Jurnal Scientia
Volume 13, Number 03, 2024, DOI 10.58471/ scientia.v13i03
ESSN 2723-7486 (Online)
https://infor.seaninstitute.org/index.php/pendidikan

Analysis Of Distribution Transformer Shifting To Address Overload And End Voltage At Gardu HJ177 In PT. PLN (Persero) Kertosono Service Unit

Tri Della Cristy Sembiring[1], Dicky Lesmana[2], Yoffi Andinata[3]
[1,2,3]Universitas Pembangunan Panca Budi, Medan, North Sumatera, Indonesia

Article Info

Keywords:
Distribution Transformer Insertion,
Overloadyesnd,
Voltage Repair at HJ177 Substation

ABSTRACT

The HJ177 substaion in its loading datareached 126.10% (± 63,054 kVA) of its capacity of 50 kVAwith an end voltaicge of 206 V and experienced avoltage dropge of 12%. The loading exceeded the maximum capacity of the stanord transformer of 80%, which has the potential for materialand finalncial losses for PT PLN (Persero) Kertosono Customer Service Unit (ULP). The voltalge drop resulting from this has exceeded SPLNT6.001-2013 of -±10% for low voltagege. Considering the matrix in the Health Index aassessment tier-1 Distribution Transformer, willingted to the percentage of tranformer loading, it's in the bald caBeca's categoryuse it is loaded ≥100%. To overcome this, an insert transformer caln be installed. With the originl load from 126.10% to 46.942% of the 50kVAcapacity, then the end voltage at the HJ177 Substation with the insertion of the transformer was originallly 206 V with avoltage drop of 12.0% increased to 213 V with avoltage drop percentage that decreased to 8.2%. The implementation of the transformer insertion for the HJ177 substation is effective in overcoming overloadyesnd improving the end voltage

Corresponding Author:
Tri Della Cristy Sembiring
Universitas Pembangunan Panca Budi, Medan, North Sumatera, Indonesia
sembiringdella@gmail.com

INTRODUCTION

In the context of the rapid growth in the communication and information technology sector, there is a corresponding increase in the importance of electrical energy systems (Venti OakaSaTya, 2018). This phenomenon presents a particular challenge for PT PLN (Persero) in managing electricity distribution in Indonesia to ensure the quality of service for consumers (Mhd Rafli and Siti Alshah, 2023) The process of electricity transmission involves generating power, transmitting it at high voltage, and distributing it at medium to low voltages to consumers. Issues often arise during the distribution process, one of which is the potential for distribution transformers to become overloaded (Mohammad Trian NugraHa, 2021).

To optimize transformer efficiency, it is essential to achieve high efficiency and minimize losses, with transformers operated close to their maximum capacity. According to

PLN standards, a transformer is considered overloaded if the load exceeds 80% of its rated capacity (Zulfikar Rezki Renyaan et al. 2022) Prolonged overload conditions can lead to insulation failure and eventual transformer damage (Tri Ongko Priyono and VaLentina, 2022). Additionally, voltage drops can affect the quality of service, leading to disruptions. This can result in power losses and energy shortfalls (ENS – Energy Not Supplied) from the affected transformer.

At Gardu HJ177 in PT. PLN (Persero) Kertosono, the load has reached 124.17% (± 62.085 kVA) of its rated capacity of 50 kVA, with a terminal voltage drop of approximately 205 V or a 12% voltage drop. This load exceeds the standard 80% maximum transformer capacity, which poses potential risks to material and financial stability for PT PLN (Persero) ULP Kertosono[6]. The resulting voltage drop exceeds the SPLNT6.001-2013 standard of ±10% for low voltage. To address this issue, the implementation of transformer replacement is proposed[4]. This study analyzes the impact of transformer replacement at Gardu HJ177 on the load capacity and voltage levels at the transformer terminals (Momrtunis, et al, 2023).

Literature Review

Distribution Substation

A distribution substation is generally known as a facility containing the electrical equipment needed to step down high voltage to medium or low voltage for further distribution. It typically includes Medium Voltage (MV) Switchgear (PHB-TM), Distribution Transformers (TD), and Low Voltage (LV) Switchgear (PHB-TR) to meet the electrical needs of various consumers, involving Medium Voltage (MV 20 kV) and Low Voltage (LV 220/380V) networks (Basisng Soeroso, et al 2016).

Shunt Substation

A shunt substation is a method used by PT. PLN (Persero) as an energy provider to prevent issues that occur when a transformer in an existing substation is overloaded. This is achieved by inserting a new substation. Factors considered by PT. PLN (Persero) when inserting a new substation to address overloads in existing transformers include (Septia NissaAzzahra et al, 2019):

1. Transformer Overload Conditions: An overload occurs when the current carried by a transformer exceeds its full load capacity, causing increased temperature and potential damage to the insulation. Transformers are deemed overloaded if they operate at ≥80% of their rated capacity (Wellem F. etal 2020)
2. Voltage Drop: Voltage drop in a distribution network can result from various factors such as line length (Km), load current (Amperes), line resistance (Ohms/Km), and other factors. The voltage drop is measured at the end of the distribution line, with permissible voltage drop limits defined by standards. For distribution transformers, a voltage drop of 3% of the rated voltage is typically acceptable, and up to 4% is allowed as per SPLN No. 72 of 1987, which covers voltage drop and sagging issues (Ni Made Seniari, et al, 2020)

Jurnal Scientia
Volume 13, Number 03, 2024, DOI 10.58471/ scientia.v13i03
ESSN 2723-7486 (Online)
https://infor.seaninstitute.org/index.php/pendidikan

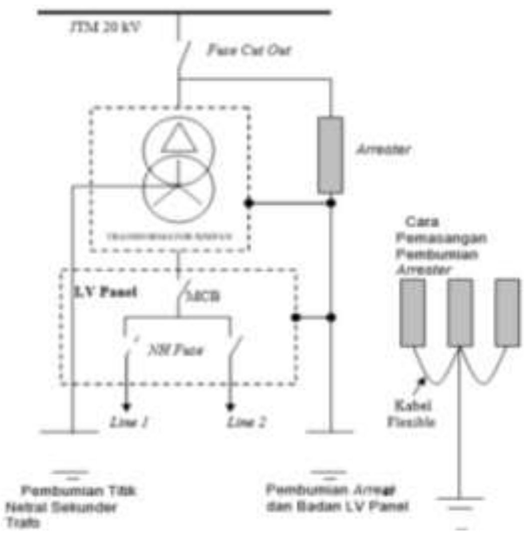

Figure 1. Transformer Insertion Line Diagram

METHOD

In this research, a series of steps using a quantitative research method were undertaken. The phases of this research include observation, interviews, literature review, data collection, data processing, and analysis as well as calculations. The flowchart of this research process is as follows:

1. Observation: Identifying and examining the current state of the system, particularly the performance and conditions of the distribution transformer and the grid.
2. Interviews: Conducting discussions with experts, technicians, or operators involved in the maintenance and operation of the electrical grid and transformers.
3. Literature Review: Reviewing existing literature, technical standards, and previous research relevant to transformer performance, overload conditions, and voltage drops.
4. Data Collection: Gathering data on transformer loads, voltage levels, and other relevant parameters from the field or through existing records.
5. Data Processing: Analyzing the collected data to determine patterns, identify problems like transformer overload or voltage drops, and evaluate the system's overall performance.
6. Analysis and Calculation: Performing detailed calculations to assess transformer capacity, load distribution, and voltage stability. This may involve calculating efficiency, losses, and the impact of potential solutions like inserting an additional transformer.

Jurnal Scientia
Volume 13, Number 03, 2024, DOI 10.58471/ scientia.v13i03
ESSN 2723-7486 (Online)
https://infor.seaninstitute.org/index.php/pendidikan

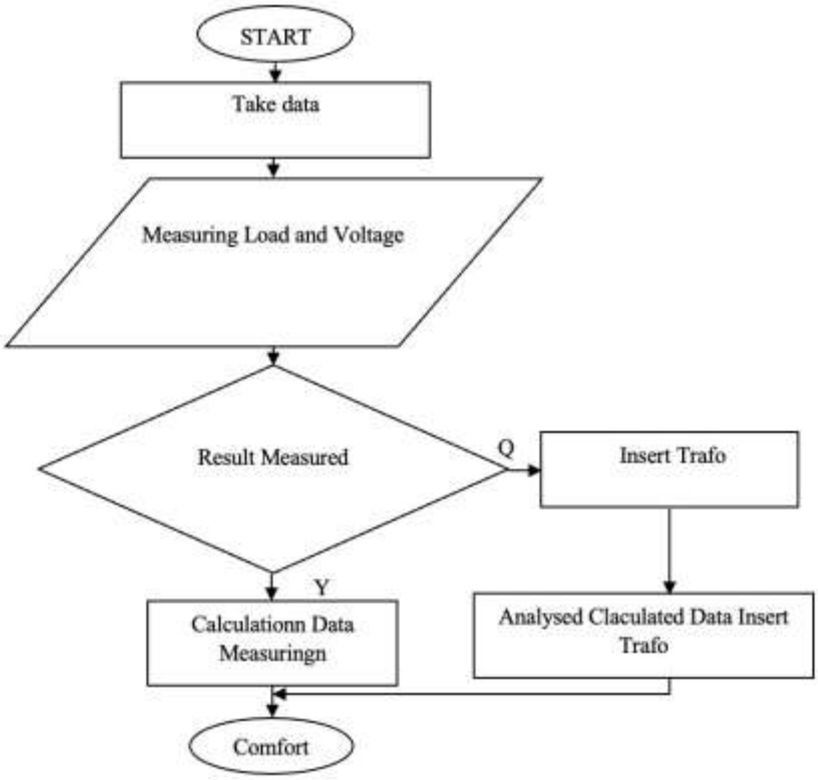

Figure 2. Research Flowchart

The data obtained from measurement results were then analyzed to determine the extent of energy savings and to perform economic calculations related to the production of crude palm oil at the palm oil mill.

RESULT

This research was conducted in the working area of PT PLN (Persero) ULP Kertosono at Substation HJ177, with data collection carried out on Wednesday, July 17, 2024, at 19:30 WIB, yielding the following results:

Table 1. Measuring Data Load

I MAX Substation (A)	Load Calculated (A)						
	Line 1			Line 2			Trafo
	R	S	T	R	S	T	
73	18	11	23	70	66	85	Generals
GeographicConditions	Measuring Load (A) Total			Load Trafo			
	R	S	T	%			
Normal	87	76	107	126,10%			

Table 2. Measuring of Substation.

Measuring Voltage (V)				Voltages (V)	% Voltage Drop
R-N	S-N	T-N	RST-N		
231	240	231	234	206	12,0%

Based on the measurement results, the load and the percentage of loading at Substation HJ177 were calculated as follows:

kVA Load:

= (IR × VR-N) + (IS × VS-N) + (IT × VT-N)
= (87 x 231) + (76 x 240) + (107 x 231)
= (20097 + 18240 + 24717)
= 63054 VA
= 63,054 kVA

% Load :

$$= \frac{kVA Beban}{kVA Trafo} x100\%$$

$$= \frac{63.054}{50} x100\%$$

$$= 126.10\%$$

Based on the calculation results, it is observed that the transformer loading reached 126.108% of its 50 kVA capacity. According to PT PLN (Persero) regulation, specifically SE No 0017.E/DIR/2014 regarding the Distribution Transformer Maintenance Method Based on Asset Management Quality, the maximum allowable loading for a transformer is 80%. Therefore, the excess load for Substation HJ177 is calculated as follows

Upper Load:

= % freen - % freen Health Index
= 126.10% - 80%
= 46.1%

After calculating and identifying the excess load on the transformer, calculations will be performed to determine the appropriate capacity of the transformer needed for the installation of an additional transformer at Substation HJ177. The calculation process to determine the required load and transformer capacity is as follows:

Load:

$$= \frac{\% Kelebihan Beban}{100\%} x 50 kVA$$

$$= \frac{46.1\%}{100\%} x 50 kVA$$

$$= 23.05 kVA$$

Jurnal Scientia
Volume 13, Number 03, 2024, DOI 10.58471/ scientia.v13i03
ESSN 2723-7486 (Online)
https://infor.seaninstitute.org/index.php/pendidikan

Required Transformer Capacity

$$= \frac{Beban(kVA)}{0.8}$$

$$= \frac{23.05}{0.8}$$

$$= 28{,}8125\, kVA$$

Based on the calculations, the load that needs to be transferred is 23.05 kVA. The required transformer capacity for the transformer insertion, considering a load of 80% according to the minimum Health Index, is 28.8125 kVA. Therefore, in accordance with the available capacity on site, a transformer with a capacity of 50 kVA will be used for insertion. After the insertion of the 50 kVA transformer, data collection was conducted again at substation HJ177 on July 27, 2024, at 19:25 WIB.

Table 3. The results of the data collection are presented in the following table

I MAX Substation(A)	Calculated Load (A)						
	Line 1			Line 2			Trafo
	R	S	T	R	S	T	
73	5	16	26	19	14	25	General
Geographich condition	Calculated	Load(A) Total		Load Trafo			
	R	S	T	%			
Normal	22,1	30,1	49,1	46.942%			

Table 4. Result Calculated Measuring Voltage

Pengukuran Tegangan (V)				Tegangan Ujung (V)	% Voltage Drop
R-N	S-N	T-N	RST-N		
232	231	232	232	213	8,2%

Calculates equation:

kVAbeban:

= (IR × VR-N) + (IS × VS-N) + (IT × VT-N)

= (22.1 x 232) + (30.1 x 231) + (49.1 x 232)

= (5127.2 + 6953.1 + 11391.2)

= 23471.5 VA

= 23,471 kVA

% Load transformator:

$$= kVABeban x 100\%$$

$$= \frac{kVABeban}{kVATrafo} x100\%$$

$$= \frac{23.471}{50} x100\%$$

$$= 46.942\%$$

CONCLUSION

Based on the results after the insertion of the new transformer, the performance of the HJ177 substation has improved significantly. Here's a summary of the findings: Transformer Load Reduction: Before insertion: 126.10% of transformer capacity, After insertion: 46.94% of transformer capacity, Transformer capacity: 50 kVA. Voltage Drop at Substation HJ177: Before insertion: 205 V, with a voltage drop percentage of 12.0%, After insertion: 213 V, with a reduced voltage drop percentage of 8.2%. Transformer Capacity Calculation: The formula used for determining the required transformer capacity is: PT=LT0.8PT=0.8LT, The calculated transformer capacity for HJ177 is 50 kVA, which effectively manages the overload condition and improves voltage regulation.

REFERENCES

[1] Venti Eka Satya,2018 “Strategi Indonesia Menghadapi Industri 4.0” Bidang Ekonomi Dan Kebijakan Publik”. INFO SINGKAT Pusat Penelitian Badan Keahlian DPR RI Vol: X, No. 09/I/Puslit/Mei/2018, ISSN 2088-2351

[2] Mhd Rafli , Siti Aisyah,2023 “Analisis Kualitas Pelayanan Digitalisasi Metode Pembayaran Tagihan Rekening Listrik Terhadap Kepuasan Pelanggan Pengguna Listrik Pada Pt. Pln (Persero) Unit Induk Wilayah Sumatera Utara” Jurnal ABDIKARYA Volume 5, No. 1, April 2023, P-ISSN : 2686-6447, E-ISSN : 2715-6605

[3] Mohammad Trian Nugraha, 2021 “Penanggulangan Overload Transformator Distribusi Dengan Metode Uprating Di Gardu Pnbs 20 Kv Ulp Pangandaran” Prosiding Seminar Nasional Energi, Telekomunikasi Dan Otomasi Sneto 2021

[4] Zulfikar Rezki Renyaan, B. J. Camerling , R. A. de Fretes, 2022 “Analisis Kelayakan Ekonomi Dan Teknik Sisip Transformator Distribusi Pada Gardu Ktb-09 Pt Pln (Persero) Up3 Masohi” i tabaos, Vol. 2 No. 3 Oktober, 2022 E-ISSN: 2829-8179

[5] Tri Ongko Priyono, Valentina, 2022 “Analisa Sisa Umur Pemakaian Transformator Tipe Rectifier Kapasitas 20 Kv Berdasarkan Perhitungan Pembebanan Di Chemical Plant Karawang” Jurnal Elektro Vol.10 No.1 Januari 2022, ISSN: 2302-4712

[6] Martunis, Muliadi,Syukri,Teuku Murisal Asyadi,Misswar ABD, 2023 “Penentuan Kapasitas Transformator Sisip Untuk Mengatasi Beban Lebih Pada ULP Merduati Kota” Jurnal Teknik Elektro dan Komputasi (ELKOM) Volume 5 Nomor 2 Agustus 2023, ISSN : 2685-1814 (Print) ISSN :2685-7677 (Online)

[7] Samsurizal, Benyamin Hadinoto, 2020 “Studi Analisis Dampak Overload Transformator Terhadap Kualitas Daya Di PT. PLN (Persero) UP3 Pondok Gede” KILAT Vol. 9, No. 1, April 2020, P-ISSN 2089-1245, E-ISSN 2655-4925DOI: https://doi.org/10.33322/kilat.v9i1.784

[8] Bambang Soeroso, Yaulie D.Y.Rindengan,ST.,MM.,MSc, Lily S. Patras,ST.,MT, 2016 “Identifikasi Gardu Distribusi Tenaga Listrik Di Kota Manado Berbasis Sistem Informasi Geografis” E-Journal Teknik Elektro dan Komputer vol 5 no.1 Januari-Maret 2016, ISSN : 2301-8402

[9] Septianissa Azzahra , Oktaria Handayani , Siti Auliya, 2019 “Studi Perbaikan Jatuh Tegangan Dan Rugi Daya Pada Jaringan Tegangan Rendah Dengan Pembangunan

Gardu Sisip Tipe Portal" Jurnal Kilat Vol. 8, No. 1, April 2019, P-Issn 2089-1245, E-Issn 2655-4925

[10] Wellem F. Galla ,Agusthinus S. Sampeallo , Julian I. Daris, 2020 "Analisis Gangguan Hubung Singkat Pada Saluran Udara 20 Kv Di Penyulang Naioni Pt. Pln (Persero) Ulp Kupang Untuk Menentukan Kapasitas Pemutusan Fuse Cut Out Menggunakan Etap 12.6" Jurnal Media Elektro / Vol. IX / No. 2 P-ISSN 2252-6692 | E-ISSN 2715-4963

[11] Wawan Setiawan Anjas, Muh. Ilham, 2022 "Analisis Pembebanan Trafo Sebelum Penambahan Gardu Sisipan Terhadap Besarnya Kapasitas Daya untuk Memperbaiki Pembebanan pada Gardu Distribusi" VERTEX ELEKTRO Jurnal Teknik Elektro UNISMUH Volume 14 Nomor 2, Agustus 2022 P-ISSN : 1979-9772, E-ISSN : 2714-7487 OJS : https://journal.unismuh.ac.id/index.php/vertex/index

[12] Ni Made Seniari, M. Najmul Fadli, I Made Ginarsa, 2020 "Analisis Rencana Pemasangan Transformator Sisipan Pada Saluran Transformator Distribusi Penyulang Pagutan(Studi Kasus: Transformator Distribusi AM097Di Jalan Banda Seraya,Pagesangan, Kota Mataram), Dielektrika, [P-ISSN 2086-9487] [E-ISSN 2579-650x Vol. 7, No.1:56-63, Pebruari 2020