Socialization Of Waste To Energy Transformation: Innovation And Future Opportunities In Penang Island

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Abstract.

Effective waste management is a major challenge in the modern era, especially with the increasing volume of waste produced by society. Transforming waste into energy offers an innovative solution that not only reduces environmental impact but also opens up economic and social opportunities. Through technologies such as biogas, incineration, pyrolysis, and gasification, waste can be converted into sustainable renewable energy sources. This socialization aims to increase public and stakeholder awareness of the importance of innovative waste management and its benefits for the environment and future economy.By understanding the technology, opportunities, and challenges that exist, it is hoped that the community and government can play an active role in supporting the mission towards more environmentally friendly waste management and reducing carbon emissions.

Keywords: *Socialization; Effective waste management and Penang Island.*

I. INTRODUCTION

In September 2024, several places in Malaysia were hit by flash floods and storms including Penang. In the area, the tide was seen high, causing a natural disaster, the flood in Penang caused chaos and made local residents look so panicked. This incident was caused by plastic waste that was thrown away by local residents carelessly, so the plastic waste returned to land when the water receded, as seen in picture 1 [1].

Fig 1. Photo of the floods in Penang leaving behind a lot of plastic waste

For the problem of plastic waste, especially in Malaysia, it needs to be handled so that unexpected natural disasters do not occur again. One way to handle plastic waste or including inorganic waste is by recycling so that it can be made into something that has value and function . In recent years, the development of waste-to-energy processing technology has grown rapidly as a sustainable solution to overcome waste problems and energy needs that focus on increasing efficiency and reducing environmental impacts. Technologies such as incineration with advanced filtration, pyrolysis, and gasification have improved performance, enabling the conversion of waste into clean energy with lower emissions.The economic and environmental aspects of various technologies emphasize the importance of integrating environmentally friendly technologies, such as gasification and biogas, which can reduce carbon emissions and produce cost-competitive energy.

This study also suggests that government policies and incentives are very influential in accelerating the adoption of this technology at the national and local levels. In innovations in converting municipal waste into bioenergy. They introduce new methods in anaerobic fermentation and thermal pyrolysis that can increase energy yields from organic waste and municipal solid waste. With the support of appropriate policies and continuously developing technological innovations, waste-to-energy transformation becomes a strategic solution in achieving sustainable development and responsible waste management.The definition of recycling here is one way to use used goods to be reused into useful items or can also be processed into goods that can be bought and sold [6-8]. Therefore, one of the best alternatives is to process waste through recycling. Waste management aims to improve public health and environmental quality and make waste a resource [9-10]. Become more skilled in processing waste, the community is more skilled in managing waste, and the community is able to be creative with inorganic waste through the transformation of paper and plastic waste into art as an added economic value [11].

With this recycling, it is expected to overcome environmental pollution, especially minimizing greenhouse gases. The latest alternative, especially plastic waste, can be used as fuel by recycling it into briquettes [1]. A study in South Africa showed that plastic recycling can save greenhouse gas emissions is to provide counseling to overcome plastic problems.Based on the waste problem in Penang, one solution is to handle plastic waste by processing it into oil as an alternative material to replace fuel or coal. So that it can be used to produce alternative energy and reduce greenhouse gas emissions. Based on the problems described above, the solution that will be implemented is to provide assistance in processing plastic waste through training for PERMAD administrators and members, using simple tools that can produce oil through the pyrolysis process, where this oil can be used as a substitute for fuel or coal which can be sold to the public as an alternative fuel.Community Service conducted in the PERMAD unity group aims to provide counseling on making briquettes, especially from plastic waste to reduce greenhouse gas emissions. These plastic briquettes are very useful as alternative fuels that are useful and beneficial and the surrounding environment will be healthier, free from odor and germs.

II. PROBLEMS AND SOLUTIONS

Based on the problems described above, we intend to conduct community service activities with the topic "Utilization Of Plastic Waste Into Briquettes As An Alternative Fuel To Minimize Greenhouse Gase.

Table 1. Permad Partner Problems

No	Problem	Description
1	Accumulation of unprocessed plastic waste	PERMAD members collect inorganic waste, especially plastic waste, to be turned into oil as an alternative fuel.
2	The lack of scientific and technological knowledge regarding useless inorganic waste can be useful and can improve the economy.	PERMAD members generally do not have scientific and technological knowledge related to knowledge about how plastic waste can be processed into oil products through the pyrolysis process which is useful as an alternative fuel and has a selling value.

Based on the problems described above, the solution that will be implemented is to provide assistance in processing plastic waste into oil through training for PERMAD administrators and members, using simple tools that produce oil as an alternative fuel that can be sold to the community.Table 2. Alternative Solutions Are Offered As Follows;

Table 2. Alternative Solutions

No	Solution	Outcome Target
1	Providing learning assistance, counseling and training on the utilization of plastic waste into oil to PERMAD administrators and members.	• Module for making oil as an alternative fuel from plastic waste
2	Providing training assistance on how to make oil from plastic waste through the pyrolysis process carried out by a team of lecturers and students from Mercu Buana University accompanied by a special trainer.	Improving the ability of PERMADI administrators and members in mastering the technique of making briquettes from plastic waste.

III. ACTIVITY IMPLEMENTATION STAGES

The cut plastic is put into the pyrolysis cylinder/reactor. The combustion chamber is used as fuel. The blower is turned on when the fuel starts to burn. The reactor heater is set according to the process temperature, namely at temperatures of 350℃, 400℃, 450℃ respectively. After reaching the specified temperature, the time is counted as the initial time. After combustion occurs, turn off the blower and close the combustion chamber on the pyrolysis device until the temperature starts to increase. and the operation is stopped when no more oil liquid is produced, then left to cool, design of the device can be seen in Figure 2.

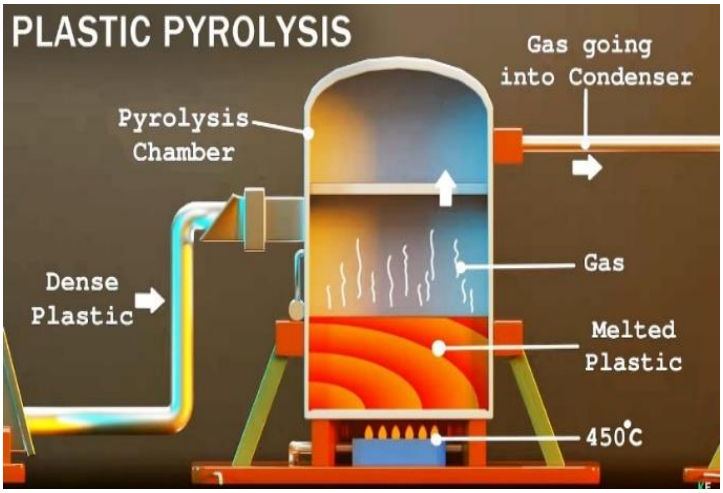

Fig 2. Design of Pyrolysis Process tool from plastic waste into alternative fuel oil

IV. RESULTS OF ACTIVITY IMPLEMENTATI

The target of this activity is PERMAD members located approximately 118 KM from the Mercu Buana University campus. The implementation method used in this activity is in the form of counseling on how to process plastic waste, especially those that can be processed into products that can be traded to create selling value to increase the economic level of partners. The PPM team went directly to the location both during the opening and presentation of materials and Q&A discussions. In order for this program to run smoothly, before all activities began, socialization was carried out to related parties, who are interested in the sustainability of this program. With this socialization, it is hoped that all related parties can fully support this program both institutionally, materially and morally.We report that the Community Partnership Program (PKM) activities in Penang Island with PERMAD Partners consisting of Indonesian Migrant Workers who generally work in factories, we started by conducting initial exploration when preparing the proposal to find out the problems, solutions and targets and asking for the willingness of partners to sign a letter of cooperation.

PKM Utilization of Plastic Waste into Oil as an Alternative Fuel.The increasing amount of plastic waste is a serious problem throughout the world, including Indonesia. Plastic waste that is not managed properly can pollute the environment, threaten the health of humans and other living things, and cause ecosystem damage. On the other hand, the need for energy sources is increasing while the availability of fossil fuels is decreasing and their prices are unstable. Therefore, innovation is needed in waste management and the search for alternative energy sources that are environmentally friendly. One promising innovation is utilizing plastic waste into oil as an alternative fuel. This technology not only helps reduce the volume of plastic waste in the environment, but also produces energy that can be used as a substitute for fossil fuels.

The objectives of the Extension in Penang Island are;

- Increase public awareness of the potential of managing plastic waste into fuel
- Provide an understanding of the process of converting plastic waste into oil
- Encourage community participation in sustainable and innovative waste management

Plastic waste is one of the types of waste that is most difficult to decompose naturally. Based on data from the Ministry of Environment and Forestry, Indonesia produces around 3.2 million tons of plastic waste per year, most of which ends up in the ocean, threatening marine life and terrestrial ecosystems.

The negative impacts of plastic waste include:

- Clogging waterways and causing flooding
- Polluting soil and water sources
- Endangering human and living creature health through exposure to chemicals from plastic

Plastic Waste Utilization Concept

Traditional recycling only reduces the volume of plastic waste, but pyrolysis technology offers a solution to convert plastic waste into fuel. This conversion is done through a process called pyrolysis, which is heating plastic waste in conditions without oxygen, resulting in hydrocarbons that can be processed into oil.

Process of Converting Plastic Waste into Oil

The Pyrolysis process is the main method in converting plastic waste into oil. Here is a brief explanation of the process:

1. Preparation of Plastic Waste Plastic waste is washed and cut into small pieces to facilitate the process.
2. Heating in Pyrolysis Reactor**: Plastic waste is put into a reactor that is heated to a temperature of around 300–500°C without oxygen.
3. Formation of Hydrocarbons**: At this temperature, plastic waste melts and decomposes into hydrocarbon gas and liquid.
4. Condensation The resulting gas is cooled and condensed into oil.
5. Oil Collection: Pyrolysis oil is collected and can be used as fuel.

Tools and materials needed:

- Pyrolysis reactor
- Heater and temperature control system
- Cooling and condensation system
- Clean and cut plastic waste

Benefits and Potential

- Reduces the volume of plastic waste in the environment, thereby helping to overcome pollution and overloaded landfills
- Produces alternative fuels that can be used for combustion in industry or vehicles- Supporting sustainable energy development and reducing dependence on fossil fuels

Challenges and Constraints

- Availability of adequate technology and tools
- Regulation and safety standards in the processing and use of pyrolysis oil
- Potential health and environmental risks if the process is not carried out properly
- Quite large initial investment costs

Implementation Steps

- Educate the community and industry players about the benefits and process of converting plastic waste
- Development of small to large scale pyrolysis facilities
- Government support through regulations and incentives
- Good waste management and efficient collection of raw materials

The utilization of plastic waste into oil as an alternative fuel is a strategic innovation that can answer two problems at once: reducing environmental pollution and meeting energy needs. Pyrolysis technology offers an effective solution, but requires technological support, regulations, and public awareness for its success. With continuous collaboration and innovation, the utilization of plastic waste can be part of a cleaner and more environmentally friendly future energy solution.Through this outreach, it is hoped that the community will become more aware of the importance of innovative and environmentally friendly waste management. The use of pyrolysis technology to convert plastic waste into oil is a real step towards creating a cleaner environment and sustainable energy sources. The evaluation results of this outreach were conducted using questionnaires and interviews. Where the results of the questionnaire showed that in general the partners were satisfied with the holding of this Community Service, almost 90% stated that they were satisfied. Beberapa kegiatan PKM dapat dilihat pada Gambar 3.

Fig 3. Kegiatan Penyuluhan Team Dosen Teknik Mesin UMB pada Mitra PERMAD di Pulau Pinang

V. CONCLUSION

Community service activities at Mitra PERMAD, an association of Indonesian Migrant Workers in Pulau Pinang, have been implemented and completed according to the target of providing counseling on the processing of inorganic waste, especially plastic waste which is processed using the Pyrolysis method to be used as fuel oil for fuel that can be used to produce energy.

VI. ACKNOWLEDGEMENTS

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REFERENCES

[1] (https://trends.tribunnews.com/2024/09/20/bumi-bak-balas-dendam-viral-laut-pasang-di-malaysia-kembalikan-sampah-manusia-ke-daratan

[2] Juliya Ascha Riandis, Agus Restu Setyawati1, Dan Ari Susandy Sanjaya.2020. Pengolahan Sampah Plastik Dengan Metode Pirolisis Menjadi Bahan Bakar Minyak. ***Jurnal Chemurgy.*** Vol. 05, No.1, Juni 2021, 8-14

[3] Alfi Tranggono, Nanang Romandoni dkk 2021, PKM Penerapan IPTEK dalam Pengolahan Sampah Organik Menjadi Pupuk Organik , ***Jurnal Pengabdian Kepada Masyarakat Dikemas*** Vol. 5, No. 2

[4] Novi Marliani, 2014. Pemanfaatan Limbah Rumah Tangga (Sampah Anorganik) Sebagai Bentuk Implementasi Dari Pendidikan Lingkungan Hidup. ***Jurnal Formatif,*** Vol 4 No.2 Hal 124-132.

[5] Andy & Lina Purnama, 2019. Eksibisi Daur Ulang Sampah Anorganik, ***Jurnal STUPA*** Vol. 1, No. 1, April 2019. hlm: 376-389

[6] I Gusti Ayu Arwati, , Euis Nina, Nur & Diana Lutfiana, 2021, Developmentand Applicationofappropriate Technology To Recyclewasteperformed, ***Dinasti International Journal of Management Science***, Volume 2, Issue 4, March 2021

[7] Zico Fakhrur Rozi , Dian Samitra , Harmoko, 2021, Pengolahan Sampah Organik Rumah Tangga Menjadi Pupuk Organik Di Kelurahan Ponorogo Kota Lubuklinggau, ***Jurnal Cemerlang: Pengabdian pada Masyarakat*** ,Vol. 4, No. 1, Desember 2021, 14 – 21

[8] Rozaidin, 2020. Penerapan Akuntansi Pondok Pesantren (Studi pada Koperasi Pondok Pesantren Al Hasyimi Kabupaten Pekalongan), ***Journal of Economic Studies Ekonomika Syariah***, Vol 4, No.2 hal 136 – 147.

[9] I Gusti Ayu Arwati,Euis Nina, Nur & Nur Endah Retno Wuryandari, 2020, Overcoming Obstacles In The Development Of Ikrt / Umk Through Application Of Appropriate Technology, ***Dinasti International Journal of Digital Business Management***, Volume 1, Issue 3, May 2020.

[10] Hari Siitiyawatji, I Gusti Ayu Arwat, dkk.2023. Pengolaltan Sampah Orgaruk & Anorg,mik; Produk Daur Ulang; Digital Marketing. Akutansi Humaniora , ***Jurnal pengabdian Masyarakat*** , Vol 2.

[11] I G A Arwati et.al. 2024. Counseling And Making Environment Friendly Cleansing Using Fruit And Flower Extractsin The Framework Of Increasing The Welfare Of Teachers And Preparing Independent Entrepreneurship For SMA-IT Studentsriyadhussholihiin Islamic Boarding School- Cimanuk-Pandegelang. ***International Journal Of Community Service***, vol

[12] Kementerian Lingkungan Hidup dan Kehutanan RI. Data Sampah Nasional 2023.

[13] Zhang, et al. "Plastic waste to fuel: a review." Renewable and Sustainable Energy Reviews, 2020

[14] S. Ahmad, et al. "Pyrolysis of plastic waste: A review." Waste Management, 2019.

[15] Badan Standardisasi Nasional (BSN). Standar Proses Pirolisis Plastik.