CONSERVATION OF ENERGY USING IOT : A SURVEY

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Abstract : ***Internet of Things is a rapidly expanding technology for the future industries and to change the lifestyle of people. Within sensors, actuators connecting smart objects with the Cloud and provides us services like mobile healthcare, smart transportation system, energy conservation system etc. This paper explains the various aspects of energy conservation system using internet of things. It also lists benefits and some limitations on implementation of Energy Conservation with IoT. This paper also includes some of the IoT enabling technologies which are making energy conservation system work with smart phones and tablets becoming the major user interface between users and things. This research is to develop a prototype product of a online Monitoring system that allows the user to monitor the energy consumption continuously. The enhancement done in existing system is to monitor data anytime and anywhere using internet and a web based application. The study of associated hardware and software is included. The hardware involved in this study is to build monitoring board and software involves the programming done in embedded C language to control the micro controller. PHP language is used as server side scripting to publish the current values at the web browser. This prototype of a Web-Based Energy Monitoring has met all the objectives derived and planned. Using this prototype wastage of energy can be reduced in larger amount.***

IndexTerms - Arduino, NodeMcu, PHP, Appache, Embedded system, Programming, IOT, Cloud computing, GNS3, Proteus.

I. INTRODUCTION

Energy is one of the most important source in human life and there are both renewable and non-renewable resources of energy. Non-Renewable resources of energy like oil, natural gas are near extinction. The need is to conserve the energy so that these limited sources of energy can be used for maximum time. Internet is the one revolutionary technology that has changed the way of living, made the world kind of a true global village. More and more objects are connecting with the Internet and it helps in emergence of Internet of Things (IoT) which is changing almost every field like IT, Energy, Banking, Homes etc. Billions and trillions (in future) of sensors create a mesh which can help automate the things and helps in faster and more managed world. Organizations, all around the world are finding ways to reduce and control their energy consumption that automatically helps them in reduction of power and overhead expenses.

This also will help in energy management, which was kind of impossible before. With IoT, energy consumption can be dynamically monitored and with that an organization can find out when and where it is spending too much and devices can be either turned off when not in use automatically or their power level can be reduced, which can automatically reduce the consumption and energy rates. Cisco predicts that there will be around 50 billion devices connected to the Internet by 2020. Below is the figure depicting the rise of IoT from a Cisco White Paper on IoT :

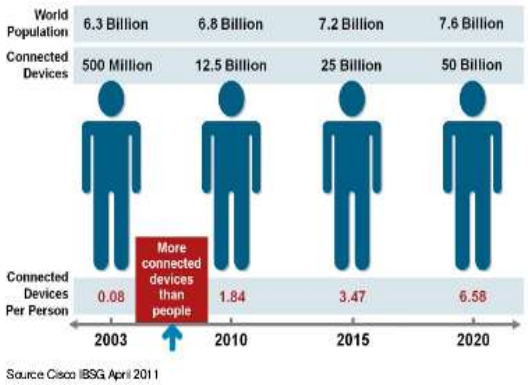

Figure 1 | Rise of IoT | Source – Cisco IBSG, April 2011

Energy Giant GE has introduced two products, one is "Predix" which is a cloud based analytics fabric which will process and make useful the humongous amount of data that IoT produced, other thing GE introduced is "Current", which harnesses the horsepower specifically for energy related initiatives. Both these products work together which helps in reducing energy consumption. According to GE, it will reduce the customer electricity bills by 10 percent to 20 percent. GE is not the only big company which has move towards IoT for energy management. Other companies like Intel, Tatung, Apple, LG, Cisco, Google, Samsung etc are also moving to IoT for energy management. Energy future is totally linked with technologies like Internet of Things, Cloud Computing now, where energy is monitored and managed from the brains sitting in the cloud and it helps automate the things in best possible manner. Impact of IoT on energy efficiency will be huge. According to Gartner, IoT value estimate will be from $300 billion to close to $2000 billion depends on the IoT market.

II. LITERATURE SURVEY

S. no.	Citation	Year	Contribution
1	D. Holcomb, L. Wenchao, and S. S. A"	2009	Explores whether anomalous energy consumption and basic sensors might be used to guide whole building error detection and fault diagnosis. With a set of sensors that is well-suited to the faults of interest, diagnosis may be possible. A consideration when using energy consumption for error detection is that many faults have little or no impact on energy consumption; if these faults have other undesirable effects, then an alternative approach for detection is needed.
2	J. Kun, L. Yan and S. Zhen, Y. Yuebin	2012	Energy Management Control Framework for building operation optimization and control is proposed in this paper. This framework enables the exploration of the saving potential of several energy saving strategies which are also proposed in this paper. This framework is also an enabler for active occupant-driven control and micro-zoning control which incorporates occupants' real-time requests and predicted schedule and task information to optimize BAS operation and control. Co-simulation platform with MATLAB/SIMULINK and Energy Plus is used to implement the proposed EMC framework, strategies and simulations on a real building model that is generated from the Intelligent Workplace (IW) building at Carnegie Mellon University. The simulation results verified the feasibility and effectiveness of the proposed EMC framework and strategies.
3	S. Makonin, F. Popowich, T. Moon and B. Gill	2013	In this paper, we have shown how open source components can be used to create solutions that help conserve energy. Our open source prototype can be reproduced, used, and extended by anyone who is interested in conserving energy now. Most importantly, homeowners and occupants will have access to the raw consumption data to do with as they see fit. Our future work involves adding a load disaggregation algorithm that would notify occupants as to which appliances are running and how much power each is consuming. This is an important feature that can be used to help occupants decide if they would like to participate in a demand-response call from the utility. If so, what appliance, or appliances would need to be powered down to meet the amount of power reduction required of the demand-response call. Without load disaggregation, the realization of demand-response will not be seen.
4	N. Prakash and D. Swathika	2014	The control of submersible pump based on pressure from water outlet from pump used is going to be implemented. Pressure level from the outlet of pump is monitored periodically. Temperature, current are monitored. The overall efficiency can be increased by utilizing the electricity effectively. This monitoring and control system can be used for pumping water from well and to supply water to the agricultural land.
5	R. Rajeshwari	2015	WSN is significant to prolong network lifetime so that more data can be collected by the sink. A new mobile sink routing and data gathering method has used through network clustering based on proposed clustering technique. To extend the energy efficient methods must be employed for data gathering and aggregation in order to achieve long network lifetime. Efficient data aggregations not only provide energy conservation but also remove redundancy data and hence provide useful data only. To provide security for data transmission to Mobile Sink.
6	Sourabh Dey	2015	In, this paper it has mentioned how the energy are being wasted in spite of knowing that energy are very much short now a days. Some, process are mentioned how basically energy is misused in the house hold works. So, a very

			common solution now days are found out i.e. automation which has a vast field. But, very few persons are familiar with this term and equipments. Here, various kinds of electronic gadgets and equipments have discussed to solve the problem of wastage of energy in the house. And by this process and more upcoming technologies providing us great helpful to everyone even to the disable persons and handicap too who have the difficulties to walk and turn on\off the light. Some of the process are discussed here are affordable one for every person now days and some may not be. Wireless features are now days very popular in the market and in demand by the every person for making the life more luxurious one and very relax able one.
7	ZuraidahTharo, et al.	2016	The current consumed by lighting load using the inverter is much smaller compared to the current 0.76A only destroyed the light weight without using an inverter which reached 1.3A. Active power (consumption) lamps using the much smaller inverter which is only 135,63W compared with positive control (use) of the light load without using an inverter which reached 185.64W
8	R. Renuga Devi	2016	In this paper, we presented the strengths and weaknesses of each protocol by providing a classification and comparison by considering the important design issues. As sensor networks are designed for the specific applications, there may be different requirements of QoS. From this study, it is clear that it is impossible to design a routing algorithm that may give high performance for all applications under all scenarios. But while designing the routing algorithm, these design issues may be considered to obtain comparatively better performance.
9	A. Namvate, et al.	2017	Remotely ON/OFF the electrical appliances. Check the status of electrical devices at home. If the user finds electrical appliances are ON then user can operate or OFF appliances using android application from outside the home. Using this system we can successfully save electrical energy.

III. IOT ENABLERS FOR ENERGY CONSERVATION SYSTEM

With IoT emerging rapidly in all the fields and helping in reducing costs, faster and more accurate deployment of services, one must think about the different IoT enablers that make Internet of Things ticks. The technologies which can be used to make an Energy Conservation System based on IoT works are explained below :

1) Embedded system: Embedded system employs a combination of software & hardware to perform a specific function. It is a part of a larger system which may not be a "computer" Works in a reactive & time constrained environment. Any electronic system that uses a CPU chip, but that is not a general-purpose workstation, desktop or laptop computer is known as embedded system. Such systems generally use microprocessors; microcontroller or they may use custom-designed chips or both.
2) Arduino: Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, Max MSP).
3) Programming in Arduino: In arduino programming is done with sketchbook provided by arduino itself. This sketchbook is the IDE + Compiler + Burner Software, a combined package for programming an arduino board.

Figure 3 | Arduino Sketchbook | Source - https://cdn-learn.adafruit.com

4) NodeMCU: NodeMCU is an open source platform developed mainly for IoT. It includes on-chip ESP-12 module to communicate with wireless modem/routers. Its firmware runs on the ESP8266 WIFI SOC from Espressif Systems. The name "NodeMCU" comes from the firmware of the module not from the hardware. Language used in firmware is Lua scripting language. The coding is done by using the arduino platform. The language used to code the NodeMCU is "embedded C".

Figure 4 | NodeMCU | Source - https://ESP8266-NodeMcu-WiFi-Development-Board

5) Apache Server: Web Server is used to host web pages and web applications. There are different variants of web servers present in the industry for web server like Microsoft Internet Information Server(IIS), Apache Server, Apache Tomcat etc. Apache is an open source web server which holds the largest share in the web server industry. Almost all the hosting providers and cloud providers provide the services through Apache Web Server. One of the best things about Apache is that it can be implemented in almost all the major Operating System Platforms like Windows, Linux, Unix etc. Wamp/Xampp can be used to install Apache and create web server environment on Windows and Linux. It is kind of a package that has multiple applications integrated in it like Apache, MySQL or MariaDB and PHP.
6) Temperature sensor: Temperature sensor is used to read the temperature of particular location or area. Temperature sensor used in this circuit is DHT11. Sensor is used to fetch the temperature of particular location and transmit it to the arduino which will further transmit it to cloud.

Figure 5 | DHT11 | Source - https://www.inventelectronics.com

7) Cloud computing: Cloud Computing and Internet of Things are very much linked with each other in a manner that in order to make IOT a success, clouds play a very important role. Cloud is mainly divided into three different types i.e. iaas, saas and paas. As with IOT, different devices are connected with the internet and can be accessed from any place at any time, the data that is fetched via the machines can be stored in the clouds like Amazon AWS, any private cloud created by the company. Cloud is the paradigm shift in the IT industry and the businesses worldwide which can be used with different aspects of IOT in order to make it a huge success. All the data fetched from the machines by sensors for example are stored in the clouds and can be used at any time to make decision making. Also companies like Microsoft, Amazon, Google, IBM etc are providing cloud based applications that can help making IOT successful and these IOT based applications can be used from any place with the presence of the internet. So IOT and Clouds are the two big things in the current IT industry and both the making a radical shift in the industry and innovating businesses worldwide.
8) Relay: A relay is a switch which can be operated electrically. electromagnet is used in many relays to mechanically operate a switch, but many other principles are also used, such as solid-state relays. Relays are used to control a circuit by a separate low-power signal, or where one signal is used to control several circuits. The very first relays were used as an amplifier in long distance telegraph circuits: the purpose is to repeat the signal coming in from one circuit and re-transmitted it on another circuit.

Figure 6 | Relay | Source - https://www.jaycar.com.au

9) LPG Gas Detector: A LPG gas locator is a gadget that recognizes the nearness of LPG gas in a zone. It is utilized as a piece of a security framework in houses. This sensor/gear is likewise used to recognize a gas spillage specifically territory and can interface with a controller so a procedure can be consequently begin or close down. A gas identifier can sound an alert in the region where the hole is happening, which can assist experts with fixing the spillage. Gas spill identification is the way toward recognizing gas spills by sensors. These sensors more often than not utilize a notice to client on cell phone utilizing the application and web availability organ discernable caution to alarm individuals when a gas has been recognized. these sensors are utilized for an extensive variety of uses and can be found in mechanical plants, refineries, pharmaceutical assembling, fumigation offices, paper mash factories, air ship and shipbuilding offices, hazardous materials tasks, and homes.

Figure 7 | Gas sensor | Source - https://solderingsunday.com

IV. LANGUAGES USED

1) Embedded C: Embedded C language is used to program the controller (Arduino). It is developed from C and C++ language. It is the most commonly used language to control the hardware using controller. Code written in this language is very much easy and user friendly.
2) Android: Android is used to develop the mobile application. This language is used because it is the most common platform to work on. These days maximum multimedia phones are using android platform. It will help us to connect to the device using internet and operate the impotent tasks.
3) PHP: PHP is an abbreviation of Hypertext Preprocessor. It is a server-side scripting language which is used to create dynamic sites. It is an open source software and works fine with MySQL. It is an HTML-embedded Web scripting language. The syntax of PHP language is borrowed from C language. This language is used to connect the web page with the server.
4) MySQL: MySQL is also an open source software. It is a relational database management system(RDBMS). SQL stands for Structured Query Language. It is the most popular and best RDBMS used for developing a variety of web-based software applications. With the help of MySQL, we can process the information, manage, retrieve and update the data.

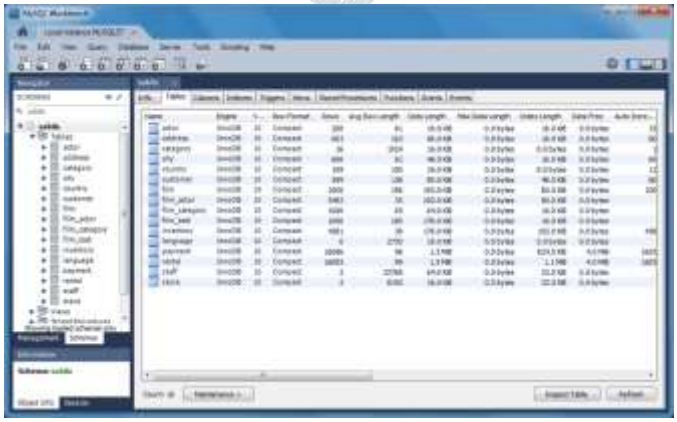

Figure 8 | MySQL | Source - https://dev.mysql.com

Simulators Used

1) XAMPP: XAMPP is a free and easy configurable apache distribution which contains Apache server which process the PHP script. Since, XAMPP runs on all the operating system, it has higher priority level as compared to other tools such as WAMP(Windows, Apache, MySQL And PHP), LAMP(Linux, Apache, MySQL and PHP) And MAMP(Mac operating system, Apache, MySQL and PHP).XAMPP is a local server and has the ability to host unlimited websites on it. XAMPP is powerful and reliable simulator which

runs on few resources. XAMPP server software provide us an environment for testing MYSQL, PHP, Apache and Perl projects on our local machine. The XAMPP installation process is quite simple and fast. As, XAMPP is a free tool, we can run server side script such as PHP without using any remote web server.

Figure 9 | XAMPP Server | Source - https://sourceforge.net

2) Proteus: Proteus simulator is used to design the electronic circuits. Hardware circuit used are designed on computer using the simulator which will help in reaching the desired output. This software will simulate electronic circuit. Coding done in any compiler for any controller can be imported to operate the desired functions from microcontroller.

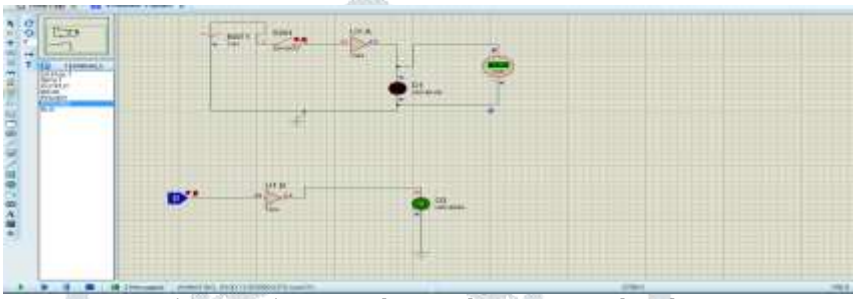

Figure 10 | Proteus | Source - https://electronics.stackexchange.com

3) GNS3: GNS3 is used as a simulator to connect the IOT device with the simulated network. GNS3 is a simulator that runs Cisco and Juniper Router OS and Firewalls which can be used to connect the device with the network and helps in encrypting the traffic that is going from one end to other end. It can simulate a Virtual Private Network and test the IoT traffic over the VPN by using GNS3.

Example :

1) Cisco developed a product for smart energy conservation using internet of things, including Cisco Energy Wise Management (formerly JouleX). Energy Wise Management monitors, measures, and manages the energy of many IP connected systems. Cisco developed policies and embed them in Energy Wise to drive energy consumption savings on those systems.
2) A few projects are also in process for the future of the Internet of Everything regarding power consumption savings through the use of sensors. Currently, 1977 devices are being tracked for energy consumption in Cisco's Tokyo campus, including:

- Printers, where device reporting capabilities allow
- Power over Ethernet (PoE) monitors
- Wireless network infrastructure
- Personal telepresence
- PoE telephony

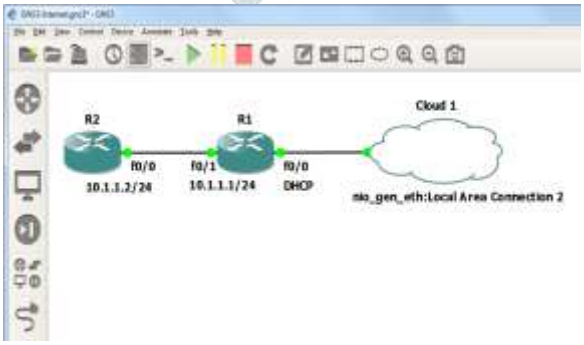

Figure 11 | GNS3 | Source - http://screencast-o-matic.com

V. EXPERIMENTAL SETUP

This research is to develop a prototype product of a online Energy Monitoring system that allows the user to monitor the energy consumption continuously. The enhancement done in existing system is to monitor data anytime and anywhere using internet and a web based application. The hardware involved in this study is to build the energy monitoring board and software involves the programming done in embedded C language to control the micro controller. PHP language is used as server side scripting to publish the current Values at the web browser. This prototype of a Web-Based Energy Monitoring has met all the objectives derived and planned.

Energy monitoring board: Energy monitoring board is developed to transmit consumption readings of electrical energy, Water and Cooking Gas in a house or industry. There are different sensor boards connected with this master energy monitoring board to operate these tasks and then give reading to main monitoring board. The main board consists of a NodeMCU, which will collect data from other boards and processes it before transmitting it to local server. Main monitoring board is also connected to wireless network using ESP8266 module. The main board can communicate continuously with server to get updates, using these updates board can operate several tasks like switch off the main supply of electricity/water/gas. In case of leakage of gas the gas sensor will detect the leakage then transmit signal to server and turn off the main supply of the gas. In case of water consumption if there is continuous running water through meter for some time a alert message is given to the user through the mobile or web application. Using this mobile/web application user can turn off the supply of water. The application also provides the service to control or limit the usage of water, in other words users can limit their water monthly usage in the starting of the month. User can also check the usage of particular time period to control the usage. On the other hand the consumption of electrical energy can also be monitored using the main monitoring board. This board can take consumption readings from digital meter and transmit it to local server with will provide user a record of consumption. Using these records user can check time of peak usage of energy and can decrease the usage. This is only the one advantage of this system, user can also switch off or on any device remotely from anywhere. Light dependent resister is used to check the intensity of sun light which can control the lights accordingly.

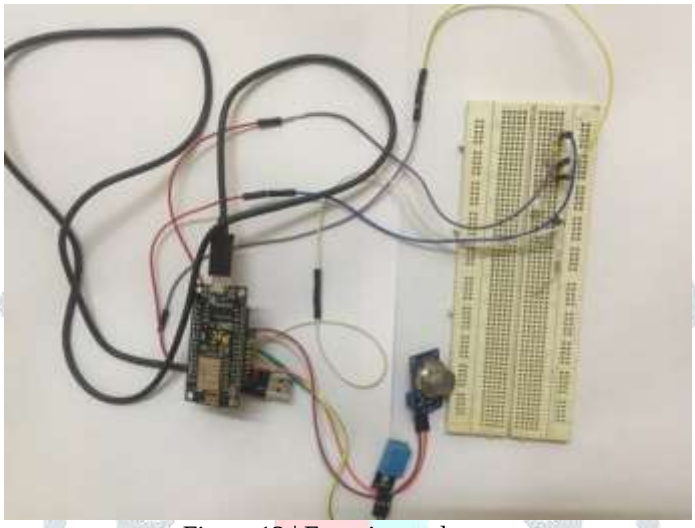

Figure 12 | Experimental setup

VI. BLOCK DIAGRAM

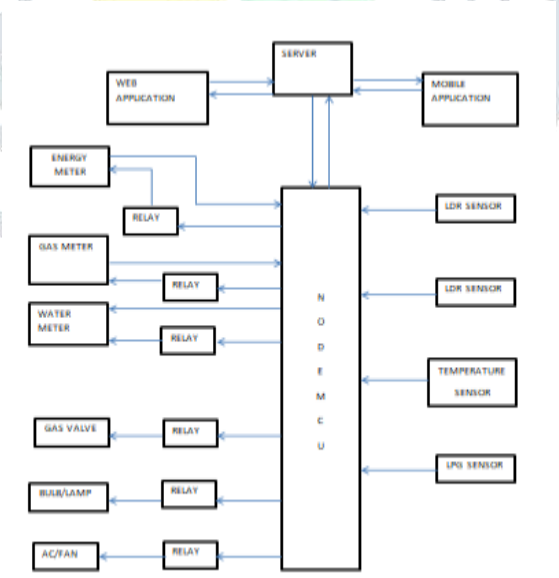

Figure 13 | Block diagram of experimental setup

VII. APPLICATIONS

1) Water consumption monitoring and control: By the use of electronic water flow meter and controller usage of water can be monitored and recorded with respect to time. These records can be used to analyze time of maximum usage of water in a day and then a limit is set on usage. The readings of water flow meter are transmitted to database of web server which will help in continues monitoring of water consumption using android application as well as web application. These applications also provide authority to user to controlling the flow of water using electronic valve connected with the controller. This valve can control the flow of water to entire house on single click on web/android application from anywhere.

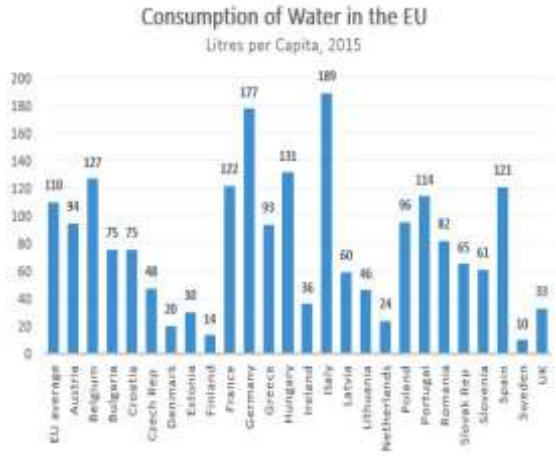

Figure 14 | Water consumption in the European Union | Source - https://www.efbw.org

2) Electricity consumption monitoring and control: controller connected with electronic energy meter can monitor and transmit user's per-minute consumption readings to database of web server. Using these readings energy bills can be generated any-time from any-where. These digital energy bills can be transferred to user by e-mails text SMS or mobile application which will reduce use of paper. Users can limit their usage of electricity by setting bar for particular time by using web or android application. These applications will help the user to monitor and control the electricity of entire house means it will provide the authority to control (ON/OFF) electrical supply of entire house remotely from anywhere in the world.

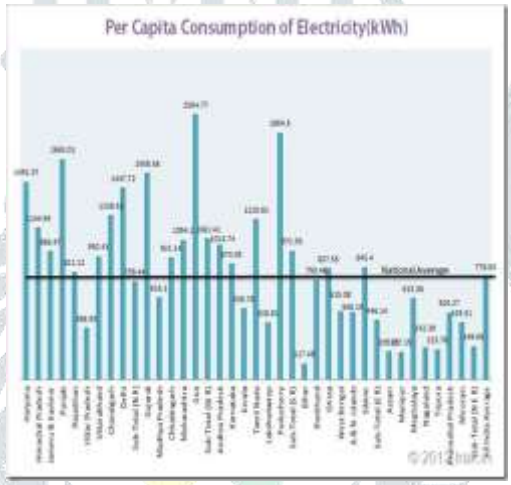

Figure 15 | Electricity consumption in India | Source - http://trak.in

3) Cooking gas/ LPG consumption monitoring and control: An electrical gas valve and electronic meter is connected in main gas supply connection of the house, these electronic meter and electrical valve are connected with controller. Electronic meter reads the gas consumption and transmits it to the controller which will further transmit the data to server database. Using the web or android application these readings can be observed from any-where in the world. This will help user to maintain records of gas consumption. User can check their previous consumptions also. Valve is used to control the main supply of gas to house. It is controlled by application (web/android)through internet connectivity. User can manually ON/OFF valve to control supply of gas.
4) LPG Leakage detection: Mq2 sensor is connected with controller to detect the leakage of LPG gas in house. When sensor detects leakage a signal is transmitted to the controller then the controller starts an alarm to warn nearby people. The controller is programmed in such a way that it will automatically turnoff the main supply of gas so that it can stop the leakage. A alert is send to the mobile application and web application through which user is informed about the leakage.

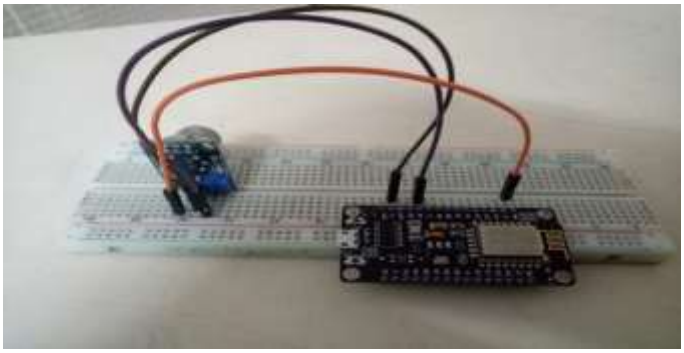

Figure 16 | Mq2 sensor connections with NodeMCU | Source - http://karkhanaindia.blogspot.com

5) LDR dependent Streetlights: Most of the electricity is used to power the streetlights. Sometimes the streetlights are working during the daylight. This happens when someone forgets to cut the supply. Streetlights can work automatically if light dependent resistor is connected with it. This will save a large amount of electricity. LDR will detect the amount of sunlight present and take action for streetlight. If the intensity of sunlight is low then it will turn on the streetlights automatically and if the intensity of sunlight is high it will turn-off the lights.

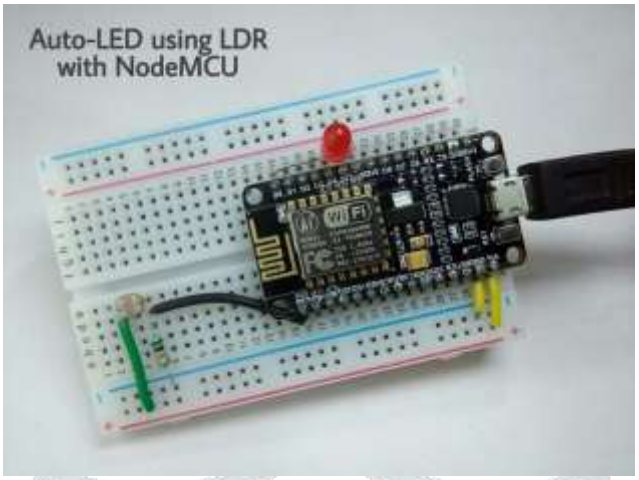

Figure 17 | Auto-LED using LDR with NodeMCU | Source - https://cdn.instructables.com

VIII. ADVANTAGES

1) It can save maximum amount of energy.
2) Monitoring of consumption is done using internet.
3) Devices can be controlled using internet/mobile application.
4) Appliances with higher energy consumption can be monitored.
5) Alarm system will alert user on excess use of energy (turning on light in daytime).
6) In situations like gas/water leakage it will turn off the main supply and inform the user.

IX. LIMITATIONS

1) To control and monitor multimedia phones are required
2) 24x7 internet connectivity is must.
3) Hacking is possible

X. CONCLUSION

Energy conservation system using IoT is combination of hardware and software. Using the hardware like sensors & microcontroller and software with data storage at the cloud will help monitor the Energy generation and consumption remotely. This also includes the tasks like data acquisition, data monitoring, data storing and managing. Using the android application reading of every sensor can be monitored remotely. With every object related with energy in an organization is managed and monitored in centralized manner using IoT and cloud based application, it will reduce the energy consumption and expenses.

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