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A Comparative Analysis Of Linear And Nonlinear Loads On The Performance Of Three-Phase Synchronous Generators

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ABSTRACT

This Study Aims To Analysed And Compare The Effects Of Linear And Nonlinear Loads On The Performance Of A Three-Phase Synchronous Generator. Linear Loads, Characterized By A Proportional Relationship Between Voltage And Current, And Nonlinear Loads, Which Produce Harmonic Distortion In Current And Voltage, Can Affect The Stability And Efficiency Of Generator Operation. In This Study, Various Loading Scenarios Were Tested Using A Software-Based Simulation Model. The Results Of The Analysis Show That Nonlinear Loads Cause A Significant Increase In Harmonic Distortion In The System, Which Has The Potential To Reduce The Efficiency And Operational Life Of The Generator. In Contrast, Linear Loads Tend To Produce More Stable And Efficient Generator Performance. These Findings Provide Important Insights Into The Design And Selection Of Appropriate Loads To Maintain Optimal Performance Of Three-Phase Synchronous Generators.

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INTRODUCTION

In The Electricity Industry, Three-Phase Synchronous Generators Play A Key Role In Generating Electrical Power. Changes In Load Patterns Generated By Modern Electronic Equipment And Systems Can Impact Generator Performance. The Difference Between Linear And Non-Linear Loads In An Electrical System Can Affect The Stability And Operational Efficiency Of Synchronous Generators.

Linear Loads, Such As Resistive Lamps And Heaters, Have Characteristics That Are Proportional To Voltage And Current. Meanwhile, Non-Linear Loads, Such As Electronic Loads And Electric Motors, Can Cause Harmonic Distortion In Voltage And Current Waves. This Study Aims To Conduct A Comparative Analysis Of Linear And Non-Linear Loads On The Performance Of Three-Phase Synchronous Generators. By Understanding The Impact Of Both Types Of Loads, It Is Hoped That Solutions Can Be Found To Improve The Efficiency And Operational Reliability Of Synchronous Generators In The Face Of Load Variations.

A Three-Phase Synchronous Generator Is One Of The Main Components In A Power Generation System, Which Plays A Role In Converting Mechanical Energy Into Electrical Energy. The Performance Of This Generator Is Greatly Influenced By The Type Of Load

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Connected To It, Both Linear And Nonlinear Loads. Linear Loads, Such As Induction Motors And Resistive Heaters, Have Characteristics Where The Current Drawn From The Generator Has The Same Waveform As The Applied Voltage. In Contrast, Nonlinear Loads, Such As Electronic Devices That Use Rectifiers Or Inverters, Produce Currents With Harmonic Distortion That Can Cause The Voltage To Become Non-Sinusoidal.

Harmonic Distortion Produced By Nonlinear Loads Can Have A Negative Impact On The Performance Of Synchronous Generators. These Effects Include Increased Power Losses, Excessive Heating Of The Stator Windings, And Decreased Efficiency And Operational Stability Of The Generator. In Addition, The Harmonics Produced Can Damage Other Components In The Power System, Such As Transformers And Protection Devices. Therefore, Understanding How The Type Of Load Affects The Performance Of Synchronous Generators Is Very Important In The Planning And Operation Of Electric Power Systems.

This Study Focuses On A Comparative Analysis Between Linear And Nonlinear Loads On The Performance Of Three-Phase Synchronous Generators. Using Computer Simulation, This Study Will Examine Important Parameters Such As Harmonic Distortion, Efficiency, And Voltage Stability Under Various Loading Scenarios. The Results Of This Study Are Expected To Provide Practical Recommendations In The Selection And Management Of Loads To Maintain Optimal Performance Of Synchronous Generators.

Literature Review

Definition And Construction Of Synchronous Generators

Generators Are One Of The Main Equipment In An Electric Power Plant, Both In Hydroelectric Power Plants, Gas Power Plants And Steam Power Plants (Weed, 1988). A Synchronous Generator Is An Electrical Generating Machine That Converts Input Energy In The Form Of Mechanical Energy Into Output Energy In The Form Of Electrical Energy. Synchronous Generators Are Also Called Alternators Or Alternating Generators (Ac) Because The Output Voltage Of A Synchronous Generator Is Alternating Voltage.

According To Anderson Pm (1982), Synchronous Generators Can Produce Energy Sources, Namely: Alternating Voltage, Therefore Synchronous Generators Are Also Called Ac Generators. It Is Said To Be A Synchronous Generator Because The Number Of Rotations Of The Rotor Is The Same As The Number Of Rotations Of The Magnetic Field In The Stator. This Synchronous Speed Is Produced From The Rotational Speed Of The Rotor With The Magnetic Poles Rotating At The Same Speed As The Rotating Field In The Stator.

The Definition Of A Synchronous Generator Means That The Synchronous Generator Rotor, Which Consists Of A Field Winding With A Direct Current Supply, Will Produce A Magnetic Field That Rotates At The Same Speed As The Rotational Speed Of The Rotor. Synchronous Machines Cannot Start Themselves Because The Poles Are Heavy And Cannot Suddenly Follow The Speed Of The Rotating Field When The Switch Is Connected To The Network, Therefore A Starting Aid (Prime Mover) Is Needed.

The Armature Coil Is Also Called The Stator Coil Because It Is In A Fixed Place, While The Rotor Coil With Magnetic Poles Is Rotated Together By Mechanical Power. In General, The Construction Of A Synchronous Generator Consists Of A Stator (A Stationary Part) And A Rotor (A Moving Part). Both Are Related Symmetrical And Cylindrical Magnetic Circuits.

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Apart From That, Synchronous Generators Have An Air Gap Between The Stator And Rotor Which Functions As A Place For The Rotor To Rotate And A Place For Flux Or Induction Of Electrical Energy From The Rotor To The Stator.

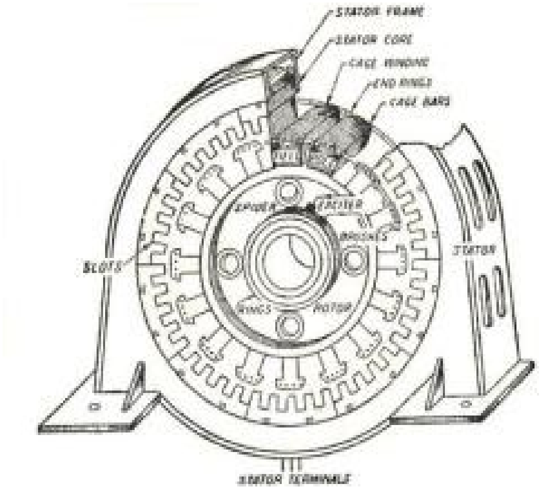

Figure 1. Synchronous Generator Construction

Stator

The Stator Is The Part That Functions As A Place To Receive Magnetic Induction From The Rotor. The Ac Current That Will Go To The Load Is Channeled Through The Stator. The Stator Is In The Form Of A Cylindrical Frame With Many Coils Of Conductor Wire. The Stator Winding Is The Place To Generate Voltage. The Stator Is Made Of Ferromagnetic Material Which Is Shaped And Laminated To Reduce Eddy Current Losses.

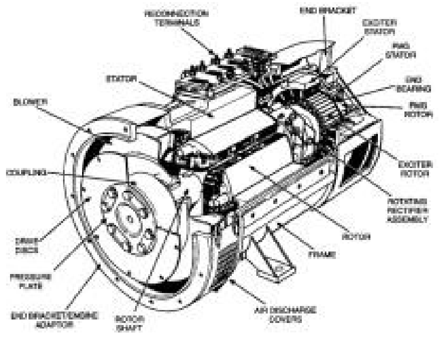

Figure 2. Stator Framework And Core

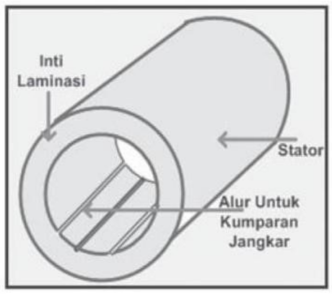

Figure 3. Stator Core And Grooves In The Stator

The Stator Consists Of Several Main Components, Namely:

a. Stator Frame, Made Of Cast Iron Which Functions To Support The Anchor Core.
b. The Stator Core Is Made Of Soft Iron (Silicon Steel).
c. The Groove (Slot) Functions As A Place To Place The Stator Windings (Coils). There Are 3 (Three) Forms Of Stator Grooves, Namely: Open, Half Open, And Closed As In Figure 4 Below:

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Figure 4. Groove Shapes

d. Stator Coil (Anchor Coil)

The Stator Coil (Anchor) Is Usually Made Of Copper. This Coil Is Where The Induced Emf Arises. There Are Two Types Of Stator (Anchor) Windings Commonly Used By Three-Phase Synchronous Machines, Namely:

1) Single Layer Winding (Single Layer Winding)

In A Single Layer Winding, The Phase Coils Are Separated By 120 Electrical Degrees Or 60 Mechanical Degrees, One Full Emf Cycle Will Be Produced If The Rotor With 4 Poles Rotates 180 Mechanical Degrees.

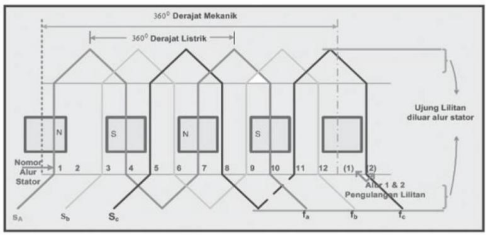

Figure 5. Single Layer Winding Of A Three Phase Synchronous Generator

2) Double Layer Winding (Double Layer Winding)

A Form Of Double-Layer Winding That Is Generally Widely Used As In Figure 6. In Each Groove There Are Two Sides Of The Winding And Each Winding Has More Than One Turn. The Part Of The Winding That Does Not Lie In The Groove Is Usually Called The Winding Overhang, So There Is No Tension In The Winding Overhang.

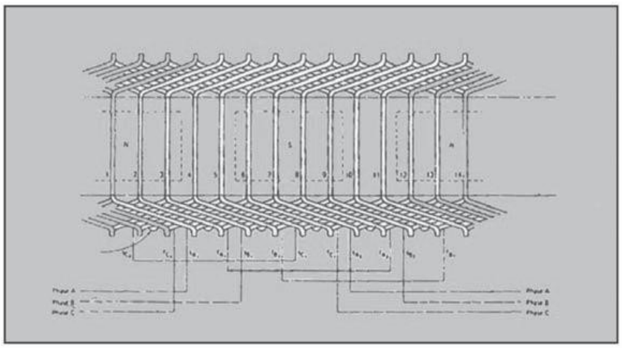

Figure 6. Double Layer Winding Of Three Phase Synchronous Generator

Rotor

The Rotor Is A Rotating Part Whose Function Is To Generate A Magnetic Field Which Produces Voltage And Will Be Induced Into The Stator. On The Rotor There Are Magnetic

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Poles With Their Windings Carrying Direct Current, Passing Through The Sliding Rings And Brushes. The Rotor Consists Of Four Main Components, Namely:

a. Slip Ring Or Sliding Ring
   The Slip Ring Is A Metal Ring That Circles The Rotor Shaft But Is Separated By Certain Insulation, Made Of Brass Or Copper Which Is Installed On The Shaft Using Insulating Material. The Rotor Coil Terminal Is Attached To The Slip Ring And Then Connected To A Direct Current Source Via A Brush Which Is Attached To The Slip Ring. This Slip Ring Rotates Together With The Shaft And Rotor. There Are Two Slip Rings, Each Slip Ring Can Shift The Charcoal Brush, Which Is The Positive And Negative Brush, Which Is Useful For Channeling Magnetic Amplifier Current To The Magnetic Winding On The Rotor.
b. Brush
   The Brush Is Made Of A Certain Carbon Material, Functions As A Rotary Switch To Flow Dc Current To The Field Coil On The Synchronous Generator Rotor.
c. Rotor Coil (Field Coil)
   The Rotor Coil Is An Element That Plays A Major Role In Producing A Magnetic Field. This Coil Gets Direct Current From A Certain Excitation Source.
d. Rotor Shaft
   The Rotor Shaft Is The Place Where The Field Coil Is Placed, Where On The Rotor Shaft Slots Have Been Formed Parallel To The Rotor Shaft.

The Rotor Magnetic Field Pole Can Be A Salient Pole And A Non-Salient Pole.

1) Salient Pole Type (Sailent Pole)
   In The Silent Pole Type, The Magnetic Poles Protrude From The Surface Rotor. The Field Windings Are Connected In Series. When This Field Winding Is Supplied By An Exciter, The Adjacent Poles Will Form Opposite Poles. Rotors With Protruding Poles Are Generally Used In Synchronous Generators With Low And Medium Rotational Speeds (200–400rpm). Generators Like This Are Usually Coupled To Diesel Engines Or Water Turbines In Power Generation Systems. Prominent Pole Rotors Are Good For Low And Medium Rotations, Because:
   a. Protruding Poles Will Experience Large Wind Losses And Make Noise If Rotated At High Speed.
   b. The Protruding Pole Construction Is Not Strong Enough To Withstand Mechanical Stress When Rotated At High Speed.

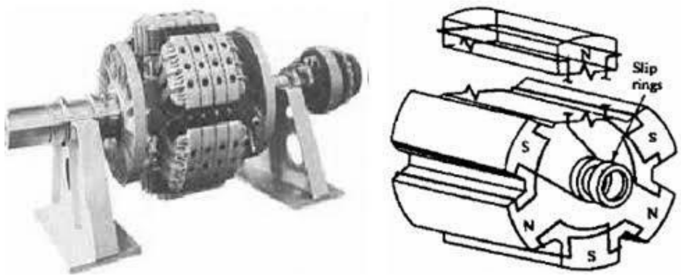

Figure 7. Protruding Pole Rotor

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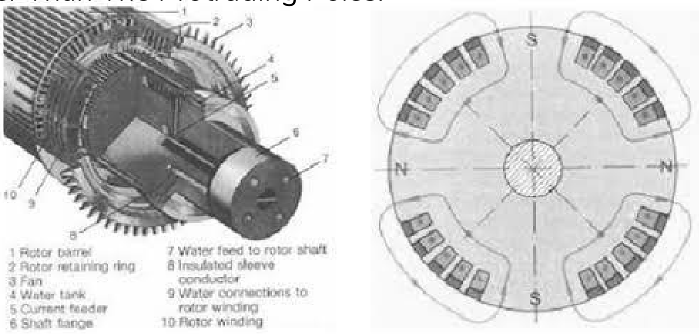
2) Cylindrical Pole Type (Non Sailent Pole)
In The Non-Silent Pole Type, The Construction Of The Magnetic Poles Is Flat Rotor Surface. This Type Of Rotor Is Made Of Fine Forged Steel In A Cylindrical Shape Which Has Grooves Made On The Outside. The Field Windings Are Installed In Grooves On The Outside And Are Connected In Series. Cylindrical Pole Type Rotors Are Generally Used In Synchronous Generator With High Rotational Speed (1500 – 3000) Rpm As Found In Steam Power Plants. Cylindrical Rotors Are Good For Use At High Rotation Speeds Because:
a. The Construction Has Good Mechanical Strength At High Rotational Speeds.
b. The Distribution Around The Rotor Approaches A Sine Wave Shape So That It Is Better Than The Protruding Poles.



(a) (b)

Figure 8 (A) Non-Salient Rotor, (B) Rotor Cross-Section

Working Principles Of Prime Mover And Synchronous Generator

The Prime Mover Of The Generator At The Sipansihaporas Hydroelectric Power Plant Is A Water Turbine, Both In Unit 1 And Unit 2. The Water Turbine Used In The Generator Prime Mover Is A Reaction Turbine Type Francis Vertical Sharf Turbine. A Water Turbine Is A Conversion Machine That Converts The Potential Energy Of Water Into Mechanical Energy. Mechanical Energy Is Generated In The Form Of Rotation Of The Turbine Shaft Can Be Directly Or With The Help Of A Reduction Gear Connected To The Driven Mechanism. To Produce Electrical Energy, The Mechanism That Is Driven Is The Generator Shaft.

On The Turbine Wheel There Are Blades, Which Are A Plate Construction With A Certain Shape And Cross-Section, Water As The Working Fluid Flows Through The Space Between The Blades, So That The Turbine Wheel Will Be Able To Rotate And A Force Will Act On The Blades. This Style Will Happen Because There Is A Change In Momentum Of The Working Fluid, Water Flowing Between The Blades. The Blade Should Be Shaped In Such A Way That Changes In Momentum Can Occur In The Water Working Fluid (Wiranto, 1997).

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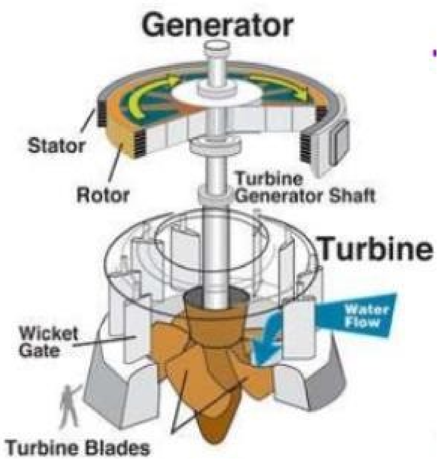

Figure 9. Water Turbine

Turbine Power The Power Of A Water Turbine Is Determined By The Amount Of Water Discharge And The Height Of The Water Fall (Head) As Well As The Efficiency Of The Water Turbine. The Water Turbine Power Formula Is:

P= Hturbinex P X Q Xgx H (1)

METHOD

This Research Was Conducted At The Sipansihaporas Hydroelectric Power Plant Unit 1 And Unit 2 Located In The Villages Of Husor, Sibuluan And Sihaporas, Sibolga District, Central Tapanuli Regency, North Sumatra Province. The Data Used In This Research Is Specification Data For The Turbine, Generator And Penstock And Daily Logsheet.

Table 1. Generator Specification Data For Unit 1 Of The Sipansihaporas Hydroelectric Power Plant

Manufacturing	Maidensha Corp Japan
Power	39000 Kva
Voltage	11000 V
Current	2047 A
Frequency	50 Hz
Round	429 Min-
Standard	Iec 34
Ratings	Continuous

Number Of Phases	3
Power Factor	0.85
Number Of Poles	14
Isolation Class	F
Serial No	F8n5554ri
Tag Excitation	160 V
Field Flow	807 A

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Protection	Ip44
Cooling	Ic7a1w7
Cooling	Ic7a1w7

Table 2. Turbine Specification Data For Unit 1 Of Sipansihaporas Hydroelectric Power Plant

Manufacturing	Toshiba Corporation
Type	Vertical Sharf Francis Turbine
Serial No.	M2117071 Cr 1101
Direction Of Rotation	Counterclockwise
Power	34 Mw
Normal Fall Height	131.6
Debit	27.9
Normal Spin	429 Rpm
Number Of Spoons	13

Table 3. Penstock Specification Data For Unit 1 Of The Sipansihaporas Hydroelectric Power Plant

Manufacturing	Impsa – Batara Consortium
Type	Above Ground
Diameter	2.2 – 3.7 M
Long	278.21 M
Fall Height	128.4
Wall Thickness	10 – 12- 14 Mm

RESULT

Data Analysis Based On Specification Data

In The Sipansihaporas Hydroelectric Power Plant, The Prime Mover Of The Synchronous Generator Is A Water Turbine Connected By A Shaft To The Generator. So The Output Power From The Turbine Is The Input Power To The Generator. From Table 1 The Data Is Obtained: Pout Turbine= Pin Generator= 34 Mw Based On Table 1 And Using Formula 2.25, The Generator Output Power Calculation Is Obtained As Follows

Pout Generator

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

$=\sqrt{3} \times 11000 \text{ V} \times 2047 \text{ A} \times 0.85$

$=33150500$ Watts

$= 33.15$ Mw

So The Efficiency Value Of The Synchronous Generator In Unit 1 Of The Sipansihaporas Hydroelectric Power Plant Based On Specification Data Is 97.5%.

At Unit 2 Of The Sipansihaporas Hydroelectric Power Plant

In The Sipansihaporas Hydroelectric Power Plant, The Prime Mover Of The Synchronous Generator Is A Water Turbine Connected By A Shaft To The Generator. So The Output Power From The Turbine Is The Input Power To The Generator. From Table 3 The Data Is Obtained:

Pout Turbine= Pin Generator= 17.6 Mw

Based On Table 4 And Using Formula 2.25, The Generator Output Power Calculation Is Obtained As Follows:

Pout Generator =√3 X V X I X Cosφ
=√3 X 11000 V X 1050 A X 0.85
=17004409 Watts
=17,004 Mw

So The Efficiency Value Of The Synchronous Generator In Unit 2 Of The Sipansihaporas Hydroelectric Power Plant Based On Specification Data Is 96.61%.

Table 4. Results Of Power Analysis Input And Efficiency Comparison Of Unit 1 And Unit 2 Of The Sipansihaporas Hydroelectric Mpower Plant

No	Time	Unit 1			Unit 2		
		Pout (Mw)	Pin (Mw)	Efficiency (%)	Pout (Mw)	Pin (Mw)	Efficiency (%)
1	09.00	-	-	-	-	-	-
2	10.00	-	-	-	-	-	-
3	11.00	-	-	-	-	-	-
4	12.00	-	-	-	-	-	-
5	13.00	-	-	-	-	-	-
6	14.00	-	-	-	-	-	-
7	15.00	-	-	-	-	-	-
8	16.00	-	-	-	-	-	-
9	17.00	-	-	-	-	-	-
10	18.00	-	-	-	-	-	-
11	19.00	-	-	-	-	-	-
12	20.00	-	-	-	-	-	-
13	21.00	-	-	-	17.1	20,350	84.03
14	22.00	-	-	-	17.1	20,042	85.32
15	23.00	33.1	34,475	96.01	15.7	18,819	83.43
16	24.00	33.2	34,641	95.84	14.9	17,919	83.15
17	01.00	33.1	34,616	95.62	14.7	17,739	82.87
18	02.00	33.3	35,495	93.82	17.1	20,311	84.19
19	03.00	33.0	34,768	94.91	14.8	18,181	81.40
20	04.00	26.4	28,721	91.92	17.2	20,701	83.09
21	05.00	26.6	29,005	91.71	17.2	20,673	83.20

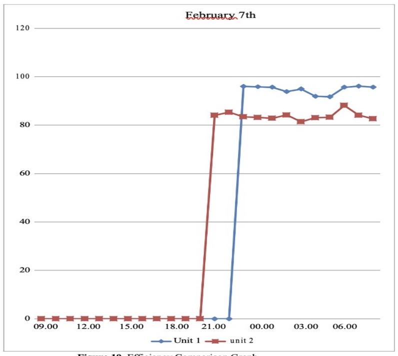

Figure 10. Efficiency Comparison Graph

Table 5. Results Of Input Power Analysis And Efficiency Comparison Of Unit 1 And Unit 2 Of Sipansihaporas Hydroelectric Power Plant On Saturday,

No.	Time	Unit 1 Pout (Mw)	Unit 1 Pin (Mw)	Unit 1 Efficiency (%)	Unit 2 Pout (Mw)	Unit 2 Pin (Mw)	Unit 2 Efficiency (%)
1	09.00	32.9	34,271	96.00	17.0	20,244	83.98
2	10.00	33.0	34,372	96.01	16.8	19,995	84.02
3	11.00	33.0	34,494	95.67	17.2	20,917	82.23
4	12.00	33.0	34,537	95.55	17.2	21,041	81.75
5	13.00	33.0	34,654	95.23	17.2	20,543	83.73
6	14.00	33.0	34,654	95.23	17.2	20,668	83.22
7	15.00	33.0	34,743	94.98	17.2	21,132	81.39
8	16.00	33.0	34,602	95.37	17.2	20,696	83.11
9	17.00	33.0	34,602	95.37	17.2	20,452	84.10
10	18.00	32.9	34,628	95.01	17.2	20,892	82.33
11	19.00	33.1	34,602	95.66	17.2	20,486	83.96
12	20.00	33.1	34,487	95.98	17.2	20,668	83.22
13	21.00	33.2	34,743	95.56	17.2	20,730	82.97
14	22.00	33.1	34,462	96.05	17.2	21,165	81.27
15	23.00	33.0	34,577	95.44	17.2	21,103	81.51
16	24.00	33.0	34,436	95.83	17.3	20,543	84.21
17	01.00	33.1	34,526	95.87	17.2	21,103	81.51
18	02.00	32.9	34,501	95.36	17.2	20,979	81.99
19	03.00	26.8	28,921	92.67	16.5	19,791	83.37
20	04.00	26.1	28,156	92.70	14.8	18,270	81.01
21	05.00	26.1	28,398	91.91	14.3	17,629	81.12
22	06.00	26.4	28,559	92.44	14.3	18,014	79.38
23	07.00	26.0	28,418	91.49	14.6	18,142	80.48
24	08.00	25.9	28,297	91.53	14.2	17,886	79.39

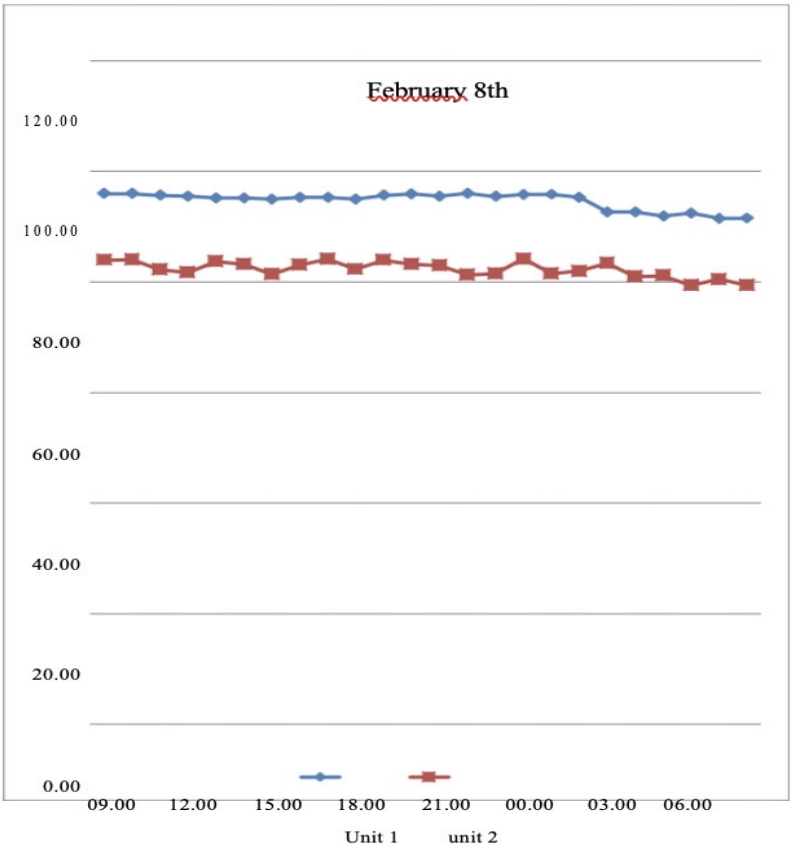

Figure 11. Efficiency Comparison Graph On February

CONCLUSION

Based On The Results Of The Author's Analysis, The Following Conclusions Are Obtained: Based On Specification Data, The Efficiency Of Unit 1 Is 97.50% And The Efficiency Of Unit 2 Is 96.61%. Based On Daily Data, The Average Efficiency Of Unit 1 Is 93.88%, With The Highest And Lowest Efficiency Being 97.00% And 73.15%. And The Average Efficiency Of Unit 2 Was Obtained At 82.49% With The Highest And Lowest Efficiency Being 88.17% And 73.68%. There Is A Difference In Efficiency Between Specification Data And Daily Data, For Unit 1 It Is 3.62% And For Unit 2 It Is 14.12%. Whether Based On Specification Data Or Daily Data, The Efficiency Of The Generator At The Sipansihaporas Hydroelectric Power Plant In Unit 1 Is Better Than In Unit 2.

References

[1] B. Satria, Alam, H., & Rahmaniar, R. (2023). Monitoring Air Quality System Based On Smart Device Intelligent. *Jurnal Ekonomi*, *12*(01), 1745-1752.
[2] Dalimunthe, E. (2021). Rancang Bangun Papan Informasi Keberadaan Seseorang Berbantuan Komputer. *Jurnal Vorteks*, *2*(2), 78-84.
[3] Rahmaniar, R., Syahputra, M. R., Lesmana, D., & Junaidi, A. (2022). Sosialisasi Pemahaman Bahaya Tegangan Sentuh Dan Hubung Singkat Sistem Kelistrikan Bagi

Masyarakat Desa Kota Pari. *Reswara: Jurnal Pengabdian Kepada Masyarakat*, *3*(2), 357-362.

[4] Siagian, A., Dalimunthe, M. E., & Tharo, Z. (2023). Analisis Kehandalan Sistem Konfigurasi Jaringan Penyulang 20 Kv Di Pt. Pln (Persero) Ulp Pakam Kota Berbasis Matlab. *Jurnal Rekayasa Elektro Sriwijaya*, *5*(1), 18-31.

[5] Pradana, Dkk. "Prototipe Pembangkit Listrik Termoelektrik Generator Menggunakan Penghantar Panas Aluminium, Kuningan Daan Seng." Jurnal Teknik Elektro 9.2 (2020).

[6] Sasmita, Sandy Angriawan, Et Al. "Alternatif Pembangkit Energi Listrik Menggunakan Prinsip Termoelektrik Generator." Tesla: Jurnal Teknik Elektro 21.1 (2019): 57-61.

[7] S. Aryza, Lubis, Z., Indrawan, M. I., Efendi, S., & Sihombing, P. (2021). Analyzed New Design Data Driven Modelling Of Piezoelectric Power Generating System. *Budapest International Research And Critics Institute-Journal (Birci-Journal)*, *4*(3), 5537-5547.

[8] S. Aryza., Lubis, Z., & Putra, K. (2024). Sosialisasi Sistem Proteksi Over Voltage Kantor Lurah Kelambir Lima Berbasiskan Iot. Jurnal Hasil Pengabdian Masyarakat (Juribmas), 3(1), 306-314.