Energy-efficient lighting control systems - results from the Finnish demonstration office building

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1. Synopsis

Different types of lighting control strategies were analysed and demonstrated in one office building in Finland. Part of the control system was installed using new control network technology (LON).

2. Abstract

Measurements and calculations in the Finnish office building showed that the savings potential of daylight control (dimming) was between 24 - 40 %. The effect of occupancy control varies a lot. Measured occupancy rate in the test rooms in the demonstration building varied between 45 - 100 % during office hours. The effect of the set point value of the lighting system was found to be considerable. Economical calculations showed that daylighting and occupancy controls were cost-efficient, when traditional technology was used. The LON technology is more flexible and economical in buildings, where many changes (e.g. partition movements) occur.

Users' ability to affect on the lighting and the picture quality of the monitor using keyboard of their own PC was tested. Users' experiences were evaluated by interviews. In the implemented system, users' attitudes were found to be quite positive. In the evaluated system users preferred using the control system manually rather than automatically (closed loop control).

3. Introduction

Different control strategies and set point selections have a substantial effect on the energy use and functioning of the lighting system in the office building. By exploiting new integrated technology users capability of influencing their own working environment is increasing. The user will be able to control technical systems which leads to demand based use and consideration of individual requirements. That all will increase human satisfaction.

Different types of control systems were demonstrated in the Finnish office building (Figure 3-1). The main emphasis was put on lighting control analysis.

The demonstration building is located in Helsinki. It has three storeys and a parking area in the basement. The heated floor area is about 7.000 m^2.

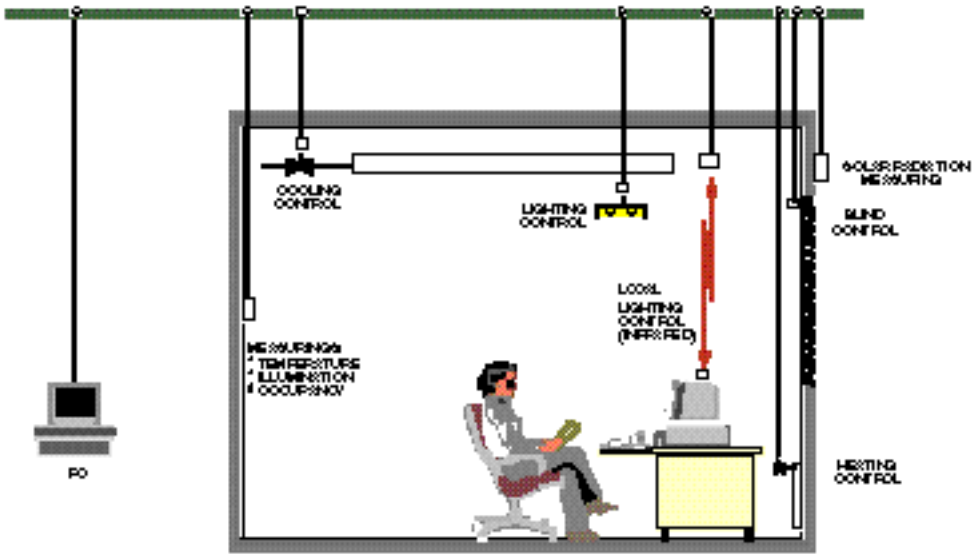

Figure 3-1. Principle of integrating building subsystems in the Finnish demonstration office building by using control network technology.

4. Methodology

The demonstrated systems were installed in five typical office rooms:
- 1. room: Reference room with original control system.
- 2. room: Controlling lights depending on the occupancy.
- 3. room: Controlling lights depending on both the occupancy and daylighting.
- 4. and 5. rooms: Integrated control of lights (occupancy and daylighting), solar shades (blinds), heating and cooling. The lighting was occasionally also locally controlled using PC and monitor with AutoBrite module.

The control system was developed using the Lonworks control network technology. ET-bus was used to read the measurement data.

5. Results

The energy efficiency of daylight responsive lighting control system (dimming) is presented in figure 5-1. The yearly energy consumption was simulated using weather data of Helsinki (1979). Shorter measurement periods during the year 1995 were found to be correlative to the simulated results. The yearly savings in lighting energy consumption was 24 % of the consumption of the time controlled system. The control point in the analyses was in the center of the office room. The simulations showed that changing the control position towards the window (1/4 depth) leads to savings of 40 % and decreased average illuminance level, as well.

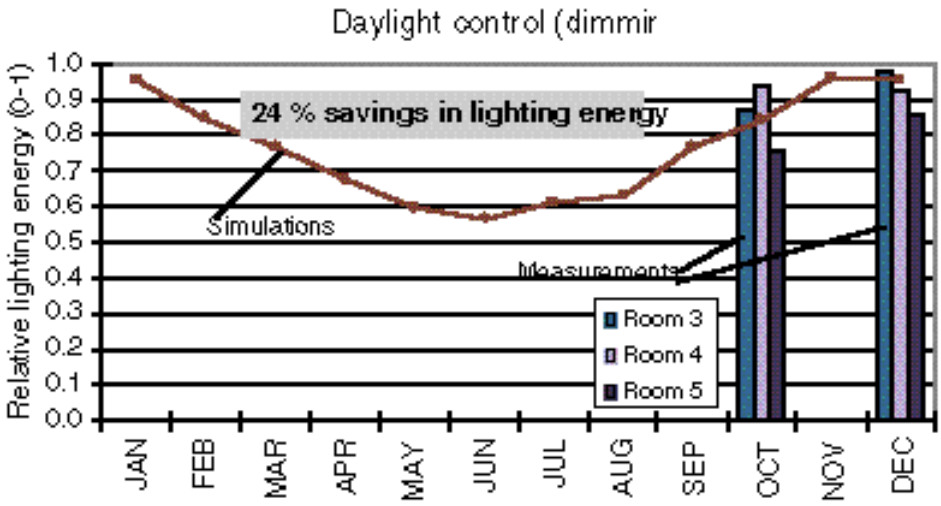

Figure 5-1. The relative lighting energy consumption of the daylight control in Finnish office building located in Helsinki.

Occupancy control of lighting is a very energy efficient way to get savings in the electricity consumption of the office building. The saving potential of the occupancy linking depends on the occupancy patterns. It is most promising in offices having only one or two workers per room and having variable occupation. The measurements in the office building showed a large variation (35-90 %) in average weekly occupation time. It is not possible to give a general value for occupancy rate based on the measurements.

The integrated lighting and PC-monitor picture control system was installed in the test room. The so called AutoBrite module controls the brightness and contrast of the screen according to the changing lighting situation. Also the lighting system can be controlled directly using the keyboard of PC. The practical example of the way to use the control system is: if the user starts to work with PC, the room is too bright and the worker can lower the illuminance level in the room via the PC keybord. The energy effects of the control system (without daylight control) can be estimated using the characteristic curve of the lamps. In the demonstrated office building the maximum illuminance level 1300 lx in the center of the room is produced by 320 W electric power. The decrease of the illuminance level to 500 lx decreases the power input to 183 W (decrease 43 %). It is not possible to estimate the users respond to the possibility of changing the illuminance level. So the exact energy effect of the AutoBrite system depends on the user. The possibility of controling the visual environment increases the satisfaction of the users. The users responses to the automation were quite positive (Linnanen 1996).

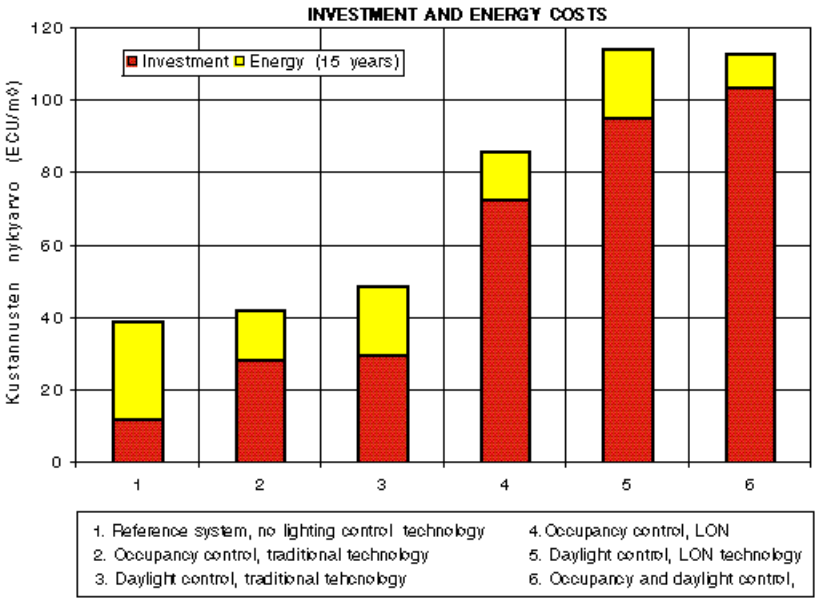

Figure 5-2. The current value of investment and energy costs using different lighting control systems and technology. The average occupancy rate was 50 %.

Economic calculations (Figure 5-2) showed that the overall costs of occupancy and daylight controls were almost the same as with the reference system when traditional technology was used. Using LON-technology the costs were 2-3 times higher than reference system. However the LON technology is more flexible and savings in dynamic buildings can be considerable. In the demonstration building about 100 changes per year are required to have the same overall costs than using traditional technology.

6. Conclusions

The control system consisted of the control of heating, cooling and lighting. Only the energy consumption of the lighting control system was presented in this paper. The economic analyses showed that the dimming and occupancy control systems are economically viable when using the traditional technology. The profitability of the new technology was not so good due to the present price of the LON components - the decrease of the price of the components and inclusion of the system flexibility (modification in the control strategies and location of the internal walls and lighting fixtures) in the economical analyses gives an additional justification for the new technology.

References

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