IoT Based Smart Home Energy Management System with Implementation of Renewable Energy

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Abstract **The proposed system is aimed to provide a better and cost-effective system for home automation. Here we are proposing an IoT based home automation with a hybrid renewable energy source. Where we are utilizing solar energy and wind energy for home where the total power consumption from the conventional energy get reduces. Also, we going to automate all the home devices and increasing the security of the home as well. The proposed system will be very compact in size which does not require any computer and it is completely standalone. The actual work of the controller is to monitor sensors data, controlling and scheduling home appliances. The proof-of-concept model consist of hardware and software both parts.**

Keywords **— Renewable energy, IoT, Home Automation, Sensors, NodeMCU, Adafruit Cloud server.**

I. INTRODUCTION

Today's energy dilemma has turned into a worldwide issue. We must limit the amount of electricity wasted in our daily lives. However, as more home gadgets are installed, electricity usage rises year after year. As a result, energy conservation is now a top focus. Due to the scarcity of fossil fuels, these generations have begun to experiment with alternative forms of electricity generation, such as renewable energy sources. Solar, wind, and water resources may be found almost any place on the planet. [3] Renewable energy sources (RES) are a viable option for addressing rural energy demands, decreasing pollution, and encouraging economic development. A smart home is one that incorporates cutting-edge technology. A Smart Home is a home that uses new technologies to monitor the in-house temperature, out-of-house climate changes, control and monitor home appliances, and communicate with people all over the world. Smart homes have the potential to increase energy efficiency, lower energy costs, and reduce carbon footprint by incorporating renewable resources. [1]

Now a days in home areas world most considerable topic is energy saving and generation of power by smart home energy management system by using solar panel and wind turbine. Usage of wireless devices is increasing day by day so this application helps us to know the energy consumption and generation.[10].

Individual commercial entities frequently employ energy management systems to monitor, measure, and control their electrical building loads. Energy management systems can be used to control devices such as HVAC units and lighting systems from a central place, such as a retail, grocery, or restaurant establishment. [2] Metering, submetering, and monitoring services are all available through energy management systems, allowing facility and building managers to obtain data and insight to make better educated decisions about energy operations throughout their facilities.

The current energy crisis necessitates a large reduction in overall energy consumption. Energy conservation and renewable energy sources (RES) are two options for addressing the issue. Residential energy demand is quickly increasing due to the growing number of household appliances and consumer devices. To save money and reduce energy consumption, a well-designed home energy management system (HEMS) is required. The use of power line communication (PLC) to optimize household power consumption has been investigated. A home appliance monitoring, comparison, and control HEM has been proposed. RES such as photovoltaic energy systems and wind energy systems are also used to save energy for residents.

The proposed system consisting IoT microcontroller, various sensor, appliances and some security purposed actuators. The complete system will be explained in system development as follow.

II. SYSTEM DEVELOPMENT

A. Hardware

The complete system having microcontroller, sensors and actuators and energy generation. At the first level the instead of conventional energy, system using non-

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conventional energy sources like solar energy and wind energy. After that this hybrid energy will feed to controlling unit, where the NodeMCU IoT inbuilt microcontroller is controlling the all process. Here various sensors like temperature sensor, Light sensor, LPG sensor is connected with microcontroller after that there are two relays are connected with the microcontroller for ON/OFF the appliances automatically.

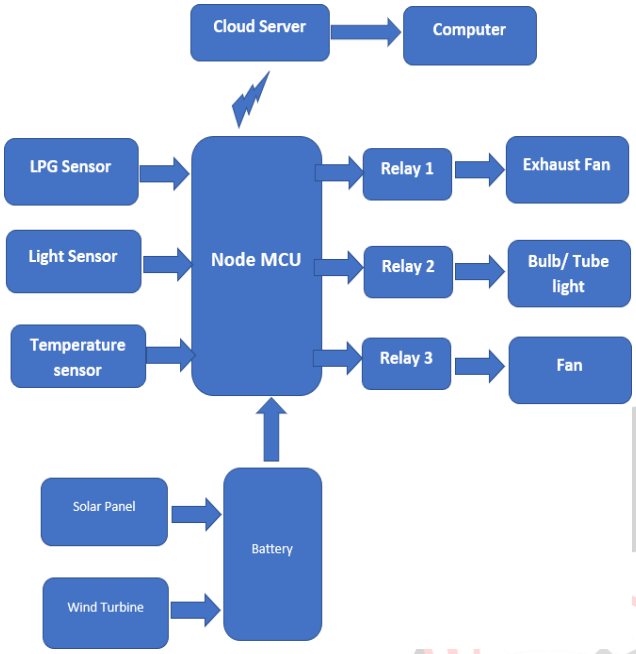

Fig 2.1 Block Diagram of Proposed System

For automation there is Light sensor and temperature sensor connected where light sensor detects the light intensity and if there is low intensity of light relay 1 of tubelight will be turned on and if there is sufficient light in room tubelight will be turned OFF automatically. Also, temperature sensor detects room temperature then according to temperature condition fan relay will be functioning ON or OFF. Here LPG sensor is connected for safety purpose, if there is any condition of leakage of LPG gas sensor will detect it and then buzzer will get ON and exhaust fan also gets ON.

B. Software

In software portion, there is cloud server which is used for the IoT part and firmware for the microcontroller. Firstly, the firmware is written in C using Arduino IDE software as per requirement and uploaded in the NodeMCU. After that as per configuration of firmware microcontroller collect all data from sensor and sends to the cloud server continuously. After receiving data on cloud server, it handles data and shows the data on web browser. From the cloud server we can also operate fan and tubelight manually. For this system Adafruit cloud server is used.

III. PERFORMANCE ANALYSIS

A. Temperature Analysis

The following table shows the values of the temperature is measured and uploaded on cloud server for two days at the same time.

Table 3.1 Temperature analysis

Sr. No.	Day1 (Time)	Actual output (Degree Celsius)	Measured Output (Degree Celsius)	Day2 (Time)	Actual output (Degree Celsius)	Measured Output (Degree Celsius)
1.	10.30 am	26.4	26.1	10.30 am	27.1	26.7
2.	11.30 am	32.5	32.9	11.30 am	27.9	28.3
3.	12.30 pm	33.7	33.2	12.30 pm	28.7	29.2
4.	01.30 pm	33.9	32.7	01.30 pm	31.2	30.5
5.	02.30 pm	32.8	33.1	02.30 pm	33.1	33.7
6.	03.30 pm	32.0	32.5	03.30 pm	31.7	32.1
7.	04.30 pm	27.3	27.8	04.30 pm	28.3	27.4

B. Graphical representation of temperature Analysis

The graphical representation of data is shown in below figures for same days, where green line indicates the actual temperature measured and blue line indicates the reading taken by the proposed system.

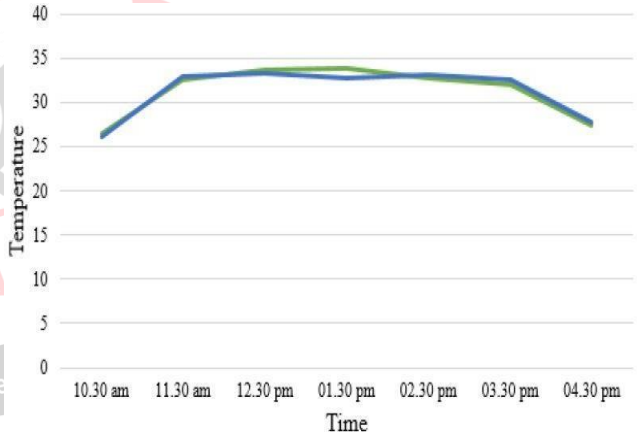

Fig 3.1 Graphical Representation of Day 1 temperature

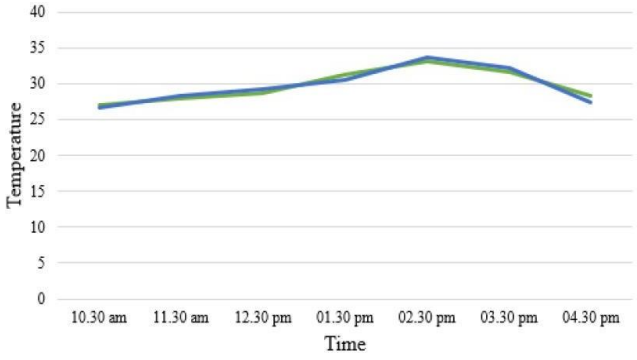

Fig 3.2 Graphical Representation of Day 2 temperature

C. Light Intensity Analysis

The table shown below showing the data of two day which is measured from proposed system and actual reading.

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Table 3.2 Light Intensity Values

Sr. No.	Day1 (Time)	Light Intensity by Lux-Meter (in Lux)	Light Intensity by System (in Lux)	Day2 (Time)	Light Intensity by Lux-Meter (in Lux)	Light Intensity by System (in Lux)
1.	10.30 am	57	42	10.30 am	62	54
2.	11.30 am	259	231	11.30 am	186	169
3.	12.30 pm	326	308	12.30 pm	216	185
4.	01.30 pm	289	251	01.30 pm	386	371
5.	02.30 pm	254	227	02.30 pm	411	392
6.	03.30 pm	181	162	03.30 pm	314	289
7.	04.30 pm	62	53	04.30 pm	102	91

D. Graphical Representation of Light sensor Data

The graphical representation of sensor data is shown in figure 3.3 and 3.4 for Day1 and Day2 respectively. Where green line indicating actual reading and blue line showing the sensor data of proposed system.

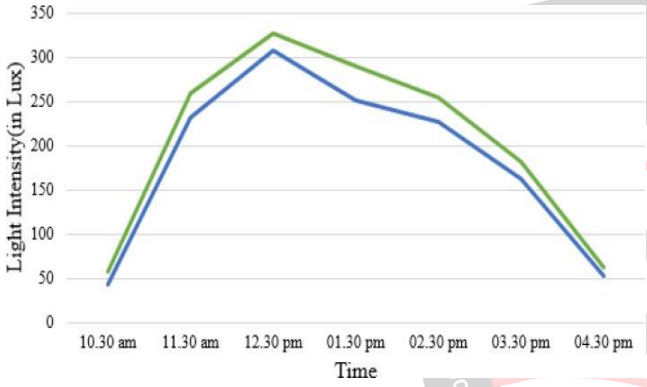

Fig 3.3 Graphical Representation of Light data for Day 1

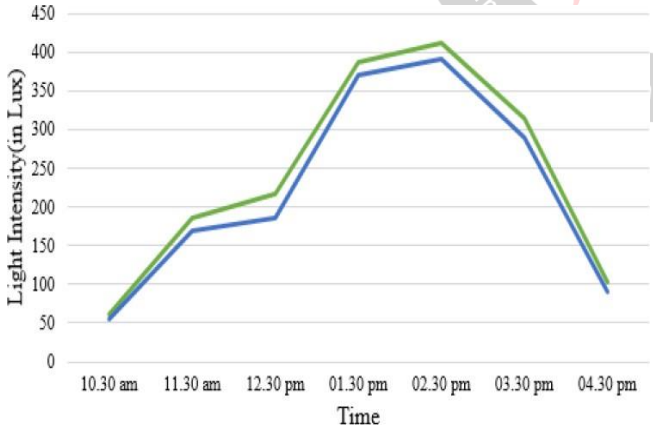

Fig 3.4 Graphical Representation of Light data for Day 2

E. Hardware

The actual hardware is shown in figure 3.5

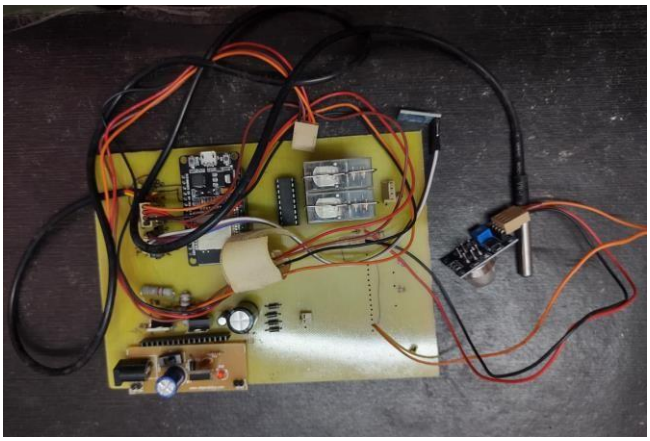

Fig 3.5 Actual Hardware Setup

F. Cloud Server Output

The output of proposed system on cloud server is shown in figure 3.6.

Fig 3.6 Cloud Server Output

IV. CONCLUSION

Home automation is implemented for monitoring home environmental condition like ambient light, room temperature, water level in water tank, leakage of LPG gas using light sensor, temperature sensor, level sensor and gas sensor. Arduino Nano controller along with Arduino IDE software is used to perform required task and data sends on Adafruit server successfully. Microcontroller require very less time to transmit the data as compared to wireless data transmission. Temperature sensor performance is very closed to the standard performance. Very easy to operate hence the system will improve the quality of life without human interaction.

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