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# A Review on Smart Energy Meter Based on IOT

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**ABSTRACT**
In recent years, electrical appliances are increased in a huge amount. Along with this, the consumption of electrical power has also increased. so that the demand for electrical power is also increased. As the decrease in electrical energy sources due to the high consumption of the individual appliances. it should be controlled in order to overcome the above problem. Here it can be measured, controlled, and tracked the power consumption of electrical power of individual appliances. An accurate power measurement can't be achieved by using a conventional type of energy meter. As the customer cannot control and monitor the power consumption by each appliance. In the growth of the smart grid in the power system, efficient energy consumption plays a major role. By using the implementation and design of an Internet of Things (IoT) the above problems can be minimized. It is a cost-effective, minimalistic, efficient, and iot based energy meter. The smart energy meter will measure the individual unit power consumption of the appliances. It also sends notifications when it reaches the maximum load. The energy meter is classified into 3 types. They are electro-mechanical meters, electronic meter, and smart energy meter

## INTRODUCTION

In the present Indian situation, traditional utility grids are still predominant. Conventional electric meters delivered by the Government's electricity supply boards calculate the power ingestion of the whole company, apartments, house, and industry on a monthly source. This suggests that consumers don't have any kind of idea to supervisor the power consumption of particular appliances. The purchasers cannot approach the energy usage moreover due to the lack of communication ability. The billing system recognizes only the complete utilization in this process the purchasers have no idea about their performance with respect to the utilization. So, that the purchasers also lack information concerning the operational performance of their electrical domestic device. Electrical metering technology has created great advancement compared with a century ago. mainly, in the countries in which the temperatures are very high, electrical devices like air conditioning consume a high amount of power, creating an even more challenging situation for the power purchaser manage the power usage. Energy conservation in the sense of energy optimization according to the electrical device requirement. Inspecting When the electrical device consumes the energy in the best way(efficiently) the depletion of energy can be minimized. The energy inspecting tool is the best structure for creating effective energy conservation. Inspecting is the way to find the additional use of energy without having any interruption in the growth rate and efficiency. This new smart device is obligatory for well-organized inspection and controlling of industrial equipment in any kind of industry and eliminates their making costs [1]. In the present situations, these industries need a self-system to turn off/turn on the load when the load is not required during a specific production period. Using the help of energy conservation, we can hoard 15% to 30% of the total energy. the new smart device is an energy meter, which is divided into analog and digital scheming the energy meter is an extremely challenging task because vast factors predominate the digital meter performance. The precision of an analog meter will be disturbed due to the increase in the temperature. Analog meter absences changes in precision over extended periods of time and stability due to the manufacturing faults and the mechanical properties like strength mass and spring will be changed. In order to face the above problem an updated technology integration is used in the development. The analog energy meter can't be able to sense manually it can only measure power in one direction this is one of the disadvantages of analog energy meters hence excess generation from non-conventional sources cannot happen. The best ways of electrical energy generation, distribution, transmission, utilization, and implementation of different kinds of levels of automation using wide-area controlling and improvement of smart meters.

The exactness of measurement, isolation, and fault detection can also be accurately predicted by calculated electrical parameters along with universal timestamps in the transmission system [4]. The reliability of the transmission grid can be improved because of this. In the search for updates and improvements to this energy meter, there have many changes occurred which have caused weight and size. The invention of the digital electronic meter has completely replaced the way of electrical parameters values. The digital electronic meter has a high resolution, greater efficiency, low current and voltage functioning, easy reading, and easy installation [3]. This kind of digital electronic meter mainly consists of the voltage and

current transducer which provides the result of current and voltage samples. The system on chip (SOC), which can easily port with any kind of sensor. An Analog-To-Digital Converter (ADC) and the digital signal processing architecture will order the next-generation meter's time to market, life expectancy, and unit cost. One of the best advantages of a smart electronic energy meter is a customer-based application developed in order to control the turnoff/turn-on. Without any interaction of the human being the electrical power supply is monitored with the help of a GSM modem. The power system is protected by means of power system protection from defectives by separating defective equipment from the remaining equipment. The fuses, protective relays, instrument transformer, circuit breakers, and so on are the few types of protection equipment that are available in the market. It is a necessary condition for all the residence and industries to keep a fuse and circuit breakers to protect the buildings and industries from failures, simple wiring problems, and fire hazards.

The conventional energy meter has its own lot of disadvantages and lots of annoyances due to the old implemented plans supplied by the state electricity supply company in power management system due to this both the energy consumers and the suppliers are facing many issues. The bill collector records the electrical bill of the consumers with the help of a handy meter which is used to record the bill and the bill collector is an employee in the electrical power supply. The bill collector has to visit every house of the consumer which is a time taking process and as it there is human interaction, they may be chances of human errors and lead to the wrong bill generation. This data is collected on a monthly basis if due to any reason the bill collector has not taken the electric bill, then the cost of the units may be increased [5]. The consumers have an idea about the power usage by using a prepaid system so that they use it in a more well-organized way. The electronic energy meter is designed using IoT and the GSM module. As IoT is basically a large, coherent, network of sensing and communication devices it can be used to control various quantities.

## LITERARURE SURVEY

Scheming the energy meter is an extremely challenging task because vast factors predominate the digital meter performance. The precision of an analog meter will be disturbed due to the increase in the temperature. Analog meter absences changes in precision over extended periods of time and stability due to the manufacturing faults and the mechanical properties like strength mass and spring will be changed. In order to face the above problem an updated technology integration is used in the development. The analog energy meter can't be able to sense manually it can only measure power in one direction this is one of the disadvantages of analog energy meters hence excess generation from non-conventional sources cannot happen. The best ways of electrical energy generation, distribution, transmission, utilization, and implementation of different kinds of levels of automation using wide-area controlling and improvement of smart meters.

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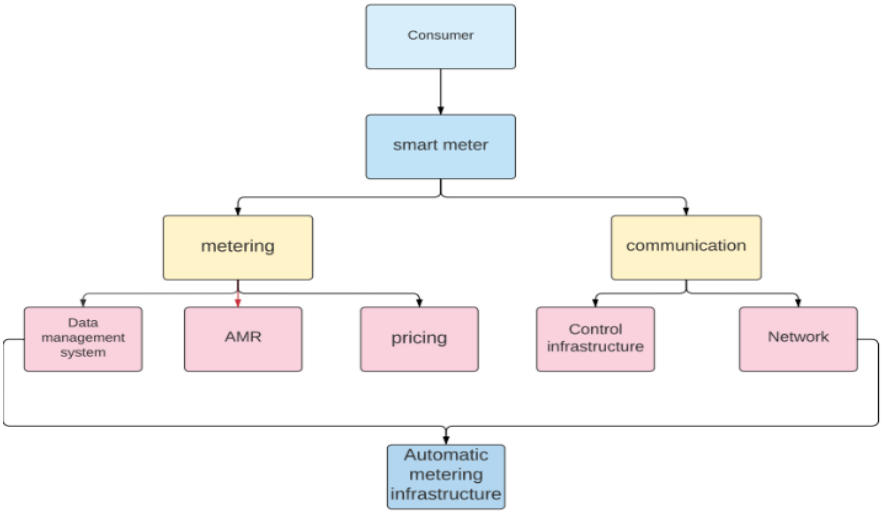


**FIGURE 1:** Picture of a Smart Meter

## BACKGROUND AND RELATED WORK

Electric meter or simply energy meters are used to notice and give how much energy is consumed by electric devices and displays it. These meters were been used in both households and industries since the 1800s. In every country energy meters become popular in the 1960s. Before the 1960s power generation, distribution and electric power grids are not familiar. Later electrical power grids reach to a high level by providing quality and security [7].

As population and industries increases power consumption also started increasing in an unexpected way. To supply the increasing demand power plants are also increased. After the 19$^{th}$ century, Power grids were entered into a new phase including smart technology, the Internet of Things, and Sensors. Electrical power grids are then evolved as Smart grids. Though there is a change in grids, not much change is observed in energy meters. In both electrical and smart grids mostly conventional energy meters are used. The consumption of energy detected by using traditional methods is called conventional energy meters.

## CONVENTIONAL ENERGY METER

Analog and electronic meters are basically called conventional meters as they are used from the beginning. Conventional meters require manual operation i.e. a reader must take the readings of the meter and then the bill is generated by using those readings. Conventional energy meters are basically of two types:

(A). Electromechanical system which helps to detect the power consumption by using a mechanical disc. By counting the number of revolutions made by the disc in meter over a particular time duration number of watts of power consumed is calculated.

Another method is
(B). The electronic energy meter, are digital meters that represent the measured power consumption through LCD or LED screen. They are developed by using digital microtechnology (DMT). It is better than electric meters but still has some disadvantages. They are

- Errors in taking readings
- Irregular information
- Time taken procedure
- Power theft
- One-way communication
- No control over power consumption

To overcome these limitations Automatic Reading meter (AMR). It collects the data about the consumption of energy and transfers it to a database for billing. Though it is far better than electronic and electric energy meters is also a one-way communication meter. No great security and many disadvantages. To overcome all these limitations smart energy meters are introduced.

In smart energy meters, End to end communication is possible, two-way communications, fault detection, and fault analysis, etc. These smart meters are introduced to develop smart cities. Pre-paid billing is also done in smart energy meters. The smart grid allows integration, control, and interaction from utility to consumer.

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## SMART METER TYPES

The usual type of electrical meter used is an electromechanical watt-hour meter. The magnetic flux on a conductive metal disc is produced due to the passing of power through the meter feeds induction coil. The rotation of the disk at a speed is in proportion to the power flux. The rotation of the disc of the energy meter is counted for the purpose of the bill provided for the consumers. This kind of future makes this to use widely. whatever it may be the new futures for controlling and monitoring the power grid have existed new future meters. This made to use electronic meters instead of electrochemical [8]. This made this smatter which means that added some extra features which are useful for both the customers and producers. The consumers can automictically can knows the usage of the power and as well as for providers without any access of human energy. Real-time pricing has been controlled by the producers by remote control of the meters and the power delivery process, levelling of the load is more professional.

This type of smart meter can also be updated by other modules. This can be achieved by adding an open structure this improves many numbers of modules to be added and innovations [9]. This smart meter is more flexible by the use of common add-ons, modules for the purpose of additional communication interfaces, alarms, and storage. The smart meter's first evolution says about the consumption details back to the power provider, achieving remote meter reading (RMR) and AMR. So that the producers can able to read data without the involutions of humans being from a long distance. Due to this, we can achieve active monitoring, monitoring results can be sent to long-distance and overall data on network.

SGs included some more additional futures to this. They are

- Bidirectional communication
- Two-way metering and billing
- Home devices control and monitoring
- Power extortion detection
- Management of demand and load
- Discovery of system defects
- Smart cities evolution
- Security improvement
- Emission control

By using an albeit conventional meter we can display and measure total power consumption. By using a smart energy meter, we can measure it for a short interval of time this may be of a minute [11]. It is easy and accurate to estimate that hoe long consumers stay home, what type of electrical equipment are available, whether they are any alarm and security devices, and also special conditions like medical emergencies. From this, we can say the behaviour of households can be easily estimated without any use of an algorithm

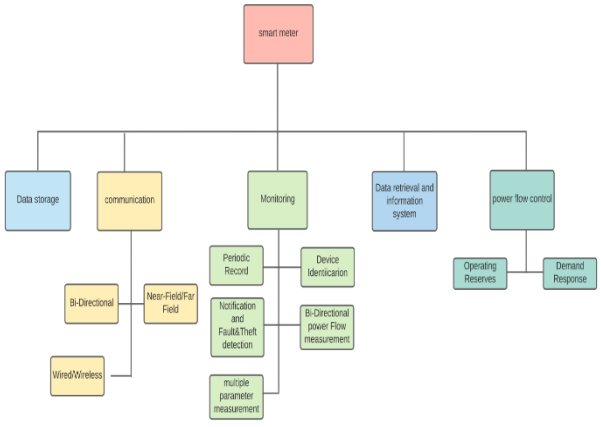


**FIGURE 2:** Functions of a smart meter

## EVOLUTION OF SMART METERS

The evolution of smart meters is classified into mainly 3 types. They are

*A. Electro-mechanical.*
*B. Electronic digital meter.*
*C. Smart meter.*

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- ***Electro-mechanical***

One of the most commonly used and first types of electrical meter is the electromechanical watt-hour meter. It mainly consists of a rotating metal disc and an inductive coil. The rotating disk rotates due to the production of magnetic flux in which the power flows through it. This rotating disk is proportional to the power, the usage of power by the consumers. The rotation of the disk is also counted. the electromechanical meters are becoming more popular because of their design and structure but this has not provided any kind of extra features. But the power grid requirement and technological improvement have improved controlling and monitoring this made the electronic meter development.

- ***Electro digital meter***

Digital micro technology (DMT) is used in the construction of electronic meters. this type of electronic meter is mainly focused to restrict the usage of heavy moving components. These meters are the underpinning for the digital meters the main reason behind this is that digital meters are more accurate as they are of digital type. This meter came as a good asset has an extra feature can we introduced and technology progressed which makes this electronic meter smarter. The contractors can able to provide power efficiently to the consumers by Real-Time Pricing (RTP) and deploying load levelling [10]. This type of electronic digital meter is mainly consisting of flexibility nature as there is a possibility of adding new features by using plugging in extra modules. The energy distributors can know about the usage of the electrical power without any introduction of the human whereas in the first-generation digital electronics meters will report the energy consumption by the consumers this can be done by remote meter reading (RMR) and automated meter reading (AMR). The second generation of digital electronics meters is introduced due to the first-generation digital electronics meters including advanced metering infrastructure (AMI) through which the energy demand can be managed. advanced metering infrastructure (AMI) SMs consists of tracking of the smart energy consumption which has storage and transmission of the data which can be used for the exchange of information servers in data networks. This makes the improvement of smart meters.

The smart meter smart features are:

- Controlling of the devices
- Monitoring of the devices
- Load management
- Power thefts
- Identification of system's faults
- Billing management
- Data storage

- ***Smart meter***

The control, analysis, and monitoring of the power can be achieved by recording the power usage and this stored data can be transferred to the central data server this process can be done from time to time. due to this, there is the development of SEMS which are of efficient and effective

The functioning of SMs is given in Figure 3and is explained as follows.

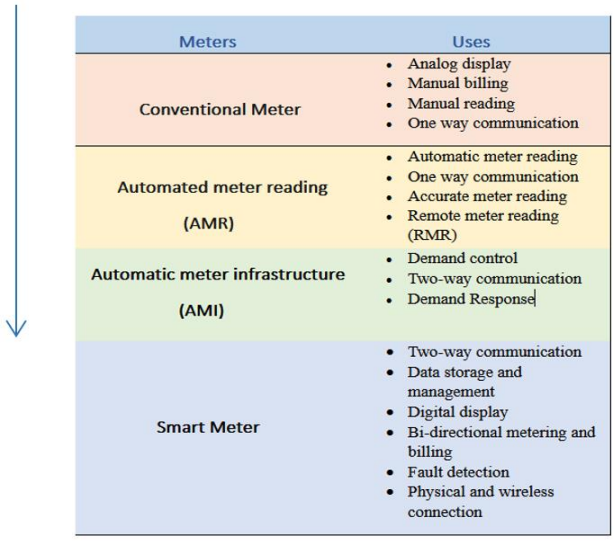


**FIGURE 3:** Evolution of an energy meter

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## SYSTEM DESIGN AND SPECIFICATIONS

- ***Proposed system***

In the current smart grid still, conventional energy meters are using. To overcome the limitations of those meters we propose smart energy meters and smart appliances by using IoT.

In existing meters, there is no clear information and no data about usage of power on daily basis, no clear and accurate billing. In the proposed system, accurate billing, day-to-day analysis on power usage, remote controlling of devices, two-way communication, warns of defects in the system are done and no labour is used for billing and prepaid billing can also be done. By using smart energy meters power theft can also control [12]. And by Automation devices, we can control devices from anywhere and we can reduce the power consumption when. It provides great home security. It also increases appliances' functionality.

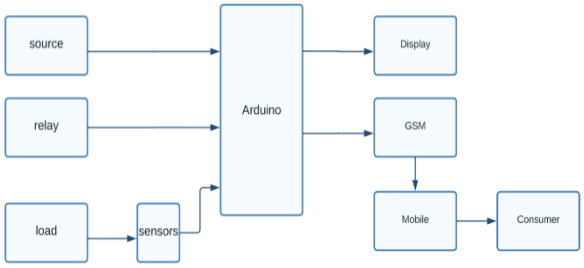


**FIGURE 4:** Circuit diagram of energy meter

- ***System specification***

To design a system, some features and parameters are taken into consideration. They are:

- Complexity
- Envision
- Operational cost
- Efficiency
- Components
- Security

Based on these parameters, a smart energy meter will design using Arduino Uno, which is a microcontroller board. It is low-cost, easy to understand, and easy to program. In our proposed smart energy system, Arduino and smart energy meter is interfaced with LCD, supply, loads, protection devices, GSM module, and mobile.

The global system for mobile communication (GSM) module is designed for wireless communication. It collects data from the energy meter and passes information to mobile. We can connect this GSM to any mobile and can receive calls and SMS by using GPRS. It has the ability to support multiple devices. This GSM module is connected to Arduino. When the input is turned on the Arduino will communicate with the GSM module by using AT commands and send messages to a programmed mobile number. We can use the GSM shield also.

Protection devices are used to protect the circuit and devices that are connected to the smart energy meter. Here relay is used to protect the system. It is an electrically operated switch; they are used to control a circuit by a separate low-power signal. It is connected between load and supply to detect faults. LCD extended as Liquid Crystal Display. It is a flat panel display which is used to display what we want. In this system, we used to display the energy meter readings. LCD is connected to Arduino. Current sensors are also used in smart energy meters. It is a device that detects electric current and generates a signal proportional to that current. These current sensors are connected to Arduino and the load.

Optocoupler is used in this proposed system which is a semiconductor device that allows an electrical signal to transmit between two isolated circuits. It is connected between the energy meter and micro-controller (Arduino).

## CONSTRUCTION OF ENERGY METER

There are four main systems in the construction of energy meters. They are:

- Driving system
- Moving system

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- Braking system and Registering system
- *Driving system*

In this system, shunt and series electromagnets of laminated construction. A coil has a large number of turns of a fine wire that wound on the middle leg of the shunt magnet. It is a pressure or voltage coil and connected across the supply, which is used to produce a high ratio of inductance to resistance. Copper-shaded rings are provided on the central leg of the shunt magnet which is known as the current coil [14]. It connects in series with the load to carry the load current

- *Moving system*

In a moving system, the energy meter consists of a rotating aluminium disk mounted on a vertical spindle. The fluxes produced from the two electromagnets induce the eddy currents in the disc. Due to this, the disc will rotate it determines the energy consumed by the load in a certain time interval.

- *Braking system*

The braking system provides the required necessary breaking action to the disc. This is done by exerting breaking torque. This is used to control the speed of rotating speed.

- *Registering system*

This system is attached to the moving system. It counts the number of revolutions made by the disk and gives the power consumed by the load over a considered period of time.

## WORKING

Based on the supply there are two types of energy meters:

1. Single-phase energy meter
2. three-phase energy meter

*Single-phase energy meter*

The basic working principle of Single-phase energy meter
is based on:
A). Mechanism of rotation of aluminum disc and
B). Mechanism of counting and displaying the power consumed.
A Single-phase energy meter is connected to the loads with a single-phase supply [13]. When the load is connected to the meter magnetic flux is produced by both pressure and current coils on that mounted on magnets. This flux links with disc and eddy currents are flowing in it. Because of this eddy current and magnetic flux, a torque is produced in the disc and makes it rotate. With this rotation of the disc, we can calculate the power consumed by the loads. In smart energy meters, we use microcontrollers and sensors and display the power consumed by loads on LCD.

*A. Three-phase energy meter*

Three-phase energy meter working is almost similar to single phase energy meter. This Three-phase energy meter is used to measure the power consumption of three-phase loads. This energy meter is constructed by connecting two single-phase energy meters. These two energy meters readings are added to measure the total energy consumption of three-phase loads.

When the load is connected to the meter both pressure and current coils produce magnetic flux which is mounted on series and shunt magnets. This flux is linked with disc and eddy currents are flow in it and torque is produced. As the disc is attached to the spindle it also rotates and gives the reading of energy consumption. In another single-phase meter also do the same and these two meters readings are added and the energy consumption of three-phase loads is obtained.

## CONCLUSION

This paper discussed the smart energy meter based on IOT has reviewed different papers and selected best suited smart energy meter based on iot due its efficiency and that meter can be used in households and industries to measure the consumption of the individual electrical appliances without any disrupting of the current operation of the appliances. Consumers can monitor and control the consumption of the data. with the help of this, the consumers can evaluate the working condition of the appliances. as the consumers have an idea about the working conditions of the appliances they can be to save the electric power by reducing the losses. So that the power is saved for the future generation. bidirectional communication, two-way metering, and billing, home devices control and monitoring, power extortion detection, management of demand and load can be achieved by using this kind of smart energy meter based on the IOT.

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**REFERENCES**

[1] V. S. K. M. Balijepalli, V. Pradhan, S. A. Khaparde, and R. M. Shereef, ‘‘Review of demand response under smart grid paradigm,’’ in Proc. ISGT2011-India, Dec. 2011, pp. 236–243, doi: 10.1109/ISETIndia.2011.6145388.J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[2] M. Suresh, U. Muthukumar, and J. Chandapillai, ‘‘A novel smart water meter based on IoT and smartphone app for city distribution management,’’ in Proc. IEEE Region 10 Symp. (TENSYMP), Jul. 2017, pp. 1–5, doi: 10.1109/TENCONSpring.2017.8070088. K. Elissa, “Title of paper if known,” unpublished.

[3] C. Keyer and F. Leferink, ‘‘Conducted interference on smart meters,’’ in Proc. IEEE Int. Symp. Electromagn. Compat. Signal/Power Integrity (EMCSI), Aug. 2017, pp. 608–611, doi: 10.1109/ISEMC.2017.8077940.

[4] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[5] Q. Sun, H. Li, Z. Ma, C. Wang, J. Campillo, Q. Zhang, F. Wallin, and J. Guo, ‘‘A comprehensive review of smart energy meters in intelligent energy networks,’’ IEEE Internet Things J., vol. 3, no. 4, pp. 464–479, Aug. 2016, doi: 10.1109/JIOT.2015.2512325.

[6] D. Baimel, S. Tapuchi, and N. Baimel, ‘‘Smart grid communication technologies- overview, research challenges and opportunities,’’ in Proc. Int. Symp. Power Electron., Electr. Drives, Autom. Motion (SPEEDAM), Jun. 2016, pp. 116–120, doi: 10.1109/SPEEDAM.2016.7526014.

[7] Y. Kabalci, ‘‘A survey on smart metering and smart grid communication,’’ Renew. Sustain. Energy Rev., vol. 57, pp. 302–318, May 2016, doi: 10.1016/j.rser.2015.12.114.

[8] X. Liu, L. Golab, W. Golab, I. F. Ilyas, and S. Jin, ‘‘Smart meter data analytics: Systems, algorithms, and benchmarking,’’ ACM Trans. Database Syst., vol. 42, no. 1, pp. 1–39, Mar. 2017, doi: 10.1145/3004295.

[9] M. Díaz, C. Martín, and B. Rubio, ‘‘State-of-the-art, challenges, and open issues in the integration of Internet of Things and cloud computing,’’ J. Netw. Comput. Appl., vol. 67, pp. 99–117, May 2016, doi: 10.1016/j.jnca.2016.01.010.

[10] Z. Sultan, Y. Jiang, A. Malik and S., F. Ahmed, ‘‘GSM based smart wireless controlled digital energy meter,” 2019 IEEE 6th International Conference on Engineering Technologies and Applied Sciences (ICETAS), Kuala Lumpur, Malaysia, 2019, pp.1-6, doi: 10.1109/ICETAS48360.2019.91174 79.

[11] IOSR Journal of Electrical and Electronics Engineering (IOSR- JEEE) e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 10, Issue 3 Ver. III (May – Jun. 2015), PP 07-13.

[12] K. Anderson, J. Du, A. Narayan, and A. E. Gamal, ‘‘GridSpice: A distributed simulation platform for the smart grid,’’ IEEE Trans. Ind. Informat., vol. 10, no. 4, pp. 2354–2363, Nov. 2014, doi: 10.1109/ TII.2014.2332115.

[13] H. T. Haider, O. H. See, and W. Elmenreich, ‘‘A review of residential demand response of smart grid,’’ Renew. Sustain. Energy Rev., vol. 59, pp. 166–178, Jun. 2016, doi: 10.1016/j.rser.2016.01.016.

[14] V. S. K. M. Balijepalli, V. Pradhan, S. A. Khaparde, and R. M. Shereef, ‘‘Review of demand response under smart grid paradigm,’’ in Proc. ISGT2011-India, Dec. 2011, pp. 236–243, doi: 10.1109/ISETIndia.2011.6145388.