VELLORE INSTITUTE OF TECHNOLOGY

TECHNICAL ANSWERS FOR REAL WORLD PROBLEMS

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Slot – TB2

J Component Project Report

Smart Electric Meter

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AIM OF THE STUDY

The proposed smart energy meter with advanced prepaid billing system is a device, to make electricity billing user friendly and much more readable to the common man and also provides a plenty of the following advantages.

• Energy Conservation

• Lots of time and power saving for electricity department

• Automatic controlling of energy meter

• User can recharge number of unit's required (prepaid system)

• Non-volatile memory based meter storage

• Implements prepaid billing system which would go a long way in making Consumers conscious of the amount of energy used and is also more economical.

• Provides automation of the billing system can abolish human involvement hence is more accurate.

• To make consumers to keep the track of energy usage.

PROBLEM STATEMENT

Electricity has become vital in everyday life. It is tough to imagine a world and human life without electricity. But the vitality of electricity has meant that people consume vast amounts of energy unmindfully and carelessly. The world's energy consumption/capita stands at a staggering 2782 KWh. At this rate the world's energy resources would get depleted very soon. Our policies of its distribution are also partially responsible for this because we are still not able to correctly estimate our exact requirement and still power theft is prevailing. On the other hand consumers are also not satisfied with the services of power companies. Most of the time they have complaints regarding statistical errors in the monthly bills.

Monitoring and keeping tracking of your electricity consumption for verification is a tedious task today since you need to go to meter reading room and take down

readings. Well it is also important to know if you are charged accordingly so the need is quite certain.

LITERATURE SURVEYS DONE ON THE PROBLEM STATEMENT

    1) Design of an Automatic Meter Reading System:

This paper describes the Automatic Meter Reading (AMR) system, an integrated and programmable meter reading and control system over existing telephone networks. The AMR system is and automated, two-way system for remote reading and management of utility meters. The meter reading and management processes are free from human involvement. Accuracy, speed, efficiency, and cost-effectiveness are the expected benefits achievable using the AMR system. The overall system is based upon the existing telephone networks, therefore the service can reach anywhere there is a telephone. All this is accomplished electronically and truly automatically, thus ending manual (and semi-automatic) meter reading and entry, call-backs, reading errors, and billing float.

    2) Data Collecting from Smart Meters in an Advanced Metering Infrastructure :

The classical solution for collecting data from energy meters, based on displacements of peoples, tends to be replaced by modern solutions: drive-by and Automated Meter Reading (AMR). Drive-by means that data are collected by mobile devices which pass near the meters. The personnel are considerably reduced and manually readings and records are eliminated. AMR means to automatically collect data from meters and send them to a central computer. The advantages of AMR are: reduced costs for meter readings, possibility to access meters otherwise difficult to attend because of their position or security reasons, support for real-time pricing, increased fraud detection, reduced read-to-bill time etc. AMR requires smart meters.

Besides their classical role, to read the consumptions, smart meters must also be able to send the readings over communication lines. For advanced infrastructures,

the meters must also be able to recognize their address and to activate/deactivate internal modules. A meter interface must fulfil the requirements of reading the data from the classical part of the meter and responding to the commands received from the lines. AMR requires a specific infrastructure. It can be unidirectional, meaning data are sent periodically by meters, or bidirectional which adds the possibility to manage the system, for example to connect/disconnect users, to collect the data from the meters according to some rules, to group the meters etc. Such an infrastructure is called Advanced Metering Infrastructure (AMI). The communication medium in an AMI system must ensure the communication smart meters data collector (or gateway) and data collector (gateway) central computer. There are two solutions: wired or wireless. The chosen 9 solution must take into account the distances between the devices and, for financial reasons, the existing infrastructure.

3) Remote Energy Monitoring, Profiling and Control Through GSM Network:

To devise an efficient metering system, the concept of Automatic Meter Reading (AMR) and Energy Profiling System (EPS) originated, which provide an effective means of energy consumption information collection, and its analysis, for accurate billing. Radio frequency based EPS can make use o+f Handheld, Mobile, and Fixed network. In handheld and touch based EPS, a handheld computer equipped with a transceiver is used (radio frequency or touch) to collect readings, but it does not make optimum use of the AMR capable meters, as meter reading personnel are required. Mobile or Drive-by meter reading is another approach where a reading device is installed in a vehicle. Due to the short range of mobility, it again requires a team for collection of meter readings. AMR can also be implemented by making use of Power Line Communication (PLC), but it has an inherent disadvantage of interference and noise, which deems it unreli- able.

Wi-Fi, ZigBee and 3G technologies have also been used for transmission of metering information, but have not being widespread as they require installation of facility/ access points to cover the designated areas and thus do not provide a cost effective solution in existing environments. Our indigenously developed GSM transmission module induce transparency in the current meter reading system, by facilitating low cost real time monitoring of consumer energy consumption.

Automation would lead to an efficient energy metering system by removing human errors. Our system also allows the energy supplier company to remotely control the consumer energy meter. A major feature is the inclusion of a user consumption profiling system, accessible to users and the energy supply company. By incorporating control coupled with profiling, An additional feature explored is the traffic profiling using Global Positioning System (GPS) to indicating the location of consumers which is extremely beneficial if used in collaboration with sensor circuits to indicate meter theft.

4) SMS-based Reconfigurable Automatic Meter Reading System:

Automatic Meter Reading (AMR) has widely at- tracted many engineers, and utility companies. AMR is not just replacing the manual meter reading with an automatic procedure, but has many advantages, some of which are listed below [1]. - Higher speed. - Improved load profile.- Automatic billing invoice.- Real time energy cost. - Load management. - Alarm warning. - Remote power switch on/off.- Tamper detection. AMR is expected to be common in future. Nowadays, different AMR schemes are continuously evolving. Furthermore, integrating with the benefits of digital energy meters, contemporary AMR systems present more advanced and flexible features than their predecessors did in the past decades. Finally, thanks to the advent of new communication 10 technologies, their competitive markets, and their ever- decreasing costs, the extinction of traditional meter reading system seems inevitable.

5) Electronic Energy Meter With Instant Billing:

The importance of proposed work can be well understood if we keep in mind the amount of electricity being stolen every day. With heavy loads on the power house one cannot track each and every household or commercial site. So to track any misuse at any stage of distribution we can use this method of billing. As a user can get his or her bill at any instant and can even pay it at any instant, so any kind of misuse by any other person can be avoided. An extensive amount of energy can be saved if we can track the misuse and the whole power problem can be

dealt with by using this technique .The chances of tempering with this are very low. It validates accuracy of utility billing charges consumption, demand and power factor. It has a real time data display and access to metering equipment and usage data. So people at power house and the person who owns the equipment both can monitor the usage whenever they want to.

METHODOLOGY

The smart meter system consists of a current sensor, voltage regulator, Node MCU, relays, arduino, analog meter and power supply module. The user account is recharged with a predetermined amount. The current sensor detects the amount of current drawn and on the basis of this, the power consumed is determined. Based on the power consumed and the per unit charge, the amount is deducted from the initial recharged amount. When the balance goes below the threshold amount, an alert is sent to the user intimating that the minimum balance has reached and the user has to recharge the account. If the user hasn't recharged and the balance reaches the cut-off value, the power supply to the user is cut until the account is recharged. All the data from the sensor and the controller is being sent to SQL server database. The values then retrieved from database is used to calculate the power and is then used in the mobile app. A notification is sent to the customer when the power reached the capacity. It notifies when there is a power shortage, over use and short circuit. Thus the smart electric meter provides an alternative to the existing manual system which is more efficient and user – friendly.

A) **NODE MCU:** Node MCU is an open source IOT platform. It includes firmware which runs on the ESP8266 WiFi SOC from Express if Systems, and hardware which is based on the ESP-12 module. The term "Node MCU" by default refers to the firmware rather than the development kits. The firmware uses the LUA scripting language. It is based on the LUA project, and built on the Express if Non-OS SDK for ESP8266. It uses many open source projects, such as LUA-CJISON and SPIFFS.

B) CURRENT SENSOR: A current sensor is a device that detects electric current in a wire, and generates a signal proportional to that current. The generated signal could be analog voltage or current or even a digital output. . The generated signal can be then used to display the measured current in an ammeter, or can be stored for further analysis in a data acquisition system, or can be used for the purpose of control.

C) VOLTAGE REGULATOR: Voltage sources in a circuit may have fluctuations resulting in not providing fixed voltage outputs. A voltage regulator IC maintains the output voltage at a constant value. 7805 IC, a member of 78xx series of fixed linear voltage regulators used to maintain such fluctuations, is a popular voltage regulator integrated circuit (IC).The xx in 78xxindicates the output voltage it provides. 7805 IC provides +5 volts regulated power supply with provisions to add a heat sink.

D) RELAY: Relay provides automatic switching in the circuit. A relay is classified into many types, a standard and generally used relay is made up of electromagnets which in general used as a switch. So relay is a switch which controls (open and close) circuits electromechanically. The main operation of this device is to make or break contact with the help of a signal without any human involvement in order to switch it ON or OFF. It is mainly used to control a high powered circuit using a low power signal. Generally a DC signal is used to control circuit which is driven by high voltage like controlling AC home appliances with DC signals from microcontrollers.

E) Arduino UNO: The main controller, connect energy meter, GSM module, and other sensors/peripherals so they can communicate each other. And Arduino UNO can only work after we uploaded the designed program into it

F) GSM MODULE: GSM operators have set up roaming agreement with foreign operator which help users to travel abroad and use their cell phones. GSM module was used for receiving SMS from users mobile phone that automatically enable the controller to take further action like switching ON and OFF electrical applications such as fan, air - conditioner, light and other

[5]. The system was integrated with microcontroller and GSM network interface using arduino or other microcontroller and software was utilized to accomplish the integration.

CIRCUIT DIAGRAM
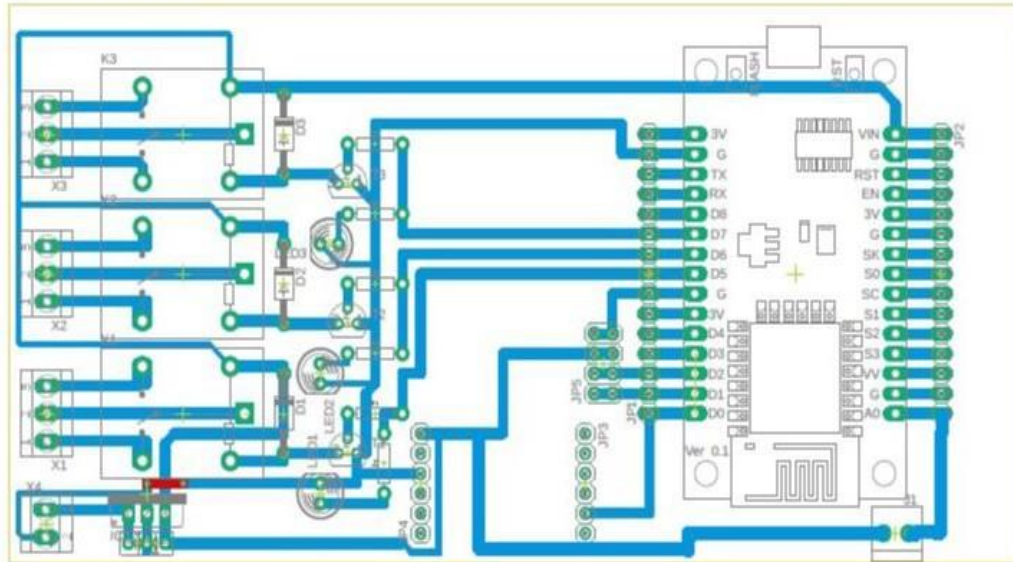
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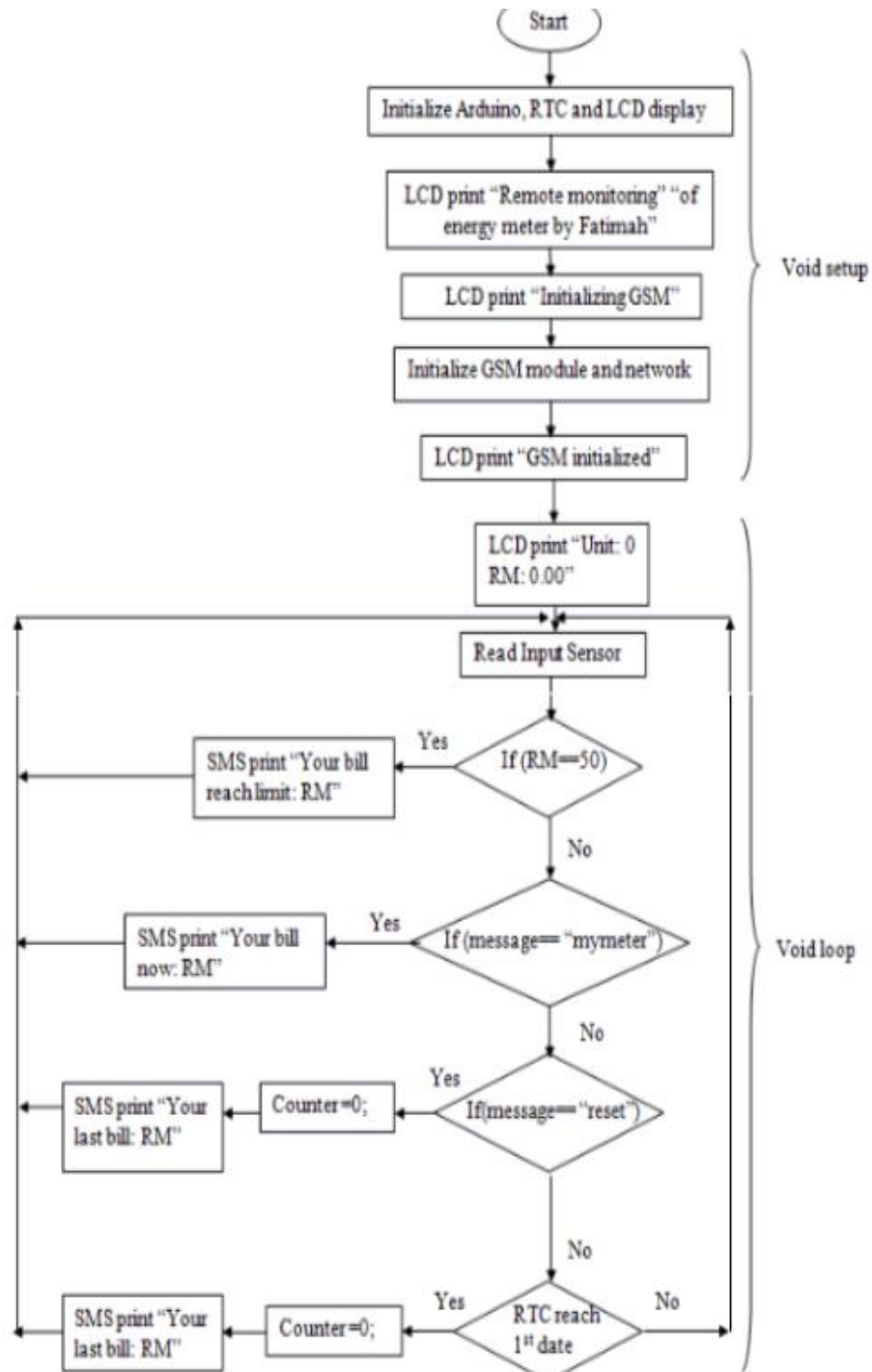
MARKETING OF THIS DEVICE

- **Improved cost saving owing to the use of smart meters make a definitive case for adoption**

Smart electric meters can assist the end-users to monitor its electricity consumption data, and thus customize their usage based on the electricity tariff rates. Smart electric meters are intelligent devices, which measure the electrical consumption along with remote meter connection and disconnection, fault detection, reporting, and analysis of the consumed electricity in units on a day-to-day basis. Smart meters can also assist in voltage & power quality monitoring and collection & storage of real-time data in the central system. Hence, a customer can access their energy consumption data anytime and take suitable measures to cut down energy costs. All these allow a reduction in consumption of electricity during peak time as customers can observe, calculate, and analyze their usage to reduce the energy consumption during peak hours, thereby effectively managing energy costs. Such crucial benefits offered by smart electric meters over the conventional meters have attracted the attention of governments and end-users and thus driven the adoption of smart electric meters over the years.

- **Demand for smart grids and energy efficiency in emerging market**

The implementation of a smart grid is in its initial stages in many developing countries. This implementation of the smart grid is being done to gauge the demand for electricity, a post which they are expected to develop the requisite advanced infrastructure which would also comprise of smart electric meters. China is expected to witness an investment of USD 300 billion from 2016 to 2020. Whereas India is expected to connect with 300 consumers by 2019. In September 2017, Tata Power Delhi Distribution Limited (India) announced its plans to roll-out 18 lakh smart meters by 2025. Where South Korea is expected to invest USD 24 billion by 2030. The development and implementation of smart grids across many countries offer a huge opportunity to the smart electric meter market, as the latter perfectly fulfill the needs of a smart grid system. For example, with the help of a smart grid, electric vehicles can identify themselves to the charging station when they are plugged in, and the electricity used can be automatically billed to the owner's account. Also, the smart electric meter communication infrastructure

can be further used to control the distributed generation of electricity remotely. Smart electric meters are a part of a virtual power plant, and therefore, they can be used to measure the electricity delivered by distributed generation to the grid. The tariff management options make it easy for grid operators to integrate renewable and nonrenewable sources to manage the demand for electricity with a perfect mix of energy sources. All these features present a huge opportunity for the smart electric meters market, as the adoption of smart electric meters is essential to meet the energy demand and increase the reliability of operations.

<u>RESULTS</u>

The proposed model of Smart electric meter is performing as expected. We were able to implement all the functions specified in our proposal. The results of our observations are as shown below:
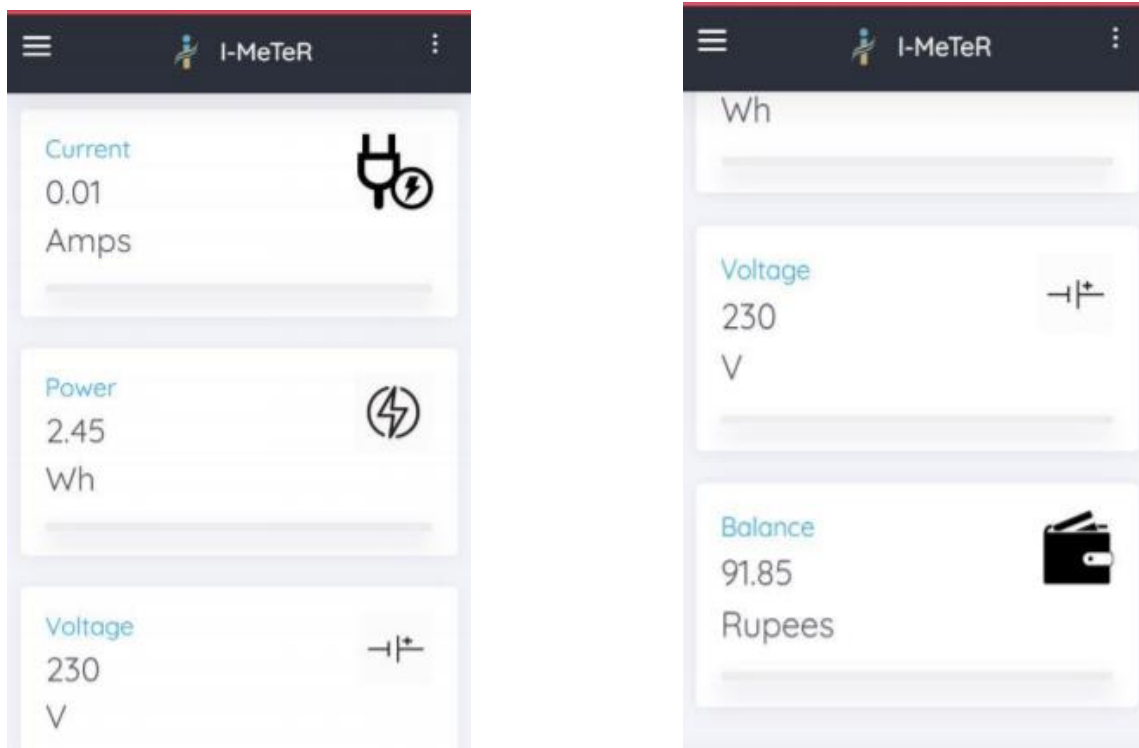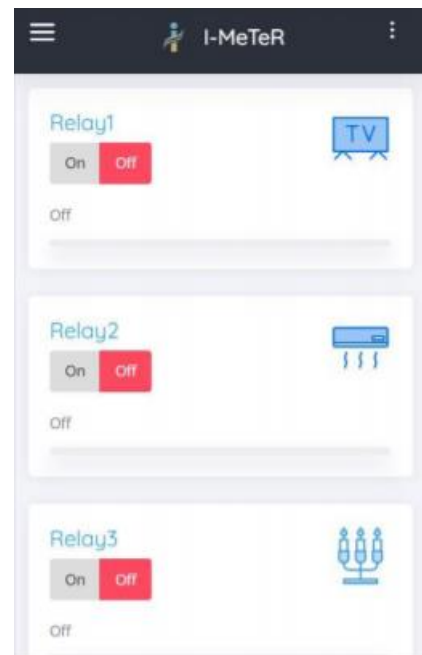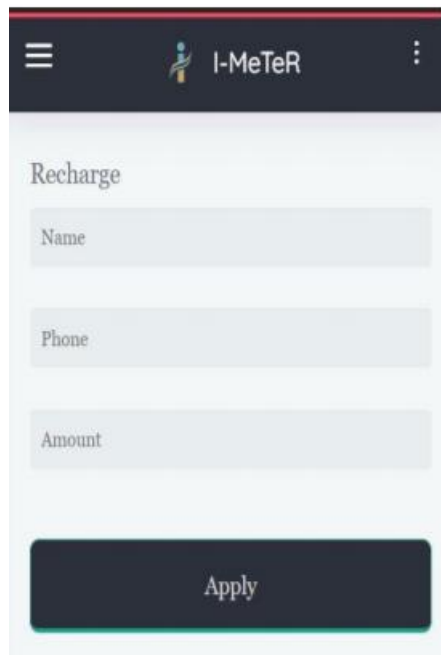
CONCLUSION

This project is intended to present an overview of smart electric meter which can control the usage of electricity on consumer said to avoid wastage of power. Smart electric meter is a concept to minimise the electricity theft with a cost-efficient manner. It is more reliable and user friendly. In this project, the user account is recharged with a pre-determined amount. The current sensor detects the amount of current drawn and on the basis of this, the power consumed is determined. Based on the power consumed and the per unit charge, the amount is deducted from the initial recharged amount. Thus, it gets deducted from the amount and a warning is given when the amount goes below the threshold value. This smart electric meter is a user – friendly platform wherein the user gets warning when the usage is exceeding the normal limit, when there is a short circuit or power shortage. It also helps in eliminating the human errors and thus makes it possible to use power resources more efficiently. This smart meter provides real time data that is useful for balancing electric loads. Integrating with an app makes it simpler to the user. This could also be integrated with the home automation system.

ADVANTAGES

1. No need to submit meter readings: Smart meters automatically send out readings to your supplier so you don't have to worry about remembering to submit them. No more standing in the rain and no more torchlights!

2. We can closely track your usage and spend: The In-Home Display can show you exactly how much energy we're using as well as the associated cost. It encourages good energy habits and some homes are already showing energy savings of 5-20%.

3. Accurate bills- no more estimates: The smart meter sends your readings automatically so you will always be billed for what we use. If we have a standard (non-smart) meter and forget to submit a reading, our supplier will have to estimate how much energy we've used over the billing period. They estimate based on the typical amount of energy we have used in the past or how much they think you will use. Sometimes the supplier's estimates are inaccurate, especially if they don't have a lot of information about your usage. With a smart meter, not only will you avoid inaccurate shock bills but also you can also avoid building a large final bill at the end of your tariff.

4. Highlights faulty appliances: The In-Home Display shows how much energy we're using at any given time, allowing us to notice any sudden spikes which may be associated with a faulty appliance. By identifying these promptly we can ensure it is dealt with quickly and safely.

5. Saving the planet: Smart meters improve your awareness of energy consumption. By changing behavioural habits and informing decisions to buy more energy efficient appliances there is less pressure on the electricity grid. Smart Energy GB estimate a 24% decrease in emissions from homes and businesses by 2030.

6. Greater selection of tariffs on offer: As we move towards a smart future, smart meters are becoming more widespread. Many suppliers favour smart meters and so are offering exclusive tariffs to households with smart meters. Smart meter exclusive tariffs are amongst some of the cheapest on offer, giving you plenty of choice. The energy market is your oyster!

7. Prepay friendly: If we have a prepayment meter, we can also upgrade to a smart meter. With a smart prepay meter we easily track how much credit we have left on your meter and even top up from your smartphone or computer. A smart meter can be switched between prepay mode and credit mode remotely so your supplier will not need to fit a new meter in your home.

DISADVANTAGES

1. Older smart meters become "dumb" once we switch

   Currently, if you have a first generation smart meter (SMETS1) when we switch supplier your smart meter may temporarily become "dumb". This means that your meter will continue to record your usage however it will lose its smart functionality and it will no longer be able to automatically send your readings to the new supplier. If you need help, just read our guide on how to read your meter manually. The Data Communications Company (DCC) is responsible for leading the enrolment and adoption of first generation (SMETS1) smart meters. As of the 29th of May 2019, they will begin connecting SMETS1 meters to communicate through the same network so if you already have a SMETS 1 meter, there's no need to get it changed.

2. In-Home Display may be inaccurate

   When you switch with a SMETS 1 meter, the In-Home Display should continue to display energy use and enable you to retrieve readings without needing to access the meter however their ability to communicate with the smart meter may be inconsistent and in some cases, they stop working entirely.

3. Poor signal

   First generation smart meters communicate using mobile networks. In the same way, your mobile signal can sometimes be a bit patchy in some areas, the same applies to smart meters. The UK's communications regulator Ofcom, report that 8% of households don't receive data from mobile networks. With the current mobile network, these homes would not be eligible for a smart meter at all. If you have a weak mobile signal, it can prevent the meter from sending readings to the

supplier. The new dedicated wireless smart meter network that has been set up by the DCC will provide coverage to at least 99.25% of premises in Great Britain.

4. A smart meter will not reduce bills alone

   Whilst having a smart meter is showing a reduction in bills, it can't reduce your usage by itself. The theory is that by being aware of your usage and spend, you are more inclined to reduce your usage. The reality may be different from home to home, especially if you don't pay attention to your smart meter.

5. Some suppliers can't support smart meters: Unfortunately, not all suppliers' offer or support smart meters.

<u>FUTURE OF SMART ELECTRIC METRES</u>

Smart meters present an exciting new opportunity for both Energy and Utility (E&U) companies and consumers. Yet, even as its rollout progresses in the U.K, there seems to be uncertainty in its business case and model. Based on the findings of our collaborative study with Utility Week, we look at the potential of smart meters, the role of the customer and how E&U companies can structure their operations to unlock immediate and future value.

A Tremendous Promise of Value

From the supplier-consumer relationship perspective, smart meters can redefine the supplier's role to that of an energy advisor. From an industry viewpoint, it can integrate new technologies and innovations across the power grid. To the users' advantage, it can drive down costs, provide transparency and flexible pricing. And from a social perspective, it can improve energy conservation, grid reliability and outage management, besides integrating the supply of renewable energy options. Much of the business case for smart meters hinges on convincing customers to genuinely change their energy usage. A positive bias among most users toward energy conservation (for both economic and environmental reasons) is an encouraging start. What is needed is to create a positive experience, both during and after the rollout. Customer experience during the rollout needs to be driven by timely and personalized information dissemination on schedules, status updates, tariff options, potential benefits and concerns of privacy and health. Post the rollout, it shifts more toward an advisory engagement. Analytics, coupled with the Internet of Things (IoT), can enable companies to provide smart solutions that

help customers efficiently manage their energy requirements. In-home displays can provide real-time feedback and empower customers to analyze their consumption patterns and maximize savings. Eight in 10 smart meter users who are enthused and engaged would recommend them to others. This underscores the vital need for providers to have the right operations' structure in place

Structuring for Success

IT, Customer Relationship Management (CRM) and customer service are the three business areas that will see the greatest impact from the smart meter rollout. The strategy will depend on helping customers realize the benefits. Analytics can support companies in offering variable pricing plans based on consumption patterns.

All change management programs should span both team structure and operations. It involves choosing the most appropriate field force model and training the team for strong customer service acumen. New capability development needs to be balanced with operational priorities to maintain high service levels as significant business processes will be impacted.

Unlocking Future Potential

The immediate opportunities of smart metering lie in the areas of data access, billing transparency, energy efficiency, performance and compliance. Analytics and technology unfold more exciting possibilities into the future.

IoT and big data analytics will pave the way for multiple devices to be connected. For E&U companies, it can improve grid intelligence and provide projection models that will combine historical data and weather forecasts to integrate the supply of renewable resources. Such innovations can take customer experience to new levels.

REALITY OF SMART ELECTRIC METRE

- **High initial investment acting as a restraint for growth in developing economis**

One of the major restraints in the deployment of smart meters is the gap between the cost-bearing party and the potential beneficiary, vis-à-vis what would the overall cost be and who would bear it. The overall cost for the installation and operation of smart meters is very high. Smart meter deployment is highly capital-intensive for utilities and consumers. Installation costs for deploying smart electric meters are too high when compared to the traditional electro-mechanical and electronic meters. For instance, smart electric meters cost somewhere around USD 100–500 as compared to the traditional meters, which have the pricing of around USD 10–30. Hence, most utilities are reluctant to shift their focus toward the deployment of new technology. In most countries, the state does not provide subsidies, and hence, funding is a serious restraint for smart electric meter deployment. Due to this reason, countries are still using traditional analogue meters, and thus act as a restraint for the smart electric meter market.

- **Cyber security & data privacy**

Smart electric meter solutions provide an array of advantages such as real-time monitoring, ability to monitor and control electricity consumption remotely, and integrative capabilities with external software to enhance the data analysis and decision-making process. Smart equipment, such as a smart electric meter, obtains information and communicates on digital networks. Moreover, this equipment can be controlled over networks, raising concerns regarding data theft and cyber-attacks. Cyber threats are the primary concern while developing any network for monitoring and control critical infrastructures.

Thus, there is a need to protect unauthorized access to the network facilities. The cyber-attacks targeted toward operational functions could result in loss of equipment control as well as unauthorized external control of equipment, hampering the monitoring process. Such sort of disruptions could range from operational irregularities such as loss of equipment and misinterpretation of the data. Unauthorized access through hacking or a cyber-attack could result in the leakage of confidential information, causing heavy losses to companies. Moreover, shortage of human resource to effectively ascertain and mitigate a cyber-threat further adds to the problem of data security and cyber-attacks. With the growing awareness of cyber security, companies are likely to invest in data & network security and implement standard and bespoke security solutions to mitigate this cyber threat. Considering these potential threats, end-users prefer conventional equipment, as the smart meter technology is misunderstood due to

the lack of knowledge. The successful implementation of the smart meter technology requires proper training, and knowledge impartment is imperative. The misuse of this data can pose a national security threat and thus acts as a challenge for the growth of the smart electric meter markets.

REFERENCES

[1]. Sh-Wei Lee, Cheng-Shong Wu, Meng-Shi Chiou, KouTan Wu A re- search paper on , Design of an Automatic Meter Reading System National Chung Cheng University

[2]. M. Popa A research paper on ,Data Collecting from Smart Meters in an Advanced Metering Infrastructure, Politehnica University,Timisoara,Romania

[3]. Adnan Rashdi, Rafia Malik, Sanam Rashid, Anam Ajmal, Sulaiman Sadiq, A research paper on, Remote Energy Monitoring, Profiling and Control Through GSM Network, 1 National University of Sciences and Technology, Islamabad, Pakistan

[4]. Ali Abdollahi, Marjan Dehghani, and Negar Zamanzadeh, A research paper on, SMS based Reconfigurable Automatic Meter Reading System

[5]. A research paper on, Electronic Energy Meter with Instant Billing

[6]. Jawed Ahmed, M. Afshar Alam, Abdul Mobin, Shahla Tarannum4, A research paper on ,A Soft Computing Approach for Obesity Assessment Computer Science, Jamia Hamdard, New Delhi

[7] B.O.Omijeh, G.I.Ighalo,"Design of A Robust Prepaid Energy Metering And Billing System",JORIND,10(3),2012.

[8] Syed Khizar Ali Zaidi I, HuraMasroor I, Syed Rehan Ashraf I and Ahmed Hassan, "Design and Implementation of Low Cost Electronic Prepaid Energy Meter", NED University of Engineering and Technology, Karachi, Pakistan, 2010.

[9] HuraMasroor I, Syed Rehan Ashraf I and Ahmed Hassan, " Design and Implementation of low cost Electronic Prepaid Energy Meter", NED University of Engineering and technology, Karachi, Pakistan, 2010.

[10] Ling Zou, Sihong Chu and Biao Guo., "The Design of Prepayment Polyphase Smart Electricity Meter System.