Lighting controls systems in individual office room at high latitude: measurement of light conditions and electricity savings

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Introduction

This paper presents measurement results of electricity use and lighting conditions in individual office rooms located in Lund, Sweden. In Sweden, lighting accounts about 10% of total electricity use in the country, while for commercial buildings, lighting can represent a large share of electricity use (20-30%). A recent literature review concluded that this electricity use may be reduced by at least 25% by using simple occupancy switch-off control systems (absence detectors) and by at least 50% using photoelectric dimming systems. This study aims to demonstrate the saving potential in individual office rooms by using different lighting control systems.

Method

The following control systems were tested with an overall installed lighting power density of 8 W/m^2 (except for the case with only task lamp):

- Automatic occupancy switch on/off + task lamp
- Manual switch on/off + task lamp
- Photoelectric dimming with automatic occupancy switch on/off + plus task lamp
- Task lamp (LED, 6W)
- No electric lighting system and no occupant (control room for measuring daylight only).

The monitored parameters in each test room were:

- Electricity use by the lighting system (Wh)
- Illuminance (lux) at three points in the room (two fixed, one adjustable on the working space) (Fig. 1)
- Satisfaction of users through a questionnaire.

In addition, global horizontal illuminance (on roof of the building) and direct/global illuminance on the vertical façade were measured.

Results

Results shown regard the first month of measurement (November 2011) and they will be followed by further investigations in other periods of the year.

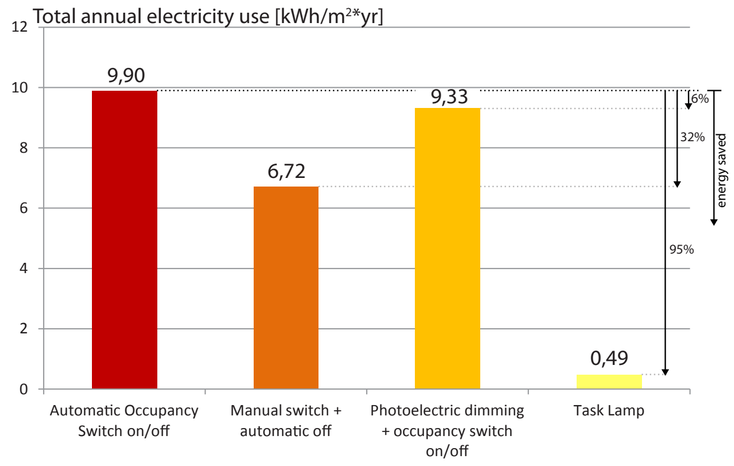

Figure 2. Electric lighting consumption

Total annual electricity use [kWh/m^2*yr] was derived multiplying the average daily consumption per 235 working days. Since the average is derived by measurement in dark November month, electricity use is generally overstimated (Fig. 2).

Task lamp shows a saving of 95% in electricity use compared to occupancy on/off system, but questionnaire displays uncomfortable working conditions for the employee with overcast sky.

Photoelectric dimming does not achieve the expected performance most probably due to the conflict with automatic occupancy on/off sensor and some

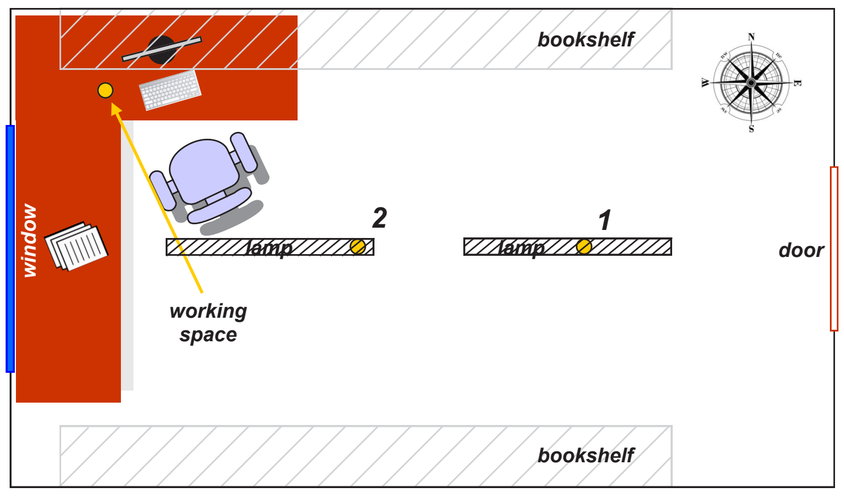

Figure 1. Plan and example picture of tested rooms (1 and 2 are luxmeters in fixed position, "working space" is a free-to-move luxmeter)

trouble with the built-in daylight sensor. This is confirmed by the low correlation between exterior illuminance and electricity use (Fig. 3)

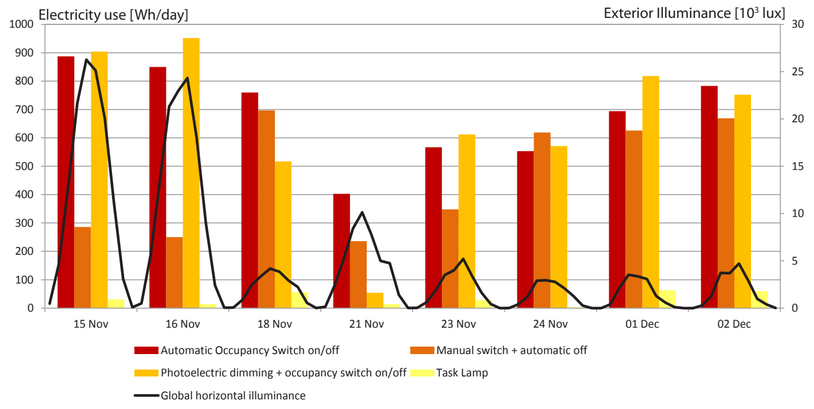

Figure 3. Daily electricity use as function of global horizontal illuminance

Manual switch on/off achieves the best performance for the combination of energy saving/users satisfaction.

Data recorded during a sunny day (November, 15th) show adaption to light conditions of the manual switch on/off compared to photoelectric dimming (Fig. 4).

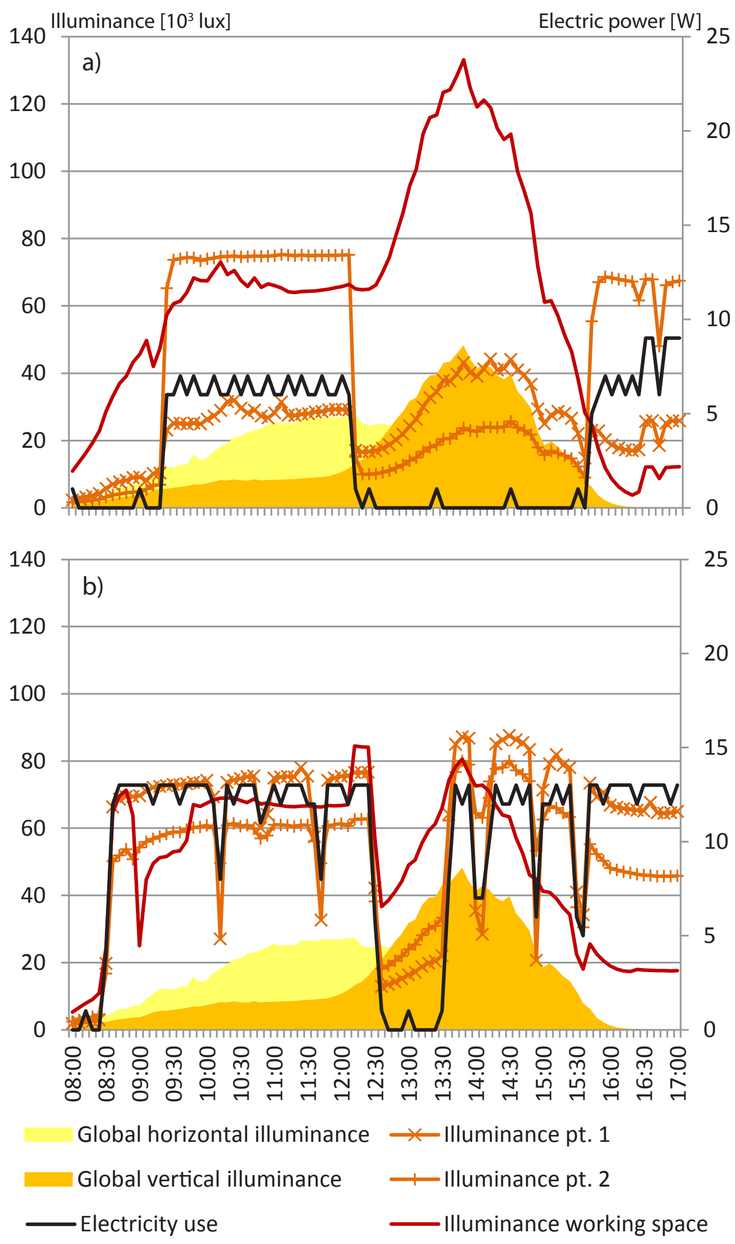

Figure 4. Illuminance levels during a sunny day (November, 15th): a) manual switch on/off, b) photoelectric dimming. Interior illuminance values are multiplied per 100.

Furthermore, due to self-consumption of the ballast, photoelectric dimming system also shows higher stand-by losses (Fig. 5).

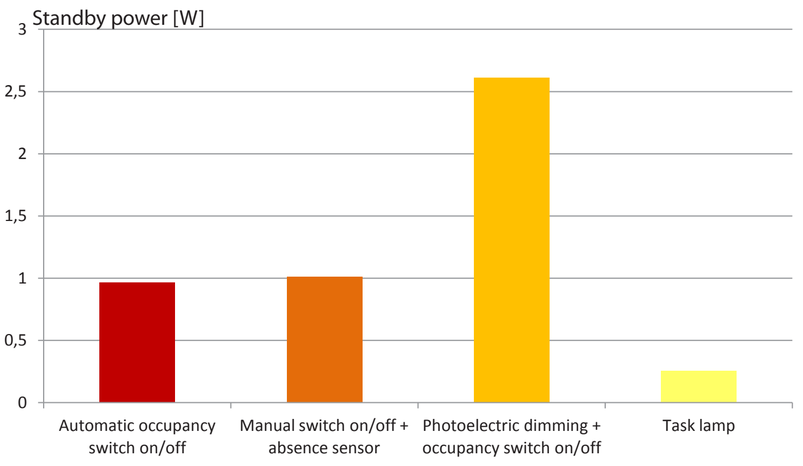

Figure 5. Electricity use in standby condition

Discussion

- Photoelectric dimming system showed relatively high energy consumption. Efficiency could be improved drastically by deactivating the occupancy on/off sensor and replacing it with a manual switch on/off combined with absence sensor and pointing the dimming sensor in other directions.
- Measurements should always be completed by subjective evaluations (questionnaire). For instance, task lamp achieved a great performance in terms of energy savings, but lighting level was considered inadequate
- The occupancy switch on/off achieved the highest electricity use but was also considered frustrating by occupants for two reasons:
  1. light levels were too high and the lighting was glaring
  2. the occupant had no possibility to turn off this glaring light.
- Classical manual switch on/off system combined with a simple occupancy switch off, shows that good performance, both energy- and comfort wise, can be obtained with relatively simple technique.

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