MICRO-MANAGEMENT OF LIGHTING CONTROLS PROJECTS

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ABSTRACT

A common lighting project is to evaluate a block of rooms for savings and payback from the use of photocells or occupancy sensors. The designer counts the fixtures to be controlled, calculates the watts used and then the expected savings. If the payback is not agreeable to the owner, the entire project is abandoned. This paper introduces a new computer-aided approach that permits the designer greater flexibility in the analysis of controls and promises a higher level of savings for any given facility, thus a shorter payback.

The computer program first prompts for the data on all the rooms in a facility, including occupied hours at present and actual hours per week the lights are required. The routine then calculates the savings and payback for every room and sorts them in descending order of savings. The designer can target only those zones with the highest potential savings so limited funds can be put to best use. The program has a full range of data entry forms and reports that output the data.

INTRODUCTION

The advent of inexpensive control devices has made it possible to realize considerable savings from the reduction of electricity spent on lighting. These controls turn off the lighting in a room or area when it is not occupied. The sensors can operate on the basis of sound, heat or light detection or a combination thereof. The sensitivity can be varied to suit the circumstances or the use of the space.

Lighting control devices are reasonably priced, dependable and available in attractive packaging. The savings can be considerable. Industrial uses of lighting controls can reduce the hourly electricity use, which is billed according to the kilowatt-hours used as well as the "demand rate". This is the extra fee billed for electricity spent during peak demand periods, usually the regular business hours. Since lights contribute heat to a space, controls also reduce the cooling load of a building. This translates into additional savings.

Each sensor type has an ideal application. The selection is primarily governed by the function of the area. The choice of rooms to be considered for controls, however, is based on economics alone. Most energy auditors select a block of rooms for controls, and fund the project based on a favorable payback. Another approach is to analyze each area individually and install the equipment in those areas with the highest individual payback. This permits many interrelated factors to be considered so that the controls accomplish the maximum possible savings.

OPTIMIZATION

The first task for the building survey is to determine the rooms to be considered for controls. There are several circumstances which the experienced designer perceives as energy saving opportunities.

1. DAYLIGHTING - Rooms with outside windows can benefit from the natural light. Small offices can extinguish the artificial lights completely, while large areas can switch the outside perimeter lamps separately.

2. MAINTENANCE - Mechanical rooms and maintenance facilities are used daily, but seldom occupied for the entire day. As a result lights are left on many hours when they are not needed.

3. LOW USE - Restrooms, lounges and conference rooms are places that see random use throughout the day, with long periods of no occupancy. A good example is a school between class breaks, when the halls and other public areas are virtually empty.

Each of these opportunities reduces use of lights during the peak use period. This is a double jeopardy time, when the utility bills are for total electricity used plus a demand charge. The latter has a significant impact on the savings calculations, so it is helpful to focus the room search on areas with occasional occupancy schedules during regular business hours.

The investigation need not be too conscientious at this point. That is, if there is doubt a room would benefit from lighting controls it should be included in the analysis. The collection and input of data is not time consuming, and adding a few extra rooms will not increase the burden of calculations since they are all performed by the computer anyway. The worst that can happen is that the payback for a room is excessive, so that installation of controls there will have to wait for electricity or equipment costs to drop.

PLAN WORK

The program first prompts for data that is specific to the entire facility.

1.	Project name
2.	Job number
3.	Electric rate - kwh
4.	Demand electric rate - kw
5.	Labor costs

If the engineering staff at the facility will be installing the equipment the labor can be listed as zero. This will improve the project payback.

The next phase of the analysis is performed using a set of blueprints of the building showing the room data, fixture data and window area. The information on each room or area that has the potential to benefit from lighting controls is entered into the program.

1.	Room - number
2.	Room - name
3.	Room - function
4.	Fixture - type
5.	Fixture - quantity
6.	Sensor - type
7.	Sensor - quantity
8.	Windows - area

The "sensor type" is specific to the function of the individual room, according to the general guidelines as follows:

Offices	Infra-red
Restrooms	Infra-red
Mechanical Rooms	Ultra-sound
Rooms with daylight	Dual technology

In general the passive infra-red (PIR) sensors are the least expensive, so they should be the preferred choice for any room with a clear view of the occupied space from the sensor location. Otherwise an ultra-sound device is called for. Rooms with daylighting available should have dual technology devices (DT) i.e. with infrared, ultrasonic and light level detection.

The size and dimensions of the rooms affects the quantity of sensors, which have a limited range. If in doubt, an extra sensor should be specified. Most have a variable sensitivity that can be adjusted to accommodate a space smaller than the design area. It is best to over-estimate equipment requirements, so that a realistic idea of cost can be obtained for the payback analysis.

SITE SURVEY

The next part of the controls audit requires several visits to the building at different times of the day to observe the status of lights in the rooms designated for controls evaluation. This will help to determine the next three factors.

1.	Lighting - existing hours
2.	Lighting - new hours
3.	Lighting - peak hours

The total of the hours lights are expected to be on is the sum of items two and three, with peak hours occurring during the regular business day. Input on these values can be obtained from the engineering staff. The frequency of lamp replacement is a relative indication of the rate of space use.

COST ANALYSIS

The next task is to provide information on the watts used by each fixture used on the premises. These are keyed to an alphanumeric abbreviation used in the room data entry form.

1. Fixture - type abbreviation
2. Fixture - watts

The same is done for the controls equipment, to provide the data to calculate the cost of installation. The program retains both the fixture and sensor data for subsequent building studies.

1. Sensor - type, abbreviation
2. Sensor - cost
3. Sensor - labor, hours

The program now has all the information needed to make a complete evaluation.

THE CALCULATIONS

Each room is evaluated individually. The estimated lighting watts, old, and new operating hours are used to determine an estimated savings:

A. watts * (old hours - new hours) * $/kwh * 52 wks

This is the savings to be expected from the hourly electricity usage rate. Additional savings are possible due to a reduction in peak demand charge. This is an hours/day quantity, calculated as follows:

watts * $/kw * 12 months

There will be additional savings from reduction in the cooling load. This is calculated by an abbreviated method.

B. $ = kwh * 3.413 * SCF/EER = kwh * 0.66 * $/kwh

Kwh = reduction in lighting wattage
SCF = seasonal cooling factor= 0.27
EER = cooling equipment efficiency = 1.39

A penalty is incurred during the heating season because the heat created by the lighting must be replaced by the HVAC system. This deduction is calculated by the abbreviated method also:

C. Htg. Loss = kwh * 3413 * SHF * Eff * $/MCF/(1030000 * .70)
= (kwh * $/MCF)/978

Kwh = reduction in lighting wattage
SHF = Seasonal Heating Factor = 0.27
Eff = Heating Equipment efficiency = 0.8

The electricity savings has two components: direct savings due to lower usage and reduced cooling load. (The heating difference is a cost penalty.)

System	Compressor Only		Compressor + Aux.	
	KW/Ton	(EER)	KW/Ton	(EER)
Window Units	1.46	8.22	1.78	6.74
Through-the-Wall	1.64	7.32	1.94	6.19
Central Air-Cool	1.71	7.03	1.85	6.50
Central Cooling Plants				
3 to 25 Tons	1.20	10.00	1.40	8.57
25 to 100 Tons	1.18	10.17	1.39	8.63
25 to 100 Tons	0.94	12.77	1.08	11.11
Over 100 Tons	0.79	15.19	0.99	12.12

Table 1: Air Conditioning EER.

Heating Plant Type	Seasonal Efficiency %
Gas Furnace	60 - 80
Oil-fired Boiler	60 - 70
Gas-fired Boiler	65 - 75
Steam Converter	90 - 95
Electric Resistance Boiler	95 - 100
Electric Resistance Strip Heaters	100
Water Loop Heat Pumps	140 - 200
Air Source Heat Pumps	175 - 250
Water Source Heat Pumps	250 - 300

Table 2: Heating System Efficiencies.

Lights Controlled During Daytime FACTOR = .1700
Lights Controlled over 24-Hour Period = .2700

Table 3: Seasonal Heating and Cooling Factors.

These savings are then divided into the cost for each installation.

$$\text{Payback} = \text{cost/savings} \qquad (5)$$

This gives the number of years required to pay for the project from the energy savings.

The final task of the software is to sort all of the projects by payback. Based on its ranking, the designer can select the best sites so that his client will obtain the most for the money spent.

CONSIDERATIONS

The designer should inquire if the building owner expects to perform any lighting conservation projects in the spaces targeted to receive controls. These include incandescent-to-fluorescent lamp conversion, re-lamping, installation of reflective inserts and de-lamping. All of these will reduce the savings for a controls project and should be taken into account before determining the controls project payback.

Another point of contention can be the determination of hours of use, which is a very judgmental task at best. One approach is to estimate the hour for each room individually, making a separate estimate based on all the information available. Then sort the rooms by task - e.g. tally all the business offices - and average the hours, using this normalized valve for all the rooms of this type.

Finally there is the problem of accounting for the time delay of the sensors. Typically there is a five minute "fuse" that will keep the fixture lit after a cessation of activity in its zone. This will increase the hours the lights are operating. An approximation of its affect can be included in the calculations by multiplying the after-project hours by a factor of 0.8. This will result in a more conservative estimate of savings.

CONCLUSION

This report has described a general approach to the installation of lighting controls in a facility with a variety of uses and occupancy schedules. This plan is typical of that followed by the energy analyst, with the added benefit of using the computer to study each individual room and to calculate individual paybacks. Upon completion of the analysis the designer can then select the best areas to target for the most effective use of limited funds.

References

Simplified ECRM CalculationSimp Calc: Manual, Governor's Energy Office, State of Texas