TASK 4.7

PROVIDE TECHNICAL FOUNDATION FOR MARKET TRANSFORMATION GROUPS TO INCREASE PENETRATION OF AUTOMATIC SHUTOFF CONTROLS

Background

Automatic shutoff lighting controls consist of two main technologies: occupancy sensors and timeclock devices. Occupancy sensors are designed to monitor small areas but can be linked together[19] to control the lights in a large area. Due to their intrinsically small area of influence, occupancy sensors are valuable for controlling small spaces (private offices, restrooms) or for spaces that tend to be used periodically (storage closets, warehouse aisles). Manual controls or time clocks may be a more cost-effective automatic shutoff technology for large spaces (open plan offices) or spaces where the pattern of use is very regimented (classrooms, state offices),.

In remodeling or retrofit applications, timeclocks are usually impractical due to the need to provide extensive rewiring and/or local override switches. In these cases, occupancy sensors remain a viable option for reducing wasted lighting energy use.

Advice from Steering Committee members in December 2001 indicated that the market for occupancy sensors in new construction is successfully transformed in states with progressive energy codes such as California. However, feedback from the subsequent industry roundtable in February 2002 indicated that energy codes in much of the nation lag behind those of the western states, such that new construction is still an important area for consideration of automatic shutoff controls.

The roundtable group indicated that market transformation groups lack credible support to predict how much energy occupancy sensors will save. Market transformation experts suggested the need for a review of available literature about the effectiveness of occupancy sensors. They saw less need for a similar review of literature regarding time clock effectiveness. Based on this advice, the LRC focused on identifying expected savings percentages from occupancy sensors.

[19] One occupancy sensor controls a much smaller area than a standard electrical branch circuit. When multiple occupancy sensors must be connected to control a larger circuit, timeclocks may be more cost-effective than tens of occupancy sensors.

Proposed Estimate of Energy Savings

The LRC consulted its extensive resource collection to compile a group of 26 case studies and claims by manufacturers regarding the effectiveness of occupancy sensor technologies. We organized the data in different ways in the various studies, often by specific room type (restrooms, hallways, coffee break rooms, conference rooms). We reviewed the literature and organized studies into broader occupancy categories based upon private ("owned") vs. shared and scheduled vs. sporadic:

- Private ("Owned") Spaces (such as single-person offices or spaces in which the user takes "ownership")
- Shared Spaces, Scheduled use (such as classrooms)
- Shared Spaces, Sporadically used (such as public spaces, open-plan offices, corridors, bathrooms, storage rooms)

Private ("Owned"), scheduled occupancy was not a legitimate category.

For private offices, all data were averaged leading to an average savings of 31.7%. This average represents a wide range of hours of use, so we also examined the percentage of energy savings in those studies that were based upon documented "core hours" between 7.5 to 10 hours per day. This analysis yielded a lower average energy savings of 26%, as expected because the former analysis was dominated by studies using longer hours of use as a base line. This latter percentage (26%) is perhaps a better estimate of potential energy savings from occupancy sensors because, for buildings showing wasted energy use outside the core hours, other technologies such as time clocks are usually more cost effective than occupancy sensors. We recommend 25% as the best estimate of energy savings for private offices with sporadic use.

For shared spaces that are only used sporadically, the average savings was 40.8%. Again, there was a wide range of hours of use, but it seems inappropriate to base energy savings on "core hours" (7.5 to 10 hours per day) because hallways, stairs, etc. can be used at any time day or night. Therefore, we recommend 40% energy savings as the best estimate for shared, sporadically occupied spaces. Note, however, that some spaces should be illuminated without occupancy if lighting is used to signal potential occupants that a business is open or if the lights being on provides occupants with a sense of security or safety.

For shared, scheduled spaces, in particular classrooms, it is often difficult to ascertain the hours of use. Classrooms are used not only for teaching during the day, but also for community activities during the night. Often more than one teacher uses the space but does not "own" the classroom. Since these spaces are sporadically used and do not have a clear "owner," occupancy sensors are a good choice for reducing wasted lighting energy. The average energy savings was 31.7%. We recommend 30% energy savings as the best of estimate for shared, scheduled, spaces. Note, however, that one study of teacher "owned" classrooms reviewed for this task showed that more energy waste due to the time delays on the occupancy sensors.

Consequently, the specifier must have a clear understanding of classroom use before applying occupancy sensors to reduce wasted energy.

Percent Savings from Occupancy Sensors
(Mean Values)

	Private ("Owned")	Shared
Sporadically Use:	25	40
Scheduled Use:		30

Table 1 - Recommended values for the three types of spaces.

Shared, Sporadically Use

	Percent Energy Savings		
Source #	**High**	**Low**	**Mean**
(1)	75	20	48.2
(2)	35	35	35.0
(3)	90	20	49.0
(4)	70	15	45.0
(7)	55	13	35.6
(9)	36	36	36.0
(10)	55	55	55.0
(10)	45	45	45.0
(10)	17	17	17.0
(11)	50	50	50.0
(11)	41	33	37.0
(14)	14.4	8.6	9.9
(15)	75	25	42.4
(17)	48	11	24.3
(19)	42	28	35.0
(20)	38	36	37.0
(42)	26	26	26.0
(42)	30	30	30.0
(42)	55	55	55.0
(43)	60	30	46.0
(44)	90	48	66.0
(45)	90	30	53.3
(46)	90	40	60.1
mean			40.8

Table 2 - High, low and mean percent of energy savings for shared spaces, sporadically used based on literature review

Private ("Owned"), Sporadically Use

	Percent Energy Savings		
Source #	**High**	**Low**	**Mean**
(1)	50	25	37.5
(2)	45	45	45.0
(3)	50	13	31.5
(4)	31	30	30.5
(5)	19	7	12.0
(6)	26	20	23.0
(7)	22	20	21.0
(10)	27	27	27.0
(12)	20	14	16.8
(13)	43	43	43.0
(16)	45	45	45.0
(17)	23	9	16.0
(19)	26	26	26.0
(43)	30	30	30.0
(44)	45	45	45.0
(45)	55	40	47.5
(46)	55	25	40.0
Mean			31.6

Table 3 - High, low and mean percent of energy savings for private ("owned"), sporadically use spaces based on literature review

Shared, Scheduled Use

	Percent Energy Savings		
Source #	**High**	**Low**	**Mean**
(2)	25	25	25.0
(3)	46	40	43.0
(4)	38	23	30.5
(5)	11	11	10.8
(17)	20	17	18.5
(18)	13	30	21.5
(40)	30	30	30.0
(41)	50	10	30.0
(44)	46	40	42.9
(45)	40	30	35.0
(46)	61	61	61.0
mean			31.7

Table 4 - High, low and mean percent of energy savings for shared spaces, scheduled use based on literature review

Sources:	
1	Advance Lighting Guidelines, California Energy Commission 1993
2	Advance Lighting Guidelines, California Energy Commission 2001
3	E Source Tech Update TU-93-8 Occupancy Sensors: Promises and Pitfalls 1999
4	EPRI "Occupancy Sensors: Positive On/off lighting control" 1992 RPT00374
5	Floyd, David B; Parker, Danny S.; Sherwin, John R.; "Measured Field Performance and Energy Savings of Occupancy Sensors: Three Case Studies" FL Energy Ctr on-line publication
6	Jennings et al "Comparison of Control Options in an advanced Ltg Controls Testbed" Proceedings IES 1999 (SF Federal Bldg)
7	Richman et al "Field Analysis of Occupancy Sensor Operation: Parameters Affecting Lighting Energy Savings" JIES96
8	Energy User News, Ambion building article, "Occupancy Sensor Retrofit to Earn 1-yr Payback" Sept 97
9	Nilsson, Erik Adelaide Lunch room"Energy-Efficient Ltg in Commercial Bldgs" CADDET 201517 (1985 case study)
10	Bohrer, James "Case Study on Occupant Sensors as an Office Lighting Control Strategy" Seattle City Light '92 RPT00315
11	Johnson, Karl F. "Keys to Successful Lighting Control Applications" New York, Illuminating Engineering Society of North America. 8-5-1996. Ref Type: Conference Proceeding1996 pp800-811
12	Pigg, Scott; Eilers, Mark; Reed, John; "Behavioral Aspects of Lighting andOccupancy Sensors in Private Offices: A Case Study of a University Office Building" ACEEE 1996
13	Maniccia,D., Rutledge,B., Rea,M.S., and Morrow,W. "Occupant use of manual lighting controls in private offices." Journal of the Illuminating Engineering Society 28, no. 2 (1999): 42-56.
14	Jennings, Judith; Colak, Nesrin; Rubinstein, Francis; "Occupancy and Time-based Lighting Controls in Open Offices" Journal IES, Summer 2002
15	Kaiser/EPRI92 (See Reference #4)
16	Chevron/EPRI92 (See Reference #4)
17	VonNeida, Bill; Maniccia, Dorene; Tweed, Allan; "An Analysis of the Energy and Cost Savings of Occupancy Snesors for Commercial Lighting Systems" 100764
18	Maniccia,D. "NLPIP Specifier reports: Occupancy sensors". 20. 1992. Troy, NY, Rensselaer Polytechnic Institute. Specifier Reports.
19	Figueiro,M.G., Rea,M.S., Rea,A.C., and Stevens,R.G. "Daylight and productivity - A field study". 2002. Washington, DC, American Council for an Energy-Efficient Economy. 2002.
20	Rea,M.S. and Jaekel,R.R. "Monitoring occupancy and light operation." Lighting Research & Technology 19, no. 2 (1987): 45-49.
	Manufacturer Claims
40	Sensorswitch. Middlesx Community College case study
41	Wattstopper general claims
42	Wattstopper Case studies
43	Mytech general claims
44	Novitas Case studies
45	Novitas General claims
46	Leviton general claims

Table 5 – Sources used to calculate proposed estimate of energy savings