Type of contribution:
→ •Editorial
•Research Paper
•Case Study
•Review Paper
•Scientific Data
•Tech. Promotion
•Case Opinion
•Short Communication

JURNAL PENGABDIAN DAN PENGEMBANGAN MASYARAKAT
DHARMAKAYANA
Journal of scientists, engineers, educators and scientific activists related to society development
Published by :
Mechanical Engineering-Universitas Bengkulu
Jalan W.R. Supratman, Kota Bengkulu 38371 A, Bengkulu, Indonesia
dharmakayana@unib.ac.id
https://ejournal.unib.ac.id/dharmakayana

Leveraging Smart Energy Meters for Precise Electricity Consumption Monitoring in Healthcare Facilities

(Rumah Sakit Tiara Sella, Kota Bengkulu, Provinsi Bengkulu)

Novalio Daratha[*1], Hendy Santosa[1], Dedi Suryadi[2], Aji Arya Dewangga[1], Adhadi Kurniawan[1], Arie Vatresia[3], Firtrianty Wardhani[4]

[1]*Electrical Engineering Department, Bengkulu University, 38371, Indonesia*
[2] *Mechanical Engineering Department, Bengkulu University, 38371, Indonesia*
[3] *Informatics Engineering Department, Bengkulu University, 38371, Indonesia*
[4] *Architecture Department, Bengkulu University, 38371, Indonesia*
[*]Corresponding Author: ndaratha@unib.ac.id

This article contributes to:
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
SUSTAINABLE DEVELOPMENT GOALS

Highlights:
1. The radiology unit is a unique unit because it requires a relatively large power requirement, namely 75 kVA which comes from the CT-Scan tool
2. The technology applied in this community service activity is the Smart Energy Meter
3. The results of measurements are saved in local SD Card and uploaded to a server.

Article info Submitted: 2025-05-09
Revised: 2025-05-13
Accepted: 2025-05-31

How to cite:
Daratha N. (2025). Leveraging Smart Energy Meters for Precise Electricity Consumption Monitoring in Healthcare Facilities

Abstract

The creation, transmission, distribution, and consumption of electrical energy are the first steps in the provision of electrical energy. The efforts that are made to conserve energy need to be continuously improved to supply electricity that is affordable. In order to conserve energy, it is necessary to have the backing of technology, laws, and legislation, in addition to applying behavioral discipline to those who utilize energy. To put it simply, a smart energy meter is one of the fundamental components of conservation technology. At the moment, the bulk of PLN's 67.6 million clients make use of traditional energy meters that are powered by electromechanical technology. The measuring device has not been incorporated with the technology that is associated with the internet of things (IoT). On the other hand, electronic items like televisions, washing machines, and air conditioners have started to adopt the Internet of Things and become smart devices. The integration of smart gadgets and smart meters enables the creation of an energy management system that can be used to the consumption and distribution of electricity in residential or commercial facilities. At Tiara Sella Hospital, which has a high monthly

(Rumah Sakit Tiara Sella, Kota Bengkulu, Provinsi Bengkulu): Dharmakayana, 2(1), 16-22.

Publisher: *Unib Press*

energy consumption, this community service project was carried out in order to measure the optimization of energy use and to determine opportunities for improvement. It is believed that the installation of this energy meter would result in improved and more reliable methods of measuring and estimating the amount of energy that is utilized within the hospital setting, which will allow for more sustainable optimization efforts.

Keywords: *Hospital Energy Consumption, Radiology Unit, Smart Energy Meter, IoT, PLN, Energy*

1. Introduction

Among the public facilities that have very high requirements for electrical energy, hospitals are among the most significant (Walters et al., 2024; Woernle et al., 2024). In order to achieve this high level of energy consumption, a variety of medical gadgets, lighting systems, air conditioning systems, and other supporting devices that are operational virtually continuously are responsible. It is possible for inefficient management of energy use to result in the waste of energy as well as a large increase in operational costs. It is therefore necessary to find a solution in order to efficiently monitor and manage the amount of electrical energy that is consumed in hospitals (Chodorowski et al., 2024; Heye et al., 2020, 2023). The smart energy meter is one example of a device that may be utilized to monitor the amount of electrical energy that is consumed. Through the provision of precise data on the consumption of electricity, this tools makes it possible to manage energy in real time. The information that is collected from the smart energy meter can assist the management of the hospital in making the appropriate decisions in order to decrease the amount of energy that is consumed, limit the possibility of waste, and improve operational efficiency. As one of the private hospitals that is experiencing continued expansion, Tiara Sella Hospital Bengkulu is an organization that is dedicated to enhancing energy efficiency as a component of its efforts to promote sustainability. However, as of this moment, the hospital does not own a system that is capable of monitoring the usage of electrical energy in a manner that is integrated. In light of this, it is challenging to analyze patterns of energy consumption and to identify management solutions that are most effective.

Tiara Sella Hospital Bengkulu will use Smart Energy Meter as a means of monitoring the amount of electricity that is consumed. With the installation of this technology, it is anticipated that the administration of the hospital will be able to obtain data regarding the utilization of power in a manner that is open, accurate, and in real time. This program may includes training for hospital staff to learn how to read data from the device and devise methods for saving energy based on the analysis of the data acquired from the device. Therefore, this service not only helps to improve the operational efficiency of the hospital, but it also adds to the efforts that are being made to lessen the negative effects that human activity has on the environment by making better use of energy. The worldwide commitment to sustainable development and responsible management of energy resources is maintained by this action, which is in keeping with the pledge.

2. Method

a. Design

The first phase involves the meticulous design of the equipment and system to be installed. This stage requires careful planning and coordination to ensure that the design aligns with the specific needs of the community. The design process includes evaluating the technical requirements, understanding the challenges faced by the community, and creating a solution that is both functional and sustainable. The design phase also involves consulting with local stakeholders to gather input, ensuring the final product meets both the practical and cultural needs of the community.

b. Purchase of Components

Once the design is finalized, the next step involves sourcing and purchasing the necessary components. This stage focuses on procuring high-quality materials and equipment to ensure the longevity and reliability of the system. Consideration is given to local availability, cost-effectiveness, and the environmental impact of the materials chosen. Collaborating with local suppliers helps reduce transportation costs and supports the local economy. Additionally, any specialized components that are not available locally are purchased and shipped in a timely manner to avoid delays.

c. Product Manufacturing

Following the procurement of materials, the product manufacturing phase begins. During this phase, the components are assembled, tested, and refined to create the final product. Skilled technicians and engineers oversee the assembly process, ensuring that all components are correctly integrated and functioning as intended. Prototypes may be developed to address any unforeseen challenges before full-scale production. Throughout the manufacturing process, quality control measures are implemented to ensure that the final product meets the required standards and specifications.

d. Installation

The installation phase involves the physical placement and setup of the equipment in the community. This process is carried out by a team of technicians who are trained in the specific installation procedures for the equipment. The installation includes connecting all systems, conducting safety checks, and ensuring that the equipment functions properly within the intended environment. Installation is typically accompanied by a thorough inspection to confirm that all safety guidelines are met and that the equipment integrates smoothly with existing infrastructure.

e. Training for Use

After installation, a training session is provided to local community members and technicians on how to use, maintain, and troubleshoot the newly installed equipment. This phase ensures that the community is fully equipped to operate the system independently and sustainably. The training program covers both basic and advanced functions of the equipment, offering practical demonstrations and hands-on experience. Additionally, local technicians are trained to provide ongoing maintenance and repair services to ensure that the equipment continues to function effectively over time.

Evaluation Process

The evaluation of the success of this community service activity is conducted in two stages. The first stage occurs immediately following the completion of the installation and training phases. At this point, the primary evaluation criteria focus on whether the equipment is installed correctly, is functioning as intended, and has been properly integrated into the community. Additionally, local technicians are assessed for their ability to monitor and maintain the equipment effectively. The second stage of the evaluation takes place at the end of the first month. During this phase, the equipment's performance is reviewed to ensure that it continues to operate without any issues. This stage also assesses the ability of the community to effectively use and maintain the equipment independently, ensuring that the system remains functional long-term. Any issues that arise during this evaluation are addressed, and additional support or adjustments are made as needed. For a more detailed overview of the community service activity evaluation framework, refer to Table 1, which outlines the specific criteria and timing for each evaluation stage.

Table 1. Evaluation Design

Stages	Milestones	Successful Indicators
Design	Design Document Availability	Design documents are available and ready to use.
Component Collections	Components have arrived as required	Shopping checklist.
Production	The components are well assembled and function properly.	Product passes initial testing.
Installation	The tool is installed and working. The tool is connected to the server.	Product installed.
Training	Technicians or operators can use the tool.	Tested technicians can use tools.

The evaluation and sustainability method of this program uses a collaborative approach to gain support and commitment in the maintenance and operation of the equipment. Once a month, the unib team can visit the Location to check the condition and collect data.

4. Result

The outcome of this community service initiative is the successful installation of a Smart Energy Meter at the designated location. This state-of-the-art tool has significantly enhanced the ability to monitor and analyze electricity consumption, providing detailed and real-time data on energy usage. The installation of the Smart Energy Meter represents a critical step towards improving the efficiency and sustainability of energy management at the location. The Smart Energy Meter delivers highly precise and granular data on electricity usage, which was previously difficult to track with traditional methods. This advanced technology allows for continuous, real-time monitoring of energy consumption patterns, giving a clearer picture of how and when electricity is being used throughout the day. With this detailed data, it is now possible to gain a deeper understanding of energy demand fluctuations, peak usage periods, and any inefficiencies in the current system.

Several key benefits have emerged from the installation of the Smart Energy Meter:

1. Accurate Electricity Consumption Analysis

   One of the primary advantages of the Smart Energy Meter is its ability to provide accurate and reliable data for electricity consumption analysis. By tracking energy usage with high precision, the tool enables more informed decision-making when it comes to managing production costs. The detailed consumption data can be used to identify areas of high energy expenditure, optimize operational efficiency, and calculate the actual cost of electricity for different processes or equipment. This helps businesses or organizations at the location to manage their budgets more effectively and reduce unnecessary energy expenses.
2. Designing a Solar Power System (PLTS)

   The information obtained from the Smart Energy Meter also plays a crucial role in planning and designing a Photovoltaic Solar Power System (PLTS) to meet the energy needs at the location. With accurate data on the daily and seasonal electricity consumption patterns, it becomes possible to design a customized solar power system that can generate sufficient energy to support the location's electricity demands. This data-driven approach ensures that the size and capacity of the solar panels, storage systems, and inverters are tailored to the specific needs of the location, promoting both energy independence and sustainability. Furthermore, by utilizing solar energy, the location can reduce reliance on the grid, lower electricity costs, and decrease its carbon footprint.
3. Long-term Impact

   In the long run, the Smart Energy Meter not only provides immediate benefits in terms of energy monitoring but also serves as a foundational tool for ongoing energy management and optimization. It allows for periodic assessments of energy consumption, enabling continuous improvements to energy efficiency strategies. The combination of detailed usage data and the potential integration of renewable energy systems like PLTS contributes to a more sustainable and economically viable energy management system at the location.

Overall, the successful installation of the Smart Energy Meter has empowered the location with the tools needed to make data-driven decisions about energy consumption and sustainability. This project serves as an important step toward achieving greater energy efficiency, reducing operational costs, and enhancing the potential for renewable energy solutions.

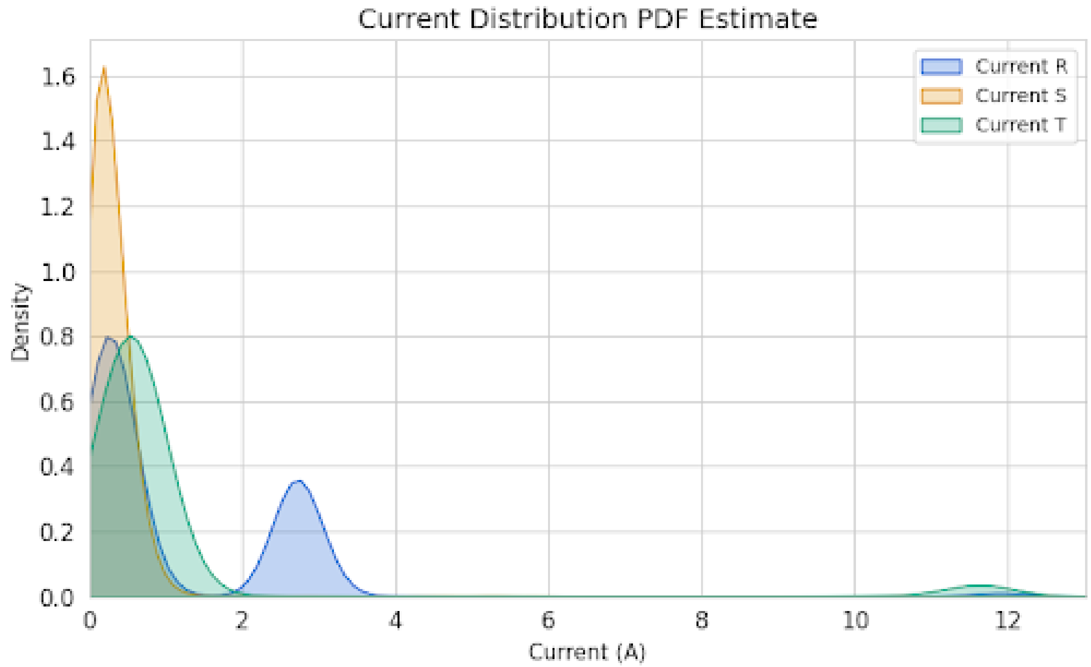

Figure 1. Reading Result for Assessment.

The team successfully installed the device at the location so that they obtained the current reading results as shown in Figure 1. The image shows the probability density function of the current in the R, S and T phases. One can see that the current is unbalanced between the three phases. The current in the S phase has one peak with an average value of approximately 0.25 A. The current in the R phase has two peaks at 0.25 A and 3 A respectively. Finally, the current in the T phase has two peaks at around 0.5 A and 11.5 A. In conclusion, we found many significant current unbalance events at the measurement location.

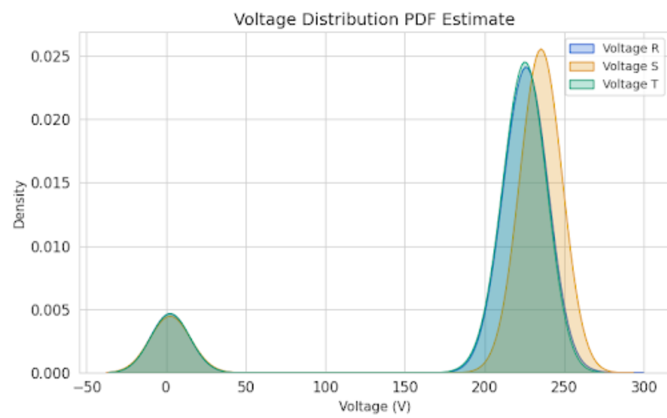

Figure 2 (a). Voltage Distribution Estimate

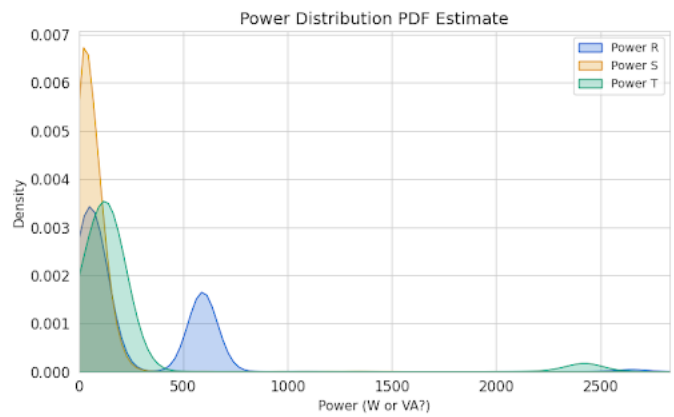

Figure 2 (b). Power Distribution Estimate

Then, the pdf of the measured voltage is shown in Figure 2(a). The figure shows the voltages at phase R, S and T have peaks around 0 V and 220 Volts. In general, one can see that phase S has the highest voltage and phase T has the lowest voltage. Voltage unbalance is also seen but not as severe as the current unbalance. Then, Figure 2(b) shows that the power behavior is greatly influenced by the current behavior. The phase with the lowest power is S. The phase with the highest power is T. Similar to the current, one can see that there is a power imbalance between the three phases.

The summary of the description above is that the electricity consumption in the radiology room is unbalanced which is somewhat common in hospitals (Pandu et al., 2021). This certainly raises curiosity about the overall electricity consumption of the building. Referring to the related regulation, current imbalance does not have a specific threshold. So, there is no potential for violation of government regulations. On the other hand, current imbalance has been reported to have several negative effects. Its technical and economic effects need to be studied further. The results of measurement shows that most of the time the radiology unit consume almost zero power. Hence, there is a room for energy conservation using scheduling approach such as mixed Integer Programming (Heye et al., 2020, 2023; Javadi et al., 2023). We hope to explore these possibilities in future works.

5. Acknowledgements

Firstly, we would like to acknowledge the financial support from University of Bengkulu through contract number 6239/UN30.15/PM/2024.We would like to acknowledge the help and support provided by Tiara Sella Hospital management and employee in the process of this project. In particular, we would like to acknowledge the support from Hega Bernoza, Syella Ania, Bambang Ade Winata, Elfa Rianti, Seki Rupiandi, Deka and all staff in Radiology unit. In addition, we would like to thanks our four students i.e. Ahmad Kadafi Anom, Pajri Yusup, Roland Rafliwan, and Andre Ali Java Zulfikar.

References

Chodorowski, M., Ognard, J., Rovira, À., Gentric, J.-C., Bourhis, D., & Ben Salem, D. (2024). Energy consumption in MRI: Determinants and management options. *Journal of Neuroradiology*, *51*(2), 182–189. Scopus. https://doi.org/10.1016/j.neurad.2023.12.001

Heye, T., Knoerl, R., Wehrle, T., Mangold, D., Cerminara, A., Loser, M., Plumeyer, M., Degen, M., Lüthy, R., Brodbeck, D., & Merkle, E. (2020). The energy consumption of Radiology: Energy- And cost-saving opportunities for CT and MRI operation. *Radiology*, *295*(3), 593–605. Scopus. https://doi.org/10.1148/radiol.2020192084

Heye, T., Meyer, M. T., Merkle, E. M., & Vosshenrich, J. (2023). Turn It Off! A Simple Method to Save Energy and CO2 Emissions in a Hospital Setting with Focus on Radiology by Monitoring Nonproductive Energy-consuming Devices. *Radiology*, *307*(4). Scopus. https://doi.org/10.1148/radiol.230162

Javadi, A., Nezhad, A. E., Nardelli, P. H. J., & Sahoo, S. (2023). Energy Management System for Energy-intensive Radiology Appliances. In Leonowicz Z. (Ed.), *Proc. - IEEE Int. Conf. Environ. Electr. Eng. IEEE Ind. Commer. Power Syst. Europe, EEEIC / I CPS Europe*. Institute of Electrical and Electronics Engineers Inc.; Scopus. https://doi.org/10.1109/EEEIC/ICPSEurope57605.2023.10194628

Pandu, S. B., Sundarabalan, C. K., Srinath, N. S., Krishnan, T. S., Priya, G. S., Balasundar, C., Sharma, J., Soundarya, G., Siano, P., & Alhelou, H. H. (2021). Power Quality Enhancement in Sensitive Local Distribution Grid Using Interval Type-II Fuzzy Logic Controlled DSTATCOM. *IEEE Access*, *9*, 59888–59899. Scopus. https://doi.org/10.1109/ACCESS.2021.3072865

Walters, H., Bowden, K., & Limphaibool, N. (2024). Reducing the carbon footprint of radiology through automatic workstation shutdown protocols. *Clinical Radiology*, *79*(11), e1284–e1287. Scopus. https://doi.org/10.1016/j.crad.2024.07.022

Woernle, A., Moore, C. M., Allen, C., & Giganti, F. (2024). Footprints in the scan: Reducing

	the carbon footprint of diagnostic tools in urology. *Current Opinion in Urology*, *34*(5), 390–395. Scopus. https://doi.org/10.1097/MOU.0000000000001196