Energy Efficient Lighting Solutions

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ABSTRACT

The IEA, section ECBCS (Energy Conservation in Buildings and Community systems), has launched the project Annex 45 'Energy Efficient Electric Lighting for Buildings', of which subtask B deals with innovative technical solutions.
Part of the work is to define the key features which are essential for the energy consumption of a lighting installation. The presentation aids to demonstrate how different lighting solutions influence energy consumption and economics, which in turn has a significant impact on the energy politics of a country.

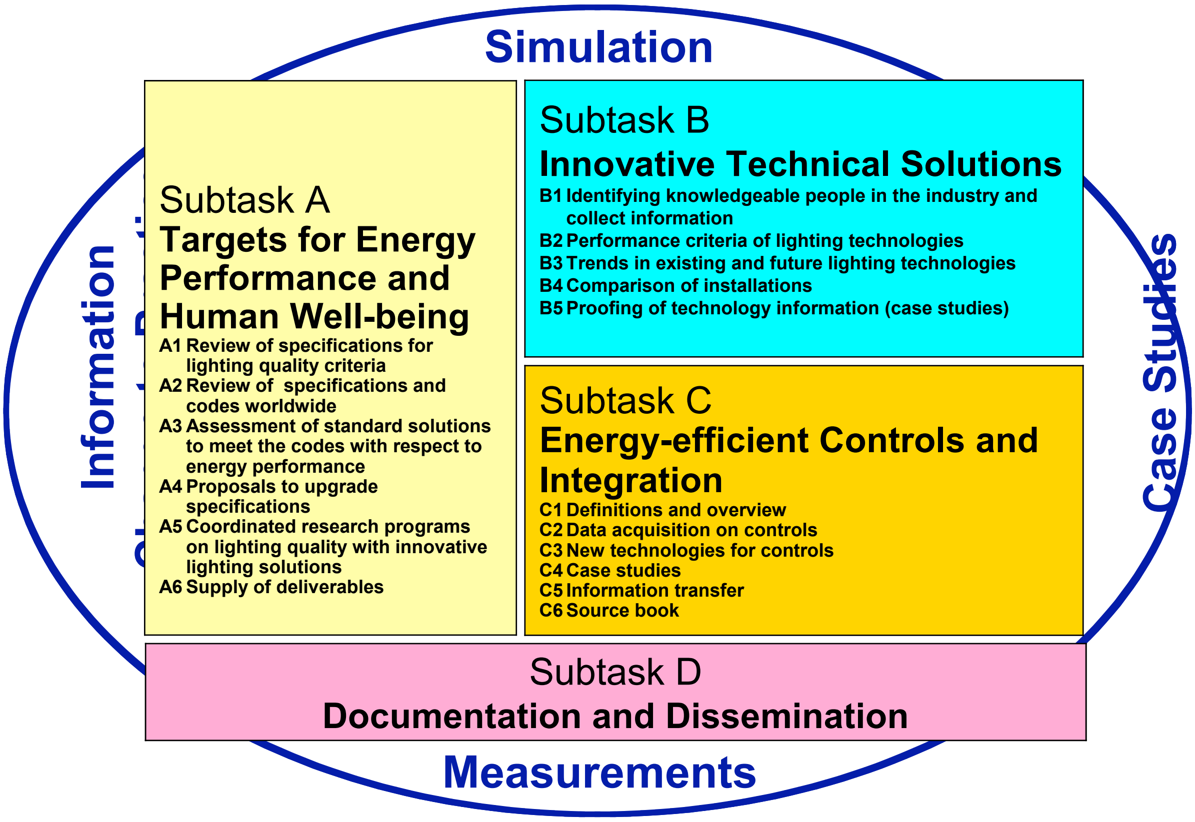

Figure: structure of Annex 45 project, subtask B
(extracted from Annex 45 status report, Prof. Liisa Halonen)

KEYWORDS

Energy, artificial light, daylight, economics, control, building.

ENERGY FOR LIGHTING

Electric lighting consumes a significant amount of energy. Approximately 20% of all energy used in buildings and about 5 % of total energy consumption in the developed world is used for lighting. Additionally the heat from lighting usually accounts for approx. 15 – 20% of a building's cooling load.
Recent forecasts of the IEA prospect that the electrical energy consumption only for building illumination will increase by 80 % in the next 20 years.

Electricity is the most valuable form of energy, to produce 1kWh needs approx. 3kWh primary energy at the mean, so the saving of electric energy has an important effect on the exploitation of non-renewable resources and helps to develop towards a sustainable world.

GENERAL ECONOMICS AND ENERGY CONSIDERATION

Unfortunately it is not well known by end users that the operation costs, especially the energy costs of a lighting installation during life cycle are the biggest part of the whole costs.

A simple appraisal with very common parameters (assumptions) shows the dimensions:

Installation costs 30,- €/m^2
Installation power density 20 W/m^2, operation time 3000 h/year (non-daylit space)

- 60 kWh/m^2year energy consumption
- 9,- €/m^2year costs for electricity (0,15€/kWh prize)
- 90,- €/m^2 for 10 years costs for electricity

- electricity costs exceed installation costs !

In the presentation we will demonstrate the effects of different parameters (e.g. interest rates, prize developments etc.) by the use of a calculation program.

LIFE CYCLE COSTS

For economic evaluation of different lighting solutions a life cycle cost analysis has to be made, this means, that all cost categories including initial (installation) and future costs (maintenance and energy) must be considered.

Initial costs are e.g. costs for the lighting equipment, wiring and control devices, and the labor for the installation of the system. Future costs may include relamping, cleaning, energy, replacement of other parts (reflectors, lenses, louvers, ballasts, etc.) or any other costs that will be incurred.

The diagramm below shows for a typical lighting installation the different type of costs.

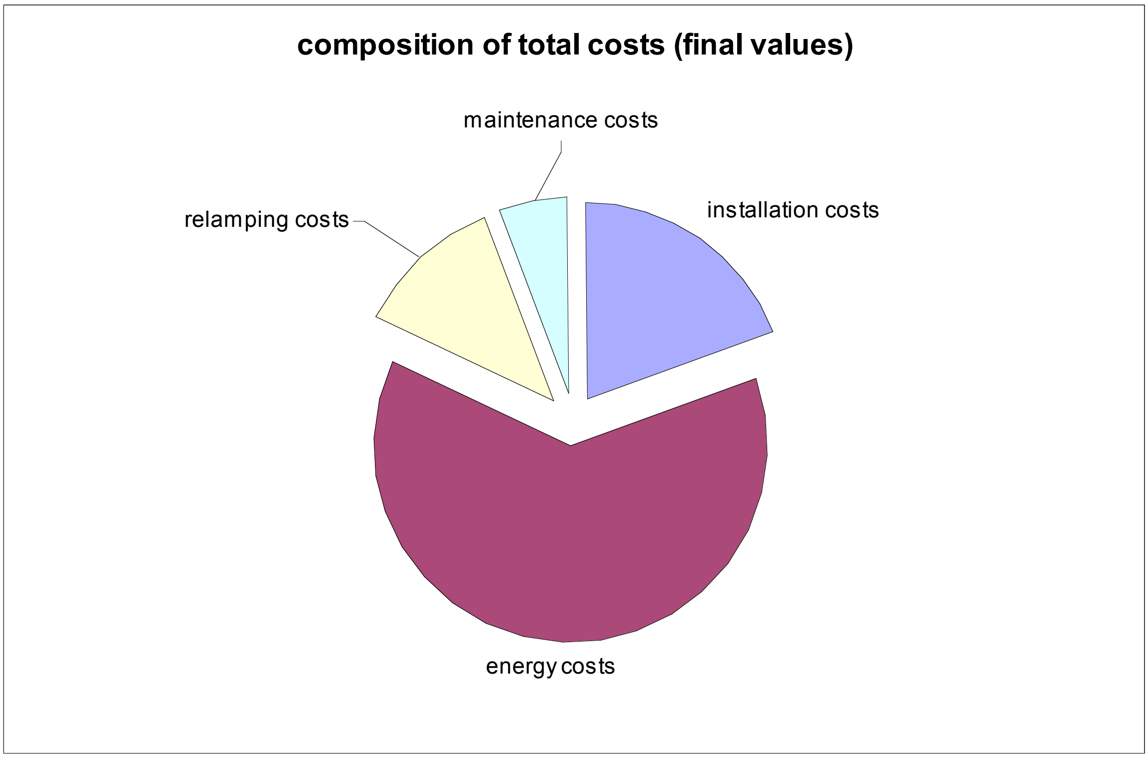

Figure: life cycle costs (dimensions) for a typical store lighting (non-daylit area).

DESIGN PROCESS FOR A ENERGY EFFICIENT LIGHTING SOLUTION

To design energy efficient lighting solutions the designer should perform life-cycle cost evaluations and economic evaluations (including payback criteria desired by the building owner).

To avoid energy waste the following simple rules has to be observed:

1. switch off the light when not needed (lighting controls).
2. use efficient and high quality lighting systems and solutions
3. use reasonable light levels (not more than needed).

Energy losses that result from poor control, system inefficiency and excessive lighting are direct costs for wasted electrical energy.

Lighting Quality

Evaluating economics and energy aspects of a lighting solution we never have to forget the goal of the system: to lighten a space regarding special requirements (needs).
Adequate illuminance and luminance levels horizontal and vertical (regarding on the room utilization, visual tasks, etc.), proper balanced luminances in the field of view, control of direct and reflected glare, and adequate color rendering are minimal conditions for a good lighting..

Steps to an energy efficient solution

We can divide three technical sections in a lighting installation:
- lamp (light source, efficacy in lm/W)
- luminaire (light output ratio)
- room (utilization factor).

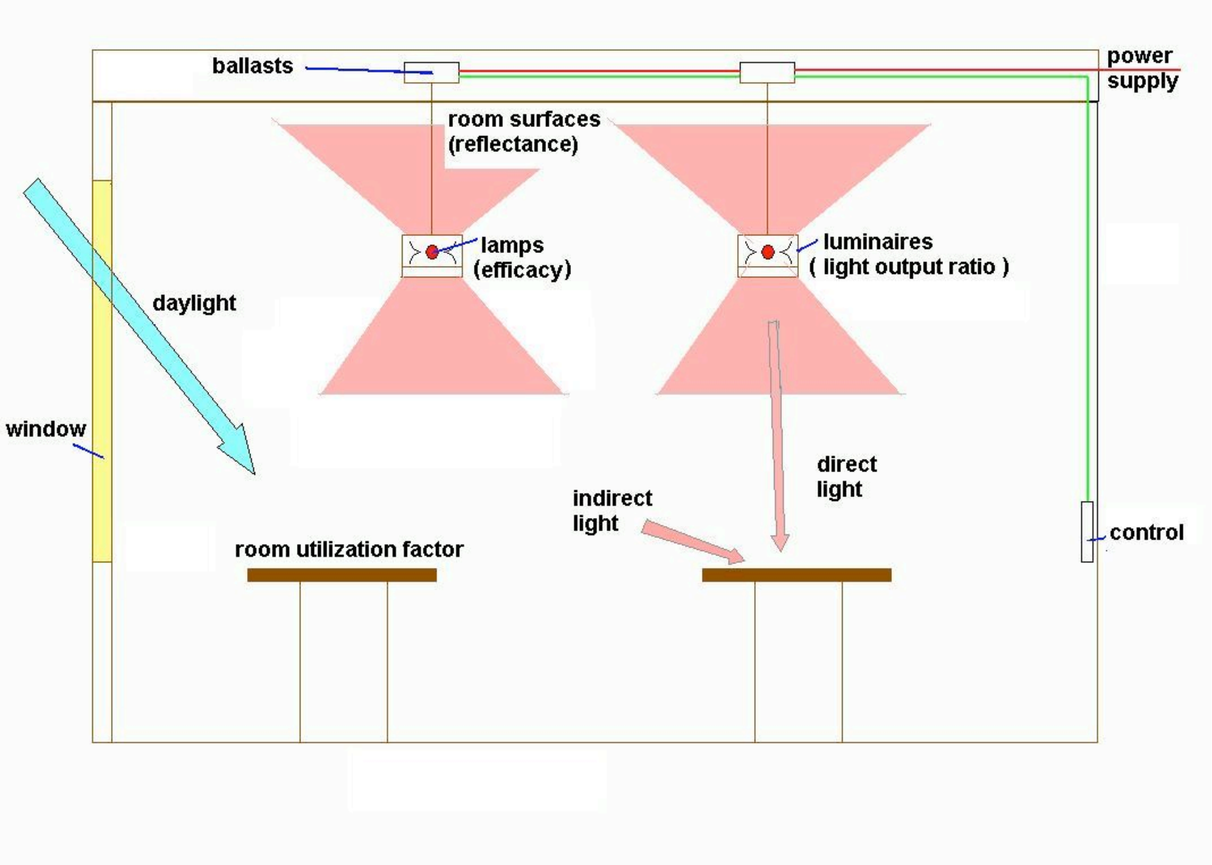

Figure: different sections of a lighting installation.

The energetical performance of these different sections are characterized by the appropriate factors (efficacy in lm/W, light output ratio, utilization factor), the sum gives the ultimate efficacy. The decrease during life time is characterized by the light loss factor.

An energy efficient lighting installation comprises
- an intelligent and energy efficient lighting concept (room utilization factor)
- the use of high quality luminaires (light output ratio) and lamps (lamp efficacy)
- intelligent controls
- a well defined maintenance schedule (light loss factor).

Daylight utilization

To avoid the need for artificial light is the first and most important design step.
The potential for daylight utilization should be evaluated early in the design development of a space. For effective use of daylight in energy management, the levels and hours of daylight availability must be determined.

MAINTENANCE

All system components are aging, and must be replaced at certain times (before dropping out). Lamp performance decreases over time before failure, dirt accumulations on luminaires and room surfaces decreases efficiencies.
Lack of maintenance has a negative effect on visual perception, human performance, safety and security, and usually wastes energy. Both effects, aging and dirt depreciation can reduce the whole efficiency of a lighting installation by 50% or even more, depending on the application and equipment used.

The following measures should be defined by a regular maintenance schedule:

- cleaning of luminaires, daylighting devices and rooms (dirt depreciation)
- relamping
- replace of other parts
- renovation resp. retrofitting of antiquated systems and components.

Below are a few examples listed (uncompleted) for energy saving measures:

- intelligent architecture, develop building and lighting concepts which use daylight, and which need artificial light only to supplement the daylight
- use of controls which dim the artificial lighting level if daylight is entering, and which switch off the electrical light if it is not needed
- use of bright surfaces (high reflectances) for interior spaces
- use lamps with high efficacy and life time
- replacement of antiquated lamps (e.g. T12 → T5), ballasts (conventional → electronical) and luminaires (e.g. if operating time > 20 years, poor optics)
- replace lamps on a regular maintenance schedule to ensure proper function (not waiting until the lamps are burning out)
- use occupant (motion) sensors to avoid light waste.

CONCLUSION

The main problem to overcome is the lack of consciousness that light is important anyway. We should use the existing techniques to avoid energy waste, and this means, that we have to raise the awareness of light and energy.