Survey Report: IoT-Based Energy Optimization in Classrooms

# Introduction

The increasing demand for smart infrastructure has pushed institutions to adopt intelligent energy-saving technologies. In classrooms, energy is often wasted due to manual operation of electrical appliances, irrespective of occupancy. This report surveys the recent research contributions in the area of IoT-based energy optimization with a focus on human detection, appliance control, and smart automation using lightweight edge computing.

# Detailed Survey of Research Papers

## IoT-Based Energy Conservation Smart Classroom System

Focus: Real-time control and monitoring of classroom devices using IoT.

Strengths: Efficient in basic energy saving.

Limitations: Lacks advanced localization or human differentiation.

Link: https://www.researchgate.net/publication/362806572

## Smart Energy Management in Classroom using IoT

Focus: Uses ML to optimize energy consumption patterns in education spaces.

Strengths: Analytical approach with usage insights.

Limitations: No real-time automation or edge deployment.

Link: https://www.researchgate.net/publication/368940902

## Energy Conservation Smart Classroom System using IoT

Focus: Cost-effective IoT-based appliance control system.

Strengths: Affordable and easy to deploy.

Limitations: No advanced sensing or AI model integration.

Link: https://www.scienceimpactpub.com/journals/index.php/IJAM/article/download/546/283/3125

## IoT-Based Energy Efficient Smart Classroom

Focus: Zonal energy control using IoT devices.

Strengths: Implements spatial control.

Limitations: Human presence detection not accurate in complex scenarios.

Link: https://www.researchgate.net/publication/348149991

## Automation of IoT-Based Classroom: Integrating Light, Fan

Focus: Automated light/fan control based on basic sensors.

Strengths: Practical implementation-oriented.

Limitations: No machine learning or human-specific logic.

Link: https://www.irjmets.com/uploadedfiles/paper/issue\_5\_may\_2024/56136/final/fin\_irjmets1716046285.pdf

## Energy Smart Saving Classroom with IoT Based

Focus: Combines IoT for access and energy usage control.

Strengths: Multi-function system.

Limitations: Lacks localized control and automation.

Link: https://www.researchgate.net/publication/345333023

## Classroom Light and Fan Automation

Focus: Basic automation of lights and fans using sensors.

Strengths: Improves energy efficiency.

Limitations: Does not adapt to real-time occupancy zones.

Link: https://www.researchgate.net/publication/366965295

## Automated Light Control for IoT Application

Focus: Practical use of IoT for daily energy-saving automation.

Strengths: Hands-on guide.

Limitations: Not optimized for classroom scale.

Link: https://www.researchgate.net/publication/371827112

## IoT-Based Smart Classroom Automation System

Focus: Real-time control and monitoring using IoT.

Strengths: Emphasizes user-friendliness.

Limitations: Manual overrides dominate automation.

Link: https://ijariie.com/AdminUploadPdf/IoT\_\_Based\_Smart\_Classroom\_Automation\_System\_ijariie26185.pdf

## IoT-Based Smart Classroom

Focus: Dynamic booking and appliance control via mobile apps.

Strengths: Mobile integration.

Limitations: Lacks true automation.

Link: https://www.researchgate.net/publication/352570013

# Identified Gaps from Literature

* - Lack of real-time, edge-level automation based on actual occupancy.
* - Inadequate zone-based control in most systems.
* - Heavy reliance on cloud infrastructure, increasing latency.
* - Few solutions integrate sensor fusion (AI vision + distance sensors).
* - Commercial systems are often expensive and not scalable.

# Pros and Cons of Existing Systems

|  |  |  |
| --- | --- | --- |
| Aspect | Pros | Cons |
| IoT Integration | Affordable, customizable | Often lacks intelligence for fine control |
| Machine Learning Integration | Offers smart decision-making | Most models are too heavy for edge devices |
| Energy Savings | Observable reduction in energy consumption | Impact limited without human-specific control |
| Commercial Systems | Reliable and user-friendly | Expensive, app-dependent, not ideal for shared environments |
| Edge AI (TinyML) | Real-time, offline functionality | Accuracy and capability trade-offs due to limited processing power |

# Conclusion

The reviewed literature clearly highlights the evolution from basic motion-based automation to intelligent, AI-driven energy optimization systems. While many existing models show promise, gaps such as lack of localized control, absence of lightweight AI deployment, and poor integration with distance-based zoning still persist. The proposed system in your project addresses these gaps by deploying a real-time, zone-aware IoT solution powered by edge-based AI. This positions your solution as an effective step toward building sustainable, intelligent classroom environments.