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Power management in smart home based on IoT application

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Abstract

The need for power in today's society is growing by the day. The use of natural resources to generate power is maximized. This document is designed to help you increase the energy efficiency of your home's electrical equipment. To reduce energy usage, appliances are connected to a simple network that can be accessed remotely over the internet. The assessment of the home's environmental conditions is gathered in the web-server and precise by smartphone or internet. This technology may also provide real-time electrical parameters in the form of a web application regularly.

Keywords: IoT, Energy management, Home automation, ArduioMega 2560, WiFi module

1. Introduction

The Internet of Things (IoT) is a popular technology right now all around the world. The Internet of Things (IoT) is about more than simply connecting devices to the Internet; it's also about making sense of the 'things' that are linked. The Internet of Things (IoT) is a broad term describing network devices' capacity to detect and gather data from the world around us, and then exchange that data via existing Internet infrastructure. Where it may be treated and used for a variety of fascinating applications.

The Internet of Things (IoT) allows objects to be sensed or controlled remotely over existing network infrastructure, allowing for more direct integration of the physical world into computer-based systems and, as a result, improved efficiency, accuracy, and economic benefit, as well as less human intervention. When IoT is combined with sensors and actuators, it becomes an example of smart technology. Smart grids, virtual power plants, smart homes, intelligent transportation, and

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smart cities are among the technologies covered. Experts predict that by 2020, the Internet of Things will include over 50 billion items.

Figure 1 depicts the IoT architecture (a). Kevin Ashton of Procter & Gamble, subsequently MIT's Auto-ID Center, invented the term "Internet of Things" in 1999. The networked objects, which are generally wireless sensors and actuators, make up Stage 1 of IoT architecture.

Sensor data gathering systems and analog-to-digital data conversion are included in Stage 2. Data is preprocessed by edge IT systems in Stage 3 before it is sent to the data center or cloud. Stage 4 analyses, manages, and stores the data on typical back-end data centre systems. Figure 1 depicts the Internet of Things' applications (b).

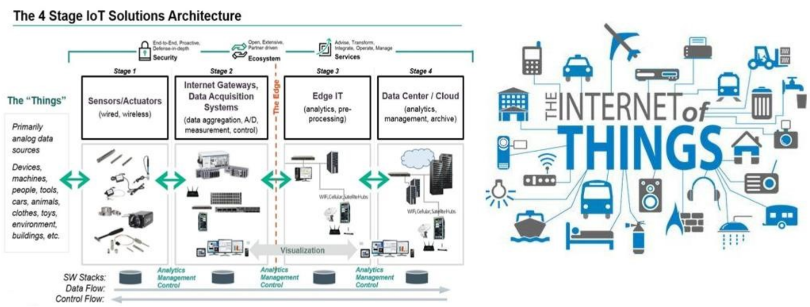

Figure 1: (a) Architecture of IoT (b) Applications of IoT

In today's society, everyone's most fundamental necessity is electricity. Every day, the amount of energy consumed rises. As a result, an energy management system must monitor and control energy usage, with the primary goal of reducing energy consumption costs and conserving natural resources. A smart house is one with lighting, heating, and technological gadgets that can be controlled remotely through the internet using a smart phone. An internet-based home automation system allows you to monitor and manage your home appliances from anywhere in the world.

Design and construct a prototype of an energy management system that shows the power spent by all devices, allowing a user to analyze the power consumption and electrical appliances in their house. This status may then be monitored and managed autonomously using the energy management system.

This system may be implemented by utilizing an integrated circuit like the Arduino MEGA 2560 Microcontroller, monitoring electrical characteristics using appropriate sensors, and calculating the total power utilized by all devices. As a result, the status of electrical equipment may be monitored and controlled via a Home Automation website from anywhere in the globe with an internet connection.

2. Literature work

With the aid of different control systems, a home automation system is utilized to operate home equipment automatically. Home automation systems utilize different control systems with suitable sensors to manage indoor and outdoor lighting, heat, ventilation, and air conditioning in the house, lock or open doors and gates, operate electrical and electronic equipment, and so on. It's utilized to cut down on labor and energy consumption while also enhancing the quality and efficiency of any system.

Design and implementation of an energy meter utilizing the PIC18F46k22 microcontroller and the Internet of Things idea. The user may monitor energy consumption in units via a web page, and the theft detection unit sends information on theft detection via PLC modem. The IoT operation is carried out via the Wi-Fi device, which sends energy meter data to a web page.

PIC18F46k22 and PIC18F2520 Microcontrollers, LCD, theft detection unit, Triac switch circuit, DB18B20 temperature sensor, PIR sensor, PLC modem, an ESP8266 Wi-Fi module make up the hardware interface circuit. The downsides of this type of system are that it necessitates changes to the house's domestic wiring and that it is unable to regulate electrical appliances [3].

Interactive Industrial Home Wireless System and Energy Management System based on the Internet of Things. In the Internet of Things (IoT) context, this system is critical for sensor data gathering and management of industrial Home Wireless Sensor Networks (WSN). We can quickly find out the Temperature, Smoke, and Fire existing in the industrial environment on the Website by detecting the values of sensors, and we can manage any scenario from anywhere in the globe using IoT.

An ARM 7 TDMI core CPU, Zigbee module, GSM module, IR sensor, PIR sensor, LDR sensor, temperature sensor, DC motor, and l6x2 LCD are among the components of the home industrial system. The disadvantages of this method include distance and network coverage. The transmission range of Zigbee is limited 10 to 200 meters, and the network might be harmed if a large number of GPRS users in the same area use the service at the same time. As a result of the congestion, data connections are slower and GSM network coverage is reduced [7].

The design and implementation of an energy meter utilizing the Arduino microcontroller in this system, which may be used to measure the power utilized by any single electrical device. The suggested energy meter's main purpose is to track power usage at the device level, upload it to a server, and operate any appliance remotely. The energy monitoring system calculates and shows the power consumption of various electrical devices via a home energy monitoring website.

The hardware for this system comprises an Arduino Nano, an ESP8266 Wi-Fi Module, and an SCT-013-030. RTC DS3231, current sensor, Nokia 5110 display module The drawbacks of this type of system is that it expects a voltage of 230Vrms and then calculates the power consumption only by current sensing. The accuracy of this device may be improved by including voltage sensing into the hardware and processing it to compute power, but the user cannot monitor the home surroundings [8].

Smart monitoring and control of home appliances, as well as a door authorization system for interaction between visitors and house/office owners, are provided by IoT-based monitoring and control of appliances for smart home systems. The Raspberry Pi, Arduino MEGA2560, 2.4-inch touch screen, Hall Effect sensor, keyboard, mouse, mic, speaker, RPi camera, and LCD screen are all part of this system. This system's user is unable to monitor power usage, and thus necessitated the installation of two Microcontrollers [5].

The embedded device connected to the smart meter via GPRS receives data from current sensors and saves it in the cloud, and the gadget switches between the two powers suppliers automatically based on load power consumption. The authenticated user can adjust the power consumption threshold voltage, as well as connect and detach the supply and various loads. An LPC2148 Microcontroller, WCS2702 Hall-Effect current sensor, GPRS wireless module, and Relay Board are included in this system's components. Because this device simply measures current value, it cannot correctly compute power usage [2].

Smart Energy Management System for the Home GSM (Global System for Mobile Communications) the main goal of this project is to switch the power supply from traditional utilities to renewable energy, namely solar energy. When the digital EB meter's threshold unit is exceeded, it optimizes power usage by converting the main power supply to renewable energy (solar energy). The hardware for this system contains a PIC16F877A, GSM, PIR sensor, LM35, Solar panel, LCD, Inverter, and EB Meter. The house appliances are not controlled by this system [6].

Energy Efficient Smart Home Automation System, which will reduce energy waste in homes by regulating device operating modes more efficiently. We will utilize a wireless sensor element network in this design to monitor physical factors (such as light and temperature) as well as the presence of users at the reception and in each of the rooms. Only the household appliances are controlled by this system [4].

Automation in the Home Using the Internet of Things, you can switch off lights, fans, and other electronic and electrical equipment remotely when they aren't in use, which helps you control your home's energy use. The user may alter the status of any appliance using the login id and password, saving time, energy, and money. A Raspberry Pi, PIR sensor, temperature sensors, humidity sensor, four mechanical limit switches for door security, LDR, and a blue-tooth module are included in this system [1].

3. Proposed system

We optimized the power consumption of electrical and electronic household equipment in the suggested system based on the environmental circumstances. The approaches utilized to increase the system's efficiency, such as constant monitoring and control of home usage devices. This might extend the life of the gadgets while lowering power costs. The proposed techniques are implemented utilizing the Internet of Things (IoT) concept.

The suggested power management system is depicted in figure 2 as a functional block diagram. This comprises several phases that must be completed for the system's intended condition to be met.

1. Power measurement unit
2. Home environment monitoring unit
3. Communication unit
4. Home appliances control unit
5. Data backup unit

4. Hardware implementation

Figure 3 depicts the Smart Power Management Hardware model used in the proposed system to optimize the power consumption of electrical and electronic household equipment based on environmental circumstances. The approaches utilized to increase the system's efficiency, such as constant monitoring and control of home usage devices. This might extend the life of the gadgets while lowering power costs. The proposed techniques are implemented utilizing the Internet of Things (IoT) concept.

Through the sensors ZMPT101B and ACS712, characteristics such as voltage (1) and current (2) are measured, and instantaneous power (3) and energy (4) are computed, which are used by electrical and electronic equipment in the home.

$$V_{rms} = VADC*(311/1023.0) \tag{1}$$

$$Irms = sqrt(IADC/n) * (75.7576/1024.0) \tag{2}$$

$$P = V_{rms} * I_{rms} \tag{3}$$

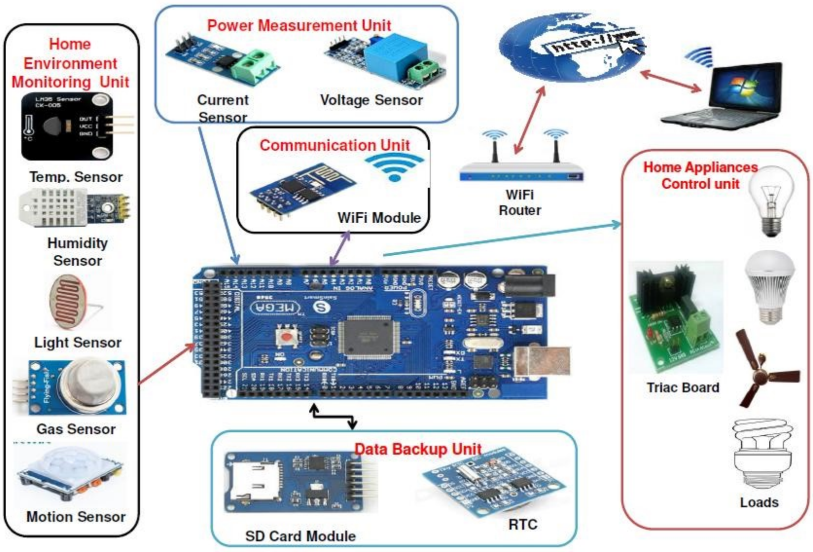

Figure 2: Proposed Power Management System

$$E = (P * time)/3600 \tag{4}$$

The Arduino Mega 2560 Microcontroller does the manipulation, which is then sent to a website over Wi-Fi. The sensors analyze the environmental variables in the home to provide greater comfort at a lower cost. For better results, these may be accomplished by putting the relevant sensor. Gas, temperature, humidity, light, and motion sensors are among the sensors. Gas leakage is a serious hazard to humans at home. To minimize this, the gas sensor MQ2 can detect different gases such as LPG, i-butane, methane, alcohol, hydrogen, and even smoke. The function of a gas sensor is similar to that of a light detector in that it changes the resistance value dependent on the gas present in the air. The controller continually monitors the resistance readings, and when the proportion of gas present in the air reaches the threshold value, the controller activates the buzzer, alerting the person to take precautions.

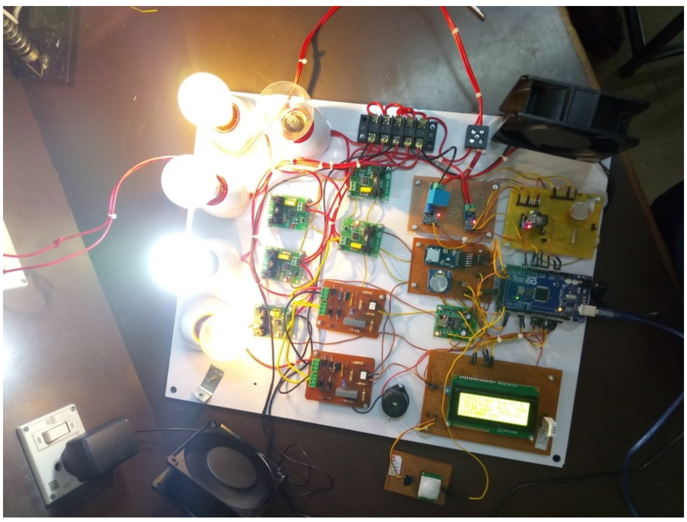

Figure 3: Smart power management hardware prototype

Three major factors, such as light, temperature, and humidity, may be used to separate the living room settings. These three factors are interdependent and might be coordinated using individual sensors for each restriction. To maintain the room's comfort, the speed of the fan is regulated by a Microcontroller through a Triac with opto-coupler driver circuit and is dependent on the room temperature via temperature sensor readings. The light and humidity are detected using the sensors LDR and DHT22, which can be used as inputs to change the brightness of the room intensity using a MOSFET-based AC dimmer driver circuit and show the humidity in percent.

The aforementioned actions are carried out only if the PIR sensor detects a human within the room, and the procedure can be carried out in any of the rooms in the house.

The monitoring system's database, which is equipped with an RTC DS1307 and an SD card module. This RTC is used to gather data in standard time and save them on a micro SD card for future use. Finally, the home's power usage and electrical expansion are broadcast to the rest of the world via the ESP8266 WiFi module, and it may be managed remotely using a mobile phone, computer, or laptop connected to the internet. HTML code was used to create the webpage for this system.

5. Result analysis

The proposed system for effective power management is being set up, and a prototype model is being tested over 24 hours in a room of the house, with the electrical and electronic equipment of the house being managed automatically.

We analyzed the power consumption of the system over 24 hours period to calculate the improvement in power consumption between the suggested model and the current system.

On the webpage, we can keep track of and regulate how the device is being used. It displays the current status, power, and energy usage, as well as the state of the home environment, and it can be controlled manually. The web page in this prototype model was created using HTML. By inputting the IP address, the user may visit the web page; after entering the IP address, a web page will display.

Device control buttons, device status and power, and energy spent by the devices are all available on the webpage. Figure 4 depicts sensor data as well as device status. The graphical depiction of ZMPT101B – voltage sensor calibration using MECO-603 Digital Multimeter is shown in Figure 5.

The voltage in the blue color bar was measured using a MECO-603 Digital Multimeter, while the voltage in the red color bar was measured with a ZMPT101B – voltage sensor.

The current sensor ACS712 is calibrated using an AC analog ammeter MECO A/7816 and a digital clamp meter MECO DT 2250 HZ auto, as shown in figure 6.

Figure 7 depicts the graphical depiction of power consumption in a typical home without load management depending on the room environment for each hour of the day.

Figure 8 depicts the graphical depiction of power consumption in a typical home with load management depending on the room environment for each hour of the day.

Figure 9 depicts a graphical depiction of the power consumption comparison between the existing and planned systems.

The blue color bar represents the existing system, which is referred to as demand power without control, while the red color bar represents the prototype model, which is also referred to as demand power without control.

The figure 10 user can see LCD of power, energy, and number of units consumed by the various electrical and electronics devices and present room temperature, LPG gas value, humidity, and light intensity of the home.

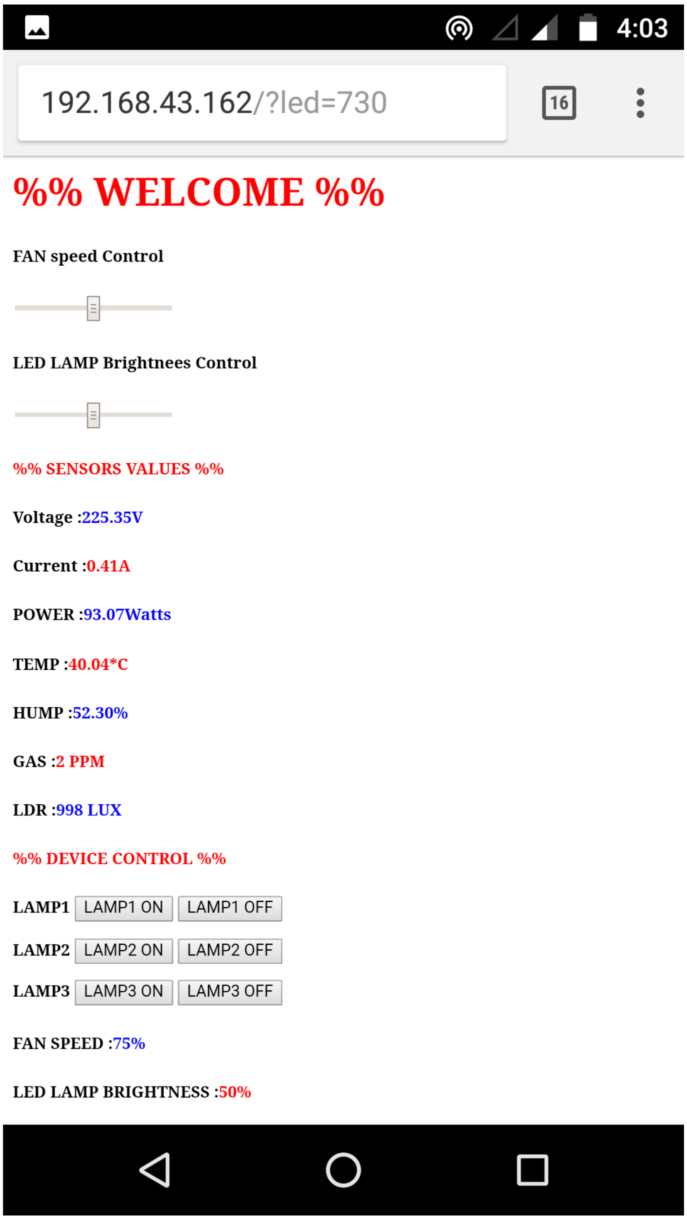

Figure 4: Webpage for the power management

6. Conclusion

Engineers' primary responsibility in terms of design is to reduce power usage. Here, power management is used to regulate the flow of electricity based on the need and the home's ambient circumstances. This implies that the suggested technology will manage the light intensity and temperature within the home automatically. The voltage and current detecting hardware for managing the appliances come next, followed by the main supply. It calculates the precise power based on supply voltage and load current.

7. Future scope

In the future, web page security might be included to prevent proxy triggers or hankers. The webpage is now built-in HTML code; however, it may be done in another graphical style to make it

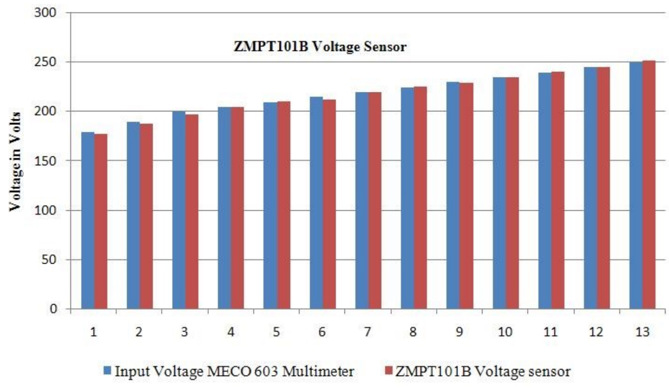

Figure 5: ZMPT101B – Voltage sensor calibration with MECO-603 digital multimeter

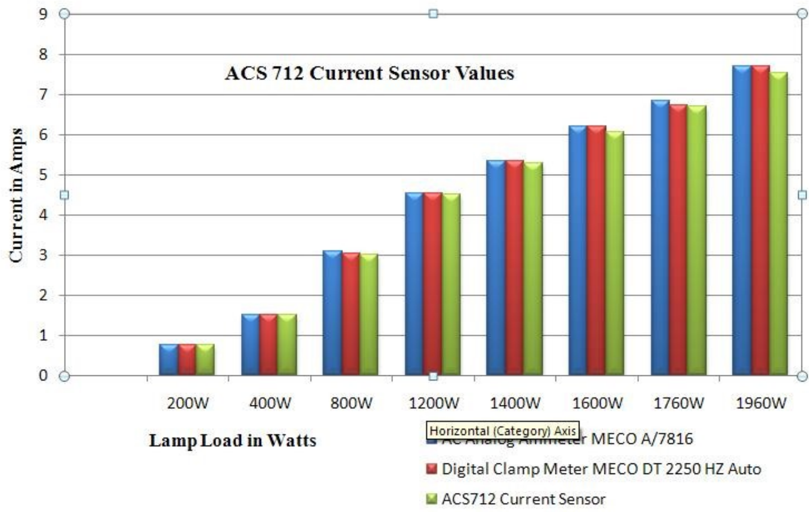

Figure 6: ACS712 – Current sensor calibrate with ac analog ammeter meco A/7816 and digital clamp meter meco dt 2250 hz auto

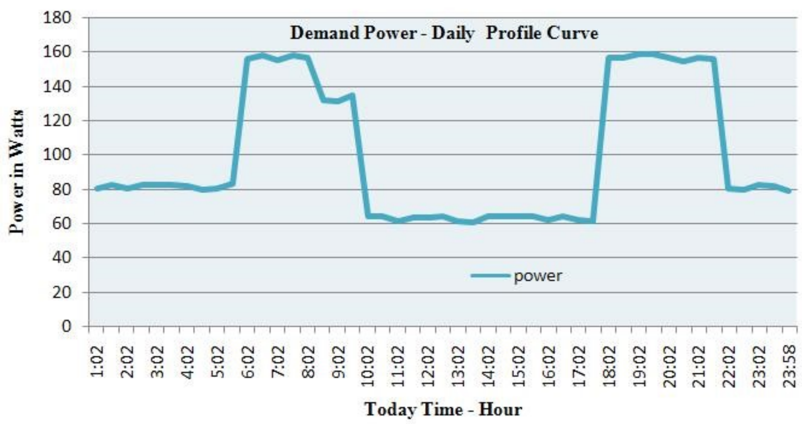

Figure 7: Demand power – normal home without control the loads based on room environment

more elegant. The data is stored on an SD card, which may be read by off-board devices and then sent to the cloud. These may be used to enhance the system by using a power management mode

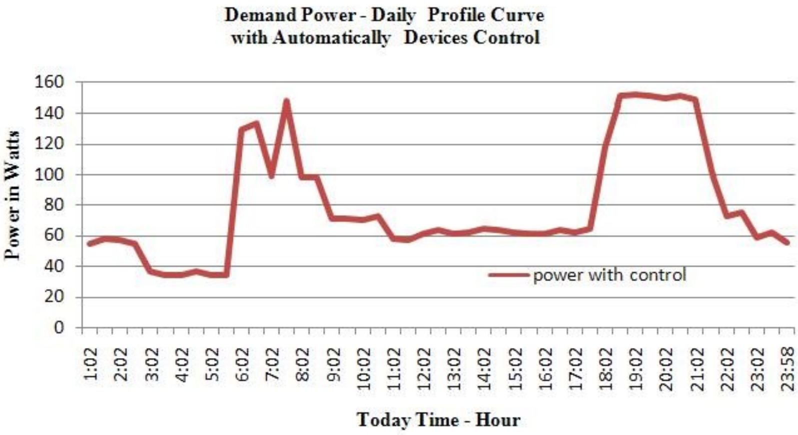

Figure 8: Demand power – normal home with control the loads based on room environment

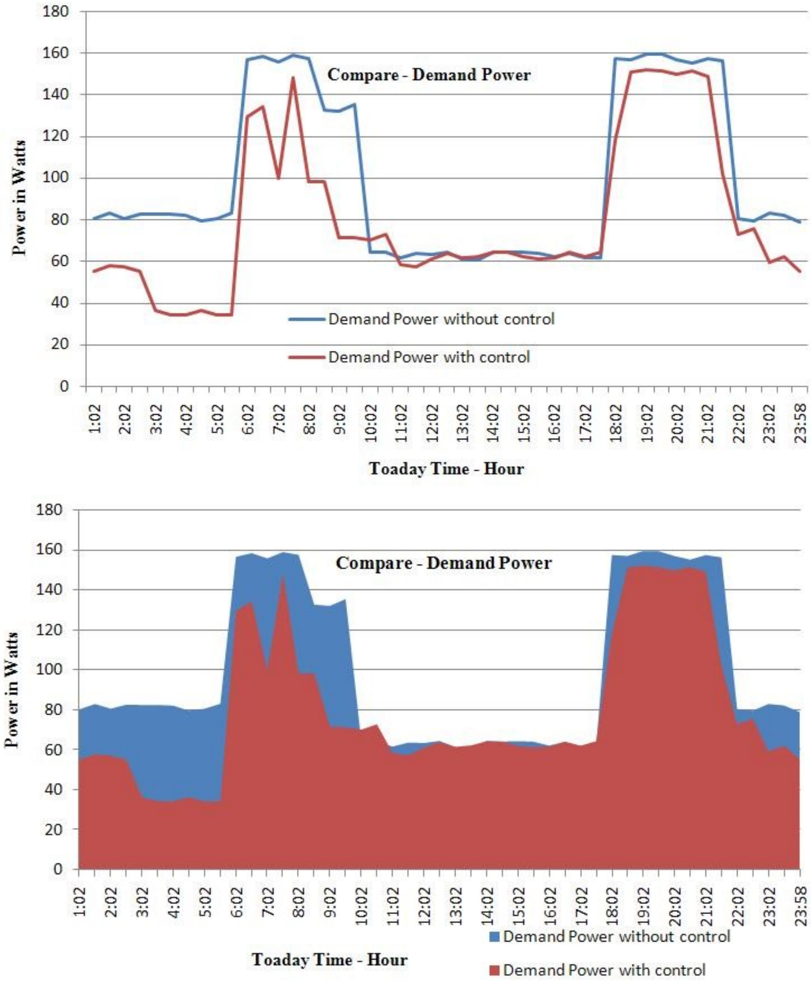

Figure 9: Pictorial representations – comparison of power consumption between the existing and proposed system

in which the demand of each house drives power generating performance and lowers transmission division maintenance costs.

Figure 10: Sensors values displayed in 20*4 LCD

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