# Design And Development Of Renewable Energy Sources For Residential Applications Using IoT

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**Abstract - This work presents the recent advancements in affordable open-source hardware platforms that enable the development of low-cost architectures for Residential Applications using Internet-of-Things (IOT). Effective and adaptable household energy management system promotes demand response projects with energy consumption and generation in smart grids. The current household energy demand management strategy cannot provide users with a choice to ensure user comfort, its time sampling accuracy is not high enough, and the operation using the rated power results in a large deviation from the actual cost. To solve this problem IOT based energy management modules are used to monitor the energy consumption of home appliances. Considering both energy consumption and generation, the proposed architecture is expected to optimize energy use and reduce the cost of electricity.**

**Keywords— IOT, Smart Meter**

## I. INTRODUCTION

India is a developing country with growing energy demand. To meet this rising energy demand, there has been a prolific increase in the implementation of alternative energy sources for generating more electricity. Therefore, a smart energy management system (SEMS) is necessary to ensure proper electrical power management, which will reduce the system energy losses. The integration of the SEMS with the internet enables consumers to observe their consumption of electricity and take action according to their budget by remotely controlling the electrical equipment. It also provides a feasible means for electric suppliers for producing bills with minimal error.

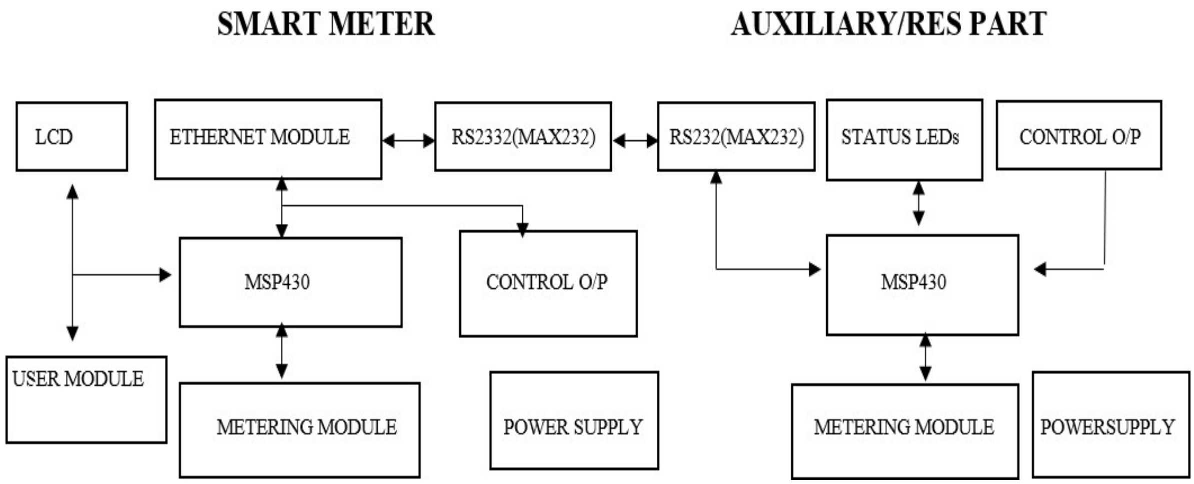
Hybrid solar power systems - These are grid-tied, which means they can push the excess power into the grid through a bi-directional electrical meter and at the same time, they also come with a battery bank. These systems could be programmed to power load from the PV power by default and then any excess power goes into the battery banks. Thus, IOT in the 21st century has become an essential requirement in different sectors all around the world.

The Internet of Things is a concept that has completely changed the way the world works by allowing a greater level of connection between inanimate objects. Things like home appliances, thermostats, and even vehicles can be included in this network and the ramifications of this change are far reaching.

## II. EXISTING SYSTEM

In the olden days electrical, electronic and electromechanical devices were supporting all the day to day life activities. Some devices were fully automated and some were semi-automated. Due to the advancement in computer and communication technology, the trend is more towards the automation of most of the activities which are needed in day to day activities with very less human intervention.

Figure 1: Existing System




This existing system is based on switching the operating mode of devices in group B between working on-grid and off-grid. Such control method is fully transparent for the controlled devices. Control is achieved by contactors installed in the main switchboard in the building. The system focuses mainly on aspects related to energy management on the consumer side. The analysis related to planning load at a higher level should be carried out by an energy supplier. The smart-meter, in cooperation with a small local renewable source and storage, allows for automatic implementation of DR/DSM scenarios planned for a larger range of grid through Tour or RTP, which can be delivered over Internet and Wi-Fi network. The concept of the developed EMS is presented in Figure 2.

Energy receivers in the household model are divided into two groups:

Group A: Low-power devices, in which TOU is not planned, connected to the grid, and are used depending on the need, preferences, and habits of the inhabitants. This group includes consumer electronics, multimedia equipment, small appliances, hand tools, etc.
Group B: Medium and high-power devices, in which working time can be planned. Due to the high nominal power, they have a significant share in total energy consumption. This group includes appliances like HVAC, washing machines, dryers, dishwashers, fridges, etc. Lighting should have been addressed, because it can be assigned to both groups, depending on the size of the building, the placement of the rooms, and the number of inhabitants.
The devices from group B significantly contributed to the energy demand in a residential building. Controlling them provides a large potential for participation in the DR/DSM programs. Inadequate control of devices from group B can cause instability of the power grid. They can also be susceptible to hacker attacks. Additionally, the devices in this group work in separate circuits which allows for integration with the EMS. Based on switching the operating mode of devices in group B between working on-grid and off-grid. Such a control method is fully transparent for the controlled devices. Control is achieved by contactors installed in the main switchboard in the building. Such an approach permits easy and practical implementation.
The smart meter uses the network interface (Wi-Fi network) and TCP/IP stack. Data gathered from the meter can be read using a website. The website is provided by the meter in the local network and transferred to the building management system and energy suppliers over the Internet. Individual functional blocks are made on separate circuit boards mounted with pin connectors on the baseboard. This solution is very beneficial during the development of the prototype. It allows testing of each of the components and their possible replacement. Measurement of electrical energy is done by means of digital signal processing.
A specialized 8-measurement module (with Analogy Devices ADE7753 chip) that cooperates by a serial peripheral interface with the microcontroller is applied. A resistive divider and shunt are used as input converters. The prototype meter is equipped with a standard LCD display. The results of measurements on the LCD display have descriptions and OBIS codes. The module, as well as the function of communication with the server that collects measurement data, performs the role of the web application server, which delivers the user's interface.

- Inadequate control of devices from group B can cause instability of the power grid
- Occupies a lot of space
- Switching energy suppliers becomes difficult
- Difficult to analyse the available generated energy through renewable energy sources manually

Connection with the module that cooperates with the RES and energy storage is possible through the serial port. A block diagram of the meter's hardware is shown in Figure 3.2. The RES measuring module consists of the same unit as the main meter but without the display. The battery voltage and current from the PVs are measured by microcontroller internal ADC.

## III. MATERIALS AND METHODS

### *A PROPOSED METHOD*

Automatic switching between electric power and renewable energy is possible with a Node MCU. A Wi-Fi module built within a microcontroller is known as a Node MCU. It is accessible to everyone and has uses in the IOT industry. Node MCU gathers information and informs users of the power status via messages or emails. The charging module determines the amount of renewable energy that is stored in the battery. The user can view the percentage of stored voltage in the battery by viewing the battery status data provided to the Arduino IOT cloud.

### *B OBJECTIVE*

The system aims to do all the controls and operations manually the construction of the system will enable easy interaction between the home devices and the user within a matter of seconds. To optimize energy consumption and track the utility cost .To reduce the man power. To automate the enabling of renewable energy source .To minimize energy costs.

### *C FLOW CHART*

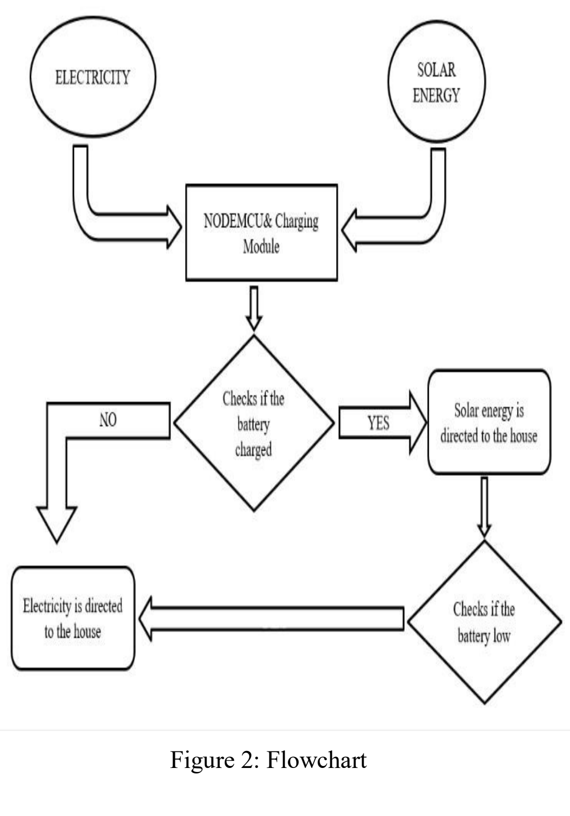



Figure 2: Flowchart

The Node MCU purpose is to check solar cell level is fully charged or not. If the battery is sufficient, the home appliances will switch to solar power. When the battery runs out, the home appliance power will switch to EB power as shown in Figure 3

*D .BLOCKDIAGRAM*

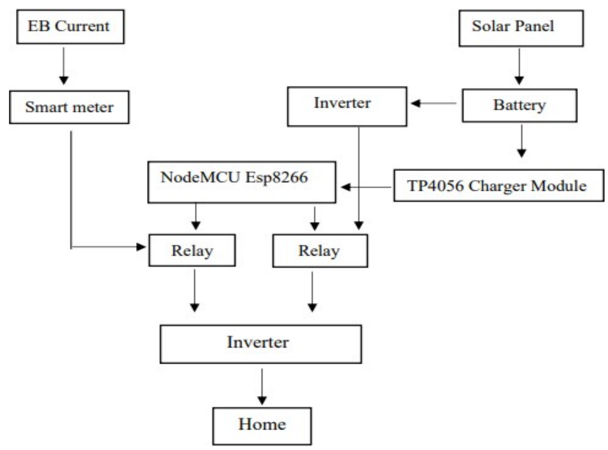



Figure 3: Block diagram

| Load Name | Power load(W) | No. of load | Total Power(W) | Operating Hours(h) | Total Energy(W) |
|---|---|---|---|---|---|
| LED Light | 10 | 4 | 40 | 4 | 160 |
| Tube Light | 18 | 4 | 72 | 4 | 288 |
| Ceiling Fan | 40 | 3 | 120 | 4 | 480 |
| TV | 50 | 1 | 50 | 4 | 200 |
| Refrigerator | 160 | 1 | 160 | 4 | 840 |
| | TOTAL POWER | | 442 | TOTAL ENERGY | 1968 |

In this block diagram system consists of a battery, an inverter, a smart energy meter, a relay and a Node MCU. Homes are provided with the energy generated on the transmission line (up to a limit). The power then needs to be changed manually. The solar panel generates solar power and the user can know the battery level through the Node MCU. Power for the home is switched from the power line to the solar panel once its battery is full. (Relay switch processing for ON/OFF) For power storage and steady power delivery, inverters are employed

A NODE MCU

NodeMCU is an open-source LUA-based firmware developed for the ESP8266 Wi-Fi chip. By exploring functionality with the ESP8266 chip, NodeMCU firmware comes with the ESP8266 Development board/kit i.e. NodeMCU Development board. Since NodeMCU is an open-source platform, its hardware design is open for editing/modification/build. NodeMCU Dev Kit/board consists of ESP8266 wifi-enabled chip. The ESP8266 is a low-cost Wi-Fi chip developed by Espressif Systems with TCP/IP protocol. There is Version2 (V2) available for NodeMCU Dev Kit i.e. NodeMCU Development Board v1.0 (Version2), which usually comes in black colored PCB. NodeMCU Development board is featured with wifi capability, analog pins, digital pins, and serial communication protocols.To get started with using NodeMCU for IoT applications first we need to know how to write/download NodeMCU firmware in NodeMCU Development Boards. And before that where this NodeMCU firmware will get as per our requirement. There are online NodeMCU custom builds available using which we can easily get our custom NodeMCU firmware as per our requirement.

SOLARPANEL

A solar cell panel, solar electric panel, photo-voltaic (PV) module, PV panel or solar panel is an assembly of photovoltaic solar cells mounted in a (usually rectangular)

Table 1: Load Calculation

frame and a neatly organized collection of PV panels is called a photovoltaic system or solar array.

Solar panels capture sunlight as a source of radiant energy, which is converted into electric energy in the form of direct current (DC) electricity. Arrays of a photovoltaic system can be used to generate solar electricity that supplies electrical equipment directly or feeds power back into an alternate current grid via an inverter system. On average, a house with monthly electricity consumption of 1000kwh requires 26-30 solar panels (Each solar panel of 320watts).

SOLAR PANEL SELECTION

Total Power Required Per Day = 442 W

Total Energy Required Per Day = 1968 W

Power Required from Solar PV(W) } = Total Energy Required Required from Solar PV (WH)

Effective Sunshine hours*System Efficiency

Total Energy Required from Solar PV } = 1968 w

Effective Sunshine hours = 6 hrs.

System Efficiency = Battery efficiency*Inverter efficiency*Other Componentt efficiency

= 0.90 * 0.95 * 0.85

System Efficiency = 0.73

Power Required from Solar Panel = 1968 * 6 * 0.73

= 450 W

Power Required from Solar Panel = 500 W (Approximately) Number of Solar Panel required = 2 Panels(250 W)

BATTERY SELECTION

Total Power Required Per Day = 442 W

Total Energy Required Per Day = 1968 W

Total required Battery Capacity } = Total Backup Energy Required Per Day/

Battery Voltage*Depth of Discharge*Battery Efficiency

= 1968/12*0.85*0.85

= 1968/8.67

Battery Selection = 200 AH

A *PROGRAMMING*

Arduino Mega, natively, supports a language that we call Arduino Programming Language, or Arduino Language. This language is based upon the Wiring development platform, which in turn is based upon Processing, which is based on p5.js. It's a long history of projects building upon other projects, in a very Open Source way. The Arduino IDE is based on the Processing IDE and the Wiring IDE which builds on top of it. When we work with Arduino we commonly use the Arduino IDE (Integrated Development Environment), a software available for all the major desktop platforms (macOS, Linux, Windows), which gives us 2 things: a programming editor with integrated libraries support, and a way to easily compile and load our Arduino programs to a board connected to the computer.
Writing codes for NodeMCU After setting up ESP8266 with Node-MCU firmware, let's see the IDE (Integrated Development Environment) required for the development of NodeMCU. NodeMCU with ESPlorer IDE Lua scripts is generally used to code the NodeMCU.

IV. RESULTS

Thing Speak is an IOT analytics platform service that allows you to aggregate, visualize, and analyze live data streams in the cloud. You can send data to Thing Speak from your devices, create instant visualization of live data, and send alerts.
Thing Speak features are Collect data in private channels, Share data with public channels, ,MATLAB® analytics and visualizations, Event scheduling, Alerts ,App integrations

Manipulating with IoT

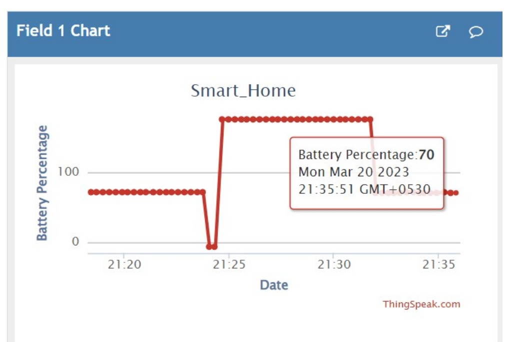



Figure 4: Battery Status in Percentage

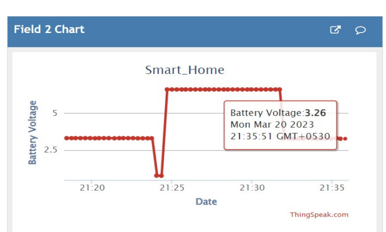


Figure 5: Battery Status in Voltage

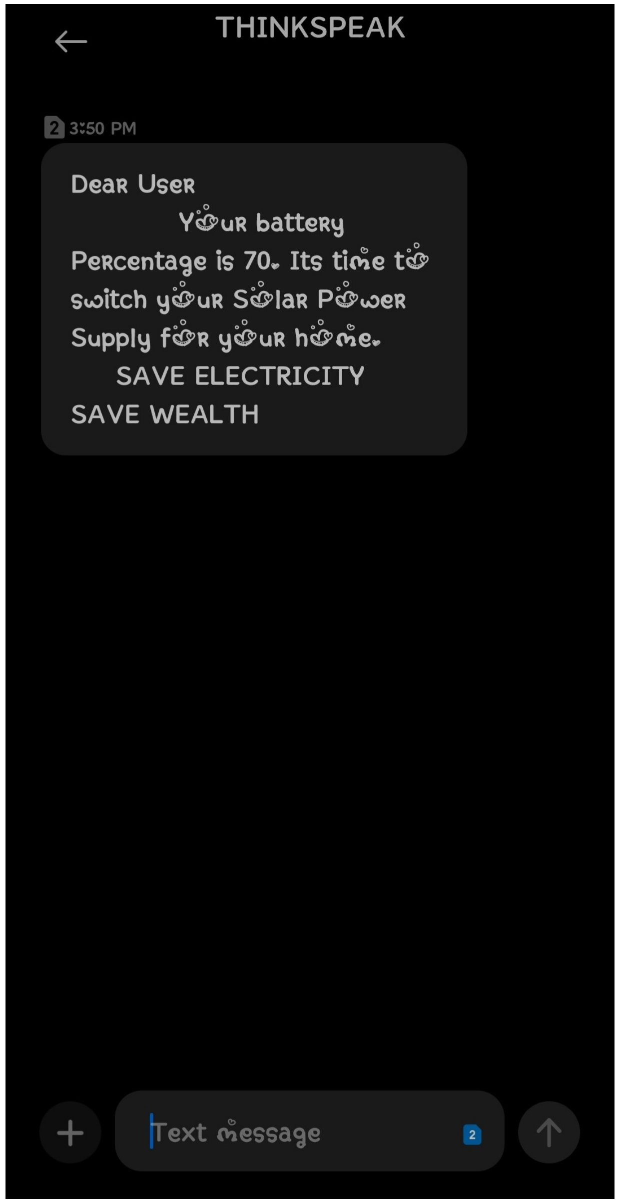



Figure 6: Message from Think Speak

## V. CONCLUSION

Ttechnological advancement of the distribution network is a continuous process. The household energy demand management strategy proposed in this project can effectively reduce the daily electricity cost .In this project, the integration of IoT with an energy management system has been demonstrated to make a more effective and reliable system compared with the conventional energy management system. The household energy demand management strategy allows the user to choose the energy to flow through the house.

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