

Managing energy and climate change in Polytechnic Mersing

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Abstract. Politeknik Mersing (PMJ) has taken a proactive role in addressing energy management, climate change, and sustainability through various best practices. Recognizing the responsibility of educational institutions in promoting environmental stewardship, PMJ has implemented initiatives that contribute to energy conservation, pollution reduction, and climate resilience. A key focus of PMJ's efforts is energy efficiency, including the use of energy-saving bulbs and the installation of solar-powered lights across the campus. These measures have significantly reduced electricity consumption while promoting renewable energy adoption. Additionally, PMJ actively participates in the Earth Hour program by shutting down the main power supply for one hour annually, fostering awareness about energy conservation among students, staff and campus residence. To optimize energy usage, PMJ has introduced a centralized temperature control system for air conditioning, ensuring sustainable energy consumption. Sensor-activated devices have also been installed to minimize energy wastage by automatically regulating lighting and electronic equipment based on occupancy. These smart energy management strategies contribute to a more efficient and eco-friendly campus. Beyond energy management, PMJ has implemented tree planting programs to combat climate change, enhance biodiversity, and offset carbon emissions. Additionally, the institution has integrated waste management practices by composting organic waste into fertilizer. This initiative not only reduces pollution and landfill dependency but also supports sustainable agriculture and contributes to mitigating global warming. The Total of 65 respondents provided feedback for this survey. As a result of these impactful initiatives, PMJ has received multiple national and international awards through competitions and green practices reporting, reinforcing its leadership in sustainability. Moving forward, PMJ remains committed to expanding its environmental initiatives, serving as a role model for other institutions, and making a lasting impact on the community and global sustainability effort.

Keyword: Transforming Education, Energy saving, carbon footprint, earth hour, tree planting & waste into fertilizer

1.0 Introduction

In response to escalating environmental challenges, higher education institutions (HEIs) are increasingly recognized as critical drivers of sustainability, energy management, and climate resilience. These institutions are uniquely positioned to serve as catalysts for environmental stewardship through education, research, infrastructure development, and community engagement. Politeknik Mersing (PMJ), in alignment with Malaysia's *Blueprint SmartGreen PolyCC 2021–2026* (2021), has demonstrated a strong commitment to sustainable development by implementing comprehensive energy and environmental management strategies. One of PMJ's primary areas of focus is energy efficiency. The institution has adopted a range of best practices aimed at reducing energy consumption and promoting the use of renewable resources. These measures include the campus-wide replacement of conventional lighting systems with energy-efficient LED bulbs and the deployment of solar-powered street lighting to harness clean energy sources. The introduction

of a centralized temperature control system for air conditioning has further optimized energy use, reducing unnecessary consumption during off-peak periods. Additionally, the integration of sensor-based technologies—such as motion-activated lighting and automated power regulation systems—has minimized energy wastage by adjusting energy use based on occupancy levels.

PMJ's commitment to sustainability extends beyond energy conservation. Environmental initiatives such as tree planting campaigns serve multiple ecological functions, including carbon sequestration, biodiversity enhancement, and the mitigation of urban heat island effects. These efforts are consistent with global climate action goals as emphasized by the *World Economic Forum* (2023), which identifies afforestation and urban greening as critical strategies for climate adaptation and mitigation. The institution has also established sustainable waste management systems that support circular economy principles. Organic waste generated on campus is converted into compost for use in sustainable agriculture projects, thereby reducing reliance on chemical fertilizers and minimizing waste sent to landfills. These actions contribute to a reduction in environmental pollution while simultaneously fostering sustainable food production practices. PMJ's engagement in global sustainability movements—such as the annual Earth Hour initiative—demonstrates its active role in raising environmental awareness and promoting behavior change among students and staff. Through participation in such programs, PMJ reinforces a culture of conservation and responsibility across the campus community.

As a result of these integrated and impactful strategies, PMJ has received numerous accolades at both national and international levels for its achievements in environmental management and green campus practices. These recognitions underscore the institution's leadership in sustainability and highlight its role as a model for other polytechnics and universities in the region. Looking forward, PMJ remains committed to scaling its sustainability initiatives by leveraging technology, fostering cross-sector collaboration, and deepening its integration of environmental education into academic and operational frameworks. These efforts are not only in line with national policy directions but also contribute meaningfully to the attainment of the United Nations Sustainable Development Goals (SDGs), particularly those related to affordable and clean energy (SDG 7), sustainable cities and communities (SDG 11), responsible consumption and production (SDG 12), and climate action (SDG 13).

1.1 Problem Statement

Despite increasing awareness of climate change and sustainability, many higher education institutions in Malaysia still face challenges in systematically managing energy consumption and reducing their carbon footprint. This includes limited adoption of renewable energy technologies, inefficient resource utilization, and a lack of integrated environmental strategies. Although PMJ has taken significant steps toward sustainability—such as energy-efficient systems, renewable energy adoption, waste composting, and water conservation—the effectiveness, scalability, and long-term impact of these initiatives have not been empirically assessed. There is a need to critically evaluate PMJ's green practices to determine their success in mitigating climate impact and their potential as a model for other HEIs.

1.2 Research Objectives

- a. To assess the impact of energy-efficient measures and renewable energy systems on PMJ's electricity consumption and carbon emissions.
- b. To examine the effectiveness of PMJ's waste management, tree planting, and water conservation programs in promoting environmental sustainability.
- c. To evaluate the level of awareness and engagement among PMJ students and staff in sustainability initiatives.
- d. To identify challenges and opportunities in scaling PMJ's green campus practices.

1.3 Research Hypotheses

- a. **H₁:** The implementation of energy-efficient technologies at PMJ significantly reduces energy consumption and operational costs.
- b. **H₂:** PMJ's integrated environmental strategies contribute to measurable reductions in carbon footprint and ecological impact.
- c. **H₃:** Awareness and participation in sustainability programs among students and staff significantly influence the success of green initiatives.

1.4 Research Interest and Rationale

This research is driven by the increasing urgency to address climate change through institutional-level transformation. As educational institutions serve not only as learning hubs but also as influencers of societal behavior, understanding how PMJ's efforts contribute to national and global sustainability goals is critical. The study will provide insight into the feasibility and effectiveness of institutional green strategies in a Malaysian context, supporting HEIs in aligning with SDGs and national sustainability frameworks.

2.0 Literature Review

Higher Education Institutions (HEIs) are increasingly recognized as pivotal agents in achieving the United Nations Sustainable Development Goals (SDGs). According to Leal Filho et al. (2021), universities and polytechnics serve as incubators for innovation, education, and civic engagement, making them ideal platforms for advancing sustainability agendas. The integration of SDGs into institutional strategies, academic curricula, and operational frameworks is identified as a critical pathway for driving transformative change within the higher education sector. Purcell et al. (2020) emphasize the necessity of interdisciplinary collaboration in addressing complex global sustainability challenges, including climate change, environmental degradation, and resource depletion. These complexities require a holistic and systems-thinking approach, wherein HEIs act not only as knowledge providers but also as facilitators of practical, on-the-ground solutions. This framework is evident in Polytechnic Mersing's approach, which integrates environmental, social,

and economic dimensions of sustainability—a model aligned with the multidimensional perspective advocated by Amaral et al. (2021).

Energy management and renewable energy adoption are central to institutional efforts in climate mitigation. Zhang et al. (2020) underline the critical importance of transitioning HEIs toward renewable energy sources, such as solar and wind power, to reduce carbon emissions and operational expenditures. Furthermore, the establishment of monitoring systems to optimize energy consumption is essential for ensuring long-term sustainability. Polytechnic Mersing's implementation of a Renewable Energy Centre since 2019, particularly for its smart agricultural projects, exemplifies this transition. These initiatives have contributed significantly to lowering campus utility costs and reducing the institution's carbon footprint, aligning with findings by Alghamdi et al. (2022), who argue that HEIs can serve as living laboratories for testing and scaling innovative green technologies. Urban greening initiatives, including afforestation and biodiversity enhancement, are also integral to climate action. The tree planting activities at Polytechnic Mersing correspond with the work of Nowak et al. (2021), who highlight the role of vegetative cover in sequestering carbon, regulating microclimates, and enhancing ecological diversity on urban campuses.

Effective waste management remains a cornerstone of sustainable campus operations. Zaman (2020) discusses the significance of recycling, composting, and circular economy practices in reducing landfill waste and promoting resource efficiency. Polytechnic Mersing's commitment to recycling and organic composting reflects the best practices identified by Hoornweg et al. (2021), who stress the role of educational campaigns and stakeholder participation in shifting behavioral norms. These activities further support SDG 12 (Responsible Consumption and Production), as described by Schroeder et al. (2019), emphasizing institutional accountability in promoting sustainable consumption patterns. Water conservation technologies have also become increasingly important. Adeyemi et al. (2020) demonstrate the potential of rainwater harvesting systems and smart irrigation technologies in reducing freshwater consumption and enhancing climate resilience. Polytechnic Mersing's implementation of rainwater harvesting systems, coupled with automated irrigation controls for agricultural and landscaping applications, aligns with the sustainable water management strategies endorsed by Mekonnen and Hoekstra (2021).

Sustainable transportation practices are another key area where HEIs can significantly reduce their carbon footprint. Shaheen et al. (2020) advocate for low-emission mobility options, including carpooling schemes, electric vehicle adoption, and subsidized public transit. Polytechnic Mersing's provision of eco-friendly commuting initiatives—such as staff carpooling and free transportation services for students to attend Friday prayers and during adverse weather—reflects the recommendations of Gössling (2021), who underscores the leadership role of HEIs in promoting green mobility infrastructure. Community engagement is fundamental to the success of sustainability efforts in HEIs. Trencher et al. (2020) argue that universities and polytechnics can act as transformative agents by fostering partnerships with local communities and promoting sustainability education beyond the confines of the campus. Polytechnic Mersing's comprehensive outreach programs, which include academic, religious, corporate social responsibility (CSR), and best practice-sharing initiatives, are consistent with the “engaged HEI” model described by Hall et al. (2020). These programs strengthen the institution's societal relevance and help build a culture of environmental responsibility across diverse stakeholders.

In summary, the literature strongly supports the strategic and operational integration of sustainability within HEIs. The case of Polytechnic Mersing demonstrates a practical application of this approach through investments in renewable energy, water and waste management, sustainable transportation, and community collaboration. By aligning institutional practices with global sustainability goals, Polytechnic Mersing exemplifies the transformative role HEIs can play in managing energy use and climate change mitigation.

3.0 Metodology

This study employs a structured and systematic approach to evaluate the sustainability initiatives at Polytechnic Mersing (PMJ) in alignment with the United Nations Sustainable Development Goals (SDGs). The research is organized into four key phases: planning and preparation, data collection, data analysis, and reporting. The study site, Polytechnic Mersing, serves as an ideal case study due to its active implementation of renewable energy solutions such as solar panels and rainwater harvesting, waste management programs including recycling and composting, and sustainable transportation initiatives carpooling and free bus services. The target population includes academic and non-academic staff, and key administrators involved in sustainability projects. A combination of stratified random sampling and purposive sampling ensures representation across different stakeholder groups, with an estimated sample size of 65 survey respondents.

Primary data is collected through structured surveys assessing awareness and participation in sustainability programs, semi-structured interviews with project leaders, and field observations documenting energy efficiency, waste segregation compliance, and transportation usage. Secondary data is gathered from institutional reports, energy consumption records, and previous studies on PMJ's sustainability efforts. Quantitative data is analyzed using descriptive and inferential statistics (via Excel and SPSS), while qualitative responses undergo thematic analysis to identify key trends and challenges. Findings are cross-validated through triangulation and benchmarked against global SDG indicators. The final phase synthesizes results into actionable insights, highlighting PMJ's strengths and areas for improvement. The study concludes with recommendations for enhancing sustainability practices in higher education institutions, ensuring that the research contributes both academically and practically to the broader discourse on sustainable development.

4.0 Results

4.1 Analysis of Awareness of Sustainability Initiatives at Politeknik Mersing

The survey results provide valuable insights into the level of awareness regarding various sustainability initiatives at Politeknik Mersing. Out of 65 respondents, the findings indicate that some initiatives are well recognized, while others require more visibility.

4.2 Section A : Sustainability On Awareness

a. High Awareness Initiatives

The most recognized initiative is tree planting activities, with 80% (52 respondents) being aware of it. This suggests that tree planting efforts have been effectively communicated and actively participated in by students and staff. Similarly, waste management Systems (69.2%) received significant awareness, indicating that recycling and waste management practices are relatively well known within the institution as shown in Figure 4.1.

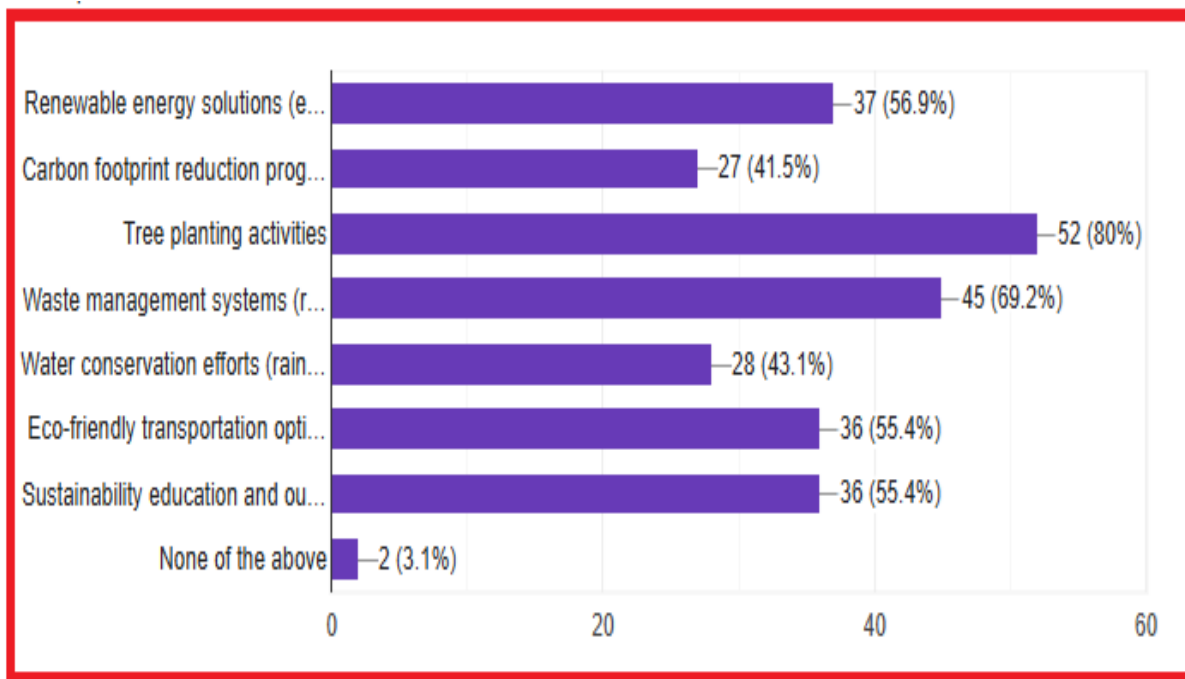


Figure 4.1: Sustainability Awareness Initiatives at Politeknik Mersing

b. Moderate Awareness Initiatives

Renewable Energy Solutions (56.9%), Eco-friendly Transportation Options (55.4%), and Sustainability Education and Outreach Programs (55.4%) fall within the moderate awareness range. These numbers suggest that while some individuals are familiar with these efforts, further promotion and engagement could help improve awareness. Given that these initiatives align with global sustainability trends, more interactive activities or educational campaigns might increase engagement.

c. Low Awareness Initiatives

The Carbon Footprint Reduction Program (41.5%) and Water Conservation Efforts (43.1%) had the lowest awareness levels among respondents. This could indicate that these initiatives either have limited visibility or are not widely implemented across campus. Enhancing communication

strategies, such as workshops, signage, or digital awareness campaigns, could improve knowledge and participation in these programs.

d. Unawareness of Sustainability Initiatives

A small percentage (3.1%) of respondents were unaware of any sustainability initiatives at Politeknik Mersing. While this number is relatively low, it highlights the need for continuous engagement efforts to ensure all members of the community are informed and involved.

Recommendations for Improvement

Increase visibility and communication such as more promotional efforts like posters, social media campaigns, and interactive sessions, can help boost awareness of lesser-known initiatives. Engage students and staff in hands on activities like workshops, competitions, and volunteer programs can encourage more participation. Incorporate sustainability into the curriculum such as embedding these initiatives into coursework or student projects can enhance understanding and commitment. Monitor and evaluate progress on conducting periodic surveys and impact assessments can track awareness levels and improve sustainability strategies.

4.3 Section B : Infrastructure and Operations

The survey responses provide insights into the effectiveness of Politeknik Mersing's infrastructure in promoting sustainability. Below is a summary of the key findings:

a. Effectiveness of Sustainability Infrastructure

67.2% of respondents believe the infrastructure is "Somewhat effective", while 29.7% consider it "Very effective." Only a small percentage found it "Not effective," suggesting that while improvements may be needed, the current infrastructure has a positive impact. This indicates that Politeknik Mersing has taken steps towards sustainability, but there is room for enhancement to reach a higher level of effectiveness.

b. Energy Efficiency and Renewable Energy Use

51.6% of respondents noticed changes related to energy efficiency or renewable energy use, while 42.2% were unsure. A small percentage did not observe any changes, indicating that while efforts have been made, awareness and visibility of these initiatives could be improved. More communication about renewable energy projects or energy-saving measures could increase recognition and engagement.

c. Waste Management Systems

54.7% rated waste management as "Good," while 25% considered it "Average." Only 17.2% rated it "Excellent," indicating that further enhancements could be beneficial. The results suggest that

while current waste management practices, such as recycling and composting, are functioning adequately, improvements could be made to move from "Good" to "Excellent."

d. Water Conservation Efforts

72.3% of respondents were "Somewhat satisfied" with water conservation efforts, while 23.1% were "Very satisfied." This suggests that initiatives like rainwater harvesting and efficient irrigation are recognized but may need additional enhancements to improve satisfaction. Future strategies could focus on expanding water conservation programs and increasing awareness of their benefits.

Recommendations for Improvement

While sustainability infrastructure is in place, some initiatives need better visibility through education, workshops, and signage. More noticeable renewable energy projects or awareness campaigns can ensure greater recognition of sustainability efforts. Strengthening recycling programs and introducing composting on a larger scale could lead to higher satisfaction levels. More energy efficient systems, water, energy and waste saving policies, and community involvement could further improve satisfaction.

4.4 Section C : Transportation and Mobility

The responses from this section provide insights into the usage and effectiveness of sustainable transportation options at Politeknik Mersing. Below is a summary of the key findings:

a. Usage of Eco-Friendly Transportation

61.5% of respondents have used eco-friendly transportation options, such as carpooling or the free student bus/van service. 38.5% have not used these options, which may indicate either a preference for personal transportation or a lack of awareness about available options. The majority of students utilizing sustainable transport suggests that these initiatives are helpful, but further promotion may encourage more participation.

b. Availability and Convenience of Sustainable Transportation

53.1% of respondents rated the availability and convenience as "Good," while 23.4% rated it as "Average." Only 18.8% rated it as "Excellent," indicating that while the system is functional, there is room for improvement. A small percentage found it "Poor," which suggests that accessibility, frequency, or coverage of sustainable transport options may need enhancement.

Recommendations for Improvement

Since a significant portion of students have not used eco-friendly transportation, better communication on availability and benefits could boost participation. Expanding bus routes,

increasing service frequency, or improving scheduling may encourage greater usage. Addressing concerns about convenience through student feedback can help refine transport services for better efficiency.

4.5 Section D: Education and Community Engagement

The survey responses provide insights into the effectiveness of Politeknik Mersing's education and community engagement. Below is a summary of the key findings:

a. Participation in Sustainability Programs

65.1% of respondents have participated in sustainability education or outreach programs organized by Polytechnic Mersing. **34.9%** have not participated. The majority of students and staff are involved in sustainability initiatives, but there is room to increase participation through better outreach or incentives.

b. Impact of Sustainability Programs

45.3% find these programs *very impactful* in raising awareness about sustainability. **50%** consider them *somewhat impactful*. A small percentage finds them *not impactful*. While most respondents acknowledge the effectiveness of these programs, there is an opportunity to enhance engagement strategies, making them more impactful.

c. Community Engagement in Sustainability Initiatives

66.7% believe Polytechnic Mersing effectively engages the local community in sustainability initiatives. 27% are "not sure". A small percentage believes there is a lack of effective engagement. The institution is making progress in involving the community, but efforts should be strengthened to improve clarity and awareness of these initiatives. Improve awareness and ensuring a stronger connection with the local community should be enhanced for better engagement by all parties.

4.6 Summary

This section presents the findings of the study on the awareness, understanding, and participation of staff and students in green initiatives at Politeknik Mersing (PMJ). The data collected from the questionnaire provides valuable insights into the level of engagement with sustainability practices on campus and highlights key areas for improvement. By analyzing the responses, this discussion aims to identify trends, strengths, and challenges in PMJ's sustainability efforts. Additionally, the findings will help guide future strategies to enhance environmental awareness, encourage greater participation, and promote a more sustainable campus environment.

4.7 Secondary Data Institutional Reports

Below is the secondary data obtained from Smartgreen PolyCC 2024 PMJ official report on energy usage and corresponding carbon emissions from 2021 to 2024 at Politeknik Mersing.

Year	CO2(Electric)	CO2(Bus)	CO2(Cars)	CO2(Motorcycle)	Total CO2 (Tonnes)
2021	2,270.11	0.77	71.5	25.44	2368.02
2022	2,008.01	0.81	76.7	21.22	2106.77
2023	1,726.92	0.85	80.33	19.19	1825.09
2024	1,358.96	0.96	90.24	18.72	1468.29

Smartgreen Polycc-PMJ 2024

4.8 Trend Summary (2021–2024)

Total CO₂ reduced by ~900 tonnes from 2021 to 2024. Despite a rise in transport-related emissions, the major reduction in electricity usage helped achieve a ~38% overall emission reduction. The analysis of PMJ's total carbon emissions from 2021 to 2024 demonstrates a commendable downward trend, indicating significant progress in institutional sustainability efforts. The total annual emissions have reduced from 2,368.02 tonnes in 2021 to 1,468.29 tonnes in 2024, a reduction of approximately 38%. This data is a strong indicator of the effectiveness of green initiatives, especially in reducing electricity consumption. The largest source of emissions of electricity consumption was significantly reduced by over 1 million kWh from 2021 to 2024, contributing to most of the overall CO₂ decline. This indicates successful implementation of energy efficiency measures or integration of renewable energy sources.

While electricity-related emissions dropped, transport-related emissions particularly from cars and buses have **increased steadily**, which reflect a higher students intake each year in campus population which needs more trips to transport students from campus to their rented homes. While the increased of staff causes the cars usage increased. Meanwhile the number of motorcycles decreased due to using bus transportation by students to campus.

Politeknik Mersing's carbon emissions data reflects an admirable commitment to climate action, with meaningful reductions achieved over four years. However, to fully realize a net-zero and climate-resilient campus, PMJ must strategically tackle transport emissions, strengthen institutional policies, and align its initiatives with national sustainability frameworks. The institution stands at a pivotal point to serve as a model for low-carbon education institutions in Malaysia through innovation, collaboration, and integrated green practices.

4.9 Challenges And Opportunities In Scaling PMJ's Green Campus Practices

Scaling PMJ's green campus practices presents both significant challenges and promising opportunities. Among the key challenges are limited financial resources, which can hinder the expansion of renewable energy infrastructure and the adoption of advanced green technologies. Additionally, the need for continuous capacity building among staff and students poses a barrier to maintaining momentum in sustainability initiatives, as behavioral change requires sustained education and engagement. Technical limitations, such as outdated infrastructure and lack of smart monitoring systems, also constrain the efficiency and scalability of current efforts. However, these challenges are matched by substantial opportunities. With Malaysia's national push toward green development under policies like the SmartGreen PolyCC Blueprint, PMJ can leverage government grants, industry partnerships, and technological innovations to accelerate its sustainability agenda. The institution's existing success and recognition provide a strong foundation for attracting research funding and collaboration with environmental organizations. Moreover, by integrating sustainability more deeply into its academic curricula and operations, PMJ can nurture a new generation of environmentally conscious graduates, amplifying its long-term impact on society and aligning its growth with global climate and sustainability goals.

5.0 Discussions

A key component of PMJ's sustainability strategy is its focus on energy-saving solutions ensured more efficient energy management and minimizing unnecessary energy usage. Beyond energy efficiency, PMJ has undertaken impactful initiatives to address climate change and promote environmental sustainability, aimed at enhancing biodiversity, improving air quality, and offsetting carbon emissions. Moreover, PMJ has integrated waste management practices by converting organic waste into fertilizer, reducing landfill dependency, and supporting sustainable agriculture. In addition to carpooling and free transportation, ensuring students and staff have reliable transportation to and from the institution. Furthermore, a dedicated bus service is available every Friday to transport students and staff to the mosque, facilitating community engagement while promoting sustainable travel options.

6.0 Conclusions

Politeknik Mersing (PMJ) has demonstrated a strong commitment to sustainability by implementing various energy conservation and environmental management initiatives. Recognizing the pivotal role of educational institutions in promoting environmental responsibility, PMJ has adopted proactive measures to enhance energy efficiency, reduce pollution, and combat climate change. The institution's dedication to sustainability has earned it multiple national and international awards through participation in green competitions and sustainability reporting, further reinforcing its position as a leader in environmental stewardship. Moving forward, PMJ remains steadfast in its mission to expand its sustainability initiatives, serving as an inspiration for other institutions and making a lasting contribution to global environmental efforts.

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