requirements for high energy efficiency levels and minimal ozone depletor releases. The Earth•Wise™ CenTraVac® chillers, with their low leakage rates and high energy efficiency, offer large commercial and industrial buildings significant savings in their cooling bills — up to 10% annually. Green Seal projects that if the Earth•Wise™ CenTraVac® chillers were used widely, the annual reduction in electricity use would be the equivalent of removing 200,000–300,000 cars from the road every year.

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ANSWERS TO YOUR QUESTIONS

What Is Green Seal Certification?

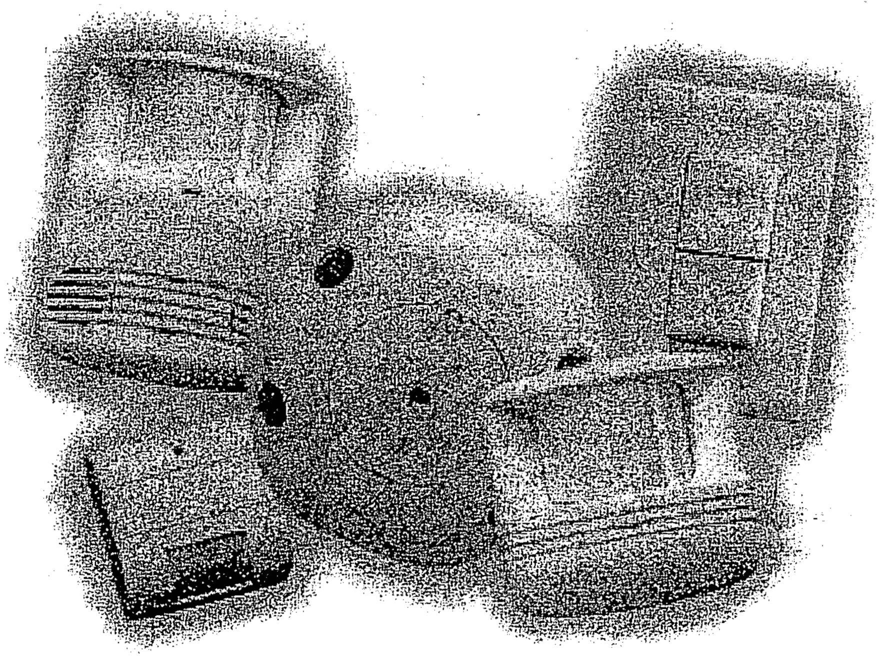
Green Seal sets environmental standards on a category-by-category basis. A study of the environmental impacts of products within a specific category is conducted, encompassing the manufacturing process, use of the product and its ultimate disposal. Product performance is examined in concert with environmental attributes. After the initial study, proposed standards are circulated for comment among manufacturers, trade associations, environmental and consumer groups, government officials and the public at large. Following a formal review of comments, Green Seal publishes the final standards and allows the use of its certification mark on products found to meet or exceed them.

Green Seal standards are periodically reviewed and updated to incorporate advances in technology and industry practices. Certified products are monitored annually to ensure continued compliance with Green Seal standards.

Who Are Environmental Partners?

Green Seal's Environmental Partners are businesses, government agencies and other organizations that have committed to taking product specific environmental impacts into account when making their purchasing decisions. Green Seal provides detailed, up-to-date discussions of environmentally responsible products and specific sources for buying them. The *Choose Green Reports* show *how* various products you buy may damage the environment, *what* products are better for your health and the environment, and *where* you can obtain them.

Occupancy Sensor Lighting Control Design Guide



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Occupancy sensor lighting control design

As many facilities professionals know, lighting can account for as much as 40% of a building's electrical usage. When much of the space being illuminated is empty, however, a company can find itself paying for wasted energy. The Watt Stopper occupancy sensors offer a reliable and convenient solution for lighting control to stop this waste.

Introduction

This application and design guide is intended to assist the lighting professional in selecting, laying out, and specifying an occupancy-based lighting control system. The guide includes an overview of general design considerations and occupancy-based control principles, a quick reference list, space-specific recommendations, and building-wide application scenarios. Together, these tools will help you in defining and implementing the optimal occupancy-based control solution for every type of building space.

Overview of process

Steps to implementing occupancy-based control programs:

- Identify whether occupancy sensing is the appropriate control strategy
- Select the appropriate occupancy sensor technology for each application
  - –evaluate space characteristics
  - –select sensor coverage pattern
  - –match the sensor technology to the application
  - –select sensor device features
- Choose the optimal mounting configuration
- Install and adjust the sensor

Quick reference tools

For a quick overview of the design process, this guide includes a flow chart that illustrates the principal steps involved in developing and implementing an occupancy sensor application. In addition, you'll find a quick reference list that offers critical design guidance in the form of "do's" and "don'ts." These are located on the next two pages of this guide.

Tip! The Watt Stopper's application experts are available for design support and assistance during any phase of a lighting control project. They are ready to help with occupancy sensor, lighting control panel, daylighting, or any lighting control design question. Call The Watt Stopper's technical support at 800/879-8585.

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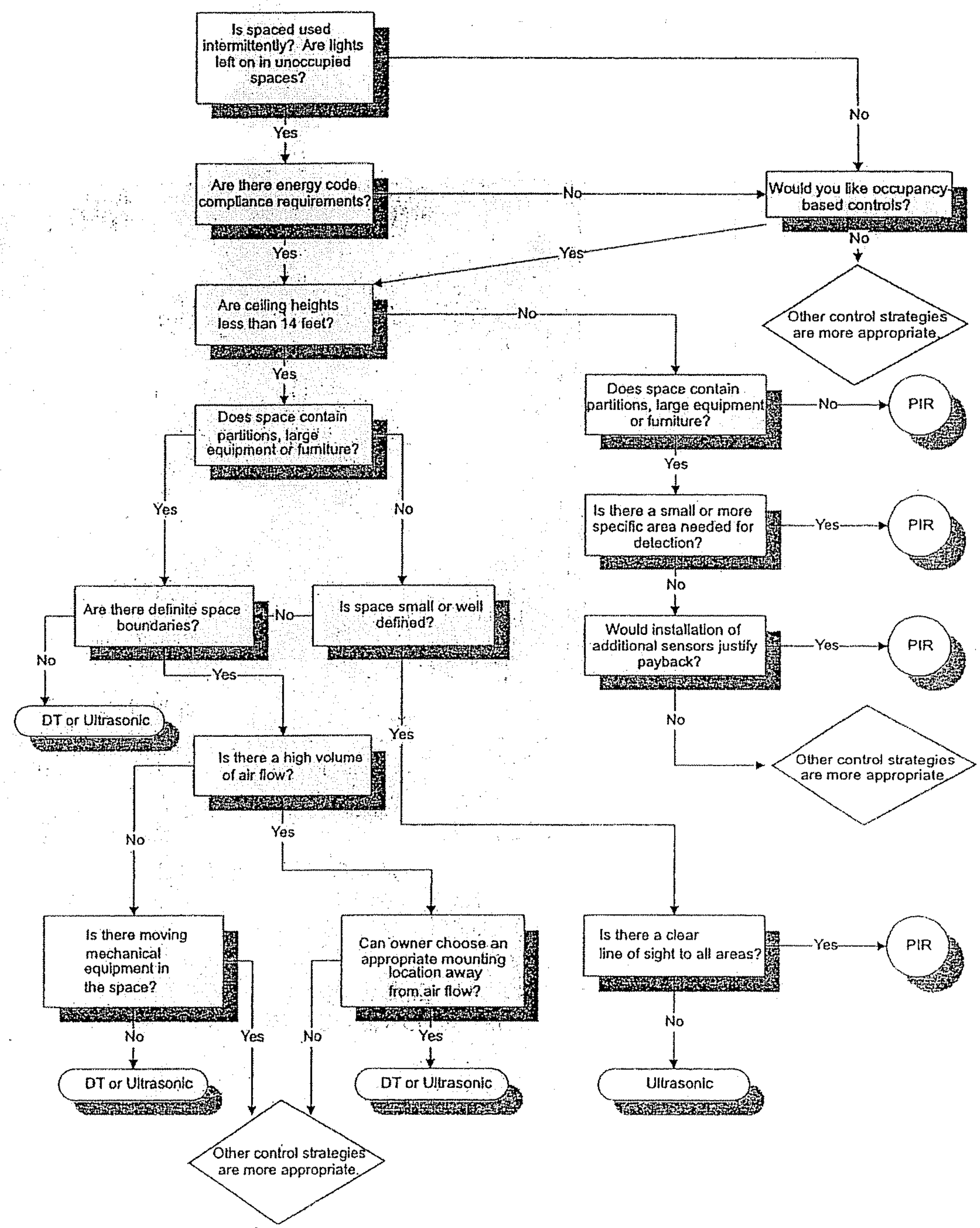
Design considerations in occupancy-based control



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Quick technical reference list

Designers and installers can use this general list of "Do's and Don'ts" as a quick reference tool in determining the correct sensor for an application. To evaluate individual sensor models, we recommend you review the specific cut sheet for that model, located in this binder under the "Products" tab.

Do	Don't
• Use ultrasonic sensors in areas screened by partitions or furniture • Use PIR in enclosed spaces • Create zones controlled by different sensors to manage lighting in large areas • Use dual technology sensors for areas with very low activity levels • Install sensors on a vibration-free, stable surfaces • Position sensors above or close to the main areas of activity in a space • Mask the sensor lens to define coverage of the controlled zone even more accurately • Integrate sensor use with other control methods (i.e. scheduled control, daylighting.) • Educate occupants about the new devices and what to expect	• Use ultrasonic sensors in spaces with heavy air flow • Install ultrasonic sensors in spaces where the ceiling height exceeds 14 feet • Use PIR sensors in spaces where there are fixtures or furniture that obstruct a clear line of sight • Install PIR sensors so that their line of sight continues beyond doorways • Install sensors within 6-8 feet of HVAC outlets or heating blowers • Position a wall switch sensor behind an office door • Control emergency or exit lighting with sensors • Install PIR sensors in spaces where there are extremely low levels of occupant motion

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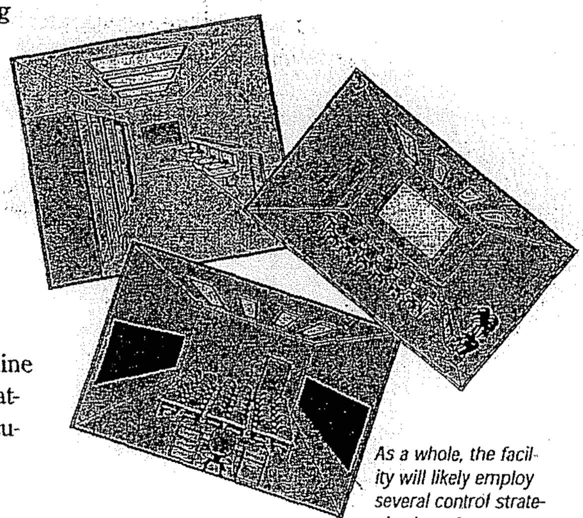
Selecting the control strategy

In developing a lighting control program, lighting professionals must consider important energy management factors:

- Is the company interested in obtaining energy savings?
- Are there energy code compliance requirements for lighting control?



As a whole, the facility will likely employ several control strategies in various areas.

Occupancy patterns

Once energy saving goals are clarified, and any code compliance issues addressed, attention can turn to the appropriate control strategy. Ideally, this will be the strategy that best suits the space under consideration. So to determine whether an occupancy-based control strategy is the appropriate choice for a particular area, the project team must evaluate the usage pattern of that area.

Certain usage patterns are particularly suited to occupancy-based control. You can identify these situations quickly by determining the answers to these preliminary questions:

- Are there periods of time when a building space (or portions of it) is unoccupied?
- Is energy being wasted due to lights being left on in unoccupied spaces?
- Do occupants or maintenance personnel leave the lights on after business hours?
- Is the space intermittently used?

Yes?

If some or all of the answers to these questions are "yes," occupancy sensors are a viable control option. Combining this control strategy with others, such as time scheduled or daylighting control, can maximize energy savings and reduce wasteful lighting.

Don't Know?

If the answers are "don't know," you may need to assess lighting use in order to answer these questions by conducting a lighting audit.

Tip! Audit tools such as The Watt Stopper's InteliTimer Pro light logger can assist you in identifying the energy saving potential of specific spaces.

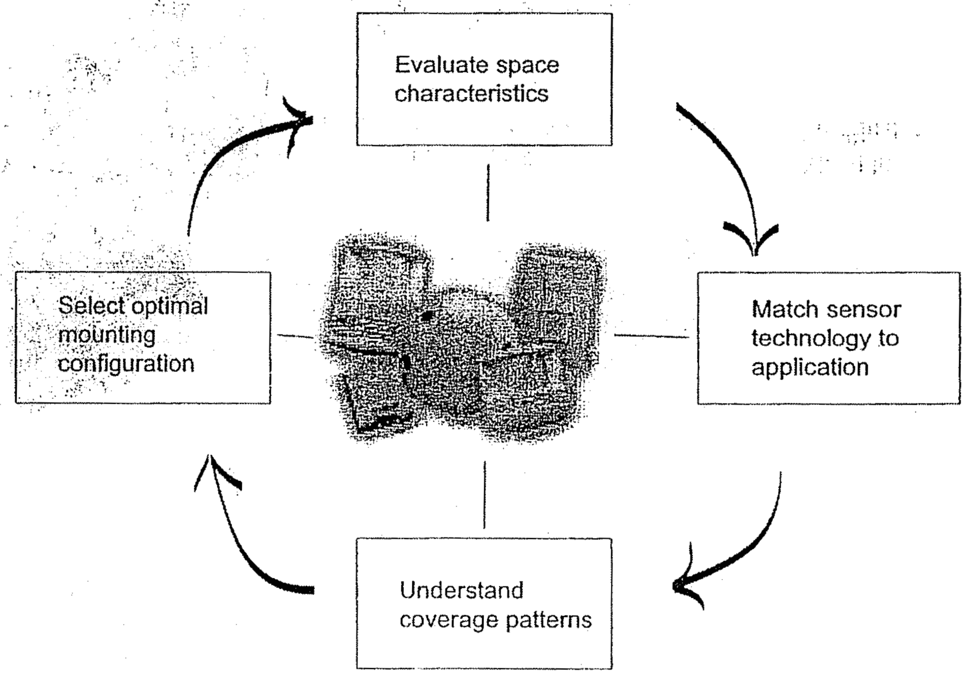
No?

If the answers are "no," occupancy-based control may not be the appropriate solution for your facility. Our technical support team can help you identify the most effective Watt Stopper control solution for your facility.

Selecting the proper occupancy sensor

Important factors

Identifying the ideal occupancy sensor for a particular application involves the consideration of several factors that are equally critical to an effective control solution. While project members may be assessing these factors simultaneously, each is essential to the ultimate result. Because different sensor technologies work best under different circumstances, incorporating these factors into the decision making process will provide optimal results:



Evaluating space characteristics

Evaluating the application's characteristics means reviewing the physical characteristics of the space under consideration. Designers should become familiar with:

- Room/space size and shape
- Location(s) of occupant activity and non-activity
- Location of walls, doors, windows and drapes
- Ceiling height
- Partition height and location
- Location of shelves, book cases, file cabinets, and large equipment
- Large objects that would block or alter a sensor's coverage
- Location of HVAC ducts & fans
- Areas with available sunlight for added light level sensing
- Location of desk/workspace – orientation with regards to walls, partitions and other obstacles

Tip! Special attention should be paid to high levels of vibration and/or air flow, extreme temperature conditions, and unusually low levels of activity, because these issues may lead to alternate technology solutions.

Matching sensor technology to applications

Sensor technologies

Occupancy sensors use passive infrared, ultrasonic, or a combination of these technologies.

Passive infrared (PIR) technology. This relies on "line-of-sight" coverage to detect occupancy by sensing the difference in heat emitted by humans in motion from that of the background space.

Ultrasonic technology. This utilizes the Doppler principle to detect occupancy through emitting ultrasonic sound waves throughout a space.

Dual technology (DT): These sensors employ both PIR and ultrasonic technologies. DT sensors will activate lights when both sensing technologies detect occupancy, but will continue to hold lighting on as long as only one technology detects continued occupancy.

The matrix below summarizes these technologies and the space characteristics that would favor the use of one technology over another in a specific application.

Occupancy sensor matrix

	PIR wall switches	PIR ceiling & wall mount sensors	Ultrasonic ceiling sensors	Dual Technology sensors
Coverage type	- line of sight - cut off	- line of sight - cut off	- volumetric - no clear cut off	- complete coverage - cut off
Compatible physical characteristics	- smaller, enclosed spaces	- spaces where the sensor has a view of the activity	- open spaces - spaces with obstacles - bathroom	- classroom - spaces with low motion levels by occupants
Incompatible physical characteristics	- low motion levels by occupants - obstacles blocking sensor view	- low motion levels by occupants - obstacles blocking sensor view	- high ceilings - high levels of vibration or air flow	- high levels of air flow - warehouse

Note: "Cut off" refers to the ability to clearly define or limit sensor coverage so that detection capability will not intrude into adjacent spaces.

Coverage patterns

Product coverage patterns

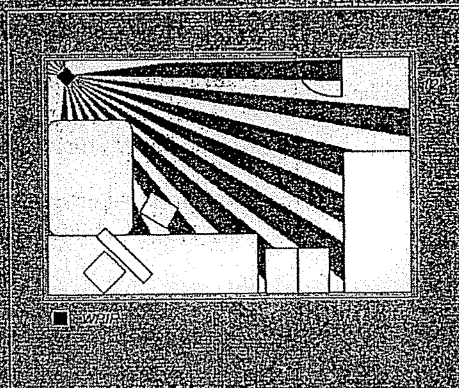
Once the technology choice is made, many different coverage sizes and shapes are available within each sensor technology. Thus, a specific sensor may be a better choice than another for a particular space. Familiarity with these coverage patterns will help engineers make the right selection.

Example (Directional coverage)

In a small, enclosed space such as a private office, the WS PIR wall switch provides a maximum coverage of 900 square feet while the WPIR ceiling mount PIR sensor affords a maximum coverage of 300 square feet. These sensors offer coverage patterns that cover the space well, and the multiple levels ensure detection on the desktop.

Products Used

PIR occupancy sensors (models WS and WPIR)



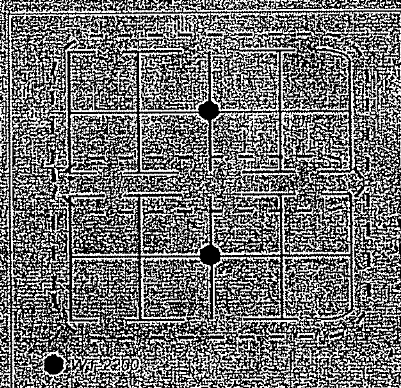
Tip! Keep in mind whether occupants will be engaged in gross motions, such as walking, or fine motions, such as hand work. Coverages change depending on motion type.

Example (Omni-directional coverage)

In an open, partitioned office area, designers select ultrasonic sensors to ensure coverage that will not be affected by the obstructing partitions. To adequately cover the entire space, multiple sensors are used. Each sensor is positioned to cover a specific zone in the office area.

Products Used

ultrasonic occupancy sensors (model WT-2200)



Tip! When creating zones of coverage, such as the coverage illustrated in the example above, installers should take care to ensure that individual sensor coverages overlap by 10-20%.

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Product features

When selecting specific occupancy sensor models, lighting designers should also consider model features, which can add functionality and flexibility to the control solution.

Light level

Built-in light level sensing

This feature holds lighting systems off when natural light levels are above a pre-set level. At the same time, users can control the operation of the feature by adjusting the settings or employing an override capability. This feature is available in several Watt Stopper PIR wall switches and ceiling sensors.

Tip! This feature is recommended for spaces that have access to abundant natural light, such as offices around building perimeters, or areas around atriums and skylights. Although multiple sensors may be used, only one sensor should be actively utilizing the light level feature within a controlled area.

Example	Product Used
Lobby lighting in a medical clinic surrounds a large atrium with skylights. A single sensor controls adjacent lights. This sensor includes the light level sensing feature, which controls the central lamp in each fixture. When occupants enter at 8:30 a.m., the other two lamps in each fixture switch on. However, because there is adequate natural light, the central lamp in each fixture remains off. When the day becomes overcast at noon and light levels become inadequate, the feature will signal the central lamp in each fixture to switch on.	CX-100 sensor power pack

ON mode operation

Automatic ON or Manual ON

With the automatic ON feature, lights automatically turn on when occupants enter a controlled area. And once the space is vacated and the user-set time delay elapses, lights automatically turn off. This functionality affords occupants "hands-free" lighting with maximal convenience. The manual ON feature requires the occupant to turn the lights on manually. This capability provides the greatest energy savings possible.

Example	Products Used
In a supervisor's office, the supervisor is frequently out of the room at meetings. However, her staff often come into the office to leave reports or messages on her desk. To maximize energy savings, the room's lights are controlled by a wall switch that includes the manual ON feature. This avoids switching the lights on with frequent walk-through activity.	WI wall switch sensor

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Product features (cont.)

Isolated relay

Isolated relay

Available in some PIR, ultrasonic, and DT sensors, the single-pole, double-throw isolated relay enables interfacing with a facility's HVAC, EMS, or monitoring systems.

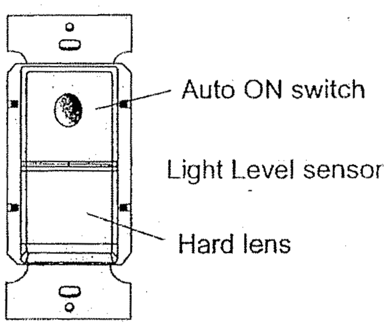
Example	Products Used
A school selected sensors for classroom use that included the isolated relay feature. Because this feature integrates the facility's lighting with its HVAC system, people entering the campus at night, such as teachers coming to prepare for the next day's lessons or PTA members attending meetings, will trigger not only the necessary lighting, but the heat or air conditioning as well.	DT-200 sensors, power packs

Vandal resistant lens

Hard lens

Wall switches that are placed in public spaces or schools require a lens that can stand up to substantial contact. Up to five times the thickness of comparable wall switch lens, this hard lens makes the device resistant to vandalism or unintentional damage.

Tip! Use the WA or WD wall switches with hard lenses in offices where there may be an increased risk of vandalism, such as teachers' or public offices, or areas where there could be a greater risk of damage, such as storage rooms.



This WA wall switch includes the light level sensing, automatic ON, and hard lens features

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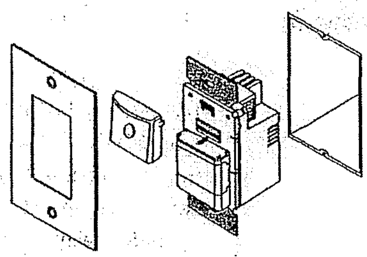
Occupancy sensor mounting choices

Configuration types

Watt Stopper sensors are available in two basic mounting configurations to facilitate proper installation and use:

- wall switch replacements
- ceiling or wall mount sensors with power packs



WA sensor replaces conventional wall switch

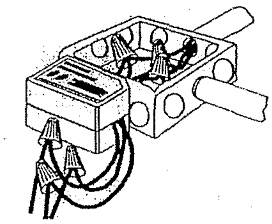
Wall switch replacements

Wall switch replacements are designed to replace existing wall switches, or for installation in wall switch locations in new buildings.

Wall switch replacements utilize PIR technology and therefore require a clear line of sight of the coverage area. They are best suited to small enclosed offices or rooms.

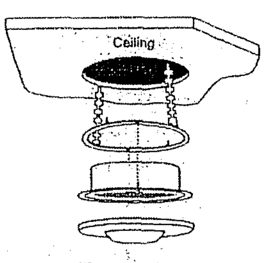
Ceiling/Wall Mount Sensors

For ceiling or wall mount installations, an occupancy sensor system includes the sensor itself and a power pack. The power pack transforms power to 24 VDC (the voltage the sensor needs for operation) and contains a relay that is used to switch the load. These sensors are available in a variety of models utilizing different sensing technologies and offering different features and coverage patterns.

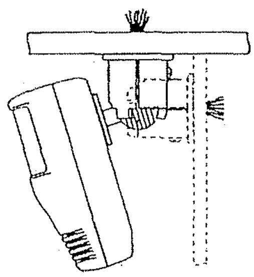


Power packs are used when ceiling sensors are selected

Some sensors are recommended for ceiling mount use, such as the CI-200, W series, WT series, and WPIR. Others, such as the CX and DT series, contain built-in bracket systems that provide ceiling mounting as well as wall mounting. This is important for applications where the ceiling is unavailable for sensor installation.



CI-200 ceiling mount sensor



The DT-200 sensor can be installed on the ceiling (outlined here in black) or on the wall (outlined here as dotted line)

Example

In an older building, private offices around the building perimeter contain walls constructed from brick masonry and standard acoustic tile ceiling. The installer selects a ceiling mount sensor that easily installs.

Products Used

PIR occupancy sensors (model CI-200), power packs

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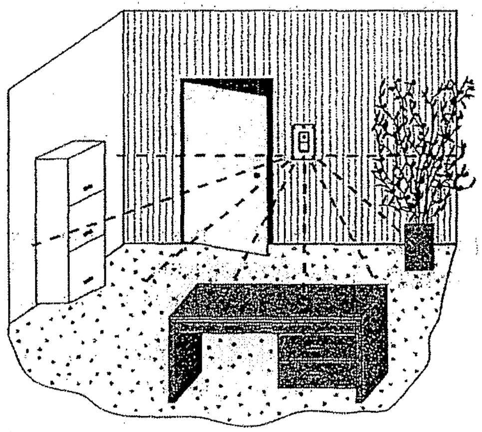
Sensor placement, installation, and settings

Sensor placement

In determining the correct location for sensors, installers should position the device so it has the best view of the entire coverage area. Care should be taken to minimize the possibility of false ONs or OFFs due to sensor location. For instance, an ultrasonic sensor should not be positioned near an open doorway, since a passerby could trigger a false ON. An ultrasonic sensor should also not be positioned near an HVAC return or air supply diffuser.



This PIR wall switch has been positioned to look into the room rather than out the door, minimizing the possibility of false triggers. Nothing is obstructing the sensor's view and it faces the front of the worker.

Tip! When installing ultrasonic sensors, installers should position the receiving side toward the area of greatest traffic.

Wiring considerations

When installing the sensor, the contractor should wire it according to instructions to eliminate any functional problems or sensor damage. For instance, all Watt Stopper wall switch sensors require grounding for proper functioning. Thus, if an installer fails to properly ground this type of sensor, it will not work as designed.

Wall switch replacements typically use line voltage and are designed to fit within a standard switch box. Thus, installation requires no special wiring or relays. Installers using our decorator style switches (WS, WA, or WD series switches) must install the devices with either a single or double gang cover plate, depending on the type of switching involved. With the WI series, installers need not use a cover plate for single gang boxes, although plates will be needed for double gang boxes.

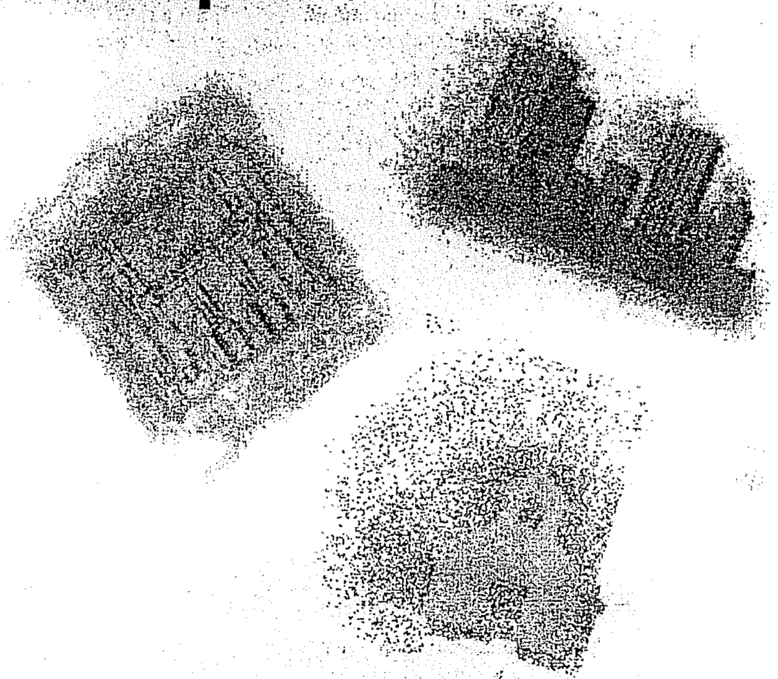
Many of The Watt Stopper's wall switch sensors feature terminal style wiring. This contractor friendly screw terminal wiring system eliminates the need for wire nuts, making installation quicker and easier.

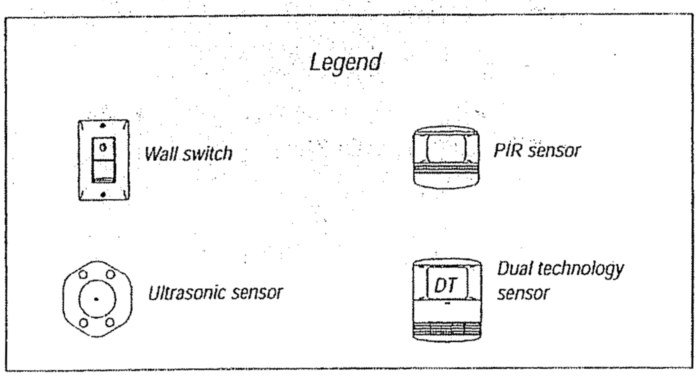
Adjusting sensors

Following sensor installation, additional adjustments may need to be made. This is not uncommon, and is often due to last minute changes in furniture or fixture placement. Ideally, the sensor settings for sensitivity and time delays should match the activity levels of the monitored spaces.

Tip! Installers can use The Watt Stopper's coverage templates to lay out sensors on facility blueprints.

Application Examples





Note: The graphics in this section are intended to illustrate the text discussion. They are not intended to represent actual implementations.

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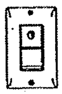
Applications in specific building spaces

PIR wall switches (WI, WA, WS, WD series)



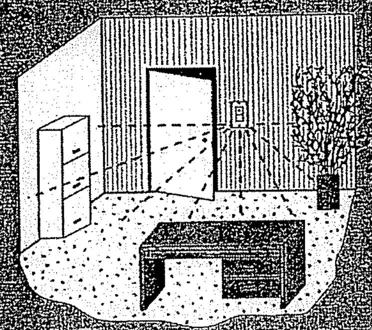
- Small individual enclosed offices
- Small utility rooms
- Teachers' offices

Example

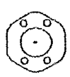
In a small enclosed private office, compact fluorescent overhead lights are controlled by PIR wall switches. Since the room is only about 200 square feet in size, the switch provides adequate coverage while minimizing costs.

Products Used

WS PIR wall switch



Ultrasonic sensors (W, WT series)



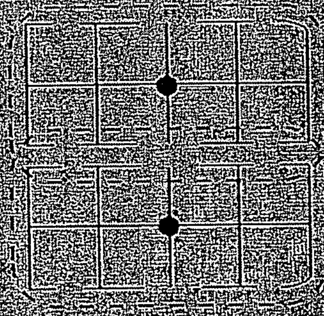
- Conference rooms
- Open office spaces
- Corridors
- Restrooms

Example

In an open office area, tall partitions create semi-private cubicles. Ultrasonic occupancy sensors are selected for ceiling mounting because they can "see" around these types of obstacles.

Products Used

Ultrasonic occupancy sensors (model W-2000A or WT-2200) power packs



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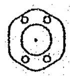
Applications in specific building spaces (cont.)

Ultrasonic sensors (W, WT series)

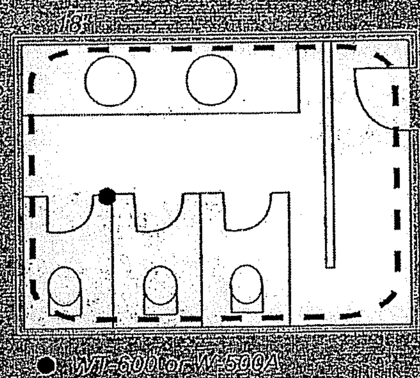


Example

In a small, three-stall restroom, only one ultrasonic sensor is needed to provide adequate coverage over the stall partitions and the washbasin area.

Products Used

Ultrasonic occupancy sensor (model W-500A or WT-600), power pack



Dual technology sensors (DT-200)

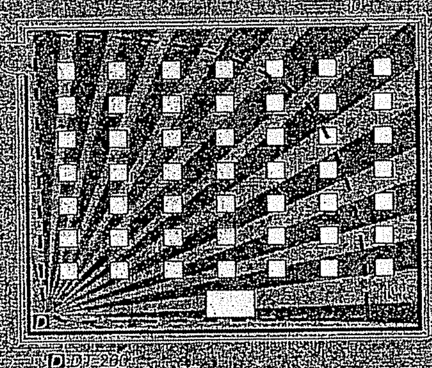
- Conference rooms
- Open office spaces
- Large classrooms
- Multi-purpose rooms
- Banquet rooms
- Meeting rooms
- Storage areas
- Stockrooms

Example

An elementary school classroom contains 30 students, one teacher and two teaching assistants. To accommodate the varying levels of activity in the room and reduce the potential for false triggers, dual technology sensors are installed.

Products Used

Dual technology sensor (model DT-200), power pack



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Applications in specific building spaces (cont.)

PIR sensors (CX-100,CI-200, WPIR)

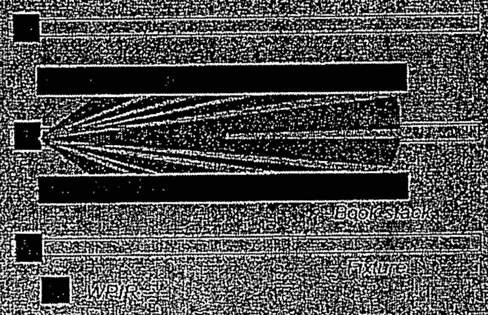
- Stockrooms
- Storage areas
- Corridors
- Conference rooms
- Classrooms
- Gyms
- Multipurpose rooms
- Enclosed offices
- Computer rooms

Example

In a library, PIR occupancy sensors are chosen to control lighting in the aisleways between book shelves because they are intermittently used and can be positioned to provide exact cut-off at aisle entryways.

Products Used

WPIR occupancy sensors, power packs

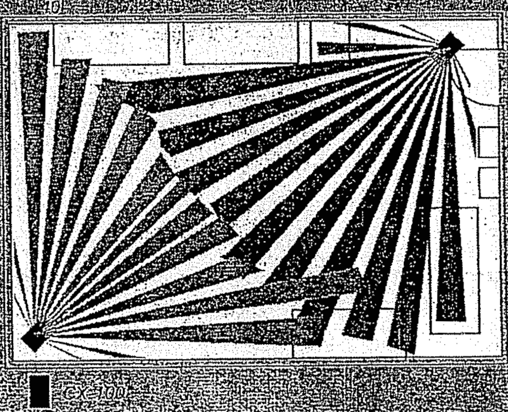


Example

Lighting in a hotel's master utility room is controlled by PIR sensors. The room, accessed periodically throughout the day by facilities personnel for up to 1/2 hour at a time, is approximately 1200 square feet in size.

Products Used

Ceiling-mounted CX-100 occupancy sensors, power packs



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Facility-wide applications

Organizations of all types can benefit from occupancy sensor use in a variety of spaces throughout the facility. Among the business sectors employing occupancy sensors for lighting control include:

- Financial services institutions (i.e., banks, credit unions, investment firms)
- Government facilities
- Hospitals and health care facilities
- Industrial buildings and warehouses
- Commercial buildings
- Educational institutions (i.e., schools, universities)
- Athletic facilities (i.e., health clubs, sports arenas)
- Correctional facilities
- Retail stores
- Hotels
- Houses of worship

In most cases, the differing nature of spaces within a facility will require that sensors of different types be used. Lighting professionals can choose the sensors they need from The Watt Stopper's comprehensive line of occupancy sensors. Together, these different sensors provide a complete occupancy-based control solution.

The specific application case studies that follow explore the use of different sensor types throughout facilities that represent some of the largest business sectors: commercial buildings, retail stores, hotels, and educational institutions.

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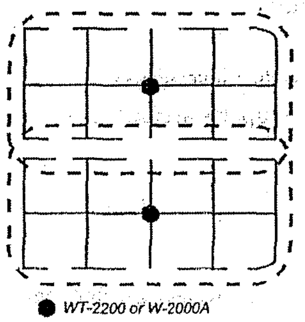
Application - Commercial office building

Application scenarios

- large open areas divided into partitioned cubicles
- utility rooms
- employee break rooms
- restrooms
- individual offices
- other examples not shown (conference rooms, computer rooms, lobbies, warehouses)

Open area control



The WT-2200 or W-2000A is most often used in open office areas for its 360° coverage and capability to bounce ultrasonic off partitions, walls, floors, and other reflecting objects to better sense motion. A typical layout would be to place sensors to control the office area in zones that overlap. The coverage can range from 20'x20' to a maximum of 40'x40'. Typical zones average 25'x25' with an overlap to enable motion detection up to 30'x30'.

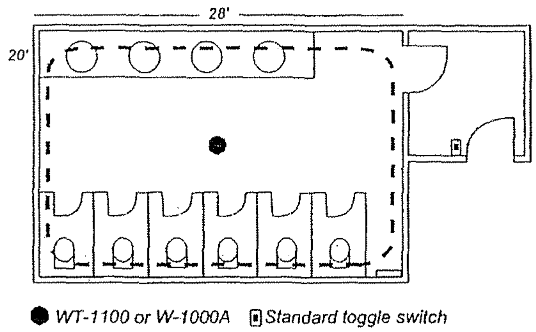
Small room control

Because the utility rooms are small, enclosed, and intermittently used, a PIR wall switch is the ideal choice. To ensure detection as soon as occupants enter the room, the device is positioned on a wall opposite the doorway, so that lights turn on immediately. With average room dimensions of 300 square feet, the WS coverage pattern of 180° and 900 square feet is more than adequate.

Small lunch/break room

For a large, combination lunch/break room, the recommended sensor choice is an ultrasonic sensor. Placement of the sensor would ideally be above the main areas of activity. For rooms ranging from 500-800 square feet in size, a single WT-1100 or W-1000A should be used. For rooms ranging from 800-1500 square feet in size, a single WT-2200 or W-2000A would be preferred. Rooms larger than 1500 square feet can be controlled via ultrasonic sensors by dividing the room's coverage into zones.

Restrooms



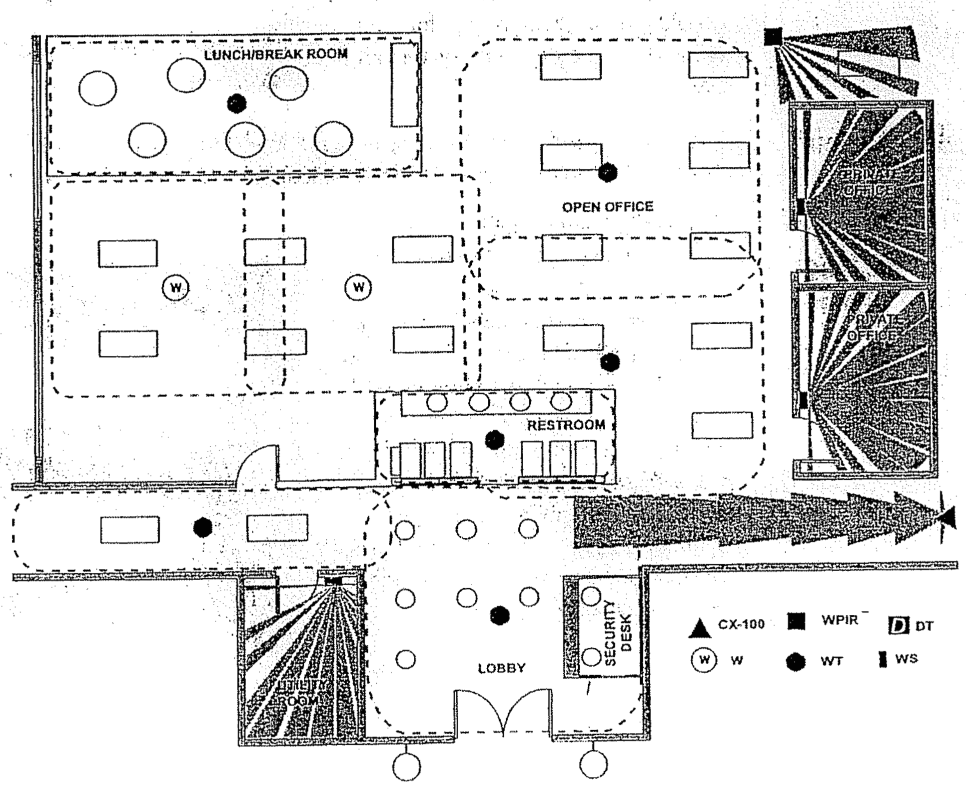
The buildings' restrooms average 6 stalls and 600 square feet. For these spaces, ultrasonic ceiling sensors are the recommended choice, as the stall partitions would inhibit the effectiveness of PIR technology. Models WT-1100 or W-1000A will provide adequate coverage with the use of one sensor per restroom.

Application - Commercial office building (cont.)

Enclosed private offices

The office building contains numerous small private offices. These range in size from 300 square feet to 500 square feet. Most of the offices are occupied by workers who require a greater degree of quiet and privacy to perform their responsibilities, such as engineers and accounting professionals. An ideal sensor for these offices is the PIR wall switch, such as the WS, WA, WD, or WI models.

Facility schematic



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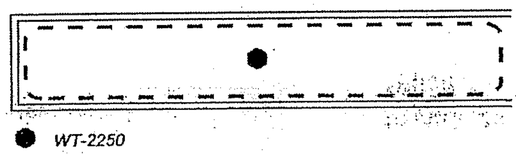
Application - Hotel

Application scenarios

- guest floor corridors
- guest rooms
- banquet rooms
- public restrooms
- other examples not shown (utility rooms, small offices, gym/public rooms)

Corridors

The WT-2250 provides coverage for areas up to 10' x 90.' Sensor placement should emphasize coverage for main entrance areas, such as elevators and stairways.

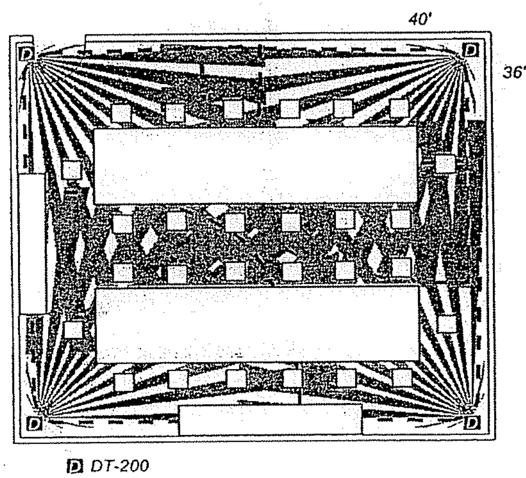


Guest rooms

In guest rooms, the bathroom lighting is controlled by a wall switch PIR sensor. The WD-270 would be suitable and would add manual dimming control for guests.

Banquet/ meeting rooms

Banquet/meeting rooms vary widely in size and function. Many that are used for conference sessions, where the occupants may be engaged in very low levels of activity, would benefit from the use of DT-200 sensors to minimize the occurrence of false offs. Smaller banquet rooms could be fitted with PIR wall switches. A hotel with a combination of smaller and larger banquet rooms will use several different types of sensors to ensure optimal coverage for each specific space.



Public restrooms

Lighting in the public restrooms is suitable for occupancy sensor control. These facilities, usually located near banquet/meeting rooms or the main lobby, are often continuously illuminated although they may only be used for brief periods of time. As with restrooms generally, an ultrasonic sensor would be the suggested choice.

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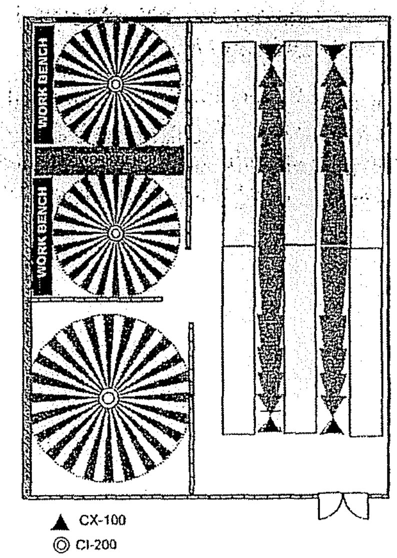
Application - Retail store

Application scenarios

- stockroom/warehouse
- refrigerated storage area
- merchandising displays
- customer restrooms
- sales floor
- other examples not shown (small offices, utility rooms, break room)

Stockroom/ Warehouse



Stockrooms and warehouses are often intermittently used throughout the day. To reduce energy consumption, lighting in individual aisleways is controlled by creating an individual zone for each aisle. Each zone is controlled by two CX-100-4 sensors located at the aisleway entrance and pointing inward. Open areas are best controlled with CI-200 sensors as long as there are no obstructions. You can team sensor control with other control strategies, such as daylighting or scheduled control for other stockroom/warehouse areas (i.e., loading docks) that have access to natural light.

Tip! Facilities using high intensity discharge (HID) lighting can employ The Watt Stopper's DM-100 controller together with sensors to provide occupancy-based control of these lights. For more information, turn to the DM-100 cut sheet and HID control applications in this binder.

Merchandising displays

While the principal purpose of lighting in merchandising displays is product enhancement, lighting control may be important for other reasons. For instance, product displays of perishable items, such as pastries or other food items, may be susceptible to undesirable spoilage from exposure to extended lighting. Switching display lights off via occupancy sensors enhances product life while ensuring an effective product display. In the deli area of an upscale supermarket, two levels of lighting are employed, one to continually provide basic illumination. The second level of lighting, positioned above displays of gourmet breads and cheeses, is controlled by CI-200 sensors. These lights come on when the sensors detect the approach of a customer.

Application - Retail store (cont.)

Refrigerated storage areas

Lighting in cold storage areas, such as meat lockers, is best controlled by the CB-100 PIR sensor, which is designed specifically for cold temperatures and is more sensitive to motion in cold conditions. In placing the sensors, we recommend that entrances and staging areas are well covered.

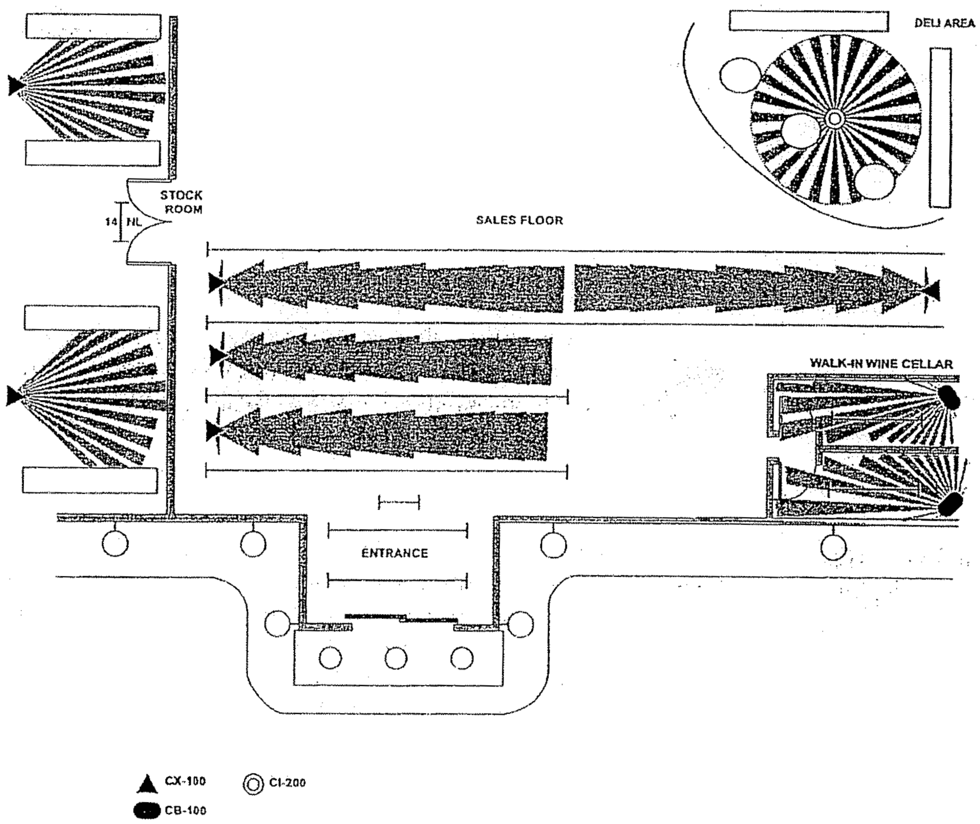
Customer restrooms

Significant energy savings can be obtained by controlling lighting in customer restrooms. Usually left on continually throughout business hours, as well as while employees are restocking or cleaning the sales areas, these lights can be switched off when the restroom is vacant. Ultrasonic technology is best suited to many restroom configurations, as it can overcome obstacles such as partitions. In single restrooms without stalls, a PIR wall switch sensor with a vandal-resistant lens would also be a good choice.

Sales floor aisleways

Lighting on the sales floor itself can also be controlled. Often, the retail facility maintains full lighting throughout the intervals before and after regular business hours during which personnel restock and clean. By controlling individual aisleways with sensors, only those lights in areas where employees are working will switch on (or, in the case of HID, switch to full output).

Facility schematic

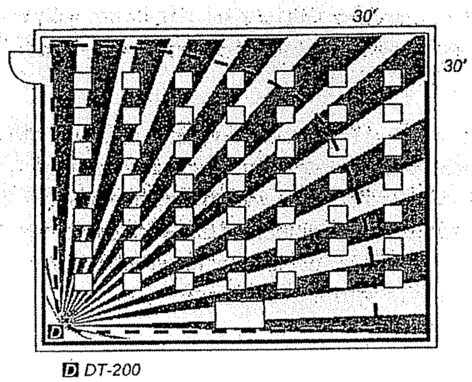


Application - Educational facility

Application scenarios

- classrooms
- library
- gymnasium
- lobby
- other examples not shown (locker rooms, hallways, faculty offices, utility rooms)

Classrooms

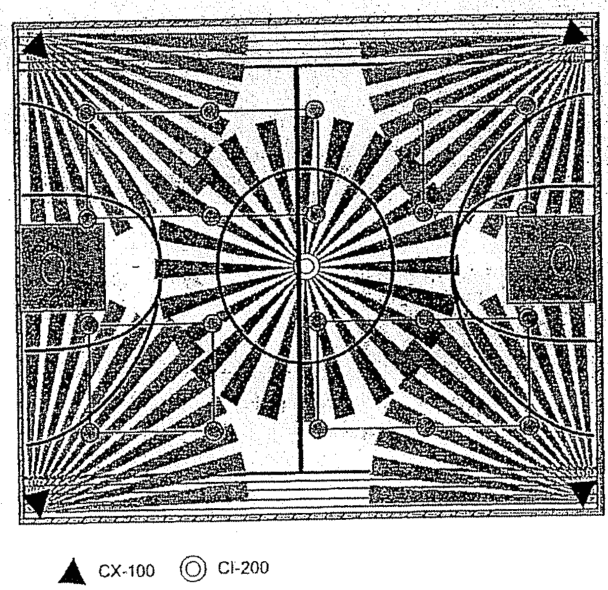


The DT-200 is the recommended sensor for classroom use. It will accommodate the lower levels of activity without creating false triggers.

Libraries

In libraries, both the open areas and the book stacks are controlled by occupancy sensors. The book stacks are individually zoned and controlled by PIR sensors (WPIR or CX-100 are good choices). Open areas are controlled by ultrasonic sensors (WT-1100, WT-2200, W-1000A, or W-2000A). In study areas where occupant activity may be quite low, the DT-200 will work well.

Gymnasiums



To ensure effective coverage of the gym floor, zones are overlapped. By dividing the floor into different zones, lights in one zone can be turned off while vacant even if adjacent areas are occupied.

Application - Educational facility (cont.)

Lobby

In this building, the lobby is a single-story, open area. With ceiling heights that average 12 feet, the area's lighting can be effectively controlled with ultrasonic sensors. Because the lobby is not totally enclosed, but flows into adjoining spaces, WT sensors are used to provide overlapping zone coverage.

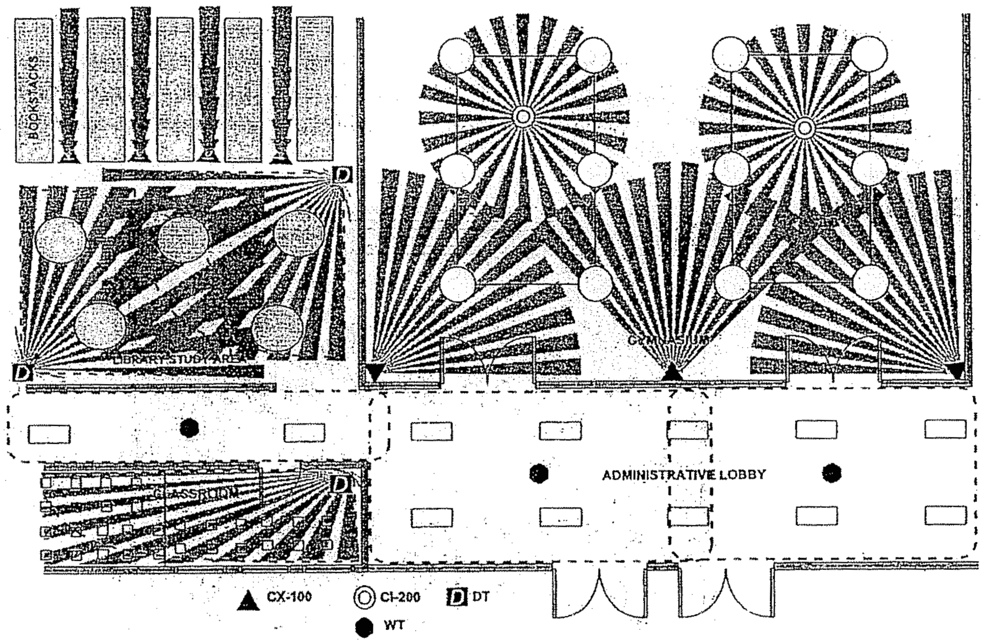
Hallways

In this building, the hallway leads into an open area on one end with openings into the library and classrooms. While each sensor technology can work well in hallway applications, the suggested sensor in this example is an ultrasonic WT model. This is usually the best choice in a general use hallway, such as this one, or in hallways with walls and ceiling heights under 14 feet. In hallways where precise cut-off is needed, a PIR sensor would be the preferred choice.

Faculty offices

Another ideal application for sensors in academic settings is faculty offices. For small enclosed offices, PIR sensors are recommended. They provide defined coverage patterns and do not trigger lights on when individuals walk by office entrances. PIR wall switch sensors are most popular as long as the orientation of the work space faces the sensor location. Additionally, the hard lens of the WA model is ideal to prevent sensor damage by vandals. In other orientations, a ceiling mount sensor is preferred.

Facility schematic



Sensor Type	P&S Model	Appropriate Application
Residential Sensors		
Automatic Wall Switch	MCS	**Use in storage rooms, walk-in closets and pantries.** 600 sq. ft. coverage, with 1 minute time delay for quick off.
Automatic Wall Switch	MCU	**For laundry rooms, half baths and hallways.** 5 minute time off.
Automatic Wall Switch	MCB	**Use in nurseries, bedrooms and basements.** Manual ON (No Auto ON). 15 minute time off.
Small Offices		
Automatic Wall Switch	WS3000 OSC3000	**Small, individual offices.** Sensors should have a direct, clear, front view of stationary occupants. Be sure sensors will not be blocked by doors, filing cabinets, etc.
360° Ceiling Mount or Wide Angle	WA1001 CS1001	**Small, individual offices where wall switch location is a problem.** For offices with general activities, WA1001 will work well placed in the corner. If there are obstacles present, the CS1001 will provide 360° coverage from the center of the office.
Ultrasonic	US1001	**Offices with large obstacles or stationary workers.** The US1001 covers up to 750 sq. ft., detects around obstacles, and is more sensitive to small movements than PIR sensors. It should be placed close to the area of activity and out of view of doors so waves do not exit the room.
Conference and Training Rooms		
360° Ceiling Mount	CS1001	**Small conference rooms where a ceiling mount sensor is required.** They should be located where they will have a clear view of the entire room but cannot see out the door.
Automatic Wall Switch	WS3000 OSC3000	**Small conference rooms under 300 sq. ft.** To ensure detection at the far end of a room, it is recommended that the wall switch sensor be within 20 feet of the farthest wall.
Ultrasonic	US1001	**Small conference rooms** without moving equipment that may falsely activate the sensor. The US1001 works well in a room up to 750 sq. ft. Multiple sensors may be used in larger rooms.
Wide Angle	WA1001	**Medium size conference rooms** (400-1000 sq. ft.) without obstacles that may block a PIR sensor's view. The WA1001 ceiling mount sensor works effectively
Wide Angle or 360° Ceiling Mount	CS1001 WA1001	**Conference rooms 1000 and 2500 sq. ft.** Two WA1001 will work well when installed in opposite corners. One of the sensors should be placed to immediately sense occupants entering the room. For rooms **greater than 2500 sq. ft.**, use multiple CS1001 or WA1001 sensors in zones.
Lunch, Copy, and Utility Rooms		
Automatic Wall Switch or 360° Ceiling Mount	OSC3000 WS3000 CS1001	A wall sensor is suitable for **break rooms up to 300 sq. ft.** if there is a clear view of the room from the light switch. For a room with an open wall that leads to other areas, masking material is included so the coverage zone may be more tightly defined. Using a CS1001 ceiling mount sensor is an alternative to masking.
360° Ceiling Mount or Wide Angle	CS1001 WA1001	In **break areas between 500 and 800 sq. ft.**, use CS1001 PIR ceiling mount sensors. Rooms between **800 and 1500 sq. ft.** require WA1001 sensors. For areas **greater than 1500 sq. ft.**, break the room into zones and use multiple sensors
Automatic Wall Switch	WS3000 OSC3000	In **copy and work rooms smaller than 300 sq. ft.**, an automatic switch works well; however, if large copiers block the sensor's view, use a ceiling mount PIR sensor.
Wide Angle	WA1001	For larger **copy rooms**, mounting a WA1001 PIR sensor in the corner is most effective. Place them so that tall objects do not obstruct the sensor's view of the room. For rooms exceeding 1200 sq. ft., use multiple sensors.
Automatic Wall Switch/ Ultrasonic	WS3000 US1001	An automatic wall switch sensor will work well in a **utility room smaller than 300 sq. ft.**; however, if occupants spend lengthy periods of time behind cabinets or other structures, an ultrasonic sensor is a better choice.
360° Ceiling Mount	WA1001 CS1001	**Utility rooms greater than 300 sq. ft.** require a PIR ceiling mount sensor because high air flow causes false triggering in ultrasonic models.
Restrooms		
Ultrasonic	US1001	Due to the many partitions in **commercial restrooms**, an ultrasonic ceiling mount sensor is needed. Multiple sensors may be used in larger restrooms.
Hallways		
PIR Wall Mount	HS1001	In **hallways without walls or where coverage masking is required**, HS1001 PIR sensors are perfect. When mounted between 10 and 14 feet high, they provide a coverage area of up to 10' x 90'. Sensors should be focused on areas where people will be entering the space.

Examples of savings and payback

EXAMPLE 1

Large office using a WA1001 Passive Infrared Sensor

Six 88-watt, 3-lamp fixtures = 0.528 kW x $0.08/kWh = $0.04224/hr
Savings = 35 hours per week
Total hours saved = 1,820 hrs/yr
Annual Savings = $76.88; 5 Year Savings = $384.40
Total estimated cost including power pack: (Product and Labor) = $140.00
Payback = 21.85 months
ROI = $76.88 ÷ $140.00 = 54.92%

EXAMPLE 2

Individual office using a WS1001 Automatic Wall Switch

Three 88-watt, 3-lamp fixtures = 0.264 kW x $0.08/kWh = $0.02112/hr
Savings = 50 hours per week
Total hours saved = 2,600 hrs/yr
Annual Savings = $54.91; 5 Year Savings = $274.55
Total estimated cost: (Product and Labor) = $54.00
Payback = 11.80 months
ROI = $54.91 ÷ $54.00 = 101.68%

EXAMPLE 3

Restroom using a US1001 Ultrasonic Occupancy Sensor

Four 88-watt, 3-lamp fixtures = 0.352 kW x $0.08/kWh = $0.02816/hr
Savings = 75 hours per week
Total hours saved = 3,900 hrs/yr
Annual Savings = $109.82; 5 Year Savings = $549.10
Total estimated cost: (Product and Labor) = $160.00
Payback = 17.48 months
ROI = $109.82 ÷ $160.00 = 68.65%

Multi-Sensor Installation

For applications requiring more than one sensor, **the load per power pack should not exceed 64mA**. Use the following table to calculate the maximum number of sensors per power pack.

WA1001	CS1001	HS1001	US1001	AR120/277
8mA	8mA	8mA	28mA	36mA

Examples:

2 x US1001(28mA) = 56mA ✔
This is an acceptable load because it is less than 64mA.

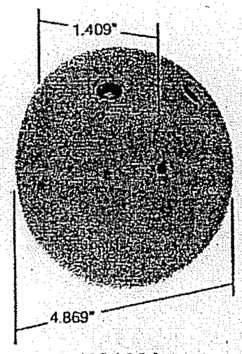
2 x US1001(28mA) + 1 x AR120/277(36mA) = 92mA ✗
This is **not** an acceptable load because it is greater than 64mA.

Ultrasonic Ceiling Sensors

Pass & Seymour legrand

Features – US1001

- ASIC provides high immunity to RFI and EMI.
- 180° coverage.
- 750 sq. ft. coverage capability.
- Adjustable sensitivity settings.
- Time delay adjustable from 15 seconds to 30 minutes.
- Solid state, crystal controlled.
- Advanced Signal Processing Circuitry.
- Logic Key/ON bypass.
- Temperature and humidity resistant 32 kHz receivers.
- Compatible with 120VAC or 277VAC, 60 Hz lighting systems.
- Class 2 low-voltage device.
- Positive detection indicator (per California Title 24).
- 5 year warranty.
- cULus listed.



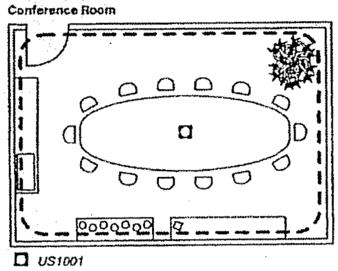
US1001

Catalog Number	Description	Voltage	Current	Coverage	Color
Ultrasonic Ceiling Sensor					
US1001	Ultrasonic Ceiling Occupancy Sensor	24VDC	28mA	360°; 750 sq. ft.	White

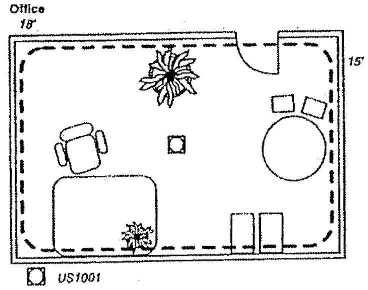
Reference Page K-10 for Power Packs.

US1001

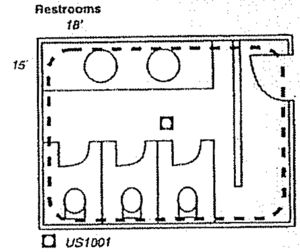
Conference Room



Office



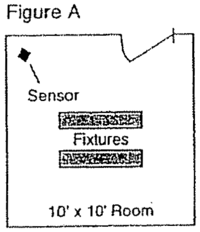
Restrooms



In commercial restrooms, the US1001 will be able to provide reliable occupancy detection for the entire space. This ultrasonic sensor is able to see over stall doors and walls and over other partitions.

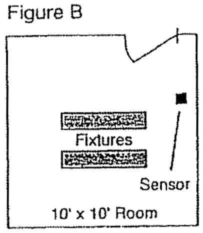
Enclosed Office Sensor Placement

Figure A



Correct

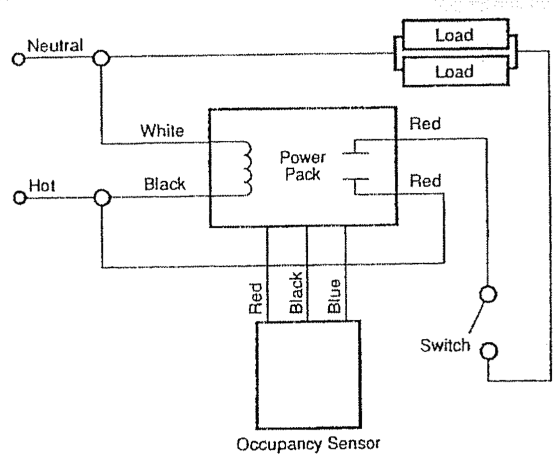
Figure B



Incorrect

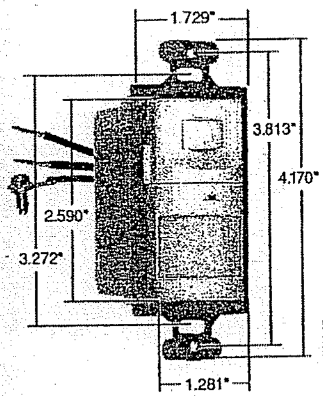
For enclosed spaces, place sensors as in Figure A. Sensors placed as in Figure B may see out the door and cause false triggers.

Standard Wiring

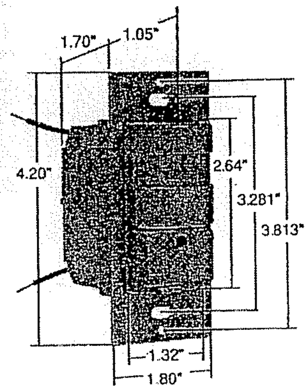


All devices listed on this page conform to NEMA WD-1.

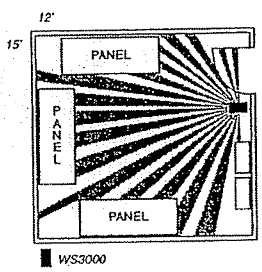
Passive Infrared Sensors

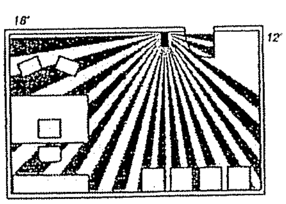


WS3000



OSC3000





Placement for PIR wall switch sensor

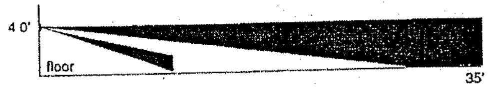
Features – Wall Switch Occupancy Sensors

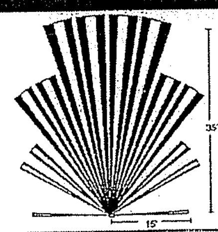
- ASIC provides high immunity to RFI and EMI.
- Compact, decorator design replaces existing wall switch.
- Integrated light level sensor works from 2 to 200 footcandles.
- Compatible with all electronic and magnetic ballasts, PL lamp ballasts, compact fluorescent.
- 5 year warranty.
- cULus listed.
- 180° coverage of up to 900 sq. ft.
- Dual 120/277VAC operation.
- 30% to 60% energy savings.
- Positive detection indicator (per California Title 24).
- No minimum load requirement (WS3000).
- Adjustable sensitivity from 20% to 100% (WS3000).
- Patented voltage drop protection (WS3000).
- Patented Zero Crossing Circuitry (WS3000).

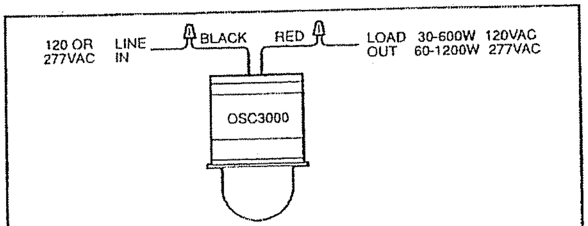
Catalog Number	Description	Voltage	Load Requirements	Coverage	Time Delay	Color
PIR Automatic Wall Switches – 3 Wire Technology						
WS3000-I WS3000-W WS3000-GRY WS3000-LA	Passive Infrared Occupancy Sensor	120/277VAC; 60 Hz	800W Max. at 120V 1200W Max. at 277V	180°, up to 900 sq. ft.	30 sec. to 30 min.	Ivory White Gray Lt. Almond
PIR Automatic Wall Switches – 2 Wire Technology						
OSC3000-I OSC3000-W OSC3000-GRY OSC3000-LA	Passive Infrared Occupancy Sensor	120/277VAC; 60 Hz	600W Max. at 120V 1200W Max. at 277V	180°, up to 900 sq. ft.	60 sec. to 15 min.	Ivory White Gray Lt. Almond

Planning a Layout

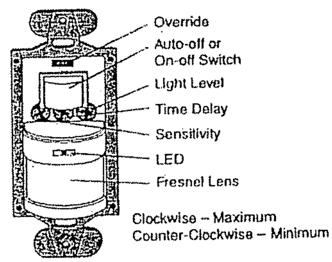
The WS3000's 2-level lens provides superior coverage at desktop level by allowing the sensor to detect vertical as well as horizontal motion. Coverage shown is for walking motion. Under optimum conditions with a high level of activity and with no barriers or obstacles, coverage can reach a maximum of 900 square feet. Under a typical, desktop level of activity, when mounted at 4 feet, coverage is 300 square feet.



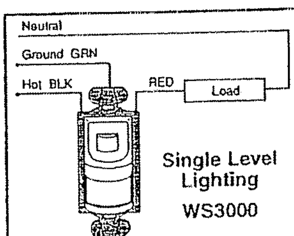




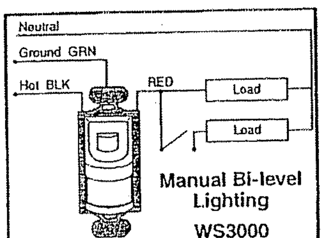
OSC3000 Wiring Diagram



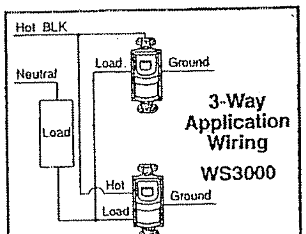
WS3000



Single Level Lighting
WS3000



Manual Bi-level Lighting
WS3000

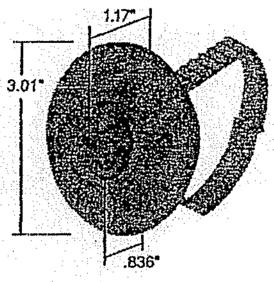


3-Way Application Wiring
WS3000

All devices listed on this page conform to NEMA WD-1.

Pass & Seymour
legrand

Occupancy Sensors
Passive Infrared Sensors

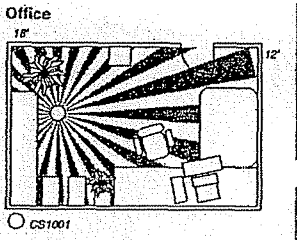


CS1001

Features – CS1001

- ASIC provides high immunity to RFI and EMI.
- 120° viewing angle, circular coverage.
- 40' nominal viewing range. Up to 900 sq. ft.
- 5 different mounting methods for a variety of applications.
- Hinged mounting plate and directional arrow allow for adjustments to room layout.
- May be box-mounted utilizing SS1001 wall plate.
- Automatic 4 minute test cycle on power-up (factory built-in setting).
- Four element detectors for maximum sensitivity.
- Fresnel lens with multi-segment design allows greatest viewing angle.
- Compatible with 120VAC or 277VAC, 60 Hz lighting systems.
- Class 2 low voltage device.
- Preset 20 minute time-off delay maximizes energy efficiency.
- Positive detection indicator (per California Title 24).
- 5 year warranty.
- cULus listed.

Office



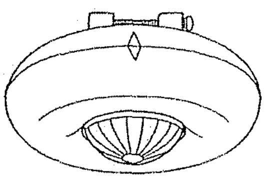
Here, the CS1001's 360 degree coverage provides coverage of the entire office.

Catalog Number	Description	Voltage	Current Draw	Color
PIR Ceiling Sensor				
CS1001	Passive Infrared Occupancy Sensor	24VDC	8mA	White

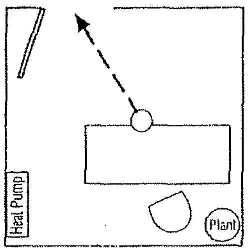
Catalog Number	Description	Ratings
Accessories		
SS1001	Single Gang Stainless Steel Wall Plate for CS1001 Box Mounting	302 Stainless Steel, 1.203" diameter hole

Reference Page K-10 for Power Packs.

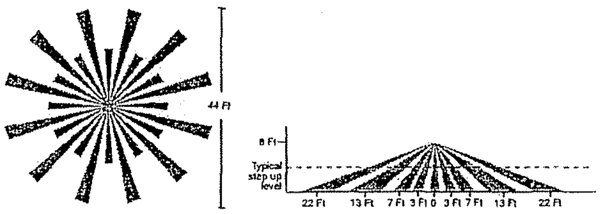
Planning a Layout



Arrows for aiming



Point the arrow at a doorway or an area of activity.



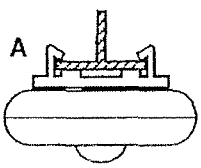
Coverage shown is maximum and represents coverage for half-step walking motion. Under ideal conditions, with no barriers or obstacles, coverage for half-step walking motion can reach up to 1200 sq. ft. For typical desktop level of activity, coverage can reach up to 600 sq. ft.

Installation

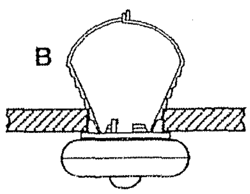
The CS1001 has several mounting options:
A) It can be attached to the grid system of a suspended ceiling with built-in clips.
B) It can be clipped into a hole drilled into the ceiling or panel.
C) It can be mounted onto a wallplate (P&S Cat.# SS1001) for box mounting.

It can also be surface mounted using #8 flat-head screws.

A



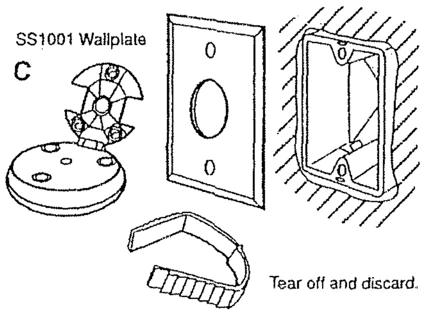
B



Drill a 1-1/2" diameter hole.

SS1001 Wallplate

C



Tear off and discard.

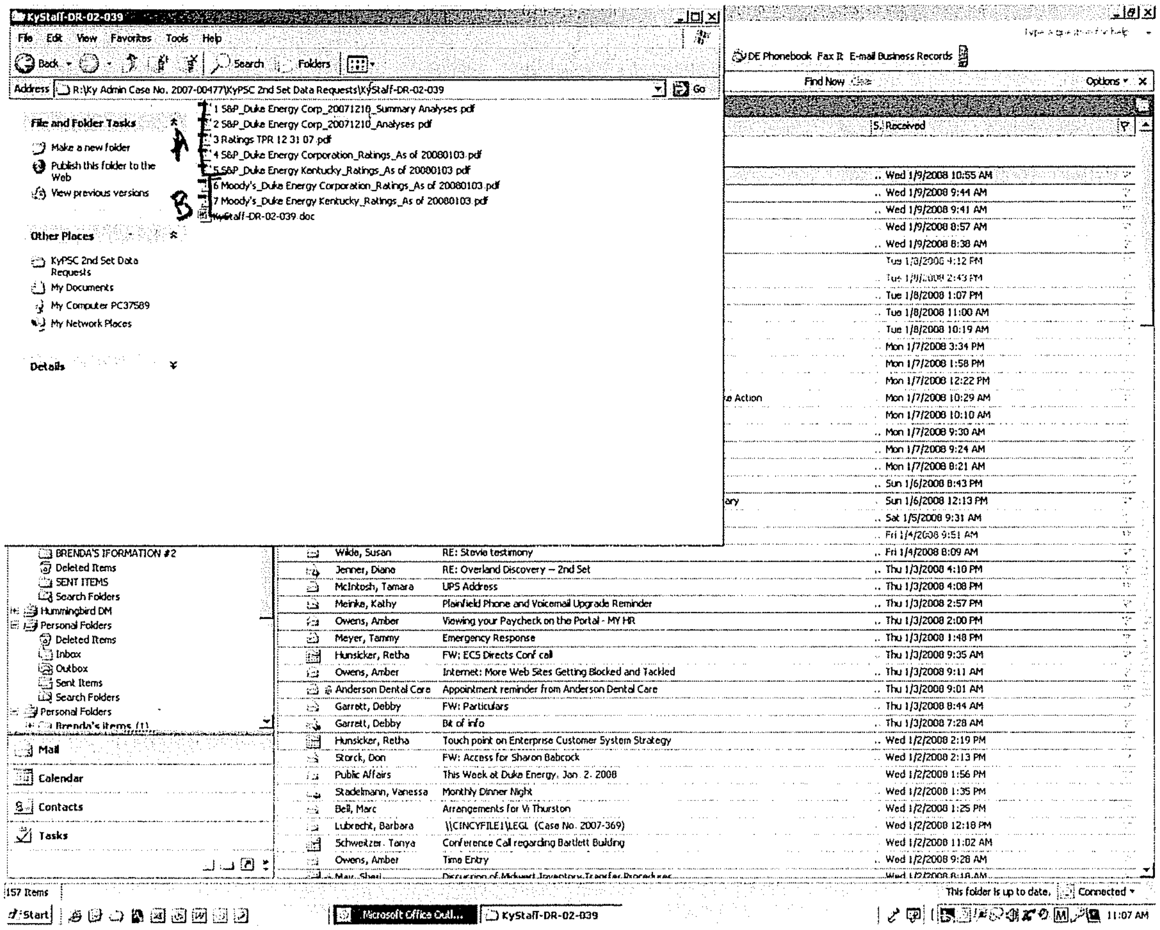
All devices listed on this page conform to NEMA WD-1.

Occupancy Sensors
Passive Infrared Sensors

01-082 Two-way sensor
01-091 Two-way corridor sensor
01-230 Wall Switch 24 VAC
01-220 Wall switch 15 VDC
01-300 Two-way Super Dual Tech sensor
01-310 One-Way Super Dual Tech sensor
01-320 High Bay sensor
02-PCC Photocell controller

Products By Model Number

Model Number	Description	Coverage	Accessory Require-ments	Tech Sheet (PDF)	Installation Instructions (PDF)	Specs (Word or PDF))	No (C Auto
01-060	Small area, one-way sensor	150 - 500 sq. ft.	Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Templat *1 to 1 sca*
01-072	One-way sensor	500 - 900 sq. ft.	Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template Template Template *All templ* *1 to 1 sca*
01-BAS074	One-way, BAS/EMS sensor	150 - 900 sq. ft.	Transformer	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template *All templ* *1 to 1 sca*
01-076	One-way sensor	Up to 900 sq. ft.	Relay & Transformer	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template *All templ* *1 to 1 sca*
01-077	One-way, airflow tolerant sensor	530 - 840 sq. ft.	Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template *All templ* *1 to 1 sca*
01-082	Two-way room sensor	900 - 2,100 sq. ft.	Relay & Transformer	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template *All templ* *1 to 1 sca*
01-083	Two-way room sensor	900 - 2,100 sq. ft.	Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template Template Template


KyStaff-DR-02-039
File Edit View Favorites Tools Help
Back Search Folders
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File and Folder Tasks
Make a new folder
Publish this folder to the Web
View previous versions
Other Places
KyPSC 2nd Set Data Requests
My Documents
My Computer PC37589
My Network Places
Details
A
B
1 S&P_Duke Energy Corp_20071210_Summary Analyses.pdf
2 S&P_Duke Energy Corp_20071210_Analyses.pdf
3 Ratings TPR 12 31 07.pdf
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Options
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Sun 1/6/2008 12:13 PM
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Fri 1/4/2008 9:51 AM
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Hummingbird DM
Personal Folders
Deleted Items
Inbox
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Brenda's items (1)
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Calendar
Contacts
Tasks
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Jenner, Diane RE: Overland Discovery – 2nd Set Thu 1/3/2008 4:10 PM
McIntosh, Tamara UPS Address Thu 1/3/2008 4:08 PM
Meinke, Kathy Plainfield Phone and Voicemail Upgrade Reminder Thu 1/3/2008 2:57 PM
Owens, Amber Viewing your Paycheck on the Portal - MY HR Thu 1/3/2008 2:00 PM
Meyer, Tammy Emergency Response Thu 1/3/2008 1:48 PM
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Storck, Don FW: Access for Sharon Babcock Wed 1/2/2008 2:13 PM
Public Affairs This Week at Duke Energy, Jan. 2, 2008 Wed 1/2/2008 1:56 PM
Stadelmann, Vanessa Monthly Dinner Night Wed 1/2/2008 1:35 PM
Bell, Marc Arrangements for Vi Thurston Wed 1/2/2008 1:25 PM
Lubrecht, Barbara \\CINCYFILE1\LEGL (Case No. 2007-369) Wed 1/2/2008 12:18 PM
Schweizer, Tonya Conference Call regarding Bartlett Building Wed 1/2/2008 11:02 AM
Owens, Amber Time Entry Wed 1/2/2008 9:28 AM
157 Items
This folder is up to date. Connected
Start
Microsoft Office Outl...
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11:07 AM

							All templ *1 to 1 sca*
01-BAS084	Two-way BAS/EMS interface sensor	900 - 2,100 sq. ft.	Transformer	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template *All templ* *1 to 1 sca*
01-087	Two-way, airflow tolerant sensor	840 - 1,680 linear ft.	Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template *All templ* *1 to 1 sca*
01-091	Two-way corridor / warehouse sensor	To 100 linear ft.	Relay & Transformer	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template *All templ* *1 to 1 sca*
01-092	Two-way corridor / warehouse sensor	To 100 linear ft.	Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template Template Template *All templ* *1 to 1 sca*
01-BAS094	Two-way, BAS/EMS corridor and warehouse sensor	To 100 linear ft.	Transformer	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template *All templ* *1 to 1 sca*
01-100	One-way sensor	500 - 1,270 sq. ft.	Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template Template Template *All templ* *1 to 1 sca*
01-110	Two-way, large room sensor	1,270 - 2,850 sq. ft.	Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template Template Template *All templ* *1 to 1 sca*
01-160	Small area, one-way sensor	150 - 500 sq. ft.	Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template *1 to 1 sca*
01-170	One-way corridor / warehouse sensor	To 50 linear ft.	Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format)	Template Template

						Specifications (pdf fomat)	Template Template Template Template *All templ* *1 to 1 sca*
01-180	One-way enclosed corridor sensor	To 50 linear ft.	Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template *All templ* *1 to 1 sca*
01-190	Two-way enclosed corridor sensor	936 - 1,400 sq. ft.	Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template *All templ* *1 to 1 sca*
01-220	Automatic wall switch; 15 VDC	up to 300 sq. ft.	Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template *1 to 1 sca*
01-230	Automatic wall switch; 24 VAC	up to 300 sq. ft.	Relay & Transformer	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template *1 to 1 sca*
01-250	Automatic wall switch;120/277 VAC, neutral	up to 300 sq. ft.	None	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template *1 to 1 sca*
01-BAS260	Automatic wall switch; 24 VAC BAS/EMS interface	up to 300 sq. ft.	Transformer or BAS/EMS	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template *1 to 1 sca*
01-BAS300	Two-way Super Dual Tech	300 - 1,750 sq. ft.	Switchpack or BAS	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template *1 to 1 sca*
01-BAS310	One-way Super Dual Tech	150 - 900 sq. ft.	Switchpack or BAS	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template *1 to 1 sca*
01-320	High Bay Sensor	600 - 800 sq. ft.	Switchpack or BAS	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template Template Template Template Template Template *All templ* *1 to 1 sca*
01-BAS340	Extreme Temperature Sensor	up to 1,500 sq. ft.	Switchpack or BAS	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template *1 to 1 sca*
01-400	Automatic Self-Adjusting Wall Switch, 120/277 VAC (Contact Novitas Customer Service to confirm product availability.)	up to 300 sq. ft.	None	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template *1 to 1 sca*
01-DL400	Automatic Dual Level Self-Adjusting Wall Switch, 120/277 VAC (Contact Novitas Customer Service to confirm product availability.)	up to 300 sq. ft.	None	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template *1 to 1 sca*

01-PCI	Indoor photocell sensor	Indoor Use	Controller & Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template 1 to 1 sca
01-PCO	Outdoor photocell sensor	Outdoor Use	Controller & Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template 1 to 1 sca
01-PCA	Atrium photocell sensor	For Atriums	Controller & Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template 1 to 1 sca
01-PCS	Skylight photocell sensor	For Skylights	Controller & Switchpack	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template 1 to 1 sca
01-PDI	Indoor photodiode sensor	Indoor Use	None	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template 1 to 1 sca
02-PCC	Photocell controller		None	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Template 1 to 1 sca
04-011	Adapter plate for ceiling sensors		None	Does Not Apply	Does Not Apply	Does Not Apply	Does No
05-030	Digital Wall Switch Timer	Does Not Apply	None	Tech Sheet	Installation Instructions	Specifications (Word Format) Specifications (pdf fomat)	Does No
12-021	Sensor guard for Models 01-60 - 01-094 & 01-170		None	Does Not Apply	Does Not Apply	Does Not Apply	Does No
12-030	Sensor guard for Novitas Models 01-100/01-160/01-180		None	Does Not Apply	Does Not Apply	Does Not Apply	Does No
12-040	Sensor guard for Novitas Models 01-100 & 01-190		None	Does Not Apply	Does Not Apply	Does Not Apply	Does No
12-050	Sensor guard for Model 01-300		None	Does Not Apply	Does Not Apply	Does Not Apply	Does No
12-060	Sensor guard for Model 01-320		None	Does Not Apply	Does Not Apply	Does Not Apply	Does No
12-070	Sensor guard for Model 01-340		None	Does Not Apply	Does Not Apply	Does Not Apply	Does No
13-041	EMS/BAS Switchpack		None	Tech Sheet	Does Not Apply	Specifications (Word Format) Specifications (pdf fomat)	Template 1 to 1 sca
13-051	Heavy duty switchpack with zero-crossing; 120/277 VAC		None	Tech Sheet	Does Not Apply	Specifications (Word Format) Specifications (pdf fomat)	Template 1 to 1 sca
13-061	Heavy duty switchpack; 347 VAC		None	Tech Sheet	Does Not Apply	Not Available	Template 1 to 1 sca
13-071	Heavy duty switchpack;220/240 VAC		None	Tech Sheet	Does Not Apply	Not Available	Template 1 to 1 sca

Technology

LED Traffic Lights

Energy Savings – kWh

The energy savings varies for red, green and yellow signals. Savings also varies for round lamps, arrows and pedestrian signals. Extra detail on California, Wisconsin and Texan programs is attached.

In general savings are greater on car traffic signals and costs for the lamps are generally less than for pedestrian signals. The recommendations include a breakdown between the two types of signals.

Traffic signal (per lamp average)	275 kWh, .085 KW
Pedestrian signal	150 kWh, .044 KW

Summer Peak Savings

See information above, and attachments

Measure Life

Lamps rated for 30,000 to 40,000 hours which would provide for a 10 to 15 year life on traffic signal lights. We have seen municipalities plan for a 5 to 7 year change out schedule. Assume 6 years.

Initial One-Time Cost

Lamp costs vary significantly. Green generally cost 50% more than yellow or red. Pedestrian lamps generally 50% to 100% more expansive than traffic lamps.

Traffic Signals	$50/lamp
Pedestrian	$100/lamp

Suggested Incentive

Traffic Signals	$10/lamp
Pedestrian	$5/lamp

We have seen incentives recently as high as $35/lamp (even higher when technology first became available) but feel lower incentives are adequate.

With a $10 incentive paybacks are often in the 3 to 4 year range based on energy savings. There is also a substantial labor savings in lamp change outs hat make the overall payback much more favorable.

Requirements

There are Energy Star Program Requirements for LED Traffic Signals. Partner Commitments and Eligibility Criteria are attached.

Signals must be connected to a metered electric service. Some utilities charge municipalities per fixture or per intersection for traffic lights.

Existing Energy Standards

Energy Star. Guidelines attached.

Source of Info

LED Traffic signal programs from Texas, California and Wisconsin. Energy Star website. Manufacturers website.

ENERGY STAR® Program Requirements for Traffic Signals

Partner Commitments

Commitment

The following are the terms of the ENERGY STAR Partnership Agreement as it pertains to the manufacturing of ENERGY STAR qualified traffic signals. The ENERGY STAR Partner must adhere to the following program requirements:

- comply with current ENERGY STAR Eligibility Criteria, defining the performance criteria that must be met for use of the ENERGY STAR certification mark on traffic signals and specifying the testing criteria for traffic signals. EPA may, at its discretion, conduct tests on products that are referred to as ENERGY STAR qualified. These products may be obtained on the open market, or voluntarily supplied by Partner at EPA's request;

- comply with current ENERGY STAR Logo Use Guidelines, describing how the ENERGY STAR labels and name may be used. Partner is responsible for adhering to these guidelines and for ensuring that its authorized representatives, such as advertising agencies, dealers, and distributors, are also in compliance;

- qualify at least one ENERGY STAR labeled traffic signal model within one year of activating the traffic signals portion of the agreement. When Partner qualifies the product, it must meet the specification (e.g., Tier 1 or 2) in effect at that time;

- provide clear and consistent labeling of ENERGY STAR qualified traffic signals. The ENERGY STAR label must be clearly displayed on the product packaging, in product literature (i.e., user manuals, spec sheets, etc.), and on the manufacturer's Internet site where information about ENERGY STAR qualified models is displayed;

- provide to EPA, on an annual basis, an updated list of ENERGY STAR qualifying traffic signal models. Once the Partner submits its first list of ENERGY STAR labeled traffic signal models, the Partner will be listed as an ENERGY STAR Partner. Partner must provide annual updates in order to remain on the list of participating product manufacturers;

- provide to EPA, on an annual basis, unit shipment data or other market indicators to assist in determining the market penetration of ENERGY STAR. Specifically, Partner must submit the total number of ENERGY STAR qualified traffic signals shipped (in units by model) or an equivalent measurement as agreed to in advance by EPA and Partner. Partner is also encouraged to provide ENERGY STAR qualified unit shipment data segmented by meaningful product characteristics (e.g., capacity, size, speed, or other as relevant), total unit shipments for each model in its product line, and percent of total unit shipments that qualify as ENERGY STAR. The data for each calendar year should be submitted to EPA, preferably in electronic format, no later than the following March and may be provided directly from the Partner or through a third party. The data will be used by EPA only for program evaluation purposes and will be closely controlled. If requested under the Freedom of Information Act (FOIA), EPA will argue that the data is exempt. Any information used will be masked by EPA so as to protect the confidentiality of the Partner;

- notify EPA of a change in the designated responsible party or contacts for traffic signals within 30 days.

Performance for Special Distinction

In order to receive additional recognition and/or support from EPA for its efforts within the Partnership, the ENERGY STAR Partner may consider the following voluntary measures and should keep EPA informed on the progress of these efforts:

- consider energy efficiency improvements in company facilities and pursue the ENERGY STAR label for buildings;

- purchase ENERGY STAR labeled products. Revise the company purchasing or procurement specifications to include ENERGY STAR. Provide procurement officials' contact information to EPA for periodic updates and coordination. Circulate general ENERGY STAR labeled product information to employees for use when purchasing products for their homes;

- ensure the power management feature is enabled on all ENERGY STAR qualified monitors in use in company facilities, particularly upon installation and after service is performed;

- provide general information about the ENERGY STAR program to employees whose jobs are relevant to the development, marketing, sales, and service of current ENERGY STAR labeled product models;

- feature the ENERGY STAR label(s) on Partner Web site and in other promotional materials. If information concerning ENERGY STAR is provided on the Partner Web site as specified by the ENERGY STAR Web Linking Policy (this document can be found in the Partner Resources section on the ENERGY STAR Web site at www.energystar.gov), EPA may provide links where appropriate to the Partner Web site;

- provide a simple plan to EPA outlining specific measures Partner plans to undertake beyond the program requirements listed above. By doing so, EPA may be able to coordinate, communicate, and/or promote Partner's activities, provide an EPA representative, or include news about the event in the ENERGY STAR newsletter, on the ENERGY STAR Web pages, etc. The plan may be as simple as providing a list of planned activities or planned milestones that Partner would like EPA to be aware of. For example, activities may include: (1) increase the availability of ENERGY STAR labeled products by converting the entire product line within two years to meet ENERGY STAR guidelines; (2) demonstrate the economic and environmental benefits of energy efficiency through special in-store displays twice a year; (3) provide information to users (via the Web site and user's manual) about energy-saving features and operating characteristics of ENERGY STAR qualified products, and (4) build awareness of the ENERGY STAR Partnership and brand identity by collaborating with EPA on one print advertorial and one live press event;

- provide quarterly, written updates to EPA as to the efforts undertaken by Partner to increase availability of ENERGY STAR qualified products, and to promote awareness of ENERGY STAR and its message.

ENERGY STAR® Program Requirements for Traffic Signals

Eligibility Criteria

Below is the product specification (Version 1.1) for ENERGY STAR qualified traffic signals. A product must meet all of the identified criteria if it is to be qualified as ENERGY STAR by its manufacturer.

This traffic signal specification is based on a low energy requirement and conformance to the Institute for Transportation Engineers (ITE) "Interim LED Purchase Specification, Vehicle Traffic Control Signal Heads, Part 2: Light Emitting Diode (LED) Vehicle Traffic Signal Modules" (VTCSH Part 2). At this time, only the LED technology meets such requirements and therefore the specification includes terms specific to LED traffic signals. However, EPA is open to any other (non-LED) technology that meets both the EPA specification and ITE's VTCSH Part 1 or Part 2 requirements, or a future relevant ITE specification. Manufacturers are encouraged to contact EPA with such technology only if they are able to meet such requirements.

1) Definitions: Below is a brief description of an LED traffic signal and related terms as relevant to ENERGY STAR.

   A. Vehicular Traffic Signal: A power-operated illuminated traffic control device, other than a barricade warning light or a steady illuminated lamp, by which traffic is warned or directed to take some specific action.

   B. Modules: Standard 8-inch (200 mm) or 12-inch (300 mm) round traffic signal indications (balls). They consist of the light source and the lens (usually a sealed unit) that communicate movement messages (stop, caution or prepare to stop, and go) to drivers through red, yellow, and green colors. Arrow modules in the same colors are used to indicate turning movements. Pedestrian modules are used to convey movement information to pedestrians.

   C. Traffic Signal Head: The combination of the traffic signal housing, with the modules (red, yellow, and green) installed in it. The head typically contains three modules and the necessary wiring, although it may also include arrow modules.

   D. LED Lamps or LEDs: The individual light-emitting diodes (LEDs), which can be set on a circuit board in any arrangement.

   E. LED Traffic Signal: The generic term used to describe the combination of signal heads or modules that use LEDs as the source of light. The combination also incorporates the housing unit at an intersection along with any internal components and support structures.

2) Qualifying Products: For the purposes of ENERGY STAR, LED traffic signal modules include the following:

   A. LED Vehicular Traffic Signal Modules, including Arrow Modules
   B. LED Pedestrian Signal Modules

   Other (non-LED) technology products may be considered if they meet ITE's VTCSH Part 1 or 2 (or other relevant future ITE specification), as well as the requirements of this specification.

3) Energy-Efficiency Specifications for Qualifying Products: Products listed in Section 2 that meet the criteria outlined in Table 1 below and that meet the minimum performance requirements of the

appropriate ITE specification (either current or future) may qualify as ENERGY STAR. The wattage requirements in the table below are to be met by the individual module, not the traffic signal heads as defined in Section 1(C). These levels include power demand from the LED power circuit.

Table 1: Energy-Efficiency Criteria for ENERGY STAR Qualified Traffic Signal Modules

Module Type	Maximum Wattage (at 74°C)	Nominal Wattage (at 25°C)
12" Red Ball	17	11
8" Red Ball	13	8
12" Red Arrow	12	9
12" Green Ball	15	15
8" Green Ball	12	12
12" Green Arrow	11	11
Combination Walking Man/Hand	16	13
Walking Man	12	9
Orange Hand	16	13

4) Test Criteria: The products must meet the minimum performance requirements of the relevant ITE specification, and be tested under the conditions presented in Section 6.4.2 of the VTCSH Part 2.

5) Effective Date: The date that manufacturers may begin to qualify products as ENERGY STAR will be defined as the *effective date* of the agreement. The ENERGY STAR Traffic Signal specification is effective immediately.

6) Future Specification Revisions: ENERGY STAR reserves the right to change the specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. In keeping with current policy, revisions to the specification will be arrived at through industry discussions. Specifically with regard to traffic signals, EPA expects that revisions to this specification will be discussed once the ITE specification is final for arrows and pedestrian heads. In addition, discussion will be necessary once ITE compliant amber balls and arrows are developed and marketed by manufacturers.

FY04 GRANT LED TRAFFIC LAMP INSTALLATION REPORT
Calculation Sheet

focus on energy℠
The power is within you.

Partner (location) Name: ENTER PARTNER NAME HERE (i.e. "Dane County")
Installation Date Range: Start: End: << enter as installation date in STAR
Electric Utility: ENTER UTILITY NAME HERE (i.e. "Alliant Energy")

ITEM:	Model Number	Aproximate Order Price per lamp**	Incentive $'s Per Lamp	Per year kWh Savings	kW Reduction	Approximate $'s Saved Per year	Qty Installed	Total kWh	Total kW	Total Incentive	Total $ Saved
ROUND LAMPS											
12" Red	TSL-12R-MH-A-1	$48.40	$10.00	337	0.088	$20.00		0	0	$0	$0
12" Yellow	TSL-12Y-MG-A-1	$55.48	$10.00	181	0.0825	$11.00		0	0	$0	$0
12" Green	TSL-12G-MH-A-1	$107.35	$10.00	271	0.0825	$16.00		0	0	$0	$0
8" Red	TSL-08R-MG	$47.00	$10.00	337	0.088	$20.00		0	0	$0	$0
8" Yellow	TSL-08Y-MG	$51.00	$10.00	181	0.0825	$11.00		0	0	$0	$0
8" Green	TSL-08G-MG	$74.00	$10.00	271	0.0825	$16.00		0	0	$0	$0
ARROWS											
12" Red	TSL-RA-MF	$46.00	$10.00	337	0.088	$20.00		0	0	$0	$0
12" Yellow	TSL-YA-MF	$44.55	$10.00	181	0.0825	$11.00		0	0	$0	$0
12" Green	TSL-GA-MF	$75.72	$10.00	271	0.0825	$16.00		0	0	$0	$0
PEDESTRIAN											
16" Hand/Walking Person Side by Side, Filled/Filled	TSL-PED-DP-16-FS-A	$130.00	$5.00	154	0.047	$9.00		0	0	$0	$0
16" Hand/Walking Person Overlay, Filled/Filled	TSL-PED-OL-16-FS	$124.00	$5.00	154	0.047	$9.00		0	0	$0	$0
12" Hand/Walking Person Overlay, Filled/Outline	TP-12-OL-FH-OM	$116.50	$5.00	154	0.047	$9.00		0	0	$0	$0
12" Hand/Walking Person Overlay, Outline/Outline	TP-16G-HM-110	$124.00	$5.00	154	0.047	$9.00		0	0	$0	$0
12" Hand/Walking Person Overlay, Filled/Filled	TP-12-OL-FH-FM	$119.50	$5.00	154	0.047	$9.00		0	0	$0	$0
						Grand Totals for entry into STAR (as recommendation code 2.1):		0	0	$0	$0

** = State Bureau of Procurement Price - confirm current price

Traffic Signals Product List

List Current as of Nov. 26, 2003

Manufacturing Company Name	Brand Name	Model	Model Number	Meets ITE Specs?
Act One Communications Inc.	Act One	T1	T1-08G-1	Y
Act One Communications Inc.	Act One	T1	T1-08R-1	Y
Act One Communications Inc.	Act One	T1	T1-08R-4	Y
Act One Communications Inc.	Act One	T1	T1-12G-1	Y
Act One Communications Inc.	Act One	T1	T1-12R-1	Y
Act One Communications Inc.	Act One	T1	T1-12R-4	Y
Act One Communications Inc.	Act One	T1	T1-8G-1	Y
Act One Communications Inc.	Act One	T1	T1-8G-4	Y
Act One Communications Inc.	Act One	T1	T1-8R-1	Y
Act One Communications Inc.	Act One	TA	TA-12G-1	N
Act One Communications Inc.	Act One	TA	TA-12R-1	N
Act One Communications Inc.	Act One	TP	TP-14WP-1	N
Act One Communications Inc.	Act One	TP	TP-16WP-1	N
American Bright Optoelectronics Corporation	American Bright Optoelectronics	ATS-200	ATS-2001G01	Y
American Bright Optoelectronics Corporation	American Bright Optoelectronics	ATS-200	ATS-2001R01	Y
American Bright Optoelectronics Corporation	American Bright Optoelectronics	ATS-300	ATS-3001G01	Y
American Bright Optoelectronics Corporation	American Bright Optoelectronics	ATS-300	ATS-3001R01	Y
American Bright Optoelectronics Corporation	American Bright Optoelectronics	ATS-300	ATS-3002G01	N
American Bright Optoelectronics Corporation	American Bright Optoelectronics	ATS-300	ATS-3002R01	N
Dialight	Dialight	430	430-1314-001	N
Dialight	Dialight	430	430-2170-001	Y
Dialight	Dialight	430	430-2374-001	N
Dialight	Dialight	430	430-5401-001	N
Dialight	Dialight	430	430-5770-001	N
Dialight	Dialight	430	430-6471-001	N
Dialight	Dialight	430	430-6472-001	N
Dialight	Dialight	430	430-6473-001	N
Dialight	Dialight	430	430-6474-001	N
Dialight	Dialight	430	430-6475-001	N

Dialight	Dialight	430	430-6771-001	N
Dialight	Dialight	430	430-6774-001	N
Dialight	Dialight	430	430-7770-001	N
Dialight	Dialight	431	431-2171-005	Y
Dialight	Dialight	431	431-2271-005	Y
Dialight	Dialight	432	432-1314-001	N
Dialight	Dialight	432	432-2170-001	Y
Dialight	Dialight	432	432-2220-001	Y
Dialight	Dialight	432	432-2270-001	Y
Dialight	Dialight	432	432-2324-001	N
Dialight	Dialight	432	432-2374-001	N
Dialight	Dialight	432	432-5401-001	N
Dialight	Dialight	433	433-1110-003	Y
Dialight	Dialight	433	433-1210-003	Y
Dialight	Dialight	433	433-2120-001	Y
Dialight	Dialight	433	433-2170-001	Y
Dialight	Dialight	433	433-2220-001	Y
Dialight	Dialight	433	433-2270-001	Y
Excellence Optoelectronics, Inc. (EOI)	EOI	TRA	G12DF-6	
Excellence Optoelectronics, Inc. (EOI)	EOI	TRV	G12DF	Y
Excellence Optoelectronics, Inc. (EOI)	EOI		TRA-G12DG-G2	Y
Excellence Optoelectronics, Inc. (EOI)	EOI		TRA-R12EG-B1	Y
Excellence Optoelectronics, Inc. (EOI)	EOI		TRV-R08EG-N	Y
GELcore, LLC	GE LED	D series	DR4-RTFB-23A-22	Y
GELcore, LLC	GE LED	DR6 series	DR6-GCA2-01A	
GELcore, LLC	GE LED	P series	PS6-CFL3-01A	N
GELcore, LLC	GE LED	P series	PS6-PFH1-01A	N
GELcore, LLC	GE LED	P series	PS7-CFC1-01A	N
GELcore, LLC	GE LED	P series	PS7-CFL3-01A	N
GELcore, LLC	GE LED Signals	DR4 Series	DR4-GCFB-20A	Y
GELcore, LLC	GE LED Signals	DR4 Series	DR4-GCFB-20A-41	Y
GELcore, LLC	GE LED Signals	DR4 Series	DR4-GCFB-23A	Y
GELcore, LLC	GE LED Signals	DR4 Series	DR4-GCFB-23A-22	Y
GELcore, LLC	GE LED Signals	DR4 Series	DR4-GCFB-23A-41	Y
GELcore, LLC	GE LED Signals	DR4 Series	DR4-GTFB-20A	Y
GELcore, LLC	GE LED Signals	DR6 series	DR6-RTA3-01A-22	
GELcore, LLC	GE LED Signals	DR6 Series	DR6-GCAAN-21A	

GELcore, LLC	GE LED Signals	DR6 Series	DR6-GCFB-20A	Y
GELcore, LLC	GE LED Signals	DR6 Series	DR6-GCFB-20A-41	Y
GELcore, LLC	GE LED Signals	DR6 Series	DR6-GCFB-23A-22	Y
GELcore, LLC	GE LED Signals	DR6 Series	DR6-GTA2-01A	
GELcore, LLC	GE LED Signals	DR6 Series	DR6-GTA3-01A	
GELcore, LLC	GE LED Signals	DR6 Series	DR6-GTAAN-21A	
GELcore, LLC	GE LED Signals	DR6 Series	DR6-GTFB-20A	Y
GELcore, LLC	GE LED Signals	DR6 Series	DR6-RTAAN-21A	
GELcore, LLC	GE LED Signals	DR6 Series	DR6-RTFB-20A	Y
GELcore, LLC	GE LED Signals	DR6 Series	DR6-RTFB-23A	Y
GELcore, LLC	GE LED Signals	DR6 Series	DR6-RTFB-23A-22	Y
GELcore, LLC	GE LED Signals	DR6 series	DR6-GCFB-23A	Y
GELcore, LLC	GE LED Signals	PS6 Series	PS6-CFL1-01A	
GELcore, LLC	GE LED Signals	PS7 series	PS7-CFC1-01A-10	
GELcore, LLC	GELcore	8" Red Full Ball	DR4-RTFB-20A	Y
GELcore, LLC	signal	DR4-RTFB	DR4-RTFB-23A	Y
GELcore, LLC	signal	DR6 Series	DR6-GCA3-01A	
GELcore, LLC	signal	DR6 Series	DR6-GCA3-01A-22	
GELcore, LLC	signal	DR6-GCFB	DR6-GCFB-23A-41	Y
GELcore, LLC	signal	P series	PS6-CFC5-01A	N
GELcore, LLC	signal	P series	PS7-CFC1-01A-10	N
GELcore, LLC	signal	P series	PS7-CFC2-01A	N
GELcore, LLC	signal	P series	PS7-CFC3-01A	N
GELcore, LLC	signal	P series	PS7-CFL1-01A	N
GELcore, LLC	signal	P series	PS7-CFL2-01A	N
GELcore, LLC	signal	P series	PS7-PNH1-01A	N
GELcore, LLC	signal	P series	PS7-PNH1-01A-22	N
LEDtronics, Inc.	LEDtronics	Traffic LED	TRF108-OBG-120	Y
LEDtronics, Inc.	LEDtronics	Traffic LED	TRF112-OGB-120	
LEDtronics, Inc.	LEDtronics	Traffic LED	TRF112OER120A	
LEDtronics, Inc.	LEDtronics	Traffic LED	TRF12AOBG-120	Y
LEDtronics, Inc.	LEDtronics	Traffic LED	TRF12AOER120	Y
Leotek Electronics USA Corp.	Leotek	EV	TSL-EV08G-HP2	Y
Leotek Electronics USA Corp.	Leotek	EV	TSL-EV08R-HP2	Y
Leotek Electronics USA Corp.	Leotek	EV	TSL-EV12G-HP2	Y
Leotek Electronics USA Corp.	Leotek	EV	TSL-EV12G-HP3	Y
Leotek Electronics USA Corp.	Leotek	EV	TSL-EV12R-HP3	Y

Leotek Electronics USA Corp.	Leotek	Leotek	TSL-08G-MF	Y
Leotek Electronics USA Corp.	Leotek	Leotek	TSL-O8R-MF	Y
Leotek Electronics USA Corp.	Leotek	MF	TSL-12GA-MF	
Leotek Electronics USA Corp.	Leotek	MF	TSL-12RA-MF	
Leotek Electronics USA Corp.	Leotek	MG	TSL-08G-MG	Y
Leotek Electronics USA Corp.	Leotek	MG	TSL-08R-MG	Y
Leotek Electronics USA Corp.	Leotek	MG	TSL-12G-MG	Y
Leotek Electronics USA Corp.	Leotek	MG	TSL-12GA-MG	
Leotek Electronics USA Corp.	Leotek	MG	TSL-12R-MG	Y
Leotek Electronics USA Corp.	Leotek	MG	TSL-12RA-MG	
Leotek Electronics USA Corp.	Leotek	MH	TSL-12G-MH	Y
Leotek Electronics USA Corp.	Leotek	MH	TSL-12R-MH	Y
Leotek Electronics USA Corp.	Leotek	PED	TP12A-EH	
Leotek Electronics USA Corp.	Leotek	PED	TP12A-WM	
Leotek Electronics USA Corp.	Leotek	PED	TP12B-EH	
Leotek Electronics USA Corp.	Leotek	PED	TP12B-WM	
Leotek Electronics USA Corp.	Leotek	PED	TP12G-HM	
Leotek Electronics USA Corp.	Leotek	PED	TP12H-HM	
Leotek Electronics USA Corp.	Leotek	PED	TP12K-HM	
Leotek Electronics USA Corp.	Leotek	PED	TP14D-HM	
Leotek Electronics USA Corp.	Leotek	PED	TP16C-HM	
Leotek Electronics USA Corp.	Leotek	PED	TP16D-HM	
Leotek Electronics USA Corp.	Leotek	PED	TP16E-HM	
Leotek Electronics USA Corp.	Leotek	PED	TP16F-HM	
Leotek Electronics USA Corp.	Leotek	PED	TP16G-HM	
Leotek Electronics USA Corp.	Leotek	PED	TP16H-HM	
Leotek Electronics USA Corp.	Leotek	PED	TP16K-HM	
Leotek Electronics USA Corp.	Leotek	Ped	TP16B-OH-21G	
Leotek Electronics USA Corp.	Leotek	Ped	TP16B-WM-21G	
Leotek Electronics USA Corp.	Leotek	Ped	TSL-PED-DP-16	

Technology

Plug Load Occupancy Control

Energy Savings – kWh

Computer Monitors	Continuous Use	50 to 80 watts	
	Standby Mode	0 to 12 watts	Avg. Est. = 8 watts
Computer	Continuous	55 to 75 watts	
	Energy Saver Mode	20 to 30 watts	
Lighting	1 lamp 18" T-8 or T-12 magnetic/std	19 watts	
	2 lamp 18" T-8 or T-12 magnetic/std	36 watts	
	1 lamp 24" T-8 or T-12 magnetic/std	26 watts	
	2 lamp 24" T-8 or T-12 magnetic/std	52 watts	
	1 lamp 36" T-8 or T-12 magnetic/std	46 watts	
	1 lamp 24" T-8 electronic	16 watts	
	2 lamp 24" T-8 electronic	31 watts	Avg. Est. = 30 watts
Laser Printers	Continuous Use	130 to 550 watts	
	Idle Use	10 to 125 watts	Avg. Est. = 50 watts
Copiers	Continuous Use	400 to 1100 watts	
	Idle Use	20 to 300 watts	Avg. Est. = 120 watts
Fax, stamp machine, scanner etc.	Idle Use or Energy Saver Mode		Avg. Est. = 50 watts

Savings per work area – Assume only monitor and lighting left on in 25% of areas for an average of 10 hours/day (including weekends)

$$\frac{(8\text{ watts} + 30\text{ watts}) \times 10\text{ hours/day} \times 365\text{ days/year} \times .25}{1000\text{ watts/kWh}} = 139\text{ kWh}$$

Savings per document station

$$\frac{(50 + 120 + 50) \times 10\text{ hours/day} \times 365\text{ days/year} \times .25}{1000\text{ watts/kWh}} = 803\text{ kWh}$$

Please note that work station savings could be significantly greater with assumption of additional loads (fans, heaters, radios, etc) or increase in 25% savings factor.

Summer Peak Savings

Assume reduction only during unoccupied periods.

Measure Life

5 years. Occupancy control equipment will likely last longer but measure life reduced because of probability of bypass or non-use because some versions of this technology are not hard wired.

Initial One-Time Cost

Vary widely from low of $80 for single office/cubicle or document station occupancy sensor with plug load powerstrip. Outlets wired to a separate switch (i.e. – no rewiring) can also provide for installations below $100.

Cost in new construction to wire outlets separate from computer circuit is also a modest and highly variable cost ($50 to $250). Could tie control into lighting circuit and sensor to enhance economics.

Controls companies and some office cubicle manufacturers are offering "Personal Environmental Modules" which are individual space controls. Cost usually several hundred dollars and up.

Several hundred dollar cost likely for rewiring on document stations and individual work spaces without proper circuitry or where plug load powerstrip and occupancy sensor don't work.

Based on above, assume $150 average cost although variable from $80 to $400+.

Any Recurring Costs

None

Suggested Incentive

$15/work station (Individual office or cubicle)
$40/central document station (Multi user area with fax, copier, printer, etc.)

It's possible that document station can be controlled by a single power strip with sensor at a cost of $80 to $100 which would result in a high percentage incentive.

Requirements

Control of at least two devices in workstation (task lighting, monitor, printer, fax, space heater, fan, etc)

Control of at least three devices in central document station

Advise against controlling computers with occupancy control.

Existing Energy Standards

None Found

Source of Info

June 2000 ASHRAE Journal Study, 2001 ASHRAE Fundamentals, manufacturers websites

Heat Gain From Office Equipment

By Christopher Wilkins, P.E. Member ASHRAE and M.H. Hosni, Ph.D. Member ASHRAE

ASHRAE Technical Committee 4.1, Load Calculation Methods, has completed two recent research projects and the results will be of interest to engineers who perform cooling load calculations. ASHRAE Research Project RP-822 focused on development of a method by which the actual heat gain and radiant and convective split from equipment in buildings could be measured [Hosni et al., 1996]. This methodology then was incorporated into a second research project, RP-1055, where the technique was applied to a wide range of equipment [Hosni et al., 1999]. A research team at Kansas State University, led by M.H. Hosni, completed both of these research projects. This research was followed up independent research by Wilkins and McGaffin, 1994.

The independent research by Wilkins and McGaffin produced significant data on the overall building load as measured at panels serving distinct areas within a building. Data was also collected on the measured power consumption of individual items of office equipment. The TC 4.1 research as executed by Hosni et al., expanded on this by obtaining data in a more controlled and formal manner.

Hosni's work for TC 4.1 also included measurement of the radiant and convective split of the heat gain from the equipment. Documentation relative to radiant and convective split is relevant when using advanced load methods.

Research Project RP-1055 obtained heat gain measurements from office, laboratory, and hospital equipment. The final effort of this research was to take the collected data and identify patterns or generalizations that could be widely used for common applications. It was discovered that results for general office equipment could be generalized, but results from laboratory and hospital equipment proved too diverse.

Here we will present generalized guidelines based on the results of all previously mentioned research for office equipment. The reader is encouraged to consult the project's final report and the technical paper (Hosni et al., 1999) for detailed discussions of results for laboratory and hospital equipment.

Nameplate vs. Measured

It is now well documented that nameplate data overstates the actual power consumption of office equipment. Power consumption of this type of equipment is assumed to be equal to the total (radiant plus convective) heat gain. Many engineers would find it convenient if a standard number or ratio could be applied to all nameplate data to obtain a useful estimation of the actual heat gain. All research completed to date, however, suggests that this is not possible.

In Hosni et al., 1999 work as part of RP-1055, they found that for general office equipment with nameplate power consumption of less than 1,000 W, that the actual total heat gain to nameplate ratio ranged from 25% to 50%. When all tested equipment was considered, the range was broader. The conclusion was that if the nameplate was the only information known and no actual heat gain data were available for similar equipment, then it would be conservative to use 50% of nameplate and most accurate if 25% of nameplate were used. Wilkins and McGaffin also found a wide range in this ratio.

Use of this type of blanket ratio could introduce a large degree of error into calculations. Nameplate data for similar equipment varied widely but the actual measured heat gain data was consistent. Applying a generalized ratio could introduce an error of 100% or more. Much better results can be obtained by considering the heat gain as being predictable based on the type of equipment, not based on nameplate data.

Results by Equipment Type

The data collected in RP-1055 for all

About the Authors

M.H. Hosni, Ph.D., is professor of mechanical engineering and the director of the Institute for Environmental Research at Kansas State University. He has been the principal investigator (PI) and Co-PI for RP-822 and RP-1055. He is the chair of the Handbook Committee for ASHRAE Technical Committee (TC) 5.3, Room Air Distribution. **Christopher Wilkins, P.E.**, is group leader for Hallam Associates in Burlington, Vt. He is a member of TC 4.1, Load Calculation Data and Procedures, and TC 4.12, Integrated Building Design.

equipment tested was sorted and reviewed in an attempt to identify trends or generalizations that could be presented for use by practicing engineers. It was discovered that clear patterns could be established for office equipment but that laboratory and hospital equipment was too diverse to be generalized. Office equipment was grouped into categories such as computers, monitors, printers, facsimile machines, and copiers. Results for the measured heat gain of equipment within a given group were then analyzed to establish patterns.

	Continuous (watts)	Energy Saver (watts)
Average Value	55	20
Conservative Value	65	25
Highly Conservative Value	75	30
Based on 386, 486, and Pentium grade [illegible]		

Table 1: Typical heat gain from computers.

Computers

Hosni et al. tested a total of eight computers of Pentium or 486 grade. Four were tested together with a monitor and four were tested alone. The measured maximum ranged from 52 W to 70 W. The nameplate power ranged from 165 W to 759 W. The heat gain from computers tested with monitors was determined by subtracting a typical value for a monitor from the total of the two. Wilkins and McGaffin reported data on 12 computers of 486 grade and older. The average heat gain for the 12 was 56 W and the average nameplate was 391 W. The average heat gain for all 20 computers tested was 55.6 W.

The heat gain from computers showed little reduction when idle versus operational. The exception was computers equipped with the Energy Star energy-saver feature. This feature will place a computer in a "sleep" mode if it remains idle for a preset period of time. Hosni et al., 1999 found that the heat gain reduced to a typical value of 18 W when in sleep mode. This sleep mode on an individual piece of equipment likely will not affect the peak-cooling load but it could affect the diversity factor and maximum heat gain of larger areas within a building.

Two conclusions can be drawn from these data. The first is that nameplate data on computers should be ignored when performing cooling load calculations. The second is that a typical value for heat gain from a computer can be established and applied in cooling load calculations to obtain practical results. Engineers typically want to be conservative in cooling load calculations. *Table 1* allows engineers to choose heat gain values for computers with varying degrees of safety factor.

Monitors

The magnitude of the nameplate power consumption for all monitors tested by Hosni et al. ranged from 168 W to 565 W.

Monitor Size	Continuous (watts)	Energy Saver (watts)
Small Monitor (13 in. to 16 in.)	55	0
Medium Monitor (17 in. to 19 in.)	70	0
Large Monitor (19 in. to 20 in.)	80	0
Typical values for monitors displaying Windows.		

Table 2: Typical heat gain from monitors.

Device Size	Continuous (watts)	1 page per min. (watts)	Idle (watts)
Small Desktop	130	75	10
Desktop	215	100	35
Small Office	320	160	70
Large Office	550	275	125

Table 3: Typical heat gain from laser printers.

The measured maximum total heat gain of all monitors tested ranged from 53 W to 86 W. The monitors tested ranged from 14 in. to 20 in. (36 cm to 51 cm). Hosni et al., 1999 found that the measured total heat gain correlated closely with monitor size. Hosni et al., 1999 developed the following relationship to estimate the heat gain from monitors as a function of monitor size:

$$\text{Heat Gain} = 5 \times S - 20$$

Where S is the monitor size in inches and heat gain is in units of watts. For example, a 15 in. (38 cm) monitor would have a heat gain of 55 W.

Wilkins and McGaffin did not sort their data by monitor size. They presented data on 10 monitors (13 in. to 19 in. [33 cm to 48 cm]) and found that the average value for the heat gain was 60 W. Their testing was done in 1992 when DOS still was used and the Windows operating system was being introduced. They discovered that monitors displaying Windows consumed more power than monitors displaying DOS. *Table 2* is a quick reference for engineers who may prefer a table to an equation. The energy-saver mode for monitors reduces the power consumption and heat gain to zero. *Table 2* is derived from research by both Hosni and Wilkins.

Laser Printers

Hosni et al., 1999 found that the power consumed by laser printers, and therefore the heat gain, depended largely on the level of throughput for which the printer was designed. *Table 3* presents data on four general categories of laser printers. Hosni et al., 1999 opined that smaller printers are used more intermittently and that the larger printers may run continuously for longer periods of time.

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Device	Continuous (watts)	1 page per min. (watts)	Idle (watts)
Desktop Copier	400	85	20
Office Copier	1100	400	300

Table 4: Typical heat gain from copiers.

Device	Continuous (watts)	Idle (watts)
Facsimile Machine	30	15
Image Scanner	25	[illegible]
Dot Matrix Printer	50	25

Table 5: Typical heat gain from miscellaneous equipment.

These data can be applied in at least two ways. The most obvious is to take the value for continuous operation and then apply an appropriate diversity factor. Diversity factors are discussed further later. This likely would be most appropriate for larger open office areas. Another approach could be to take the value that most closely matches the expected operation of the printer with no diversity. This may be appropriate when considering a single room or small area.

Copiers

Hosni et al., 1999 presented data on a total of five copy machines. Copy machines were considered to be of two types, desktop and office. Office-type copiers represented freestanding office grade copiers. Larger machines used in production environments were not addressed. *Table 4* represents a summary of the results. Hosni et al., 1999 observed that it would be unlikely that desktop copiers would be operated continuously but that office copiers were of the type that often are operated continuously for periods of an hour or more.

Freestanding office-type copy machines often are installed in rooms outside the primary occupied area of an office. These copy rooms generally can tolerate a short-term increase in temperature caused by a period of continuous copier operation. Engineers must consider each application and determine the appropriate mode of operation.

Miscellaneous Equipment

Table 5 lists a few other types of equipment that may be encountered. Values for facsimile machines and image scanners are based on data from Hosni et al., 1999. The values presented for dot matrix printers are compiled from data presented by Hosni et al., 1999 and by Wilkins and McGaffin, 1994.

Diversity

The actual peak heat gain for all equipment in a common area of a building is less than the sum of the peak for each because of usage diversity. It is important to have a clear understanding of what diversity is, if the data presented here is to be applied accurately. Diversity, as discussed here, is not related to the

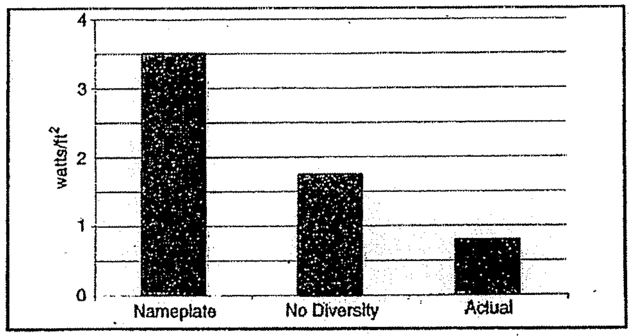

Figure 1: Load factor comparison.

discrepancy between nameplate data and the measured heat gain. Diversity enters into the equation when some equipment is idle or turned off and is not contributing its maximum heat or power to the overall cooling load of a given space or system within a building.

Wilkins and McGaffin were able to measure diversity with a combination of measurements at dedicated equipment power panels and detailed inventories of equipment in the areas served by the panels. Their work encompassed 23 areas within five different buildings totaling more than 275,000 ft² (25 550 m²). The first step was a survey to account for every piece of equipment in the space and to measure the power consumption of each. The peak power consumption (assumed to be equal to peak total heat gain) of all equipment was summed to provide a value for the maximum possible total heat gain of the equipment in the area.

Continuous measurements were taken for a period of one workweek at the equipment panels serving the area. Care was taken during the survey to assure that only receptacles wired to the equipment panels were powering equipment. The peak power consumption recorded at the equipment panel represented the actual peak total heat gain of all equipment in the space. The ratio of the measured peak at the equipment panels and the sum of the maximum of each individual item of equipment is the usage diversity.

Diversity was found to range between 37% and 78% with the average (normalized based on area) being 46%. *Figure 1* illustrates the relationship between nameplate, the sum of the peaks, and the actual with diversity accounted for. *Figure 1* is taken from Wilkins and McGaffin and is based on the average of the total area tested. Data on actual diversity can be used as a guide but diversity will vary significantly for spaces with different occupants. The proper diversity factor for an office of mail order catalog telephone operators will be different from that of an office of sales representatives who travel regularly.

Heat Gain per Unit Area

Wilkins and McGaffin found in the areas that they tested that the actual heat gain per unit area ranged from 0.44 W/ft² to 1.05 W/ft² with an average (normalized based on area) of 0.81 W/ft². These data were compiled based on 275,000 ft² (25 550 m²) of office space in five buildings. These spaces were fully occupied and highly automated with a computer and monitor at every workstation. *Table 6* presents a range of load factors

Type of Space	Load Factor	Description
Light Load	0.5	Assumes 167 ft²/workstation with computer and monitor at each, plus printer and facsimile. Computer, monitor, and facsimile diversity 0.67, printer diversity 0.33.
Medium Load	1.0	Assumes 125 ft²/workstation with computer and monitor at each, plus printer and facsimile. Computer, monitor, and facsimile diversity 0.75, printer diversity 0.50.
Medium/Heavy Load	1.5	Assumes 100 ft²/workstation with computer and monitor at each, plus printer and facsimile. Computer and monitor diversity 0.75, printer and facsimile diversity 0.50.
Heavy Load	2.0	Assumes 83 ft²/workstation with computer and monitor at each, plus printer and facsimile. Computer and monitor diversity 1.0, printer and facsimile diversity 0.50.

Table 6: Typical equipment load factors.

with a subjective description of the type of space to which they would apply.

Wilkins and McGaffin performed tests in 275,000 ft² (25 550 m²) of highly automated spaces, comprising 21 unique areas in five different buildings. The maximum load factor they reported was 1.08 W/ft². This corresponds to a medium load density space based on the subjective classifications presented in *Table 6*. It is likely that the medium load density will be appropriate for most standard office spaces. Medium/heavy or heavy load densities may be encountered but can be considered extremely conservative estimates even for densely populated and highly automated spaces. Other research supports this, including work

Device	Fan	Radiant	Convective
Computer	Yes	10% to 15%	85% to 90%
Monitor	No	35% to 40%	60% to 65%
Computer and Monitor	[illegible]	20% to 30%	70% to 80%
Laser Printer	Yes	10% to 20%	80% to 90%
Copier	Yes	20% to 25%	75% to 80%
Facsimile	No	30% to 35%	65% to 70%

Table 7: Radiant-convective split.

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by Komor in 1997. Komor performed a consolidation of data obtained from several sources and in all cases, his findings were consistent with *Table 6*.

Radiant Convective Split

Office equipment produces both radiant and convective heat gains. Convective heat gain is converted instantly to cooling load while radiant heat gain is absorbed first by the building mass and then converted to cooling load over time. This distinction can impact the time and the magnitude of the peak cooling load. Hosni et al., 1998 developed a method to measure radiant heat gain from equipment using a net radiometer mounted on an articulating arm.

Hosni et al., 1999 found that the radiant-convective split for equipment was fairly uniform. The most important differentiating feature was whether or not the equipment had a cooling fan. *Table 7* is a summary of Hosni et al., 1999 results.

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Future Trends

The data that we have presented here is based on contemporary equipment. The relevance of these data in the future is certainly a legitimate question. The Lawrence Berkley National Laboratory sponsored research in 1995 and reported that equipment energy intensity will decrease until 2002 and then begin to increase slowly through 2010. To date, this prediction has proven accurate. It is likely that the data presented here will be relevant for several more years.

Conclusions

Heat gain from equipment is an important contributor to the overall heat gain of a space. The information presented in this article should be a useful tool to engineers performing cooling loads or energy analyses. We also hope that equipment manufacturers understand the importance of nameplate values for cooling load calculations and take appropriate steps to provide more realistic power consumption information.

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Data Assembly

Building Characteristics. Obtain characteristics of the building. Building materials, component size, external surface colors, and shape are usually determined from building plans and specifications.

Configuration. Determine building location, orientation, and external shading from building plans and specifications. Shading from adjacent buildings can be determined by a site plan or by visiting the proposed site but should be carefully evaluated as to its probable permanence before it is included in the calculation. The possibility of abnormally high ground-reflected solar radiation (i.e., from adjacent water, sand, or parking lots) or solar load from adjacent reflective buildings should not be overlooked.

Outdoor Design Conditions. Obtain appropriate weather data, and select outdoor design conditions. For outdoor design conditions for a large number of weather stations, see Chapter 27. Note, however, that these values for the design dry-bulb and mean coincident wet-bulb temperatures may vary considerably from data traditionally used in various areas. Use judgment to ensure that results are consistent with expectations. Also, consider prevailing wind velocity and the relationship of a project site to the selected weather station.

In recent years, several research projects have greatly expanded the amount of available weather data (Colliver et al. 1995, 1998, 2000). In addition to the conventional dry-bulb with mean coincident wet-bulb, data are now available for wet-bulb and dew-point with mean coincident dry-bulb. The peak load for a space that requires both large quantities of outside air and close control of moisture may occur at peak wet-bulb or peak dew-point conditions when the corresponding dry-bulb temperature is significantly lower than normal design conditions.

Indoor Design Conditions. Select indoor design conditions, such as indoor dry-bulb temperature, indoor wet-bulb temperature, and ventilation rate. Include permissible variations and control limits.

Operating Schedules. Obtain a proposed schedule of lighting, occupancy, internal equipment, appliances, and processes that contribute to the internal thermal load. Determine the probability that the cooling equipment will be operated continuously or shut off during unoccupied periods (e.g., nights and/or weekends).

Date and Time. Select the time of day and month to do the cooling load calculation. Frequently, several different times of day and several different months must be analyzed to determine the peak load time. The particular day and month are often dictated by peak solar conditions. For southern exposures in north latitudes above 32° having large fenestration areas, the peak space cooling load usually occurs in December or January. To calculate a space cooling load under these conditions, the warmest temperature for the winter months must be known. These data can be found for the United States in Chapter 27, Table 4B.

Additional Considerations

The proper design and sizing of all-air or air-and-water central air-conditioning systems require more than calculation of the cooling load in the space to be conditioned. The type of air-conditioning system, fan energy, fan location, duct heat loss and gain, duct leakage, heat extraction lighting systems, and type of return air system all affect system load and component sizing. Adequate system design and component sizing require that system performance be analyzed as a series of psychrometric processes.

HEAT SOURCES AND HEAT GAIN CALCULATION CONCEPTS

TIME DELAY EFFECT

The energy absorbed by walls, floor, furniture, etc., contributes to space cooling load only after a time lag, with some part of this energy still present and reradiating after the heat sources have been switched off or are no longer present (Figure 2).

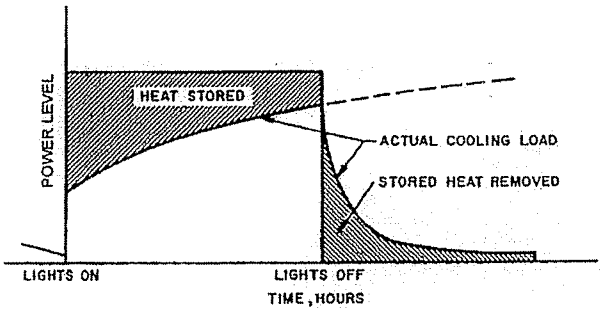

Fig. 2 Thermal Storage Effect in Cooling Load from Lights

There is always significant delay between the time of switching on or otherwise activating a heat source and the point when reradiated energy equals that being instantaneously stored. This time lag must be considered when calculating cooling load because the load felt by the space can be much lower than the instantaneous heat gain being generated, and the peak load for the space may be affected significantly.

PEOPLE

Table 1 gives representative rates at which heat and moisture are given off by human beings in different states of activity. Often these sensible and latent heat gains constitute a large fraction of the total load. Even for short-term occupancy, the extra heat and moisture brought in by people may be significant. Chapter 8 should be consulted for detailed information; however, Table 1 summarizes design data representing conditions commonly encountered.

The conversion of sensible heat gain from people to space cooling load is affected by the thermal storage characteristics of that space, since some percentage of the sensible load is radiant energy. Latent heat gains are considered instantaneous.

LIGHTING

Because lighting is often the major space cooling load component, an accurate estimate of the space heat gain it imposes is needed. Calculation of this load component is not straightforward; the rate of cooling load due to lighting at any given moment can be quite different from the heat equivalent of power supplied instantaneously to those lights.

Instantaneous Heat Gain from Lighting

The primary source of heat from lighting comes from light-emitting elements, or lamps, although significant additional heat may be generated from associated appurtenances in the light fixtures that house such lamps. Generally, the instantaneous rate of heat gain from electric lighting may be calculated from

$$q_{el} = 3.41 W F_{ul} F_{sa} \tag{1}$$

where

q_{el} = heat gain, Btu/h
W = total light wattage
F_{ul} = lighting use factor
F_{sa} = lighting special allowance factor

The **total light wattage** is obtained from the ratings of all lamps installed, both for general illumination and for display use.

The **lighting use factor** is the ratio of the wattage in use, for the conditions under which the load estimate is being made, to the total

Table 1 Representative Rates at Which Heat and Moisture Are Given Off by Human Beings in Different States of Activity

Degree of Activity	Location	Total Heat, Btu/h Adult Male	Total Heat, Btu/h Adjusted, M/F[a]	Sensible Heat, Btu/h	Latent Heat, Btu/h	% Sensible Heat that is Radiant[b] Low V	% Sensible Heat that is Radiant[b] High V
Seated at theater	Theater, matinee	390	330	225	105		
Seated at theater, night	Theater, night	390	350	245	105	60	27
Seated, very light work	Offices, hotels, apartments	450	400	245	155		
Moderately active office work	Offices, hotels, apartments	475	450	250	200		
Standing, light work; walking	Department store; retail store	550	450	250	200	58	38
Walking, standing	Drug store, bank	550	500	250	250		
Sedentary work	Restaurant[c]	490	550	275	275		
Light bench work	Factory	800	750	275	475		
Moderate dancing	Dance hall	900	850	305	545	49	35
Walking 3 mph; light machine work	Factory	1000	1000	375	625		
Bowling[d]	Bowling alley	1500	1450	580	870		
Heavy work	Factory	1500	1450	580	870	54	19
Heavy machine work; lifting	Factory	1600	1600	635	965		
Athletics	Gymnasium	2000	1800	710	1090		

Notes:
1. Tabulated values are based on 75°F room dry-bulb temperature. For 80°F room dry bulb, the total heat remains the same, but the sensible heat values should be decreased by approximately 20%, and the latent heat values increased accordingly.
2. Also refer to Table 4, Chapter 8, for additional rates of metabolic heat generation.
3. All values are rounded to nearest 5 Btu/h.

[a]Adjusted heat gain is based on normal percentage of men, women, and children for the application listed, with the postulate that the gain from an adult female is 85% of that for an adult male, and that the gain from a child is 75% of that for an adult male.

[b]Values approximated from data in Table 6, Chapter 8, where V is air velocity with limits shown in that table.

[c]Adjusted heat gain includes 60 Btu/h for food per individual (30 Btu/h sensible and 30 Btu/h latent).

[d]Figure one person per alley actually bowling, and all others as sitting (400 Btu/h) or standing or walking slowly (550 Btu/h).

installed wattage. For commercial applications such as stores, the use factor would generally be unity.

The **special allowance factor** is for fluorescent fixtures and/or fixtures that are either ventilated or installed so that only part of their heat goes to the conditioned space. For fluorescent or high-intensity discharge fixtures, the special allowance factor accounts primarily for ballast losses. Table 2 shows that the special allowance factor for a two-lamp fluorescent fixture ranges from 0.94 for T8 lamps with an electronic ballast to 1.21 for energy-saver T12 lamps with a standard electromagnetic ballast. High-intensity discharge fixtures, such as metal halide, may have special allowance factors varying from 1.07 to 1.44, depending on the lamp wattage and quantity of lamps per fixture, and should be dealt with individually. A wide variety of lamp and ballast combinations is available, and ballast catalog data provide the overall fixture wattage.

For ventilated or recessed fixtures, manufacturers' or other data must be sought to establish the fraction of the total wattage that may be expected to enter the conditioned space directly (and subject to time lag effect) versus that which must be picked up by return air or in some other appropriate manner.

Light Heat Components

Cooling load caused by lights recessed into ceiling cavities is made up of two components: one part (known as the **heat-to-space** load) comes from the light heat directly contributing to the space heat gain, and the other is the light heat released into the above-ceiling cavity, which (if used as a return air plenum) is mostly picked up by the return air that passes over or through the light fixtures. In such a ceiling return air plenum, this second part of the load (sometimes referred to as **heat-to-return**) never enters the conditioned space. It does, however, add to the overall load and significantly influences the load calculation.

Even though the total cooling load imposed on the cooling coil from these two components remains the same, the larger the fraction of heat output picked up by the return air, the more the space cooling load is reduced. The minimum required airflow rate for the conditioned space is decreased as the space cooling load decreases. Supply fan power decreases accordingly, which ultimately results in reduced energy consumption for the system and possibly reduced equipment size as well.

For ordinary design load estimation, the heat gain for each component may be calculated simply as a fraction of the total lighting load by using judgment to estimate heat-to-space and heat-to-return percentages (Mitalas and Kimura 1971).

Return Air Light Fixtures

Two generic types of return air light fixture are available—those that allow and those that do not allow return air to flow through the lamp chamber. The first type is sometimes called a heat-of-light fixture. The percentage of light heat released through the plenum side of various ventilated fixtures can be obtained from lighting fixture manufacturers. For representative data, see Nevins et al. (1971). Even unventilated fixtures lose some heat to plenum spaces; however, most of the heat ultimately enters the conditioned space from a dead-air plenum or is picked up by return air via ceiling return air openings. The percentage of heat to return air ranges from 40 to 60% for heat-to-return ventilated fixtures or 15 to 25% for unventilated fixtures.

Plenum Temperatures

As heat from lighting is picked up by the return air, the temperature differential between the ceiling cavity and the conditioned space causes part of that heat to flow from the ceiling back to the conditioned space. Return air from the conditioned space can be ducted to capture light heat without passing through a ceiling plenum as such, or the ceiling space can be used as a return air plenum, causing the distribution of light heat to be handled in distinctly different ways. Most plenum temperatures do not rise more than 1 to 3°F above space temperature, thus generating only a relatively small thermal gradient for heat transfer through plenum surfaces but

Table 2 Typical Nonincandescent Light Fixtures

Description	Ballast	Watts/Lamp	Lamps/Fixture	Lamp Watts	Fixture Watts	Special Allowance Factor
Compact Fluorescent Fixtures						
Twin, (1) 5 W lamp	Mag-Std	5	1	5	9	1.80
Twin, (1) 7 W lamp	Mag-Std	7	1	7	10	1.43
Twin, (1) 9 W lamp	Mag-Std	9	1	9	11	1.22
Quad, (1) 13 W lamp	Mag-Std	13	1	13	17	1.31
Quad, (2) 18 W lamp	Mag-Std	18	2	36	45	1.25
Quad, (2) 22 W lamp	Mag-Std	22	2	44	48	1.09
Quad, (2) 26 W lamp	Mag-Std	26	2	52	66	1.27
Twin, (2) 40 W lamp	Mag-Std	40	2	80	85	1.06
Quad, (1) 13 W lamp	Electronic	13	1	13	15	1.15
Quad, (1) 26 W lamp	Electronic	26	1	26	27	1.04
Quad, (2) 18 W lamp	Electronic	18	2	36	38	1.06
Quad, (2) 26 W lamp	Electronic	26	2	52	50	0.96
Twin or multi, (2) 32 W lamp	Electronic	32	2	64	62	0.97
Fluorescent Fixtures						
(1) 18 in., T8 lamp	Mag-Std	15	1	15	19	1.27
(1) 18 in., T12 lamp	Mag-Std	15	1	15	19	1.27
(2) 18 in., T8 lamp	Mag-Std	15	2	30	36	1.20
(2) 18 in., T12 lamp	Mag-Std	15	2	30	36	1.20
(1) 24 in., T8 lamp	Mag-Std	17	1	17	24	1.41
(1) 24 in., T12 lamp	Mag-Std	20	1	20	28	1.40
(2) 24 in., T12 lamp	Mag-Std	20	2	40	56	1.40
(1) 24 in., T12 HO lamp	Mag-Std	35	1	35	62	1.77
(2) 24 in., T12 HO lamp	Mag-Std	35	2	70	90	1.29
(1) 24 in., T8 lamp	Electronic	17	1	17	16	0.94
(2) 24 in., T8 lamp	Electronic	17	2	34	31	0.91
(1) 36 in., T12 lamp	Mag-Std	30	1	30	46	1.53
(2) 36 in., T12 lamp	Mag-Std	30	2	60	81	1.35
(1) 36 in., T12 ES lamp	Mag-Std	25	1	25	42	1.68
(2) 36 in., T12 ES lamp	Mag-Std	25	2	50	73	1.46
(1) 36 in., T12 HO lamp	Mag-Std	50	1	50	70	1.40
(2) 36 in., T12 HO lamp	Mag-Std	50	2	100	114	1.14
(2) 36 in., T12 lamp	Mag-ES	30	2	60	74	1.23
(2) 36 in., T12 ES lamp	Mag-ES	25	2	50	66	1.32
(1) 36 in., T12 lamp	Electronic	30	1	30	31	1.03
(1) 36 in., T12 ES lamp	Electronic	25	1	25	26	1.04
(1) 36 in., T8 lamp	Electronic	25	1	25	24	0.96
(2) 36 in., T12 lamp	Electronic	30	2	60	58	0.97
(2) 36 in., T12 ES lamp	Electronic	25	2	50	50	1.00
(2) 36 in., T8 lamp	Electronic	25	2	50	46	0.92
(2) 36 in., T8 HO lamp	Electronic	25	2	50	50	1.00
(2) 36 in., T8 VHO lamp	Electronic	25	2	50	70	1.40
(1) 48 in., T12 lamp	Mag-Std	40	1	40	55	1.38
(2) 48 in., T12 lamp	Mag-Std	40	2	80	92	1.15
(3) 48 in., T12 lamp	Mag-Std	40	3	120	140	1.17
(4) 48 in., T12 lamp	Mag-Std	40	4	160	184	1.15
(1) 48 in., T12 ES lamp	Mag-Std	34	1	34	48	1.41
(2) 48 in., T12 ES lamp	Mag-Std	34	2	68	82	1.21
(3) 48 in., T12 ES lamp	Mag-Std	34	3	102	100	0.98
(4) 48 in., T12 ES lamp	Mag-Std	34	4	136	164	1.21
(1) 48 in., T12 ES lamp	Mag-ES	34	1	34	43	1.26
(2) 48 in., T12 ES lamp	Mag-ES	34	2	68	72	1.06
(3) 48 in., T12 ES lamp	Mag-ES	34	3	102	115	1.13
(4) 48 in., T12 ES lamp	Mag-ES	34	4	136	144	1.06
(1) 48 in., T8 lamp	Mag-ES	32	1	32	35	1.09
(2) 48 in., T8 lamp	Mag-ES	32	2	64	71	1.11
(3) 48 in., T8 lamp	Mag-ES	32	3	96	110	1.15
(4) 48 in., T8 lamp	Mag-ES	32	4	128	142	1.11
(1) 48 in., T12 ES lamp	Electronic	34	1	34	32	0.94
(2) 48 in., T12 ES lamp	Electronic	34	2	68	60	0.88
(3) 48 in., T12 ES lamp	Electronic	34	3	102	92	0.90
(4) 48 in., T12 ES lamp	Electronic	34	4	136	120	0.88
(1) 48 in., T8 lamp	Electronic	32	1	32	32	1.00
(2) 48 in., T8 lamp	Electronic	32	2	64	60	0.94
(3) 48 in., T8 lamp	Electronic	32	3	96	93	0.97
(4) 48 in., T8 lamp	Electronic	32	4	128	120	0.94
(1) 60 in., T12 lamp	Mag-Std	50	1	50	63	1.26
(2) 60 in., T12 lamp	Mag-Std	50	2	100	128	1.28
(1) 60 in., T12 HO lamp	Mag-Std	75	1	75	92	1.23
(2) 60 in., T12 HO lamp	Mag-Std	75	2	150	168	1.12
(1) 60 in., T12 ES VHO lamp	Mag-Std	135	1	135	165	1.22
(2) 60 in., T12 ES VHO lamp	Mag-Std	135	2	270	310	1.15
(1) 60 in., T12 HO lamp	Mag-ES	75	1	75	88	1.17
(2) 60 in., T12 HO lamp	Mag-ES	75	2	150	176	1.17
(1) 60 in., T12 lamp	Electronic	50	1	50	44	0.88
(2) 60 in., T12 lamp	Electronic	50	2	100	88	0.88
(1) 60 in., T12 HO lamp	Electronic	75	1	75	69	0.92
(2) 60 in., T12 HO lamp	Electronic	75	2	150	138	0.92
(1) 60 in., T8 lamp	Electronic	40	1	40	36	0.90
(2) 60 in., T8 lamp	Electronic	40	2	80	72	0.90
(3) 60 in., T8 lamp	Electronic	40	3	120	106	0.88
(4) 60 in., T8 lamp	Electronic	40	4	160	134	0.84
(1) 72 in., T12 lamp	Mag-Std	55	1	55	76	1.38
(2) 72 in., T12 lamp	Mag-Std	55	2	110	122	1.11
(3) 72 in., T12 lamp	Mag-Std	55	3	165	202	1.22
(4) 72 in., T12 lamp	Mag-Std	55	4	220	244	1.11
(1) 72 in., T12 HO lamp	Mag-Std	85	1	85	120	1.41
(2) 72 in., T12 HO lamp	Mag-Std	85	2	170	220	1.29
(1) 72 in., T12 VHO lamp	Mag-Std	160	1	160	180	1.13
(2) 72 in., T12 VHO lamp	Mag-Std	160	2	320	330	1.03
(2) 72 in., T12 lamp	Mag-ES	55	2	110	122	1.11
(4) 72 in., T12 lamp	Mag-ES	55	4	220	244	1.11
(2) 72 in., T12 HO lamp	Mag-ES	85	2	170	194	1.14
(4) 72 in., T12 HO lamp	Mag-ES	85	4	340	388	1.14
(1) 72 in., T12 lamp	Electronic	55	1	55	68	1.24
(2) 72 in., T12 lamp	Electronic	55	2	110	108	0.98
(3) 72 in., T12 lamp	Electronic	55	3	165	176	1.07
(4) 72 in., T12 lamp	Electronic	55	4	220	216	0.98
(1) 96 in., T12 ES lamp	Mag-Std	60	1	60	75	1.25
(2) 96 in., T12 ES lamp	Mag-Std	60	2	120	128	1.07
(3) 96 in., T12 ES lamp	Mag-Std	60	3	180	203	1.13
(4) 96 in., T12 ES lamp	Mag-Std	60	4	240	256	1.07
(1) 96 in., T12 ES HO lamp	Mag-Std	95	1	95	112	1.18
(2) 96 in., T12 ES HO lamp	Mag-Std	95	2	190	227	1.19
(3) 96 in., T12 ES HO lamp	Mag-Std	95	3	285	380	1.33
(4) 96 in., T12 ES HO lamp	Mag-Std	95	4	380	454	1.19
(1) 96 in., T12 ES VHO lamp	Mag-Std	185	1	185	205	1.11
(2) 96 in., T12 ES VHO lamp	Mag-Std	185	2	370	380	1.03
(3) 96 in., T12 ES VHO lamp	Mag-Std	185	3	555	585	1.05
(4) 96 in., T12 ES VHO lamp	Mag-Std	185	4	740	760	1.03
(2) 96 in., T12 ES lamp	Mag-ES	60	2	120	123	1.03
(3) 96 in., T12 ES lamp	Mag-ES	60	3	180	210	1.17
(4) 96 in., T12 ES lamp	Mag-ES	60	4	240	246	1.03
(2) 96 in., T12 ES HO lamp	Mag-ES	95	2	190	207	1.09
(4) 96 in., T12 ES HO lamp	Mag-ES	95	4	380	414	1.09

Table 2 Typical Nonincandescent Light Fixtures (*Concluded*)

Description	Ballast	Watts/Lamp	Lamps/Fixture	Lamp Watts	Fixture Watts	Special Allowance Factor	Description	Ballast	Watts/Lamp	Lamps/Fixture	Lamp Watts	Fixture Watts	Special Allowance Factor
(1) 96 in., T12 ES lamp	Electronic	60	1	60	69	1.15	(1) 96 in., T8 HO lamp	Electronic	59	1	59	68	1.15
(2) 96 in., T12 ES lamp	Electronic	60	2	120	110	0.92	(1) 96 in., T8 VHO lamp	Electronic	59	1	59	71	1.20
(3) 96 in., T12 ES lamp	Electronic	60	3	180	179	0.99	(2) 96 in., T8 lamp	Electronic	59	2	118	109	0.92
(4) 96 in., T12 ES lamp	Electronic	60	4	240	220	0.92	(3) 96 in., T8 lamp	Electronic	59	3	177	167	0.94
(1) 96 in., T12 ES HO lamp	Electronic	95	1	95	80	0.84	(4) 96 in., T8 lamp	Electronic	59	4	236	219	0.93
(2) 96 in., T12 ES HO lamp	Electronic	95	2	190	173	0.91	(2) 96 in., T8 HO lamp	Electronic	86	2	172	160	0.93
(4) 96 in., T12 ES HO lamp	Electronic	95	4	380	346	0.91	(4) 96 in., T8 HO lamp	Electronic	86	4	344	320	0.93
(1) 96 in., T8 lamp	Electronic	59	1	59	58	0.98							
Circular Fluorescent Fixtures													
Circlite, (1) 20 W lamp	Mag-PH	20	1	20	20	1.00	(2) 8 in. circular lamp	Mag-RS	22	2	44	52	1.18
Circlite, (1) 22 W lamp	Mag-PH	22	1	22	20	0.91	(1) 12 in. circular lamp	Mag-RS	32	1	32	31	0.97
Circline, (1) 32 W lamp	Mag-PH	32	1	32	40	1.25	(2) 12 in. circular lamp	Mag-RS	32	2	64	62	0.97
(1) 6 in. circular lamp	Mag-RS	20	1	20	25	1.25	(1) 16 in. circular lamp	Mag-Std	40	1	40	35	0.88
(1) 8 in. circular lamp	Mag-RS	22	1	22	26	1.18							
High-Pressure Sodium Fixtures													
(1) 35 W lamp	HID	35	1	35	46	1.31	(1) 250 W lamp	HID	250	1	250	295	1.18
(1) 50 W lamp	HID	50	1	50	66	1.32	(1) 310 W lamp	HID	310	1	310	365	1.18
(1) 70 W lamp	HID	70	1	70	95	1.36	(1) 360 W lamp	HID	360	1	360	414	1.15
(1) 100 W lamp	HID	100	1	100	138	1.38	(1) 400 W lamp	HID	400	1	400	465	1.16
(1) 150 W lamp	HID	150	1	150	188	1.25	(1) 1000 W lamp	HID	1000	1	1000	1100	1.10
(1) 200 W lamp	HID	200	1	200	250	1.25							
Metal Halide Fixtures													
(1) 32 W lamp	HID	32	1	32	43	1.34	(1) 250 W lamp	HID	250	1	250	295	1.18
(1) 50 W lamp	HID	50	1	50	72	1.44	(1) 400 W lamp	HID	400	1	400	458	1.15
(1) 70 W lamp	HID	70	1	70	95	1.36	(2) 400 W lamp	HID	400	2	800	916	1.15
(1) 100 W lamp	HID	100	1	100	128	1.28	(1) 750 W lamp	HID	750	1	750	850	1.13
(1) 150 W lamp	HID	150	1	150	190	1.27	(1) 1000 W lamp	HID	1000	1	1000	1080	1.08
(1) 175 W lamp	HID	175	1	175	215	1.23	(1) 1500 W lamp	HID	1500	1	1500	1610	1.07
Mercury Vapor Fixtures													
(1) 40 W lamp	HID	40	1	40	50	1.25	(1) 250 W lamp	HID	250	1	250	290	1.16
(1) 50 W lamp	HID	50	1	50	74	1.48	(1) 400 W lamp	HID	400	1	400	455	1.14
(1) 75 W lamp	HID	75	1	75	93	1.24	(2) 400 W lamp	HID	400	2	800	910	1.14
(1) 100 W lamp	HID	100	1	100	125	1.25	(1) 700 W lamp	HID	700	1	700	780	1.11
(1) 175 W lamp	HID	175	1	175	205	1.17	(1) 1000 W lamp	HID	1000	1	1000	1075	1.08

Abbreviations: Mag = electromagnetic; ES = energy saver; Std = standard; HID = high-intensity discharge; HO = high output; VHO = very high output; PH = preheat; RS = rapid start

a relatively large percentage reduction in space cooling load. (Many engineers believe that a major reason for plenum temperatures not becoming more elevated is due to leakage into the plenum from supply air ducts normally concealed there.)

Energy Balance

Where the ceiling space is used as a return air plenum, an energy balance requires that the heat picked up from the lights into the return air (1) become a part of the cooling load to the return air (represented by a temperature rise of the return air as it passes through the ceiling space), (2) be partially transferred back into the conditioned space through the ceiling material below, and/or (3) may be partially "lost" (from the space) through the floor surfaces above the plenum. In a multistory building, the conditioned space frequently gains heat through its floor from a similar plenum below, offsetting the loss just mentioned. The radiant component of heat leaving the ceiling or floor surface of a plenum is normally so small that all such heat transfer is considered convective for calculation purposes.

Figure 3 shows a schematic diagram of a typical return air plenum. The following equations, using the heat flow directions shown

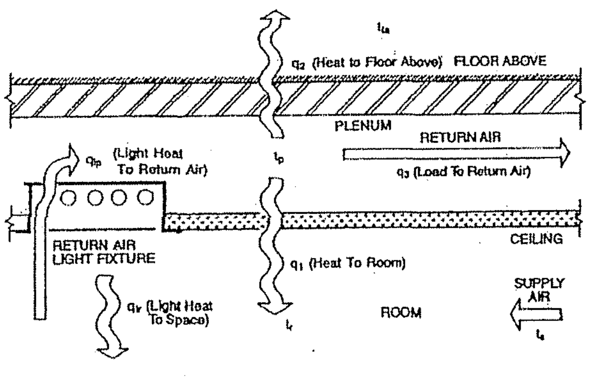

Fig. 3 Schematic Diagram of Typical Return Air Plenum

in Figure 3, represent the heat balance of a return air plenum design for a typical interior room in a multifloor building:

$$q_1 = U_c A_c (t_p - t_r) \tag{2}$$

$$q_2 = U_f A_f (t_p - t_{fa}) \quad (3)$$

$$q_3 = 1.1Q(t_p - t_r) \quad (4)$$

$$q_{lp} - q_2 - q_1 - q_3 = 0 \quad (5)$$

$$Q = \frac{q_r + q_1}{1.1(t_r - t_s)} \quad (6)$$

where

q_1 = heat gain to space from plenum through ceiling, Btu/h
q_2 = heat loss from plenum through floor above, Btu/h
q_3 = heat gain "pickup" by return air, Btu/h
Q = return airflow, cfm
q_{lp} = light heat gain to plenum via return air, Btu/h
q_{lr} = light heat gain to space, Btu/h
q_f = heat gain from plenum below, through floor, Btu/h
q_w = heat gain from exterior wall, Btu/h
q_r = space cooling load, including appropriate treatment of q_{lr}, q_f, and/or q_w, Btu/h
t_p = plenum temperature, °F
t_r = space temperature, °F
t_{fa} = space temperature of floor above, °F
t_s = supply air temperature, °F

From heat balance Equation (5), t_p can be found as the resultant return air temperature or plenum temperature. The results, although rigorous and best solved by computer, are important in determining the cooling load, which affects equipment size selection, future energy consumption, and other factors.

Equations (2) through (6) are simplified to illustrate the heat balance relationship. Heat gain into a return air plenum is not limited to the heat of lights alone. Exterior walls directly exposed to the ceiling space will transfer heat directly to or from the return air. For single-story buildings or the top floor of a multistory building, the roof heat gain or loss enters or leaves the ceiling plenum rather than entering or leaving the conditioned space directly. The supply air quantity calculated by Equation (6) is only for the conditioned space under consideration and is assumed equal to the return air quantity.

The amount of airflow through a return plenum above a conditioned space may not be limited to that supplied into the space under consideration; it will, however, have no noticeable effect on plenum temperature if the surplus comes from an adjacent plenum operating under similar conditions. Where special conditions exist, heat balance Equations (2) through (6) must be modified appropriately. Finally, even though the building's thermal storage has some effect, the amount of heat entering the return air is small and may be considered as convective for calculation purposes.

ELECTRIC MOTORS

Instantaneous heat gain from equipment operated by electric motors within a conditioned space is calculated as

$$q_{em} = 2545(P/E_M)F_{UM}F_{LM} \quad (7)$$

where

q_{em} = heat equivalent of equipment operation, Btu/h
P = motor power rating, hp
E_M = motor efficiency, decimal fraction < 1.0
F_{UM} = motor use factor, 1.0 or decimal fraction < 1.0
F_{LM} = motor load factor, 1.0 or decimal fraction < 1.0

The motor use factor may be applied when motor use is known to be intermittent with significant nonuse during all hours of operation (e.g., overhead door operator). For conventional applications, its value would be 1.0.

The motor load factor is the fraction of the rated load being delivered under the conditions of the cooling load estimate. In Equation (7), it is assumed that both the motor and the driven equipment are in the conditioned space. If the motor is outside the space or airstream,

$$q_{em} = 2545PF_{UM}F_{LM} \quad (8)$$

When the motor is inside the conditioned space or airstream but the driven machine is outside,

$$q_{em} = 2545P\left(\frac{1.0 - E_M}{E_M}\right)F_{UM}F_{LM} \quad (9)$$

Equation (9) also applies to a fan or pump in the conditioned space that exhausts air or pumps fluid outside that space.

Tables 3A and 3B give average efficiencies and related data representative of typical electric motors, generally derived from the lower efficiencies reported by several manufacturers of open, drip-proof motors. These reports indicate that totally enclosed

Table 3A Average Efficiencies and Related Data Representative of Typical Electric Motors

Motor Nameplate or Rated Horsepower	Motor Type	Nominal rpm	Full Load Motor Efficiency, %	A: Motor in, Driven Equipment in, Btu/h	B: Motor out, Driven Equipment in, Btu/h	C: Motor in, Driven Equipment out, Btu/h
				Location of Motor and Driven Equipment with Respect to Conditioned Space or Airstream		
0.05	Shaded pole	1500	35	360	130	240
0.08	Shaded pole	1500	35	580	200	380
0.125	Shaded pole	1500	35	900	320	590
0.16	Shaded pole	1500	35	1,160	400	760
0.25	Split phase	1750	54	1,180	640	540
0.33	Split phase	1750	56	1,500	840	660
0.50	Split phase	1750	60	2,120	1,270	850
0.75	3-phase	1750	72	2,650	1,900	740
1	3-phase	1750	75	3,390	2,550	850
1.5	3-phase	1750	77	4,960	3,820	1,140
2	3-phase	1750	79	6,440	5,090	1,350
3	3-phase	1750	81	9,430	7,640	1,790
5	3-phase	1750	82	15,500	12,700	2,790
7.5	3-phase	1750	84	22,700	19,100	3,640
10	3-phase	1750	85	29,900	24,500	4,490
15	3-phase	1750	86	44,400	38,200	6,210
20	3-phase	1750	87	58,500	50,900	7,610
25	3-phase	1750	88	72,300	63,600	8,680
30	3-phase	1750	89	85,700	76,300	9,440
40	3-phase	1750	89	114,000	102,000	12,600
50	3-phase	1750	89	143,000	127,000	15,700
60	3-phase	1750	89	172,000	153,000	18,900
75	3-phase	1750	90	212,000	191,000	21,200
100	3-phase	1750	90	283,000	255,000	28,300
125	3-phase	1750	90	353,000	318,000	35,300
150	3-phase	1750	91	420,000	382,000	37,800
200	3-phase	1750	91	569,000	509,000	50,300
250	3-phase	1750	91	699,000	636,000	62,900

Table 3B Typical Overload Limits with Standard Motors

Motor Type	Horsepower: 0.05 to 0.25	0.16 to 0.33	0.67 to 0.75	1 and up
AC open	1.4	1.35	1.25	1.15
AC TEFC[a] and DC	—	1.0	1.0	1.0

Note: Some shaded pole, capacitor start, and special purpose motors have a service factor varying from 1.0 up to 1.75.
[a]Some totally enclosed fan-cooled (TEFC) motors have a service factor above 1.0.

fan-cooled (TEFC) motors are slightly more efficient. For speeds lower or higher than those listed, efficiencies may be 1 to 3% lower or higher, depending on the manufacturer. Should actual voltages at motors be appreciably higher or lower than rated nameplate voltage, efficiencies in either case will be lower. If electric motor load is an appreciable portion of cooling load, the motor efficiency should be obtained from the manufacturer. Also, depending on design, the maximum efficiency might occur anywhere between 75 to 110% of full load; if underloaded or overloaded, the efficiency could vary from the manufacturer's listing.

Overloading or Underloading

Heat output of a motor is generally proportional to the motor load, within the overload limits. Because of typically high no-load motor current, fixed losses, and other reasons, F_{LM} is generally assumed to be unity, and no adjustment should be made for underloading or overloading unless the situation is fixed, can be accurately established, and the reduced load efficiency data can be obtained from the motor manufacturer.

Radiation and Convection

Unless the manufacturer's technical literature indicates otherwise, the heat gain normally should be equally divided between radiant and convective components for the subsequent cooling load calculations.

APPLIANCES

In a cooling load estimate, heat gain from all appliances—electrical, gas, or steam—should be taken into account. Because of the variety of appliances, applications, schedules, use, and installations, estimates can be very subjective. Often, the only information available about heat gain from equipment is that on its nameplate.

Cooking Appliances

These appliances include common heat-producing cooking equipment found in conditioned commercial kitchens. Marn (1962) concluded that appliance surfaces contributed most of the heat to commercial kitchens and that when applicances were installed under an effective hood, the cooling load was independent of the fuel or energy used for similar equipment performing the same operations.

Gordon et al. (1994) and Smith et al. (1995) found that gas appliances may exhibit slightly higher heat gains than their electric counterparts under wall-canopy hoods operated at typical ventilation rates. This is due to the fact that the heat contained in the combustion products exhausted from a gas appliance may increase the temperatures of the appliance and surrounding surfaces, as well as the hood above the appliance, more than the heat produced by its electric counterpart. These higher temperature surfaces radiate heat to the kitchen, adding moderately to the radiant gain directly associated with the appliance cooking surface.

Marn (1962) confirmed that where the appliances are installed under an effective hood, only radiant gain adds to the cooling load; convected and latent heat from the cooking process and combustion products are exhausted and do not enter the kitchen. Gordon et al. (1994) and Smith et al. (1995) substantiated these findings.

Sensible Heat Gain for Hooded Cooking Appliances. To establish a heat gain value, nameplate energy input ratings may be used with appropriate usage and radiation factors. Where specific rating data are not available (nameplate missing, equipment not yet purchased, etc.) or as an alternative approach, recommended heat gains listed in Table 5 for a wide variety of commonly encountered equipment items may be used. In estimating the appliance load, probabilities of simultaneous use and operation for different appliances located in the same space must be considered.

The radiant heat gain from hooded cooking equipment can range from 15 to 45% of the actual appliance energy consumption (Talbert et al. 1973, Gordon et al. 1994, Smith et al. 1995). This ratio of heat gain to appliance energy consumption may be expressed as a radiation factor. It is a function of both appliance type and fuel source. The radiation factor F_R is applied to the average rate of appliance energy consumption, determined by applying usage factor F_U to the nameplate or rated energy input. Marn (1962) found that radiant heat temperature rise can be substantially reduced by shielding the fronts of cooking appliances. Although this approach may not always be practical in a commercial kitchen, radiant gains can also be reduced by adding side panels or partial enclosures that are integrated with the exhaust hood.

Heat Gain from Meals. For each meal served, the heat transferred to the dining space is approximately 50 Btu/h, of which 75% is sensible and 25% is latent.

Heat Gain for Electric and Steam Appliances. The average rate of appliance energy consumption can be estimated from the nameplate or rated energy input q_{input} by applying a duty cycle or usage factor F_U. Thus, the sensible heat gain $q_{sensible}$ for generic types of electric, steam, and gas appliances installed under a hood can be estimated using one of the following equations:

$$q_{sensible} = q_{input} F_U F_R \tag{10}$$

or

$$q_{sensible} = q_{input} F_L \tag{11}$$

where F_L is defined as the ratio of sensible heat gain to the manufacturer's rated energy input.

Table 4 lists usage factors, radiation factors, and load factors based on appliance energy consumption rate for typical electrical, steam, and gas appliances under standby or idle conditions.

Unhooded Equipment. For all cooking appliances not installed under an exhaust hood or directly vent-connected and located in the conditioned area, the heat gain may be estimated as 50% ($F_U = 0.50$)

Table 4A Hooded Electric Appliance Usage Factors, Radiation Factors, and Load Factors

Appliance	Usage Factor F_U	Radiation Factor F_R	Load Factor $F_L = F_U F_R$ Elec/Steam
Griddle	0.16	0.45	0.07
Fryer	0.06	0.43	0.03
Convection oven	0.42	0.17	0.07
Charbroiler	0.83	0.29	0.24
Open-top range without oven	0.34	0.46	0.16
Hot-top range			
without oven	0.79	0.47	0.37
with oven	0.59	0.48	0.28
Steam cooker	0.13	0.30	0.04

Sources: Alereza and Breen (1984), Fisher (1998).

Table 4B Hooded Gas Appliance Usage Factors, Radiation Factors, and Load Factors

Appliance	Usage Factor F_U	Radiation Factor F_R	Load Factor $F_L = F_U F_R$ Gas
Griddle	0.25	0.25	0.06
Fryer	0.07	0.35	0.02
Convection oven	0.42	0.20	0.08
Charbroiler	0.62	0.18	0.11
Open-top range without oven	0.34	0.17	0.06

Sources: Alereza and Breen (1984), Fisher (1998).

or the rated hourly input, regardless of the type of energy or fuel used. On average, 34% of the heat may be assumed to be latent and the remaining 66% sensible. Note that cooking appliances ventilated by "ductless" hoods should be treated as unhooded appliances from the perspective of estimating heat gain. In other words, all energy consumed by the appliance and all moisture produced by the cooking process is introduced to the kitchen as a sensible or latent cooling load.

Recommended Heat Gain Values. As an alternative procedure, Table 5 lists recommended rates of heat gain from typical commercial cooking appliances. The data in the "with hood" columns assume installation under a properly designed exhaust hood connected to a mechanical fan exhaust system.

Hospital and Laboratory Equipment

Hospital and laboratory equipment items are major sources of heat gain in conditioned spaces. Care must be taken in evaluating the probability and duration of simultaneous usage when many components are concentrated in one area, such as a laboratory, an operating room, etc. Commonly, heat gain from equipment in a laboratory ranges from 15 to 70 Btu/h·ft^2 or, in laboratories with outdoor exposure, as much as four times the heat gain from all other sources combined.

Medical Equipment. It is more difficult to provide generalized heat gain recommendations for medical equipment than for general office equipment because medical equipment is much more varied in type and in application. Some heat gain testing has been done and can be presented, but the equipment included represents only a small sample of the type of equipment that may be encountered.

The data presented for medical equipment in Table 6 are relevant for portable and bench-top equipment. Medical equipment is very specific and can vary greatly from application to application. The data are presented to provide guidance in only the most general sense. For large equipment, such as MRI, engineers must obtain heat gain from the manufacturer.

Laboratory Equipment. Equipment in laboratories is similar to medical equipment in that it will vary significantly from space to space. Chapter 13 of the 1999 *ASHRAE Handbook—Applications* discusses heat gain from equipment, stating that it may range from 5 to 25 W/ft^2 in highly automated laboratories. Table 7 lists some values for laboratory equipment, but, as is the case for medical equipment, it is for general guidance only. Wilkins and Cook (1999) also examined laboratory equipment heat gains.

Office Equipment

Computers, printers, copiers, calculators, checkwriters, posting machines, etc., can generate 3 to 4 Btu/h·ft^2 for general offices or 6 to 7 Btu/h·ft^2 for purchasing and accounting departments. ASHRAE *Research Project* 822 developed a method to measure the actual heat gain from equipment in buildings and the radiant/convective percentages (Hosni et al. 1998; Jones et al. 1998). This methodology was then incorporated into ASHRAE *Research Project* 1055 and applied to a wide range of equipment (Hosni et al. 1999) as a follow-up to independent research by Wilkins et al. (1991) and Wilkins and McGaffin (1994). Komor (1997) found similar results. Analysis of measured data showed that results for office equipment could be generalized, but results from laboratory and hospital equipment proved too diverse. The following general guidelines for office equipment are a result of these studies.

Nameplate Versus Measured Energy Use. Nameplate data rarely reflect the actual power consumption of office equipment. Actual power consumption of such equipment is assumed equal to the total (radiant plus convective) heat gain, but the ratio of such energy to the nameplate value varies widely. ASHRAE *Research Project* 1055 (Hosni et al. 1999) found that for general office equipment with nameplate power consumption of less than 1000 W, the actual ratio of total heat gain to nameplate ranged from 25% to 50%, but when all tested equipment is considered, the range is broader. Generally, if the nameplate value is the only information known and no actual heat gain data are available for similar equipment, it would be conservative to use 50% of nameplate as heat gain and more nearly correct if 25% of nameplate were used. Much better results can be obtained, however, by considering the heat gain as being predictable based on the type of equipment.

Office equipment is grouped into categories such as computers, monitors, printers, facsimile machines, and copiers, with heat gain results within each group analyzed to establish patterns.

Computers. Based on tests by Hosni et al. (1999) and Wilkins and McGaffin (1994), nameplate values on computers should be ignored when performing cooling load calculations. Table 8 presents typical heat gain values for computers with varying degrees of safety factor.

Monitors. Based on monitors tested by Hosni et al. (1999), heat gain correlates approximately with screen size as

$$q_{mon} = 5S - 20 \qquad (12)$$

where

q_{mon} = heat gain from monitor, W
S = nominal screen size, in.

Wilkins and McGaffin tested ten monitors (13 to 19 in.), finding the average heat gain value to be 60 W. This testing was done in 1992 when DOS was prevalent and the Windows™ operating system was just being introduced. Monitors displaying Windows consumed more power than those displaying DOS. Table 8 tabulates typical values.

Laser Printers. Hosni et al. (1999) found that the power consumed by laser printers, and therefore the heat gain, depended largely on the level of throughput for which the printer was designed. It was observed that smaller printers are used more intermittently and that larger printers may run continuously for longer periods. Table 9 presents data on laser printers.

These data can be applied by taking the value for continuous operation and then applying an appropriate diversity factor. This would likely be most appropriate for larger open office areas. Another approach could be to take the value that most closely matches the expected operation of the printer with no diversity. This may be appropriate when considering a single room or small area.

Copiers. Hosni et al. (1999) also tested five copy machines considered to be of two types, desktop and office (freestanding high-volume copiers). Larger machines used in production environments were not addressed. Table 9 summarizes of the results. It was observed that desktop copiers rarely operated continuously but that office copiers frequently operated continuously for periods of an hour or more.

Miscellaneous Office Equipment. Table 10 presents data on miscellaneous office equipment such as vending machines and mailing equipment.

Diversity. The ratio of the measured peak electrical load at the equipment panels to the sum of the maximum electrical load of each individual item of equipment is the usage diversity. A small, one- or two-person office containing equipment listed in Tables 8 through 10 can be expected to contribute heat gain to the space at the sum of the appropriate listed values. Progressively larger areas with many equipment items will always experience some degree of usage diversity resulting from whatever percentage of such equipment is not in operation at any given time.

Wilkins and McGaffin (1994) measured diversity in 23 areas within five different buildings totaling over 275,000 ft^2. Diversity was found to range between 37 and 78%, with the average (normalized based on area) being 46%. Figure 4 illustrates the relationship between nameplate, the sum of the peaks, and the actual electical load with diversity accounted for, based on the average of the total

Table 5 Recommended Rates of Heat Gain From Typical Commercial Cooking Appliances

		Energy Rate, Btu/h		Recommended Rate of Heat Gain,[a] Btu/h			
				Without Hood			With Hood
Appliance	Size	Rated	Standby	Sensible	Latent	Total	Sensible
Electric, No Hood Required							
Barbeque (pit), per pound of food capacity	80 to 300 lb	136	—	86	50	136	42
Barbeque (pressurized), per pound of food capacity	44 lb	327	—	109	54	163	50
Blender, per quart of capacity	1 to 4 qt	1,550	—	1,000	520	1,520	480
Braising pan, per quart of capacity	108 to 140 qt	360	—	180	95	275	132
Cabinet (large hot holding)	16.2 to 17.3 ft^3	7,100	—	610	340	960	290
Cabinet (large hot serving)	37.4 to 406 ft^3	6,820	—	610	310	920	280
Cabinet (large proofing)	16 to 17 ft^3	693	—	610	310	920	280
Cabinet (small hot holding)	3.2 to 6.4 ft^3	3,070	—	270	140	410	130
Cabinet (very hot holding)	17.3 ft^3	21,000	—	1,880	960	2,830	850
Can opener		580	—	580	—	580	0
Coffee brewer	12 cup/2 burners	5,660	—	3,750	1,910	5,660	1,810
Coffee heater, per boiling burner	1 to 2 burners	2,290	—	1,500	790	2,290	720
Coffee heater, per warming burner	1 to 2 burners	340	—	230	110	340	110
Coffee/hot water boiling urn, per quart of capacity	11.6 qt	390	—	256	132	388	123
Coffee brewing urn (large), per quart of capacity	23 to 40 qt	2,130	—	1,420	710	2,130	680
Coffee brewing urn (small), per quart of capacity	10.6 qt	1,350	—	908	445	1,353	416
Cutter (large)	18 in. bowl	2,560	—	2,560	—	2,560	0
Cutter (small)	14 in. bowl	1,260	—	1,260	—	1,260	0
Cutter and mixer (large)	30 to 48 qt	12,730	—	12,730	—	12730	0
Dishwasher (hood type, chemical sanitizing), per 100 dishes/h	950 to 2000 dishes/h	1,300	—	170	370	540	170
Dishwasher (hood type, water sanitizing), per 100 dishes/h	950 to 2000 dishes/h	1,300	—	190	420	610	190
Dishwasher (conveyor type, chemical sanitizing), per 100 dishes/h	5000 to 9000 dishes/h	1,160	—	140	330	470	150
Dishwasher (conveyor type, water sanitizing), per 100 dishes/h	5000 to 9000 dishes/h	1,160	—	150	370	520	170
Display case (refrigerated), per 10 ft^3 of interior	6 to 67 ft^3	1,540	—	617	0	617	0
Dough roller (large)	2 rollers	5,490	—	5,490	—	5,490	0
Dough roller (small)	1 roller	1,570	—	140	—	140	0
Egg cooker	12 eggs	6,140	—	2,900	1,940	4,850	1,570
Food processor	2.4 qt	1,770	—	1,770	—	1,770	0
Food warmer (infrared bulb), per lamp	1 to 6 bulbs	850	—	850	—	850	850
Food warmer (shelf type), per square foot of surface	3 to 9 ft^2	930	—	740	190	930	260
Food warmer (infrared tube), per foot of length	39 to 53 in.	990	—	990	—	990	990
Food warmer (well type), per cubic foot of well	0.7 to 2.5 ft^3	3,620	—	1,200	610	1,810	580
Freezer (large)	73	4,570	—	1,840	—	1,840	0
Freezer (small)	18	2,760	—	1,090	—	1,090	0
Griddle/grill (large), per square foot of cooking surface	4.6 to 11.8 ft^2	9,200	—	615	343	958	343
Griddle/grill (small), per square foot of cooking surface	2.2 to 4.5 ft^2	8,300	—	545	308	853	298
Hot dog broiler	48 to 56 hot dogs	3,960	—	340	170	510	160
Hot plate (double burner, high speed)		16,720	—	7,810	5,430	13,240	6,240
Hot plate (double burner, stockpot)		13,650	—	6,380	4,440	10,820	5,080
Hot plate (single burner, high speed)		9,550	—	4,470	3,110	7,580	3,550
Hot water urn (large), per quart of capacity	56 qt	416	—	161	52	213	68
Hot water urn (small), per quart of capacity	8 qt	738	—	285	95	380	123
Ice maker (large)	220 lb/day	3,720	—	9,320	—	9,320	0
Ice maker (small)	110 lb/day	2,560	—	6,410	—	6,410	0
Microwave oven (heavy duty, commercial)	0.7 ft^3	8,970	—	8,970	—	8,970	0
Microwave oven (residential type)	1 ft^3	2,050 to 4,780	—	2,050 to 4,780	—	2,050 to 4,780	0
Mixer (large), per quart of capacity	81 qt	94	—	94	—	94	0
Mixer (small), per quart of capacity	12 to 76 qt	48	—	48	—	48	0
Press cooker (hamburger)	300 patties/h	7,510	—	4,950	2,560	7510	2,390
Refrigerator (large), per 10 ft^3 of interior space	25 to 74 ft^3	753	—	300	—	300	0
Refrigerator (small), per 10 ft^3 of interior space	6 to 25 ft^3	1,670	—	665	—	665	0
Rotisserie	300 hamburgers/h	10,920	—	7,200	3,720	10,920	3,480
Serving cart (hot), per cubic foot of well	1.8 to 3.2 ft^3	2,050	—	680	340	1,020	328
Serving drawer (large)	252 to 336 dinner rolls	3,750	—	480	34	510	150
Serving drawer (small)	84 to 168 dinner rolls	2,730	—	340	34	380	110
Skillet (tilting), per quart of capacity	48 to 132 qt	580	—	293	161	454	218
Slicer, per square foot of slicing carriage	0.65 to 0.97 ft^2	680	—	682	—	682	216
Soup cooker, per quart of well	7.4 to 11.6 qt	416	—	142	78	220	68
Steam cooker, per cubic foot of compartment	32 to 64 qt	20,700	—	1,640	1,050	2,690	784
Steam kettle (large), per quart of capacity	80 to 320 qt	300	—	23	16	39	13
Steam kettle (small), per quart of capacity	24 to 48 qt	840	—	68	45	113	32
Syrup warmer, per quart of capacity	11.6 qt	284	—	94	52	146	45

Table 5 Recommended Rates of Heat Gain From Typical Commercial Cooking Appliances (*Concluded*)

		Energy Rate, Btu/h		Recommended Rate of Heat Gain,[a] Btu/h			
				Without Hood			With Hood
Appliance	Size	Rated	Standby	Sensible	Latent	Total	Sensible
Toaster (bun toasts on one side only)	1400 buns/h	5,120	—	2,730	2,420	5,150	1,640
Toaster (large conveyor)	720 slices/h	10,920	—	2,900	2,560	5,460	1,740
Toaster (small conveyor)	360 slices/h	7,170	—	1,910	1,670	3,580	1,160
Toaster (large pop-up)	10 slice	18,080	—	9,590	8,500	18,080	5,800
Toaster (small pop-up)	4 slice	8,430	—	4,470	3,960	8,430	2,700
Waffle iron	75 in^2	5,600	—	2,390	3,210	5,600	1,770
Electric, Exhaust Hood Required							
Broiler (conveyor infrared), per square foot of cooking area	2 to 102 ft^2	19,230	—	—	—	—	3,840
Broiler (single deck infrared), per square foot of broiling area	2.6 to 9.8 ft^2	10,870	—	—	—	—	2,150
Charbroiler, per linear foot of cooking surface	2 to 8 linear ft	11,000	9,300	—	—	—	2,800
Fryer (deep fat)	35 to 50 lb oil	48,000	2,900	—	—	—	1,200
Fryer (pressurized), per pound of fat capacity	13 to 33 lb	1565	—	—	—	—	59
Oven (full-size convection)		41,000	4,600	—	—	—	2,900
Oven (large deck baking with 537 ft^3 decks), per cubic foot of oven space	15 to 46 ft^3	1,670	—	—	—	—	69
Oven (roasting), per cubic foot of oven space	7.8 to 23 ft^3	27,350	—	—	—	—	113
Oven (small convection), per cubic foot of oven space	1.4 to 5.3 ft^3	10,340	—	—	—	—	147
Oven (small deck baking with 272 ft^3 decks), per cubic foot of oven space	7.8 to 23 ft^3	2,760	—	—	—	—	113
Open range top, per 2 element section	2 to 6 elements	14,000	4,600	—	—	—	2,100
Range (hot top/fry top), per square foot of cooking surface	4 to 8 ft^2	7,260	—	—	—	—	2,690
Range (oven section), per cubic foot of oven space	4.2 to 11.3 ft^3	3,940	—	—	—	—	160
Griddle, per linear foot of cooking surface	2 to 8 linear ft	19,500	3,100	—	—	—	1,400
Gas, No Hood Required							
Broiler, per square foot of broiling area	2.7 ft^2	14,800	660[b]	5,310	2,860	8,170	1,220
Cheese melter, per square foot of cooking surface	2.5 to 5.1 ft^2	10,300	660[b]	3,690	1,980	5,670	850
Dishwasher (hood type, chemical sanitizing), per 100 dishes/h	950 to 2,000 dishes/h	1,740	660[b]	510	200	710	230
Dishwasher (hood type, water sanitizing), per 100 dishes/h	950 to 2,000 dishes/h	1,740	660[b]	570	220	790	250
Dishwasher (conveyor type, chemical sanitizing), per 100 dishes/h	5,000 to 9,000 dishes/h	1,370	660[b]	330	70	400	130
Dishwasher (conveyor type, water sanitizing), per 100 dishes/h	5,000 to 9,000 dishes/h	1,370	660[b]	370	80	450	140
Griddle/grill (large), per square foot of cooking surface	4.6 to 11.8 ft^2	17,000	330	1,140	610	1,750	460
Griddle/grill (small), per square foot of cooking surface	2.5 to 4.5 ft^2	14,400	330	970	510	1,480	400
Hot plate	2 burners	19,200	1,325[b]	11,700	3,470	15,200	3,410
Oven (pizza), per square foot of hearth	6.4 to 12.9 ft^2	4,740	660[b]	623	220	843	85
Gas, Exhaust Hood Required							
Braising pan, per quart of capacity	105 to 140 qt	9,840	660[b]	—	—	—	2,430
Broiler, per square foot of broiling area	3.7 to 3.9 ft^2	21,800	530	—	—	—	1,800
Broiler (large conveyor, infrared), per square foot of cooking area/minute	2 to 102 ft^2	51,300	1,990	—	—	—	5,340
Broiler (standard infrared), per square foot of broiling area	2.4 to 9.4 ft^2	1,940	530	—	—	—	1,600
Charbroiler (large), per linear foot of cooking area	2 to 8 linear ft	36,000	22,000	—	—	—	3,800
Fryer (deep fat)	35 to 50 oil cap.	80,000	5,600	—	—	—	1,900
Oven (bake deck), per cubic foot of oven space	5.3 to 16.2 ft^3	7,670	660[b]	—	—	—	140
Oven (convection), full size		70,000	29,400	—	—	—	5,700
Oven (pizza), per square foot of oven hearth	9.3 to 25.8 ft^2	7,240	660[b]	—	—	—	130
Oven (roasting), per cubic foot of oven space	9 to 28 ft^3	4,300	660[b]	—	—	—	77
Oven (twin bake deck), per cubic foot of oven space	11 to 22 ft^3	4,390	660[b]	—	—	—	78
Range (burners), per 2 burner section	2 to 10 burners	33,600	1,325	—	—	—	6,590
Range (hot top or fry top), per square foot of cooking surface	3 to 8 ft^2	11,800	330	—	—	—	3,390
Range (large stock pot)	3 burners	100,000	1,990	—	—	—	19,600
Range (small stock pot)	2 burners	40,000	1,330	—	—	—	7,830
Griddle, per linear foot of cooking surface	2 to 8 linear ft	25,000	6,300				1,600
Range top, open burner (per 2 burner section)	2 to 6 elements	40,000	13,600				2,200
Steam							
Compartment steamer, per pound of food capacity/h	46 to 450 lb	280	—	22	14	36	11
Dishwasher (hood type, chemical sanitizing), per 100 dishes/h	950 to 2,000 dishes/h	3,150	—	880	380	1,260	410
Dishwasher (hood type, water sanitizing), per 100 dishes/h	950 to 2,000 dishes/h	3,150	—	980	420	1,400	450
Dishwasher (conveyor, chemical sanitizing), per 100 dishes/h	5,000 to 9,000 dishes/h	1,180	—	140	330	470	150
Dishwasher (conveyor, water sanitizing), per 100 dishes/h	5,000 to 9,000 dishes/h	1,180	—	150	370	520	170
Steam kettle, per quart of capacity	13 to 32 qt	500	—	39	25	64	19

Sources: Alereza and Breen (1984), Fisher (1998).

[a] *In some cases, heat gain data are given per unit of capacity. In those cases, the heat gain is calculated by: q = (recommended heat gain per unit of capacity) × (capacity)*

[b] Standby input rating is given for entire appliance regardless of size.

Table 6 Recommended Heat Gain from Typical Medical Equipment

Equipment	Nameplate, W	Peak, W	Average, W
Anesthesia system	250	177	166
Blanket warmer	500	504	221
Blood pressure meter	180	33	29
Blood warmer	360	204	114
ECG/RESP	1440	54	50
Electrosurgery	1000	147	109
Endoscope	1688	605	596
Harmonical scalpel	230	60	59
Hysteroscopic pump	180	35	34
Laser sonics	1200	256	229
Optical microscope	330	65	63
Pulse oximeter	72	21	20
Stress treadmill	N/A	198	173
Ultrasound system	1800	1063	1050
Vacuum suction	621	337	302
X-ray system	968		82
X-ray system	1725	534	480
X-ray system	2070		18

Source: Hosni et al. (1999).

Table 7 Recommended Heat Gain from Typical Laboratory Equipment

Equipment	Nameplate, W	Peak, W	Average, W
Analytical balance	7	7	7
Centrifuge	138	89	87
Centrifuge	288	136	132
Centrifuge	5500	1176	730
Electrochemical analyzer	50	45	44
Electrochemical analyzer	100	85	84
Flame photometer	180	107	105
Fluorescent microscope	150	144	143
Fluorescent microscope	200	205	178
Function generator	58	29	29
Incubator	515	461	451
Incubator	600	479	264
Incubator	3125	1335	1222
Orbital shaker	100	16	16
Oscilloscope	72	38	38
Oscilloscope	345	99	97
Rotary evaporator	75	74	73
Rotary evaporator	94	29	28
Spectronics	36	31	31
Spectrophotometer	575	106	104
Spectrophotometer	200	122	121
Spectrophotometer	N/A	127	125
Spectro fluorometer	340	405	395
Thermocycler	1840	965	641
Thermocycler	N/A	233	198
Tissue culture	475	132	46
Tissue culture	2346	1178	1146

Source: Hosni et al. (1999).

area tested. Data on actual diversity can be used as a guide, but diversity varies significantly with occupancy. The proper diversity factor for an office of mail order catalog telephone operators is different from that for an office of sales representatives who travel regularly.

Heat Gain per Unit Area. Wilkins (1998) and Wilkins and Hosni (2000) summarized the recent research on a heat gain per unit area basis. The diversity testing showed that the actual heat gain per unit area, or load factor, ranged from 0.44 to 1.08 W/ft^2, with an average (normalized based on area) of 0.81 W/ft^2. Spaces tested

Table 8 Recommended Heat Gain from Typical Computer Equipment

	Continuous, W	Energy Saver Mode, W
Computers[a]		
Average value	55	20
Conservative value	65	25
Highly conservative value	75	30
Monitors[b]		
Small monitor (13 to 15 in.)	55	0
Medium monitor (16 to 18 in.)	70	0
Large monitor (19 to 20 in.)	80	0

Sources: Hosni et al. (1999), Wilkins and McGaffin (1994).
[a]Based on 386, 486, and Pentium grade.
[b]Typical values for monitors displaying Windows environment.

Table 9 Recommended Heat Gain from Typical Laser Printers and Copiers

	Continuous, W	1 page per min., W	Idle, W
Laser Printers			
Small desktop	130	75	10
Desktop	215	100	35
Small office	320	160	70
Large office	550	275	125
Copiers			
Desktop copier	400	85	20
Office copier	1,100	400	300

Source: Hosni et al. (1999).

Table 10 Recommended Heat Gain from Miscellaneous Office Equipment

Appliance	Maximum Input Rating, W	Recommended Rate of Heat Gain, W
Mail-processing equipment		
Folding machine	125	80
Inserting machine, 3,600 to 6,800 pieces/h	600 to 3,300	390 to 2,150
Labeling machine, 1,500 to 30,000 pieces/h	600 to 6,600	390 to 4,300
Postage meter	230	150
Vending machines		
Cigarette	72	72
Cold food/beverage	1,150 to 1,920	575 to 960
Hot beverage	1,725	862
Snack	240 to 275	240 to 275
Other		
Bar code printer	440	370
Cash registers	60	48
Check processing workstation, 12 pockets	4,800	2,470
Coffee maker, 10 cups	1,500	1,050 W sens., 1,540 Btu/h latent
Microfiche reader	85	85
Microfilm reader	520	520
Microfilm reader/printer	1,150	1,150
Microwave oven, 1 ft^3	600	400
Paper shredder	250 to 3,000	200 to 2,420
Water cooler, 32 qt/h	700	350

Table 11 Recommended Load Factors for Various Types of Offices

Load Density of Office	Load Factor, W/ft²	Description
Light	0.5	Assumes 167 ft²/workstation (6 workstations per 1000 ft²) with computer and monitor at each plus printer and fax. Computer, monitor, and fax diversity 0.67, printer diversity 0.33.
Medium	1	Assumes 125 ft²/workstation (8 workstations per 1000 ft²) with computer and monitor at each plus printer and fax. Computer, monitor, and fax diversity 0.75, printer diversity 0.50.
Medium/ Heavy	1.5	Assumes 100 ft²/workstation (10 workstations per 1000 ft²) with computer and monitor at each plus printer and fax. Computer and monitor diversity 0.75, printer and fax diversity 0.50.
Heavy	2	Assumes 83 ft²/workstation (12 workstations per 1000 ft²) with computer and monitor at each plus printer and fax. Computer and monitor diversity 1.0, printer and fax diversity 0.50.

Source: Wilkins and McGaffin (1994).

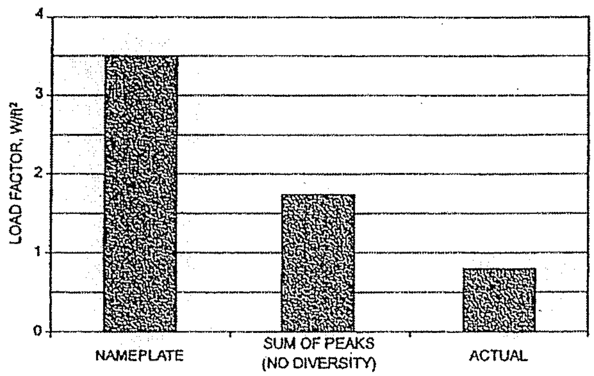

Fig. 4 Office Equipment Load Factor Comparison
(Wilkins and McGaffin 1994)

Table 12 Cooling Load Estimates for Various Office Load Densities

	Number	Each, W	Total, W	Diversity	Load, W
Light Load Density[a]					
Computers	6	55	330	0.67	220
Monitors	6	55	330	0.67	220
Laser printer—small desk top	1	130	130	0.33	43
Fax machine	1	15	15	0.67	10
Total Area Load					494
Recommended equipment load factor = 0.5 W/ft²					
Medium Load Density[a]					
Computers	8	65	520	0.75	390
Monitors	8	70	560	0.75	420
Laser printer—desk	1	215	215	0.5	108
Fax machine	1	15	15	0.75	11
Total Area Load					929
Recommended equipment load factor = 1.0 W/ft²					
Medium/Heavy Load Density[a]					
Computers	10	65	650	1	650
Monitors	10	70	700	1	700
Laser printer—small office	1	320	320	0.5	160
Facsimile machine	1	30	30	0.5	15
Total Area Load					1525
Recommended equipment load factor = 1.5 W/ft²					
Heavy Load Density[a]					
Computers	12	75	900	1	900
Monitors	12	80	960	1	960
Laser printer-small office	1	320	320	0.5	160
Facsimile machine	1	30	30	0.5	15
Total Area Load					2035
Recommended equipment load factor = 2.0 W/ft²					

Source: Wilkins and McGaffin (1994).
[a] See Table 11 for descriptions of load densities.

were fully occupied and highly automated, comprising 21 unique areas in five buildings, with a computer and monitor at every workstation. Table 11 presents a range of load factors with a subjective description of the type of space to which they would apply. Table 12 presents more specific data that can be used to better quantify the amount of equipment in a space and the expected load factor. The medium load density is likely to be appropriate for most standard office spaces. Medium/heavy or heavy load densities may be encountered but can be considered extremely conservative estimates even for densely populated and highly automated spaces.

Radiant Convective Split. Hosni et al. (1999) found that the radiant-convective split for equipment was fairly uniform, the most important differentiating feature being whether or not the equipment had a cooling fan. Table 13 is a summary of those results.

Table 13 Summary of Radiant-Convective Split for Office Equipment

Device	Fan	Radiant	Convective
Computer	Yes	10 to 15%	85 to 90%
Monitor	No	35 to 40%	60 to 65%
Computer and monitor	—	20 to 30%	70 to 80%
Laser printer	Yes	10 to 20%	80 to 90%
Copier	Yes	20 to 25%	75 to 80%
Fax machine	No	30 to 35%	65 to 70%

Source: Hosni et al. (1999).

HEAT GAIN THROUGH FENESTRATION AREAS

The primary weather-related variable influencing the cooling load for a building is solar radiation. The effect of solar radiation is more pronounced and immediate in its impact on exposed nonopaque surfaces. The calculation of solar heat gain and conductive heat transfer through various glazing materials and associated mounting frames, with or without interior and/or exterior shading devices, is discussed in Chapter 30. This chapter covers the application of such data to the overall heat gain evaluation and the conversion of the calculated heat gain into a composite cooling load for the conditioned space. Table 14 includes some useful solar equations.

Fenestration Direct Solar, Diffuse Solar, and Conductive Heat Gains

For fenestration heat gain, use the following equations:

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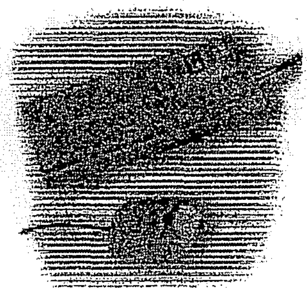


- Saves energy by controlling desktop equipment
- Consists of an eight outlet power strip with surge suppression and a personal occupancy sensor
- 6 outlets on the power strip are controlled by occupancy; 2 outlets uncontrolled
- Power strip has lifetime product warranty and a $25,000 connected equipment warranty

System Information

The Isolé IDP-3050 is an energy saving control system which provides maximum surge and noise suppression. It consists of the eight outlet Power Strip and the Personal Sensor.

Operation

The IDP-3050 functions by turning office power devices on and off based on occupancy. The Personal Sensor connects to the power strip with the attached cable. It automatically turns all connected devices on when the workspace becomes occupied. Connected devices will turn off after the space is unoccupied and the time delay elapses.

Power Strip

The power strip contains 6 outlets controlled by occupancy and 2 outlets which are uncontrolled. Devices to plug into the controlled outlets include computer monitors, task lights, space heaters, fans and other equipment that can be turned off during unoccupied periods. The power strip provides surge and noise suppression with a UL 1449 rating of 330V, 720 Joule rating, and maximum surge amperage of 54,000 Amps. It features a resettable circuit breaker and two LEDs which indicate that the outlet is wired and grounded properly and the surge protection is functioning. The power strip carries a $25,000 connected equipment warranty.

Personal Sensor

The Personal Sensor utilizes Watt Stopper's advanced passive infrared technology to detect occupancy. It features a small, low-profile and attractive appearance. It also features a user-adjustable time delay of 30 seconds to 30 minutes and ASIC technology for superior performance and immunity to RFI and EMI. Installation for the IDP-3050 system is simple and quick and requires no hardwiring.

Applications

The Isolé IDP-3050 is energy saving power strip option for the modern office. Power for most devices in our offices is typically left on throughout the work day regardless of occupancy. The IDP-3050 ends this waste in an economical manner, thus making standard power strips obsolete. Applications include workstations, open office cubicles, offices, and engineering stations.

Power Strip Specifications

- Eight outlets; six controlled, two uncontrolled
- Electrical rating: 120VAC, 15A, 50/60Hz
- 15A dry contact relay
- 15 Amp resettable circuit breaker
- LED indicates correct wiring and grounding
- LED indicates surge protection is functioning
- Eight foot cord, black
- Flat offset plug for wire management
- One uncontrolled outlet and one controlled outlet are wall transformer enabled • UL 1449 rating: 330V
- Circuit: High Energy, Multi-stage hybrid
- Noise filtration 0-25db (94.38%)
- Joule rating: 720 Joules
- Maximum surge amperage: 54,000 Amps
- Protection modes: 330V L-N, 330V L-G, 330V N-G
- Ground protected for safety; will not operate without a grounded outlet
- Response time: instantaneous
- Let through voltage: 140V
- Initial clamping voltage: 200V
- UL & CUL listed
- Lifetime warranty; $25,000 connected equipment warranty

Personal Sensor Specifications

- Advanced passive infrared technology
- Fresnel lens
- Coverage of 120°, up to 300 square feet
- ASIC technology reduces components and enhances reliability
- Adjustable time delay of 30 seconds to 30 minutes
- 9' connector cable
- Supply voltage: 12 VDC
- UL & CUL listed
- 5 year warranty

Product Literature

Cut Sheets
Installation Instructions

0 2

Additional Product Information

Coverage and Mounting
Ordering Information
Unit Controls

Technology

Light Tube Commercial Skylight.

This technology is essentially a 10" to 21" diameter skylight with a prismatic or translucent lens that reflects light captured from a roof opening through a highly specular reflective tube down to the mounted fixture height. When in use, a light tube fixture resembles a metal halide fixture. Uses include grocery, school, retail and other single story commercial buildings.

Estimated Energy Savings – kWh

As noted on the following table, the average savings is calculated to be 361 kWh. Please note, this assumes only 21" and 14" installations.

Brand/size	Lumen Output	Equivalent	KW	kWh
Solatube 21"	13,500-20,500	2-3LF32T8 172W	0.172	481.6
14"	6000-9100	1-3LF32T8	0.086	240.8
10"	3000-4600	3-18W quad	0.054	151.2
		AVERAGE	0.129	361.2

2800 hours per year used for savings calculations. Manufacturers maintain that light overcast conditions still allow for adequate output to offset electric light use.

Summer Peak Savings

There would be a fairly high correlation between sunlight available for the light tube and summer peak demand. Using 90% of the 0.129 KW average shown above results in a demand reduction estimate of 0.116 KW.

Measure Life

Warranty is 10 years. We have assumed a 14 year average life.

Initial One-Time Cost

Do it yourself kits range in price from approximately $300 to $500. Labor to install varies (approx. $200-$400) based on the type of roof deck. Average cost assumed to be on the low end, $500. Unless installations are easy and straightforward we don't feel many customers will utilize this technology. New construction installations are less expensive, and likely more viable.

Any Recurring Costs

Flashing may need occasional maintenance and lens many need cleaning.

Suggested Incentive

California Commercial Skylight program offers $56 for each installed 21" Solatube skylight. California incentives tend to be fairly high on a cost per kWh basis. This technology appears to have a relatively low savings level compared to the cost thus an extensive incentive is difficult to justify. We recommend using $25 for the analysis. We see this as most cost effective in the new construction market where installation costs are lower and planning and design can maximize savings.

Requirements

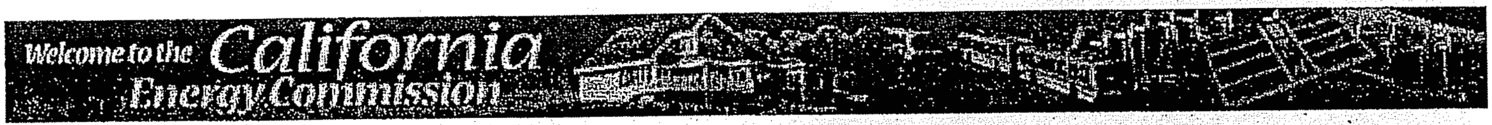
Commercial and Industrial interior spaces that would otherwise require electric lighting between 1-4PM on weekdays during the summer to reduce peak demand.

Existing Energy Standards

There are currently no standards for this technology.

Source of Info

California Energy Commission website www.energy.ca.gov, www.evsolar.com/daylighting.htm, www.elitesolarsystems.com, www.Solatube.com/solamaster.htm , www.dayliteco.com, PG&E Daylighting McDonald's case study, manufacturer's web sites,



Commercial Skylight Incentive Program

WHAT is the Commercial Skylight Incentive Program?

Commercial Skylight Incentive Program has $1 million available to commercial customers who want to lower their peak electricity use for indoor lighting by installing Solatube International's **SolaMaster 21-inch model tubular skylight systems.**

Solatube tubular skylights transfer daylight into building interiors. Light passes through an acrylic dome, down a reflective tubing, and through a diffuser to provide interior lighting directly from sunlight. Photo controls **are added** to switch conventional electric lighting systems off during daytime hours, resulting in lower peak load electricity use.

Customers will receive a price reduction or rebate of $56 per installed skylight. Each skylight can save over 500 kilowatt-hours per year and reduce peak electricity demand by 0.22 KW

WHO & WHAT are Eligible?

Commercial customers throughout California with office, warehouse or other space currently using electricity for lighting between 2 p.m. and 6 p.m. on non-holiday weekdays between June 1 and September 30.

WHAT are the Program Requirements?

- Solatube-trained licensed contractors must perform the installation.
- Lighting controls must be installed with the skylights to ensure that existing lighting operates only when necessary.
- Installation and commissioning of all skylights must be completed by June 1, 2002
- Customers must agree to provide access to their facilities for Energy Commission staff and the Commission's measurement and verification contractor to verify installation and energy savings.
- The incentive may not be combined with any other incentive or rebate offer on the Solatube commercial skylighting system received from a utility rebate or incentive program.

HOW Do I Apply?

Contact Solatube International, Inc. for more information at:
1-888-476-5288 ext398

For product information visit:

http://www.solatube.com/solamaster.htm

MORE Information on Energy Efficiency for Businesses

Check out the Consumer Energy Center at
www.consumerenergycenter.org

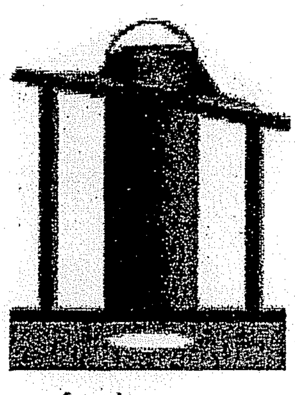
Can't find the information you need online?

E-mail peakload@energy.state.ca.us
Phone: 1-800-555-7794

EV Solar Products
2655 N. Highway 89, Chino Valley, AZ 86323
ph: 928-636-2201 fax: 928-636-1664
email: info@evsolar.com

Tubular Skylights

Natural Light



Tubular Skylights are an easy way to add light to dark areas of your home. In addition to the free daytime operating costs, the Natural Light tubular skylights do not contribute to heat loss or gain, unlike standard framed-in skylights. As a bonus, tubular skylights often qualify for local tax credits as an energy conservation device.
These units are easily installed by the homeowner, or we can arrange installation in the tri-city area.
All kits include dome, stress collar, roof jack, 4' light pipe, trim ring, diffuser and hardware kit. All sizes except the 21" kit comes with either a flat for slanted roof jack. The 21" kit comes with a flat roof jack only. The diffuser is available in soft white or prismatic, please specify at the time of order.

Options:
Evening Light Kit - In instances where a room is too small to have both a skylight and light fixture, Natural Light has a solution. Natural light has two light kits available that add either an incandescent or fluorescent bulb inside the light tube and wired to the wall switch.
Integrated Exhaust System - The bathroom is one of the most popular rooms for added light. However, large amounts of warm moist air can be an issue. Natural light has developed an integrated skylight exhaust system system that once again combines two functions in one. The Super Vent Fan (SVF) is capable of exhausting 125 CFM.

10" Kit	$202.00
2' Extension pipe	$27.00
13" Kit	$256.00
2' Extension pipe	$29.00
18" Kit	$372.00
2' Extension pipe	$45.00
21" Kit	$480.00
2' Extension pipe	$58.00

Light Kit	$25.00
Light Kit - Fluorescent	$87.00
Super Vent Fan Kit	$260.00

All prices subject to change without notice.
If you would like to place an order please e-mail us or call 928-636-2201. We accept all major credit cards.

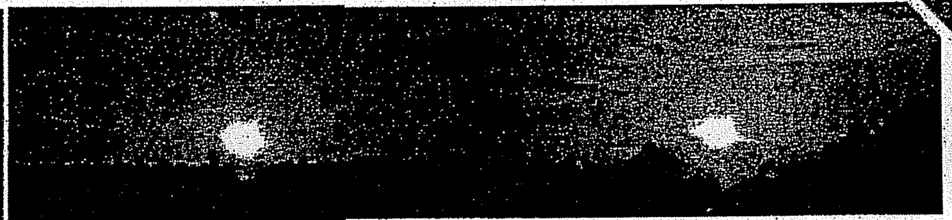
Return to Top of Page

Return to Pricing Menu

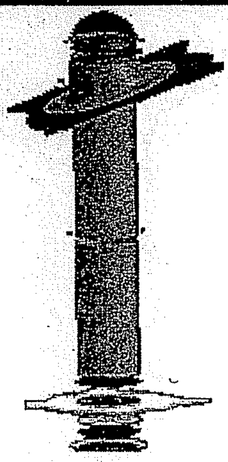
Return to Main Menu

E-mail EV Solar

Updated June 25, 2002



Home About Us Products Residential Commercial Dealer Info Contact



Elite Solar Systems
Tubular Skylights
& Attic Fans
310 E. Comstock Dr.
Chandler, AZ 85225
Phone 480.635.9748
Toll Free:
866-772-5418
Fax 480.635.9767

ROC #170005

Products

One piece aluminum flashing specially designed to fit flat or pitched roofs,with shingle,tile or foam coverings,etc...

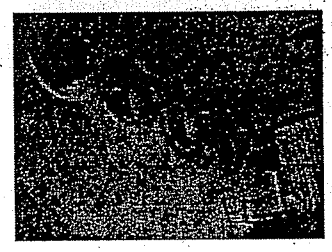
We offer a great variety of sizes for your residential, commercial and industrial needs. We recommend 10"-13" or 18" sizes for houses with flat or pitched roofs and these sizes plus 21" and 24" for commercial and industrial buildings with flat roofs.

10" Tubular skylight perfect for laundry rooms which is available with a 42 watt flourescent light kit or vent.

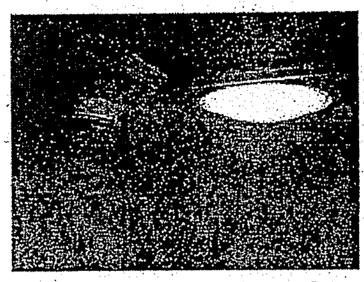
We provide a aluminum skirt with a tile installation for extra protection on leakage, where the aluminum conforms with the tile.

Examples

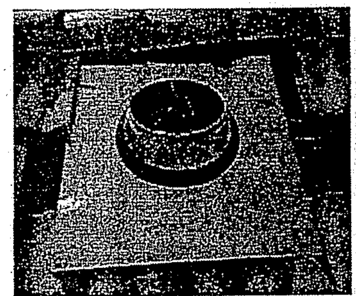
Flashing



10"-13"-18"-21" & 24" Dia.



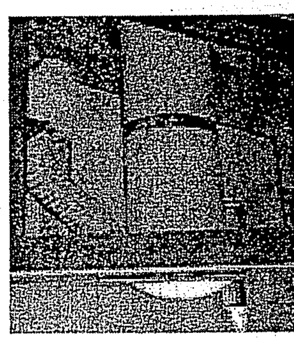
10" perfect for laundry rooms



Aluminum skirt w/EPDM rubber

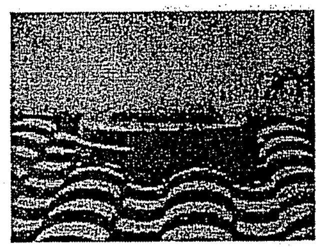
The Elite 3 in 1

Skylight for solar daylighting, light kit for night use and powerful ventillator. It will eliminate extra fixtures in the ceiling. Excellent for bathrooms and laundry rooms, available only with 10" skylight.



3 in 1 unit

We also offer a specially designed Solar Powered Attic Fan. This product will also contribute significantly in lowering your electric bill by pulling hot and humid air from the attic and will stretch the lifetime of your air conditioning.



Elite Solar Powered Attic Fan

This Solar Powered Fan can also be retrofited to ventilate the garage. It will remove hot and humid air in the warm seasons as well as any harmful fumes caused by automobiles or stored chemicals year round.

Elite Solar Powered Garage Vent

A very appealing look. All our ceiling and decorative rings are made from aluminum and powder coated.
ALL ALUMINUM COMPONENTS, FLASHINGS, COVERS, HOUSINGS, COWLINGS AND RINGS.

White domed diffuser to soften the sunlight in any place of your home.

DO IT YOURSELF KIT
10" Tubular Skylight Kit - $159.00
13" Tubular Skylight Kit - $195.00
18" Tubular Skylight Kit - $295.00
21" Tubular Skylight Kit - $345.00
24" Tubular Skylight Kit - $445.00

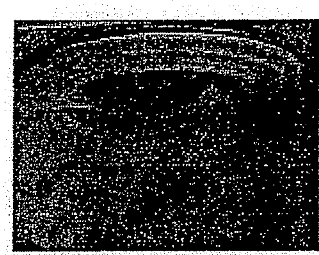
Solar Powered Attic Fan - $349.00
Solar Powered Garage Ventilator - $395.00

Each Kit Comes with 4 Feet of Light Tube
Made in the USA

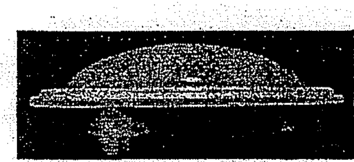
Approximate Coverage Area for Tubular Skylights.
10" Approx. 150 sq. ft
13" Approx. 250 sq. ft
18" Approx. 400 sq. ft
21" Approx. 500 sq. ft
24" Approx. 600 sq. ft

310 E. Comstock Dr. Chandler, AZ. 85225
Phone: 480-635-9748
Fax: 480-635-9767

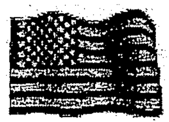
CALL FOR WHOLESALE PRICING



Decorative Ceiling Rings



White Domed Diffuser



MADE IN USA

innovative natural lighting

Your #1 Solatube Source

SOLATUBE. THE MIRACLE SKYLIGHT®

Are You Considering Another Brand of Tubular Skylight?

Click Here First!

Home | **10" Solatube** | **14" Solatube** | **21" SolaMaster** | **SolarStar** | **Product Specs** | **Contact Us**

D-I-Y Kit Pricing

10" & 14" Unit Basic Kits include:

Pre-assembled top and bottom adjustable-angle tubes.
Ceiling diffuser, impact resistant dome, metal flashing, seals, fasteners, instructions.

Solatube makes a flashing for every type of roof.

All flashings are one-piece fabrications.
Ten Year warranty on all Solatube skylight components.

SOLATUBE DIY PRICES INCLUDE SHIPPING/HANDLING IN THE CONTINENTAL U.S.A.

10" DIY Kit: $329.00*

Includes 10" Basic Kit, 4' INFINITY® tubing.
Standard Flashing options: Pitched; 4" tall flat; 6" tall flat.

10" Extension Tubing:

To minimize cost and waste, extension tubing is available in two lengths.

10" - "C" Tubes = 16" length, per section.	$28.00*
10" - "D" Tubes = 24" length, per section.	$45.00*

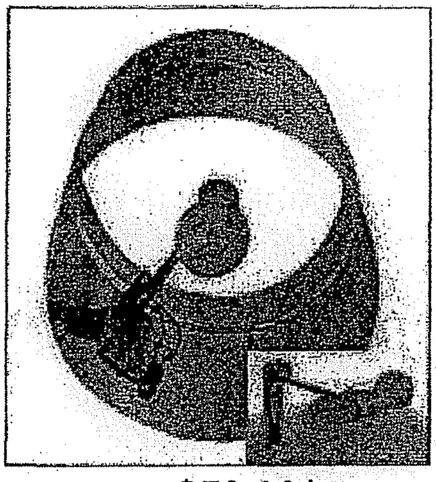
14" DIY Kit: $439.00*

Includes 14" Basic Kit, 4' INFINITY® tubing.
Standard Flashing options: Pitched; 4" tall flat; 6" tall flat.

14" Extension Tubing:

To minimize cost and waste, extension tubing is available in two lengths.

14" - "C" Tubes = 16" length, per section.	$32.00*
14" - "D" Tubes = 24" length, per section.	$55.00*



Optional Light Kits:

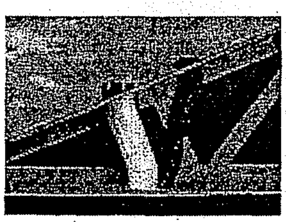
Solatube Light Kits are approved by Underwriter Laboratories®. Designed exclusively for Solatube skylights, and are not approved for any other purpose. Three year warranty. <u>Bulbs not included.</u>
INL installers are not Licensed Electricians, Electrical service is the responsibility of homeowner.

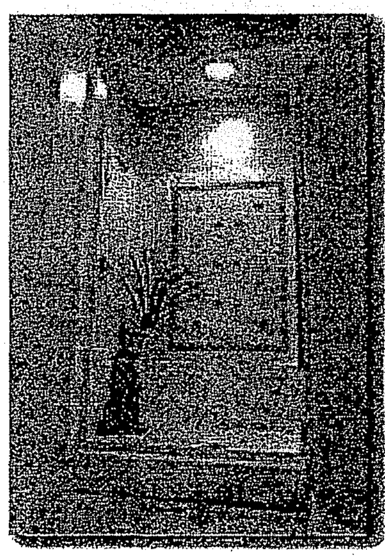
10" Light Kit: <u>$70.00</u>*
Incandescent or fluorescent.
14" Light Kit: <u>$80.00</u>*
Incandescent or fluorescent.
Energy-efficient, 26 watt CF bulbs. <u>$21.00</u>*

Optional Ventilation Kit:

<u>$209.00</u>*

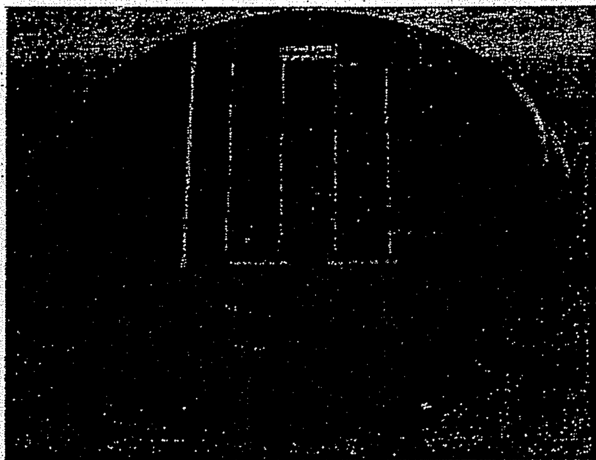
Available for 10" unit only, and may be combined with a Light Kit.
INL installers not Licensed Electricians, service Homeowner responsibility.
Underwriter Laboratories® approved.
Five year Electrical component warranty.
Ten Year Warranty on all other components.
Unit has an attractive, low-profile ventilation grill.
Fan motor moves up to 110 cubic feet of air per minute.
Venturi design maximizes airflow and prevents back draft.
Quiet, remote mounted fan ensures vibration free operation.
Optional Roof Vent Cap has a protective screen to keep insects out.

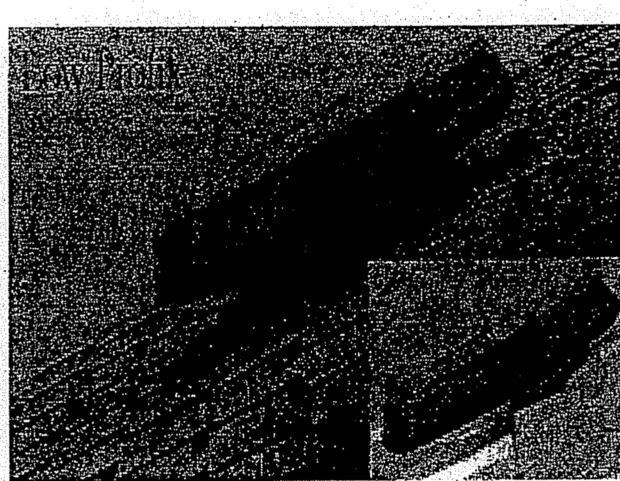




*Sales tax may be extra. Prices Are Subject to Change Without Notice.

install.





Includes: 1 - Pre-assembled unit, fasteners, sealant, instructions. For more information on SOLAR STAR, click here!

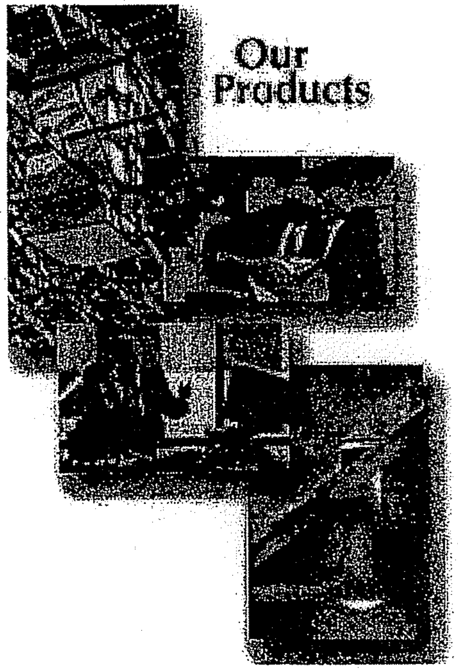
SOLAR. The Natural Choice. Clean, Dependable, and Free.

INNOVATIVE NATURAL LIGHTING

817 551 0998

Daylite Natural Lighting Technologies "Let There Be Light"

THE PREMIER PROVIDER OF NATURAL LIGHTING SOLUTIONS



DayLite™ 8" & 12" Solar Tube

Fill the room with healthy, natural light. And,save energy, which will also save you money!

The Daylite Tube is a highly reflective, cylindrical skylight, that runs from the roof down into a room providing the illuminance of full spectrum lighting. Sunlight enters the tube through a clear acrylic dome. The inner prismatic lens ("fly-eye") captures the light from all angles and collimates it down the reflective tube, to be evenly spread through out the room via a second prismatic diffuser lens.

On sunny days, the Daylite Tube can provide the equivalence of 738 Watts of incandescent light. Even on cloudy days, the Daylite Tube can provide 100 to 180 watts of illuminance.

Tap in to the free light source. Effective use of our most natural energy resource on this planet, the sun, ensures there is less depletion of the ozone layer and prevents air pollution.

Features

- A factory sealed, double dome on the roof providing complete isolation from external weather conditions.
- The dome "fly-eye" lens and lower diffuser lens are multi-faceted prismatic moldings that trap a second layer of air for additional isolation.
- The tube material is Aluminum, the internal finish is a highly reflective