Smart Energy-Saving Room Using Occupancy Count + Ambient Light Sensing

1. Problem Statement

Electricity is often wasted when lights and fans remain switched ON in unoccupied rooms or during daylight hours. Conventional systems relying on motion detection (PIR sensors) are not always reliable, especially when occupants are stationary. This leads to significant energy loss in homes, offices, and classrooms. There is a need for an intelligent system that not only detects room occupancy accurately but also considers ambient light levels to optimize energy usage.

2. Scope of the Solution

This project presents a smart, microcontroller-based solution that uses two IR sensors to detect entry and exit, maintaining an accurate count of people in a room. It uses an LDR (Light Dependent Resistor) to measure ambient light levels. A relay module or LED is used to switch lights ON/OFF based on occupancy and light conditions. The system operates autonomously using an Arduino UNO and can be extended with IoT features using ESP32. It can be deployed in homes, classrooms, meeting rooms, and other smart building environments.

3. Required Components

- Arduino UNO
- 2 × IR sensors (TCRT5000 or modules)
- LDR + 10kΩ resistor (for voltage divider)
- 1 × LED + 220Ω resistor (or relay module)
- Breadboard and jumper wires
- Tinkercad (for simulation)
- Arduino IDE (for coding)

4. Circuit Description and Working

The system uses two IR sensors to detect entry and exit events. These are connected to Arduino digital pins (D2 and D3) and increment or decrement a person counter. An LDR connected to analog pin A0 senses the ambient light. If at least one person is in the room and the ambient light is low (below a threshold), the Arduino turns ON the relay or LED connected to D8. Otherwise, it turns it OFF. This ensures that lights are used only when necessary.

5. Simulation and Output

The system was simulated in Tinkercad. Push buttons were used to simulate the IR sensor triggers for entry and exit. The serial monitor shows live updates of the occupancy count

and ambient light readings. When the room is occupied and dark, the LED turns ON. Otherwise, it remains OFF.

6. Conclusion

This prototype successfully demonstrates an energy-efficient system that intelligently controls lighting based on both occupancy and natural light. It can reduce electricity consumption in smart buildings and be extended to larger systems with IoT integration, LCD displays, or even mobile app control.