# Real Time Automation Systems for Home Electrical Energy Waste Reduction

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## Abstract

Mostly in home and office appliances, lights and fans are manually controlled which leads to power waste. They are left ON even if there is no usage of them. Their operation is not controlled by environmental conditions like daylight and temperature variation. By making a smart automated controlling system for appliances we can save huge amounts of power. In this paper, we are providing a solution for preventing the waste of home electric power in a comfortable and cost effective way. Our system utilizes the use of Infrared Object Detection Sensors and the Motion Sensors. Depending on the person's presence, devices such as lamps, fans, etc. are switched on or off. An example of an apartment is given for the system application. The cost is calculated and the investment impact on the long run is discussed.

**Keywords:** *Smart Lighting, SMS (Short Message Service), Ultrasonic sensor Hc-sr04, Automation Systems, Bluetooth, Android, ESP8266, ESP32, NodeMCU.*

## 1. Introduction

More energy is required by home appliances like light, air conditioners, or fan (heating, cooling) that are physically kept under control, which leads to power consumption. By using smart automatic controlling systems, we can save huge amounts of home electric power. Home automation can boost comfort and security in homes. It can also save and invest money. It influences the climate and then lower utility bills will result. If the user leaves home to conserve fuel, prevent a short circuit, and so on the user must switch off all lights, fans, and electricity. Occasionally, we fail to turn them off. So, we must return home to sign off. This consumes time, power and money and generates a lot of worrying sensations. The new technology in the world is the smart home that prevents such circumstances. Experts expect smart lighting to replace normal lighting in the near future and become the major industry [1, 2, 20].

The systems for home automation are rapidly increasing. They are used to provide all people with comfort, convenience and safety. The majority of home automation systems are now used to provide comfort for the elderly and disabled and to reduce human labour [3] and consumed power.

This paper aims to prevent the consumption of energy in an adequate and cost-effective way. A system for automatically controlling the home appliances is proposed. When the user enters a room, the light and fan will automatically turn ON, and when the user exits, they will automatically turn OFF. The paper uses PIR sensors and Infrared object detection sensors.

This paper is composed of five sections. The first section is an introduction and the second section is a literature review. The third section gives the methodology and the fourth section explains the results. The fifth section highlights some conclusions as well as some points for the future research. A list of the used references is given at the end of the paper.

## 2. Literature Review

The previous research shows that home appliances, such as lights, dryers, stoves, etc, are controlled by three methods: IR, Bluetooth, and GSM. The Remotexy software creates an application for the android computer while Arduino IDE creates a design for Arduino. This offers a cost-efficient, convenient and easy-to-use home automation framework and an enhanced energy saving feature [4].

Different technologies, such as ZigBee [5], Z-Wave [6], Global Mobile System (GSM)[7], General Packet Radio Service (GPRS)[8], Infrared[9], wireless fidelity (Wi-Fi)[10-11] and Bluetooth[12], have their own advantages and disadvantages in each system. A wireless home automation system with a Bluetooth-based base can be installed in the existing home at a low price and easy to install [13]. In a physical range from 10 m to 100 m, Bluetooth technology is capable of sending data in series up to 3 Mbps according to the Bluetooth system type.

The smart home model allows controlling any devices through voice reorganization technology [14].The home appliances can be controlled through voice and touch system using Bluetooth module [15]. The devices can be controlled by a fingerprint process, after the double verification to grant access to the home [16]. Also it can control the appliances by sending commands through email; that time Internet should be active at home and user end [17]. The Internet protocol can be used to control an android smartphone for any emergency from remote places [18]. The remote access system of home appliances can be done with the GSM communication [19].

## 3. The Proposed System

In this section, we explain the hardware and algorithm components of the design. Also, the implementation of these components will be illustrated. Fig.1 shows the block diagram of the proposed system.

### 3.1 Hardware Components Used in the System:

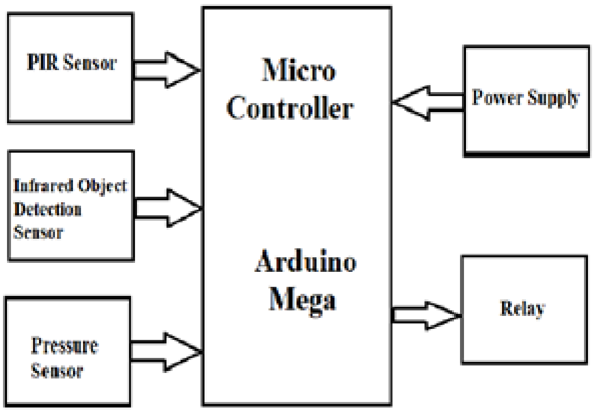



**Fig.1 Block diagram of the proposed system**

### 3.1.1 Arduino Mega

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button [21]. It is programmed based on Arduino (IDE).

### 3.1.2 Passive Infrared Sensor

A passive infrared sensor allows sensing motion, used to detect whether a person has stimulated in or out of the sensor's range. They are undersized, cheap, low-power, and simple to use. PIRs are essentially made of pyroelectric sensors, which can detect levels of infrared radiation [22].

### 3.1.3 Infrared Object Detection Sensor

This infrared object detection sensor has a pair of infrared transmitting and receiving LEDs. Infrared is emitted at a certain frequency, and when meets an obstacle (reflecting surface), reflected infrared is received. After the comparator circuit processing, the green indicator will light up. At the same time, a digital signal (a low-level signal) is detected at the OUT pin [23]. The distance can be adjusted using the potentiometer knob. The effective distance range is(2 ~ 30) cm, the working voltage is 3.3V to 5V and the detection angle is 35°. When the LED indicator is red, the power turns on, and the color turns green meaning detection.

### 3.1.4 Relay

Relay is an electromagnetic device, used to separate two circuits electrically and attach them magnetically. It is used to control the switching of an electrical circuit OFF or ON at high AC voltage by means of a low DC control voltage. Relay is a very useful tool for allowing one circuit to control another circuit, whereas they are totally disconnected. They are used to interface a low voltage electronic circuit with a high voltage electrical circuit.

### 3.1.5 Pressure Sensor

This sensor is a very thin, robust, polymer device that decreases in resistance when pressure is increased on the surface of the sensor. It is used to sense pressure, weight, contacts, and as a touch sensor. These sensors are simple to set up. Fig.2 shows the circuit diagram of the proposed system.

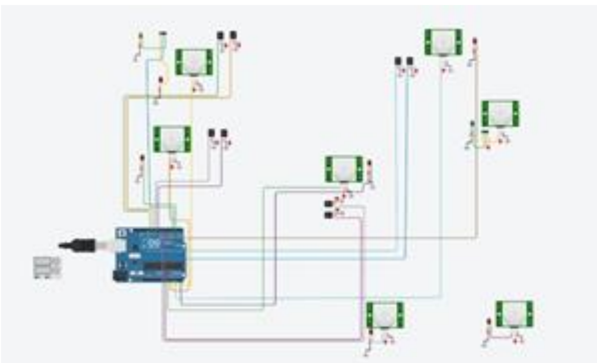


**Fig.2 Circuit diagram of the proposed system**

### 3.2 Design and Implementation of the Smart System

A simple example of a smart apartment is shown in Fig.3. The control of apartment appliances is based on using two Infrared object detection sensors at the entrance of each room as in Fig.٤. One PIR sensor is mounted in the ceiling of each room and two pressure sensors are located under an office chair and under the bed to sense a person's pressure. The aim of putting two IR sensors, not one to determine the person’s direction, is he going to enter the room or leave it? Then, the lighting switch is turned ON/OFF. Also, it counts the number of people in the room.

The Arduino has an input power. When the IR and PIR sensors detect the person entrance, they send signals to Arduino and it will give the output through a relay and the light or fan will be switched ON


**Fig.3 Simple model of smart home**

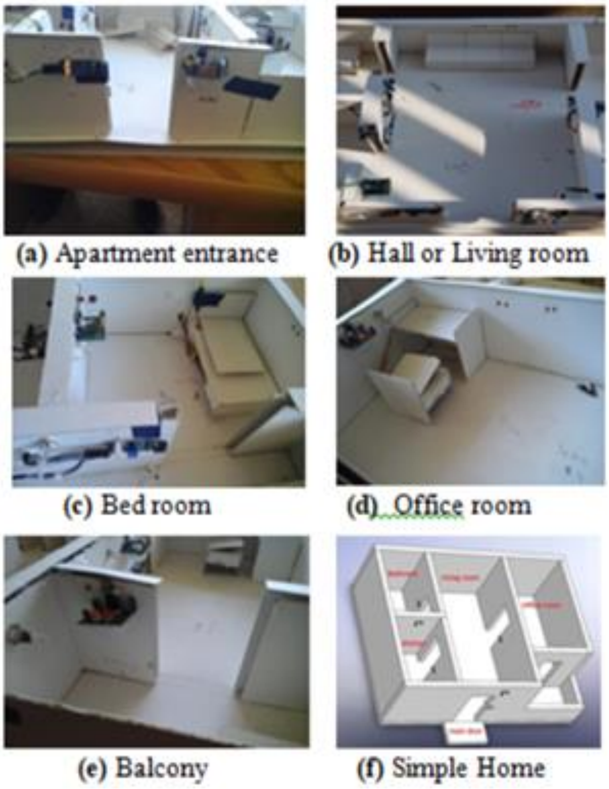



**Fig.4 Rooms of the applicable model**

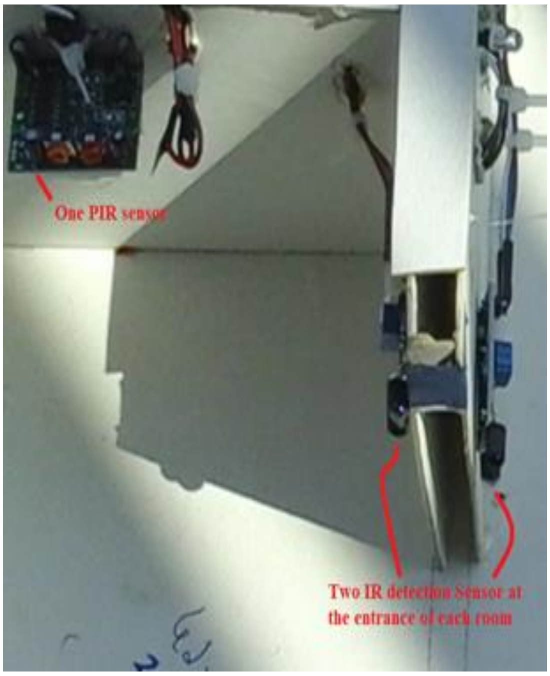
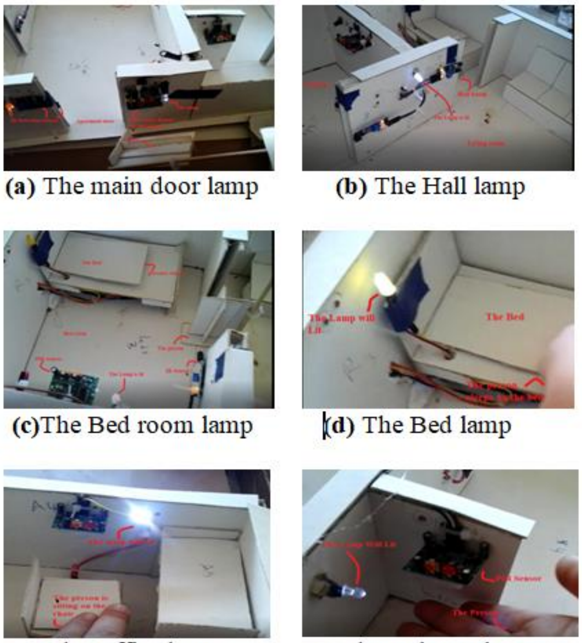



**Fig.5 The number of sensors in each room**



**(a)** The main door lamp **(b)** The Hall lamp

**(c)**The Bed room lamp **(d)** The Bed lamp

**(c)**The Office lamp **(d)** The Balcony lamp

**Fig.6The Lighting cases for different rooms**

The simple model of applicable smart home rooms consists of a living room, a bedroom, an office room, a kitchen and a bathroom (the same devices), as well as a balcony as in Figs .3,4. There are two Infrared object detection sensors at the entrance of each room and one PIR sensor in the ceiling of each room as in Figs.5,6.

### 3.3.2The System Scenario

(1) At first, the system is in the "disable" state.

The following scenarios can be applied to compute the energy consumption in the apartment. These scenarios can be taken like units to be generalized for the whole building and then for a whole city. Some modifications may be needed for the buildings to control the lighting devices of areas not used for living. The same concept may be allied for cities to control the devices in the streets.

**(2) If there is a person in the apartment**

**a) Living room (Hall) and apartment door**

1. In Fig 7 (a), when someone is moving in front of the apartment door, the lamp there will be lit.
2. When someone enters the hall in the apartment, the IR sensor counts the number of people entering the room, and when the PIR sensor senses a movement of anyone, the lamp lights up as in Fig7(b). If the sensor does not sense the movement, the lamp will turn on for seven seconds and then turns off.
3. Living room component cost = 2 IR + Motion Sensor = (2*30) + 40 = 100 L.E

4. The consumption power for 40 W/h bulb and 100 W/h fan = 140 W/h

**(a)** The main door lamp **(b)** The Hall lamp

**Fig.7 The Lighting cases for Hall and apartment door**

## B) Bedroom

1. When a person enters the bedroom, the large lamp lights up as in Fig.8(a), when the person sits in bed, the pressure sensor sends a signal to the Arduino, the large lamp turns off and the small lamp turns on as in Fig.8(b).
2. Bed room component cost = 2 IR + Motion Sensor + Pressure Sensor = (2 * 30) + 40 + 80 = 180 L.E
3. The consumption power for 40 W/h bulb and 100 W/h fan = 140 W/h


**(a)**The Bed room lamp **(b)** The Bed lamp

**Fig.8 The Lighting cases for the bed and bed room**

## C) The Office room

1. There are two lamps in the office room, a lamp for the room and a lamp for the office. Only when a person enters the office room, the room lamp lights up and when he sits on the office chair, the pressure sensor sends a signal to the Arduino and the office lamp is lit. If the person stands up, the office lamp switches off. Fig.9 explains these situations. When the person moves in front of the office without sitting on the office chair, the office lamp will stay turned on. When the person stops in front of the office, the office lamp turns on for 7 seconds, and then it is turned off.

2. Office room component cost = 2 IR + 2 Motion Sensor + Pressure Sensor = (2 * 30) +(2 * 40) + 80 = 220 L.E
3. The consumption power for 40 W/h bulb and 100 W/h fan = 140 W/h


**Fig.9 The Lighting cases for the office room**

### D) Kitchen or bathroom

1. When someone enters the kitchen, the IR sensor counts the number of people entering the kitchen, and when the PIR sensor senses a movement of anyone, the lamp turns on. When the sensor does not sense the movement, the lamp will turn on for seven seconds and then turns off.
2. Kitchen component cost = 2 IR + Motion Sensor = (2 * 30) + 40 = 100 L.E
3. The consumption power is 40 W/h Lamp.

### E) Balcony

1. In this system, only one motion sensor is used as in Fig.10.
2. Balcony component cost = Motion Sensor = 40 L.E
3. The consumption power is 40 W/h Lamp.


**Fig.10 The Lighting on the balcony**

**(3) If there are many persons in the apartment**

For example, when five people enter the apartment, the motion sensor in the living room will read one (Motion_1=1) and the number of people increases to five as shown in Fig.11 and in section one (people_1=0,1,…,5). Assume that they are distributed onto the different places in the apartment as follows: One person entered the kitchen as in section two (Motion_2=1, people_2=1), two persons entered the office room as in section three (Motion_3=1,people_3=1,2), and two persons entered the bedroom as in section four (Motion_4=1, people_4=1,2), Thus, the hall would be empty and the hall lamp will turn off as in the bottom of section one (Motion_1=0, people_1=0) where the number of people decreases from five to zero (Motion_1=0 , people_1=5,…,0).

When the user leaves the kitchen to the hall, the kitchen lamp will turn off. If the person went outside the apartment and the hall lamp will turn off. Likewise, if the two persons in the bedroom went out to the hall, one by one, the bedroom lamp will turn off. If they went outside the apartment, the hall lamp will turn off. The same happens for the two people in the office room. The people movements in the apartment can be displayed on a monitoring screen as shown in Fig.11 which shows the occupied and empty places.


**Fig.11 Movement of people inside the apartment**

### 3.3.3 Sensors flow chart

**(a) IR detection Sensor node**

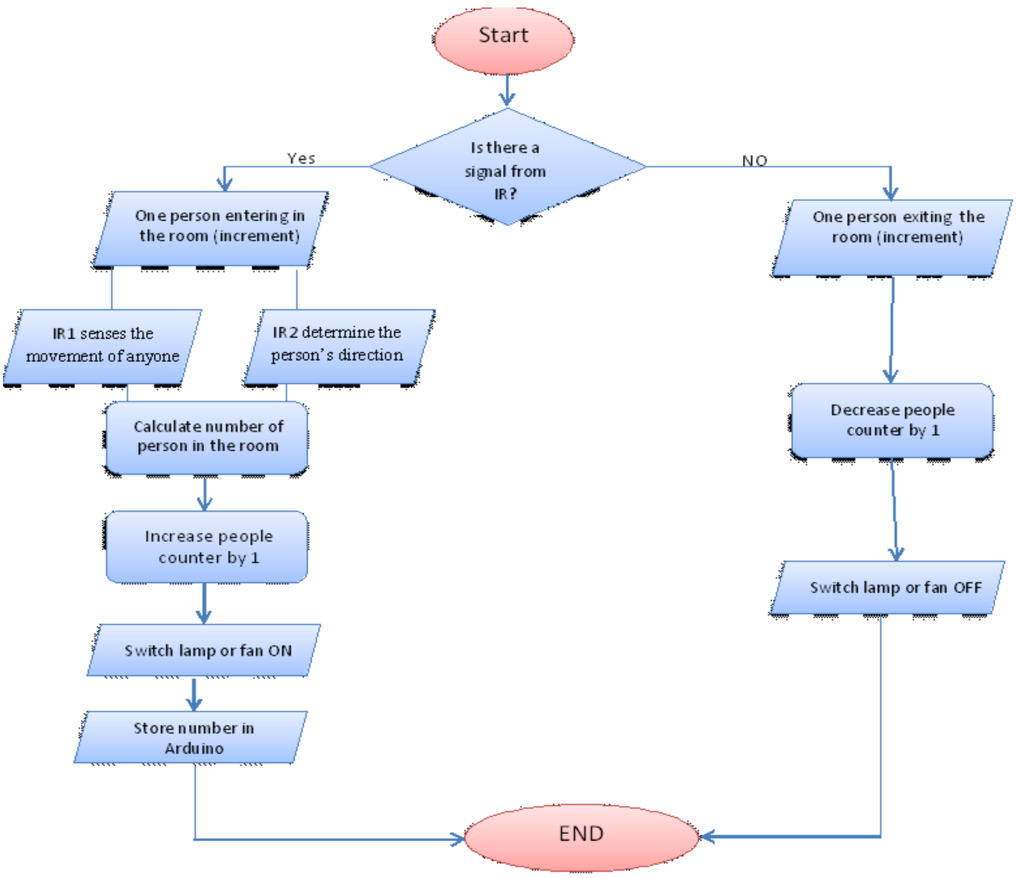



**Fig.12 The IR Sensor node algorithm**

**(b) The PIR Sensor node**

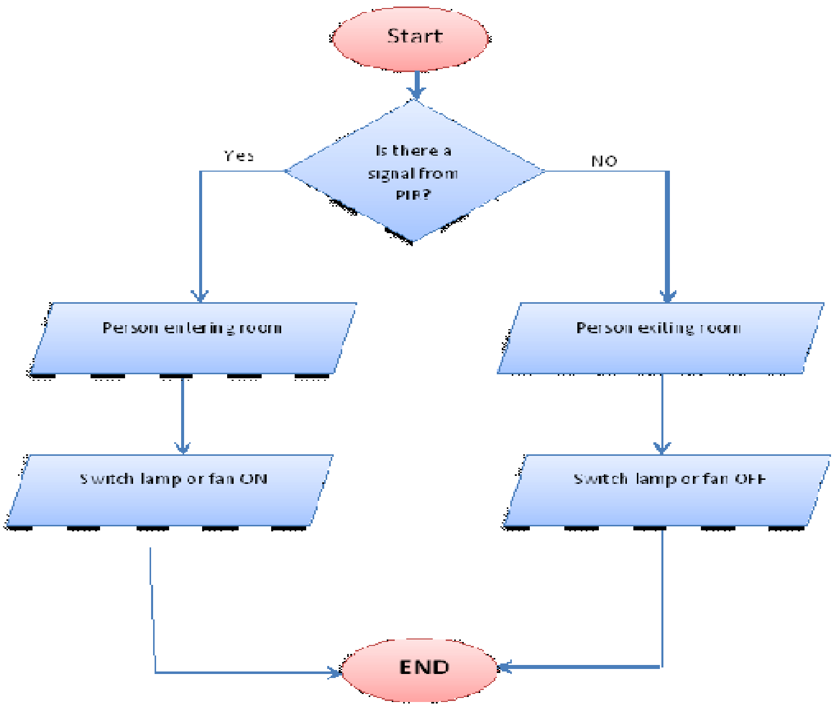



**Fig.13 The PIR Sensor node algorithm**

**(c) The Pressure sensor node**

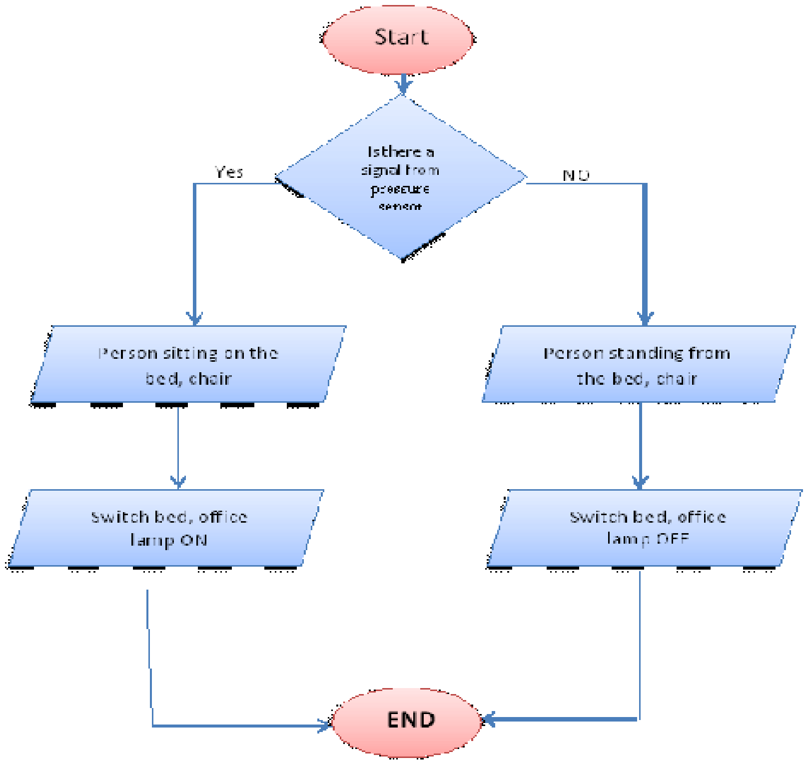



**Fig.14 The pressure sensor node algorithm**

## 4. Results and discussions

### 4.1 Energy calculation for a Smart Apartment

In this paper, we used the 40 W bulbs for lighting and 100 W fan for airing. We measured the power using the normal housing 220 V. The energy consumption is calculated for ten hours which may be the normal night time. Assuming that there is a 40 W bulb and a 100 W fan in each room, the consumption of each room is computed as 140 W. The kitchen, bathroom, balcony, and office are only using 40 W bulbs.

**a) The consumed energy cost in an apartment**

Thus, the corresponding power consumption of an apartment consisting of three rooms, a hall, a kitchen, a bathroom, two balconies and an office, is calculated sequentially as: (140*3) + 140 + 140 + 140 + 140 + 140 + 140 = 760W/h
Imposing wasted power within ten hours per day= 760*10 =7600 W/day
Wasted power within ten hours per month = 7600*30 = 228 KW/month
Kilowatt cost = 1 L.E
The total cost of wasted power within ten hours per month = 228 L.E
The total cost of wasted power within ten hours every year = 2736 L.E

**b) The system price**

The cost of purchasing the components of a smart apartment consisting of three rooms, a hall, a kitchen, a bathroom, and 2 balconies and a corridor as shown in Table. 1.
Every room has 2 IR and one PIR sensors = (2*30) + 40 = 100 L.E
Every office has one PIR, pressure sensors = 40 + 80 = 120 L.E
Every bed has one pressure sensor = 80 L.E

Every balcony has one PIR sensor =40 L.E
In front of the house it needs one PIR sensor = 40 L.E
Every bulb, fan, or any device need one relay =15L.E

**c) The system price versus the consumed energy cost**

It is concluded from the above that the costs of this smart system (for an entire apartment for a medium-sized family=1800 L.E) are less than the annual wasted power cost for only ten hours (2736 L.E). Fig.15 shows the amount of power that can be wasted within 10 to 15 hours daily for every year.

**Table 1 Smart system costs**

| Component | Cost | Number | Total cost |
|---|---|---|---|
| PIR sensor | 40 L.E | 10 | 400 |
| IRDetection Sensor | 30 L.E | 14 | 420 |
| Pressure Sensor | 80 L.E | 3 | 240 |
| Relay | 15 L.E | 17 | 255 |
| Arduino Mega | 300 L.E | 1 | 300 |
| Wires | 175 L.E | as needed | 175 |
| **Total coast** | | | **1800** |

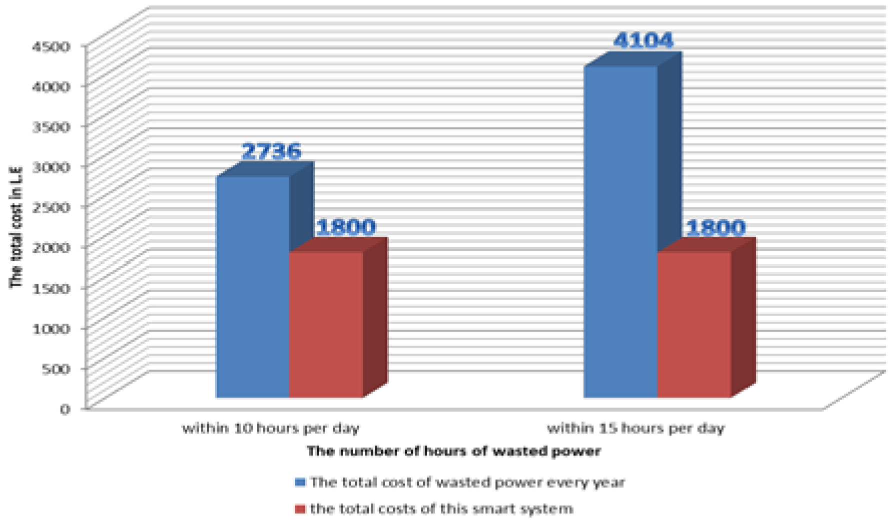



**Fig.15 Comparison between wasted power and smart system cost**

## 4.2. Wasted energy in the whole building

Wasted energy in a whole house can be calculated by multiplying the total cost of the apartment wasted energy within ten hours per month by the number of apartments in all buildings. If there are ten apartments in the building, the total cost of wasted energy within ten hours per month in the whole building= 2280 L.E and the total cost of wasted energy within ten hours every year in the whole building = 27360 L.E

Most of the appliances in the house and office including light and fan are operated manually, leading to wasted electricity. And if there is no use, they are left on. In this paper, we propose a solution for the convenient and cost-efficient prevention of waste of electricity. This system includes two Infrared object detection sensor at the entrance of each room to determine the direction of people and their number in the room, one PIR sensor in the ceiling of each room to sense the movement, and one pressure sensor under an office chair or bed to sense a person's pressure. It is proposed that such an intelligent power-saving device saves power and expands the user console level with the lowest cost. Where has been proven the costs of this smart system Much less than wasted power costs within ten hours at least. This system is used to reduce power consumption it is possible to reach high effectiveness in energy management.

## 5. Conclusions add and Future Work

In this paper, we introduced a smart automated controlling system for controlling the lighting of home appliances. This saves huge amounts of energy. We provided a solution for preventing the waste of home electrical energy in a comfortable and cost-effective way. Our system utilizes the use of Infrared Object Detection Sensors and Motion Sensors. Depending on the person's presence, devices such as lamps, fans, etc. are switched on or off. An example of an apartment is given for the system application. Also, calculations for a whole building composed of 10 apartments are given. The cost is calculated and the investment impact, in the long run, is discussed. This system can be extended and applied to a whole city or district.

In the future, authors may use the ideas of this paper to put a system which can be used to give smart protocols to reduce energy consumption in real houses and cities. Also, they intend to apply the artificial intelligence techniques in these protocols to have sense the places of energy waste and optimize their use.

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