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TREADMILL GENERATOR POWER ANALYSIS DUE TO SPEED AND TIME CHANGES

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Abstract
The increasing global demand for electricity and the depletion of fossil fuel reserves have intensified the need to develop renewable and environmentally sustainable energy sources. One promising alternative is the utilization of human kinetic energy generated during physical exercise. This study investigates the potential of a manual treadmill as a micro-scale electricity generation system by converting kinetic energy into electrical energy through a direct current (DC) generator. The research aims to analyze the electrical power output produced under different treadmill operating conditions and to evaluate the feasibility of this system as an alternative renewable energy source. An experimental method was employed by testing three treadmill speed variations (10 km/h, 20 km/h, and 40 km/h) and three operating durations (15, 30, and 45 minutes). The measured parameters included generator rotational speed, output voltage, electric current, electrical power, and the amount of energy stored in a 12 V/5 Ah battery. The findings indicate that increasing treadmill speed significantly improves voltage, current, and power output, resulting in greater electrical energy storage. However, prolonged operation leads to a gradual decrease in current output due to human physical fatigue, which affects the stability and efficiency of energy conversion. Overall, the study demonstrates that a manual treadmill has considerable potential as a renewable micro-power generation system for low-power electrical applications, emergency electricity supply, and sustainable energy development, while promoting environmentally friendly utilization of human-generated kinetic energy.

Keywords: enewable energy, kinetic energy conversion, manual treadmill, DC generator, micro power generation, electrical energy

Abstrak
Penelitian ini dilatarbelakangi oleh pentingnya pengembangan sumber energi terbarukan yang ramah lingkungan dan efisien sebagai respons terhadap meningkatnya kebutuhan energi listrik serta keterbatasan sumber energi fosil. Salah satu alternatif yang berpotensi dikembangkan adalah pemanfaatan energi kinetik yang dihasilkan dari aktivitas fisik manusia melalui treadmill manual. Penelitian ini bertujuan untuk menganalisis daya listrik yang dihasilkan oleh generator DC yang dipasang pada treadmill manual berdasarkan variasi kecepatan dan lama waktu pengoperasian. Penelitian menggunakan metode eksperimen dengan tiga variasi kecepatan, yaitu 10 km/jam, 20 km/jam, dan 40 km/jam, serta tiga variasi waktu pengujian, yaitu 15 menit, 30 menit, dan 45 menit. Parameter yang diukur meliputi tegangan, arus, daya listrik yang

dihasilkan, serta energi yang tersimpan pada baterai 12 V 5 Ah. Hasil penelitian menunjukkan bahwa peningkatan kecepatan treadmill berpengaruh langsung terhadap peningkatan tegangan, arus, dan daya listrik yang dihasilkan, sehingga energi yang tersimpan pada baterai juga semakin besar. Namun demikian, efisiensi sistem dipengaruhi oleh kestabilan tenaga yang dihasilkan pengguna, di mana penurunan kemampuan fisik selama pengoperasian menyebabkan arus listrik cenderung menurun pada durasi yang lebih lama. Temuan ini menunjukkan bahwa treadmill manual memiliki potensi untuk dikembangkan sebagai pembangkit listrik skala mikro yang memanfaatkan energi kinetik manusia, terutama untuk memenuhi kebutuhan listrik berdaya rendah serta mendukung pengembangan teknologi energi terbarukan yang berkelanjutan.
Kata kunci: *energi terbarukan, energi kinetik, generator DC, pembangkit listrik skala mikro, treadmill manual.*

INTRODUCTION

The twenty-first century has witnessed an unprecedented increase in global energy consumption driven by rapid population growth, industrial expansion, urbanization, and technological advancement. Electricity has become one of the most fundamental human needs because almost every sector of modern life—including education, healthcare, transportation, communication, manufacturing, and household activities—depends heavily on a stable electricity supply. Access to reliable electrical energy is now considered one of the major indicators of national development and economic competitiveness. According to the International Energy Agency, global electricity demand continues to rise every year due to increasing digitalization, electrification of transportation systems, and industrial modernization (International Energy Agency [IEA], 2023). Consequently, countries worldwide are challenged not only to increase electricity production but also to ensure that energy generation remains environmentally sustainable and economically feasible.

Indonesia is no exception to this global trend. As one of the world's largest archipelagic countries, Indonesia consists of more than seventeen thousand islands with highly diverse geographical characteristics. Supplying electricity to remote islands, mountainous regions, and isolated communities remains one of the country's greatest infrastructure challenges. Although the national electrification ratio has increased significantly during the last decade, disparities in electricity availability between urban and rural regions still exist. Electricity demand continues to increase annually as a consequence of population growth, economic development, industrial expansion, and improvements in people's quality of life (Yani, 2021). The increasing dependence on electrical energy requires Indonesia to continuously improve both electricity generation capacity and energy distribution systems while simultaneously reducing environmental degradation caused by conventional energy sources.

The increasing demand for electricity is closely associated with population growth. The global population surpassed eight billion people in recent years, resulting in significantly higher energy consumption across almost every sector. Larger populations require more residential buildings, transportation systems, manufacturing industries, communication infrastructure, hospitals, educational institutions, and commercial facilities, all of which depend heavily on electrical power. However, while energy demand continues to rise rapidly, the availability of conventional energy resources is becoming increasingly limited. Fossil fuels—including coal, petroleum, and natural gas—are finite resources that require millions of years to form naturally. Continuous exploitation without adequate replacement inevitably leads to resource depletion and long-term energy insecurity (Mustika, 2020).

Beyond resource depletion, fossil fuel consumption contributes substantially to environmental degradation. The combustion of coal, petroleum, and natural gas produces large quantities of carbon dioxide (CO_2), methane (CH_4), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and particulate matter that accelerate global warming, climate change, acid rain, and air pollution. The Intergovernmental Panel on Climate Change has consistently emphasized that greenhouse gas emissions from fossil fuel combustion remain the dominant driver of anthropogenic climate change (IPCC, 2023). Rising global temperatures have resulted in increasingly frequent extreme weather events, prolonged droughts, floods, sea-level rise, biodiversity loss, and significant threats to food security and human health. Consequently, reducing dependence on fossil fuels has become a strategic priority for governments worldwide.

The Indonesian government has responded to these challenges by promoting renewable energy development through various national energy policies. Renewable energy refers to energy obtained from naturally replenishing resources, including solar radiation, wind, hydropower, geothermal energy, ocean waves, tidal movement, and biomass. Unlike fossil fuels, renewable energy sources can be continuously regenerated and generally produce significantly lower greenhouse gas emissions. The transition toward renewable energy is therefore viewed as an essential strategy for achieving sustainable development while supporting global commitments to carbon emission reduction (Putri & Yushardi, 2023).

Recent studies indicate that Indonesia possesses enormous renewable energy potential. The country has abundant geothermal reserves due to its location within the Pacific Ring of Fire, extensive solar irradiation throughout the year, substantial hydropower resources, strong coastal wind potential, and abundant biomass generated from agricultural activities (Larobu et al., 2024). Nevertheless, despite this enormous potential, renewable energy contributes only a relatively small proportion of the national electricity mix. Financial constraints, technological limitations, infrastructure challenges, and public awareness remain major barriers to wider renewable energy adoption.

In addition to conventional renewable energy technologies, researchers have increasingly explored unconventional energy harvesting methods capable of capturing energy from daily human activities. Human motion represents a promising renewable energy source because mechanical energy generated during walking, running, cycling, or exercising can be converted into electrical energy using electromechanical conversion systems. Such systems generally employ generators, permanent magnets, flywheels, gears, or piezoelectric devices to transform kinetic energy into usable electricity.

Among various human-powered energy harvesting technologies, treadmills offer particularly interesting opportunities. Treadmills are widely available in homes, schools, universities, fitness centers, rehabilitation facilities, and sports complexes. During exercise, users generate considerable mechanical energy through continuous running or walking. Under conventional conditions, this kinetic energy is dissipated entirely as heat through friction without producing any additional benefits. By integrating an electrical generator into the treadmill mechanism, rotational kinetic energy can be converted into electrical power that may be stored in batteries or directly utilized to power low-energy electrical devices.

Kinetic energy harvesting through treadmills represents one form of micro-scale renewable energy generation. Although the amount of electricity generated by a single treadmill may be relatively limited, the cumulative energy produced by multiple users operating continuously within fitness centers or educational institutions may become significant. Moreover, such systems simultaneously promote physical fitness and renewable energy awareness, creating both environmental and educational benefits (Ulva et al., 2023).

Electrical energy has become an indispensable component of modern society. Almost every electronic device—including lighting systems, computers, mobile phones, medical equipment, laboratory instruments, and communication technologies—depends entirely on electricity (Demeianto et al., 2021). Consequently, exploring alternative electricity generation methods that utilize existing human activities represents an innovative strategy for supporting sustainable energy development while reducing environmental impacts.

Previous research concerning renewable energy has predominantly focused on solar photovoltaic systems, wind turbines, hydroelectric power plants, biomass conversion technologies, geothermal power generation, and ocean energy. These technologies undoubtedly possess enormous generation capacities but often require substantial investment costs, sophisticated infrastructure, extensive land use, and advanced maintenance systems. Comparatively fewer studies have investigated simple renewable energy technologies that can be implemented using equipment already available in everyday environments.

Several studies investigating human-powered electricity generation have demonstrated promising results. Human kinetic energy harvested through bicycles, exercise equipment, and pedestrian footstep systems has successfully generated sufficient electricity to charge batteries, illuminate LED lighting systems, and power small electronic devices. Nevertheless, most existing studies focus primarily on prototype development rather than comprehensive analyses of energy conversion efficiency, mechanical losses, rotational dynamics, and optimization of generator performance.

Furthermore, previous investigations generally evaluate electricity generation under laboratory conditions without examining practical implementation within public fitness facilities. The integration of treadmill-based electricity generation into fitness centers remains relatively underexplored despite its considerable practical potential. In addition, public understanding regarding the possibility of converting exercise activities into renewable electrical energy remains limited. Consequently, significant opportunities remain for developing simple, affordable, and environmentally friendly energy harvesting systems utilizing treadmill technology.

Based on the review of previous literature, several research gaps can be identified. First, existing studies primarily emphasize large-scale renewable energy technologies while giving relatively limited attention to micro-scale human-powered energy harvesting systems. Second, few studies comprehensively analyze the relationship between treadmill rotational speed, mechanical transmission, generator output voltage, electric current, and power generation efficiency. Third, studies investigating treadmill-based electricity generation within the Indonesian context remain scarce, particularly those considering practical implementation under local environmental and operational conditions.

Therefore, this study seeks to address these research gaps by developing and evaluating a treadmill-based renewable energy generation system capable of converting rotational kinetic energy into electrical energy. The study systematically measures rotational speed, voltage, current, electrical power, and conversion efficiency under different operating conditions. Through quantitative analysis, the research aims to identify the optimal operating parameters that maximize electrical energy production while maintaining practical usability for sports activities.

The novelty of this research lies in integrating treadmill exercise with renewable electricity generation through a practical and low-cost energy harvesting system. Unlike previous studies that mainly emphasize prototype construction, this research focuses on systematic performance evaluation, efficiency analysis, and optimization of electrical output. The findings are expected to contribute both theoretically and practically to renewable energy research by expanding scientific understanding of human-powered electricity generation while providing an alternative approach for sustainable energy utilization in educational institutions, fitness centers, and community facilities. Ultimately, this research supports Indonesia's transition toward sustainable energy systems by demonstrating that even everyday physical activities possess meaningful potential to contribute to future renewable electricity production.

METHOD

This study employed an experimental testing method combined with quantitative measurement techniques to evaluate the electrical power generated by a manually operated treadmill-based micro power plant. The research was conducted at the Algiffary Workshop on **Monday, June 30, 2025**, over one full day of testing. The experimental setting was designed to analyze the conversion of human kinetic energy into electrical energy through a DC generator driven by a manual treadmill transmission system. Quantitative measurements focused on generator rotational speed, output voltage, current, and electrical power under predetermined operating conditions. According to Creswell and Creswell (2018), experimental research is appropriate for investigating causal relationships between variables through controlled testing procedures, while quantitative measurements provide objective and accurate data for engineering analysis. Similarly, Kalpakjian and Schmid (2020) emphasize that experimental testing is essential for evaluating the performance and efficiency of mechanical and electrical energy conversion systems.

The research utilized several measuring instruments and electrical components to ensure accurate testing. Measurement instruments included a tachometer to determine generator rotational speed, a digital multimeter for voltage and current measurements, a caliper for dimensional verification, a measuring tape, pliers, a complete tool set, and an electric impact wrench for assembly. The primary materials consisted of a DC generator, V-belt transmission, 12 V/5 Ah battery, 220 W inverter, 12 V step-down transformer, voltmeter, 10 W LED lamp, lamp holder, electrical cables, and insulation tape. These components collectively formed a simple micro power generation system capable of converting kinetic energy into usable electrical energy (Chapman, 2019).

Table 1. Research Instruments

NO.	INSTRUMENT	QUANTITY	FUNCTION
1	Tachometer	1	Measures generator rotational speed (RPM)
2	Digital Multimeter	1	Measures voltage and current
3	Electric Impact Wrench	1	Mechanical assembly
4	Vernier Caliper	1	Dimensional measurement
5	Tool Set	1	Equipment installation
6	Pliers	1	Electrical wiring
7	Measuring Tape	1	Dimensional measurement

Table 2. Research Materials

NO.	MATERIAL	QUANTITY	FUNCTION
1	DC Generator	1	Converts mechanical energy into electrical energy
2	V-Belt	1	Power transmission
3	220 W Inverter	1	Converts DC to AC
4	12 V/5 Ah Battery	1	Energy storage
5	Voltmeter	1	Voltage monitoring
6	10 W LED Lamp	1	Electrical load
7	Lamp Holder	1	Lamp connection
8	Electrical Cable	2	Electrical wiring
9	12 V Step-Down Transformer	1	Voltage regulation
10	Electrical Insulation Tape	1	Circuit insulation

Data collection was conducted through direct experimental testing by operating the manual treadmill at predetermined speed and duration intervals. During treadmill operation, human mechanical energy was transmitted through the V-belt mechanism to rotate the DC generator. The generator converted rotational kinetic energy into electrical energy based on the principle of electromagnetic induction, as explained by Faraday's Law (Chapman, 2019). The generated electrical output was regulated through a 12 V step-down transformer before charging the battery, while the stored energy was subsequently converted from direct current (DC) to alternating current (AC) by a 220 W inverter to power a 10 W lamp. Output voltage, current, generator speed, and electrical power were recorded continuously during testing. The electrical power generated was calculated using the equation P = V × I, where *P* represents power (W), *V* is voltage (V), and *I* is current (A) (Bird, 2020).

The electrical distribution system was arranged in a sequential configuration beginning with the DC generator, followed by the voltage regulation unit, battery storage, inverter, and electrical load. Appropriate electrical cables, connectors, and protective insulation were employed throughout the circuit to ensure operational safety and measurement reliability. Such an experimental configuration enables a systematic evaluation of the feasibility of utilizing manual treadmill kinetic energy as a renewable micro-scale electricity generation system, consistent with renewable energy conversion principles proposed by Boyle (2021).

Table 3. Experimental Data Collection Procedure

STAGE	ACTIVITY	EXPECTED OUTPUT
PREPARATION	Installation of all electrical and mechanical components	Functional testing system
OPERATION	Manual treadmill operated at predetermined speed	Generator rotation
MEASUREMENT	Recording RPM, voltage, current, and power	Experimental data
ANALYSIS	Calculation of electrical power output	Generator performance evaluation

Table 4. Electrical Distribution Network

COMPONENT	FUNCTION
MANUAL TREADMILL	Produces kinetic energy
V-BELT TRANSMISSION	Transfers mechanical rotation
DC GENERATOR	Converts mechanical energy into electricity
12 V STEP-DOWN TRANSFORMER	Regulates voltage
12 V/5 AH BATTERY	Stores electrical energy
220 W INVERTER	Converts DC into AC
10 W LAMP	Electrical load/output

RESULTS AND DISCUSSION

A. Data Collection

Data collection was carried out to determine the effect of speed and time variations on the power generated by DC generators. Measurements are made by setting the speed at a certain value and a predetermined time, then recording the power generated by the generator. This method aims to analyze the power produced by the generator due to changes in speed and time.

B. Measurement of Wheel to Transmission Speed

Speed measurement from the wheel to the transmission is carried out to determine the stability and efficiency of the drive system under various speed conditions and time duration. The test was carried out at three speed levels, namely 10 km/h, 20 km/h, and 40 km/h. At each speed, measurements were taken over three different time intervals, namely 15 minutes, 30 minutes, and 45 minutes. Measurements are made using sensors or measuring instruments mounted on the wheels or transmission shaft to record the actual speed transmitted. This process aims to observe whether there is a change in speed values during running time and evaluate the consistency of system performance at each speed.

Once all the speed data has been collected for each time and speed level, the next step is to calculate the average value of the three measurement results at each speed. For example, for a speed of 10 km/h, data is taken at the 15th, 30th, and 45th minutes, then the average value of all three is sought. The same process is carried out for speeds of 20 km/h and 40 km/h. This average value is a representation of the performance of the transmission system at each speed level, and the results are used for further analysis, such as comparing the efficiency between speeds or assessing the stability of the transmission system against load and operating duration.

Table 5. Speed Measurement Results

SPEED	**MINUTE TO**	**RPM**	**AVERAGE RPM**
10 KM/H	15	155	153,33
	15	145	
	15	160	
	30	122	125,67
	30	127	
	30	128	
	45	103	106
	45	105	
	45	108	
20 KM/H	15	257	260,67
	15	260	
	15	265	
	30	240	244
	30	245	

	30	247	
	45	235	
	45	238	237,67
	45	240	
	15	731	
	15	735	728,67
	15	720	
40KM/H	30	680	
	30	684	684
	30	688	
	45	528	
	45	524	527,33
	45	530	

C. Transmission Speed Measurement To Generator

To find out the speed of the driver we must first know the ratio of the pulley first by taking data on the tool that we analyze and it is known that the size of the driving puley is 70mm and for the driven puley is 80mm. After that we use the ratio formula on the pulley and find the speed at which the pulley is moved:

$$\text{Rasio Pulley} = \frac{\text{D1}}{\text{D2}}$$

Where:

D1 : Drive pulley diameter (*Pulley Driver*)

D2 : Diameter of the actuated pulley (*Driven pulley*)

$$\text{Rasio Pulley} = \frac{70}{80} = 0{,}875$$

Once the Driver speed is found now we search for the rpm driven speed or generator using the formula:

$$\text{Driven RPM} = \text{Driver RPM x} \frac{\text{D2}}{\text{D1}}$$

Table 6. Comparison of Transmission RPM and Generator RPM

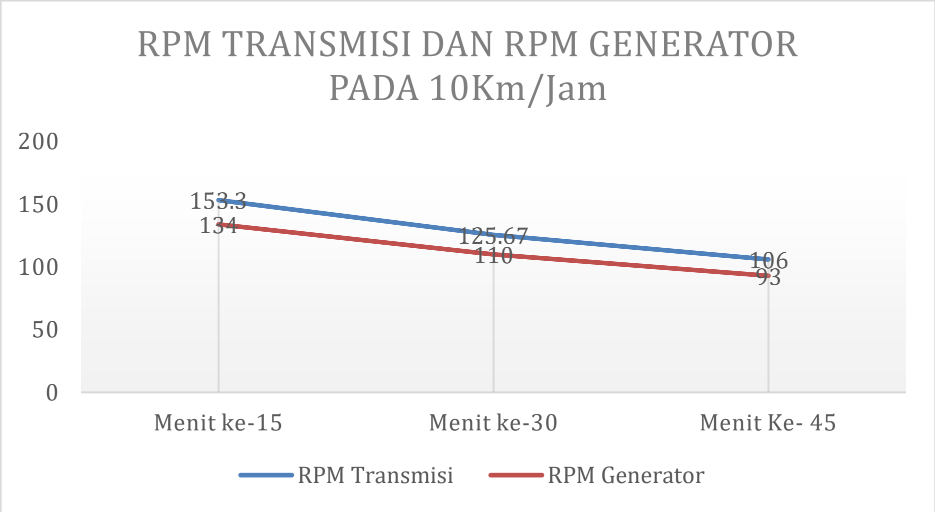
SPEED	MINUTE TO	TRANSMISSION RPM	RATIO	RPM GENERATOR
10KM/H	15	153,3	0,875	134
	30	125,67	0,875	110
	45	106	0,875	93
20KM/H	15	260,67	0,875	228
	30	244	0,875	213,5
	45	237,67	0,875	208
40KM/H	15	728,67	0,875	638
	30	684	0,875	598,5
	45	527,3	0,875	461,5

Measurement of the transmission speed to the generator is carried out to determine the amount of rotation that is passed from the drive pulley to the driven pulley so that it can rotate the generator. This process begins by calculating the pulley ratio, which is the ratio between the diameter of the driving pulley and the driven pulley. In this study, the diameter of the drive pulley was set at 70 mm, while the driven pulley had a diameter of 80 mm. Thus, the pulley ratio can be calculated using the formula Pulley Ratio = D1 ÷ D2, so that a value of 70 ÷ 80 = 0.875 is obtained. This value indicates that every single full turn on the drive pulley will result in 0.875 revolutions on the driven pulley.

The next step is to determine the rotation speed of the driven pulley or generator by using the formula Driven RPM = Driver RPM × (D2 ÷ D1). Calculations were made at three variations of treadmill speed, namely 10 km/h, 20 km/h, and 40 km/h, with data taken at time intervals of 15, 30, and 45 minutes. Based on the calculation results, at a treadmill speed of 10 km/h, the generator rotation (Driven RPM) is 134 RPM in the 15th minute, then decreases to 110 RPM in the 30th minute, and 93 RPM in the 45th minute. For a treadmill speed of 20 km/h, the Driven RPM value reached 228 RPM in the 15th minute, 213.5 RPM in the 30th minute, and 208 RPM in the 45th minute. Meanwhile, at a treadmill speed of 40 km/h, the value obtained is much greater, namely 638 RPM in the 15th minute, 598.5 RPM in the 30th minute, and 461.5 RPM in the 45th minute.

From this data, it can be seen that the higher the treadmill speed, the greater the spin received by the generator. However, the decrease in RPM as the test time increases at the same speed indicates the influence of other factors, such as changes in load or mechanical fatigue due to increased friction during the test. In other words, the efficiency of power transmission from the drive pulley to the generator is affected by the initial speed as well as the operating conditions during the test. This information is important to know the performance of the transmission system in producing electrical energy optimally.

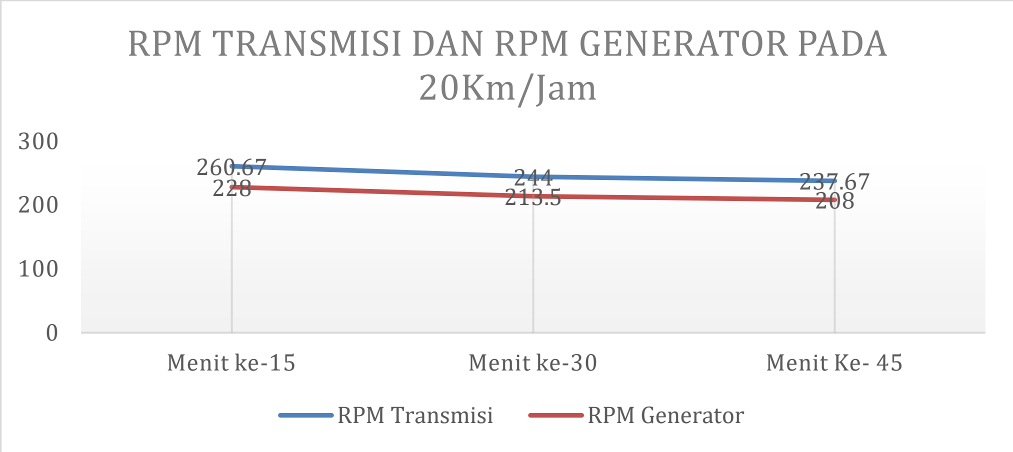
Figure 1. Transmission RPM and RPM Comparison Chart



Generator at a speed of 10 Km/H

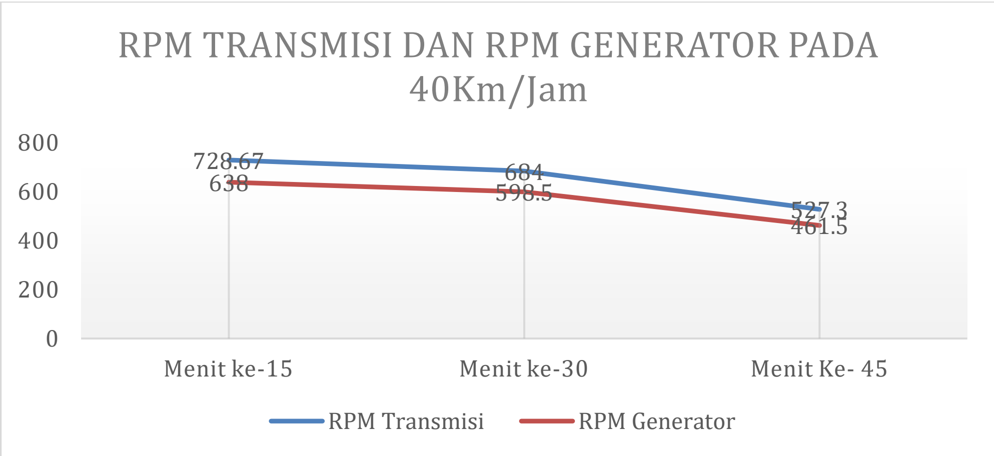
Figure 4.4 shows the comparison between the transmission RPM (drive pulley) and generator RPM (driven pulley) at a treadmill speed of 10 km/h with three test time intervals, namely the 15th minute, the 30th minute, and the 45th minute. Based on the graph, it can be seen that the transmission RPM value is higher compared to the generator RPM at each measurement point. In the 15th minute, the transmission RPM was 153.3, while the generator RPM was 134. In the 30th minute, both values decreased, where the transmission RPM became 125.67 and the generator RPM became 110. Furthermore, in the 45th minute, the transmission RPM dropped back to 106 and the generator RPM reached 93. This decrease occurs gradually as the testing time increases. The RPM decrease pattern shows the influence of load and friction on the transmission system, so that the power transfer efficiency is slightly reduced over time. Overall, this graph confirms that the difference between the transmission RPM and the generator RPM is consistent with the pulley ratio used, which is 0.875.

Figure 2. Transmission RPM and RPM Comparison Chart



Generator at 20 Km/H

Figure 3. Transmission RPM and RPM Comparison Chart



Generator at a speed of 40 Km/H

D. Relationship of RPM Speed with Power

The relationship between RPM (Revolutions Per Minute) speed and generator power on a treadmill is direct, meaning that the higher the shaft rotation speed (RPM), the greater the electrical power that can be produced by the generator, This test was carried out to find out the relationship between the speed of movement, pulley transmission ratio, and electric power produced by the generator:

E. Processing Result Data

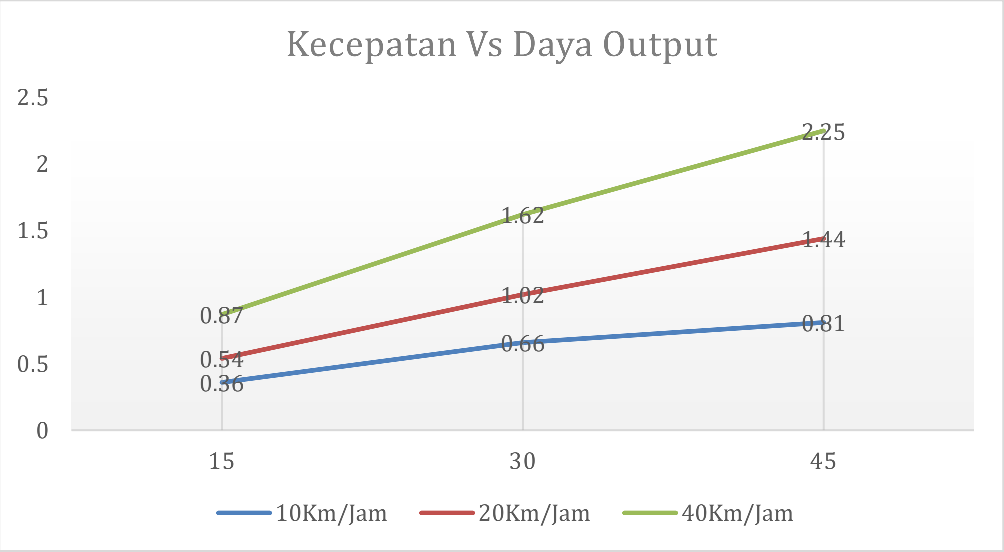
Table 7. Data Processing Results

WHEEL SPEED (KM/H)	MINUTE	RPM GENERATOR	GENERATOR VOLT	GENERATOR CURR	OUTPUT POWER	POWER COEFFICIENT	ENERGY (WH)	TOTAL POWER INPUT	STATE OR CHARGE

			AGE (V)	ENT (A)	(WA TTS)				
10	15	134	12	0,12	1,440	0,078	0,36		3,05%
10	30	110	12	0,11	1,320	0,095	0,66	1,83	
10	45	93	12	0,09	1,080	0,113	0,81		
20	15	228	12	0,18	2,160	0,046	0,54		5,00%
20	30	213,5	12	0,17	2,040	0,049	1,02	3,00	
20	45	208	12	0,16	1,920	0,050	1,44		
40	15	638	12	0,29	3,480	0,016	0,87		7,90%
40	30	598,5	12	0,27	3,240	0,018	1,62	4,74	
40	45	461,5	12	0,25	3,000	0,023	2,25		

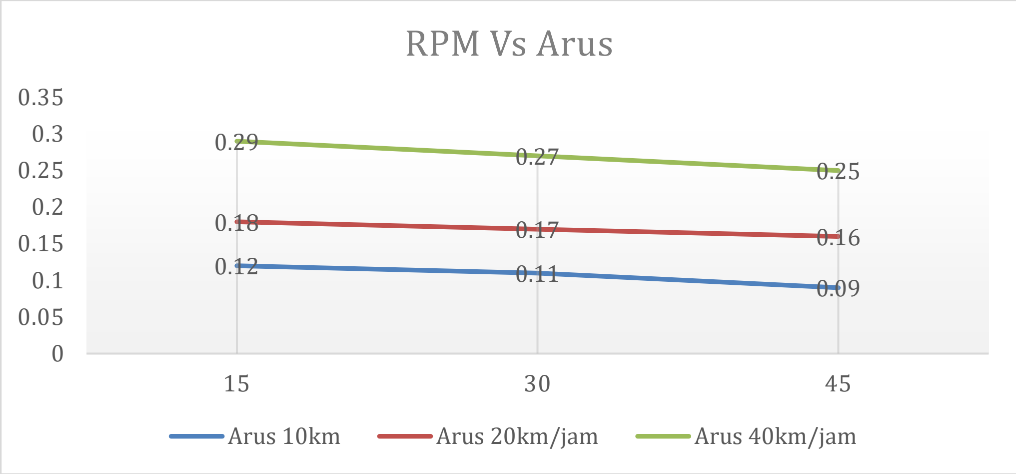
In this study, the relationship between the speed of the vehicle's wheels and the power generated by the generator was analyzed to see how much the increase in speed affects the output of electrical power. Based on Table 4.3 Data Processing Results, it can be seen that the higher the wheel speed (in Km/H), the generator RPM, current (A), and output power (Watts) also increase.

Figure 4. Speed and Power Graph generated by the Generator



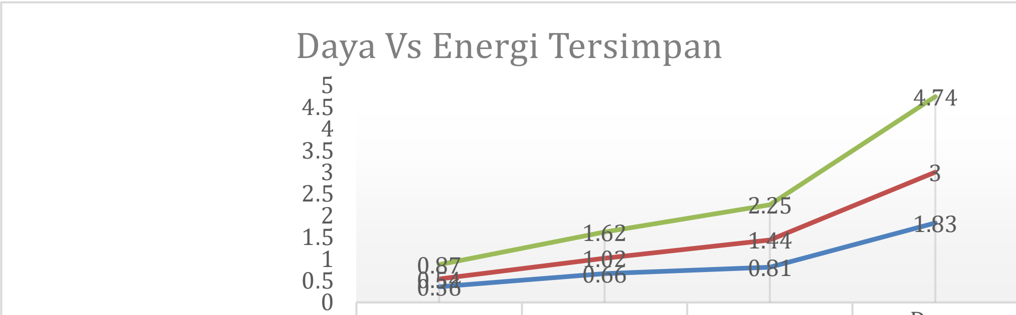
The speed and power generated are related between the speed of the vehicle's wheels to the power generated by the generator at three different speeds, namely 10 Km/H, 20 Km/H, and 40 Km/H. From the graph, it can be seen that the higher the wheel speed, the greater the power produced by the generator for each test time interval (15, 30, and 45 minutes).

Figure 5. RPM and Generated Current Graph



At a speed of 10 Km/H, the current generated decreases from 0.12 A in the 15th minute to 0.09 A in the 45th minute. The same happens at a speed of 20 Km/H, where the current decreases from 0.18 A to 0.16 A in the same time interval. Meanwhile, at the highest speed of 40 Km/H, the current decreases from 0.29 A to 0.25 A. The decrease in electric current seen in Figure 4.7 can also be explained in terms of external factors, namely human power used to turn bicycle wheels or generator drive devices. As the operating time increases (15 to 45 minutes), human physical power tends to decrease due to fatigue, so the wheel rotation is not as strong or as fast as at the beginning of the test.

Figure 6. Graph of the relationship between power and stored energy



	15	30	45	Daya Total masuk
Kecepatan 10km	0.36	0.66	0.81	1.83
Kecepatan 20km/jam	0.54	1.02	1.44	3
Kecepatan 40km/jam	0.87	1.62	2.25	4.74

Based on this graph, it can be seen that the greater the output power produced, the greater the energy stored. This applies to each wheel speed tested, which is 10 Km/H, 20 Km/H, and 40 Km/H. For example, at a speed of 10 Km/H, the power generated at the 15th minute is 0.36 Wh, increasing to 0.81 Wh at the 45th minute.

CONCLUSION

Based on the results of data processing and analysis it can be concluded that:

1. The speed of the wheel affects the output power produced by the generator. The higher the speed (Km/H), the RPM of the generator increases, resulting in greater

current and power. This is evident from data where a speed of 40 Km/H produces much higher power and energy than a speed of 10 Km/H or 20 Km/H.

2. The resulting current tends to decrease over time, although the speed is kept constant. This decrease is caused by the reduction of human power in constantly rotating the wheel, which leads to a decrease in the performance of the generator's rotation.
3. The energy stored in the system is proportional to the output power and operating time. The longer the playback time and the more power produced, the more energy is stored in the battery.
4. The efficiency of the generation system depends on the stability of the power input and speed. The high total power input is not fully converted into stored energy due to power losses and fluctuations in power input from humans.

Overall, this wheel-turning-based power generation system shows quite good performance, with the potential for increased efficiency if the drive is more stable and consistent.

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