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ANALYSIS OF THE EFFECT OF LOAD CHANGES ON THE PERFORMANCE OF SYNCHRONOUS GENERATOR UNIT 2 AT PT. PLN NUSA DAYA UNIT PLTU MALINAU

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Abstract
Changes in generator power losses are adjusted to the load needs in the field, which is constantly changing and can affect the value of the per-phase current and generator field current, causing power losses. The resulting power losses affect the efficiency of the PLTU generator. To determine the generator's efficiency due to load changes, this study was carried out using manual calculation method by collecting data on specifications, resistance, and dialy log sheets of the 2x3 MW Malinau PLTU generator unit 2 conducted at PT. Nusa Daya Unit PLTU Malinau. Based on the callculation data on May 17, the highest efficiency was 79,69% at a load 2,372 MW, while the lowest efficiency was 78,03% at a load of 2,137 MW. For the callculation results of May 18, the highets efficiency was 79,51% at a load 2,342 MW, while the lowest efficiency was 76,37% at a load of 1,941 MW. The greater the power generated by generator, the higher the efficiency of the generator and the better the generator performance.

Keywords:
PLTU; generator; load changes; power losses; efficiency

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1. Introduction

The need for electrical energy is one of the basic needs in human life today. Electrical energy produced from power plants supports human activities, including needs for industrial activities, commercial activities and people's daily life activities that must be met. The use of electrical energy isin many ways, such as lighting sources, power sources for electrical equipment, even power sourcesfor electric vehicles and the use of this electrical energy will increase every year, thereby encouragingthe electric power system to operate optimally.

PT National Electric Service Nusa Daya (PT PLN ND) is a company providing operation and maintenanceservices for power plants under 100 MW, having one of the Malinau sector plants, namely a PLTU with a capacityof 2x3 MW using coal as fuel. A steam power plant (PLTU) is a type of generator that utilizes steam (steam) fromthe results of combustion on boiler to drive a turbine which is coupled directly to a generator so that the generatorcan produce electrical energy, therefore the generator is an important component in the generating system. Efficiency of the generator greatly influences the performance of the power generation system, the greater the efficiency of thegenerator, the better the reliability of the system. The decrease in generator efficiency values occurs due to severalfactors such as generator power losses, generator trips (units shutdown), and duration of maintenance.

The power generated by the generator is adjusted to the load demand, the load received by the generatoralways changes depending on field conditions, because changes in load will result in power losses which greatlyaffect the efficiency of the generator [1].

When the electrical load changes (fluctuations), it will affect the performance of a generator. As theelectricity demand increases and the load generated increases, the generator work decreases [2].

The performance of a synchronous generator is measured by calculating efficiency, namely the comparisonbetween the generator's input and output power. If the generator operates with an efficiency below 80%, theenergy supplied is not optimal because a lot of electrical energy is lost due to losses [3].

In electrical energy generation systems, especially in synchronous generators, the generator is operated at aload that varies over time which causes instability in the generator's performance, the load changes that occur aredue to the use of electrical loads. The result of generator performance that is not optimal is that it can cause adecrease in the performance of the PLTU's electrical power system. In this research, we will analyze the effect ofload changes on the performance of generator unit 2 (two) at PLTU 2x3 MW Malinau. Some data is needed suchas specification data, obstacles, etc logsheet daily generator.

2. Method

A. Electric Power

The power triangle is the relationship between active power, reactive power and apparent power that can be expressed by representing these powers as vectors. The formula for power in a 3-phase triangular circuit is as follows [4].

$$P = \sqrt{3}\, V_L\, I_L \cos\varphi \quad (1)$$

$$Q = \sqrt{3}\, V_L\, I_L \sin\varphi \quad (2)$$

$$S = \sqrt{3}\, V_L\, I_L \quad (3)$$

With:
P = Active power (Watt)
Q = Reactive power(VAR)
S = Apparent power(VA)
V_L = 3-phase power (Volt)
I_L = 3-phase current (Ampere)
φ = power factor

B. Synchronous Generator Losses

Power losses consist of no-load losses and also copper losses, and to calculate these power losses use the following equation [1].

Loss without load:

$$Loss\ wihtout = Vt \times If \quad (4)$$

With:
Vt = Terminal voltage (Volt)
If = Field current (Ampere)

Electrical or Copper Losses:

1. Stator Winding Losses

This loss is the ohm loss that occurs in the stator winding which can be calculated using Eq.

$$Pcu\ jangkar = 3\ Ia^2 \times Ra \quad (5)$$

With:
P*cu anchor* = Stator copper loss (Watt)
Ia = Current in the stator (Ampere)

Ra = Stator resistance (Ω)

2. Rotor Winding Losses

Rotor winding losses referred to as energy losses in the field coil can be calculated using Eq.

$$Pcu\ medan = If^2 \times Rf \tag{6}$$

With:

Pc*u filed* = Rotor copper loss (Watt)

If = Current flow in the rotor winding (Ampere)

Rf = Resistance of the rotor (Ω)

So the total power loss in the generator is as in the equation:

$$\Sigma Prugi = No\text{-}load\ lass + anchor\ Pcu + filed\ Pcu \tag{7}$$

C. Synchronous Generator Efficiency

Generator efficiency is the comparison between output power and input power. As is the case with other electrical machines and transformers, the efficiency of a synchronous generator can be written as below [5].

$$\eta = \frac{Pout}{Pin} \times 100\% \tag{8}$$

$$Pin = Pout + \Sigma Prugi \tag{9}$$

With:

η = Generator efficiency

Pin = Input power (Watt)

Pout = Output power (Watt)

Generator efficiency is the ratio between the output power value and the generator input power value in MW units and is expressed in the form of a percent (%). In synchronous generators, the generator efficiency value is greatly influenced by power losses, therefore the input power is determined from the output power plus the total power losses.

D. Generator Unit 2 Generator Unit 2 Specification and Resistance Data

Specifications for generator unit 2 of PLTU Nusa Daya 2x3 MW Malinau are as in table 1.

Table 1. Generator Specification and Resistance Data

Manufactur	Luoyang Generating
Model	QFK-K3 5-2
Voltage	6,3 kV
Rated Power	3,5 MW
Rated Current	377 A
Rated Speed	3000 r/min
Rated Frequency	50 Hz
Capacity	4,118 MVA
Rated Field Voltage	77 V
Rated Field Current	239 A
Exciting current at no-load	93 A
Power Factor/Cos φ	0,85
Phase/Connected	3/Y

Efifciency	96,8 %
Resistance Stator	0,066 Ω
Resistance Rotor	0,268 Ω

E. Unit 2 Generator Loading Data

Data retrieval *logsheet* generator unit 2 was carried out for 2 days starting 17-18 May 2024. The data was obtained from the CCR room (*Central Control Room*) PLTU Nusa Daya and known parameters as in table 2 to table 3.

Table 2. Load 17 May 2024

Time	Actual Load		Frequency (Hz)	Output Voltage (kV)			*Cos φ*	Current (A)			Filed Current (If)
	MW	kVAR		R	S	T		R	S	T	
01:02	2,338	753	50.16	6,286	6,385	6,219	0,94	213	216	215	154
02:02	2,332	762	50.15	6,286	6,384	6,217	0,94	209	212	213	154
03:02	2,333	788	50.15	6,289	6,379	6,218	0,94	209	214	213	155
04:02	2,336	758	50.15	6,286	6,382	6,237	0,94	212	216	215	156
05:02	2,304	757	50.16	6,284	6,381	6,211	0,94	209	214	214	154
06:02	2,302	739	50.15	6,282	6,380	6,210	0,94	209	212	211	155
07:02	2,343	881	50.15	6,281	6,380	6,211	0,93	212	215	217	156
08:02	2,503	932	50.13	6,282	6,382	6,205	0,92	222	225	227	160
09:02	2,171	960	50.15	6,282	6,382	6,208	0,91	217	221	222	159
10:02	2,335	1,246	50.18	6,283	6,382	6,207	0,88	242	244	246	160
11:02	2,341	1,271	50.15	6,285	6,386	6,207	0,89	244	243	245	162
12:02	2,334	1,138	50.17	6,281	6,384	6,212	0,89	236	238	240	162
13:02	2,324	1,129	50.15	6,282	6,386	6,209	0,90	236	238	238	162
14:02	2,343	1,271	50.15	6,285	6,386	6,207	0,89	244	243	245	162
15:02	2,381	1,201	50.17	6,282	6,384	6,214	0,89	241	244	248	163
16:02	2,332	1,089	50.15	6,281	6,383	6,213	0,90	240	242	243	161
17:02	2,375	1,107	50.16	6,282	6,384	6,211	0,90	238	239	241	162
18:02	2,308	907	50.16	6,289	6,382	6,215	0,92	225	226	228	160
19:02	2,328	770	50.17	6,285	6,383	6,215	0,94	212	214	214	161
20:02	2,329	858	50.16	6,288	6,382	6,216	0,92	211	214	214	161
21:02	2.201	802	50.14	6,290	6,382	6,218	0,94	212	215	216	158
22:02	2.202	762	50.17	6,290	6,385	6,218	0,94	211	212	213	157
23:02	2.347	804	50.16	6,290	6,385	6,220	0,94	213	216	216	157
00:02	2.315	761	50.16	6,287	6,385	6,218	0,94	211	213	213	155

Table 3. Load 18 May 2024

Time	Actual Load		Frequency (Hz)	Output Voltage (kV)			*Cos φ*	Current (A)			Field Current (If)
	MW	kVAR		R	S	T		R	S	T	
01:02	2,273	795	50.16	6,293	6,380	6,227	0,94	220	223	222	153
02:02	2,265	849	50.17	6,274	6,383	6,194	0,93	220	224	223	152
03:02	2,257	798	50.16	6,249	6,374	6,189	0,93	219	221	223	151
04:02	2,269	796	50.18	6,273	6,382	6,194	0,94	217	221	220	152
05:02	2,252	754	50.14	6,284	6,383	6,211	0,95	215	218	218	151
06:02	2,249	810	50.15	6,282	6,380	6,209	0,94	218	221	221	150
07:02	2,268	792	50.17	6,283	6,382	6,211	0,94	216	219	220	152
08:02	2,277	865	50.14	6,208	6,380	6,246	0,93	218	222	223	154
09:02	2,285	1,025	50.15	6,281	6,380	6,203	0,91	227	231	232	156
10:02	2,232	1,170	50.14	6,280	6,384	6,205	0,88	230	232	232	156
11:02	2,009	1,106	50.21	6,287	6,385	6,216	0,86	206	208	207	154

12:02	1,990	1,180	50.16	6,287	6,382	6,220	0,85	210	213	212	152
13:02	2,177	1,031	50.15	6,285	6,383	6,217	0,90	218	220	221	153
14:02	2,251	1,181	50.16	6,283	6.383	6,216	0,88	233	235	235	154
15:02	2,236	1,223	50.15	6,274	6,385	6,192	0,87	234	237	237	154
16:02	2,245	1,167	50.17	6,267	6,385	6,192	0,88	233	235	234	154
17:02	2,360	1,155	50.14	6,269	6,381	6,194	0,89	240	242	242	158
18:02	2,353	1,006	50.16	6,267	6,378	6,193	0,91	234	237	239	156
19:02	2,395	933	50.17	6,273	6,381	6,191	0,93	226	229	232	161
20:02	2,330	1,155	50.14	6,269	6,381	6,194	0,89	240	242	242	160
21:02	2,274	877	50.19	6,272	6,386	6,191	0,93	220	222	224	160
22:02	2,263	854	50.16	6,294	6,384	6,191	0,93	220	223	223	158
23:02	2,287	834	50.16	6,296	6,381	6,232	0,94	219	222	222	156
00:02	2,238	803	50.14	6,289	6,383	6,222	0,94	218	221	220	154

3. Results and Discussion

A. *Generator Unit 2 Power Calculation*

Calculation of the output power of a 3-phase generator is done by calculating the average voltage and average current. Some of the data used in the calculations are voltage (kV), three-phase current (A), and power factor (cos φ). So the calculated output power is obtained using the equation:

- *Avarage V* $= V_R + V_S + V_T$

  = 6,286 + 6,385 + 6,219

  = 18,890 kV

  $= \frac{18{,}900}{3} = 6{,}297$ kV

- *Avarage I* $= I_R + I_S + I_T$

  = 213 +216 + 215

  $= \frac{644}{3} = 214{,}67\ A$

- *Pout* $= \sqrt{\mathbf{3}}\ V_L\ I_L \cos\varphi$

  $= \sqrt{3}$ x 6,297 x 214,67 x 0,94

  = 2,200 MW

B. *Generator Unit 2 Power Losses*

To find out the generator efficiency value, first calculate the power losses on the generator by calculating the no-load loss and copper losses (anchor and field) on the loading data for May 17 and 18. Some data used in calculations such as output voltage (Vt), field current (If), generator stator and rotor resistance (Ω), armature and field current (A) are obtained from generator specifications, *logsheet* daily generator, and *manual book*.

No-Load Loss:

- *Pno-load* = *Vt x If*

  = 6.300 x 93

  = 585.900 Watt

  = 0,5859 MW

Copper Loss Calculation:

- *R phase anchor Pcu* $= Ia^2 \times Ra$
  $= 213^2 \times 0{,}066$
  = 2.994,35 Watt
  = 0,00299 MW
- *S phase anchor Pcu* $= Ia^2 \times Ra$
  $= 216^2 \times 0{,}066$
  = 3.079,30 Watt
  = 0,00308 MW
- *T phase anchor Pcu* $= Ia^2 \times Ra$
  $= 215^2 \times 0{,}066$
  = 3.050,85 Watt
  = 0,00305 MW
- *Σ anchor Pcu* = 0,00299 + 0,00308 + 0,00305
  = 0,00912 MW
- *Field Pcu* $= If^2 \times Rf$
  $= 154^2 \times 0{,}268$
  = 6.355,89 Watt
  = 0,00636 MW

Based on the calculation results above, the total power losses are obtained using the equation:

- *ΣPloss* = *No-load loss + Σ anchorPcu + Field Pcu*

  = 0,5859 + 0,00912 + 0,00636

  = 0,601 MW

C. Calculation of Generator Efficiency Unit 2

Generator efficiency calculations are carried out starting from the parameters *Pout* (MW) the calculation results are added to *ΣPloss* to gain value *Pin* (MW). Then assess *Pin* is entered into the generator efficiency equation, then the percentage of generator efficiency in the loading data is as follows:

Pin = *Pout + ΣPloss*

Pin = 2,200 + 0,600

= 2,800 MW

$$\eta\ (gen) = \frac{Pout}{Pin} \times 100\%$$

$$\eta = \frac{2{,}200}{2{,}800} \times 100\%$$

= 79,58 %

D. Tables and Figure

The results of the calculation of electrical power, total losses and generator efficiency are presented in the form of tables and graphs and then analyzed the effect of load changes on the performance of the synchronous generator as measured by the efficiency value.

Table 4. Power Calculation Results 17 May 2024

Time	Actual Data								Calculation Data		
	Pout (MW)	Output Voltage (kV)			Current (A)			*Cos φ*			
		R	S	T	R	S	T		Avarage V (kV)	Avarage A (I)	*Pout* (MW)
01:02	2,338	6,286	6,385	6,219	213	216	215	0,94	6,297	214,67	2,200
02:02	2,332	6,286	6,384	6,217	209	212	213	0,94	6,296	211,33	2,166
03:02	2,333	6,289	6,379	6,218	209	214	213	0,94	6,295	212,00	2,173
04:02	2,336	6,286	6,382	6,237	212	216	215	0,94	6,302	214,33	2,197
05:02	2,304	6,284	6,381	6,211	209	214	214	0,94	6,292	212,33	2,176
06:02	2,302	6,282	6,380	6,210	209	212	211	0,94	6,291	210,67	2,159
07:02	2,343	6,281	6,380	6,211	212	215	217	0,93	6,291	214,67	2,177
08:02	2,503	6,282	6,382	6,205	222	225	227	0,92	6,290	224,67	2,254
09:02	2,171	6,282	6,382	6,208	217	221	222	0,91	6,291	220,00	2,183
10:02	2,335	6,283	6,382	6,207	242	244	246	0,88	6,291	244,00	2,341
11:02	2,341	6,285	6,386	6,207	244	243	245	0,89	6,293	244,00	2,368
12:02	2,334	6,281	6,384	6,212	236	238	240	0,89	6,292	238,00	2,310
13:02	2,324	6,282	6,386	6,209	236	238	238	0,90	6,292	237,33	2,329
14:02	2,343	6,285	6,386	6,207	244	243	245	0,89	6,293	244,00	2,368
15:02	2,381	6,282	6,384	6,214	241	244	248	0,89	6,293	244,33	2,371
16:02	2,332	6,281	6,383	6,213	240	242	243	0,90	6,292	241,67	2,372
17:02	2,375	6,282	6,384	6,211	238	239	241	0,90	6,292	239,33	2,349
18:02	2,308	6,289	6,382	6,215	225	226	228	0,92	6,295	226,33	2,270
19:02	2,328	6,285	6,383	6,215	212	214	214	0,94	6,294	213,33	2,186
20:02	2,329	6,288	6,382	6,216	211	214	214	0,92	6,295	213,00	2,137
21:02	2,201	6,290	6,382	6,218	212	215	216	0,94	6,297	214,33	2,197
22:02	2,202	6,290	6,385	6,218	211	212	213	0,94	6,298	212,00	2,173
23:02	2,347	6,290	6,385	6,220	213	216	216	0,94	6,298	215,00	2,204
00:02	2,315	6,287	6,385	6,218	211	213	213	0,94	6,297	212,33	2,176

Table 5. Power Calculation Results 18 May 2024

Time	Actual Data								Calculation Data		
	Pout (MW)	Output Voltage (kV)			Current (A)			Cos φ			
		R	S	T	R	S	T		Avarage V (kV)	Avarage A (I)	*Pout* (MW)
01:02	2,273	6,293	6,380	6,227	220	223	222	0,94	6,300	221,67	2,273
02:02	2,265	6,274	6,383	6,194	220	224	223	0,93	6,284	222,33	2,250
03:02	2,257	6,249	6,374	6,189	219	221	223	0,93	6,271	221,00	2,232
04:02	2,269	6,273	6,382	6,194	217	221	220	0,94	6,283	219,33	2,243
05:02	2,252	6,284	6,383	6,211	215	218	218	0,95	6,293	217,00	2,246
06:02	2,249	6,282	6,380	6,209	218	221	221	0,94	6,290	220,00	2,253
07:02	2,268	6,283	6,382	6,211	216	219	220	0,94	6,292	218,33	2,236
08:02	2,277	6,208	6,380	6,246	218	222	223	0,93	6,278	221,00	2,234
09:02	2,285	6,281	6,380	6,203	227	231	232	0,91	6,288	230,00	2,279
10:02	2,232	6,280	6,384	6,205	230	232	232	0,88	6,290	231,33	2,217
11:02	2,009	6,287	6,385	6,216	206	208	207	0,86	6,296	207,00	1,941
12:02	1,990	6,287	6,382	6,220	210	213	212	0,85	6,296	211,67	1,962
13:02	2,177	6,285	6,383	6,217	218	220	221	0,90	6,295	219,67	2,155
14:02	2,251	6,283	6.383	6,216	233	235	235	0,88	6,294	234,33	2,247
15:02	2,236	6,274	6,385	6,192	234	237	237	0,87	6,284	236,00	2,234
16:02	2,245	6,267	6,385	6,192	233	235	234	0,88	6,281	234,00	2,240
17:02	2,360	6,269	6,381	6,194	240	242	242	0,89	6,281	241,33	2,336
18:02	2,353	6,267	6,378	6,193	234	237	239	0,91	6,279	236,67	2,342

19:02	2,395	6,273	6,381	6,191	226	229	232	0,93	6,282	229,00	2,317
20:02	2,330	6,269	6,381	6,194	240	242	242	0,89	6,281	241,33	2,336
21:02	2,274	6,272	6,386	6,191	220	222	224	0,93	6,283	222,00	2,246
22:02	2,263	6,294	6,384	6,191	220	223	223	0,93	6,290	222,00	2,249
23:02	2,287	6,296	6,381	6,232	219	222	222	0,94	6,303	221,00	2,267
00:02	2,238	6,289	6,383	6,222	218	221	220	0,94	6,298	219,67	2,252

Table 6. Generator Power Losses 17 May 2024

Time	Pno-load (MW)	Anchor Pcu (MW)			Field Current (If)	Σ*P*loss (MW)
		R	S	T		
01:02	0,5859	0,00299	0,00308	0,00305	0,00636	0,601
02:02	0,5859	0,00288	0,00297	0,00299	0,00636	0,601
03:02	0,5859	0,00288	0,00302	0,00299	0,00644	0,601
04:02	0,5859	0,00297	0,00308	0,00305	0,00652	0,602
05:02	0,5859	0,00288	0,00302	0,00302	0,00636	0,601
06:02	0,5859	0,00288	0,00297	0,00294	0,00644	0,601
07:02	0,5859	0,00297	0,00305	0,00311	0,00652	0,602
08:02	0,5859	0,00325	0,00334	0,00340	0,00686	0,603
09:02	0,5859	0,00311	0,00322	0,00325	0,00678	0,602
10:02	0,5859	0,00387	0,00393	0,00399	0,00686	0,605
11:02	0,5859	0,00393	0,00390	0,00396	0,00703	0,605
12:02	0,5859	0,00368	0,00374	0,00380	0,00703	0,604
13:02	0,5859	0,00368	0,00374	0,00374	0,00703	0,604
14:02	0,5859	0,00393	0,00390	0,00396	0,00703	0,605
15:02	0,5859	0,00383	0,00393	0,00406	0,00712	0,605
16:02	0,5859	0,00380	0,00387	0,00390	0,00695	0,604
17:02	0,5859	0,00374	0,00377	0,00383	0,00703	0,604
18:02	0,5859	0,00334	0,00337	0,00343	0,00686	0,603
19:02	0,5859	0,00297	0,00302	0,00302	0,00695	0,602
20:02	0,5859	0,00294	0,00302	0,00302	0,00695	0,602
21:02	0,5859	0,00297	0,00305	0,00308	0,00669	0,602
22:02	0,5859	0,00294	0,00297	0,00299	0,00661	0,601
23:02	0,5859	0,00299	0,00308	0,00308	0,00661	0,602
00:02	0,5859	0,00294	0,00299	0,00299	0,00644	0,601

Table 7. Generator Power Losses 18 May 2024

Time	Pno-load (MW)	Anchor Pcu (MW)			Filed Current (If)	Σ*P*loss (MW)
		R	S	T		
01:02	0,5859	0,00319	0,00328	0,00325	0,00627	0,602
02:02	0,5859	0,00319	0,00331	0,00328	0,00619	0,602
03:02	0,5859	0,00317	0,00322	0,00328	0,00611	0,602
04:02	0,5859	0,00311	0,00322	0,00319	0,00619	0,602
05:02	0,5859	0,00305	0,00314	0,00314	0,00611	0,601
06:02	0,5859	0,00314	0,00322	0,00322	0,00603	0,602
07:02	0,5859	0,00308	0,00317	0,00319	0,00619	0,602
08:02	0,5859	0,00314	0,00325	0,00328	0,00636	0,602
09:02	0,5859	0,00340	0,00352	0,00355	0,00652	0,603
10:02	0,5859	0,00349	0,00355	0,00355	0,00652	0,603
11:02	0,5859	0,00280	0,00286	0,00283	0,00636	0,601
12:02	0,5859	0,00291	0,00299	0,00297	0,00619	0,601
13:02	0,5859	0,00314	0,00319	0,00322	0,00627	0,602
14:02	0,5859	0,00358	0,00364	0,00364	0,00636	0,603
15:02	0,5859	0,00361	0,00371	0,00371	0,00636	0,603
16:02	0,5859	0,00358	0,00364	0,00361	0,00636	0,603
17:02	0,5859	0,00380	0,00387	0,00387	0,00669	0,604
18:02	0,5859	0,00361	0,00371	0,00377	0,00652	0,604
19:02	0,5859	0,00337	0,00346	0,00355	0,00695	0,603
20:02	0,5859	0,00380	0,00387	0,00387	0,00686	0,604
21:02	0,5859	0,00319	0,00325	0,00331	0,00686	0,603
22:02	0,5859	0,00319	0,00328	0,00328	0,00669	0,602
23:02	0,5859	0,00317	0,00325	0,00325	0,00652	0,602
00:02	0,5859	0,00314	0,00322	0,00319	0,00636	0,602

Table 8. Generator Efficiency 17 May 2024

Time	*Pout* (MW)	*ΣPloss* (MW)	*Pin* (MW)	Efficiency (%)
01:02	2,200	0,601	2,801	78,53 %
02:02	2,166	0,601	2,767	78,28 %
03:02	2,173	0,601	2,774	78,33 %
04:02	2,197	0,602	2,799	78,51 %
05:02	2,176	0,601	2,777	78,35 %
06:02	2,159	0,601	2,760	78,22 %
07:02	2,177	0,602	2,779	78,35 %
08:02	2,254	0,603	2,857	78,90 %
09:02	2,183	0,602	2,785	78,38 %
10:02	2,341	0,605	2,946	79,48 %
11:02	2,368	0,605	2,973	79,66 %
12:02	2,310	0,604	2,914	79,27 %
13:02	2,329	0,604	2,933	79,40 %
14:02	2,368	0,605	2,973	79,66 %
15:02	2,371	0,605	2,976	79,67 %
16:02	2,372	0,604	2,976	79,69 %
17:02	2,349	0,604	2,953	79,54 %
18:02	2,270	0,603	2,873	79,01 %
19:02	2,186	0,602	2,788	78,41 %
20:02	2,137	0,602	2,739	78,03 %
21:02	2,197	0,602	2,799	78,50 %
22:02	2,173	0,601	2,774	78,32 %
23:02	2,204	0,602	2,806	78,56 %
00:02	2,176	0,601	2,777	78,35 %

Table 9. Generator Efficiency 18 May 2024

Time	*Pout* (MW)	*ΣPloss* (MW)	*Pin* (MW)	Efficiency (%)
01:02	2,273	0,602	2,875	79,06 %
02:02	2,250	0,602	2,852	78,90 %
03:02	2,232	0,602	2,834	78,77 %
04:02	2,243	0,602	2,845	78,85 %
05:02	2,246	0,601	2,847	78,88 %
06:02	2,253	0,602	2,855	78,93 %
07:02	2,236	0,602	2,838	78,80 %
08:02	2,234	0,602	2,836	78,77 %
09:02	2,279	0,603	2,882	79,08 %
10:02	2,217	0,603	2,820	78,62 %
11:02	1,941	0,601	2,542	76,37 %
12:02	1,962	0,601	2,563	76,55 %
13:02	2,155	0,602	2,757	78,17 %
14:02	2,247	0,603	2,850	78,84 %
15:02	2,234	0,603	2,837	78,74 %
16:02	2,240	0,603	2,843	78,79 %
17:02	2,336	0,604	2,940	79,45 %
18:02	2,342	0,604	2,946	79,51 %
19:02	2,317	0,603	2,920	79,34 %
20:02	2,336	0,604	2,940	79,45 %
21:02	2,246	0,603	2,849	78,85 %
22:02	2,249	0,602	2,851	78,87 %
23:02	2,267	0,602	2,869	79,01 %
00:02	2,252	0,602	2,854	78,91 %

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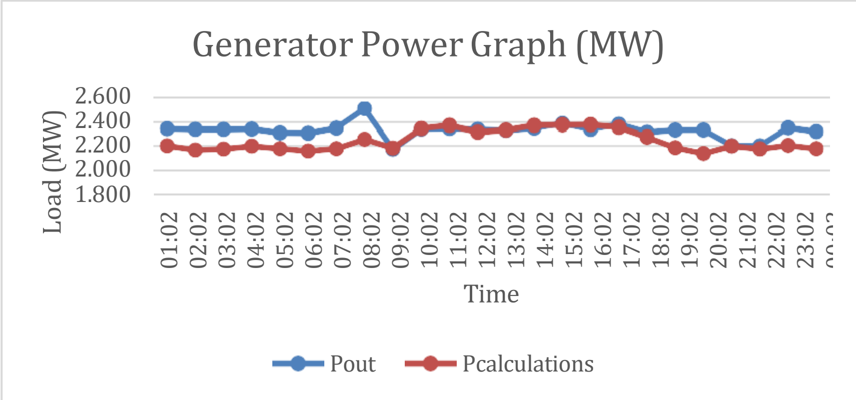

Figure 1. Actual Power Graph and Generator Calculations 17 May 2024

In Figure 1, the graph also shows changes in the generator load each hour which are not very significant with the highest load at 2,395 MW at 19:02 while the lowest load is 1,990 MW at 12:02. From the comparison graph above, it can be seen that the calculated power of the generator is very close to the value of the generator output power (Pout) at *logsheet*.

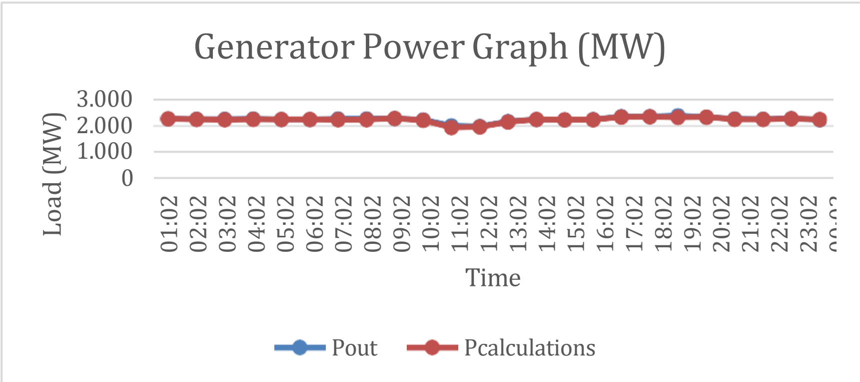

Figure 2. Actual Power Graph and Generator Calculations 18 May 2024

In Figure 2, the graph also shows changes in the generator load each hour which are not very significant with the highest load at 2,395 MW at 19:02 while the lowest load is 1,990 MW at 12:02. From the comparison graph above, it can be seen that the calculated power of the generator is very close to the value of the generator output power (Pout) at *logsheet*.

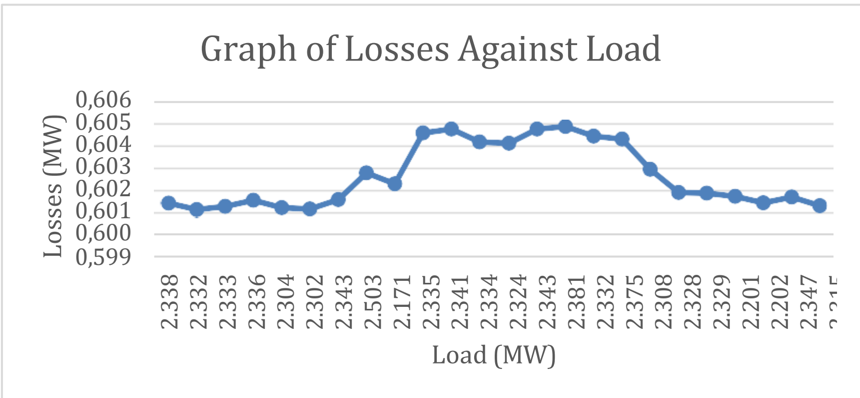

Figure 3. Graph of Losses Against Load 17 May 2024

In graph 3 of the calculation results on May 17, it can be seen that generator power losses at certain loads and times have changed. The value of power losses is influenced by phase current (A) and field current (If) due to changes in load. Based on graph 3, the highest power loss is 0.605 MW at a load of 2.381 MW, while the lowest power loss is 0.601 MW at a load of 2.332 MW.

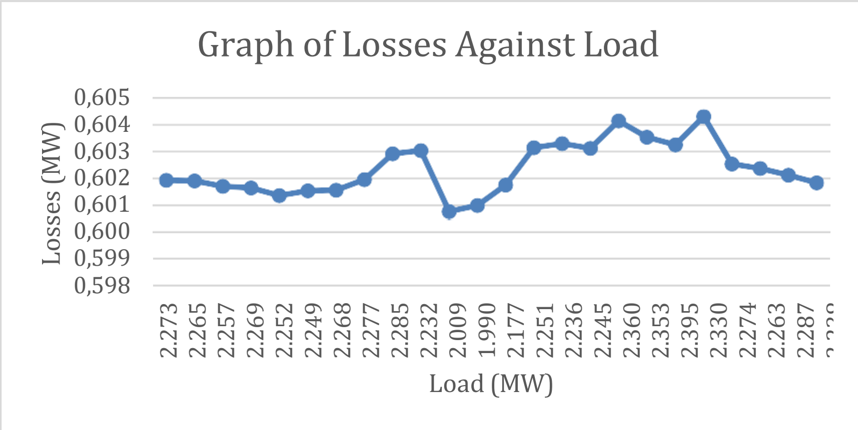

Figure 4. Graph of Losses Against Load 18 May 2024

In Figure 4, the graph of the calculation results for May 18, shows that generator power losses change every hour. The value of these power losses is influenced by the value of the phase current (A) and field current (If) due to changes in load and from the loss graph. The highest power was 0.604 MW at a load of 2.330 MW while the lowest power loss was 0.601 MW at a load of 2.009 MW.

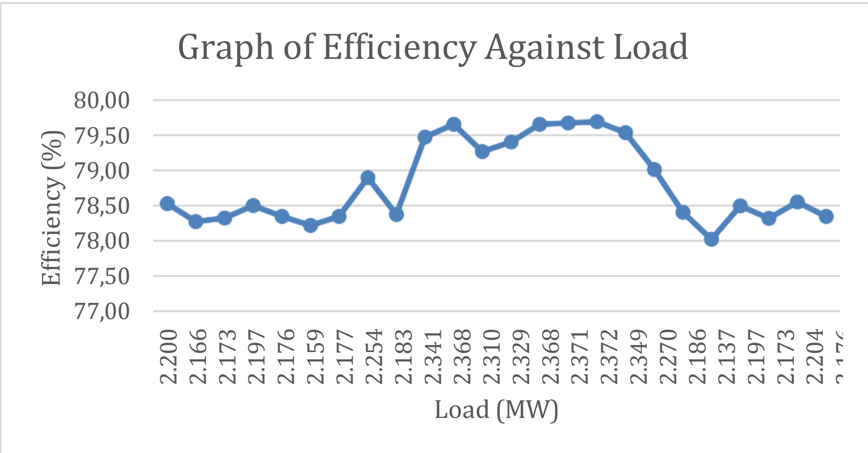

Figure 5. Graph of Efficiency Against Load 17 May 2024

In Figure 5, graph of generator efficiency against load from calculations on May 17, it can be seen that the highest efficiency was 79.69% at a load of 2,372 MW, while the lowest efficiency was 78.03% at a load of 2,137 MW. Changes in the generator power value can affect the generator efficiency value and the generator efficiency value is directly proportional to the generator output power. The greater the generator power value, the greater the efficiency, while the smaller the generator output power value, the smaller the efficiency.

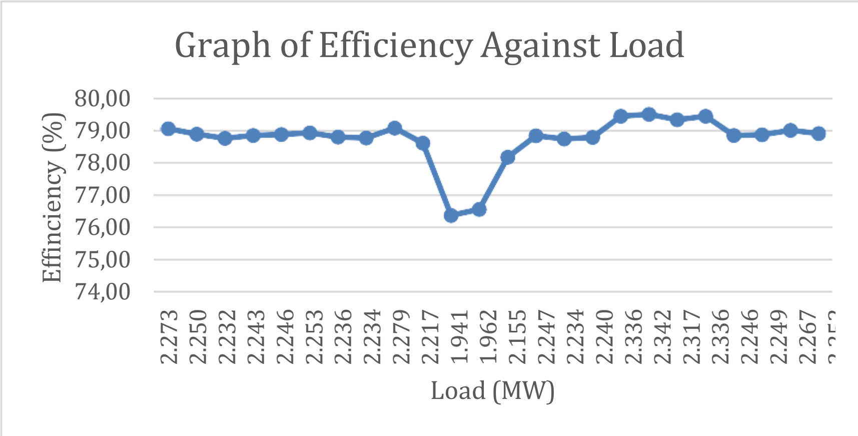

Figure 6. Graph of Efficiency Against Load 18 May 2024

In Figure 6, graph of generator efficiency against load, it can be seen that the highest efficiency was 79.51% at a load of 2,342 MW, while the lowest efficiency was 76.37% at a load of 1,941 MW. The load changes that occur are caused by the generator output power or load being adjusted to the load requirements in the field in order to reduce excess power in the generator output power (Pout) and optimize fuel use which has an impact on the generator efficiency value. With a large generator output power value (Pout), the efficiency value also gets better.

4. Conclusion

Based on the results of research on the effect of changes on the performance of generator unit two of PT. Nusa Daya PLTU Malinau Unit, the following conclusions are obtained:

1. Changes in the generator output power are adjusted to the load requirements in the field which tend to fluctuate and affect the value of the per-phase current as well as the field current or generator excitation.
2. The large values of per-phase current and generator field current cause power losses which are inversely proportional to the generator efficiency value.
3. Based on data from calculation results on May 17, the highest efficiency was 79.69% at a load of 2,372 MW while the lowest efficiency was 78.03% at a load of 2,137 MW and for calculation results on May 18 the highest efficiency was 79.51% at a load of 2,342 MW whereas the lowest efficiency was 76.37% at a load of 1,941 MW.
4. Based on the results of data calculations for 2 days, the average efficiency value on May 17 was 78.81% andon May 18 it was 78.73%.

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