NEW HORIZON
COLLEGE OF ENGINEERING
Autonomous College Permanently Affiliated to VTU, Approved by AICTE & UGC
Accredited by NAAC with 'A' Grade.

EFFICIENT ENERGY MANAGEMENT USING IoT

A MINI PROJECT REPORT

Submitted by

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the mini project work entitled "**Efficient Energy Management using IoT**" carried out by **ADITYA JAKKARADDI (1NH18EC700), MANOJ N (1NH18EC730), RAJEEV KUMAR (1NH18EC741), S SHARAN (1NH18EC742)**, bonafide students of Electronics and Communication Department, New Horizon College of Engineering, Bangalore.

The mini project report has been approved as it satisfies the academic requirements in respect of mini project work prescribed for the said degree.

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ACKNOWLEDGEMENT

The satisfaction that accompany the successful completion of any task would be, but impossible without the mention of the people who made it possible, whose constant guidance and encouragement helped us succeed.

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Abstract:

Rising costs and demand for energy force us to find smart ways to save electricity and energy. To meet the demand for energy and at the same time reduce costs, energy consumption should be monitored and controlled.

Thanks to the Internet, as one of the most important parts of our lives, many of the devices we use in our daily lives such as TV, air conditioner, refrigerator, washing machine, can be monitored and remotely controlled with the most intelligent Internet of Things (IoT) technology. Smart Home Applications as one of the smartest cities, is one of the most sought after application. Energy consumption can be well managed with the capabilities of the Internet of Things (IoT).

In this project work, "Efficient Energy Management system using IoT" the module collects energy consumption information from each device and further processes and analyse it. Since lighting and air conditioning appliances contribute to most of the electricity consumption in the buildings, monitoring them is more important. The sun position at given time and place is calculated in the cloud and the result will be sent to the MCU. From the received signal the MCU will send the control signal to the solar positioning system .The MCU will control the charging of power wall form the solar panel. The MCU will monitor the current and voltage of battery. The condition of the energy stored in battery will be set back to cloud. The user will be having the web application to view the conditions of the power wall and control the appliances.

The prototype designed by us will monitor the input, output and the power consumed. It will give us the data analysed in the cloud so that the energy can be managed in the most efficient manner. The data analysed in the cloud and by the graph obtained due the power consumption of various appliances at any given place will show us the amount of energy wasted. By this data one can understand the Wastage of energy and use every appliance in the most efficient manner. With each data that is analysed, a learning model can be created which tells us how much energy is consumed by each appliance and we can limit that much of energy to that particular appliance which saves energy.

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CHAPTER-01

INTRODUCTION

Energy is the fuel for everything happening in the universe. Humans and animals need energy for doing chores which is fulfilled by the consumption of food and liquids. Humans have built appliances which need energy or in other words, fuel, to run. Humans have also developed the kind of fuels required to run those appliances.

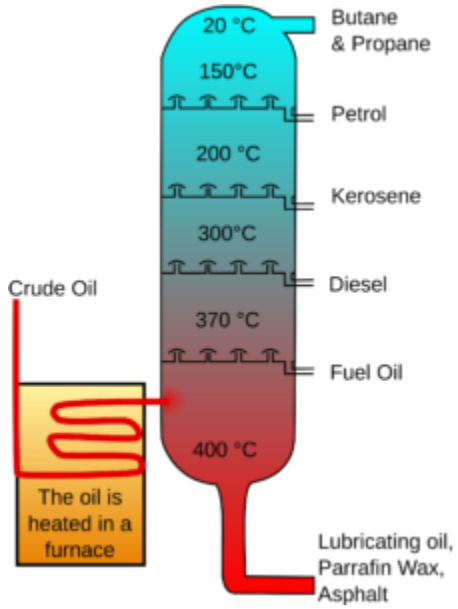

Fig. 1.1: Refining of petroleum products

For example, petroleum fuels like petrol and diesel are used to run vehicles. Fossil fuels and coal are used to generate electricity which is used for various purposes. When the threat of losing these forms of electricity generation was looming a lot, renewables sources of energy were identified to fulfil the energy (electricity) requirements of various sectors.

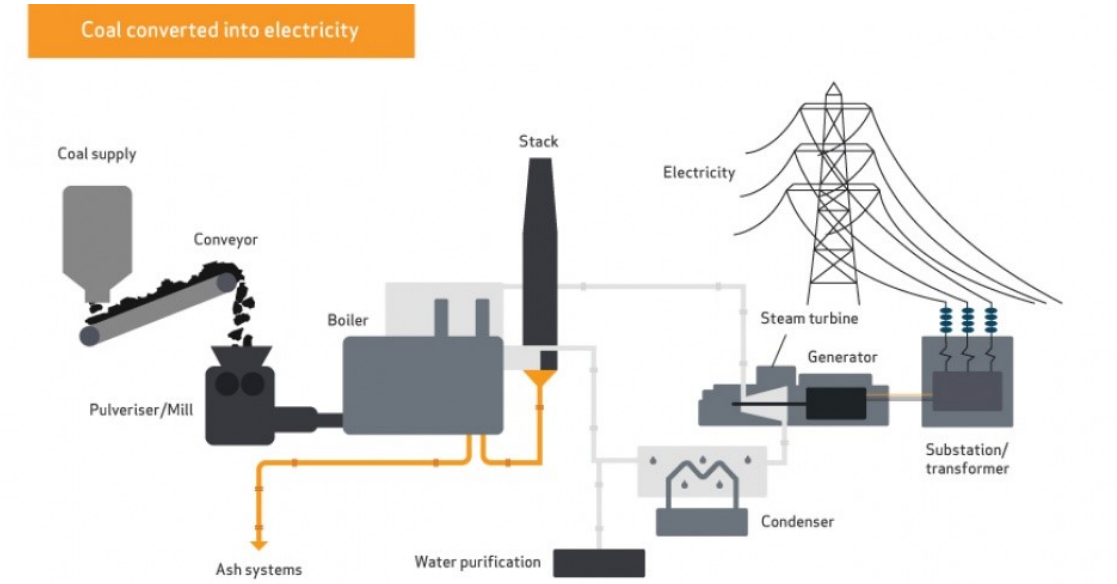

Fig. 1.2: Coal to electricity diagram

Renewable sources of energy provide means by which the source which helps in generating electricity never dries out. In other words, it is recurring in nature. Few examples of renewable sources of energy include:

1.1 Wind Energy:

This is the kind of energy or electricity which is generated by harnessing the winds blown in the atmosphere by the help of a device named Windmill. The windmills are installed at places where the wind is blowing at faster speeds. When the wind blows, the blades of the windmill rotate, which results in rotation of the turbine, and concludes in the generation of electricity.

Fig 1.3: Windmills

Fig. 1.4: Harnessing wind energy

1.2 Water Energy (Hydroelectric Energy) :

Here, energy (electricity) is generated by harnessing the power or speed of the flow of water. At the bottom of the stream, a reservoir (dam) is built. So when the stream flows with huge force from higher areas to the lower areas where the dam is situated, it enters the dam and with the force of its flow, it rotates the turbine present in the dam which is then used to generate electricity.

Fig 1.5: A Dam

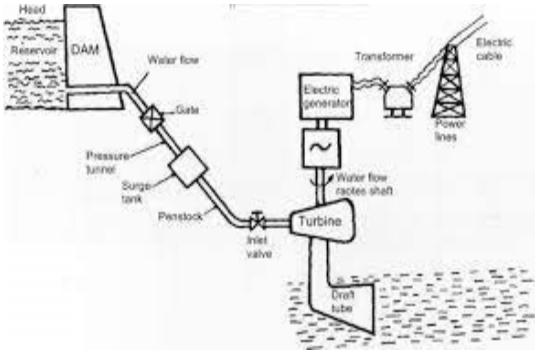

Fig1.6: Harnessing hydro energy

1.3 Solar Energy:

Here, a panel made of silicon and a few other substances is used to absorb the rays of sunlight and then convert them into electrons, i.e., generating electricity. We have used a solar panel in our project which will be discussed in further detail in the later chapters.

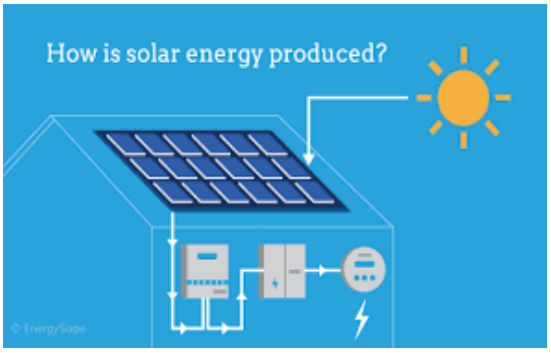

Fig 1.7: Harnessing sunlight

Fig 1.8: Solar panels

There can be two major reasons for these many ways of generation of electricity to be used in the world. Those two reasons are:

(A) Depletion of naturally occurring resources like fossil fuels, coal and petroleum.

(B) Increase in the DEMAND for electricity in the post industrialization and globalisation era.

Our project mainly deals with an underlying issue with the second reason. With the advancements in science and technology at an unforeseen pace, demand also increased substantially as electricity was required for every hour of the day.

Whilst the companies generating electricity were trying hard to meet this growing demand, there was also a lot of energy being wasted. We all have heard phrases like “Switch off the TV”, “Turn off the fans and lights while coming out of your room kiddo”, etc. Likewise, even if we are aware of such things, still almost a third of electricity generated turns out be wasted in the offices and other commercial complexes, and in few cases, our homes as well.
In other words, the appliances keep on running and consuming electricity but there is no end user who is either using or controlling that particular appliance in concern in real time. This, in turn, led to increased electricity bills and consumption as well with no desired output or result achieved.

To counter such excessive and unwanted wastage of electricity in today’s digitized world, a need for Smart Energy Management System is inevitable. A system which can monitor the consumption of electricity as well as the usage of the particular appliance and provide the data to the user on their smartphone so that they can be controlled and used in an optimal manner in order to make it cost effective as well as a well-informed consumption of electricity. It will help the consumers be well informed about the usage as well as know where the energy is being wasted and how they can reduce it.

1.4 Idea of the System:

The idea that we are proposing and which will be discussed in much more detail is based on this. The primitive system that we have built can monitor the usage of each appliance connected to it and display the same data in the form of a graph on a website which can be accessed by the user. The user can control the appliances connected via this website as well. In order to get proper electricity the solar panel adjusts itself so that it can be in the best possible position in accordance with the position of the sun so that it absorb the light rays in the best way possible. This gives the user the freedom to control the device without being physically present as well as store energy if not using it at the moment. The further details will be discussed in the upcoming chapters.

CHAPTER–02

LITERATURE REVIEW

2.1 PAPER - 1:

- TITLE : Internet of Things based Smart Energy Management for Smart Home
- AUTHOR : Mehmet Tastan
- YEAR OF PUBLICATION : 2019
- OUTCOME: He built a smart energy management system which can find the data about energy and power consumption of each appliance in the room.
- LIMITATION: Currently, the system can give information of 4 devices at any given time whilst ignoring all the other devices/appliances in real time.

2.2 PAPER – 2:

- TITLE : Intelligent Energy Management System
- AUTHORS : Maurizio Cirrincione,
  Salvatore Gaglio,
  Massimo Cossentino,
  Vincent Hilare
- YEAR OF PUBLICATION : 2009
- OUTCOME: They developed a multi agent system (MAS) which monitors and controls the appliances of each room separately by dividing the house into small packets consisting of one room each.
- LIMITATION: Installing this kind of a multi agent system (MAS) at a large scale level, in each household, is tricky as it requires a bit more sophisticated integration medium than was available at the time of the paper publication, i.e., a decade ago.

2.3 PAPER – 3:

- TITLE : More Efficient Home Energy Management System Based on ZigBee Communication and Infrared Remote Controls
- AUTHORS : Jinsoo Han,
  Ilwoo Lee,
  Chang-Sic Choi
- YEAR OF PUBLICATION : 2011
- OUTCOME: They built a system which was capable of reminding people of the things that they have forgotten like switching off certain appliances and send the user notifications and alarm the family members about the same.
- LIMITATION: When they built the system, it was facing issues while reading as well as retrieving data from the database of the system.

2.4 PAPER – 4:

- TITLE: Design and implementation of smart home energy management systems based on Zigbee.
- AUTHORS : Dae-Man Han,
  Jae-Hyun Lim
- YEAR OF PUBLICATION : 2010
- OUTCOME: The system that they built a decade ago was capable of building a network of all the devices used in the home as well as broadcasting the data about the usage of each device.
- LIMITATION: The network of home appliances that they built could be controlled only by a TV interface by applying a JAVA interface, which at that time was not available so easily to majority of the households.

2.5 PAPER – 5:

- TITLE : Home Automation using Bluetooth and IOT Modules
- AUTHORS : Dr Manoj Priyatham,
  Madhu J
- YEAR OF PUBLICATION : 2017
- OUTCOME: This system enables users to control home appliances with their pre-existing devices like smartphones by connecting the devices to the smartphone via Bluetooth or WiFi.
- LIMITATION: This framework limits the destination only to a selected access point in the house, i.e., the devices can only be controlled only from one smartphone at a time and that too within a particular range of the device.

CHAPTER–03

EXISTING SYSTEMS

In this chapter we will be talking about the systems which are already in use and are hugely impacted by the Internet of Things (IoT) technology in today's world. We will be discussing the applications in use which incorporate IoT technology under two major umbrellas:-

- Individual Appliance Control
- IoT or Bluetooth connected wireless Home Speakers

3.1 Individual Appliance Control:

Appliances that we use in our homes and workplaces need to be controlled or fed instructions that they are supposed to perform. Home appliances generally are made to perform particular functions, and can be controlled only for that function.

Normally, the appliance come with a control panel pre-installed on the appliance which the user then accommodates to control it. This sometimes is difficult as the appliance requires the physical presence of the user in order to be controlled.

So, in order to counter this one particular problem, the appliances now are compatible to be connected to smartphones wither via Bluetooth or WiFi. This way the user can control the appliances at his/her finger tips. Some of the examples of these appliances are as follows:

3.1.1 Syska LEDs:

These LEDs can be controlled via an app that can be installed in your smartphone. This app will let you connect to the LEDs with either Bluetooth or Wi-Fi at home and then control the LEDs according to your convenience whether you are physically present in the room or not.

Fig 3.1: Illustrates a box of LEDs which controlled by smartphone

3.1.2 Air Conditioners:

The electronic companies have now started rolling out ACs which can be controlled with the help of your smartphones.

Fig. 3.2: Illustrates an AC controlled by smartphone

3.1.3 Washing Machines:

These are another set of appliances which are being rolled out with Bluetooth or Wi-Fi connectivity so that they can be controlled via smartphones.

Fig 3.3: Washing Machine controlled with phone

3.2 IoT or Bluetooth connected wireless Home Speakers:

Iot or Bluetooth based wirelessly connected Home Speakers incorporate a bit more advanced version of control, i.e., these speakers can be controlled by voice of the user. The user can make the speaker perform certain easy functions by just talking to it.

The speakers can also make other devices work if they are connected by the same network. When the user instructs the speaker to do a specific task regarding another device, the speaker alerts the device concerned and makes sure that the task is performed, for example, a speaker can make the coffee maker to make the coffee and keep it ready for pouring in the morning. The speakers can also adjust according to the schedule of the user and optimize the tasks as well. Few examples of these Smart Speakers are as follows: -

3.2.1 Apple Home Pod :

This speaker lets the user do several tasks via voice commands. This latest launched speaker is capable of integrating all the appliances at your home so that they can be controlled by your voice commands.

Fig. 3.4: Apple Home Pod

3.2.2 Google Home :

This speaker also uses voice commands. This also integrates your schedules and travels if allowed to connect to your smartphone, just like others.

Fig. 3.5: Google Mini Home

3.2.3 Amazon Echo (assistant ALEXA) :

One of the first ones in the market, this speaker lets you have conversations as well as make the speaker do tasks with the help of voice commands as discussed earlier.

Fig. 3.6: Amazon Echo

CHAPTER-04

PROBLEM STATEMENT AND OBJECTIVES

Energy management is the key to saving energy in your organization. Much of the importance of energy savings stems from the global need to save energy - this global need affects energy price, emission targets, and legislation, all of which lead to several compelling reasons why you should save energy at your organization specifically.

If it were not for the global need to save energy, the term "energy management" would not have been invented. Globally we need to save energy in order to:

- Reduce the damage we do to our planet, Earth. As a human race we would probably find things difficult outside of Earth, so it makes sense to try to keep it.
- Reduce our dependence on the fossil fuels that are becoming increasingly limited in supply.

Power management is a way to control and reduce the energy consumption of your organization. And controlling and reducing the energy consumption of your organization is important because it enables you to:

- **Reduce costs** - this becomes more important as energy costs go up.
- **Reduce carbon emissions and environmental damage** - as well as the effects associated with carbon tax costs and the like, your organization may be willing to reduce its carbon footprint to promote a green, sustainable image. At least because promoting such an image is often convenient for you.
- **Reduce risk** - the more energy you use, the more likely it is that an increase in energy prices or a lack of supply could seriously affect your profits, or make it impossible for your business / organization to continue. With energy management you can reduce this risk by reducing your energy need and controlling it so that it can predict.

Fig 4.1: Energy Management using IOT

Some important issues/problems that prevail in our society or surroundings due to poor management of energy are as follows:

1. **Buildings consuming huge amount of energy which can be efficiently managed**

PROBLEM- Due to Rapid Urbanization and growing cities, there is an increase in number of buildings which alone consume approximately 30% of global energy.

The International Energy Association also predicts that electricity usage for residential appliances would grow by 12% between 2000 and 2010, eventually reaching 25% by 2020. These figures highlight the importance of managing energy use in order to improve stewardship of the environment.

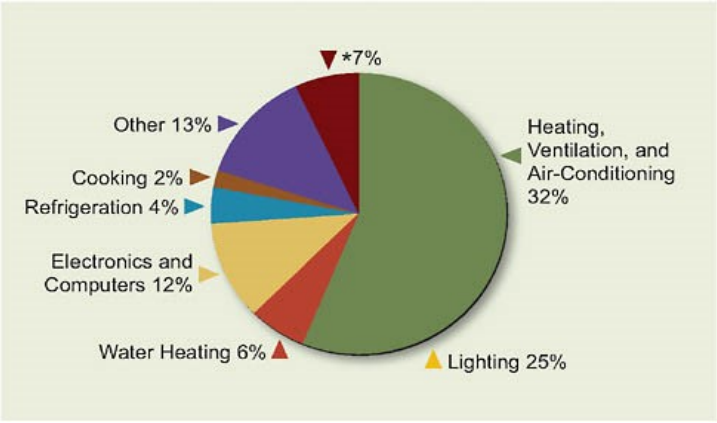

Fig 4.2: Data showing consumption of energy in various sector

OBJECTIVE- The three main objectives of building power management are to :

- reduce / manage power consumption;
- reduction of electricity bills while increasing resident's comfort and productivity;
- to improve environmental management without compromising living standards.

Sensor-enabled, wireless devices can provide better insight into human mobility patterns, helps to switch off lights and other electrical appliances when not in use resulting in saving of energy. In this work, we focus on the largest consumers of electricity in buildings - electrical appliances and lighting. Proper management of these two types of load will result in significant energy savings and energy efficiency. In order to achieve the three goals of energy management mentioned above, we need to understand the ways in which electricity consumption and individual energy consumption. This is achieved through distributed programs and one point. We therefore examine various methods and explain their pros and cons. We also explore smart lighting schemes that use limited ambient ingenuity to balance energy saving and comfort. The combination of monitoring and control of electrical energy, with intelligent lighting can lead to energy savings greater than 15% in residential areas.

So a smart building is capable enough to save a lot of energy per day by observing the pattern of lightings and usage of other electrical appliances and switching it off when the particular appliance or device is not in use. So, even though the user or owner of building forgets to switch off a device, the smart building saves time and energy both without the involvement of the humans.

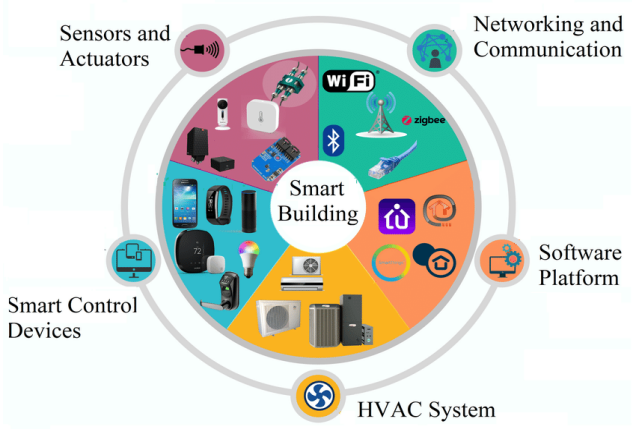

Fig 4.3: A pictorial representation of a smart building

2. **Increasing the world's population poses the threat of depleting energy resources**

PROBLEM- The world's population is growing at about 74 million a year. Population growth is no longer distributed evenly across the globe. Scientists have yet to fully determine man's ability to 'rule' the earth. Population is one of the many factors that influence the environment. We have used more resources in the last 50 years than all the personalities in front of us. The 20th century saw the largest increase in world population in human history. So more the population, more the energy consumption and hence it is very important to manage the consumption of energy wisely and effectively.

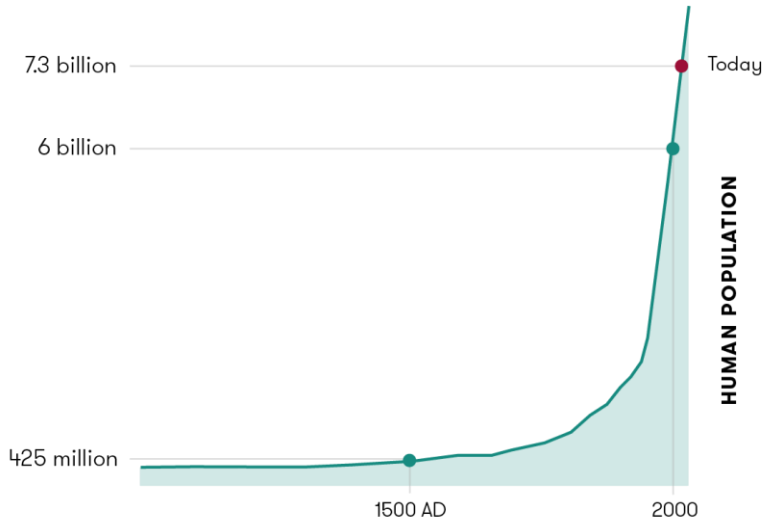

Fig 4.4: Exponential increase of population over the years

OBJECTIVE- By 2100 the global population is expected to reach 11 billion people, but this should be seen as an exciting opportunity to use the Internet of Things in forming smart cities. A truly wise city needs careful consideration of how it can provide a better, seamless experience where it lives. By enabling IoT devices to collect and analyse data from sensors, lights, and meters, it will help developers make decisions about improving infrastructure, resources and resources.

Today's advanced technology such as Internet of Things (IoT) helps to turn farms (no matter their size) into more efficient businesses. By using wise practices such as precise farming, modern farms and food processors will step up to the challenge and help feed the world's population.

3. Food and Water wastage which leads to its shortage

PROBLEM- Food and water shortages are also a huge problem. For example, 60% of the water used for agricultural irrigation today is wasted.

Moreover, in southern countries of the world, water used for irrigation represents up to 91% of general water consumption but agricultural production is equivalent to a third of production in industrialized countries as half of the water destined for irrigation evaporates due to high temperatures or gets lost due to leaks in the water supply distribution networks. To solve the water waste problem it is necessary to introduce modern technologies such as drip irrigation and renewable distribution networks but often major financial and political problems limit these options.

OBJECTIVE- Smart watering systems that sprinkle just enough water in just the right places, and that are able to detect water leaks. A smart irrigation controller adjusts irrigation automatically depending on local weather conditions. For example when it rains irrigation controls will reduce or stop your water saving irrigation. It works by automatically adjusting your top and bottom irrigation depending on the weather you put inside the controller. This is good for conserving water and, if you put the right causes, you should also make your garden healthy. It is important to look after your garden, and fix what causes if your garden looks dry or crowded with water.As we all become busy in our daily lives, technologies such as smart controls can help to intelligently perform what can be confusing and difficult at times. Instead of adjusting our weekly irrigation, within two weeks, twice a year or just once a year, smart controllers will automatically adjust daily based on local weather information (especially rain, temperature, wind and humidity). This will reduce your water consumption by at least 20% which will save you money.

Fig 4.5: IoT based sprinklers used for irrigation of crops

CHAPTER-05

PROPOSED SYSTEM

We are proposing a system which will align solar panel to perpendicular to sun rays at given time and place, we can visualize the system energy production and control electric appliances with web interface. The system which we proposed has single axis solar tracking system. This system used to align solar panels, lenses other equipment's which will use solar energy or record solar signals. The suns position will be changing every day and time, to get maximum energy for the sun we use solar tracking system which will increases the energy production of day.

5.1 Block diagram of the project

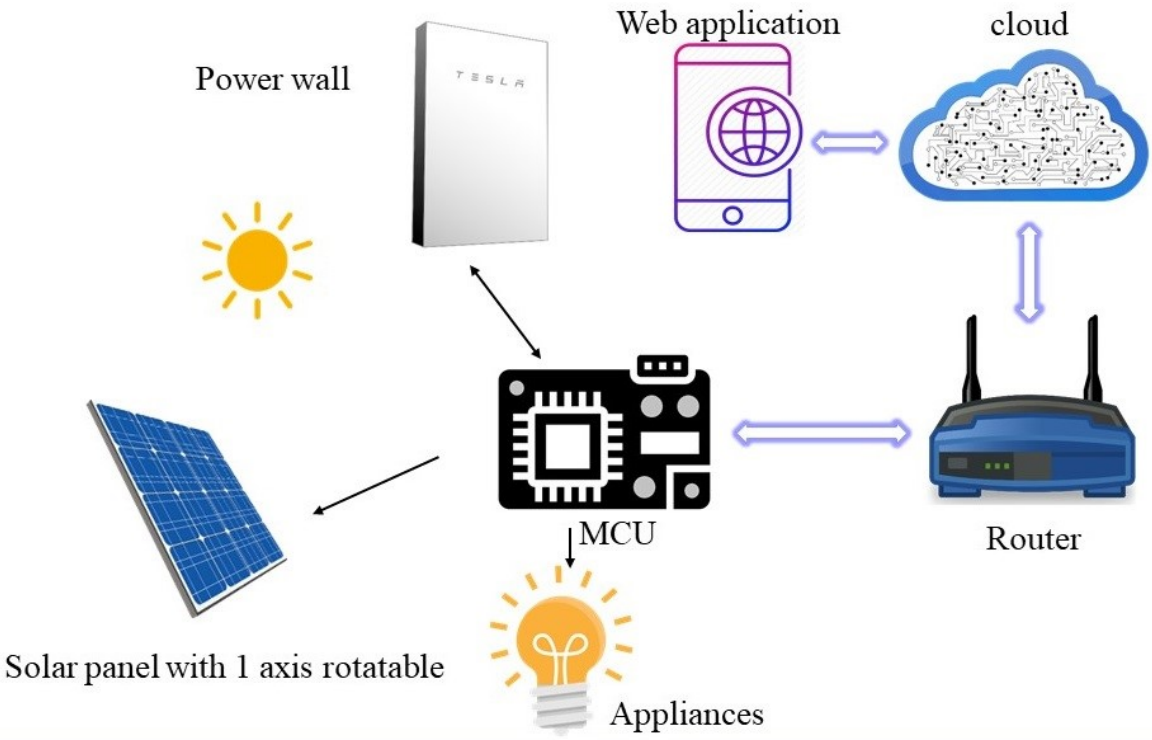

Fig 5.1: Block Diagram

- Solar tracking system we the sun position will be calculated in the cloud.
- With the web application we can control the electric appliances and we can visualize the plots of incoming energy and outgoing energy.
- The router will be used to connect the MCU to cloud.

- MCU will used to control the servo motor to align in position with data computed in cloud and MCU will monitor the incoming energy and outgoing energy.
- From the solar panel we get the electrical energy and we will charge the battery (Power wall).

5.2 Work flow

5.2.1 Cloud (server):

Solar tracking- We chose a webhosting server where we will create the files that written in PHP which is server scripting language. The sun position is calculated with the nonlinear equations.

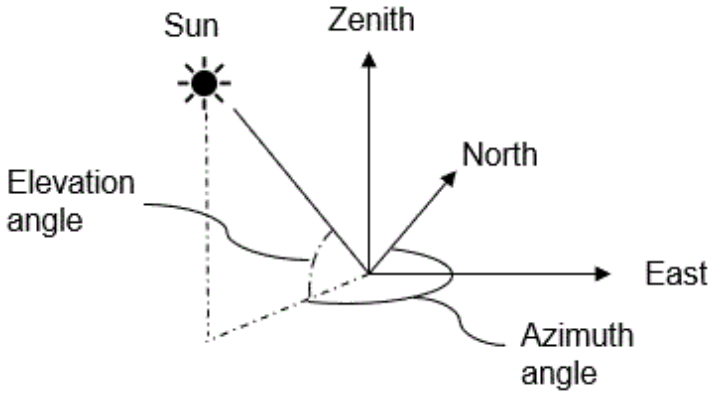

Fig 5.2: Solar angles

The angle calculation formula

- The declination angle (δ):

  $\delta = 23.45\sin°[\frac{N+284}{365} * 360°]$

  where N= day no. of the year with Jan 1=1

- The apparent solar time, AST (or local solar time) in the western longitudes are calculated from

  AST = LST + (4min/deg) (LSTM - Long) + ET

  LST= Local Standard Time

  Long= Local longitude at the position of interest

  LSTM= Local longitude of standard time meridian

  LSTM= 15° * ($\frac{Long}{15°}$) round to integer

- The hour angle (H), is the azimuthal angle of the sun's rays caused by the earth's rotation, and H can be computed from –

$$H = \frac{(No.\ of\ minutes\ past\ midnight,\ AST) - 720\ mins}{4\ min/deg}$$

- The solar altitude angle (β1) is the apparent angular height of the sun in the sky if you are facing it. The zenith angle (θz) and its complement the altitude angle (β1) are given by –

$$\cos(\theta z) = \sin(\beta 1) = \cos(L)\cos(\delta)\cos(H) + \sin(L)\sin(\delta)$$

- The solar azimuth, (α1) is the angle away from south (north in the Southern Hemisphere) and given by –

$$\cos(\alpha 1) = \frac{\sin(\beta 1)\sin(L) - \sin(\delta)}{\cos(\beta 1)\cos(L)}$$ where L= latitude

δ= declination angle

H= hour angle

With this angle we can locate the sun in spherical coordinates. We can calculate the servo angle. The servo angle will be read by the MCU for aligning Solar panel.

5.2.2 Web Interface:

The web interface helps to control the electric appliances and also to visualize the data of the Electrical parameters like voltage, current, power and energy.

The web interface program is written for front end are HTML, CSS and Java Script and for back end is PHP.

5.2.3 MCU:

Microcontroller unit which is a bridge between the cloud(server) and motor which will control the solar panel. MCU will request the data from the server, the server serves the data which is requested by the client (MCU). The data requested is the servo angle of the particular location and particulate time where we will maximum energy form the sun. The MCU will receive the data

requested and sends the appropriate signal to the servo motor. Then the MCU will measures the voltage, current and power and send to the server. With the values sent the server stores in the database for the user visualization.

5.2.4 Circuit diagram:

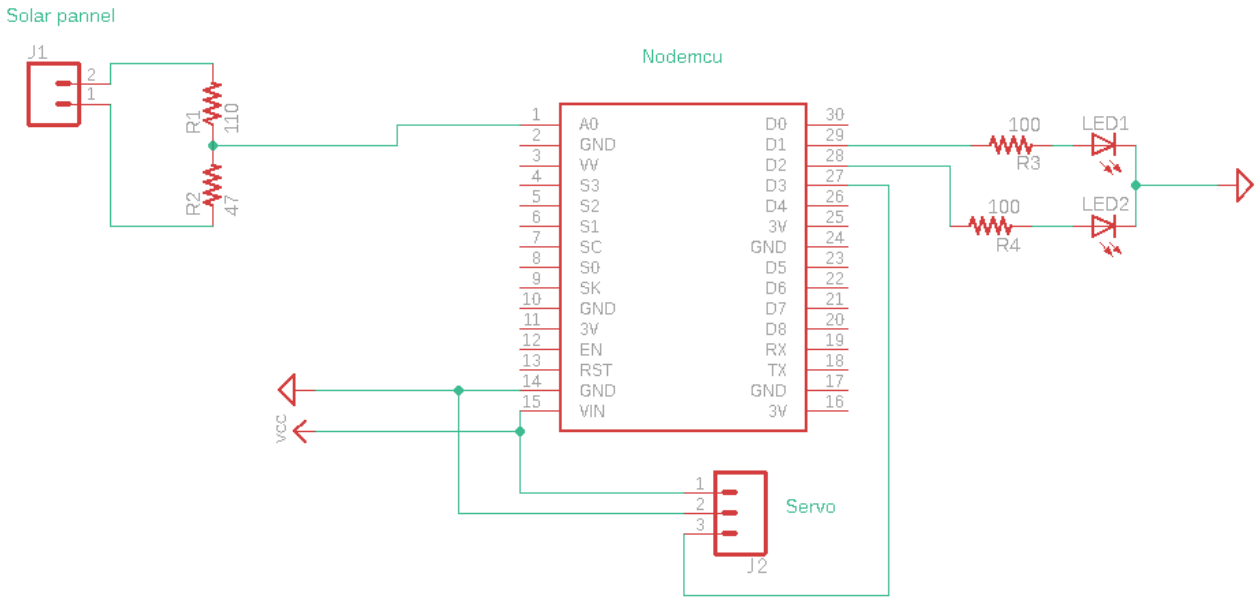

Fig 5.3: Circuit Diagram

The circuit diagram as above the MCU we are using ESP8266(NodeMCU) and servo mother to control the angle of solar panel. The two led's are the load which can be controlled remotely and the Solar panel is to be connected and the input voltage and current is with voltage divider circuit.

Chapter-06

Project Description

For the completion of the proposed project we need to meet certain specification of both the hardware and software. The specifications are as follows:

6.1: Hardware specifications:

NodeMCU

NodeMCU is an open source firmware which used for IoT and uses CPU-ESP8266. Which has memory of 128kB and Storage 4MB, it 32-bit, CPU operating voltage is 3.3V, it has one analog input and 16 general purpose input-output pins, it contains SPI, UART and I2C communication.

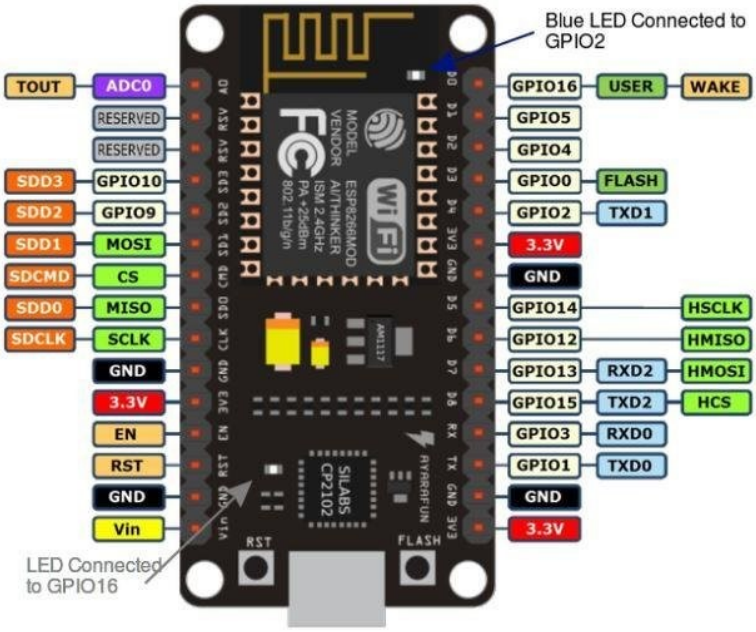

Fig 6.1.1: NodeMCU

Servo motor (SG-90):

A servomotor SG90 is an rotary actuator it allows to perfectly control the angular rotation. Servomotor contains the closed loop feedback system to align in given angle. Servomotor SG 90 is controlled by using pulses through the signal wire. The frequency of the signal is 50Hz the time period of 20ms. The angular position of the servomotor SG 90 can be controlled by pulse width 500-2400 micro sec. SG90 servo motor has torque 1.8 kg-cm, speed 0.12 sec/60degree.

Fig 6.1.2: Servo Motor (SG-90)

Solar panel:

Solar panel is an array of photo-voltaic cell. It is the device used to convert solar energy to electrical energy. The solar cells are arranged in frame to protect from mechanical damage and water. Most of the modules are rigid, but semi-flexible modules based on thin film cells are also available. The cells are electrically connected in series, to each other at the desired voltage, then in parallel to increase amperage. The power of the module is the mathematical product of the voltage and the amperage of the module.

Fig 6.1.3: Solar Panel

LED

LEDs are lights that fit effectively into an electrical circuit and efficient . Be that as it may, in contrast to conventional radiant bulbs, they don't have a fiber that will wear out, and they don't get particularly hot. They are lit up exclusively by the development of electrons in a semiconductor material, and they keep going similarly up to a standard transistor. The life expectancy of a LED outperforms the short existence of a glowing bulb by a huge number of hours.

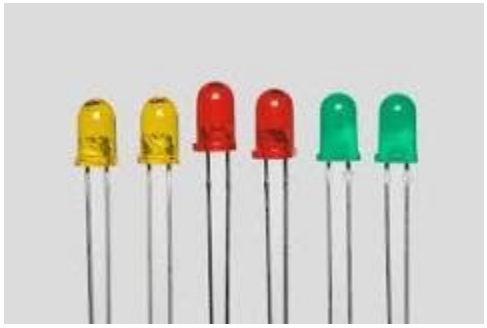

Fig 6.1.4: LED's

Resistor:

Resistors are electronic parts which have a particular, failing to change electrical opposition. The resistor's opposition restricts the progression of electrons through a circuit.

They are aloof segments, which means they just consume power (and can't create it). Resistors are generally added to circuits where they supplement dynamic segments like operation amps, microcontrollers, and other incorporated circuits. Ordinarily resistors are utilized to constrain current, partition voltages, and draw up I/O lines.

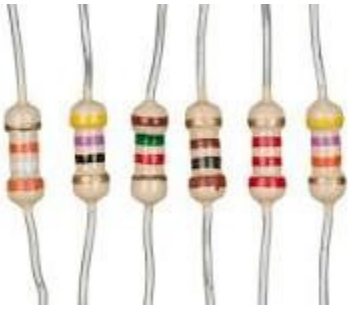

Fig 6.1.5: Resistors

Bread Board:

A breadboard is a rectangular board with many mounting gaps. They are utilized for making electrical associations between electronic parts. The associations aren't perpetual and they can be evacuated and set once more. Indeed, you can even supplant segments to redo your venture or work on a totally extraordinary one, utilizing a similar breadboard. The positive rails are shown by red lines, while the negative rails are demonstrated by dark ones.

Fig 6.1.6: Bread Board

6.2: Software Specification

Software are required to Programming the Front end and back end of the website. And to program the NodeMCU.

Microsoft Visual Studio:It is an IDE(integrated development environment) by Microsoft. It is used by developers to program webpages, web server etc. Visual Studio incorporates a code editorial manager supporting IntelliSense (the code finish segment) just as code refactoring. Other underlying apparatuses incorporate a code profiler, planner for building GUI applications, website specialist, class architect, and information base composition developer.Programming languages used are PHP and JavaScript.

Fig 6.2.1: VS Code

ARDUINO IDE

Arduino is an open-source platform utilized for building gadgets ventures. Arduino comprises of both a physical programmable circuit board (regularly referred to as a microcontroller) and a bit of programming, or IDE (Integrated Development Environment) that keeps running on your PC, used to compose and transfer PC code to the physical board.

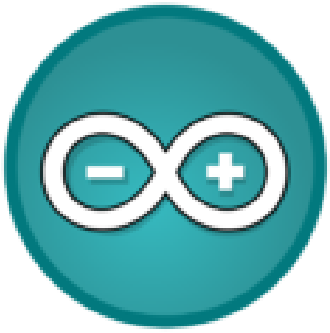

Fig 6.2.2: Arduino IDE

Library's used

1. Servo
2. WiFiClient

1. Servo:

This library allows an Arduino board to control RC (hobby) servo motors. The servos have built-in gears and a shaft that can be controlled with precision. Standard servos allow the shaft to be positioned at different angles, typically between 0 and 180 degrees. Continuously rotating servos allow the shaft rotation to be adjusted at different speeds.

2. WiFiClient:

This library used By MCU to connect to Internet with specific port number

Chapter-07

Result and Discussion

7.1 Result:

The prototype made for this project titled “Efficient Energy Management System using IoT” does give the desired results and output. The web application developed for the purpose of controlling and monitoring the usage and energy consumption shows the data accurately. The NodeMCU and web application exchange the data with each other seamlessly over a given time interval so that the current status is updated regularly for the user.It clearly shows the involtage, outvoltage, inenergy, outenergy, incurrent, outcurrent, inpower, outpower as well as whether the appliance – LED in this prototype – is ON or OFF.

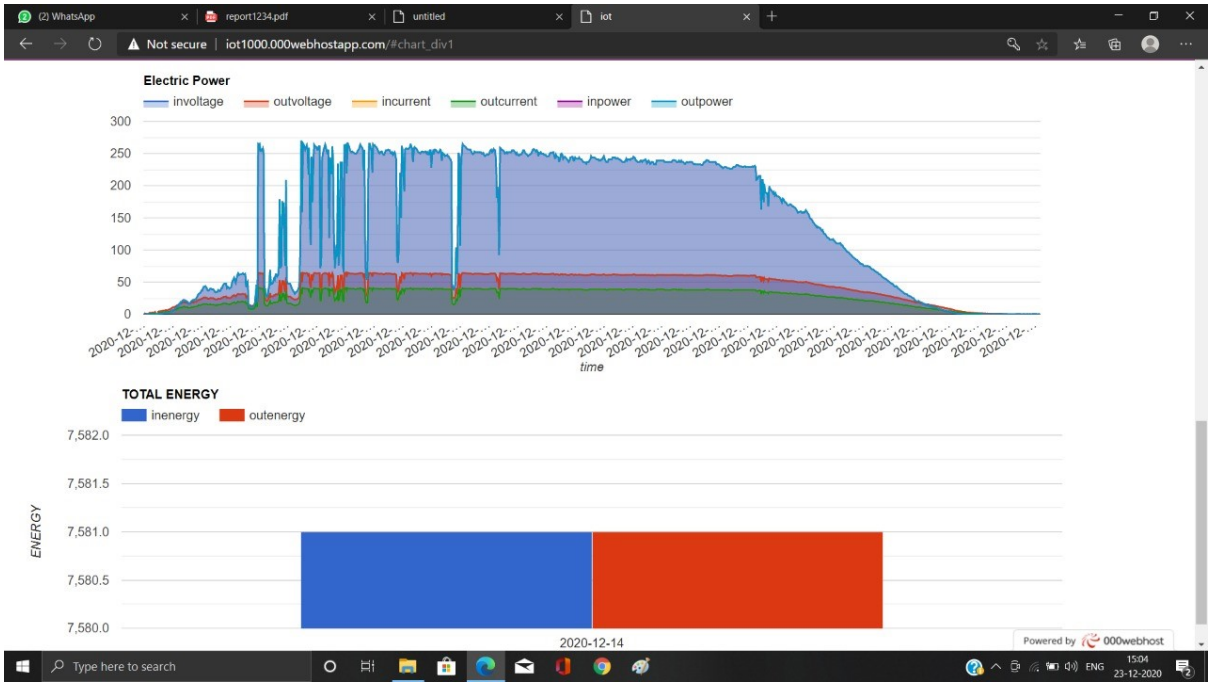

Fig. 7.1: The power consumed is indicated along with voltages and currents supplied or drawn by the appliance

Here, the web application is displaying the voltage that the appliance gets or consumes whilst working or in ON mode as well as the current it draws in order to function properly. Then, power consumed by the appliance cab be calculated by the formula POWER = VOLTAGE *CURRENT. The

data is stored in the manner that the most recent record figures are showed at the end and they just keep getting stacked to the database of the web application.

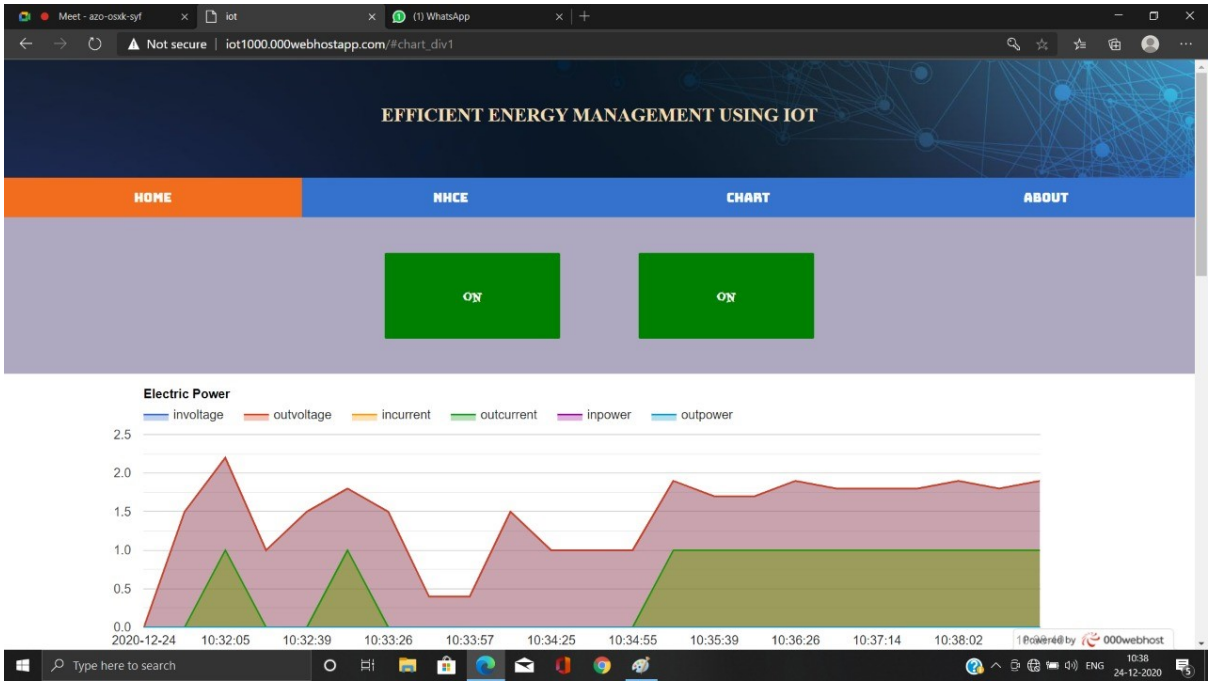

Fig. 7.2: Web application indicating the current status of the appliances

Here, the web application the showing the user the current status of the appliances being monitored by this prototype – two LEDs in this prototype. Also, the power consumed by the appliances is shown in an easy-to-read graph for the user at regular intervals of time which can be altered by the user according to his or her convenience. Hence, the letting the user control the device with ease of his/her fingertips.

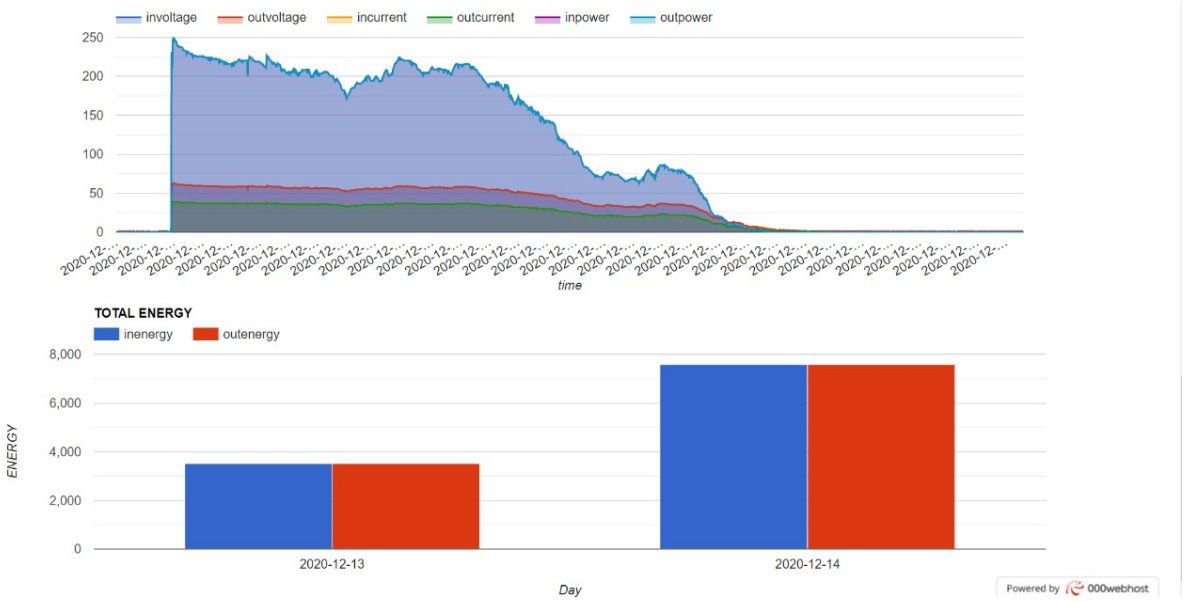

Fig 7.3: Total energy consumed by the appliances

Here, the web application is showing the energy consumed by both the appliances (LEDs) so that the user can understand the current usage pattern in more detail and use the same to analyse and control the consumption of energy as well as make sure that it is cost effective.

7.2 Discussion:

This prototype has a bi-directional data flow between the NodeMCU and the web application. The microcontroller is connected to the appliances as well as to the web application. It will analyse the usage pattern of the appliances and send it to the web application. Here, the suer will be able to see the data and control the appliances by passing instructions to the NodeMCU. The data analysed in the cloud (web application) and by the graph obtained due to the power consumption of various appliances at any given place and time will show the user the amount of energy wasted. By this data one can understand the wastage of energy and use every appliance in the most efficient manner.

With each data that is analysed, a learning model can also be created which tells us how much energy is consumed by each appliance can we also limit that much of energy to that particular appliance which saves energy.

Few advantages of Efficient energy Management System are listed below :

- Reduce amount spent on energy
- Minimize carbon emission, hence, eco-friendly
- Abides by the Government restrictions on harm to the environment
- Integrates greener sources of energy
- Optimises asset maintenance
- Involves automation as well
- Cuts operational expenses
- Gives proper understanding of energy use
- Identifies the malfunctions in time and prevents them
- Effectively combats power outages, accidents as well as blackouts
- Facilitates prediction of consumption and helps in planning the spending

Chapter-08

Conclusion and Future Scope

Conclusion

In this study, an IoT based Energy management system has been designed by in order to reduce energy consumption and unit energy cost. Thanks to the IoT-based energy management system, the user is immediately provided with information such as current values, electrical power, power, usability, humidity, temperature and light intensity. With this system, energy costs can be reduced by using devices such as a washing machine and a dishwasher that will be used at any time of the day, within hours when energy costs are low. In addition, power consumption reports can be tailored to each device such as daily, weekly, monthly and yearly. In this way, it will be easier to take the required amount of energy savings by doing research on energy consumption, where devices operate in a wide range of design applications, it turns off the appropriate device, thus ensuring security. The Energy management system directs users to use flexible devices to use at any time throughout the day, in Period I. The management system extends using data via the user interface and helps the users for taking energy saving measures.

We here have developed a better IoT system for Energy Management which takes the Humidity, Temperature and light intensity into consideration and accordingly interfaced with Arduino microcontrollers for controlling the usage of appliance like speed of fan, positioning of solar panels, light intensity rather than just switch on or off.

In this context, the proposed IoT based system facilitates energy end-users to know how much energy is consumed in total and what is the contribution of the specific end-user and other peers to that, as well as get personalized recommendations of actions for energy conservation and load shifting, along with an estimation of their impact on energy use and user comfort.

The system uses data sensors embedded in the structure and measures real-time data in terms of application of equipment, residential data, behavior data, se points, system settings etc.

Thus, it is concluded that IoT plays a major role in energy management and contribute much for green initiatives. Our future work is to explore various energy efficient techniques to reduce energy consumption in the campus environment thereby making it green by utilizing IoT.

FUTURESCOPE

Power and energy management is a large and fast-growing market, leveraging trends in and technologies from the Internet of Things, Big Data, Machine Learning, CleanTech and Asset Performance Management. This rising market is expected to reach $ 77B by 2021.

With rising public and legal pressures, problematic grid, electricity prices, and bulk waste, organizations across the industry are likely to re-examine their energy practices and ask where they can save fuel. This is especially true in the manufacturing, marketing, hospitality, education, health, and real estate sectors.

There are many solution providers out there who do really cool and innovative things when it comes to power management. I work with a company called Panoramic Power that uses energy sensors and machine learning to create understanding of what is happening to reduce waste and improve work performance. The system will generally save between 15-30% of power outages and is surprisingly alarming.

Fig 8.1: Google Nest Services

There is also a growing market for internal power management solutions. This market is not nearly as big as the organization's counterparts but it is widely discussed and therefore receives a lot of media attention. These solutions often rely on smart devices - Nest, Hive, Sensibo, Alexa etc. and compatible applications.

Fig 8.2: Switching on AC using SENSIBO device

Fig 8.3: Amazon Alexa

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2. Lavanya A., Jeevitha M. and M.A.Bhagyaveni, **"IoT-Enabled Green Campus Energy Management System"**, International Journal of Embedded Systems and Applications (IJESA), Vol 9, No.2, June 2019.

3. F. K. Shaikh, S. Zeadally & E. Exposito, **"Enabling technologies for green Internet of Things''**, IEEE Systems Journal, Vol. 11, Issue: 2, Jan 2019.

APPENDIX

Code nodeMCU

```
#include <Arduino.h>
#include <Servo.h>
#include <ESP8266WiFi.h>
#include <ESP8266WiFiMulti.h>
#include <ESP8266HTTPClient.h>
#include <WiFiClient.h>
Servo servo_1;
ESP8266WiFiMulti WiFiMulti;
const char* server="http://iot1000.000webhostapp.com/update_energy.php";
unsigned long int t1,t2;
unsigned int angle=0;
String payload="hello";
String payload1="0000";
void setup() {
  t1=millis();
  t2=millis();
 servo_1.attach(0);
  Serial.begin(115200);
  // Serial.setDebugOutput(true);
 pinMode(LED_BUILTIN,OUTPUT);
 pinMode(D1,OUTPUT);
  WiFi.mode(WIFI_STA);
  WiFiMulti.addAP("mi", "");
servo_1.write(angle);
delay(2000);
l_ed();
u_pdate();
s_ervo();
}
void loop() {
  // wait for WiFi connection
  if ((WiFiMulti.run() == WL_CONNECTED)) {
 l_ed();
  }
  delay(3000);
 if ((WiFiMulti.run() == WL_CONNECTED) and (millis()-t1)>20000) {
  u_pdate();
  t1=millis();
}
```

```
if ((WiFiMulti.run() == WL_CONNECTED) and (millis()-t2)>20000) {
    s_ervo();
  t2=millis();
}
}
void s_ervo()
{
   WiFiClient client;
   HTTPClient http;
   Serial.print("[HTTP] begin...\n");
   if (http.begin(client, "http://iot1000.000webhostapp.com/sangle1.php")) {  // HTTP
     Serial.print("[HTTP] GET...\n");
     // start connection and send HTTP header
     int httpCode = http.GET();
     // httpCode will be negative on error
     if (httpCode > 0) {
       // HTTP header has been send and Server response header has been handled
       Serial.printf("[HTTP] GET... code: %d\n", httpCode);
       // file found at server
       if (httpCode == HTTP_CODE_OK || httpCode == HTTP_CODE_MOVED_PERMANENTLY) {
          payload1 = http.getString();
         Serial.println(payload1);
    angle=payload1.toInt();
    servo_1.write(angle);
     }
     else {
       Serial.printf("[HTTP] GET... failed, error: %s\n", http.errorToString(httpCode).c_str());
     }

     http.end();
   } else {
     Serial.printf("[HTTP} Unable to connect\n");
   }
}
void u_pdate()
{

   WiFiClient client;

   HTTPClient http;
   float v,c;
   v=analogRead(A0);
   v=v*3.3/1024;
   v=v*157/47;
```

```
  c=v*1000/157;
 http.begin(server);
 http.addHeader("Content-Type", "application/x-www-form-urlencoded");
 String hr="ic="+String(c)+"&iv="+String(v)+"&oc="+String(c)+"&ov="+String(v);
 int hrr=http.POST(hr);
 Serial.print("HTTP Response code: ");
    Serial.println(hrr);
    http.end();
}
void l_ed()
{
 WiFiClient client;
   HTTPClient http;
   Serial.print("[HTTP] begin...\n");
   if (http.begin(client, "http://iot1000.000webhostapp.com/ledstatus.php")) {
    Serial.print("[HTTP] GET...\n");
         int httpCode = http.GET();
    if (httpCode > 0) {
     // HTTP header has been send and Server response header has been handled
     Serial.printf("[HTTP] GET... code: %d\n", httpCode);
    if (httpCode == HTTP_CODE_OK || httpCode == HTTP_CODE_MOVED_PERMANENTLY) {
        payload = http.getString();
       Serial.println(payload);
   if(payload[1]=='1')
   {
    digitalWrite(LED_BUILTIN,0);
   }
   if(payload[1]=='0')
   {
    digitalWrite(LED_BUILTIN,1);
   }
   if(payload[3]=='1')
   {
    digitalWrite(D1,1);
   }
   if(payload[3]=='0')
   {
    digitalWrite(D1,0);
   }
      }
    }
    else {
     Serial.printf("[HTTP] GET... failed, error: %s\n", http.errorToString(httpCode).c_str());
    }
```

```
    http.end();
  } else {
    Serial.printf("[HTTP} Unable to connect\n");
  }
}
```