Energy Meter Monitoring System Using Iot

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Abstract

Automation is needed everywhere to cut down on labor and stop electricity theft, which in India accounts for 80% of power losses. According to calculations by Bloomberg, the electrical sector struggles, leading to blackouts and costing $17 billion in lost income yearly, while the country aspires to usher in a new golden age. With the total production of the country at over 250GW as of August 2016, weak infrastructure is to blame for a number of losses, including transmission, distribution, aggregate technical, and commercial losses. Our paper focuses on identifying power theft and calculating the units from the appliance, providing notifications based on consumption. Electrical appliances can be controlled via the internet from anywhere in the world; there is no distance restriction, and they can be manually reset to resume operation. The following is a clear description of this system's primary goals: Theft of energy raises consumer bills and poses a major risk to public safety. Historically, field workers have used balance meters and physical inspections of tamper-evident seals to detect electrical theft. Notify the owner via SMS to identify the theft. Monthly rate and meter readings to the owner. Together with these configurations, an effective Internet of Things (IOT) is defined, allowing users to examine the status of theft associations and meter readings globally at any time and from any location. It also portrays the global connection environment to users. Customers are materially impacted by electricity theft in terms of expense and security. We believe that the current regulatory environment does not sufficiently incentivize suppliers to take the initiative to report fraud.

Keywords: Internet of Things (IOT), Energy, Arduino UNO, Node mcu, Acs712 current sensor, monitoring unit, reset button, Arduino ide, embedded c.

INTRODUCTION

The smart EB is a cutting-edge platform that improves upon how we currently receive electricity. Compared to now, there was a significant need for power in the past. A revamp of the current grid system is much needed, as the demand for electricity has expanded dramatically. With today's technology, the smart grid might be built in a way that leverages digital communications technology to identify and respond to changes in local usage. The system will allow information and energy to be shared back and forth between the utility and the customer in a two-way dialogue. This can alter a consumer's energy requirements by examining the feedback from the two-way conversation. Every consumer unit in this system has a smart energy meter installed, and the service provider maintains a server.

The server and the meter are both outfitted with, allowing for easier communication between the two ends via the server. The Arduino receives the energy meter's tariff data and transmits it to the server.Because the transmission system's server is cloud-connected, we may use the Internet to monitor and manage each customer's EB lines. Additionally, this method helps to cut off the EB Line for customers who fail to make their monthly bill payments on time. In addition to being simple to use and requiring less maintenance, this technology makes it possible for users to track how much electricity they use on a daily basis online. Efficiency, dependability, and security would all rise with the exchange of information and

electricity between the utility and its customers. Additionally, the smart grid makes it possible to include renewable energy technology into the system for a more ecologically friendly and greener approach.

RELATED WORK

Literature evaluation is a totally vital step inside the software improvement process. Before growing the device, it's miles crucial to determine the time element, price savings and commercial enterprise robustness. Once these things are glad, the next step is to determine which running gadget and language can be used to broaden the device. Once programmers start constructing a device, they want numerous external help. This support may be received from senior programmers, books or web sites. Before designing the system, the above concerns are taken into consideration to increase the proposed gadget.

The fundamental a part of the assignment improvement department is to very well have a look at and review all of the requirements of the challenge improvement. For every assignment, literature assessment is the maximum vital step within the software program development system. Time elements, resource necessities, manpower, economics, and organizational electricity need to be diagnosed and analysed earlier than growing the equipment and related layout. Once those elements are satisfied and carefully researched, the following step is to decide the software program specs of the specific pc, the operating machine required for the undertaking, and any software program required to transport forward. A step like growing tools and capabilities associated with them.

The intention of Internet of Things (IoT)-based smart energy management is to maximize energy utilization by analyzing power consumption patterns and monitoring energy in real-time in IoT networks, which are supported by wireless technologies and include residential homes and offices. This is important for the sustainable development of energy. Energy disaggregation, which can calculate each appliance's power usage from the overall load (e.g., aggregated data), is a crucial technological advancement for achieving smart energy management. Additionally, it provides us with a comprehensive understanding of users' everyday power-related behaviors, which can raise their awareness of power conservation and encourage them to live more sustainably. The most recent energy/power disaggregation methods and publicly available power consumption datasets are reviewed in this work. A discussion of open topics for further research is included, along with possible use cases for IoT-based smart energy management [1].

Concern over the rise of several developed and developing countries worldwide led to an increase in this demand. There were not as many power plants producing electricity in Sri Lanka. Thus, there is now a shortage of electricity. Therefore, it will be everyone's responsibility to reduce and control electricity use. Additionally, it is crucial that consumers track the data they use today. However, customers are now using conventional meters at every residence. It has not succeeded in giving the user these features. Additionally, Digital Meter is working to lessen these restrictions. The Smart Electricity Monitoring System with a Mobile Application is the main topic of this research study. This project is focused on IoT. A user-friendly mobile app allows the user to monitor the amount of electricity consumed. The automated monthly electricity bill is another feature [2].

The constant rise in energy use brought about by population growth and the daily introduction of new gadgets has created significant hurdles for consumers trying to manage their energy use. As technology advances, smart meters (SMs) are now seen as more than just instruments for monitoring energy use; they also serve as a vital component of energy management programs. Numerous benefits are associated with the use of SM, such as precise billing information, user-end consumption data, two-way communication, and remote equipment control. The most crucial component of a smart power grid is smart mobility (SM), which evaluates, measures, regulates, executes, and communicates power allocation, utilization, and consumption

at the network and individual device levels with the aid of any smart energy management system (SEMS) [3].

Automation, portability, and remote control are always being pushed for in all firms' management systems. This study presents a new IoT-based multipurpose smart energy meter for an automated billing and metering system. An ESP-8266 WiFi Module is used to monitor energy metrics, and an Arduino nano with a GSM Short Message Service (SMS) connection offers a meter reading system with predefined automatic operations. The project was modeled using Proteus 8.0 prior to the construction of the hardware implementation. The proposed system can transmit data, such as generated bills and kWh consumption, over the GSM network with the help of an embedded controller and GSM module. This data can then be fed into power companies' or organizations' existing energy management systems to provide services to customers without requiring human intervention. This makes consumer energy analysis much easier to understand and much more doable [4].

Physical energy meter reading is an antiquated idea that wastes manpower, is inefficient, prone to error, and burdens consumers because energy companies charge their customers for the labor of physically reading the meters. Although replacing the outdated energy meters is an enormous and costly undertaking, smart energy meters provide a significant solution to the aforementioned issues. In order to address the aforementioned problem, this paper presents an Internet of Things (IoT) based smart energy meter that uses Raspberry Pi devices. The old meters that are already installed can be converted to prepaid smart meters with a little tweak. Thus, there is no need to swap out the outdated energy meter. Customers can receive pertinent notifications via SMS service, simply access these meters through personalized web pages and intelligent mobile applications. Once a user has used up all of their prepaid threshold, these meters can be automatically turned ON and OFF using the smart app. SMS alerts are sent to consumers when the threshold amount is going to be exceeded [5].

EXISTING SYSTEM

The current system is somewhat complicated; previously, each person used a current transformer to measure the ac current. A current transformer is limited in its ability to perceive current to a minimum frequency, below which gain quickly decreases. A constant current cannot be sensed by a current transformer. A current transformer may be useful when measuring the current of something that is always AC, such as the power line. A current transformer cannot be used if DC current sensing is truly required. Bluetooth and GSM control of household appliances is an established system.Bluetooth no longer monitors and now has a distance parameter.

The GSM module is only used to transmit the unit consumption to the mobile device; no data is stored. The globe is currently living in such a challenging climate. The primary issue at hand is the energy crisis. By the people in our society. One way to solve this issue is to implement a system that is appropriate for controlling and monitoring power usage. Cutting back on domestic power usage is one way to tackle the current energy problem. Customers are growing at a rapid rate, and this is placing an increasing stress on the divisions that provide electricity.

Disadvantages

- Limitation of Current Sensing
- Bluetooth Range Limitation
- GSM Data Storage Limitation

- Insufficient Energy Efficiency.

REQUIREMENT ANALYSIS

Evaluation of the Rationale and Feasibility of the Proposed System

The integration of advanced metering infrastructure (AMI) and communication technologies is the aim of the proposed smart grid system, which aims to enhance electricity distribution reliability, efficiency, and security. It will alert users to their power usage using LED indications and alarms that are based on pre-established thresholds (Green for less than 50 units, Yellow for 50-90 units, and Red for more than 90 units). In addition, an LCD panel will display the alerts, and the system will use current sensors on the transmitter and receiver sides to detect power theft.

Users will be able to remotely control their electrical appliances, continuously monitor data, and store data in the cloud for analysis thanks to the Internet of Things. Along with improving voltage levels for energy efficiency and offering users the option to restart manually, the smart grid will also automatically search for flaws. The concept's primary objective is to employ Raspberry Pi to create an inexpensive platform that will link various sensors and gadgets in homes while ensuring data processing and transmission security and scalability.

PROPOSED SYSTEM

Utilizing cutting-edge communications and control technologies and procedures, the smart grid enhances security, efficiency, and dependability—all essential components of the ongoing upgrading of the infrastructure responsible for delivering electricity. Smart meters, communication networks, and information management systems make up advanced metering infrastructure (AMI), which is increasing utility operational efficiency and giving power consumers information to better manage their energy use. Utilities can employ smart grid apps to dynamically optimize voltage and reactive power levels for more efficient power use, automatically find and isolate faults to minimize outages, and monitor asset health to direct maintenance. We are proposing a project that will automatically notify consumers about their power consumption based on units consumed. Upon reaching 50 units, the message will be sent to the consumer automatically. LED indicator is also available; if it is below 50, the LED is on, if it is between 50 and 90, it is on the yellow side, and if it is above 90, it is on the red side. By installing a current sensor on both the transmitter and receiver sides, the receiver side will automatically analyze power use and provide an LCD screen alert in the event that power is stolen between the lines.

Because electrical appliances lack any sort of distance parameter and are constantly monitoring and storing data in the cloud, they can be automatically controlled via the internet. In order to increase security, efficiency, and dependability—all essential components of the ongoing modernization of the infrastructure for the transmission of electricity—the smart EB applies cutting-edge communications and control technologies and procedures. Smart meters, communication networks, and information management systems make up advanced metering infrastructure (AMI), which is increasing utility operational efficiency and giving power consumers information to better manage their energy use. Smart grid solutions enable utilities to automatically find and isolate faults to reduce outages, dynamically adjust voltage and reactive power levels for more efficient power consumption, and monitor asset health to guide maintenance. By manually restarting the function using a button.

Advantages

- Continuously monitoring.

- Current sensor sense the AC and DC current.
- Control the appliance at anywhere in the world.

SELECTED METHODODLOGIES

Internet of Things (IOT):

The IoT-based design of the smart grid system will create a network of linked devices that can readily communicate online. With the use of smart meters, sensors, and appliances, this architecture will allow real-time data exchange between the utility provider and its customers. Every gadget will have communication capabilities, enabling remote monitoring and management of energy consumption. Users will be more engaged as a result of having access to information on their power usage through web or mobile applications. Customers will be encouraged to take control of their energy use and to utilize energy more transparently thanks to this integrated approach.

Fig 1: Internet of Things (IOT)

Cloud Computing and Data Analytics:

Cloud computing will enable the smart grid system's data analysis and storage from sensors and smart meters. By utilizing cloud services, the system can securely store enormous volumes of historical power usage data, which makes it easy for utility companies and customers to access and retrieve. To improve resource management and forecasts, this data will be exposed to advanced data analytics to identify patterns, trends, and anomalies in energy consumption. This technology will also facilitate the creation of educational reports and visualizations, helping clients make informed decisions about their energy use. Scalability is another benefit of cloud computing, which will allow the system to handle more connected devices as demand grows.

Fig 2: Cloud Computing and Data Analytics

SYSTEM ARCHITECTURE

The requirements specification and the high degree device order are connected to the description of the software's general features. Many web pages are built and their relationships outlined during the architectural design process. Relationships between modules are documented, and key software components are established and broken down into processing modules and conceptual records systems. The modules listed below are defined by the suggested system.

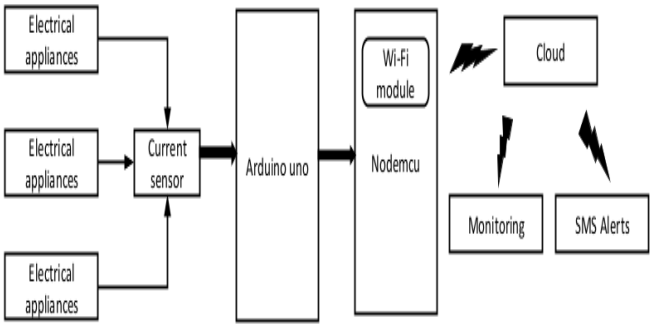

Fig 3: Proposed System Architecture

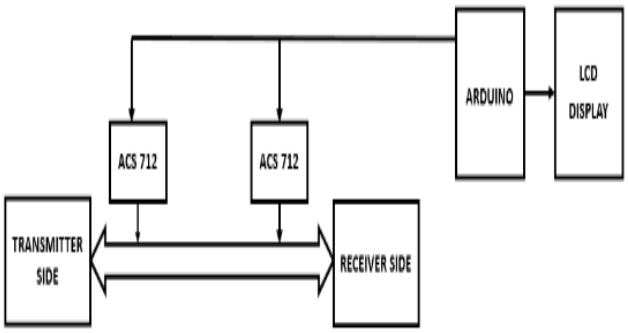

Fig 4: Block Diagram

SYSTEM MODULES

1. Electricity Meter Module.
2. Power Theft DetectionModule.
3. IoT Connectivity Module.
4. User Management Module.

Modules Descriptions

- ***Electricity Meter Module:***

The newest type of gas and electricity meters are called smart meters. The amount of gas and energy you use is precisely measured by them. Additionally, they include an in-home display (IHD) or portable, user-friendly smart energy monitor that displays your energy usage and associated costs in pounds and pence.

- ***Power Theft Detection Module:***

Presented in this system is an intelligent power theft detecting system. In order to notify the utility provider and initiate the necessary action, it promptly detects unmetered load, also known as illegal load. Highly sensitive, dependable, and effective is the system's design.

- ***IoT Connectivity Module:***

The Internet of Things (IoT) module presents the concept of expanding Internet connectivity beyond computers and related devices to include additional ordinary things or physical devices. It does this by utilizing technologies like automation, wireless sensors, and embedded systems.

- ***User Management Module:***

The application's scope of access and the content visible to devoted users can be managed with the help of the User Management Module.

HARDWARE REQUIREMENTS

- Arduino UNO.
- Node mcu.
- Acs712 current sensor.
- Monitoring unit.
- Reset button.
- LED.

Hardware Description:

Arduino UNO:

The Arduino UNO is an open-source, programmable microcontroller board that is inexpensive, versatile, and simple to use. It may be used in a wide range of electronic projects. This board can control relays, LEDs, servos, and motors as an output and can interact with other Arduino boards, Arduino shields, and Raspberry Pi boards. An ATmega328P-based microcontroller board is the Arduino UNO.

It features a 16 MHz ceramic resonator, 6 analog inputs, 14 digital input/output pins (six of which can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button. It comes with everything needed to support the microcontroller; all you need to do is power it with a battery or an AC-to-DC adapter or connect it to a computer via a USB cable to get going. You can experiment with your UNO without too much fear of making a mistake; in the worst case, you can replace the chip and restart for a few bucks.

Fig 5: Figure of Arduino Uno

NodeMCU:

NodeMCU is an open source firmware for Espressif's ESP32 and ESP8266 WiFi SOCs, based on Lua. It makes use of an SPIFFS file system based on on-module flash. The ESP8266 version of NodeMCU is placed on top of the Espressif NON-OS SDK, and it is implemented in C. Originally created as an add-on to the well-liked ESP8266-based NodeMCU development modules, the firmware may be used with any ESP module and is now a community-supported project. An open-source Internet of Things platform called NodeMCU is built around the ESP8266 Wi-Fi module.

It can be used to manage a variety of electrical devices and enable network communication between them. Just like the firmware itself, Lua code and the constant data that goes with it may be run straight from flash memory thanks to LFS. This means that Lua apps with up to 256Kb of code and read-only constants that run entirely on flash can now be created by NodeMCU developers. Data can be read and written to using the entire RAM.

Fig 6: Figure of Node MCU

Acs712 Current Sensor:

With 2.1kVRMS voltage isolation and an integrated low-resistance current conductor, the ACS712 is a fully integrated linear current sensor based on the Hall Effect. Without getting too technical, it is essentially described as a current sensor that measures and computes the applied current using its conductor. Have you ever paused to consider how much current each of your appliances uses? Knowing everything is a laborious procedure, but that is where a current sensor's capability comes in handy.

Since various devices have varying current requirements, providing them with the incorrect amount of current could lead to dire situations (overloading, etc.). Therefore, it is essential to keep an eye on the required current for applications. To do this, individuals use a current sensor, specifically the ACS712 AC/DC Current sensor. Previously, we created a basic notion of the applications for which current sensors are suitable. Well, in addition to electrical appliances, the ACS712 IC may be used in a broader range of applications due to its ability to detect both AC and DC current. It can be used for industrial, commercial, and communication applications, as well as for Arduino and other microcontroller usages.

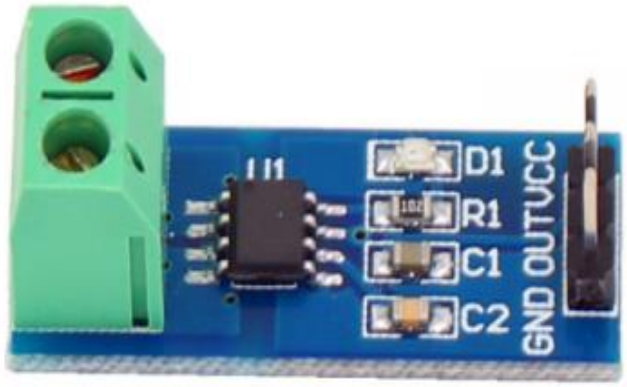

Fig 7: Figure of Acs712 current sensor

Monitoring unit:

Program and project monitoring units are specialized units inside an organization or government that are assigned the specific responsibility of supervising the advancement, efficacy, and effective execution of certain projects or programs.These units may take the form of specialized teams working on certain large-scale national projects, or they may be more adaptable organizations that manage a variety of smaller projects while making sure they are in line with larger goals and providing feedback.

The establishment of implementation units, which evaluate suggested programs for preparedness for execution and carry out monitoring to guarantee programs are carried out successfully, is one way this is done. In certain instances, they also play a part in attempting to resolve implementation issues.

Fig 8: Figure of monitoring unit

Reset button

In the event of a malfunction or freeze, you can restart a device or system by pressing the reset button, which is a hardware or software mechanism. You can start the process of resetting the device by pressing the reset button. It is akin to turning the MCU on and off to press the reset button. This only resets the microcontroller's program to its initial state, stopping all running processes. It will not get rid of the software.

Your personal data and the majority of Windows settings are preserved when you reset your computer, allowing you to complete a clean reinstallation and update of Windows. The performance,

security, surfing experience, and battery life of your device may all be enhanced by a clean installation in some circumstances.

Fig 9: Figure of Reset button

Light-emitting diode (LED):

The light-emitting diode (LED) is the most energy-efficient and rapidly developing lighting technology available today. Compared to other lighting options, quality LED light bulbs last longer, are more durable, and offer comparable or better light quality. LED is a highly energy-efficient lighting technology, and it has the potential to drastically alter the way that lighting is done in the US in the future. Residential LEDs, especially those with ENERGY STAR ratings, use at least 75% less energy and can last up to 25 times longer than incandescent lighting. The adoption of LED lighting can have a significant impact on energy savings in the US since most lighting installations will likely be powered by LED technology by 2035. The annual energy savings from LED lighting could surpass 569 TWh by 2035, which is equivalent to the annual energy output of more than 92 1,000 MW of power plants.

Fig 10: Figure of Light-emitting diode (LED)

SOFTWARE REQUIREMENTS

- Arduino ide
- Embedded c

Software Description

Arduino IDE:

The Arduino IDE is an easy-to-use, uncomplicated programming environment. The application makes it simpler to create websites and apps because to its community-driven structure and straightforward interface. Utilizing software that is suitable for beginners does not require any technological expertise. People need to attend years of schooling to learn even simple ideas before they can code. The Arduino IDE facilitates practice of newly acquired information and provides access to a strong community of software developers and other professionals, in contrast to Euphoria, Visual Studio, and Atom.

The coding program has several templates to help novice programmers. When creating apps, this can be really beneficial. Every template is appropriate for a certain purpose or scenario. Certain themes support simple codes that you can utilize to generate more complex codes, such as Blink and KeyboardLogout. Using templates might be useful when writing codes with related functions or when adding straightforward codes to algorithms with several functions.Writing code and uploading it to the board offline is made simple by the Arduino Software (IDE). For people with a bad or non-existent internet connection, we suggest it. Any Arduino board can be used with this software. The Arduino IDE is now available in two versions: IDE 1.

Fig 11: Figure of Arduino IDE

Embedded C

The most widely used programming language in the software industry for creating electronic devices is embedded C. Every electronic system processor has an embedded software component. Embedded C programming is essential to the processor's ability to carry out particular tasks. We utilize a variety of technological equipment on a daily basis, including digital cameras, washing machines, and cell phones. Every gadget in use is powered by an embedded C microcontroller that is coded. A programming language is a grouping of one or more functions. A function is a collection of statements used to carry out a certain activity.

There are fundamental components and grammatical principles in every language. Programming in the C language is intended to work with variables, character sets, data kinds, keywords, expressions, and other elements. Embedded C programming language is the name of the C language extension. Every kind of operating system has a different microcontroller programming. While there are other operating systems available, including Windows, Linux, and RTOS, there are a number of advantages with RTOS for embedded system development.

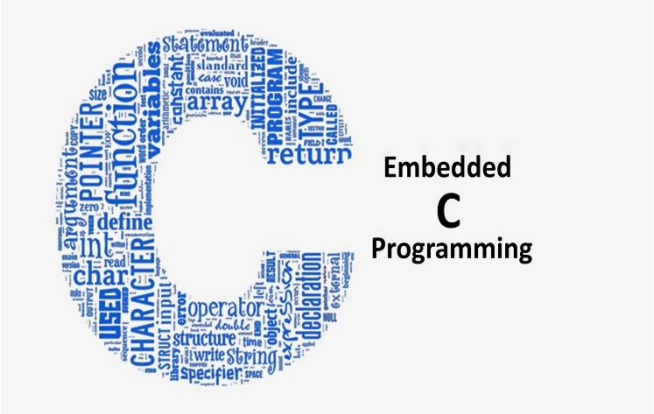

Fig 12: Figure of Embedded C

CONCLUSION

This project focuses on the IOT's networking and connectivity in the age of smart city progress.This system uses an ATMEGA328P Microcontroller unit in the embedded system domain to create and implement an energy consumption calculation based on the counting of calibration pulses. In the proposed work, an IOT and MMC based meter reading system is designed to prevent billing errors, eliminate human intervention, and continuously monitor the meter reading. The service provider can also disconnect the power source whenever a customer fails to pay the monthly bill. The following goals have been met by the project: simplicity of information availability for consumers via IOT from energy meters. Real-time theft detection at the consumer's end. Temperature and energy consumption units are displayed on LCD. The distant server's service is being disconnected.

REFERENCES

[1] G. -L. Huang, A. Anwar, S. W. Loke, A. Zaslavsky and J. Choi, "IoT-based Analysis for Smart Energy Management," 2022 IEEE 95th Vehicular Technology Conference: (VTC2022-Spring), Helsinki, Finland, 2022, pp. 1-5, doi: 10.1109/VTC2022-Spring54318.2022.9860601.

[2] A. I. R. Fernando and M. D. R. Perera, "Smart electricity monitoring and analysing an IoT system with a mobile application," 2020 International Research Conference on Smart Computing and Systems Engineering (SCSE), Colombo, Sri Lanka, 2020, pp. 75-81, doi: 10.1109/SCSE49731.2020.9312999.

[3] M. U. Saleem, M. R. Usman and M. Shakir, "Design, Implementation, and Deployment of an IoT Based Smart Energy Management System," in IEEE Access, vol. 9, pp. 59649-59664, 2021, doi: 10.1109/ACCESS.2021.3070960.

[4] M. A. H. S. Midul, S. H. Pranta, A. S. I. Biddut, S. I. Siam, M. R. Hazari and M. A. Mannan, "Design and Implementation of IoT-Based Smart Energy Meter to Augment Residential Energy Consumption," 2023 3rd International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST), Dhaka, Bangladesh, 2023, pp. 106-110, doi: 10.1109/ICREST57604.2023.10070068.

[5] Krishna Mishra Vidhanchal college Rewa MP Shreya Goyal Vinay AnandTikkiwalArun Kumar National Institute of Technology Rourkela "An IoT Based Smart Energy Management System" December 2018 DOI:10.1109/CCAA.2018.8777547 Conference: 2018 4th International Conference on Computing Communication and Automation (ICCCA).

[6] A.U. Rehman, Z. Wadud, R.M. Elavarasan, G. Hafeez, I. Khan, Z. Shafiq, H.H AlhelouAn optimal power usage scheduling in a smart grid integrated with renewable energy sources for energy management IEEE Access, 9 (2021), pp. 84619-84638 View at publisher CrossrefView in ScopusGoogle Scholar

[7] J.J. Moreno Escobar, O. Morales Matamoros, R. Tejeida Padilla, I. Lina Reyes, H. Quintana Espinosa A comprehensive review on smart grids: challenges and opportunities Sensors, 21 (21) (2021), p. 6978 View at publisherCrossrefGoogle Scholar

[8] A. Hasankhani, S. Mehdi Hakimi, M. Shafie-khah, H. Asadolahi“ Blockchain technology in the future smart grids: a comprehensive review and frameworks ,” Int. J. Electr. Power Energy Syst., 129 (2021/07/01/2021), Article 106811 View PDF View articleView in ScopusGoogle Scholar

[9] C. Perera, A. Zaslavsky, P. Christen, D. Georgakopoulos Context aware computing for the internet of things: a survey IEEE Communications Surveys & Tutorials, 16 (1) (2014), pp. 414-454 View in ScopusGoogle Scholar

[10] S. Sharda, M. Singh, K. Sharma “ Demand side management through load shifting in IoT based HEMS: overview, challenges and opportunities ,” Sustain. Cities Soc., 65 (2021), Article 102517 View PDF View articleView in ScopusGoogle Scholar

[11] A. Prasanth, S. Jayachitra “ A novel multi-objective optimization strategy for enhancing quality of service in IoT-enabled WSN applications ,” Peer-to-Peer Networking and Applications, 13 (6) (2020), pp. 1905-1920 CrossrefView in ScopusGoogle Scholar

[12] S.E. Ahmadi, N. Rezaei, H. Khayyam “ Energy management system of networked microgrids through optimal reliability-oriented day-ahead self-healing scheduling ,” Sustainable Energy, Grids and Networks, 23 (2020), Article 100387 View PDF View articleView in ScopusGoogle Scholar

[13] S.K. Rathor, D. Saxena “ Energy management system for smart grid: an overview and key issues ,” Int. J. Energy Res., 44 (6) (2020), pp. 4067-4109, 10.1002/er.4883 View in ScopusGoogle Scholar

[14] G. Alves, D. Marques, I. Silva, L.A. Guedes, M.G. Silva A methodology for dependability evaluation of smart grids Energies, 12 (9) (2019), pp. 1-23 CrossrefGoogle Scholar

[15] E. Baneshi, H. Kolahduzloo, J. Ebrahimi, M. Mahmoudian, E. Pouresmaeil, E.M.G. Rodrigues Coordinated power sharing in islanding microgrids for parallel distributed generations Electronics, 9 (11) (2020), pp. 1-16 View in ScopusGoogle Scholar

[16] H. Mehrjerdi Peer-to-peer Home Energy Management Incorporating Hydrogen Storage System and Solar Generating Units Renew. Energy (2020) Google Scholar

[17] F. Terroso-Saenz, A. González-Vidal, A. Ramallo-González, A. Skarmeta An open IoT platform for the management and analysis of energy data Future Generat. Comput. Syst., 92 (Mar. 2020), pp. 1066-1079 Google Scholar

[18] A. Jafari, T. Khalili, H.G. Ganjehlou, A. Bidram“ Optimal integration of renewable energy sources, diesel generators, and demand response program from pollution, financial, and reliability viewpoints: a multi-objective approach ,” J. Clean. Prod., 247 (2020), Article 119100 View PDF View articleView in ScopusGoogle Scholar

[19] Karthick T. Ragunthar, P. Ashok, N. Gopinath, M. Subashini A strong reinforcement parallel implementation of k-means algorithm using message passing interface Mater Today Proc, 46 (2021), pp. 3799-3802 View in ScopusGoogle Scholar

[20] M. Wei, S. Hong, M. Alam An IoT-based energy-management platform for industrial facilities Appl. Energy, 164 (Feb. 2020), pp. 607-619