Profitability of Switching off Fluorescent Lamps: TAKE-A-BREAK

EINO TETRI
Helsinki University of Technology
Lighting Laboratory

ABSTRACT

Turning off regular incandescent lamps when not needed is always profitable. With fluorescent lamps the case is different since turning off the lights shortens the lamp life. Take a Break is a software application for calculating the profitability of turning off fluorescent lamps.

Excluding the replacement expenses, turning off fluorescent lamps becomes economically profitable even for a few minutes' breaks. When the expenses of replacing lamps are included and assuming that the heat generated from the lamps can be utilized for heating, the break needs to exceed ten minutes in order to make the turning off the lights profitable.

However, the input data will vary from case to case. Therefore, the idea is that everyone should calculate the profitability of switching off fluorescent lamps for themselves.

INTRODUCTION

Illumination uses about 10% of the total electricity consumption in Finland. Switching off the lights when leaving a room saves electricity, but shortens the lamp life. Shortened lamp life increases lamp and relamping costs. Also the decrease in lighting electricity can increase heating energy. Therefore it is not possible to give an exact answer to the question, whether or not to switch off the lighting during breaks.

Because of many different input values, the calculations of the profitability of switching off fluorescent lamps were realised by a spreadsheet calculation program or Excel. With the Excel-program it is possible to calculate the profitability in different cases. The name of the program is Take a Break.

The initial values that affect the profitability are the number of switching-offs per day and the switch-off time. With conventional ballast the lamp life is shortened more than with electronic ballast, especially with short burning cycles. Lamp price, interest rate and relamping costs have an effect on both lamp and relamping costs. In some cases the switching off increases the need for heating. In the spreadsheet it is possible to give different values for the heating and electricity energy prices.

The calculated values are the total power consumption of the installation and the annual burning time. Lamp life is given both in switching-off use and without switching. The use of electricity and heat is given and the saved energy due to switching off the lamps. The program also calculates the energy, lamp and relamping costs in switching use and without switching during one year.

INPUT DATA

Table 1 shows the input data. The user of the program should give the values that are in the shadowed column. In the B column the different number of switch-offs per day and different switch-off times can be given.

First there is lamp wattage, which is normally 36W or 58W. The ballast has an effect on the lamp life, especially with short burning cycles, and on the total energy consumption. In Figure 1 there is lamp life with different burning cycles and ballasts. A lamp reaches its nominal lamp life with magnetic ballast when the burning cycle is three hours. If the ballast is electronic, it can use warm start or cold start. With warm start the lamp life is 107 % and with cold start 90% when the burning cycle is three hours. (Meyer, Nienhuis 1988) (Cayless, Marsden 1983) (Rea

Table 1. Input data for TAKE-A-BREAK program.

ROOM TO BE CALCULATED			**v. 1.0**
Classroom, Example 1			
INPUT DA TA		**A**	**B**
Lamp wattage (W)	P	36	36
Conventional ballast (2), EL warm start (3), EL cold start (4)		2	2
Lamps per luminaire	m	1	1
Number of luminaires	n	18	18
Length of a workday (h)	td	7	7
Number of switch-offs per day	spcs	6	0
Switch-off time (min)	smin	15	0
Workdays per month	d	21	21
Months of usage per year	mo	10,5	10,5
Price of one lamp ($)	hl	4,9	5
Rated lamp life (h)	tll	12000	12000
Interest rate (%)	p	5,00	5,00
Labour, one spot relamping ($/pc.)	hs	5,88	5,88
Labour, bulk relamping per lamp ($/pc.)	hb	3,92	3,92
Price of electrical energy ($/kWh)	hW	0,088	0,088
Price of heating energy ($/kWh)	hQ	0,024	0,024
Utilization factor for internal heat gains (%)	kQ	0	0
Mortality rate (%)	k	20	20

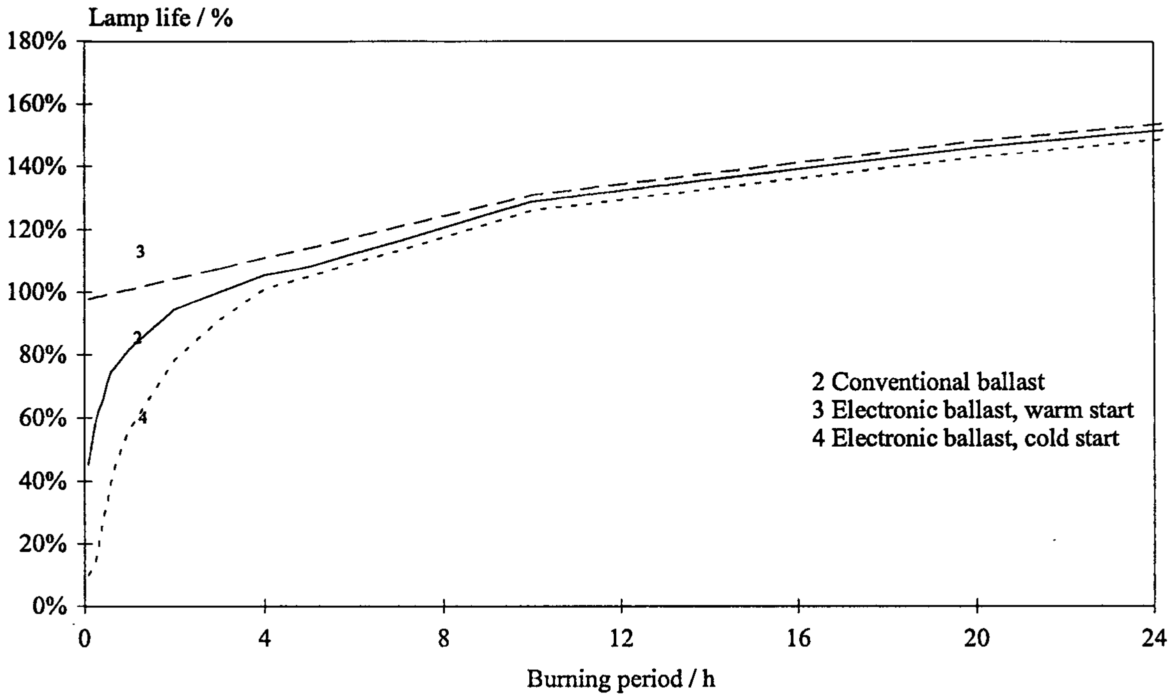

Figure 1. Effect of burning cycle on lamp life with conventional ballast (2), and electronic ballasts (3) and (4).

1993) (Halonen, Nikki 1988) (Manufacturers´ publications)

After that there is the number of lamps per luminaire and number of luminaires and the length of a workday including breaks. The number of switch-offs per day and average switch-off time are in two columns. If the normal situation is that lamps are not switched off during the workday, one can put zeroes in the other column, and then vary the number and time of switch-offs in the second column. For instance, if lamps are switched off two times for the coffee-breaks (15 minutes) and one time for the lunch-hour (1 hour) during the workday, there are three switch-offs and the average switch-off time is 30 minutes.

Other input data is workdays per month (average), months of usage per year and the price of one lamp. Rated lamp life with fluorescent lamps is normally 12 000 hours, but can be checked from the manufacturer. The interest rate and cost of spot and bulk relamping has to be defined case by case.

The power consumption of electrical appliances and artificial lighting warms up the rooms, and therefore the reduced consumption of household electricity increases

Table 2. Values that are calculated from the initial values.

Classroom, Example 1			
CALCULATED VALUES		**A**	**B**
Total power consumption incl. ballasts (W)	Ptot	810	810
Annual burning time (h)	ta	1213	1544
Burning period (h)	tbp	0,79	7,00
Actual lamp life compared to rated	kbp	76%	116%
Actual lamp life (h) with burning period tbp	tall	9164	13968
Relamping period (a)	Tr	7,6	9,0
Capital recovery factor	c	0,162	0,140

Table 3. Usage of energy and costs calculated by TAKE-A-BREAK.

Classroom, Example 2			
RESULTS, calculation 1 year			
USAGE OF ENERGY		**A**	**B**
Electrical energy (kWh)	W	982	1250
Heating energy (kWh)	Q	0	0
Total energy (kWh)	E	982	1250
Difference (kWh)		268	
Difference (%)		21	
COSTS		**A**	**B**
Electrical energy ($)	Hw	87	110
Heating energy ($)	HQ	0	0
Total energy ($)	He	87	110
Lamp ($)	Hl	14	12
One spot relamping ($)	Hs	3	2
Bulk relamping ($)	Hb	9	8
Total ($)		113	133
Difference ($)		20	
Difference (%)		15	

the amount of heating energy needed. The utilization factor for internal heat gains is 0…50% in offices in Finland (Lund 1991) and 60…80% in one-family houses (Ruuskanen et al. 1993). The prices of electrical energy and heating energy can be different, especially if district heating is used. The mortality rate has an effect only on spot relamping costs.

CALCULATED VALUES

The total power consumption is calculated by multiplying lamp wattage by lamps per luminaire and number of luminaires and a factor which takes into account the ballast losses. The factor is 1,25 if conventional ballast is used and 1,1 otherwise. The annual burning time is achieved by subtracting the time of breaks from the total burning time. The burning period is the average burning period of a workday. The program calculates the actual lamp life with the burning period by using values which are in Figure 1. For instance with a one-hour burning cycle, lamp life is 80% and with a ten-hour burning cycle 130% from the rated lamp life when conventional ballast is used. The relamping period is the actual lamp life divided by the annual burning time. The capital recovery factor is calculated from the interest rate and relamping period.

ENERGIES AND COSTS

The usage of electrical energy is calculated by multiplying the total power consumption by the annual burning time. When lamps are switched off, the total burning time is shortened. If the utilization factor for internal heat gains is given, then the increase of heating energy due to the reduced lighting power consumption will be calculated. Total energy is the sum of the electrical and the heating energies. The effect of switch-offs on the usage of energy is then given as the difference of Columns A and B in kilowatt-hours and per cents.

Costs include energy costs, lamp costs and relamping costs. Costs are summed up and the difference between Columns A and B is given both in US$ and per cents. Energy costs are divided in electrical energy and heating energy, because the price of energies can be different. Lamp cost is counted by multiplying the number of lamps by their price and by the capital recovery factor. The capital recovery factor takes into account the different burning times and lamp lives, when switch-off times and number of switch-offs are changed. Spot relamping costs are counted if lamp mortality rate is given. Bulk relamping cost is counted by dividing the cost of all lamps by relamping period.

RESULTS

In Tables 1…3 there is one example of the results achieved by Take-A-Break. If the lamps are switched off during breaks, 21% of the annual energy consumption and 15% of costs are saved. The lamp life is 76% of the rated lamp life and the burning period is 0,79 h or 47 min, when lamps are switched off during breaks. When lamps are not switched off, lamp life is 116% from the rated lamp life and the burning period is 7 hours.

If we change the electronic ballast in the above example, the difference in total energy consumption is still the same 21%, but the energy consumption in kilowatt-hours would be 869kWh in Column A and 1100kWh in Column B. The annual costs would be 97$ and 119$, respectively.

CONCLUSIONS

When the switch-off time is rather long, for example 15 minutes, there can be many switch-offs during a workday. With the input data that are used in this presentation, energy costs will be reduced more than lamp costs are increased. Also, with many switch-offs the annual burning period will be shortened and therefore the bulk relamping period is still rather long. Excluding the replacement expenses, turning off fluorescent lamps becomes economically profitable even for a few minutes' breaks.

When the switch-off time is short, the savings are reduced. When the replacement expenses of lamps are included and assuming that the heat generated from the lamps can be utilized for heating, the break needs to exceed ten minutes in order to make the turning off the lights profitable. The input data and results for this example are in Appendix 1. The room is an office, where there are three 10-minute breaks during the workday. The utilization factor for internal heat gains is 30%. The costs of illumination are almost the same with or without switching off the lamps. However, the energy consumption is still about 4% smaller when the lamps are switched off.

However, the input data will vary from case to case. Therefore the idea is that one should calculate the profitability of switching off fluorescent lamps for oneself. This program can be downloaded from MOTIVA web site http://www.otech.fi:80/MOTIVA/takabrak.htm.

ACKNOWLEDGEMENTS

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