# Smart Energy Meter

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***Abstract*— This proposed system presents an objective about Energy Meter Monitoring and Billing. This project allows the user with a detailed analysis of power consumption by them, thus giving them an idea on how to conserve energy and thereby reduce consumption and cost. The project is dependent upon Internet of Things (IOT). It is also fruitful to the energy provider as they are getting a detailed viewing of the energy consumption of the commercial sector as well as the residential spaces. The consumer is provided with a mobile application using which he/she can analyze the bill consumption. The consumer can analyze the energy variables using an android phone; this structure can provide energy savings in homes and offices. Applications for this system include workspace, office cubicles, residential areas, power plants. The system will help providing a faster recovery at the times of disaster, accurate readings and better consumer services.**
***Keywords*— Energy-meter, energy consumption, energy theft.**

## I. INTRODUCTION

The current day system of energy monitoring as well as bill generation in India makes uses electromechanical and to some extent with the aid of digital technology is more likely susceptible to errors and it consumes more power and labor. The conventional methods of using electromechanical meters are now being taken over by digital ones for more efficiency for readings. The existing power sector of India is still unable to bill efficiently for the amount of energy supplied to the masses on account of frequent thefts and different losses prone in India. One of the prime reasons is the traditional billing system which is inaccurate so many times, slow, costly, and lack in flexibility and reliability[1].Meters of the past and in function today as well in various countries have poor accuracy and lack the ability to facilitate changes in configuration. Theft detection was also a challenge. With new developments in this sector, accurate and error free implementations are now taking new strides.

Electronics, office equipment amount to up to 15-20% of the total electricity consumed by both commercial and residential sectors. Majority of this expense is due to a lot of appliances that usually operate at low power but are not used much in the real world. The better way so as to avoid wastage of funds on energy consumption is to make use of a smart energy monitoring system that monitors energy consumption. This proves as a boon for billing purposes as well. The main objective of our proposed system is to establish a energy efficient power system at the government level itself to improve energy practices in the country, avoid unnecessary wastage of non-renewable resources. It would further help in boosting the economy and also help in improving the energy blueprint for our country.

With an increased pressure to cut down consumption and improve sustainability, smart energy meter monitoring devices needs to be developed so as to address the following challenges.

Traditional methods that are being used for energy monitoring in India includes the use of human operators who visit places to manually note down the meter readings. As these human operators have to visit each houses and manually collect the readings the bill can be used only after that which requires a lot of manpower. The process of energy meter monitoring can be affected under the following circumstances :

1. If the operator by mistakenly notes down a wrong reading.
2. The meter readings can be affected by bad weather conditions.
3. Meter readings are also affected if they have been by tampered by the consumer so as to reduce the bill amount
4. If the consumer is not in attendance than the operator has to visit the place gain.

With an increase in globalization there is an increase in the number of residential and commercial areas which means that more man power will be required to cover a larger area. The cost associated with the meter reading process is also imposed on the user. Along with power theft issues and energy consumption exceeding with every passing year, it is necessary to maintain effective utilization of the available energy resources by monitoring the consumption pattern.

The main objective of the proposed system is to develop a smart energy meter is not only to measure the consumer's power consumption in KWH but also to enable and support real consumption in rupees according to consumer tariff, so meter reader does not possess the need to visit each customer for the consumed data collection and to distributed the bill slips. In the proposed system of smart energy meter there are no rotating parts .The energy consumption is calculated using measurement voltage and current with help of potential divider and ACS712 ,measure voltage and current respectively. Power product of voltage and current, its unit watt or KW and energy is product of power (watt) and time (Hour).

## II. LITERATURE SURVEY

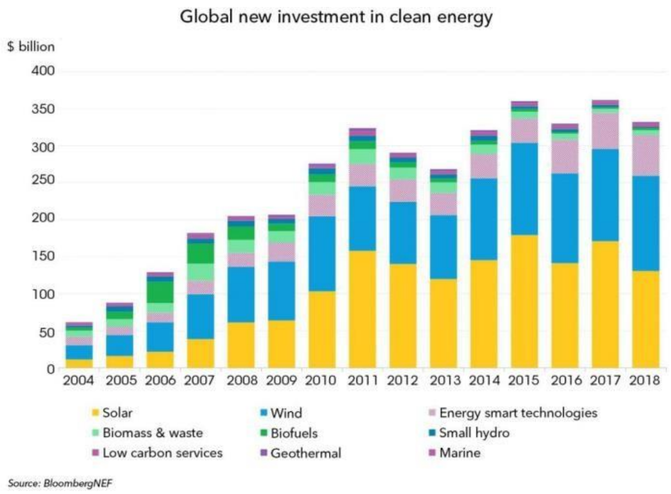
Energy consumed by a nation has a direct impact on its development factor . It's a major symbol of socioeconomic development. All the residential and commercial sectors are dependent solely on the availability of power and the infrastructure residing upon it. The municipal corporations are spending a huge chunk of the annual revenue in order to purchase energy so as to meet the ever increasing demands for public services like street lights, electricity etc. In order to suffice the increase in demands it is vital to discover alternative renewable resources or measures to cease the depletion of the existing resources and not put a strain on the environment. The above idea can be achieved through judicious consumption of existing resources, proper planning and efforts taken to find alternative options with the help of technological aid.

Current Situation of Energy Consumption and Energy Saving: Demand in our country has elevated from 450 million tons in 2000 to 770 million in 2012 and is estimated to hike up to 1250-1500 million tons oil equivalent up to the year 2030. The Indian ministry of power has adapted a two branched approach to suffice the energy demand of the public while limiting C02 emissions to avoid the damage on the ecosystem. It promotes the increased use of renewable sources. The Energy Conservation Act (EC Act) was begun in 2001 with the principle of lowering down the energy intensity of Indian economy. The Act provides administrative directive for: standards & labeling of equipment and appliances, energy conservation building codes for commercial buildings, and energy utilization standards for energy concentrated industries. Furthermore, the Act persuades the Central Govt. and the Bureau to take measures to make possible and promote energy competence in all sectors of the economy. The EC Act was amended in 2010 and the main amendments of the Act are given below:

1. The Central Government provides the energy savings certificate to the consumer with consumption that resides below the official limit.
2. The consumer whose energy consumption is more than the predetermined limit and standards shall be made to purchase the energy savings certificate to adapt with the regulations and standards.
3. Commercial spaces with a connected load of 100 kW or agreement request of 120 kVA and more will be included in the purview of ECBC under EC Act.

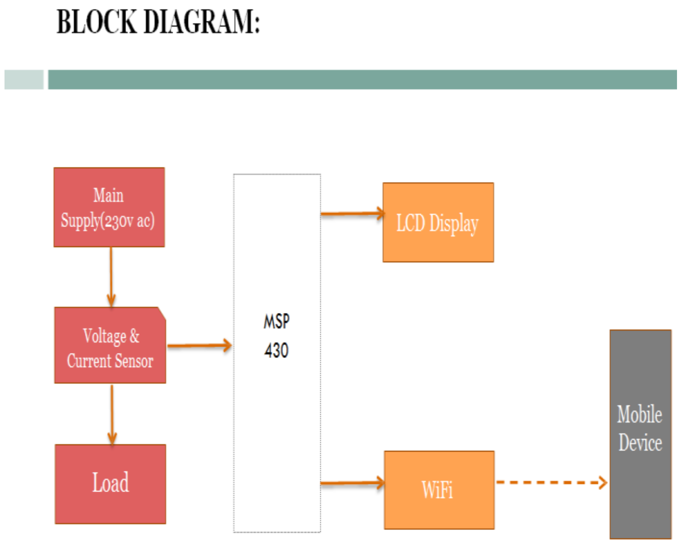
Clean Energy Investment : The Indian Energy Policy revolves around the country's ever increasing energy depletion and focuses on researching alternative options pertaining nuclear, solar, wind, tidal and other renewable options .India holds the 81th rank in being completely self-sufficient in energy consumption and regeneration with 66% as of 2014.About 80% of India's electricity generation is from fossil fuels. India is surplus in electricity generation and also marginal exporter of electricity in 2017.Since the end of calendar year 2015, huge power generation capacity has been idling for want of electricity demand. India ranks second after China in renewable production with 208.7 Million tons in 2016.[5]

The primary energy consumption in India grew by 7.9% in 2018 and is the third biggest after China and USA with 5.8% global share. Fig 2.2.1 shows the total primary energy consumption from crude oil (239.1 Million tons; 29.55%), natural gas (49.9 Million tons; 6.17%), coal (452.2 Million tons; 55.88%), nuclear energy (8.8 Million tons; 1.09%), hydro electricity (31.6 Million tons; 3.91%) and renewable power (27.5 Million tons; 3.40%) is 809.2 Million tons (excluding traditional biomass use) in the calendar year 2018.In 2018, India's net imports are nearly 205.3 million tons of crude oil and its products, 26.3 Million tons of LNG and 141.7 Million tons coal totaling to 373.3 Million tons of primary energy which is equal to 46.13% of total primary energy consumption. India is largely dependent on fossil fuel imports to meet its energy demands – by 2030, India's dependence on energy imports is expected to exceed 53% of the country's total energy consumption [6].




Energy Investment in India

## III. BLOCK DIAGRAM




The Smart Energy Meter measures the current flow and voltage periodically and then adds it up to calculate power used in an hour. The load is connected to the main supply i.e. 230 V AC. But the voltage through the load is never constant and therefore, voltage sensing unit is used in this solution. Similarly, to know the exact amount of current flowing through the load, a current sensor ACS712 is used. Further the readings of voltage and current sensor is fed to MSP 430 where it is being processed to calculate the power in KWh. MSP 430 is interfaced with a wi-fi module to provide bi-directional communication between the supplier and the consumer.

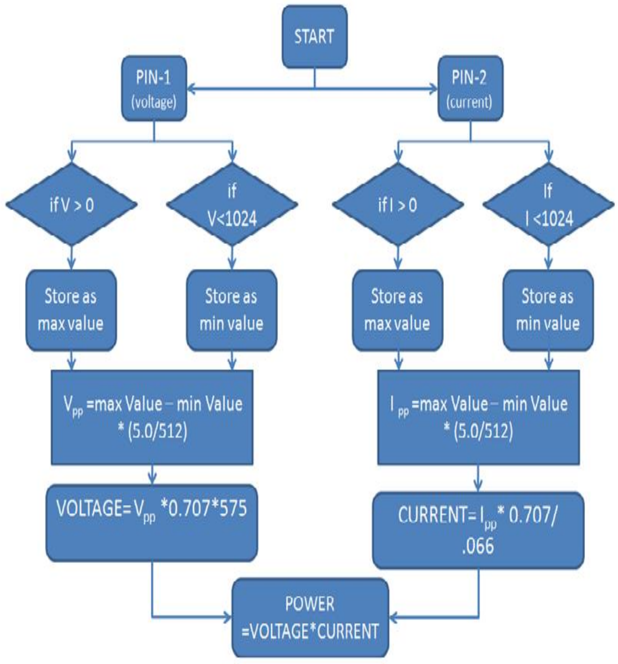
Voltage sensing unit comprises of a step down transformer which converts the voltage from 230V to 12 V. Further using voltage divider network, the voltage is further dropped down to 3.3V. This is necessary because the wi-fi module module works on 3.3V.

Current Sensor ACS712 senses the current driven by the load. It works on the hall principle. According to the principle, when there is a conductor carrying current placed in a magnetic field, there is an induction of voltage which is perpendicular to the current as well as the magnetic field. This way the sensor is used to measure the magnetic field around the conductor which carries current. The resulting voltage is in millivolts which will be proportional to the current flowing inside that conductor. The output terminal of ACS712 has an offset voltage of 2500mV. When the current flow is positive, the voltage goes above 2500mV and if the current flow is negative, it goes below 2500mV.

The microcontroller reads the value of current and voltage sensor and sends it serially to the wi-fi module. To monitor the usage of energy, an mobile application is used.

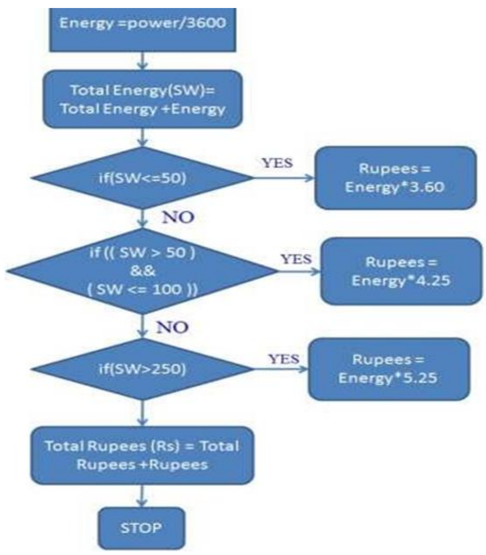
Parameters Monitored :

- Current
- Voltage
- Bill Amount




In the proposed system, a voltage divider network is used for sensing the voltage and the ACS 712 is used for sensing current. It operates on the principle of Hall Effect. The current sensor measures the voltage across the conductor as it is proportional to the current flowing through the conductor. The standard reading for the ACS 712 is in millivolts and 2500mv is the default value. Depending on the polarity of the current the recorded current reading will be greater or lesser than 2500. According to the ACS 712 Datasheet, the Analog Positive value is 1024.

Followed by it is the RMS Value Calculation for both the current and voltage. The Power is calculated whilst taking the product of current and voltage.



For instance, considering the example of the pulse calculation for a 100 watt load for a span of over 60 secs:
Pulses=3200*1000*60/1000*3600
Pulses = ~53.33 pulse/min
For the calculation of electricity consumed in a single pulse:
PF= watt/(hr*pulse)
PF=1000/60*53.33
PF=0.3125 watt in a single pulse
Units consumed = PF*Total pulse/1000
Total pulses in an hour is around 53.33*60=3198
Units consumed = 0.3125*3198/1000
Units consumed = 1 per hour
Energy consumption for a 100 watt load for 24 hours
Units consumed =1*24
Units = 24 Units
The unit rate is 10 Rupees
The amount for 24 units is given as:
Rupees= 24*10 = 240 rupees

## IV. COMPONENTS

**1). MSP430 -** There is no need for an external crystal, because the MSP430 controllers operate at 16 MHz via their internal clock source. The MSP430 operates with a launch pad that runs on Energia Software and is less than half the cost of the arduino board. The MSP430 controllers comes with two controller (a MSP430G2553 and a MSP430G2452). No separate FDTI cable is required to talk to the controller via the USB cable. It operates at 9600 baud rate. The MSP430 is a controller that supports mixed signals and is designed by Texas Instrumentation. It has been built around a 16 bit CPU. It is tremendously useful in low power operations. It is beneficial for our project as this controller targets low power embedded operations thereby reducing energy consumption Fig 2. shows the layout of MSP430 micro-controller.

Smart Energy Meter

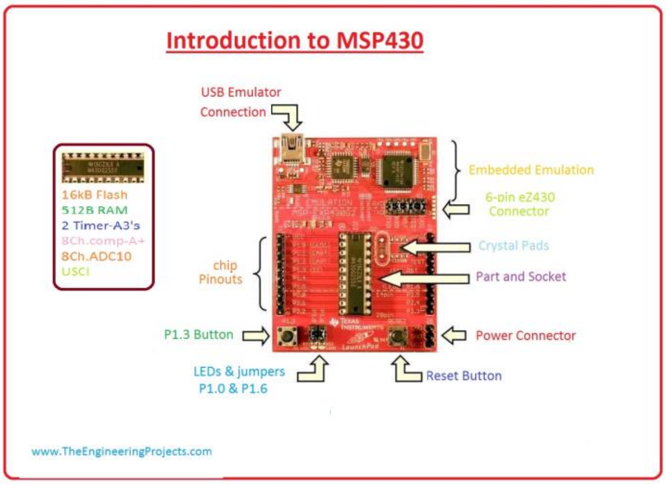



Fig. 2. Layout of MSP430.

**2). CC 33100 -** The CC 3100 is a device responsible for Wi-Fi and internet communication. its features include :
1). Simple architecture for security .
2). On chip feature for Wi-Fi and internet.
3). 8 continuous sockets for TCP and UDP.
4). To facilitate fast and secure connections of Wi-Fi and internet a crypto engine is present.
5). Connections of SSL and TSL are encrypted.
6). Advanced low power modes available.
7). Wide range of supply voltage supported.
8).UART interface present that can be easily configured with a 8 or 16 for 32 bit MCU or ASICs over a SPI. [4]

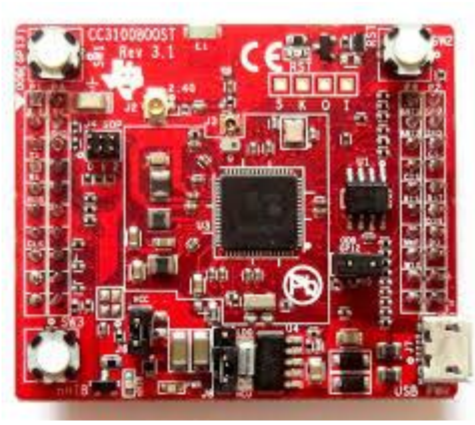


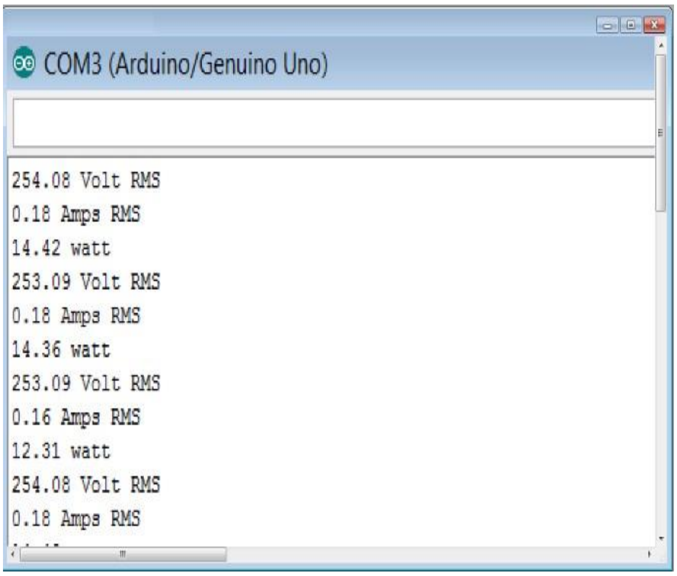
Fig.3. CC33100 WiFi Module

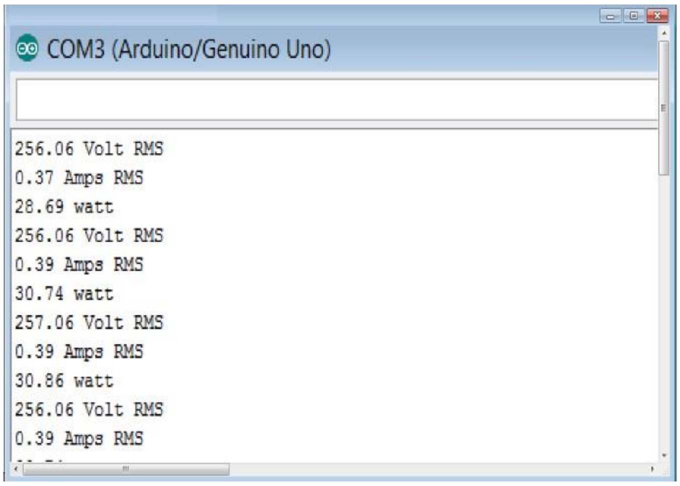
## V. RESULTS AND DISCUSSION

The system allows knowing the exact amount of power drawn by a load. This will help the user to compare various devices and select a device that consumes less power. This will result into and effective use of power and also reduce the bill amount for the user. As the user can continuously monitor the bill amount, he/she can limit the power usage depending on the bill amount they are willing to pay to the supplier. Also this will help to save a considerable amount of electricity which is the need of an hour.

The results for a 15 Watt bulb and 30 Watt bulb are shown below. By comparing both the results, it can be concluded that the power drawn by the 15 Watt bulb is exactly half of the power drawn by the 30 Watt bulb. Similarly, by comparing the power consumed by different types of load, user can choose the type of load suitable for the particular place and surrounding.

Proposed system implemented using an Arduino :




## VI. Conclusion

A country's primary growth index is vitally affected by how efficiently it utilizes its power resources and how much the stress is on generation and discovery of renewable resources. If one were to observe the current energy scenario of India, India generates sufficient amount of power but it consumes way more .

Over the years, there has been a substantial decrease in the resources and a rapid growth on expenditure. Given the climate crisis we are tending to face now, judicious and responsible behavior regarding energy seems to be a prerequisite. Therefore, our proposed idea is step in the same direction.

We are proposing to set up a system that monitors the energy utilized at a residential level and on ways to generate patterns to reduce energy consumption and reduce billing. The energy meter records the units consumed and the cloud system chosen, records and saves the data. The application designed will give the consumer the amount of units consumed and can also provide a rough idea of the bill that will be generated for the same.

The microprocessor interfaced with the devices can control the devices by switching off when not needed and when the limit is surpassed. If the same system is issued in companionship with the Government , we can monitor the energy patterns of the nation and can adopt measures to avoid wastage by allocating only as many units as required, avoiding energy-theft and reducing billing.

## VII. Acknowledgement

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