LIGHTING CONTROL SYSTEMS TO IMPROVE ENERGY PERFORMANCE AND ENVIRONMENTAL QUALITY OF BUILDINGS: LIMITS AND POTENTIALS

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ITALY
LIGHTING CONTROL SYSTEMS

Technologies usable as a tool to actuate, on the basis of input signals, a separated or integrated control of electric lighting and daylighting, in order to guarantee the required environmental lighting condition, and as a consequence to improve visual comfort while reducing electric lighting energy consumption.

- Practical role
- Energy management role
- Aesthetic role
THE SPREAD OF LIGHTING CONTROL SYSTEMS

- since the ’80

- Nowadays
  - New architectural design trends
  - New lighting technologies and products

  have boosted the choice in new control lighting products

  More emphasis on the energy management role and the aesthetic role

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New architectural design trends:

- sustainable buildings
- use of highly glazed facades
THE SPREAD OF LIGHTING CONTROL SYSTEMS

New technologies and products:

- steady diffusion of electronic ballasts
- evolution of communication protocols
- diffusion of dynamic lighting and coloured lighting
LIGHTING CONTROL SYSTEMS

Wide range of control systems, products and components
LIGHTING CONTROL and LIGHTING QUALITY

HUMAN NEEDS
- Visibility
- Task performance
- Visual comfort
- Mood and atmosphere
- Social communication
- Health, safety, well being
- Aesthetic judgment

ARCHITECTURE
- Form
- Composition
- Style
- Codes and standards

LIGHTING QUALITY

ECONOMICS AND ENVIRONMENT
- Installation
- Maintenance
- Operation
- Energy
- Environment

Lighting control systems

Lighting Quality definition developed at First CIE Symposium on Lighting Quality (Veitch, Julian, & Slater, 1998).
LIGHTING CONTROL and EUROPEAN ENERGY CODES

- prEN 15193: Energy performance of buildings – Energy requirements for lighting
- prEN 15232: Calculation methods for energy efficiency improvements by the application of integrated building automation systems
- CEN 12464: Light and lighting – Lighting of work places – Part 1: Indoor work places

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LIGHTING CONTROL and EUROPEAN ENERGY CODES


The Directive objective is to improve energy performance of buildings, by requiring:
• a methodology to calculate integrated energy performance of buildings
• minimum energy requirements for new buildings
• minimum energy requirements for large existing buildings being renovated
• energy certification of buildings
• regular inspections of building’s plants (heating and air-conditioning)

Integrated energy performance depends upon:
thermal characteristics of the building
heating installation
air-conditioning installation
ventilation
built-in lighting installation
......
LIGHTING CONTROL and EUROPEAN ENERGY CODES

prEN 15193: Energy performance of buildings – Energy requirements for lighting (in progress)

The objectives of the standard are:

• To establish conventions and procedures for the estimation of energy requirements of lighting in building
• To give a methodology for a numeric indicator of energy performance of buildings

Can be applied to existing buildings, newly designed or renovated buildings

Takes a “dynamic” use of electric light into account, considering both daylight availability and space occupancy

prEN 15232: Calculation methods for energy efficiency improvements by the application of integrated building automation systems

It establishes the provisions and methods for estimating the impact of “building automation” systems on energy performance and energy use in buildings.
LIGHTING CONTROL SYSTEMS: limits to their diffusion

Lighting control application on a large scale has not yet been achieved

- Lack of information about existing technologies
- Compatibility with other systems and equipment
- Necessity to rely on system manufactures’ technical staff
- Complexity of the commissioning phase
- Occupants complaints
- Difficulty on evaluating actual savings achievable by adopting a lighting control system
- Low impact of automation and control systems on building’s value
When the system includes interaction by natural and artificial light, the following come into play:

- **exterior daylight availability**, that depends on:
  - the space’s latitude and longitude
  - day of the month and hour of the day
  - sky conditions (overcast, clear, intermediate, etc.)

- **amount of natural light in spaces**, that depends on:
  - exterior daylight availability
  - presence of exterior obstructions
  - orientation of the environment
  - presence of shading devices
  - configuration of the environment and layout of work places

- **usage characteristics**, eg:
  - occupation profile
  - interaction between users and screening components
  - interaction between users and luminaires
  - characteristics and performance of luminaires
  - typology and architecture of the control system (control based on occupation, presence of natural light, user interest, pre-defined settings, etc., typologies of adopted sensors, groupings of terminals, etc.)
LIGHTING CONTROL SYSTEMS: limits and potentials

Research at the Politecnico di Torino’s Department of Energy

to draw up guidelines for the light control systems project

• state of the art of currently available control systems;
• calculation methods and energy performance;
• information on environmental and energy performance, degree of acceptance and ways of interaction between systems and user, in real situations.
Calculation methods and energy performance

Manual simplified methods and software applied to reference cases

Without obstruction

With obstruction

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Calculation methods and energy performance

prEN 15193: Energy performance of buildings – Energy requirements for lighting

- quick method: allows the estimation of annual lighting energy consumption of a building.

- comprehensive method: allows for a more accurate determination of the lighting energy estimation for each building room or zone and for different periods (monthly or annual).

DEPENDENCY FACTORS:

- $t$: operating time
- $F_D$: daylight dependency factor
- $F_O$: occupancy dependency factor
- $F_C$: constant illuminance factor
- $A$: useful area
CONTROL STRATEGIES

- MANUAL ON/OFF
  - quick method: + 20%
  - comprehensive method: + 37%
- LIGHT SENSOR
  - quick method: - 8%
  - comprehensive method: - 27%
- OCCUPANCY SENSOR
  - quick method: - 9%
  - comprehensive method: - 10%
- LIGHT SENSOR + OCCUPANCY SENSOR
  - quick method: - 16%
  - comprehensive method: - 34%

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With obstruction

Comprehensive method

Control Strategies

- Manual On/Off
- Light Sensor
- Occupancy Sensor
- Light Sensor + Occupancy Sensor

Leni

1° Floor 4° Floor 7° Floor

- 20%
- 30%

1° Floor 4° Floor 7° Floor

- 10%

1° Floor 4° Floor 7° Floor

- 10%

1° Floor 4° Floor 7° Floor

- 30%
- 40%

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Environmental, energy performance, degree of acceptance, ways of interaction between systems and user

SCHOOLS - objective and subjective measurements during a whole year

OFFICES - objective and subjective measurements during a whole year

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CONCLUSIONS

- Increasing interest in lighting control systems
- Increasing choice in products and solutions
- Limited diffusion and frequent lack of success of installed systems

Importance of increasing knowledge and consciousness about systems characteristics and real performances not only among the technical staffs of systems manufacturer but also among architects, lighting designers, building owner, etc.