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INTELLIGENT LIGHTING SYSTEM IN INSTITUTIONAL BUILDINGS

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Abstract

In response to the growing need for energy-efficient lighting solutions, this paper introduces an Intelligent Lighting System (ILS) designed to enhance energy conservation and user satisfaction. Conventional light control systems often face limitations in seamlessly integrating into homes and offices due to inefficiencies and design constraints. The proposed ILS leverages advanced technologies, including motion sensors, light sensors, and wireless communication, to dynamically adjust light intensity based on user movement and ambient lighting conditions. By ensuring optimal illumination while minimizing energy consumption, the system contributes significantly to sustainable energy practices.

This research outlines the comprehensive architecture of the ILS, detailing its components and operational mechanisms. The system's design project was undertaken at the Atal Bihari Vajpayee Centre for Excellence in Information Technology & Communication and Outsourcing Centre. The lighting efficiency of the ILS was rigorously simulated using DIALux software, a leading tool in lighting design and analysis. The simulation assessed various parameters such as energy efficiency, direct lighting, and environmental impact, providing a robust evaluation of the system's performance.

The study also explores practical applications and innovative ideas for implementing the ILS in diverse environments, including offices and factories. These applications demonstrate the system's versatility and effectiveness in different settings, highlighting its potential to revolutionize lighting control in both residential and commercial spaces. The findings indicate that the ILS can significantly reduce energy consumption while maintaining optimal lighting conditions, thereby promoting sustainable energy practices and enhancing user satisfaction.

Furthermore, the paper discusses the environmental benefits of the ILS, emphasizing its role in reducing carbon footprints and supporting green building initiatives. By integrating intelligent lighting solutions, businesses and homeowners can achieve substantial energy savings and contribute to broader environmental sustainability goals.

In conclusion, this paper contributes to the ongoing efforts to develop intelligent, energy-efficient lighting solutions that can be seamlessly integrated into modern living and working environments. The ILS represents a significant advancement in lighting technology, offering a practical and effective approach to energy conservation and user comfort.

Keywords – Artificial lighting design , Day light Factor , CRI , Illumination ,Luminaires , Lighting simulations

1. INTRODUCTION

Light is electromagnetic radiation visible to the human eye. It behaves as both a particle (photon) and a wave.

1. **LUMINOUS FLUX (LM):**
- Represents the overall quantity of light energy exerted by a lighting fixture in every direction.
- Deliberated in lumens (lm).
- Example: A 100-watt incandescent bulb emits around 1600 lumens of light.

2. **LUMINOUS INTENSITY (CD):**
- Describes the quantity of light energy exerted by a lighting fixture at a particular angle.
- Deliberated in candelas (cd) or lumens per steradian (lumen/sr).
- Example: A focused flashlight beam has high luminous intensity.

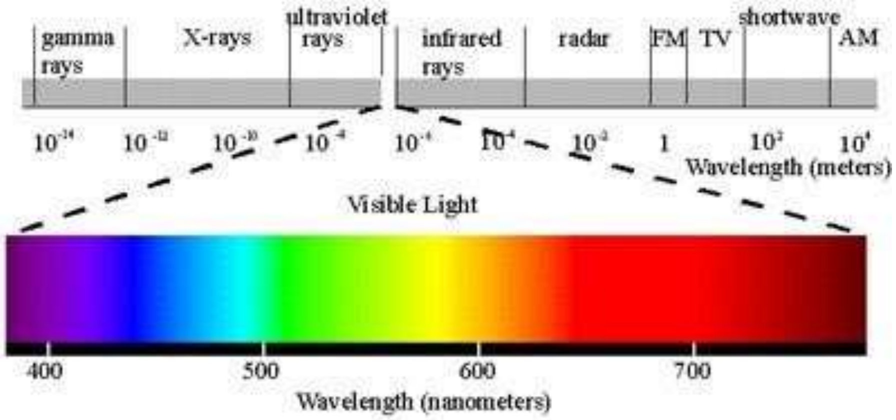


Figure 1 Light Spectrum

3. **ILLUMINATION (LUX, E):**

- Refers to ratio of total quantity of energy exerted from a lighting fixture and total surface area.
- Deliberated in lux (lm/m²).
- Example: A well-lit reading desk may have an illumination of 500 lux.

4. **LUMINANCE (CD/M² OR NIT):**

- Indicates the amount of energy reflected by a surface in a particular direction.
- Deliberated in candelas per square meter (cd/m²) or nits.
- Example: A bright computer monitor has high luminance.

5. **COLOUR RENDERING INDEX (C.R.I):**

- Range: 0 to 100, where 100 represents perfect color rendering (as seen with incandescent bulbs and sunlight).
- Examples: Incandescent bulbs have a C.R.I of 100, while CFLs typically range from 40 to 70, and LEDs can go up to 85.

6. **COLOUR TEMPERATURE (C.T.) :**

- Represents the temperature of an ideal black body emitter (like a heated metal) at which it emits light similar to a specific lighting source.
- Measured in Kelvin (K).
- Example: Incandescent bulbs emit warm light around 2700K.

7. **CORRELATED COLOUR TEMPERATURE (C.C.T.):**

- Describes the effective "whiteness" of a lighting source.
- Determines whether light appears warm (yellowish), cool (bluish), or natural (neutral).
- Example: Daylight has a CCT around 5500K.

8. **LIGHTING DISTRIBUTION SYSTEMS:**

- Direct Lighting: Provides 90-100% illumination downwards (e.g., spotlights).
- Indirect Lighting: Offers 90-100% illumination upwards (e.g., ceiling fixtures bouncing light off the ceiling).
- Semi-Direct Lighting: Balances 60-90% illumination downwards (e.g., pendant lights).
- Semi-Indirect Lighting: Balances 60-90% illumination upwards (e.g., wall sconces).
- General Diffuse Lighting (Direct-Indirect): Combines 40-60% illumination both upwards and downwards (e.g., troffer fixtures).

9. **TYPES OF LAMPS:**

- Incandescent Bulbs: High C.R.I (100), but less energy-efficient.
- Fluorescent Lamps: Moderate C.R.I (50-75), various types (T12, T8, T5, CFL, induction lamps).
- HID Lamps (High-Intensity Discharge): Low C.R.I (10-15), used for outdoor lighting (HPSV, LPS, HPM, MH).
- LEDs (Light-Emitting Diodes): C.R.I around 85, energy-efficient and versatile. Also, OLEDs (organic LEDs).

A lighting control system offers simplicity and convenience, particularly in larger spaces where traditional single switches or dimmers can be cumbersome. It allows for centralized control of all lights, making it easy to adjust lighting throughout the day without the need to manually toggle multiple switches. Automated lighting features enable lights to change automatically depending upon the time of day or occupancy, eliminating the need to remember to turn lights on or off. Strategically placed keypads allow for quick adjustments from anywhere in the home, making dimming and mood lighting effortless. Overall, the combination of these features enhances elegance and elevates the experience, whether creating a cozy evening ambiance or bright task lighting (Kaminska & Ozadowicz, 2018).

Following can be taken as instances on how these control systems can add values to the building.

- A college premises tried to incorporate Occupancy sensors in 8000 spaces and saving $1.3 million annually with a quick payback period.
- Energy management system was used by a manufacturer to manage lights, saving over $68,000 per year.
- A government laboratory empowered workers with lighting control, leading to improved visual comfort and energy savings (Kaminska & Ozadowicz, 2018).

Upgrading lighting controls can enhance worker productivity by reducing eyestrain and fatigue. The time of function was modified along with the intensity of lighting systems, commercial buildings can achieve better value.

2.1 Comfortable

Lighting controls allow users to tailor lighting levels to their personal preferences. Imagine being able to adjust the brightness in your workspace based on your mood or task. Whether it's a cozy warm glow for reading or a bright, focused light for working, personalized lighting contributes to comfort(Deo et al., 2020) .

2.2 Productive

By optimizing the work environment for specific tasks, lighting controls can reduce eyestrain and fatigue, enabling workers to concentrate more effectively for extended periods.

2.3 Energy efficient

By ensuring that lights are turned off when not needed and adjusting lighting levels to match specific tasks, energy efficiency is improved. This approach benefits both the environment and reduces utility costs (Patil et al., 2016).

LIGHTING CONTROL SYSTEM AND STRATEGIES

While the traditional approach of using individual switches or dimmers for lights works, it can be cumbersome—especially in larger homes. Imagine the effort of turning lights on in the morning, off when leaving for work, back on in the evening, and finally off at bedtime. The convenience of a lighting control system becomes evident when you consider managing multiple dimmers and switches throughout the day.

A lighting control system allows all home lighting to be controlled together. With a single button press, you can adjust multiple dimmers to the ideal brightness for various tasks—whether it's reading, watching a movie, or cleaning (Dubois et al., 2015)

3.1 Convenience and Efficiency:

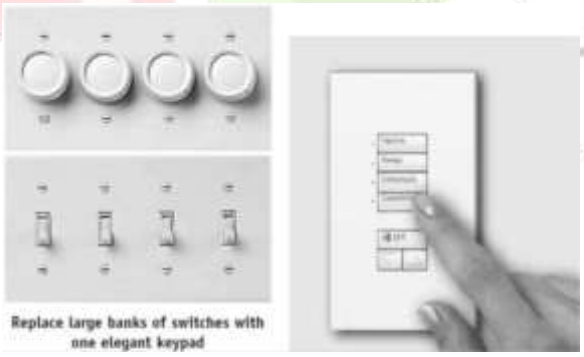


Figure 2 Comparison of old and new switches

- A lighting control system replaces a bank of individual switches or dimmers with a single keypad. This compact solution provides convenience by allowing centralized control of all lights(Francis & Rubinstein, n.d.).
- Imagine pressing one button to adjust multiple dimmers to the ideal brightness for various activities—whether it's reading, watching a movie, or cleaning (Dubois et al., 2015).

3.2 Enhanced Home Security:

- During alarm situations, the system can turn on lights to full brightness inside the home and flash them outside. This quick identification helps authorities locate the troubled home.
- Built-in time clock features simulate occupancy while you're away, deterring potential intruders (Dubois et al., 2015).

3.3 Automated Convenience:

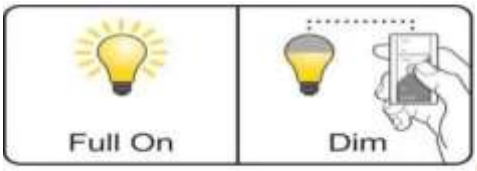
- Occupancy sensors, photo sensors, and time clock capabilities take care of controlling your lights for you.
- Energy savings occur when unnecessary lights are turned off or dimmed automatically—for instance, when you leave a room or as the sun rises (Dubois et al., 2015).

3.4 Dimming for Efficiency:

- Dimming reduces power usage. While we often associate dimming with creating different moods, it's also an effective way to save energy costs (Francis & Rubinstein, n.d.).
- Strategies Upgrading lighting controls can enhance worker productivity by reducing eyestrain and fatigue. By adjusting the time of operation and intensity of electric lighting systems, commercial buildings can achieve better value (Dubois et al., 2015).

1. **Personal Light Control:**

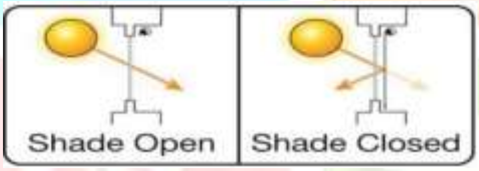
Personalized light control enables users to adjust lighting levels according to their specific needs and tasks (Gavioli et al., 2015).



10 – 20% Saving

2. **Controllable window shades**

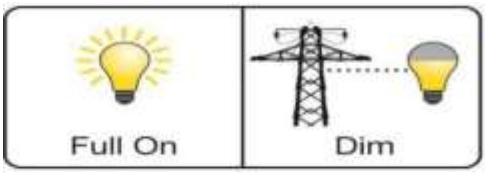
empower users to manage daylight effectively, reducing solar heat gain and minimizing glare.



30 – 50% Savings

3. **Demand response**

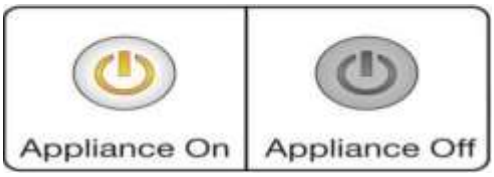
involves adjusting lighting load during peak electricity pricing to manage energy consumption effectively. Similarly, reducing HVAC load during peak times contributes to overall energy efficiency.



30 – 50% Savings

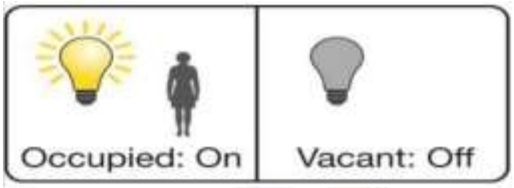
4. **Plug-load control**

involves automatically turning off task lighting and other plug loads when they are not needed.



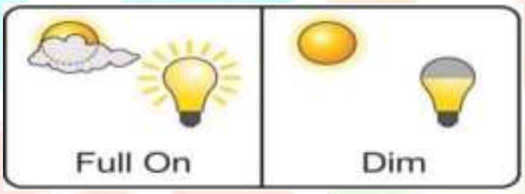
15 – 25% Savings

5. Occupancy or vacancy sensing
involves automatically turning lights off or dimming them down when a space is unoccupied. Integrating HVAC control locally or digitally complements this strategy for overall energy efficiency.



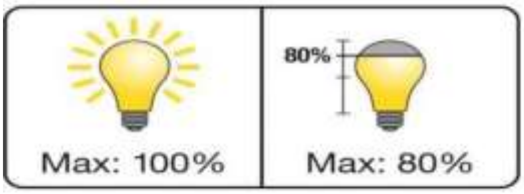
20 – 60% Savings

6. Daylight harvesting
It describes the automatic regulation of light intensity according to the natural daylight present in a space.



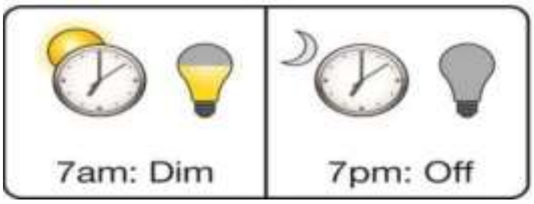
25 – 60% Savings

7. High-end trim or tuning
involves setting the target light level in a space based on occupant requirements



10– 30% Savings

8. Scheduling
involves automatically turning off lights or dimming them at specific times of the day or based on sunrise and sunset.



10 – 20% Savings

4. DESIGN

Atal Bihari Vajpayee Centre for Excellence in Information Technology & Communication and Outsourcing Centre is chosen as my design study which is an institutional building located at Ulaabaatar, Mongolia Height has Ground floor with 8 stories above , with a basement as well. The plinth area is 864 sq.m . Floor height if 3m

Figure 3 Location

Figure 4 Site, Source – Zoma Engineers

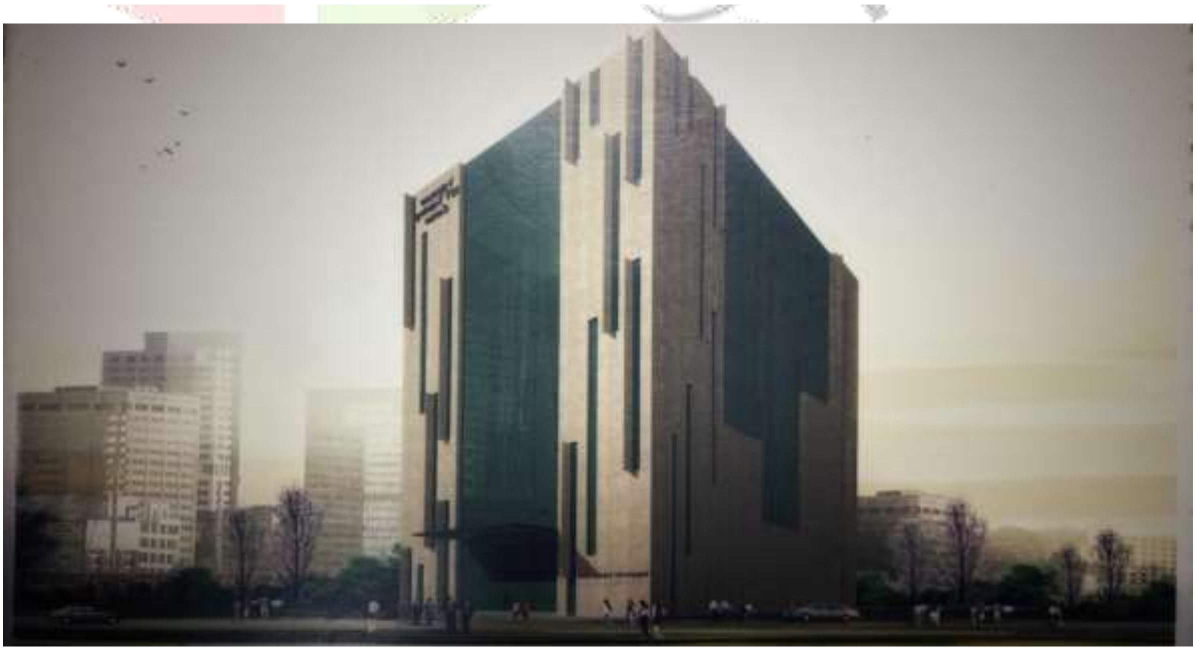


Figure 5 Building Model, Source – Zoma Engineers

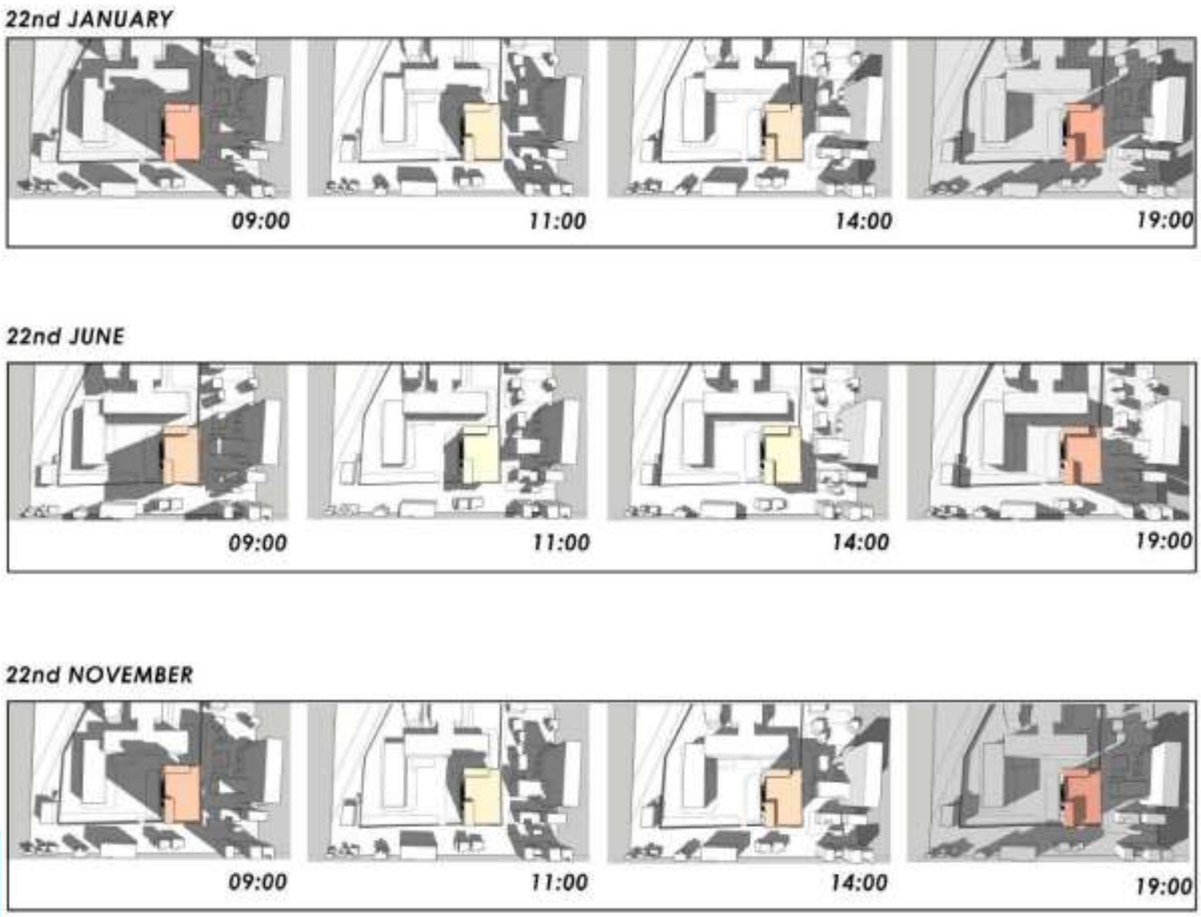


Figure 6 Shadow Analyses, Source - Author

Figure 7 Floor Plan with Lighting Design

LEGEND :-

SYMBOL	DESCRIPTION	QTY.
	35W RECESS TYPE LED LIGHT FIXTURE - IP20,	14
	35W RECESS TYPE LED LIGHT FIXTURE - IP20, (EMERGENCY LIGHT)	11
	32W RECESS TYPE LED LIGHT FIXTURE - IP20,	60
	32W RECESS TYPE LED LIGHT FIXTURE - IP20, (EMERGENCY LIGHT)	25
	18W SURFACE MOUNTED LED LIGHT FIXTURE - IP20,	04
	18W SURFACE MOUNTED LED LIGHT FIXTURE - IP20, (EMERGENCY LIGHT)	04
	11W DOWNLIGHTER LED LIGHT FIXTURE - IP20,	09
	11W DOWNLIGHTER LED LIGHT FIXTURE - IP20, (EMERGENCY LIGHT)	04
	38W SURFACE / SUSPENDED MOUNTED LED LIGHT FIXTURE - IP20,	02
	38W SURFACE / SUSPENDED MOUNTED LED LIGHT FIXTURE - IP20, (EMERGENCY LIGHT)	02
W	35W SURFACE / WALL MOUNTED LED LIGHT FIXTURE - IP66, (NORMAL / EMERGENCY LIGHT)	06
	MIRROR LIGHT IP-66	04

Energy Savings:

- In this building they have installed LED lights (Light Emitting Diodes) which has several advantages over regular lighting systems. They are incredibly efficient. On average, they can save up to 90% of electricity costs compared to traditional incandescent bulbs. That's a significant reduction.
- Unlike older bulbs, LEDs don't waste energy by emitting heat. Instead, they convert almost all their consumed energy directly into light. This efficiency means you get more illumination for less power.

Direct Lighting:

- LED lights are excellent examples of direct lighting. What does that mean? Well, they emit light in a specific direction without relying on reflectors or diffusers. As a result, you need fewer LED lights to achieve the same brightness as traditional bulbs.
- Imagine a room with LED panels on the ceiling. They evenly distribute light downward, covering the entire space efficiently.

3. Environmental Impact:

- LED lights contribute to a greener planet. Here's how:
- Reduced Energy Demand: Since LEDs use less electricity, power plants generate less energy overall. This reduction helps combat climate change by decreasing the emissions of greenhouse gases to a large extent.
- Longer Lifespan: if we compare the lifespan of LED with that of incandescent lamps, Led is by far has a better lifespan . Fewer replacements mean less waste and fewer resources used.
- Mercury-Free: Unlike fluorescent bulbs, LEDs contain no harmful mercury. This makes disposal safer for the environment.
- Outdoor Lighting: LEDs are commonly used for streetlights, traffic signals, and outdoor displays. Their efficiency helps cities save energy and reduce light pollution.

4. Ideal for Offices and Factories:

- Large spaces like office buildings and factories benefit significantly from LED lighting:
- Cost Savings: The substantial energy savings translate into lower electricity bills for businesses.
- Better Illumination: Fewer fixtures provide ample light, creating a comfortable and productive environment.
- Maintenance Reduction: With longer lifespans, maintenance teams spend less time replacing bulbs.
- Cooler Operation: LEDs emit less heat, which is crucial in spaces where temperature control matters.

5. Daylight Harvesting:

Daylight harvesting is an energy-saving technique used in commercial buildings. Here's how it works: When sufficient natural light enters a space, the electric lights automatically dim or turn off. This helps reduce energy consumption by relying on available sunlight.

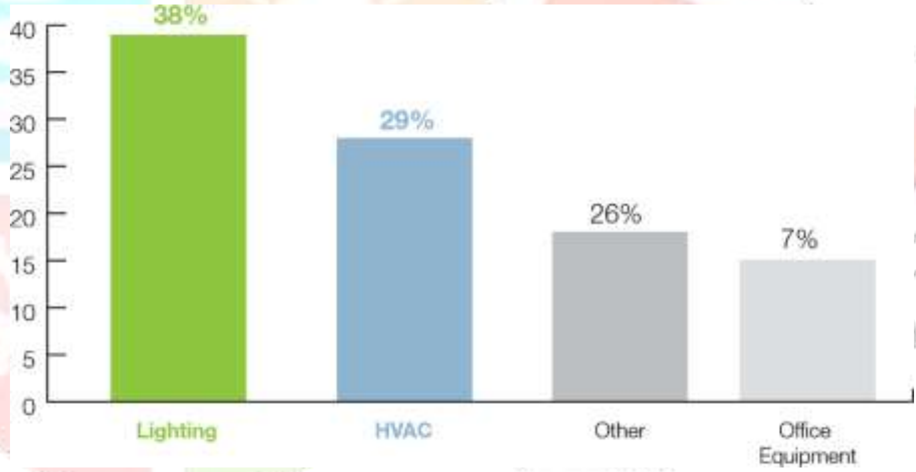


Figure 8 Annual electricity use an office building

The U.S. Department of Energy emphasizes that lighting accounts for approximately 38% of electricity usage in commercial buildings, exceeding other systems. To achieve substantial cost reductions, prioritizing lighting is essential. By implementing a thoughtfully designed daylight harvesting program, energy savings of 20-60% can be achieved, while maintaining appropriate illumination for inhabitants.

For conducting Daylight simulation, we have used DIALux software

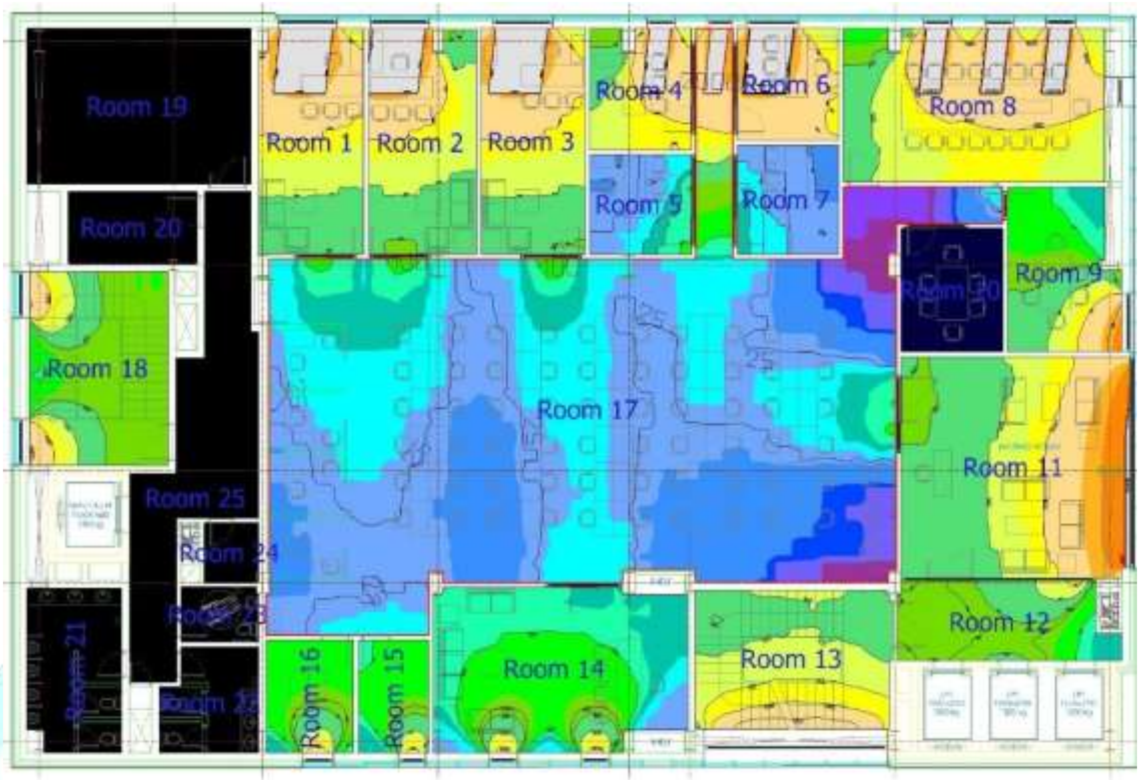


Figure 9 Daylight Simulation - Time: 9AM

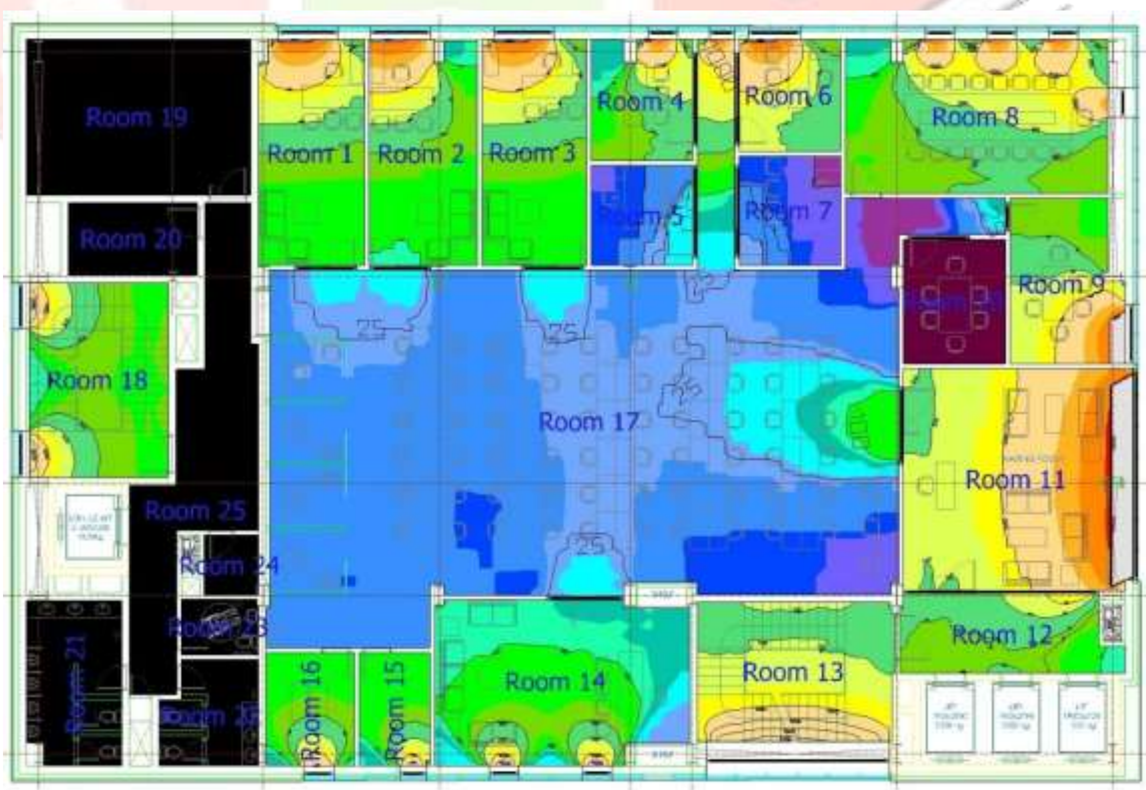


Figure 10 Daylight Simulation - Time: 12PM

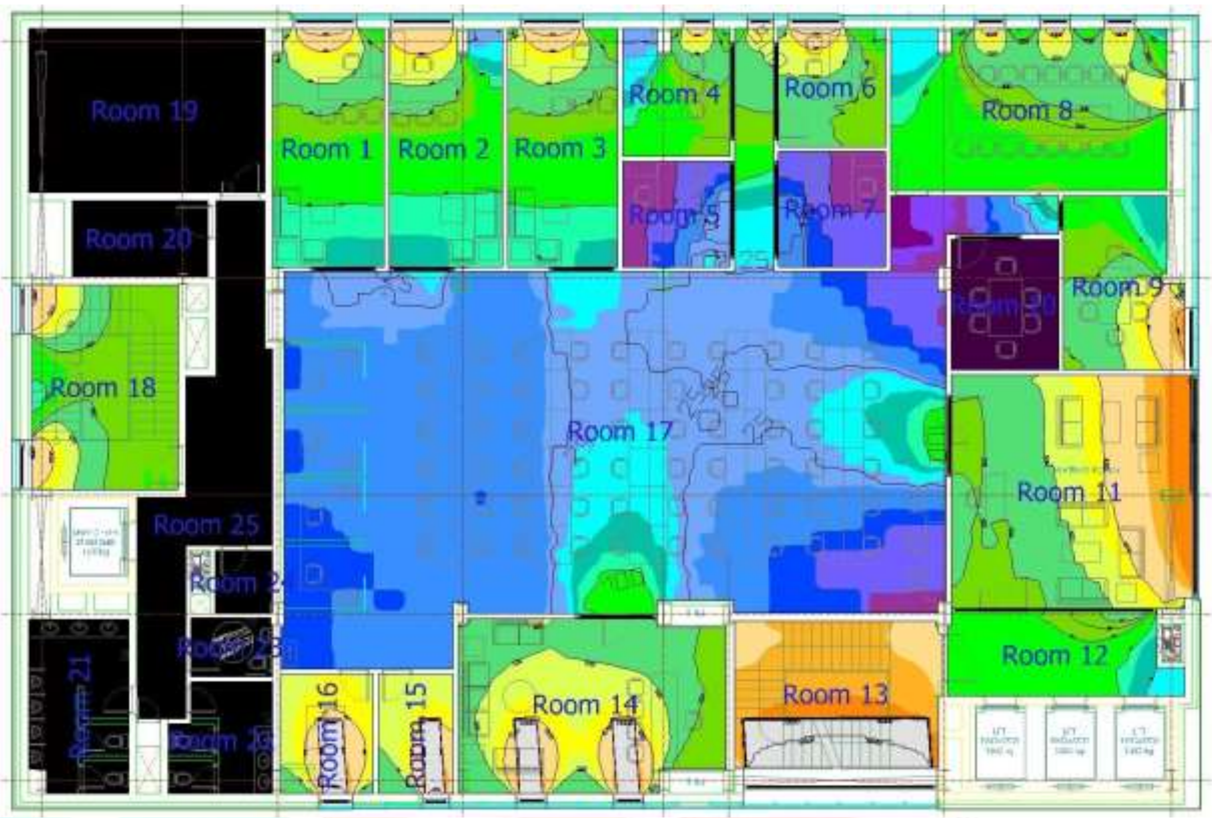


Figure 11 Daylight Simulation - Time: 4pm

Daylighting simulation tools allow us to assess how much natural light enters a room and how it's distributed. Here's what we discovered after simulating the building at different times (9 am, 12 pm, and 5 pm):

- **Sunlit Rooms:** Some rooms receive sufficient natural light during the day, eliminating the need for artificial lighting. These spaces achieve the desired lux level purely from sunlight.
- **Outer Periphery Rooms**: However, in most rooms near the outer edges of the building, we still require some artificial light. Using only 40-50% artificial lighting can achieve the desired lux level.

To harvest daylight effectively, we employ dimmers and sensors. These devices reduce electricity consumption by adjusting electric lights based on available natural light. By doing so, we can save 20-60% on energy costs. Additionally, this approach ensures that the light level remains appropriate for the space which is not too dark or bright either . The inhabitants benefit from automatic adjustments, eliminating the need for manual tweaking as daylight levels change.

Here are the results of the daylight simulation, showing the average maximum and minimum lux levels achieved by sunlight in different rooms throughout the day.

Building 1 · Storey 1 (Light scene 1)

Calculation objects

Work planes

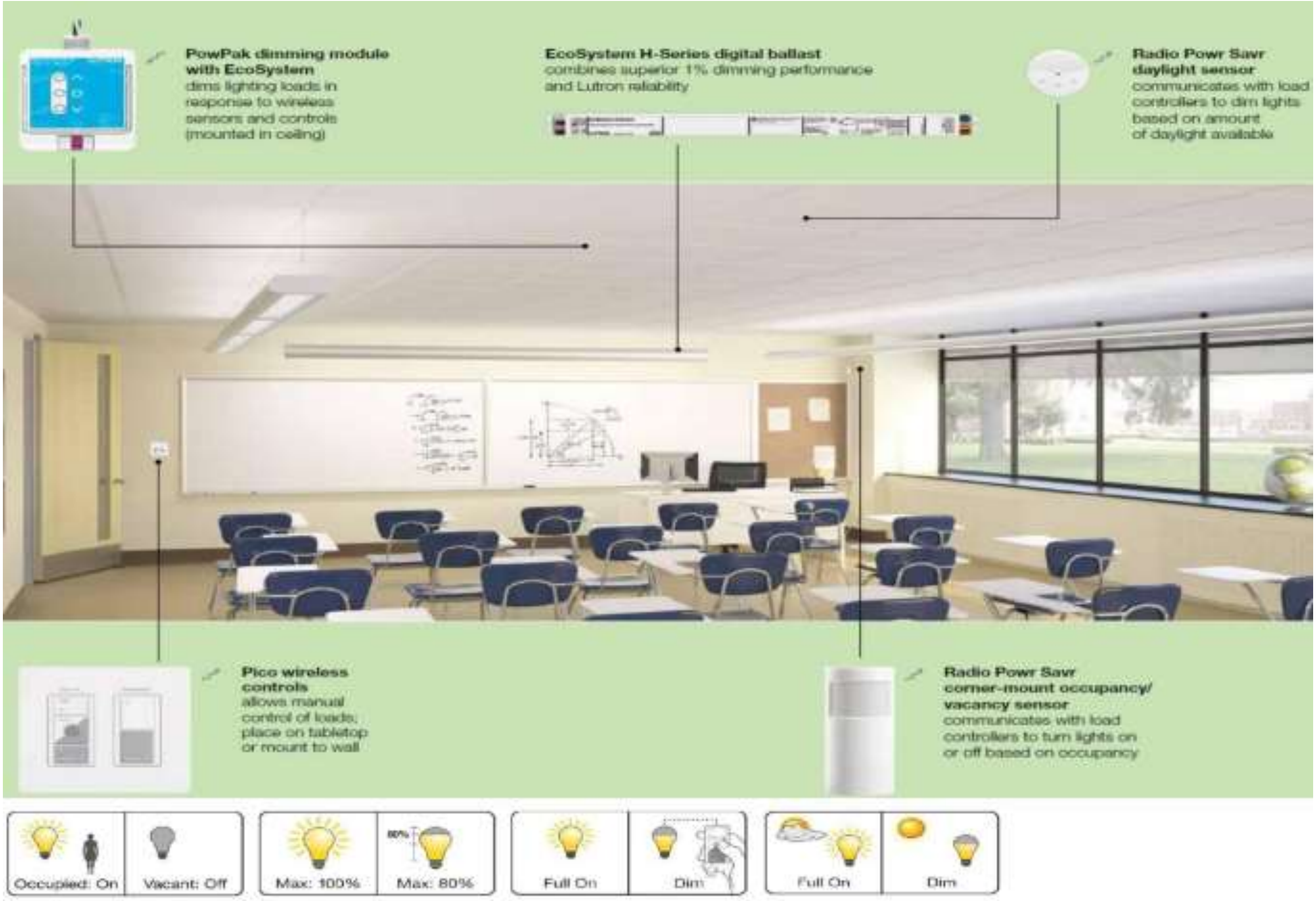
Properties	Ē (Target)	E_{min}	E_{max}	g_1	g_2	Index
Workplane (Room 1) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	663 lx (≥ 500 lx) ✓	107 lx	50234 lx	0.16	0.002	S2
Workplane (Room 2) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	599 lx (≥ 500 lx) ✓	54.3 lx	49203 lx	0.091	0.001	S4
Workplane (Room 3) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	678 lx (≥ 500 lx) ✓	104 lx	51825 lx	0.15	0.002	S6
Workplane (Room 4) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	467 lx (≥ 500 lx) ✗	57.0 lx	53169 lx	0.12	0.001	S8
Workplane (Room 5) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	15.8 lx (≥ 500 lx) ✗	7.29 lx	46.7 lx	0.46	0.16	S10
Workplane (Room 6) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	1110 lx (≥ 500 lx) ✓	225 lx	53838 lx	0.20	0.004	S12
Workplane (Room 7) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	9.37 lx (≥ 500 lx) ✗	4.52 lx	21.4 lx	0.48	0.21	S14
Workplane (Room 8) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	579 lx (≥ 500 lx) ✓	64.7 lx	53087 lx	0.11	0.001	S16
Workplane (Room 9) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	2962 lx (≥ 500 lx) ✓	147 lx	57792 lx	0.050	0.003	S18
Workplane (Room 10) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	0.80 lx (≥ 500 lx) ✗	0.80 lx	0.80 lx	1.00	1.00	S20
Workplane (Room 11) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	6260 lx (≥ 500 lx) ✓	378 lx	59499 lx	0.060	0.006	S22

Workplane (Room 12) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	330 lx (≥ 500 lx) ✗	72.2 lx	970 lx	0.22	0.074	S24
Workplane (Room 13) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	742 lx (≥ 500 lx) ✓	413 lx	1796 lx	0.56	0.23	S26
Workplane (Room 14) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	160 lx (≥ 500 lx) ✗	26.2 lx	1809 lx	0.16	0.014	S28
Workplane (Room 15) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	240 lx (≥ 500 lx) ✗	49.7 lx	1645 lx	0.21	0.030	S30
Workplane (Room 16) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	283 lx (≥ 500 lx) ✗	55.5 lx	2042 lx	0.20	0.027	S32
Workplane (Room 17) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	37.4 lx (≥ 500 lx) ✗	3.12 lx	17360 lx	0.083	0.000	S34
Workplane (Room 18) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	337 lx (≥ 500 lx) ✗	83.7 lx	1832 lx	0.25	0.046	S36
Workplane (Room 19) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	0.00 lx (≥ 500 lx) ✗	0.00 lx	0.00 lx	-	-	S38
Workplane (Room 20) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	0.00 lx (≥ 500 lx) ✗	0.00 lx	0.00 lx	-	-	S40
Workplane (Room 21) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	0.00 lx (≥ 500 lx) ✗	0.00 lx	0.00 lx	-	-	S42
Workplane (Room 22) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	0.00 lx (≥ 500 lx) ✗	0.00 lx	0.00 lx	-	-	S44
Workplane (Room 23) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	0.00 lx (≥ 500 lx) ✗	0.00 lx	0.00 lx	-	-	S46
Workplane (Room 24) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	0.00 lx (≥ 500 lx) ✗	0.00 lx	0.00 lx	-	-	S48
Workplane (Room 25) Perpendicular illuminance (adaptive) Height: 0.800 m, Wall zone: 0.000 m	0.00 lx (≥ 500 lx) ✗	0.00 lx	0.00 lx	-	-	S50

4.1 IN OFFICES:

1. One can adjust lighting according to their preferences, it enhances comfort and productivity.
2. Productivity Boost: Research indicates that there is a rise of 15% rise in productivity when they can Tailor to their specific requirements. Customizable lighting fosters a conducive work environment.
3. ROI and Energy Savings: Implementing such controls typically yields a return on investment (ROI) within approximately 3 years. Moreover, energy savings of up to 50% can be achieved by optimizing lighting based on individual requirements.

4.2 IN CLASSROOMS:



1. **Energy Efficiency and Learning Environment:** The ideal classroom seamlessly blends energy efficiency with a conducive learning environment. Achieving this balance is crucial for student well-being and productivity.
2. **Impact on Student Performance:** Classroom lighting directly influences student performance. Good lighting enhances concentration, mood, and overall cognitive function. It's more than just illumination; it's an essential part of effective education.
3. **ROI and Energy Savings:** Implementing quality lighting solutions typically yields a return on investment (ROI) within approximately 2.5 years. Moreover, optimizing lighting can lead to impressive energy savings—up to 77%.

4.3 In Conference Rooms:

ENERGY SAVING STRATEGIES

High-End Trim: Adjusting lighting fixtures to their optimal brightness level can significantly reduce energy consumption. High-end trim ensures that lights operate efficiently without unnecessary over-illumination. Occupancy/Vacancy Sensing.

Daylight Harvesting: As we discussed earlier, daylight harvesting involves using natural light effectively. By integrating sensors and dimmers, we can balance artificial lighting with available sunlight, achieving substantial energy savings.

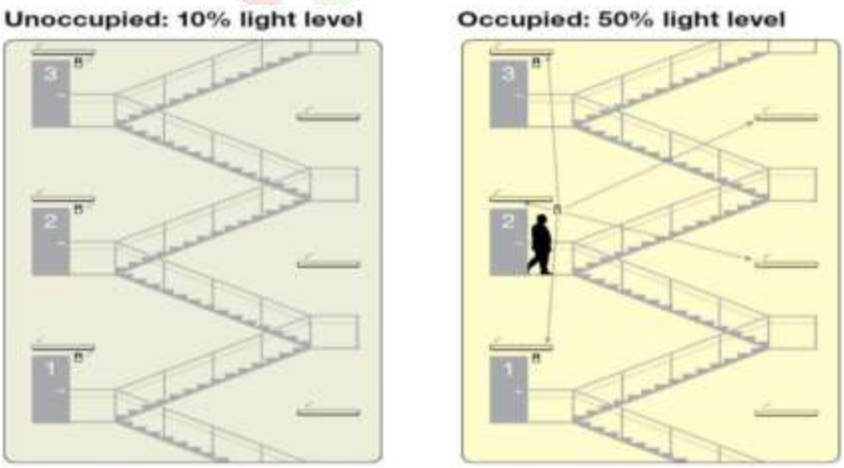
Personal Dimming Control: Allowing occupants to manage light levels as per their requirement enhances comfort and reduces unnecessary illumination. Personal dimming control ensures that each person can tailor lighting to their needs.

Controllable Window Shades: Window shades play a vital role in managing natural light. By adjusting shades to optimize daylight while minimizing glare, we maintain a comfortable environment and reduce reliance on electric lighting.

Timeclock Scheduling: Timed schedules automate lighting based on specific times of day. This ensures lights are only active when needed, contributing to overall energy efficiency.

In summary, implementing these strategies can result in impressive energy savings—up to 77%

4.4 In Staircase:



Conclusion

1. LED Lighting Efficiency: Electric lighting represents a substantial chunk (15-60%) of a structure's overall energy consumption. LED lamps offer substantial energy savings (approximately 50%) compared to fluorescent lighting. Their longer lifespan also contributes to cost-effectiveness. However, it's essential to consider aspects of lighting quality, including color rendering, light distribution, and flicker, to ensure user satisfaction.

2. Lighting Control Systems:

Electric Lighting Control: Implementing control systems can lower electric lighting consumption to a large extent. Occupancy-based systems, which adjust lighting based on user presence, show promise and can lead to energy savings ranging from 20% to 93%.

Daylight-Linked Controls: While they can result in substantial energy savings, real-world installations and estimating payback periods during the design phase can be challenging.

3. Beyond Energy Savings:

Improved quality of light: Upgrading lighting systems enhances occupant satisfaction, productivity, and overall well-being.

Corporate Image and Energy Security: A well-designed lighting retrofit positively impacts a company's image and contributes to energy security.

4. Intelligent Lighting System: Our proposed intelligent lighting system combines energy efficiency with user satisfaction:

Sensor Integration: We integrate motion and light sensors with LED luminaires.

Bluetooth Communication: The system uses Bluetooth wireless communication to operate lighting based on user needs.

Dynamic Light Intensity Adjustment: The system automatically adjusts light intensity, optimizing energy utilization.

Significant Power Reduction: Testing shows that this system significantly reduces total power consumption.

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