

Energy Wastage Management in College / Hostels

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Abstract: *Energy wastage in hostels and educational institutions is a persistent and under-addressed issue, primarily caused by human negligence and the absence of intelligent control mechanisms. Conventional solutions such as manual switching and passive infrared (PIR)-based motion detection fail to accurately determine human presence, leading to inefficient energy usage. This paper proposes an intelligent occupancy-based energy control system that integrates multi-parameter sensing, including motion detection, acoustic activity, ambient light conditions, and time-based decision logic. The system utilizes a microcontroller-based architecture to dynamically control electrical loads such as lighting and fans in a classroom environment. The proposed model demonstrates improved accuracy in occupancy detection and offers significant potential for reducing idle energy consumption, making it suitable for scalable deployment in educational institutions.*

Keywords: Energy Efficiency, Smart Classroom, Occupancy Detection, Microcontroller, Automation, Energy Conservation

I. INTRODUCTION

Energy conservation has become a critical concern in modern infrastructure, especially in educational institutions where classrooms and hostels operate for extended hours. A significant portion of energy is wasted due to lights and fans remaining switched on in unoccupied or partially occupied rooms. Traditional systems rely heavily on manual intervention or basic motion sensors, both of which are insufficient for accurately determining real occupancy. This research addresses the limitations of existing systems by proposing a smart, automated energy control solution that adapts to real-world usage conditions. The system is designed specifically for classroom environments, where occupancy patterns vary and static detection methods often fail.

PROBLEM STATEMENT

In typical classroom and hostel environments, energy wastage occurs due to:

- Lack of automated control systems
- Human negligence in switching off electrical appliances
- Inaccuracy of single-sensor systems such as PIR sensors
- Continuous operation of lighting during daylight hours

These challenges result in inefficient energy usage and increased operational costs.

PROPOSED SYSTEM

SYSTEM OVERVIEW

The proposed system is an intelligent occupancy-based control mechanism that automates the operation of classroom electrical loads. It integrates multiple sensing parameters to improve detection accuracy and reduce unnecessary energy consumption.



SYSTEM ARCHITECTURE

The system consists of the following main components:

- Multi-sensor input unit
- Microcontroller-based processing unit
- Relay-based output control unit
- Electrical load system (fans and lights)

The sensors collect environmental and activity-based data, which is processed by the microcontroller to make real-time decisions regarding load operation.

ELECTRICAL CIRCUIT DESIGN

CLASSROOM CONFIGURATION

A typical classroom setup includes:

- Multiple ceiling fans for ventilation
- LED lighting fixtures for illumination
- Optional power sockets for auxiliary devices

All electrical loads are connected in parallel to ensure uniform voltage distribution and independent operation.

CIRCUIT DISTRIBUTION

The electrical system is divided into separate circuits for:

- Lighting loads
- Fan loads
- Optional socket loads

Each circuit is protected using appropriate miniature circuit breakers (MCBs) and connected through a distribution board. This modular design enhances safety, reliability, and ease of maintenance.

INTELLIGENT CONTROL MECHANISM

MULTI-PARAMETER SENSING

Unlike traditional systems, the proposed model uses multiple sensors to detect occupancy more accurately:

- Motion Sensor (PIR): Detects physical movement
- Sound Sensor: Detects human activity such as conversation
- Light Sensor (LDR): Measures ambient light intensity
- Time Module (RTC): Enables time-based control

DECISION LOGIC

The system uses a rule-based decision algorithm to determine the operational state of electrical loads:

- Electrical loads are activated when occupancy is detected through motion or sound
- Loads are turned off after a predefined period of inactivity (Example : 10 minutes)
- Lighting is automatically disabled when sufficient natural light is available
- All loads are turned off outside scheduled operational hours

This approach ensures that the system responds dynamically to real-world conditions rather than relying on a single parameter.



OLD EQUIPMENTS STILL IN USE



Regulators and switch board



Fans



Lights

IMPLEMENTATION METHODOLOGY

HARDWARE IMPLEMENTATION

The system is implemented using:

- A microcontroller (e.g., Arduino or ESP32)
- Sensor modules for input data collection
- Relay modules for switching electrical loads
- Standard electrical wiring and protection devices



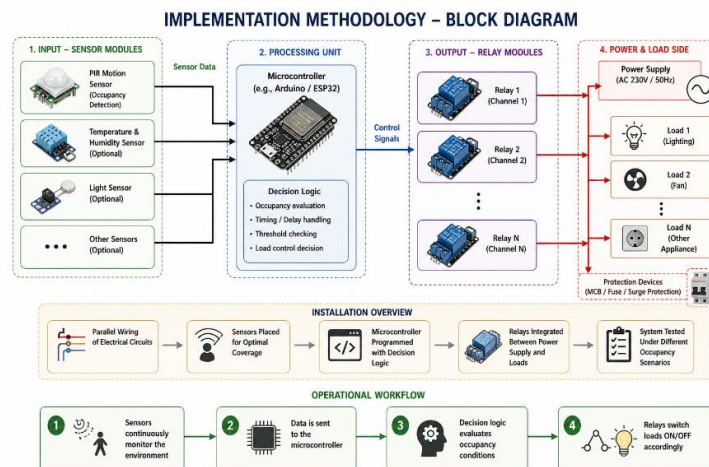
INSTALLATION PROCESS

- Electrical circuits are installed using parallel wiring
- Sensors are strategically placed for optimal coverage
- The microcontroller is programmed with decision logic
- Relays are integrated between the power supply and loads
- The system is tested under different occupancy scenarios

OPERATIONAL WORKFLOW

- Sensors continuously monitor the environment
- Data is sent to the microcontroller
- Decision logic evaluates occupancy conditions
- Relays switch loads ON/OFF accordingly

OPERATIONAL BLOCK DIAGRAM



CALCULATED POWER CONSUMPTION OF IIRD YEAR CLASSROOM IN MARCH 2026

Given :

Fans = 7 ----- 80 wh , 4hours (during class), 1-2 hour (lunch and other activities)
total = 6hours 30min average

Lights = 10 -----40 wh , same as fans

Projector = 1 -----50 wh , 2-3 times a month

CPU = 1 -----10 wh , same as projector

Power rating :

Fans = 7 * 80 wh = 560 Wh

0.560 Kwh * 6hr 30min = 3.64 Kwh

Lights = 10 * 40 wh = 400 Wh

0.400 Kwh * 6hr 30min = 2.60 Kwh



Projectors = $1 * 50 \text{ wh} = 50 \text{ wh}$
 0.05 wh

CPU = $1 * 10 = 10 \text{ wh}$
 0.01 wh

Lights + Fans (1day)
 $= 3.64\text{Kwh} + 2.6\text{Kwh}$
 $= 6.24 \text{ Kwh}$

For 20 days / 30 days (4 Sundays + 5-6 other holidays) in average
 $= 6.24\text{Kwh} * 20$
 $= 124.8\text{Kwh}$

NEW CALCULATED POWER CONSUMPTION OF IIIRD YEAR CLASSROOM IN MARCH 2026 (uses LED lights efficient fans)

1. Efficient Devices

LED lights: $40\text{W} \rightarrow 20\text{W}$

Fans (new): $80\text{W} \rightarrow 50\text{W}$

2. Smart Control Savings

Based on your logic:

Auto OFF during idle time

Daylight usage

Time control

Conservative assumption:

30% time reduction

So:

$6.5 \text{ hrs} \rightarrow \sim 4.5 \text{ hrs effective}$

NEW CALCULATIONS

Fans:

$7 \times 50 \text{ W} = 350 \text{ W} = 0.35 \text{ kW}$

Energy = $0.35 \times 4.5 = 1.58 \text{ kWh/day}$

Lights:

$10 \times 20 \text{ W} = 200 \text{ W} = 0.20 \text{ kW}$

Energy = $0.20 \times 4.5 = 0.90 \text{ kWh/day}$

Total (per day):

$= 1.58 + 0.90 = 2.48 \text{ kWh/day}$

Monthly:

$= 2.48 \times 20 = 49.6 \text{ kWh/month}$

FINAL COMPARISON

System Energy (kWh/month)

Old System = 124.8

New System = 49.6



EFFICIENCY IMPROVEMENT

Energy Saved:

$$= 124.8 - 49.6 = 75.2 \text{ kWh}$$

% Efficiency Improvement:

$$\text{"Efficiency Improvement"} = (\text{"Old"} - \text{"New"}) / \text{"Old"} \times 100$$

$$= (75.2 / 124.8) \times 100$$

$$= \approx 60.25\% \text{ energy savings}$$

The proposed system is ~55-60% more energy Efficient than the traditional system

WHY THIS HUGE IMPROVEMENT?

1. Efficient Hardware (~30–35%)

LED consumes less power

New fans are optimized

2. Smart Control (~20–30%)

No idle running

Auto shutoff

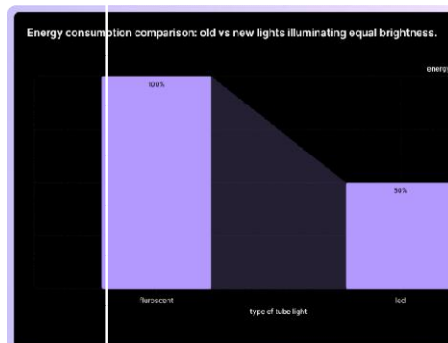
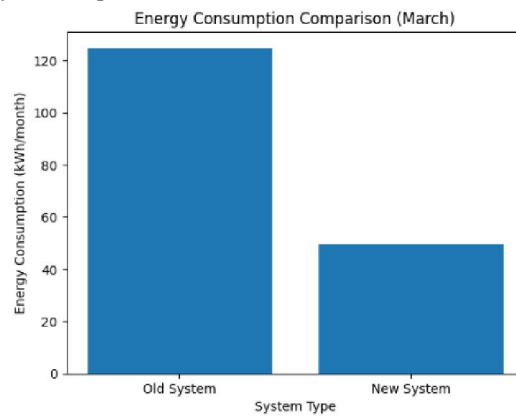
Time-based control

3. Daylight Optimization (~5–10%)

Lights OFF during daytime

GRAPH (OLD vs NEW TECHNOLOGY)

Graphical representation of energy consumption of OLD VS NEW



ADVANTAGES

- Reduces energy wastage in educational institutions
- Minimizes dependency on human intervention
- Improves accuracy of occupancy detection
- Scalable for large deployments (schools, colleges, hostels)
- Cost-effective over long-term usage

LIMITATIONS

- Initial installation cost is higher than traditional systems
- Requires proper calibration of sensors (According to the Classroom / Area of usage)
- Performance depends on correct placement of sensors

II. RESULTS AND DISCUSSION

The proposed system significantly improves the efficiency of energy usage in classroom environments. By incorporating multiple sensing parameters, the system overcomes the limitations of traditional single-sensor approaches. It effectively reduces unnecessary operation of fans and lights during idle periods and adapts to varying environmental conditions.

The system is particularly effective during:

- Idle classroom periods
- Partial occupancy scenarios
- Daytime operation with natural lighting

FUTURE SCOPE

Future improvements can include:

- Integration with IoT platforms for remote monitoring
- Machine learning-based occupancy prediction
- Mobile application for real-time control and analytics
- Expansion to full building energy management systems
- Scalable at the college level for the maximum output efficiency

III. CONCLUSION

This paper presents an intelligent occupancy-based energy control system tailored for classroom environments. By integrating multi-parameter sensing and microcontroller-based decision logic, the system provides an effective solution to the problem of energy wastage in educational institutions. The proposed approach enhances operational efficiency, reduces unnecessary energy consumption, and offers a scalable solution for modern infrastructure.

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