УДК 628. 9:621.311.1.004.183
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ПІДВИЩЕННЯ ЕКОНОМІЧНОЇ ТА ЕНЕРГЕТИЧНОЇ ЕФЕКТИВНОСТІ СИСТЕМ КЕРУВАННЯ ОСВІТЛЕННЯМ СХОДОВИХ КЛІТОК У БАГАТОПОВЕРХОВИХ ЖИТЛОВИХ БУДИНКАХ

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ENHANCING ECONOMIC AND ENERGY EFFICIENCY OF STAIRWELL LIGHTING CONTROL SYSTEMS IN HIGH-RISE RESIDENTIAL BUILDINGS

The growing focus on energy efficiency and sustainability in building design has led to increased interest in optimizing artificial lighting systems. This study, evaluates the economic and energy efficiency of artificial lighting control systems, specifically using astronomical relays and motion sensors in the stairwells of multistory residential buildings. The research aims to determine how different light sources and control systems can reduce electricity consumption and costs while maintaining safety and comfort for residents.

The primary objectives of this study are: To analyze the economic and energy efficiency of artificial lighting control systems using astronomical relays and motion sensors. To compare the performance of different light sources—halogen lamps (HL), compact fluorescent lamps (CFL), and light-emitting diodes (LED)—in terms of energy savings and cost-effectiveness. To assess the impact of resident movement patterns on the energy consumption of lighting systems.

The study utilizes a comprehensive approach, including **Data Collection**: Monthly movement intensity of residents in 9-story residential buildings in Ternopil, Ukraine, was recorded. **Energy Consumption Analysis**: The electricity consumption of lighting systems with and without control systems (continuous lighting, astronomical relays, and motion sensors) was calculated. **Cost Analysis**: The cost of ownership, including initial costs, replacement costs, and electricity costs, was evaluated for different lighting systems over ten years.

Key Findings:

1. **Astronomical Relays**:
    - Implementation of astronomical relays reduced electricity consumption by 43.31% to 50.52% across all types of light sources [1].
    - This control system is particularly effective in areas with significant variations in daylight hours throughout the year.
2. **Motion Sensors**:
    - The use of motion sensors led to substantial reductions in electricity consumption: 97.73% for HL, 95.27% for CFL, and 93.98% for LED [2].
    - Motion sensors are effective in reducing energy usage during periods of low occupancy, particularly at night.
3. **Light Sources Comparison**:
    - **Halogen Lamps (HL)**: High energy consumption and shorter lifespan compared to CFL and LED.
    - **Compact Fluorescent Lamps (CFL)**: Moderate energy consumption and longer lifespan than HL but shorter than LED.

- **Light-Emitting Diodes (LED)**: Lowest energy consumption and longest lifespan, making them the most cost-effective option over time.

4. **Economic Analysis**:
   - Over ten years, the cost of ownership for systems with HL is significantly higher than those with CFL and LED.
   - Motion sensors, despite higher initial costs, offer substantial long-term savings, particularly with HL and CFL.

The study highlights the importance of selecting appropriate lighting control systems and light sources to achieve optimal energy and economic efficiency in multistory residential buildings. While astronomical relays provide significant savings by leveraging natural daylight, motion sensors offer the highest reduction in electricity consumption by activating lights only when needed. LEDs, despite higher upfront costs, prove to be the most economical and energy-efficient light source over time [3].
Recommendations:

1. **For Building Designers and Managers**:
   - Consider integrating motion sensors and LED lighting in stairwells and common areas to maximize energy savings.
   - Evaluate the feasibility of astronomical relays in regions with variable daylight hours to further reduce energy consumption.
2. **For Policy Makers**:
   - Encourage the adoption of energy-efficient lighting systems through incentives and regulations.
   - Promote research and development of advanced lighting control technologies to enhance their affordability and effectiveness.
3. **For Future Research**:
   - Explore the long-term durability and maintenance requirements of advanced lighting control systems.
   - Investigate the user acceptance and behaviour impacts of automated lighting systems to optimize their design and implementation.

By adopting these recommendations, stakeholders can significantly contribute to the global efforts in energy conservation and sustainable development.

Conclusion. The findings underscore the potential for significant energy and cost savings through the strategic implementation of lighting control systems in residential buildings. For the most effective results, combining LED lighting with motion sensors is recommended, especially in regions with substantial daylight variation. This approach not only reduces electricity consumption and costs but also enhances environmental sustainability by lowering greenhouse gas emissions.

Reference.

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