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UTILIZATION OF ROCKWOOL WASTE AS A SILENCER IN MUFFLERS

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ABSTRACT:
The Program to Utilize Rockwool Waste as a Silencer in Mufflers is an innovation program to reduce the generation of non-B3 solid waste in equipment maintenance activities, where rockwool, which is usually waste, can be utilized by MSMEs around the company as the main material for muffler silencers in their exhaust workshop businesses. have. So, this program can be useful to support MSMEs around the company. In addition, for companies utilizing this waste, it can save waste processing costs which are routinely incurred by the company. Quantification of environmental improvements as a result of this program was able to reduce the generation of non-B3 solid waste by 750 kg (0.75 tons) and save costs of Rp. 1,687,500, - which was obtained from the calculation of cost savings for rockwool waste disposal. In addition, reducing noise on the environment refers to the Minister of the Environment Number P.56/MenLHK/Setjen/Kum.1/10/2019 concerning Noise Quality Standards for New Types of Motor Vehicles and Motor Vehicles that are being produced in Category M, Category N, and Category L, where after using rockwool as a silencer the exhaust produces noise (dB) below the threshold. noise (dB) below threshold. This innovation program also has added value in the form of a value chain, for the company it saves Rp. 1,687,500 in waste management costs. For MSME consumers, they can save a material purchase budget of IDR 1,125,000. Furthermore, for suppliers with routine maintenance activities by the company, the use of rockwool as a heat insulator for repaired equipment will always be needed. This will be an advantage for the rockwool supplier as the main and sustainable supplier, because the supplier can supply 1.2 tons per maintenance process.

Keywords: Quantification of Environmental Improvement; Savings; MSMEs; Value Added in the Form of Value Chains; Consumers; Suppliers.

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INTRODUCTION

Noise pollution increases blood pressure and therefore has long-term health effects (Surana, 2016). In addition to high blood pressure, noise and vibration also affect balance and hearing functions, while noise and vibration can damage the cochlea and cause balance disorders (Listyaningrum, 2011). With the needs of development, the use of industrial equipment and devices that cause noise and vibration in developing countries including Indonesia is increasing from time to time. This must be anticipated to prevent loss of human resources, one of which is vibration and noise dampening (Ruray, 2012).

Decree of the Minister of Health No. The Healthy Noise Act 718 of 1987 stipulates the area is divided into four zones. For zone C which includes offices, shops, commerce and markets, the noise level is around 50 □ 60 dB (Menlh.go.id, 2018). In this zone, especially in big cities, vehicle exhaust fumes are the main source of noise (Nurdiana et al., 2015). The International Organization for Standardization ISO 5130; 2002 defines instrumentation and environmental testing procedures for exhaust noise (Magazine Bruel Kjaer, 2020). Inexpensive noise reduction and simple technology requires careful planning.

One way to prevent the propagation/radiation of noise on machine parts/structures, rooms/buildings and those related to industrial noise OHS is to use acoustic materials, ie. H. Materials that absorb or dampen sound so that the noise generated can be reduced (Rohim et al., 2020). The quality of the sound insulation material is expressed by the value α (sound absorption coefficient), the higher the α the better it is used for sound insulation. The value of α varies from 0 to 1. If the value of α is 0, it means that no sound is absorbed. If α equals 1, this also means that the material absorbs 100% of the incident sound. It is believed that soft, porous and fibrous materials can absorb sound energy that hits them (Milawarni & Saifuddin, 2018). Of the three material properties, porous materials are often used. This is because relatively porous materials are cheaper and lighter than other absorbent types (Lee et al., 2012). Materials that have long been used in this type of silencer are glass wool and rock wool (Priyoko, 2011).

Incident sound waves undergo motion in the airways of porous materials (Pasaribu, 2016). Because the channel is very narrow, the frictional resistance of the flow is high, and the kinetic energy of the inflow and outflow is converted into heat energy through friction. The degree of porosity, layer thickness and frictional resistance to flow through the pores affect the final value of the absorption coefficient. Absorbent materials should reflect as little incident sound energy as possible. This can be achieved with relatively wide pores with low flow resistance. The larger the air space

in a solid material, the greater the relative probability that sound energy entering the pores will not be reflected. Conversely, if the channel is wide enough, the friction is low and the velocity of the incoming energy is also reduced.

The front surface reflects the energy of the acoustic flow which does not have time to be converted into heat energy before it reaches the more distant surface of the material. And so on, and if it is not completely absorbed, then the energy leaves the matter and is reflected back into space. Thus it can be seen that a high flow resistance means that most of the acoustic energy enters the absorption layer, whereas a low flow resistance means that only a small amount of incoming energy is absorbed.

Good indoor acoustics is influenced by objective and subjective factors that are interrelated (Wardani & Kumalasari, 2008). This objective factor is reinforced by several acoustic theories, starting with the theory of reverberation time, the most popular of which was W. C. Sabines in the 19th century. Reverberation time is the time required for the sound pressure to decrease by 60 dB after the sound source suddenly stops (Rohmah, 2012). Sabine found that reverberation time is independent of location in the room, ie. overall character of the room. The sound doesn't just disappear once the sound source is stopped, but continues for some time due to reflections from walls, ceilings, or other surfaces.

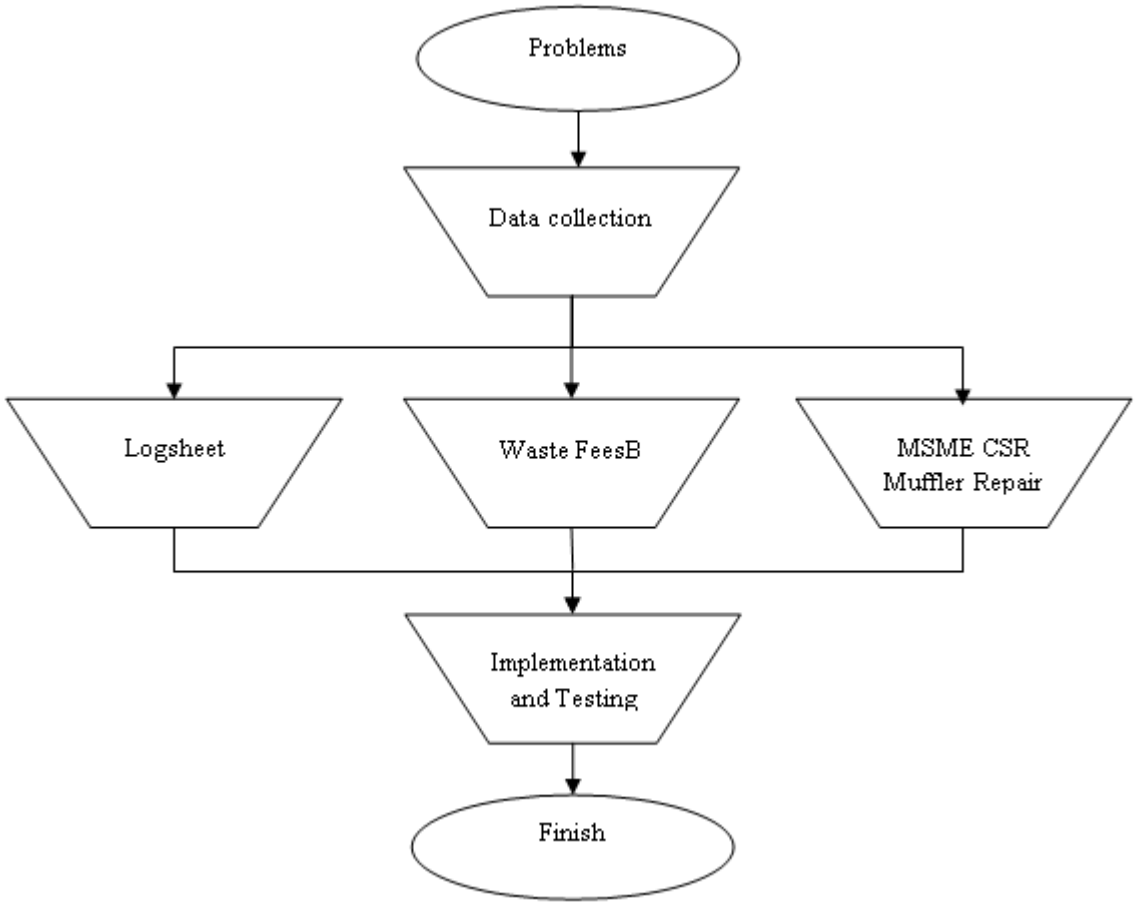
Every activity will produce residue or waste, including equipment maintenance activities carried out by PT PLN Nusantara Power UP Paiton. One of the wastes arising from equipment maintenance activities is rockwool. Rockwool is a fiber-shaped material used as a heat insulation material in power generation equipment. Insulation using rockwool is used in generator equipment with a temperature of ± 200 ˚C. Rockwool as an insulating material can maintain heat efficiency, prevent heat loss in generating equipment, and serves as a protection for workers from exposure to heat from power generation equipment.

In the process of maintaining the reliability of the generator, maintenance and replacement of equipment is carried out, so that the rockwool attached to the equipment must be dismantled and replaced. The amount of rockwool waste produced every year is quite a lot, reaching 2796 kg in the last 5 years at PT PLN Nusantara Power UP Paiton. With this amount of generation, the potential for environmental pollution that occurs due to its management is also high which results in an increase in the potential for disruption of the electricity production process. In addition to the potential disruption to the production process, high rockwool production results in increased rockwool waste management costs. At PT PLN Nusantara Power UP Paiton the cost of rockwool management reached IDR 6,291,000.00 in the last 5 year period.

With the problems that arise above, PT PLN Nusantara Power UP Paiton as a company that always encourages the development of the national economy by

providing high quality, reliable and environmentally friendly electrical energy has developed an innovative program to Utilize Rockwool Waste as an Exhaust Silencer. This program comes from the company itself, where the idea for this innovation program arose because of the high rockwool generation conditions at PT PLN Nusantara Power UP Paiton and the community around the PLTU has a professional exhaust repair service. The company's innovation stems from an opportunity to empower the community around the PLTU to utilize rockwool in overcoming existing problems. Therefore, PT PLN Nusantara Power UP Paiton carried out an innovative program of Utilizing Rockwool Waste as an Muffler Silencer with the aim of utilizing Rockwoll as a silencer material in exhausts and reducing the generation of Non-B3 Rockwool waste in the company.

RESEARCH METHODS



RESULTS AND DISCUSSION

PT PLN Nusantara Power UP Paiton carried out an innovative program of Utilizing Rockwool Waste as an Muffler Silencer which is the use of rockwool which is usually not utilized to be converted into a

muffler silencer material. This innovation was implemented for the first time in Indonesia in the power generation sector according to Best Practice 2021 from the Ministry of Environment and Forestry and has never been implemented in the aspect of non-B3 solid waste.

A. System Change from the Innovation Program

The Rockwool Waste Utilization Program as an Muffler Silencer has an impact on component changes, namely process improvement where there are changes in the treatment of rockwool waste, with the following explanation:

1. Conditions before the program:

   The company performs equipment maintenance on overhaul activities every 2 times in 1 year. In these maintenance activities, routine pipe replacement in the tube boiler is carried out as well as repair of tool components in generator equipment. Rockwool, which is used to protect equipment that has temperatures above 200 degrees Celsius, will become waste after replacing equipment during maintenance activities. Furthermore, rockwool waste will be transported and processed by the waste manager.

2. Conditions after the program:

   In maintenance activities, rockwool waste is one of the wastes that has not been utilized. With this program, the company had the idea to utilize rockwool waste as a muffler material for motorized vehicles and this rockwool waste could be utilized by the community as the main material for muffler silencers in their muffler workshop business. So, this program can be useful to support MSMEs around the company.

The process improvement that is being carried out is to utilize rockwool waste which is usually unused to be used by the community as the supporting capacity of MSMEs in the community, namely Rockwool waste is used as an exhaust muffler at MSME workshops.

B. Environmental Impact of the Innovation Program

The resulting environmental impact is that this innovation program can reduce the generation of non-B3 solid waste by 750 kg (0.75 tons) and reduce noise in the environment referring to the Minister of the Environment Number P.56/MenLHK/Setjen/Kum.1/10/2019 Concerning the Noise Quality Standards for New Types of Motor Vehicles and Motor Vehicles that are being produced in Category M, Category N, and Category L, where after using rockwool as a muffler, the exhaust produces noise (dB) below the threshold. This program is also included in product sharing eco-innovation where the results of the innovation can be used by the community which is equivalent to a cost savings of IDR 2,812,500.-. The calculation of the absolute value and budget savings for the innovation program is as follows:

1. Absolute yield calculation

   Absolute calculations are carried out by collecting data on the rockwool weighing used and the following data is obtained:

Year	Rockwool waste generated (ton)	Utilized rockwool waste (ton)
2021	0,750	0,750

2. Calculation of budget savings

   The purchase price of the muffler silencer material is Rp. 1,500,000/ton (Rp. 20,000/kg). The price of rockwool waste disposal is IDR 2,250,000/ton.

   Savings on Purchase of Rockwool Materials
   = Absolute Result x Material Price
   = 0.75 tons x IDR 1,500,000/ton
   = IDR 1,125,000

   Rockwool Waste Savings
   = Absolute Yield x Waste Price
   = 0.75 tons x IDR 2,250,000/ton
   = IDR 1,687,500

   Total Savings
   = Material Purchase Savings + Waste Savings
   = IDR 1,125,000 + IDR 1,687,500
   = IDR 2,812,500

C. Value Added Innovation Program

The added value of this innovation program is in the form of a value chain, which is able to reduce used material waste at PT PLN Nusantara Power UP Paiton and also provides benefits for consumers/users, namely the MSME management community. The advantages derived from this program are:

1. Manufacturer/company

   Can have a positive impact on the environment because it can reduce the generation of Non-B3 Rockwool Waste. By utilizing it, it can save management costs in the form of waste costs of IDR 1,687,500 and reduce the potential for environmental pollution.

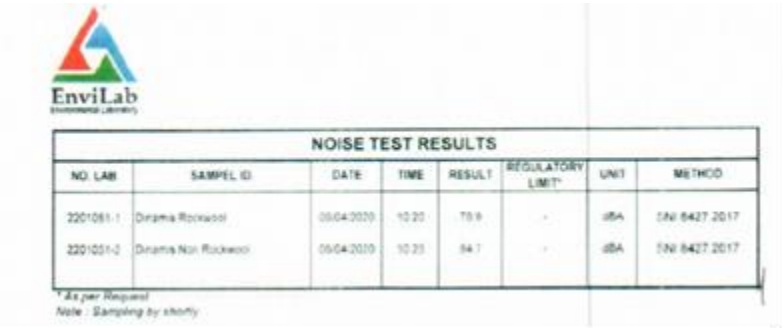
2. Consumer

   According to the results of noise measurements, the exhaust of motor vehicles using sound absorbers from rockwool waste does not exceed the noise threshold of <80 dB. For exhaust shop business owners, they can save a material purchase budget of Rp. 1,125,000.-.

3. Suppliers

   With routine maintenance activities by the company, the use of rockwool as a heat insulator for repaired equipment will always be needed. This will be an advantage for the rockwool supplier as the main and sustainable supplier, because the

supplier can supply 1.2 tons per maintenance process.



EnviLab

NOISE TEST RESULTS

NO. LAB	SAMPEL ID	DATE	TIME	RESULT	REGULATORY LIMIT*	UNIT	METHOD
2201051-1	Drama Rockwool	06/04/2020	10.20	78.9	-	dBA	SNI 8427:2017
2201051-2	Drama Non Rockwool	06/04/2020	10.23	84.7	-	dBA	SNI 8427:2017

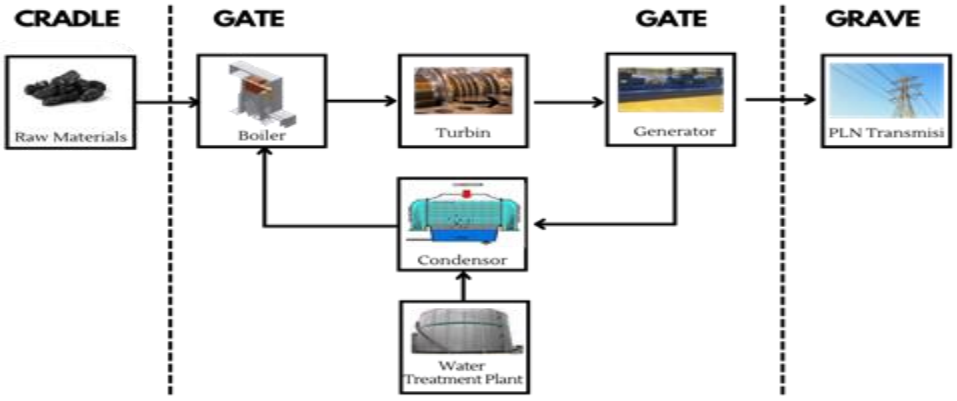
*As per Request
Note : Sampling by shortly

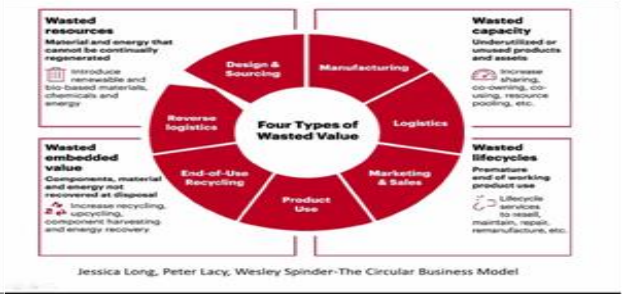
D. Noise testing

To ensure that the use of rockwool waste as a silencer in the exhaust complies with quality standard regulations, refer to the Minister of the Environment Number P.56/MenLHK/Setjen/Kum.1/10/2019 concerning Noise Quality Standards for New Types of Motor Vehicles and Motor Vehicles that are currently produced in Category M, Category N, and Category L, the sound intensity test was carried out with the following results.

No	Waste Type	Product	Quality standards	Test results	Information
1	*Rockwool*	Silencer	80dB	78,9 dB	Below threshold
2	*No Rockwool*	Silencer	80dB	84,7 dB	Above threshold

E. Scope & LCA 2021





The innovation program for Utilizing Rockwool Waste as an Muffler Silencer is an innovation of use of product neither consumes material nor generates waste which is carried out in boilers and has been included in the scope of the 2021 Life Cycle Assessment (LCA) study. In the LCA study, boilers are included in the Production scope. Whereas in the Circular Business Model, this program is an innovation of waste embedded value (increase recycling), in which there is process optimization to utilize rockwool waste into products that have economic value.

CONCLUSION

This program is the first program carried out in the PLTU Sector and no similar program is found in the 2019-2021 Ministry of Environment and Forestry Best Practice Book. Quantification of environmental improvements as a result of this program was able to reduce the generation of non-B3 solid waste by 750 kg (0.75 tons) and save costs of Rp. 1,687,500, - which was obtained from the calculation of cost savings for rockwool waste disposal. In addition, reducing noise on the environment refers to the Minister of the Environment Number P.56/MenLHK/Setjen/Kum.1/10/2019 concerning Noise Quality Standards for New Types of Motor Vehicles and Motor Vehicles that are being produced in Category M, Category N, and Category L, where after using rockwool as a silencer the exhaust produces noise (dB) below the threshold.

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BIBLIOGRAFI

Lee, J., Kim, G., & Ha, C. (2012). Sound absorption properties of polyurethane/nano-silica nanocomposite foams. *Journal of Applied Polymer Science*, *123*(4), 2384–

2390. https://doi.org/10.1002/app.34755.

Listyaningrum, A. W. (2011). *Pengaruh Intensitas Kebisingan Terhadap Ambang Dengar pada Tenaga Kerja di PT Sekar Bengawan Kabupaten Karanganyar*. UNS (Sebelas Maret University).

Magazine Bruel Kjaer. (2020). *The International Sound and Vibration No. 2, 2003*.

Menlh.go.id. (2018). *Penilaian kwantitatif Kebisingan*.

Milawarni, M., & Saifuddin, S. (2018). Pembuatan Plazore dari Plastik Bekas dengan Media Minyak Jelantah dan Aplikasi sebagai Peredam Bunyi. *Jurnal Teknologi Kimia Unimal*, *6*(2), 52–62. https://doi.org/10.29103/jtku.v6i2.475.

Nurdiana, N., Wahyudi, M., & Mahyunis, M. (2015). Pengukuran Tingkat Kebisingan Knalpot Mobil Penampang Oval secara Simulasi. *Mekanik*, *1*(2), 329140.

Pasaribu, M. H. (2016). *Studi Eksperimental Perbandingan Karakteristik Kebisingan Knalpot Standart Satria Fu 150 dengan Knalpot Komposit Serat Batang Kelapa Sawit Berdasarkan pada Kecepatan*.

Priyoko, B. B. (2011). *Pembuatan Panel Akustik Material Komposit Serat Alami Ampas Tebu (Saccharum Officinarum) Dan Ijuk*. Universitas Islam Indonesia.

Rohim, A. M., Fianti, F., & Nurbaiti, U. (2020). Potensi Sekam Padi dan Jerami sebagai Alternatif Material Akustik. *Physics Education Research Journal*, *2*(1), 35–42. https://doi.org/10.21580/perj.2020.2.1.4883.

Rohmah, O. B. M. (2012). *Analisis Waktu Dengung (Reverberation Time) Pada Ruang Kuliah B Iii. 01 A Fmipa Uns Surakarta*. UNS (Sebelas Maret University).

Ruray, R. R. (2012). *Gangguan Pendengaran Akibat Bising pada Pekerja Bagian Maintenance di PT. Eastern Flour Mills Makassar*. Universitas Hasanuddin.

Surana, T. J. E. A. (2016). *Hubungan Paparan Kebisingan dengan Peningkatan Tekanan Darah pada Pekerja Ground Handling di Bandara Supadio Pontianak*.

Wardani, L. K., & Kumalasari, Y. (2008). Sistem Akustik Pada Interior Kapel Rumah Sakit Katolik Vincentius a Paulo Di Surabaya. *Dimensi Interior*, *6*(1), 63–72. https://doi.org/10.9744/interior.6.1.pp.%2063-72.