SMART CLASSROOM ENERGY OPTIMIZATION SYSTEM USING PREDICTIVE ANALYTICS

Project Proposal

Project Title

Smart Classroom Energy Optimization System Using Predictive Analytics

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1. Introduction

Energy conservation has become an important concern for educational institutions due to rising electricity costs and environmental impact. In colleges and universities, classrooms consume a significant amount of energy through lights, fans, and air conditioners. Often, these devices remain operational even when classrooms are partially occupied or completely vacant.

Most existing energy management solutions depend on manual monitoring or expensive IoT-based sensor systems. Manual control is inefficient, and hardware-based solutions are costly and difficult to maintain. Therefore, there is a need for a software-based, intelligent, and cost-effective system that can optimize classroom energy usage without relying on physical sensors.

This project proposes a Smart Classroom Energy Optimization System that uses class schedules, historical attendance data, and predictive analytics to estimate classroom occupancy and generate energy usage recommendations. The system helps administrators reduce energy wastage while maintaining a comfortable learning environment.

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2. Problem Statement

Educational institutions experience significant energy wastage due to inefficient classroom energy usage. Electrical appliances remain switched on even when classrooms are underutilized or unused. There is no intelligent system that predicts classroom occupancy in advance and optimizes energy usage accordingly.

Manual supervision is unreliable and time-consuming, while IoT-based solutions require additional infrastructure and cost. Hence, a software-driven system that predicts occupancy and suggests energy optimization actions is required.

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3. Proposed Solution

The proposed system analyzes: - Existing class timetables - Historical attendance records - Classroom capacity and subject type

Using this data, the system: 1. Predicts the probability of classroom occupancy 2. Applies rule-based logic to decide optimal energy usage 3. Generates energy usage recommendations 4. Produces energy consumption and savings reports

The system does not create class schedules or physically control devices. Instead, it acts as a decision-support system for administrators.

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4. Objectives

1. To collect and organize classroom-related data, including class schedules, classroom capacity, subject type, and historical attendance records.
2. To preprocess and analyze the collected data by cleaning, formatting, and selecting relevant features required for occupancy prediction.
3. To design and implement a machine learning model that predicts classroom occupancy levels based on timetable and historical usage patterns.
4. To develop a rule-based energy optimization engine that generates energy usage recommendations using predicted occupancy levels.
5. To design and implement a backend system for managing classroom data, schedules, and prediction results.
6. To develop a user-friendly frontend interface for administrators to view occupancy predictions, energy recommendations, and reports.
7. To estimate classroom energy consumption and potential energy savings using predefined power usage parameters.
8. To evaluate the performance of the prediction model using appropriate metrics such as accuracy and consistency.
9. To integrate all system modules into a complete decision-support system for classroom energy optimization.

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5. Scope of the Project

The scope of this project includes: - Web-based or mobile-based application - Classroom and timetable management - Occupancy prediction using machine learning - Rule-based energy optimization - Visualization of energy usage and savings

Out of Scope: - Real-time sensor-based monitoring - Automatic device switching - Physical hardware integration

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6. System Overview

Inputs

- Class timetable (day, time slot, subject)
- Classroom capacity
- Historical attendance percentage
- Subject type (theory/lab)

Processing

- Data preprocessing
- Occupancy prediction using ML
- Energy optimization using rule-based logic

Outputs

- Predicted occupancy percentage
- Energy usage recommendation (lights/AC ON/OFF)
- Estimated energy consumption
- Energy saving reports and dashboards

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7. System Architecture (Module Description)

1. User Authentication Module

- Admin login
- Role-based access

2. Timetable & Classroom Management Module

- Upload or enter class schedules
- Manage classroom details

3. Occupancy Prediction Module

- Uses historical data
- Predicts occupancy probability

4. Energy Optimization Rule Engine

- Applies predefined rules
- Generates recommendations

5. Analytics & Reporting Module

- Energy usage charts
- Daily/weekly/monthly reports

8. Methodology

1. Collect timetable and attendance data
2. Preprocess data and extract features
3. Train a machine learning model for occupancy prediction
4. Apply rule-based logic for energy optimization
5. Display results through dashboards and reports

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9. Machine Learning Approach

Algorithm Used

- Logistic Regression (primary)
- Decision Tree (optional)

Input Features

- Day of the week
- Time slot
- Subject type
- Attendance percentage
- Room capacity

Output

- Occupancy probability (Low / Medium / High)

Evaluation Metrics

- Accuracy
- Prediction consistency

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10. Energy Optimization Logic

Occupancy Level	Recommendation
< 30%	Lights OFF, AC OFF
30–60%	Lights ON, AC OFF
> 60%	Lights ON, AC ON

Energy consumption is estimated using predefined power values for classroom devices.

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11. Technology Stack

- Frontend: HTML, CSS, Bootstrap / Flutter
- Backend: Flask or Django (Python)
- Machine Learning: Python, Scikit-learn
- Database: SQLite
- Visualization: Chart.js

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12. Expected Outcomes

- Accurate prediction of classroom occupancy
- Reduction in energy wastage
- Clear energy optimization recommendations
- Analytical reports for decision-making
- Improved energy management efficiency

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13. Team Structure & Responsibilities

- Member 1: Frontend design and user interface
- Member 2: Backend development and database
- Member 3: Machine learning and analytics

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14. Project Timeline

Week	Task
1	Requirement analysis & design
2	UI & database schema
3	Backend implementation
4	ML model development
5	Integration & testing
6	Documentation & presentation

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15. Future Enhancements

- Integration with IoT sensors
- Real-time occupancy tracking
- Mobile app notifications
- Automatic device control

16. Conclusion

The Smart Classroom Energy Optimization System offers a practical, scalable, and cost-effective approach to reducing energy wastage in educational institutions. By using predictive analytics and intelligent decision-making, the system supports sustainable energy usage without requiring expensive hardware.