OPEN ACCESS
Global Journal of Research in Engineering & Computer Sciences
ISSN: 2583-2727 (Online)
Volume 04| Issue 05 | Sept.-Oct. | 2024
Journal homepage: https://gjrpublication.com/gjrecs/
Review Article

Overcoming Facility Management Challenges using IoT-Based Smart Energy Management Systems

* Isa Ali Ibrahim [1], Muhammad Ahmad Baballe [2]

[1]School of Information and Communications Technology, Federal University of Technology Owerri, Imo State, Nigeria.
https://orcid.org/0000-0002-1418-9911
[2]Department of Mechatronics Engineering, Nigerian Defence Academy (NDA), Kaduna, Nigeria.
https://orcid.org/0000-0001-9441-7023
DOI: 10.5281/zenodo.13823585 **Submission Date:** 10 Aug. 2024 | **Published Date:** 21 Sept. 2024

***Corresponding author:** Isa Ali Ibrahim
School of Information and Communications Technology, Federal University of Technology Owerri, Imo State, Nigeria.
ORCID: 0000-0002-1418-9911

Abstract
This Study explores the crucial role of energy-efficient power management and monitoring systems in reducing energy costs using the internet of things (IoT). These systems provide real-time feedback on operating procedures, optimise energy usage, and detect excessive consumption due to equipment failures or poor maintenance. This is essential as the cost of energy is becoming more expensive in many countries. By visualising energy consumption trends and forecasting future demand, businesses can make informed decisions. This research addresses common challenges in facility management and offers practical solutions, highlighting the importance of autonomous energy monitoring in achieving sustainable energy management.

Keywords: *IoT, Energy Management Solution, Challenges, Remote Terminal Unit, Multifunction Meter.*

I. INTRODUCTION
Power management and monitoring systems are actually energy-efficient methods that usually aid the power managers by providing comments on different operating practices and the inferences of the power management systems. They likewise mentor on the level of energy usage that is expected in a particular period of time. These management systems likewise provide information in advance regarding excess energy consumption due to malfunctioning of equipment or lack of effective maintenance. The purpose of power management systems is to support business managers in detecting surplus usage of energy, predicting the inclination in consumption of energy by envisioning it and calculating the usage of power in the future. An independent energy monitoring system is a part of energy management, which is an endless process. As a first step, the area, for example, plant area, office building, process steps, etc., for which energy conservation measures are required should be identified and a basic model must be built for that area. Process steps can also be considered as a field for energy conservation measures to professionally use energy. As a next step, the energy in the existing situation is measured and monitored, which will result in the creation of a basic archetypal. The basic prototypical can be constructed either with the aid of historical information about energy that is consumed or from the standard information given by the manufacturers. After creating the basic archetypal, we can implement the program of energy conservation measures. By this way, we can improve the effectiveness of the power utilisation of the system and likewise replace devices that consume high energy. Once this energy conservation measure program is implemented, then from the results of the program, we can actually compare between the basic prototypical and actual energy usage [1].

II. LITERATURE REVIEW
This research aims to deliver the methods involved in the control of load in industry during heavy traffic with the aid of programmable logic controllers (PLC). Furthermore, it likewise clarifies the use of monitoring all the load parameters of the motor on a personal computer (PC). In the considered paper, we have implemented the multifunction meter (MFM) to PLC communication with Modbus Remote Terminal Unit (RTU) communication; direct values from the MFM are taken as feedback to the PLC. Firstly, constant current values for a single load are taken into consideration, and if any higher

load is being applied to the current load, the difference in amps rating is taken as reference and the extra load gets tripped at the same time power is managed. With the aid of energy meters, voltage and ampere ratings are constantly observed. If differences in loads are observed rather than any pre-defined load, alarms occur in Supervisory Control and Data Acquisition (SCADA) and power and energy are managed [1]. In this research, we discuss how we remotely monitor and control the home power management system through the cloud using any Internet-enabled device as a remote controller, even when we are not in the vicinity of the house [2]. In this paper, by applying Message Queuing Telemetry Transport (MQTT), an Internet of Things (IoT) standard protocol, to the Zigbee network environment, MQTT performs the role without adding a separate gateway and automatically controls power and standby power through weight-based usage pattern analysis. As a result of comparing and evaluating the implemented system with previous studies, it was confirmed that the average power consumption was reduced by about 3.25% and the average standby power consumption by 13.06% [3]. In this paper, an algorithm for removing the features of home appliances and automatically building a database to identify home appliances is designed and presented. For the verification, a software library supporting this algorithm has been implemented and added to a power management system server, which has already been executed to support real-time monitoring of home appliances' power consumption status and control their power. The executed system consists of a system server and clients, each of which measures the power consumed by a home appliance plugged into it and transmits the information to the server in real-time over a wireless network. Through experiments, it is verified that it is possible to identify any home appliance connected to a specific client [4]. This paper describes a system that combines mechanisms for home appliance protection and management. The proposed system is centrally managed by a microcontroller with a liquid crystal display (LCD) interface and a push button for user management. Voltage limits and power consumption by loads are regulated by the system, making it very suitable for home use. The software module driving the microcontroller was implemented using the C programming language. The power management system allows users to create ON/OFF schedules and other user-defined requirements [5]. This study presents the feasibility study of home appliances to be applied for appliance to grid mode of operation. The analysis includes topology and control modifications to support the concept of a supportive platform provided by smart homes and smart grid. Home appliances are then proposed as new distributed reactive sources, which are utilised to resolve the issue of voltage regulation as well as produce reactive power locally for voltage stability. This study discusses the technical transitions in current home appliances to accommodate auxiliary functionality of grid reactive power support (RPS) and how it can fit into the home energy management system architecture to provide the required RPS [6]. In this research, we primarily focus on the design and implementation of a GSM-based household power management system to remotely control at most ten home appliances through a mobile phone connected to an automated device's microcontroller using wireless technology. This developed system allows the user to start or stop appliances from afar and sends back a message to familiarise the user with the status (ON/OFF) of all the devices under consideration. Thus, from the design and implementation of the GSM based household power management system, users can control their household appliances outside their abodes using mobile phones, manage their power consumption and prevent unauthorized individuals from controlling their appliances [7].

III. SMART ENERGY MANAGEMENT SOLUTIONS FOR FACILITY MANAGEMENT CHALLENGESS

1. Inefficient sources of reliable data collection

When it comes to optimising the energy consumption of buildings and facilities, energy data plays a major role. unfortunately, a lot of commercial, residential, and industrial buildings don't even come close to gathering trustworthy statistics on energy usage. They rely on manually collected data from meters and a conventional building management system. Ultimately, it turns out to be unnecessary and counterproductive since it doesn't offer any trustworthy information regarding patterns of energy consumption, wasting the facilities' resources and time.

Installing an Internet of Things (IoT)-based energy management system (EMS) is the best way to address this problem. The critical energy data can be automatically gathered and consolidated into a centralised platform by this solution. What is the final outcome? In order to provide the best possible results for energy consumption, it improves the real estate and facility management sectors' accessibility, convenience, and decision-making capacity.

2. Unnecessary wastage of energy

Today, energy waste is a problem that all companies must deal with. Facility and real estate management is not an exception! What is the cause of this? Inadequate maintenance, incorrect configurations, and malfunctioning systems! They don't provide efficient energy usage patterns or dependability. Not only that, but this malfunctioning equipment can malfunction at any time, leading building managers to wonder, what went wrong? By the time they arrange routine checks, they have already lost a great deal of time, effort, and money.

Timely adoption of intelligent energy solutions is preferable. The robust and Internet of Things (IoT)-based energy management system (EMS) collects real-time data on energy use in various building sections while reducing the possibility of human mistake.

Real estate managers are thus able to tackle the problem of energy waste. They are able to manage building interruptions and make proactive decisions about where to allocate energy. When building managers implement IoT-based EMS, there will be no more unplanned equipment failures or energy waste. Ultimately, it establishes energy KPIs for reliable and long-lasting outcomes.

3. No plan for energy upgrading projects

These days, it's imperative that the facilities management and real estate industries have sincere initiatives that advance the concept of energy efficiency. When purchasing a building, new age audiences also take this into account.

Many facilities lack the detailed energy data necessary to verify this requirement. As a result, their sources of energy consumption become unstable. The moment has come for them to fund energy-related upgrades or retrofits that provide a higher return on investment (ROI).

A real-time energy management solution can quantify potential savings in a project. At the same time, they can verify the impact of the energy decisions they have made so far. In the end, it allows them to quickly increase the scale of the project they are interested in.

4. Too much time consumption in energy reporting Facilities managers have important duties to do. That includes reporting on energy use and trends. It is expected of them to report on the actions they have taken to promote energy efficiency. Producing energy reports is a difficult operation that demands solid research, data integrity, and a defined benchmark.

With EMS, there's not much work required. It can automatically produce energy reports on a regular basis, which will increase team productivity. Not only that, but they may also share the energy report with management after customising it to guarantee optimal outcomes. As the activities grow in size, this clever technology shows to be quite beneficial.

Building managers have a better long-term likelihood of success when they match the policies with the comfort of the residents.

5. Sudden equipment breakdown

By ensuring that maintenance is done when it is required, a proactive maintenance strategy that incorporates routine and preventive maintenance schedules will help to extend the lifespan of assets. The implementation of preventive maintenance doesn't have to be costly or difficult. If you have a good plan in place, you won't need to depend on reactive maintenance.

IV. COMPONENTS USED IN THE IMPLEMENTATION OF THE POWER MANAGEMENT AND MONITORING SYSTEM

1. Programmable Logic Controller: The most frequently used digital computer in industrial mechanical processes for automation is the Programmable Logic Controller (PLC). The PLC finds its applications in processes like the controlling of machines on assembly lines, amusement rides, etc. The key purpose of the design of PLC is to be used in many industries and machines for both analog and digital inputs and outputs. The features of the PLC are that it can be operated in extreme temperature ranges and is not affected by any electrical noises.

2. Multifunction Energy Meters: They are used for monitoring electrical installations. The Multifunction energy meter is used to monitor and measure all the electrical parameters such as active power, voltage, apparent power, current, power factor, reactive power, active energy, phase angle and so on.

3. The remote terminal unit (RTU): This is a microprocessor-based electronic device used in industrial control systems (ICS) to connect various hardware to distributed control systems (DCS) or supervisory control and data acquisition (SCADA). The RTUs pass sensor information from input streams in control loops to an output stream to be forwarded on to centralized control in an ICS. The RTUs automatically negotiate connections to either local or remote controls. The RTUs monitor both digital and analog field information. The RTU gets the information from sensors monitoring target industrial process variables and then forwards that information onto centralised monitoring and control. The hardware of the RTU contains the setup software required to connect information output streams, communication protocols, and built-in troubleshooting. The devices are often powered by alternative current (AC) mains with direct current (DC) converters and sometimes battery backup.

4. The supervisory control and data acquisition (SCADA): SCADA Systems are vital for industrial organisations since they help to maintain efficiency, process information for smarter decisions, and communicate system issues to help mitigate downtime. The basic SCADA architecture begins with programmable logic controllers (PLCs) or remote terminal units (RTUs). The PLCs and RTUs are microcomputers that communicate with an array of objects such as factory HMLs, machines, sensors, and end devices, and then route the data from those objects to computers with SCADA software. The SCADA software processes, distributes, and displays the information, helping operators and other employees analyse the information and make significant decisions. For instance, the SCADA system quickly informs an operator that a batch of products is showing a high incidence of errors. The operator pauses the operation and views the SCADA system information through an HMI to determine the cause of the issue. The operator reviews the information and discovers that Machine 4 was malfunctioning. The SCADA system's ability to inform the operator of an issue aids him to resolve it and prevent further loss of product.

V. ENERGY MANAGEMENT SYSTEMS IMPACTS

1. Cost Reduction: The major reimbursements of implementing a facilities management system are the reduction in operational costs such as cooling, heating, lighting, and water services. The energy management aids incessantly tracking

your energy usage over a period of time and storing this information so you can have constant access to your building's historical energy performance, allowing you to make calculated cost predictions on future usage. As many businesses across industries have struggled to adapt to the cost implications caused by the COVID-19 pandemic, one way to reduce your current operational costs is through energy management, with studies showing businesses can save up to almost 39.8% on average costs over a twelve-month period.

2. Lowered Carbon Footprint: The carbon footprint of your property is the total amount of greenhouse gases generated by our actions and is directly linked to the energy that it consumes. Having a system in place to continuously measure and control this can aid in highlighting deficiencies in your energy system that can be improved upon to lessen your environmental impact. According to the International Energy Agency (IEA), the building and construction industries are responsible for about 29.8% of global energy usage and almost 39.9% of overall carbon emissions. As many governments around the world are considering how to reduce overall emissions, energy-reduction strategies will be more important than ever, with studies showing how smart energy controls such as Energy Management Systems can reduce worldwide buildings' energy consumption by 10% by 2039.

3. Enhanced Productivity and Wellbeing: An additional major aspect of energy management (EMS) is the ability to control every aspect of your building's energy performance, such as HVAC and lighting, enabling you to create a comfortable working environment for staff. 60% of the workers are said to be disappointed with the temperature and lighting control within an office environment, which has had negative effects on the overall productivity, with at least 89.9% of the employees affected over a twelve-month period. As mentioned earlier, an energy management system will help reduce your building's carbon footprint through the employment of energy-efficient measures. Globally, as more and more people are becoming more environmentally mindful, improving your building's energy management is a more modern method of improving your employee gratification.

4. Return-on-Investment: Energy management systems (EMS) frequently include built-in cost-saving features such as emitting less power during peak periods, offering revenue-generating programs, and detecting potential energy leaks. alone will help you see an almost immediate return on investment after the initial installation cost of an EMS. It is imperative to highlight that businesses and property owners who implement systems that are customized for their unique building needs to improve ROI as each premise has different requirements. For instance, healthcare buildings such as hospitals may need increased energy usage over a sustained time period, whereas educational facilities such as schools may want more energy throughout the daytime period and less overnight.

5. Improved Brand Image: Implementing an Energy Management System (EMS) into your business and building can help improve the image of your brand to potential investors and other key stakeholders. Companies around the globe are highlighting what they are doing to make their practices more environmentally friendly, and introducing an Energy Management System (EMS) can be a good place to start. Making this change isn't just for big businesses, as increasing numbers of small and medium-sized companies are starting to recognise the advantages of implementing energy savings procedures. People are now looking to be involved with companies that are doing their part for the planet, which is why these businesses see annual growth of 15% compared to their competitors [8].

V. CONCLUSION

This review study suggests a method that tracks how much energy is used across various plant divisions. SCADA keeps track of the real energy used and also does a comparison. Energy waste is assessed and compared to the regular requirements for energy usage. The suggested system has the ability to sound an alert in an emergency. The energy management system's influence is also covered [10].

REFERENCES

1. K. Ganesan, N. V. A. Grace, P. A. S. Dhas, "Auto Power Management System", Turkish Journal of Computer and Mathematics Education Vol.12, No.12, pp. 804-809, 2021.
2. Maiti, S. Sivanesan, "Controlling and Monitoring of Home Power Management Systems through Public Cloud Services", pp. 1-6, s publication at: https://www.researchgate.net/publication/299447247.
3. Y. Jang, S. Lee, "Design and Implementation of MQTT-based Power Management System through Analysis of Home Appliance Usage Patterns" Journal of Next-generation Convergence Information Services Technology, Vol.9, No.4, pp.363-375, http://dx.doi.org/10.29056/jncist, 2020.
4. S. Hong, K. Choi, J. Hong, "Design for Automatic Building of a Device Database and Device Identification Algorithm in Power Management System", Journal of Korean Institute of Intelligent Systems, Vol. 24, No. 4, pp. 403-411 http://dx.doi.org/10.5391/JKIIS, pp. 403-411, August 2014.
5. O. O. Basorun, "Home Appliances Power Management System Journal of Advancement in Engineering and Technology, Journal homepage: http://scienceq.org/Journals/JAET.php, Vol. 3, No. 3, pp. 1-3, 15 September 2015.
6. S. Gautam, D. D. Lu, W. Xiao, Y. Lu, "Realisation of RPS from electrical home appliances in a smart home energy management system" IET Smart Grid, e http://creativecommons.org/licenses/, Vol. 3, No. 1, pp. 11-21, 2020.
7. M. Young, the Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.
8. https://lawlerconsulting.com/5-benefits-of-an-energy-management-system/.
9. https://zenatix.com/top-5-energy-management-challenges-of-the-real-estate-and-facility-managers/.

10. Aliyu H. M., Ibrahim U. T., Abdu Isah, A. Sani M., Adamu Bello, & Muhammad A. Baballe. (2022). The Impact of the Energy Management and Monitoring System. Global Journal of Research in Engineering & Computer Sciences, 2(4), 14– 18. https://doi.org/10.5281/zenodo.7059951.

CITATION
Isa A.I., & Muhammad A. B. (2024). Overcoming Facility Management Challenges using IoT-Based Smart Energy Management Systems. In Global Journal of Research in Engineering & Computer Sciences (Vol. 4, Number 5, pp. 95–99). https://doi.org/10.5281/zenodo.13823585