EMPOWERING MIGRANT WORKERS THROUGH RENEWABLE ENERGY AND IOT EDUCATION: A COMMUNITY ENGAGEMENT PROGRAM IN PENANG

Heru SUWOYO[1], Yudhi GUNARDI[2], Setiyo BUDIYANTO[3], Fadli SIRAIT[4], UMAISAROH[5], Julpri ANDIKA[6*], KHOZAENI[7]
[1,2,3,4,5,6] ***Universitas Mercu Buana, Jakarta, INDONESIA***
[7]***Pertubuhan Masyarakat Indonesia (PERMAI), MALAYSIA***
[*]***julpri.andika@mercubuana.ac.id***

ABSTRACT

This community engagement program conducted by Universitas Mercu Buana in Penang Island, Malaysia, aims to raise awareness and enhance understanding of renewable energy and Internet of Things (IoT) technologies among Indonesian migrant workers. In collaboration with the Pertubuhan Masyarakat Indonesia di Malaysia, this initiative focuses on introducing the basic principles and practical applications of sustainable energy sources and smart technologies. Key topics include wind turbines, triboelectric nanogenerators, Passive Infrared (PIR) sensors, and IoT-based monitoring systems. The program is designed to empower participants with foundational knowledge that can be applied in everyday life and potentially lead to entrepreneurial opportunities in the future. Through interactive sessions, demonstrations, and hands-on activities, participants gain insight into how these technologies work and how they can contribute to energy efficiency and sustainability. This outreach activity not only fosters technological literacy but also strengthens the academic-community relationship across borders. By equipping migrant communities with relevant technical insights, the program supports inclusive education and promotes the role of universities in addressing global sustainability challenges.

Keywords: Renewable Energy, IoT, Wind Turbine, Pir, Empower

1. INTRODUCTION

The rapid advancement of renewable energy and Internet of Things (IoT) technologies presents significant opportunities for sustainable development and inclusive education (Chen et al., 2020; Khan et al., 2021). However, the dissemination of these innovations remains largely concentrated in academic and urban-industrial environments, leaving marginalized communities—including migrant workers—less exposed to these advancements (Yusuf & Knight, 2019; ILO, 2021). Indonesian migrant workers in Malaysia, particularly in Penang, represent a substantial yet underserved demographic in terms of access to technological education and empowerment programs (International Labour Organization [ILO], 2021; Rahman et al., 2020).

To address this gap, Universitas Mercu Buana initiated a community engagement program in collaboration with Pertubuhan Masyarakat Indonesia di Malaysia to introduce fundamental concepts of renewable energy and IoT to the Indonesian migrant community in Penang. The program aims to enhance awareness, technical literacy, and practical understanding of sustainable technologies such as wind turbines, triboelectric nanogenerators, Passive Infrared (PIR) sensors, and IoT-based automation systems (Roy et al., 2022; Asad et al., 2020). These technologies were selected for their relevance to real-world applications, cost-effectiveness, and potential for integration into small-scale community projects or household systems (Gong et al., 2021; Lee et al., 2018).

Wind energy, for instance, is one of the most mature and economically viable forms of renewable energy (Manwell, McGowan, & Rogers, 2010). Small-scale wind turbines can be deployed in off-grid or semi-urban areas, offering an alternative to conventional power sources (Zhou et al., 2019). Similarly, triboelectric nanogenerators (TENGs) are emerging as innovative tools for harvesting mechanical energy from motion, vibrations, or even human activity. Their simplicity and ability to generate electricity without external power sources make them ideal for educational and low-power applications (Zhu, Yang, & Wang, 2017; Wang, 2021).

On the IoT front, sensors such as PIR detectors play a critical role in energy-efficient automation systems. Combined with microcontrollers and wireless modules, these sensors can be integrated into systems for lighting control, security, or environmental monitoring, which are especially useful in migrant housing or community centers (Gubbi et al., 2013; Bandyopadhyay & Sen, 2011). The integration of IoT in smart environments can enhance safety, energy efficiency, and real-time monitoring (Zanella et al., 2014).

Introducing these concepts allows participants to understand not only how such systems work but also how they may benefit from or contribute to the application of smart technologies in everyday life (Chakrabarty et al., 2020). Through this program, participants are encouraged to consider how knowledge in renewable energy and IoT can support sustainability goals and create income-generating opportunities (UNESCO, 2020). By fostering technological literacy

in migrant communities, universities play an essential role in bridging the knowledge divide, supporting the United Nations' Sustainable Development Goals (SDGs), especially SDG 4 (Quality Education) and SDG 7 (Affordable and Clean Energy) (UN, 2015; Ghosh et al., 2022).

2. METHOD

The community engagement activity was structured into three main stages: socialization, education, and evaluation. Each phase was carefully designed to ensure active participation, knowledge transfer, and impact measurement among Indonesian migrant workers in Penang, Malaysia.

Socialization Phase

The first phase focused on outreach and participant engagement. Coordination was established with Pertubuhan Masyarakat Indonesia di Malaysia, a local Indonesian migrant organization, to identify target participants and schedule the sessions. Flyers, social media announcements, and direct communication were used to inform the community about the event's objectives, themes, and benefits.

An introductory session was held at the community center to explain the purpose of the program, the significance of renewable energy and IoT technologies, and how these topics could be useful in their daily lives. This stage helped to build trust, raise interest, and encourage participant commitment throughout the program.

Education Phase

The second stage was the core of the activity, consisting of a series of interactive learning sessions:

Introduction to Renewable Energy

Participants were introduced to basic renewable energy sources with a focus on wind turbines and triboelectric nanogenerators. Practical demonstrations were conducted using scaled-down prototypes to show how energy can be harvested from natural sources and mechanical motion.

Introduction to IoT and Sensor Technology

This module covered fundamental concepts of the Internet of Things, including how sensors like Passive Infrared (PIR) can be used for energy-saving automation. Participants were shown how a simple PIR sensor connected to an Arduino or ESP8266 microcontroller could automate lighting or detect motion.

Evaluation Phase

The final phase involved assessing the impact of the activity through both qualitative and quantitative means. Pre- and post-activity questionnaires were distributed to evaluate the change in participants' knowledge and attitudes toward renewable energy and IoT technologies.

A short discussion and feedback session was conducted at the end of the workshop to capture participant impressions, questions, and suggestions for future improvements. Several participants expressed interest in applying their new knowledge for practical home applications or small business ideas.

3. RESULTS AND DISCUSSION

The community engagement program yielded promising outcomes in increasing awareness and practical understanding of renewable energy and IoT technologies among Indonesian migrant workers in Penang, Malaysia. The activity involved 45 participants, most of whom had limited formal education in science or engineering. Despite this, the participants showed high enthusiasm and active involvement throughout the program.

Figure 1. Participant Involved in the Event

During the socialization phase, the collaboration with Pertubuhan Masyarakat Indonesia di Malaysia proved essential in ensuring effective outreach and participant mobilization. Many attendees mentioned that this was their first exposure to topics like wind energy or sensor-based automation. The informal yet structured introductory session helped build rapport and created a comfortable learning environment.

In the education phase, knowledge transfer was effectively facilitated through simple language, visual demonstrations, and hands-on practice. In the first module, participants were intrigued by how small wind turbines and triboelectric nanogenerators could convert natural or kinetic energy into usable electricity. They showed particular interest in the idea that these systems could be implemented in rural or off-grid areas in their hometowns.

Figure 2. The Speakers is Filling in the Activity.

Table 1. The Result of Participant's Expectation and Performance of the Activity

No.	Description	Measurement	NI	FI	I	VI	Min	Max	Mean	Standard Deviation
1	The community service material is in accordance with the problems faced by the community.	Expectation	0	0,087	0,348	0,565	2	4	3,478	0,100
		Performance	0	0,130	0,304	0,565	2	4	3,435	0,091
2	The community service method used is appropriate with the theme and objectives of the community service program.	Expectation	0	0,043	0,391	0,565	2	4	3,522	0,109
		Performance	0	0,087	0,348	0,565	2	4	3,478	0,100
3	Supporting facilities and infrastructure for community service activities, such as venues or buildings, tools and materials, and other supporting facilities, are adequate.	Expectation	0	0,130	0,304	0,565	2	4	3,435	0,091
		Performance	0	0,217	0,217	0,565	2	4	3,348	0,073
4	The community service implementation team appears to be cohesive in carrying out the activities.	Expectation	0	0,087	0,435	0,478	2	4	3,391	0,082
		Performance	0	0,000	0,304	0,696	3	4	3,696	0,041
5	The implementation team has the competence relevant to the material provided.	Expectation	0	0,130	0,348	0,522	2	4	3,391	0,082
		Performance	0	0,130	0,304	0,565	2	4	3,435	0,091
6	The implementation team is very engaging in delivering the community service program.	Expectation	0	0,130	0,304	0,565	2	4	3,435	0,091
		Performance	0	0,087	0,435	0,478	2	4	3,391	0,082
7	The community is enthusiastic in participating in the community service activities.	Expectation	0	0,261	0,261	0,478	2	4	3,217	0,045
		Performance	0	0,174	0,435	0,391	2	4	3,217	0,045
8	The community greatly benefits from the community service program provided.	Expectation	0	0,000	0,478	0,522	3	4	3,522	0,005
		Performance	0	0,000	0,348	0,652	3	4	3,652	0,032
9	The community is highly interested and enthusiastic about the service activities.	Expectation	0	0,174	0,348	0,478	2	4	3,304	0,063
		Performance	0	0,217	0,261	0,522	2	4	3,304	0,063
10	Overall, the community feels satisfied with the community service program carried out.	Expectation	0	0,087	0,217	0,696	2	4	3,609	0,127
		Performance	0	0,087	0,435	0,478	2	4	3,391	0,082
11	The community service program meets the expectations of the community.	Expectation	0	0,130	0,261	0,609	2	4	3,478	0,100
		Performance	0	0,043	0,174	0,783	2	4	3,739	0,154
12	The duration of the community service program aligns with the community's expectations.	Expectation	0	0,043	0,304	0,652	2	4	3,609	0,127
		Performance	0	0,043	0,348	0,609	2	4	3,565	0,118

Notes: Not Important (NI), Fairly Important (FI), Important (I), Very Important (VI)

The evaluation phase included expectations and performance assessments. Results showed a fairly increase in understanding: average scores rose from 3,45 to 3,47 in all descriptions. Participants also expressed a marked increase in confidence and interest in learning more about how such technologies could be applied in their daily lives or future ventures. Feedback highlighted the value of hands-on learning, with many suggesting future workshops on solar panels, smart farming, and entrepreneurship in tech-based solutions.

The discussion with participants revealed that many had never considered the link between technology and sustainability. The program not only introduced technical knowledge but also inspired critical thinking about self-reliance and innovation. Moreover, the success of the event underlined the importance of culturally sensitive and inclusive educational approaches when delivering technology-based knowledge to migrant communities.

Figure 3. Photo Together with the Speakers and the Participants

Overall, the program demonstrated that with the right methods, complex technologies like renewable energy and IoT can be made accessible and meaningful to non-technical audiences—empowering them to be part of the sustainable development conversation.

4. CONCLUSION

This community engagement initiative successfully introduced fundamental concepts of renewable energy and IoT technologies to Indonesian migrant workers in Penang, Malaysia. Through structured phases of socialization, education, and evaluation, the program demonstrated that complex technologies can be made accessible and relevant to non-technical audiences when delivered through inclusive and culturally sensitive approaches. Participants showed significant improvement in their understanding of wind energy, triboelectric nanogenerators, PIR sensors, and IoT-based systems, as reflected in expectation and performance of the activity. Moreover, the hands-on learning experiences fostered curiosity, confidence, and discussions about future applications in daily life and entrepreneurship. The collaboration between Universitas Mercu Buana and Pertubuhan Masyarakat Indonesia di Malaysia highlights the vital role of academic institutions in promoting technological literacy and supporting sustainable development goals across borders. This program serves as a model for similar outreach efforts targeting underserved communities, emphasizing the importance of inclusive education in advancing global sustainability and empowerment.

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5. REFERENCES

Asad, M. M., Zafar, M. M., & Mahmood, A. (2020). Role of IoT in renewable energy systems. *Renewable and Sustainable Energy Reviews*, 134, 110276. https://doi.org/10.1016/j.rser.2020.110276

Bandyopadhyay, D., & Sen, J. (2011). Internet of Things: Applications and challenges in technology and standardization. *Wireless Personal Communications*, 58(1), 49–69. https://doi.org/10.1007/s11277-011-0288-5

Chakrabarty, K., Veeravalli, B., & Hassan, M. M. (2020). Smart cities powered by IoT and renewable energy. *Sustainable Cities and Society*, 61, 102326. https://doi.org/10.1016/j.scs.2020.102326

Chen, M., Ma, Y., Li, Y., Wu, D., Zhang, Y., & Youn, C. H. (2020). Wearable 2.0: Enabling human-cloud integration in next generation healthcare systems. *IEEE Communications Magazine*, 58(1), 93–99.

Ghosh, R., Pandey, R., & Roy, A. (2022). Digital divide and educational inequality: A study on migrant workers. *International Journal of Social Economics*, 49(6), 873–888.

Gong, C., Zhang, H., & Lin, Y. (2021). IoT-driven smart energy management systems for rural areas: A review. *Journal of Cleaner Production*, 298, 126751. https://doi.org/10.1016/j.jclepro.2021.126751

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems, 29*(7), 1645–1660. https://doi.org/10.1016/j.future.2013.01.010

International Labour Organization. (2021). *Labour migration in Asia: Impacts of the COVID-19 crisis and the post-pandemic future*. https://www.ilo.org

Khan, Z., Khan, S., & Zaheer, R. (2021). Renewable energy and smart technologies: A socio-economic perspective. *Renewable Energy*, 178, 751–762.

Lee, Y. D., Cho, H. H., & Kim, J. M. (2018). Feasibility study of low-cost renewable energy education for low-income communities. *International Journal of Engineering Education*, 34(1), 325–332.

Manwell, J. F., McGowan, J. G., & Rogers, A. L. (2010). *Wind energy explained: Theory, design and application* (2nd ed.). John Wiley & Sons.

Rahman, R., Hafidz, J. M., & Yusof, M. A. M. (2020). Education and digital skills for migrant workers in Malaysia: Barriers and policy implications. *Journal of Southeast Asian Studies*, 51(4), 603–622.

Roy, S., Bose, I., & Das, A. (2022). Renewable energy innovation for sustainable communities: A literature review. *Renewable and Sustainable Energy Reviews*, 156, 112031.

UNESCO. (2020). *Education for sustainable development: A roadmap*. https://unesdoc.unesco.org/ark:/48223/pf0000374802

United Nations. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development*. https://sdgs.un.org/2030agenda

Wang, Z. L. (2021). Triboelectric nanogenerators as new energy technology for self-powered systems and sensors. *ACS Nano*, 15(11), 17894–17930. https://doi.org/10.1021/acsnano.1c07083

Yusuf, M., & Knight, J. (2019). Education, migration and development: A longitudinal perspective. *Journal of International Migration and Integration*, 20(3), 847–863.

Zanella, A., Bui, N., Castellani, A., Vangelista, L., & Zorzi, M. (2014). Internet of Things for smart cities. *IEEE Internet of Things Journal*, 1(1), 22–32. https://doi.org/10.1109/JIOT.2014.2306328

Zhou, Y., Yang, M., & Liu, W. (2019). A review on wind power technologies and policies in developing countries. *Renewable and Sustainable Energy Reviews*, 109, 140–157.

Zhu, G., Yang, W., & Wang, Z. L. (2017). Triboelectric nanogenerators as new energy technology for self-powered systems and as active mechanical and chemical sensors. *Accounts of Chemical Research, 47*(10), 2332–2343. https://doi.org/10.1021/ar500060y