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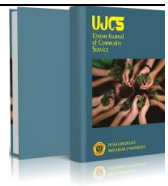

Integration of Microhydro Power Plant with Internet-Based Monitoring System for Energy Independent Villages

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Abstract: This community service activity aims to integrate Internet of Things (IoT) technology into the monitoring system of a Microhydro Power Plant (PLTMH) in Argamukti Village, Majalengka Regency. The village has significant renewable energy potential, but challenges in real-time energy production monitoring have hindered the plant's optimal performance. By implementing an IoT-based monitoring system, the operational efficiency of the PLTMH can be significantly improved. This program includes training in IoT device installation and guidance for local communities in operating and maintaining the system. The results show a 20% increase in energy production efficiency compared to the period before the monitoring system was implemented. Furthermore, the local community is empowered to manage energy resources independently, supporting the establishment of Energy Self-Sufficient Villages. This initiative aligns with government efforts to promote renewable energy usage in rural areas. The IoT technology implementation also opens opportunities for applications in other sectors such as smart farming and water management, which can sustainably enhance the local community's welfare.

Keywords: Microhydro; Internet of Things; Energy Management; Energy Self-Sufficient Village; Rural Development.

Introduction

Renewable energy is increasingly becoming a major focus in various sustainable development initiatives, especially in rural areas that have not been fully reached by conventional electricity networks. One form of renewable energy that has great potential in Indonesia is Microhydro Power Plant (MHP) (Nugroho & Sunaryo, 2014). MHP is a clean energy source that can be used independently by village communities, especially in areas that have river flow with stable water discharge (Sumirat et al., 2018).

Argamukti Village, Argapura Sub-district, Majalengka Regency, is one of the villages that has great potential in the utilisation of micro-hydro energy. However, the main challenge faced is the lack of an efficient monitoring system in the management of electrical energy production. The inability to monitor electricity production in real-time leads to low operational efficiency and potentially disrupted electricity supply (Murtadlo, 2016). In addition, the lack of public awareness of renewable energy technology is also a barrier to its implementation (Alatas et al., 2021).

In recent years, the government has encouraged the use of renewable energy to reduce dependence on fossil fuels that are running out (Ilham, 2024). One of the efforts made is the application of digital technology such as the Internet of Things (IoT) in renewable energy monitoring systems (Limanseto, 2024). This technology allows real-time monitoring and data analysis, so that energy management can be carried out more efficiently and responsively to changing needs (Kurniadi Wardana et al., 2023). With this technology, operators can perform predictive maintenance that reduces the potential for

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equipment damage due to late maintenance (Hamidi Rahmat, 2024).

In addition, community adaptation to the use of new technology is also a determining factor for the success of IoT implementation in MHP systems (Paramita, 2024). Training and education are crucial steps in improving the community's understanding of the benefits and how to use the technology. Thus, the sustainability of the programme can be ensured, and villagers can independently manage their energy resources (RI, 2008).

In addition to technical aspects, economic factors are also an important consideration in the development of MHP. Based on research conducted by Nugroho & Sunaryo (2014), the implementation of MHP can reduce the village's dependence on fossil fuels whose prices fluctuate. By utilising micro-hydro energy, the operational costs of households and small and medium enterprises can be reduced, thus encouraging local economic growth.

Furthermore, the success of renewable energy programmes such as MHP is also highly dependent on policy support from local and central governments (Hamidi Rahmat, 2024). Regulations that support the development and maintenance of community-based energy will accelerate the transformation of villages towards energy independence. Some regions have implemented incentive policies for villages that develop renewable energy, such as subsidising equipment and technical training for communities. This step is important to ensure that villages with renewable energy potential can develop sustainably.

To overcome these challenges, IoT technology is applied in the MHP monitoring system in Argamukti Village. With the implementation of IoT, monitoring of energy production can be done in real-time, thus enabling faster repair and optimisation. In addition, the application of this technology also aims to increase community empowerment in managing energy independently, which in turn can support the Energy Independent Village programme (Paramita, 2024). With this approach, Argamukti Village is expected to become a pilot model in the application of digital technology-based renewable energy in Indonesia.

Method

This activity was held on September 21, 2024, in Argamukti Village. There were more than 36 participants including village officials and members of the "Canghegar" Forest Farmers Group. The method used was technical training on the IoT system, hardware installation, and assistance in the operation of the MHP monitoring system. This training focused on improving the community's skills in using new technology and maintaining the MHP that has been integrated with IoT. The methods used in this activity are as follows:

1. Initial Socialization and IoT Introduction: The activity began with socialization to the community regarding the basic concepts of Internet of Things (IoT) technology and how this technology can be applied in renewable energy monitoring systems. Participants were given an understanding of the benefits of IoT in improving the efficiency and transparency of energy management.

Figure 1. Socialization of using new technology and maintenance of MHPs that have been integrated with IoT

2. IoT Installation Technical Training: After socialization, the technical training continued, which included the installation of IoT hardware, sensors, and communication modules on the MHP. This training is conducted directly by the technical team with step-by-step guidance so that participants can understand the installation process and device configuration.
3. IoT Installation Technical Training: After socialization, the technical training continued, which included the installation of IoT hardware, sensors, and communication modules on the MHP. This training is conducted directly by the technical team with step-by-step guidance so that participants can understand the installation process and device configuration.

Figure 2. Argamukti Village community training on IoT-based MHP management

4. Maintenance and Troubleshooting: The team also provided training on how to perform routine maintenance of IoT devices as well as basic troubleshooting. This aims to ensure that the community can independently manage and repair the system in case of technical glitches.
5. Periodic Evaluation and Monitoring: After training and implementation of the system, periodic evaluations were conducted to ensure the system was working as planned. The technical team monitors the energy output produced and compares it with the period before the IoT implementation to measure the effectiveness of the technology.

Result and Discussion

The implementation of IoT in the MHP in Argamukti Village successfully increased the efficiency of electricity production by 20% compared to before the implementation of the monitoring system. Solutions developed to address environmental challenges such as extreme weather involved the use of weather-resistant materials and technologies that can adapt to the environment. The program also involves intensive training for the community in the operation and maintenance of the MHP, so that they can be actively involved in the management of renewable energy in their village.

1. Improved Energy Efficiency After the implementation of the IoT-based monitoring system, energy production efficiency increased by 20% compared to the period before the system was implemented. This is because real-time monitoring allows operators to directly know the operational conditions of the plant, such as voltage, current, and power produced, so that corrective actions can be taken quickly if necessary. Previously, delays in monitoring plant conditions often led to suboptimal energy production, especially during changes in environmental conditions or electrical loads. The data collected from IoT devices also helps operators identify energy consumption trends and potential equipment performance degradation earlier, allowing for proactive maintenance.
2. Community Empowerment The training provided to the community not only improved their technical capabilities in operating IoT-based systems, but also raised awareness of the importance of energy management independently. The Argamukti Village community now has the ability to monitor and manage the MHP directly through a mobile application, which allows them to interact with the system remotely. In addition, the program has successfully created more active community involvement in renewable energy management. The local community has understood how to maintain IoT devices and resolve basic technical glitches, reducing dependency on outsiders.
3. Adaptation to Environmental Challenges One of the challenges faced in implementing this system is the environmental conditions of Argamukti Village which often experiences extreme weather, such as heavy rain and strong winds. To overcome this problem, the solution developed is the use of weather-resistant materials on IoT devices, such as sensors and communication modules, as well as the placement of tools in protected locations. The IoT technology used is also able to adapt to changing environmental conditions, such as fluctuations in electricity loads caused by people's energy usage patterns. The real-time monitoring system allows more flexible power distribution settings so that the system can continue to work stably under uncertain conditions.
4. Potential for Development in Other Sectors The successful implementation of IoT in MHP opens up opportunities for the development of this technology in other sectors, such as smart agriculture and water management. With the availability of accurate and real-time data, communities can optimize the use of other natural resources with a more efficient and sustainable approach. For example, IoT sensors can be used to monitor soil moisture or irrigation water flow so that agricultural activities in Argamukti Village can be more productive.

Figure 3. IoT device place on MHP in Argamukti Village

Figure 4. Installation process of IoT devices on MHP in Argamukti Village

Figure 5. Real-time monitoring process in the application with IoT devices at the MHP in Argamukti Village

Table 1. Results Real-time monitoring process in the application with IoT devices on MHP in Argamukti Village

Time	Voltage	Current	Power	Energy	Frequency	pf
11:00:15	220	0.05	5.2	0.01	50	0.45
11:00:14	220	0.05	5.2	0.01	50	0.44
11:00:13	220	0.05	5.2	0.01	50	0.45
11:00:12	220	0.05	5.2	0.01	50	0.44
11:00:11	220	0.05	5.2	0.01	50	0.45
11:00:10	220	0.05	5.2	0.01	50	0.45
11:00:09	220	0.05	5.2	0.01	50	0.45
11:00:08	220	0.05	5.2	0.01	50	0.45
11:00:07	220	0.05	5.2	0.01	50	0.45
11:00:06	220	0.05	5.2	0.01	50	0.45
11:00:05	220	0.05	5.1	0.01	50	0.44
11:00:04	220	0.05	5.2	0.01	50	0.45
11:00:03	220	0.051	5.2	0.01	50	0.44
11:00:02	220	0.051	5.2	0.01	50	0.44
11:00:01	220	0.051	5.2	0.01	50	0.44
11:00:00	220	0.05	5.2	0.01	50	0.44

This is one of the implementations of IoT technology in the management of rural areas using IoT which used to be conventional, now you no longer have to come to Puncak or the place where the tool is stored.

Conclusion

This activity successfully improved the efficiency and sustainability of energy management in Argamukti Village through the application of IoT technology to the MHP. This IoT-based solution has a positive impact on energy production and empowers the community to manage their local resources independently. Argamukti Village is an example of successful renewable energy implementation in mountainous areas.

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