Analysis of Electrical Energy Consumption Due to the Influence of Passenger Weight on the Medan Fair Plaza Elevator

Ghysella Apriany Silaban
e-mail: ghysellaapriany23905@gmail.com
Rahmaniar
e-mail: rahmaniar@dosen.pancabudi.ac.id
Dino Evrianto
e-mail: derivianto@gmail.com

Universitas Pembangunan Panca Budi

Abstract
An elevator is a mechanical device designed to facilitate vertical transportation of people or goods between floors within a building. This system operates automatically through a drive motor and specific control mechanisms, enabling time and energy efficiency in multi-story structures. This study aims to evaluate the extent to which passenger load influences the power and electrical energy consumption of the elevator drive motor at Plaza Medan Fair, particularly when operated at 0%, 50%, and 100% of its maximum load capacity. The method applied in this research involved direct data collection on-site.
Observations revealed that under no-load conditions (0 kg), the power required for upward movement reached 4.62 kW, with a total energy usage of 55.44 kWh over a 12-hour period. At 50% load (approximately 525 kg), the power increased to 7.61 kW, and energy consumption rose to 91.32 kWh. At full load (±1050 kg), the elevator consumed 8.21 kW. During downward movement, the elevator with no load consumed 5.51 kW of power and 66.12 kWh of energy. With a 50% load, the power used was 7.12 kW and energy consumption reached 85.44 kWh. At full capacity during descent, power consumption was recorded at 7.34 kW with 88.08 kWh of energy used.These findings confirm that variations in passenger load significantly affect both the power demand and energy usage of the elevator's drive motor. Therefore, regular maintenance and performance checks are essential to ensure the lift operates efficiently and reliably.

Keywords: *Active Power, Electrical Energy, elevator Motor, Consumption*

Introduction

Elevators act as an important means of transportation in multi-storey buildings, as they provide ease of passenger mobility between floors. Elevators are generally used in high-rise buildings for office, residential, commercial, and industrial purposes. (Kafila & Rahajoeningroem, 2022) The existence of elevators can contribute to increased efficiency and comfort, especially in high-rise buildings, as it allows users to move between floors quickly and safely without using stairs. (Conceptual Planning and Design, 2022)

Plaza Medan Fair is a shopping center with many visitors every day, so the operational load of the elevator is very dynamic. Plaza Medan Fair is located on Jalan Gatot Subroto, one of the main lanes located in the central business district of Medan City (Liyando Situngki, 2020). This strategic location is also close to the bus terminal which provides access to Kualanamu International Airport, so it can contribute to the high number of visitors. Considering that this building has five floors, a vertical transportation system such as an elevator is needed to support the smooth mobility of building users, both visitors and staff. This study aims to examine the extent to which passenger weight plays a role in influencing the level of electrical power consumption in the Elevator system (Jakarta Smart City et al., 2023)[1].

Since each elevator has different floor heights, passenger and freight capacities, and speeds, the electric motors used are AC motors and are selected and used according to the needs of each elevator. (Rahmadani, 2023)These variations result in deviations in the current and voltage used by each elevator. It is therefore very important to conduct additional research on how current and voltage variations can arise in electric motors when the elevator is operating. (Ridina, 2024)

Literature Review

Definition of Elevator

1. An elevator is a vertical transportation device designed to facilitate the movement of individuals or objects between floors within a building structure. In general, elevators work by using a mechanical drive system and towing cables controlled by electric motors, allowing for faster and more efficient movement than the use of stairs. The presence of elevators is very important, especially in high-rise buildings, because it is able to support the mobility of residents, increase accessibility, and facilitate the optimal distribution of goods in daily activities.
2. Working Principle of Elevator. The elevator moves by utilizing an electric motor that drives a pulley to pull or lower the cabin via steel cables. When the motor is activated, the cable will roll or release on the pulley, so that the elevator cab can go up or down as ordered.[4] In addition, there is a counterweight system that functions to balance the load of the elevator cabin, so that the motor does not work too hard and energy use becomes more efficient. This entire process is controlled by a control panel that ensures the elevator stops right on each floor.
3. According to Pangathousands (2020), the elevator system consists of two main types of components, namely static (immovable) parts and dynamic (moving) parts.

Components Statis (Stationary Components):

This component includes elements that do not undergo movement while the elevator is operating, including:

1. Guide rail
2. Traction engine
3. Peredam (buffer)

Dynamic Components (Moving Components):

This component includes parts that move during the elevator operating process.

1. Train
2. weight
3. Floor doors
4. Romless machine
5. Tali baja (wire rope)

Active Power

P, dengan satuan **W (watt)**Click or tap here to enter text.

Formula of 1 phase active power:

P = V x I x body x $\varphi\sqrt{3}$

With the following information:

1. P expresses the active power in watts
2. V is a large voltage in volts
3. I is a flowing electric current, measured in amperes
4. COS φ indicates the value of the power factor that describes the efficiency of energy consumption

Electrical Energy

Electrical energy is a type of energy produced from the movement of electrical charge in a closed circuit. This energy is usually denoted by the letter **E** and measured in kilowatt-hours (kWh) (Pangaribuan, 2020). The amount of electrical energy used can be calculated using the following equation:

E = P × t

With the following information:

E is the electrical energy consumed, expressed in kilowatt-hours (kWh)

P indicates the power of the power tool, in watts

t is the duration of use, which can be expressed in units of hours or seconds

Research Methodology

This research was carried out at Plaza Medan Fair on May 5, 2025 – May 7, 2025 from 10.00 – 12.00 WIB. Address: Jl. Gattot Subroto no. 30 kec. Medan Petisah city of Medan, North Sumatra.

The stages carried out in the implementation of this research method to obtain the data and information needed are described as follows: 1. Data Collection Process. The data collection process is one of the important stages in research, because it serves to obtain information that will be used as a basis for the analysis process. In this study, data was obtained directly from the research location, namely the Medan Fair Plaza. The information collected covers various aspects relevant to the research objectives.

1. Elevator specifications at PT. Plaza Medan Fair
2. Specification of the elevator motor at Plaza Medan Fair
3. Passenger weight data on the elevator
4. Calculating the power used by the electric motor elevator
5. Calculate the use of electrical energy on the motorcycle caused by variations in the weight of the passenger's load.

Results

Observation Results Data

The information that was successfully collected during the research process at Plaza Medan Fair included several types of data, one of which was:

A. Technical Data of Elevator Specifications

Table 1. Elevator Specifications

Elevator Specifications	
Elevator Type	SIGMA Elevator
Drive mode	VVVF (Variable Voltage Variable Frequensi)
Speed	60m/minute
Control modde	G1C
Type motor	Permanent magnet
Number of capacities	±15 people or 1050 kg

B. Technical specification data of motors used as drives in elevator systems

Table 2. Elevator Motor Specifications

Specification of Lift Motor	
Lift speed	60m/min
Load	1050 kg
Current	21,1 A
Power	9.1 kW
Voltage	380 V
Frequensi	12,1 Hz

C. Passenger Capacity Information

From the results of the research, data was obtained that the maximum load that the elevator can transport is 1050 kg. Therefore, the test conditions are divided into three load categories, namely:

1. Full load, when the number of passengers reaches a total weight of 1050 kg.
2. The load is medium, with an estimated passenger weight of around 525 kg.
3. Loadless, where the elevator operates without carrying any passengers at all (0 kg).

D. Elevator weight information at the time of no passengers (0 kg or 0%).

The first measurement is taken when the load capacity of the elevator is 0% or 0 kg. The elevator is measured 2 times, namely when the elevator moves up from the lowest floor to the top floor, while the next measurement is taken when the elevator descends back from the upper floor to the ground floor.

Table 3. Motor Current Measurement 0%

Motor current measurement								
car load			motor current		source voltage		frequency	
%	Medical history		start	run	start	run	start	run

0	0	Up	14.6A	8.2A	376 V	383V	0	12Hz
0	0	Down	15.3A	9.7A	360 V	386V	0	12Hz

Then measurements are taken when the elevator load capacity is 50% or ±525 Kg. The elevator is measured 2 times, namely when the elevator goes up from the lowest floor to the top floor, while the next measurement is taken when the elevator descends back from the upper floor to the ground floor.

Table 4. Motor Current Measurement 50%

Motor current measurement								
car load			motor current		source voltage		frequency	
%	Medical history		start	run	start	run	start	Run
50	±525	Up	15.3A	13.5A	375V	383V	0	12Hz
50	±525	Down	14.8A	12.7A	373 V	381V	0	12Hz

The last measurement is taken when the load capacity of the elevator is 100% or Kg. The elevator is measured 2 times as well, When the elevator rises from the lowest floor to the top floor, while the next measurement is taken when the elevator descends back from the upper floor to the ground floor± 1050.

Table 5. Motor Current Measurement 100%

Motor current measurement								
Car Load			motor current		source voltage		frequency	
%	Medical history		Start	Run	Start	Run	Start	Run
100	1050	Up	17.5A	14.5A	376V	385V	0	12Hz
100	1050	Down	16.2A	12.9A	379 V	387V	0	12Hz

Calculation of Power Consumption When Elevator Moves Up

The use of electric power by the drive motor when the elevator moves upwards with load conditions of 0% (0 kg), 50% (±525 kg), and 100% (±1050 kg) can be calculated through the following stages:

a. Loadless condition (0 kg)

When the elevator is operating without carrying passengers, or is in a load condition of 0%, power consumption is calculated based on actual measurements as the unit moves upwards.

$P = V \times I \times \cos \varphi \times \sqrt{3}$

$P = 383 \times 8.2 \times 04.62$

P = 4.623.7269 w : 1000

P = 4,62 kw

b. Medium Load Conditions (±525 kg or 50%)

When the lift is operating with a load of about half of the maximum capacity, i.e. ±525 kg, the power used can be calculated using the formula: 50% or (kg)±525

$P = V \times I \times \cos \varphi \times \sqrt{3}$

$P = 383 \times 13.5 \times 0.85 \times \sqrt{3}$

P = 7. 612, 2333 W: 1000

P = 7.61 kw

c. Full Load Condition (±1050 kg or 100%)

When the elevator carries a maximum load of ±1050 kg, the electrical power calculation is carried out using the basic formula of the three-phase system, to determine the amount of energy required by the motor to drive the elevator at full capacity. $P = V \times I \times \cos \varphi \times \sqrt{3}$

$P = 385 \times 14{,}5 \times 0{,}85 \times \sqrt{3}$

P = 8.218,7975 w :1000

P= 8,21 kw

Table 6. Elevator Power on Boarding

Power table when elevator rises with 0%, 50%, 100% capacity	
Load capacity	Daya (P)
0% (0 kg)	4.62 kW
50% (±525 kg)	7.61 kW
100% (±1050 kg)	8.21 kW

Calculation of Electrical Power Consumption When the Elevator Moves Down

The amount of electrical power required by the drive motor when the elevator moves down, whether in a condition of no load (0 kg), medium load (±525 kg), or full load (±1050 kg), can be determined through the following calculations:

a. No-Load Condition (0 kg)

When the elevator descends without carrying passengers, or in a state of 0% load, the power consumption value is calculated based on actual measurements from the electrical system during the descent process.

$P = V \times I \times \cos \varphi \times \sqrt{3}$

$P = 386 \times 9{,}7 \times 0{,}85 \times \sqrt{3}$

P = 5.512,3729 w: 1000

P = 5,51 kw

b. Medium Load Condition (kg)±525

When the elevator descends the floor carrying a load of about half of its maximum capacity, which is ±525 kg, the electrical power consumption is calculated to find out how much energy the motor uses during the descent process.

$P = V \times I \times \cos \varphi \times \sqrt{3}$

$P = 381 \times 12{,}7 \times 0{,}85 \times \sqrt{3}$

P = 7.123,7431 w: 1000

P = 7,12 kw

c. Full Load Conditions or 1050±

When the elevator descends the floor in a state of carrying a maximum load of about ±1050 kg, calculations are made to determine the electrical power required by the motor during the descent process at full capacity.

$P = V \times I \times \cos \varphi \times \sqrt{3}$

$P = 387 \times 12{,}9 \times 0.85 \times \sqrt{3}$

P = 7.349,8796 w: 1000

P = 7,34 kw

Table 7. Elevator Power when Descending

Power table when elevator goes down with 0%, 50%, 100% capacity	
Beban	Daya (P)
0% (0 kg)	5.51 kW
50% (kg),±525	7.12 kW
100% (±1050 kg)	7.34 kW

Graph of Calculation of Motor Power When the Elevator Rises and Falls

a. The following graph shows the results of the calculation of the electrical power used by the elevator drive motor when operating in an upward direction. This calculation includes three different loading conditions, namely when there is no load (0 kg or 0%), half load (about 520 kg or 50%), and full load (1050 kg or 100%). These three conditions are used as the basis for describing the variation in power requirements required by the elevator system during the lifting process.

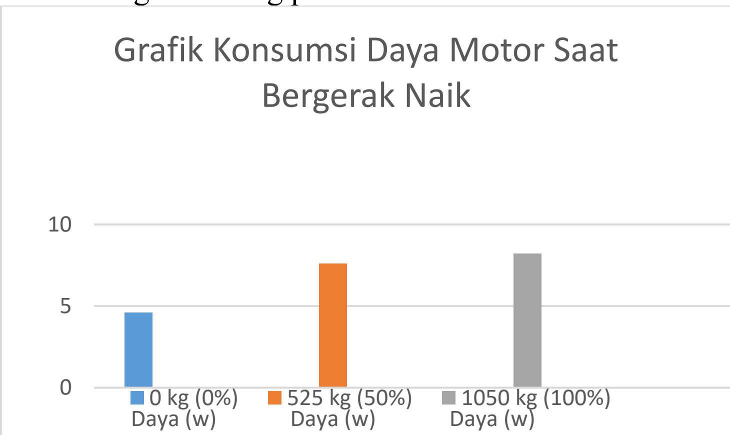

Figure 1. Graph of Motor Power Consumption When Moving Up

In the no-load condition (0 kg or 0%), the elevator drive motor consumes 4.62 kW of power. When the elevator goes up carrying a load of about 525 kg or half of its capacity, the power used increases to 7.61 kW. The power requirement increases again to 8.21 kW when the load reaches full capacity, which is around 1050 kg.

b. The following graph shows the results of the calculation of the electrical power used by the elevator drive motor when operating downward. This calculation includes three different loading conditions, namely when there is no load (0 kg or 0%), half load (about 520 kg or 50%), and full load (1050 kg or 100%). These three conditions are used as the basis for describing the variation in power requirements required by the elevator system during the lowering process.

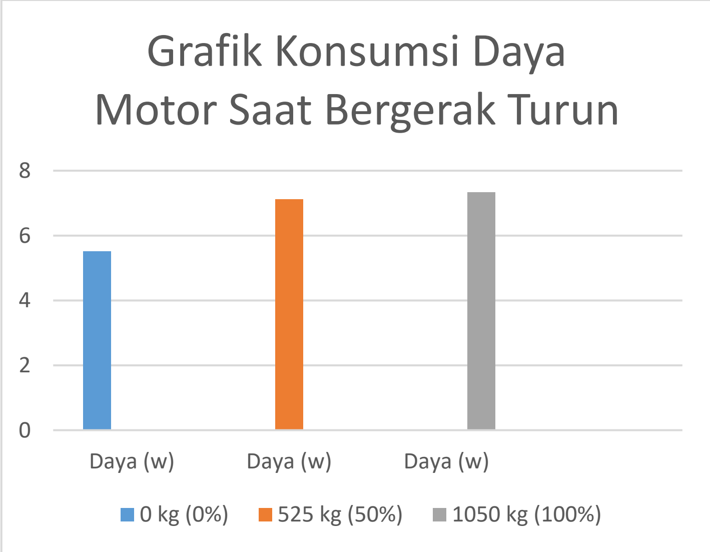

Figure 2. Graph of Motor Power Consumption When Moving Down

When the elevator moves down without carrying a load (0 kg or 0%), the recorded power from the drive motor is 5.51 kW. As the load increases to about 525 kg (50% of capacity), the power requirement increases to 7.12 kW. The power rose again to 7.34 kW when the elevator descended the floor with a full load, which was about 1050 kg.

Results of Elevator energy consumption calculation when Ascending and Descending

When the elevator operates towards the upper floor, the power consumed by the electric motor varies depending on the load being transported, i.e. at no load (0%), medium load (50%), and full load (100%). The calculation of the electrical energy used in each condition is as follows:

a. Burden 0% (0 kg passenger)
   Electrical energy used:
   $W = P \times t$
   $W = 4{,}62$ kW × 12 jam = 55,44 kWh
b. Burden 50% (±525 kg passenger)
   Electrical energy used:
   $W = P \times t$
   $W = 7{,}61$ kW × 12 jam = 91,32 kWh
c. Burden 100% (±1050 kg passenger)
   Electrical energy used:
   $W = P \times t$
   $W = 8{,}21$ kW × 12 jam = 98,52 kWh

Table 8. Electrical Energy when the Elevator Rises

Elevator electric energy consumption when rising with 0%, 50%, 100% capacity	
Beban	Electrical energy (kwh)
0% (0 kg)	55.44 kWh
50% (kg),±525	91.32 kWh
100% (±1050 kg)	98.52 kWh

During the lowering process, the electrical energy requirements of the elevator vary according to the amount of load carried, i.e. in conditions of no load (0 kg or 0%), half load (±525 kg or 50%), and maximum load (±1050 kg or 100%). The energy used by the drive motor in each of these conditions can be calculated by the following equation:

a. Burden 0% (0 kg)
Energy calculation:
$W = P \times t$
$W = 5{,}51\ kW \times 12\ jam = 66{,}12\ kWh$

b. Burden 50% (±525 kg)
Energy calculation:
$W = P \times t$
$W = 7{,}12\ kW \times 12\ jam = 85{,}44\ kWh$

c. Burden 100% (±1050 kg)
Energy calculation:
$W = P \times t$
$W = 7{,}34\ kW \times 12\ jam = 88{,}08\ kWh$

Table 9. Electrical Energy when the Elevator Goes Down

Energy consumption Electric elevator when down with 0%, 50%, 100% capacity	
Load capacity elevator	Electrical Energy (kwh)
0% (0 kg)	66.12 kWh
50% (kg),±525	85.44 kWh
100% (±1050 kg)	88.08 kWh

Graph of Electrical Energy Consumption During Elevator Up and Down

a. Grafik Konsumsi Energi Listrik Saat Lift Bergerak Naik

The following graph presents the amount of electrical energy used by the elevator motor when moving upwards under three different load conditions, namely no load (0 kg or 0%), medium load (±525 kg or 50%), and maximum load (±1050 kg or 100%).

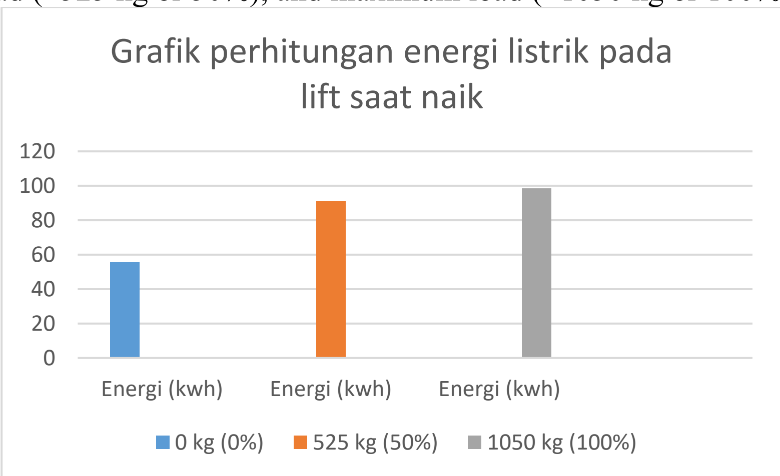

Figure 3. Graph of Electrical Energy as the Elevator Rises

When there is no load (0 kg or 0%), the electrical energy consumption by the elevator motor is recorded at 66.12 kWh. When the elevator carries a load of about 525 kg (equivalent to 50%), the elevator motor uses 85.44 kWh of energy when moving up. While when the elevator carries a maximum load of about 1050 kg (100%), the energy used by the drive motor to lift it is recorded at 88.08 kWh.

b. Energy Consumption Graph When Elevator Moves Down

The following is presented a graph of the calculation of electrical energy consumption by the driving motor when the elevator descends the floor in three different load conditions: unloaded (0 kg or 0%), medium load (±525 kg atau 50%) and full load (±1050 kg or 100%).

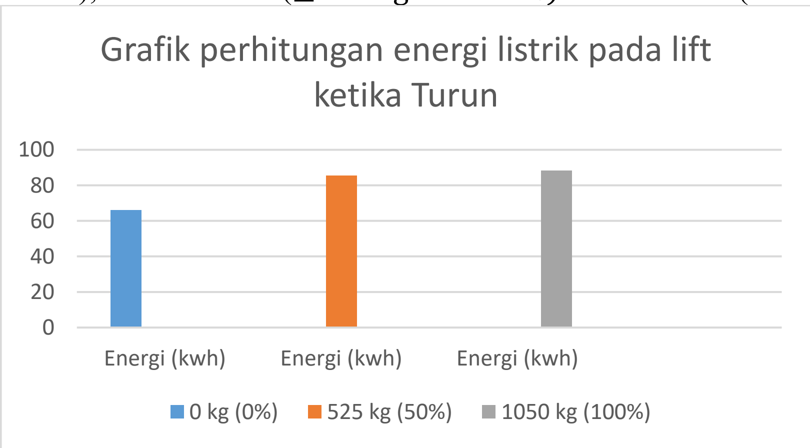

Figure 4. Graph of electrical energy when the elevator goes down

When there is no load (0 kg or 0%), the elevator motor consumes 66.12 kWh of electrical energy. When the elevator moves down with a load of about 525 kg (50%), the energy required by the motor to carry out the descent process reaches 85.44 kWh. Meanwhile, at full load conditions of around 1050 kg (100%), the electrical energy used by the motor during the elevator moving down was recorded at 88.08 kWh

Conclusion

From the data from the measurements, calculations, and analyses that have been carried out, it can be concluded that the power consumption in the elevator motor has a close relationship with the amount of load transported. The higher the total load mass, the more power and energy needed to drive the elevator. Therefore, the number of passengers transported directly has an impact on the amount of power and electrical energy consumption of elevator motors operating at Plaza Medan Fair

1. From the existing data when the elevator is given a load of 0% (0kg), the power output of the elevator motor when ascending is 4.62 kw and when descending the power output is 5.51 kw. At the time of a load of 50% (525 kg) at the time of increase the power output is 7.61 kw and at the time of the lift it is 7.12 kw. And when the elevator goes up with a load capacity of 100% (1050 kg), the power required is 8.21 kw and when it goes down is 7.34 kw.
2. From the existing data when the elevator is given a load of 0% (0kg), the electrical energy emitted by the elevator motor when it rises is 55.44 kwh and when it comes down the power output is 66.12 kw. At the time of a load of 50% (525 kg) at the time of increase the power output is 7.61 kw and at the time of the lift it is 7.12 kw. And when the elevator goes up with a load capacity of 100% (1050 kg), the power required is 8.21 kw and when it goes down is 98.2 kwh.

References

[1] R. Rahmaniar, K. Khairul, A. Junaidi, and D. K. Sari, "Analysis of Shadow Effect on Solar PV Plant using Helioscope Simulation Technology in Palipi Village," *JTEV (Jurnal Teknik Elektro dan Vokasional)*, vol. 9, no. 1, p. 75, May 2023, doi: 10.24036/jtev.v9i1.122372.

[2] M. F. Robby Wardani1, Zuraidah Tharo2, "Konsumsi Energi Listrik pada Penggunaan Lift Penumpang di Rumah Sakit Adam Malik Medan," *Jurnal Rekayasa Elektro Sriwijaya, Vol. 5, No. 1*, 2023.

[3] S. Wijaya, Jemy, Leman, "Konstruksi Bangunan Gedung dan Infrastruktur yang Berkelanjutan dan Berkeselamatan," Ir. D. Kushartomo, Dr. Widodo, Linggasari, Ed., LPPI UNTAR (UNTAR Press), 2021, p. 471.

[4] Ir. C. Heri Prasetyo, M.T, *Perancangan Sistem Transportasi Vertikal Bangunan Tinggi Perhitungan dan Perancangan berdasarkan SNI 03-6573-2001*. Lembaga Penerbitan Universitas Nasional (LPU-UNAS), 2022.

[5] A. B. Pradana, U. Y. Oktiawati, J. T. Putra, D. W. F. S. N. Giyatno, and A. Surriani, "Interpretasi Praktis Terhadap Istilah-Istilah Daya pada Rangkaian Listrik Satu Fase Sinusoidal," *Jurnal Listrik, Instrumentasi dan Elektronika Terapan (JuLIET)*, vol. 1, no. 1, pp. 1–5, 2021, doi: 10.22146/juliet.v1i1.53847.

[6] A. M. Rahmadani, *Analisis Penumpang Terhadap Kuat Arus dan Tegangan Motor Elevator si Proyek Podomoro City Deli Medan*, Medan: Universitas Pembangunan Panca Budi, 2023.

[7] R. Riandha, *Rancang Bangun Prototipe Elevator 3 Lantai Berbasis Mikro Kontroler Arduino Uno Atmega328*, 2024. [Online]. Available: https://rama.unimal.ac.id/id/eprint/402/

[8] R. Wardani, Z. Tharo, and M. Fadli, "Konsumsi Energi Listrik pada Penggunaan Lift Penumpang di Rumah Sakit Adam Malik Medan," *J. Rekayasa Elektro Sriwijaya*, vol. 5, no. 1, 2023.

[9] J. Wijaya and S. Leman, *Konstruksi Bangunan Gedung dan Infrastruktur yang Berkelanjutan dan Berkeselamatan*, I. D. Kushartomo, Widodo, and Linggasari, Eds., Jakarta: LPPI UNTAR (UNTAR Press), 2021. [Online]. Available: http://repository.untar.ac.id/39311/1/SIPIL-FT-978-623-6463-09-3%20REV%201SEPT.pdf

[10] R. Rahmaniar, M. B, and A. Juniadi, "Pemanfaatan Inovasi Teknologi EBT Panel Surya pada Mesin Serut Lidi untuk Pemberdayaan Masyarakat Desa Bandar Senembah," *Jurnal SOLMA*, vol. 12, no. 3, pp. 1186–1194, Dec. 2023, doi: 10.22236/solma.v12i3.12860.

[11] S. T. Hamdani, S. Anisah, and S. T. M. T. Zuraidah, "Monograf Implementasi Pembangkit Listrik Tenaga Surya (Plts) Untuk Rumah Tinggal."