

Analysis of Electrical System Reliability for Premium Customer after Installation of Automatic Change Over Switch (ACOS) - A Case Study

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ABSTRACT

PT. PLN is the electricity company that distributes electricity to customers, always tries to improve the quality of system reliability. So, it can continue to distribute electrical energy to customers and reduce the decline in Energy Not Supplied (ENS) on the PLN side. One way for PLN to avoid blackouts to the customers, especially premium customers, from planned or unplanned blackouts by installing an Automatic Change Over Switch (ACOS) on the incoming customer side. This paper aims to analysis of electrical system reliability for premium customers after Installation of Automatic Change Over Switch (ACOS). Data collection was carried out on the premium customer of 328 electricity distribution system supplied by the Senangin Feeder or Abadi Feeder from GI Garuda Sakti, Pekanbaru with a power transformer capacity at TD#4 of 60 MVA with a feeder length of 10.25 KMs using medium voltage cable channels, with a radial system. From the results of calculations carried out on the Senangin feeder, which supplies electrical energy to customers, the SAIFI (System Average Interruption Frequency Index) index value was 71,647 outages/year in 2018 and SAIDI (System Average Interruption Duration Index) was 3.44 hours/year in 2018, while the Energy Not Supplied (ENS) value in 2018 was 33,781.83 kWh and 5,124.36 kWh in 2019.

KEYWORDS: *Automatic Change Over Switch (ACOS), Energy Not Supplied (ENS), SAIDI, SAIFI, Senangin feeder.*

1.0 INTRODUCTION

PT. PLN (Persero), especially in the distribution sector, has an

important role in distributing electrical energy to customers. Power outages, whether planned or unplanned, are a big challenge for electricity service providers such as PLN. The impact is not only felt by household customers, but also by the business sector, which is highly dependent on a stable electricity supply. Therefore, improving service to customers during outages is a top priority. If the distribution of electrical energy experiences a blackout, it will result in losses for customers and PLN in the sale of electrical energy. In reality, the electricity distributed cannot always be continuous due to problem in the electric power systems, which result in power outages to customers. Now PT. PLN (Persero) has provided the latest service, namely a special service to customers, with an Automatic Change Over Switch (ACOS) installation system at incoming customers, thereby creating reliable electricity supply and continuity of service. This service is a priority for premium customers. During a blackout, both planned and unplanned blackouts result in the cessation of sales of electrical energy at PLN, resulting in high levels of undistributed energy or Energy Not Supplied (ENS). Therefore, the using of automation technology in electrical systems can increase reliability and efficiency [1-9].

The installation of an ACOS on the customer side is expected to increase the reliability of electricity supply, which is reflected in a decrease in the values of SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) [10-15]. SAIDI measures the average duration of outages each customer experiences in a year. The SAIFI measures the average frequency of outages each customer experiences in a year. With ACOS, customers can automatically switch to a backup power source when an outage occurs, reducing the duration and frequency of outages they experience. SAIDI and SAIFI calculations before and after ACOS installation can be done by collecting outage data from the SCADA (Supervisory Control and Data Acquisition) system and customer data. Comparison of the SAIDI and SAIFI values before and after ACOS installation will provide an idea of the effectiveness of ACOS in improving the reliability of electricity supply [16].

Apart from SAIDI and SAIFI, the installation of ACOS is also expected to reduce the Energy Not Supplied (ENS) value. ENS measures the amount of electrical energy that is not

distributed to customers due to blackouts. With the automation technology in electrical systems such as ACOS, customers can minimize the duration of outages and thereby reduce the amount of undistributed energy [17-24]. ENS calculations before and after ACOS installation can be done by collecting customer load data and outage data from the SCADA system. A comparison of ENS values before and after ACOS installation will provide an idea of the effectiveness of ACOS in reducing energy losses due to blackouts [25]. The effectiveness of ACOS in increasing the reliability of electricity supply and reducing ENS also depends on its integration with the overall distribution network system [26-29]. ACOS must be integrated with distribution network protection and control systems to ensure that power source switching occurs safely and efficiently. Apart from that, regular ACOS maintenance is also important to ensure that the device functions properly when needed [30]. Therefore, SAIDI, SAIFI, and ENS calculations before and after ACOS installation can provide valuable information about the effectiveness of these devices in increasing the reliability of electricity supply and reducing energy losses.

The greater the ENS value, the greater the kWh that is not sold and this means that the greater the losses suffered. The large Energy Not Supplied (ENS) values that have occurred so far are one of the contributing causes of the failure to achieve electrical energy sales performance [31-32]. The PLN has made various efforts to always distribute electrical energy and ensure customer satisfaction. This research aims to analyze the SAIDI and SAIFI values at feeders before and after installing the Automatic Change Over Switch (ACOS) and evaluate the ENS values for premium customers. It is hoped that this research will be useful in reducing or eliminating Energy Not Supplied (ENS) for premium PLN customers. It can also reduce costs to customers, due to the use of generators by customers, and support the implementation of clean energy.

2.0 METHODS

This research methodology was carried out using a quantitative approach by collecting data sourced from Premium 328 (Living World) customer, which was customer who have the largest power contracts as Medium Voltage customers, namely with a power tariff of LB3 5190000 kVA. Customer 328 was one of the kWh sales revenue suppliers at PLN UP3 Pekanbaru (PLN UP3 Pekanbaru, 2019). The 20 kV Distribution System for 328 customers is supplied by the Senangin Feeder, which originates from the Garuda Sakti Main Substation (GI) with a feeder load of 103 A (PLN UP3 Pekanbaru, 2019). Data collection consists of primary data by conducting direct observation or participating in data collection, documentation, testing, as well as conducting interviews and discussions to collect the required information and data. Data was taken including the historical data from PLN and surveys of premium customers who use ACOS. Data collected included SAIFI, SAIDI, and ENS indices before and after ACOS installation. In addition, interviews with PLN technicians and operational managers were also conducted to gain perspectives regarding the challenges and successes in implementing ACOS. Data was collected at PLN UP3 Pekanbaru, Indonesia.

Next, data processing was carried out such as (a) data on the Number of Feeder Disorders in GIGS in 2018 and 2019, (b) data on Senangin Feeder Disorders for 2018 and 2019, (c) Senangin Feeder Conductor Technical Data and (d) data on customers experiencing outages and customers served and data on the causes of disruptions at the Senangin Feeder. Hence, the calculations and analysis of system reliability indices were carried out, namely SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) [33-34]. This research involves an in-depth understanding of how disruptions in various components of the power grid contribute to the frequency and duration of outages experienced by customers. Data processing was carried out using MS Excel software to analyze the comparison between the reliability index values before and after ACOS installation. This analysis aims to determine whether there are significant changes in the reliability of the electrical system after ACOS installation. The next stage was to calculate and analyze the short circuit current at the Senangin Feeder, either manually or using ETAP 12.6 software. Manual calculations will involve an understanding of network impedance and interference sources, while the use of ETAP will provide more comprehensive results by considering various interference scenarios.

2.1 Distribution System of 20kV for Premium Customer Code of 328

Especially for Medium Voltage (MV) customers at PT PLN (Persero), there is a premium customer service program, namely a special service for Medium Voltage customers by providing electricity supply from 2 different sources with an Automatic Change Over Switch (ACOS) installation system to incoming customers. Thus, the supply and continuity of electricity voltage is reliable and Medium Voltage customers no longer need to use a generator if the supply at the main feeder goes out. Therefore, it is important to install an Automatic Change Over Switch (ACOS) for Medium Voltage customers or customers who have registered as premium customers. Senangin feeder disturbance data in 2018 is presented in Table 1 and data for 2019 (August) is presented in Table 2. The Single Line Transformer Diagram of the Senangin and Bawal Feeders is presented in Figure 1.

2.2 Single Line Customer Diagram for Premium Customer of 328

The electricity distribution system for customer 328 (Living World) is supplied by the Senangin Feeder / Abadi Feeder from GI Garuda Sakti with a power transformer capacity at TD#4 of 60 MVA with a feeder length of 10.25 kms using Medium Voltage Cable Channels with a radial system as in Figure 2. Customer 328 in Figure 2 was supplied from GD 328 (Customer Substation) and GH 328 Baung (Connection Substation) where the Automatic Change Over Switch (ACOS) was placed, and if there was a disturbance at the Senangin feeder, the Automatic Change Over Switch (ACOS) automatically works and the electricity supply to the customer of Distribution Substation 328 (GD328) will change to a Bawal feeder as in depicted in Figure 3. In Figure 4 presents a single line power flow configuration diagram for the Senangin feeder and Bawal feeder using ETAP 12.6 Software.

Table 1: Data on disruptions to the Senangin feeder in 2018

No	Date	Feeder	Load (A)	Number of Customers Outage	Duration Outage	Hours Customer Outage	Information
1	4-Jan-18	Senangin	109	1	75	1.25	Entered gradually, safely, normalization takes a long time because the trip alarm didn't appear on Scada Apd
2	11-Feb-18	Senangin	123	3,283	11	601.88	Entered gradually safely, no problems found
3	15-May-18	Senangin	179	1,530	13	331.5	Entered gradually, safely, <i>E2_Alam</i> , strong wind rain
4	7-Jul-18	Senangin	128	3,283	84	4,596.20	Safe gradual normalization (for normalization of the Garuda Gh Arengka department, normalization for the new block relay can be normalized so that it does not repeat itself)
5	9-Jul-18	Senangin	212	4,200	42	2,940	Trouble found damaged transformer arrester location Jl. Tuban
6	13-Jul-18	Senangin	167	3,283	1	37.39	Temporary disorders
7	14-Jul-18	Senangin	178	1,530	0	8.07	Temporary disorders
8	14-Jul-18	Senangin	152	3,283	13	711.32	Normalized After Relay Couple Gh 328 Blocked Trip simultaneously with arengka department gh 104 arengka and p. gigs cloth folding, weasel found trouble regarding sutm
9	26-Sep-18	Senangin	113	3,283	9	492.45	Temporary disruption, repeated trips
10	26-Sep-18	Senangin	81	1	4	0.07	Billboards attached to the location network on Jl Arengka
11	5-Oct-18	Senangin	194	4,200	29	2,030	Trip simultaneously with inc 328, couple, Arengka area, billboard disturbed regarding sutm location near <i>Simpang SKA</i>
12	31-Dec-18	Senangin	202	4,200	97	6,790	
Total			1.838	32.077	378	18,540	

(Source: PLN UP3 Pekanbaru, 2019)

Table 2: Data on disruptions to the Senangin feeder in 2019

No	Date	Feeder	Load (A)	Amount	Indication	Cause Group	Information
1	26/03/19	Senangin	242	37	GFR INST	E4_KITE/PUNNEL	Baleho Wire Attached to Network Location Jl. Nangka
2	10/5/2019	Senangin	23	9	NONE	E1_OTHERS	Simultaneous Trip of 5 Feeders.

(Source: PLN UP3 Pekanbaru, 2019)

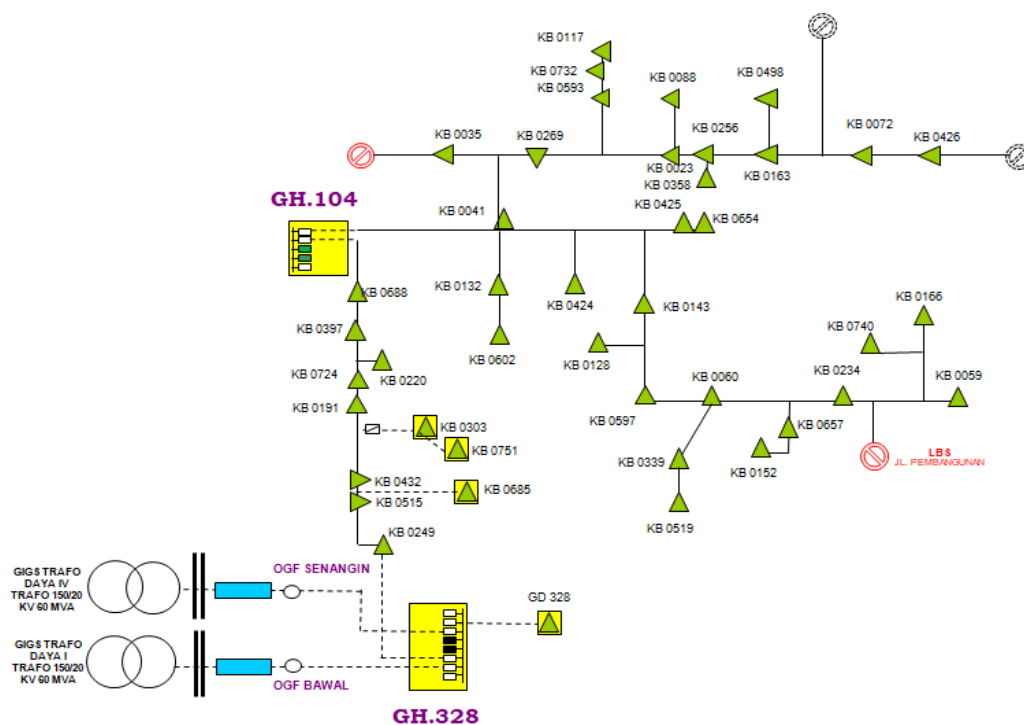


Figure 1: Single line transformer diagram for feeders of Senangin and Bawal

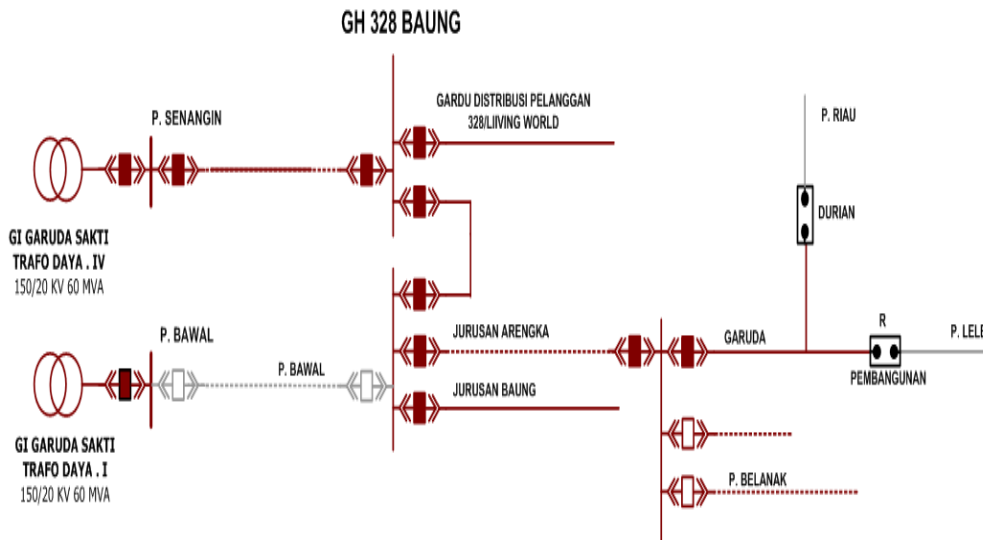


Figure 2: Single line diagram of the Senangin feeder before ACOS installation.

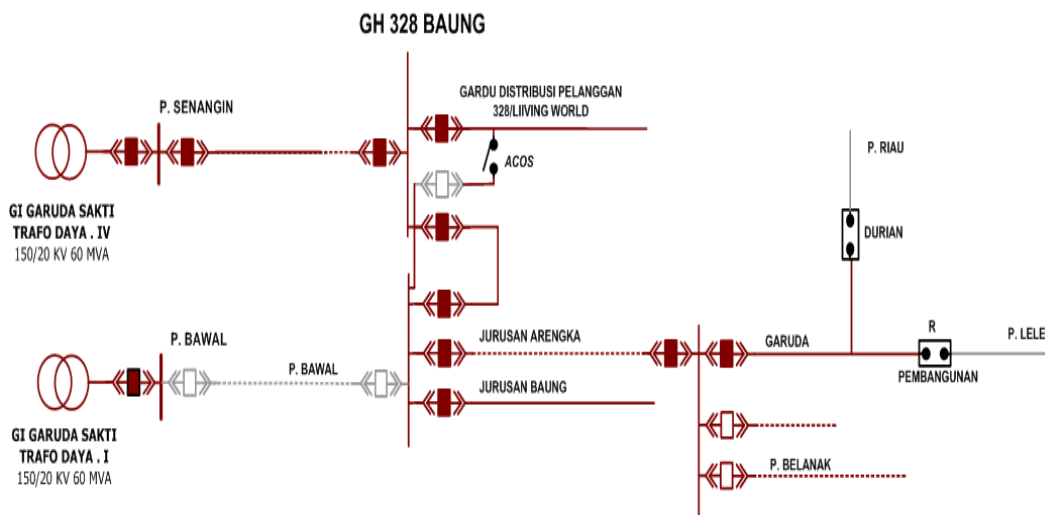


Figure 3: Single line diagram of the Senangin feeder after ACOS installation

2.3 Technical Data for Senangin Feeder and Bawal Feeder

The Senangin feeder was supplied from the Substation (GH). The conductor was used XLPE with a cross-sectional area of 150 mm². The Senangin feeder has a network length of 10.25 kms. With a source impedance value of:

Short circuit MVA= 2171.7 MVA

Positive sequence source impedance (Z_{s1}) = 0.010052 + j 4.60359 Ohm.

Negative sequence source impedance (Z_{s2})= 0.010052 + j 4.60359 Ohm.

Zero sequence source impedance (Z_{s0})= 45.5106 + j 60.9842 Ohm.

The technical data of the Senangin feeder conductor was based on data from PT PLN (Persero) UP3 Pekanbaru as follows:

Sender Type = XLPE (medium voltage cable channels).

Cross-sectional area = 150 mm²

Feeder Length = 10.25 kms

Network Voltage = 20 kV

Positive sequence channel impedance (Z_{L1}) = 0.265 + j 0.106 Ohm

Negative sequence channel impedance (Z_{L2}) = 0.265 + j 0.106 Ohm

Zero sequence channel impedance (Z_{L0})= 0.795 + j 0.265 Ohm

To facilitate calculations, the impedance values of the Senangin and Bawal feeder channels are converted into units per unit (pu), as follows:

One base (MVA) = 60 MVA

The basic system voltage is 20 kV = 20 kV

Basic Impedance: $Z_{base} = \frac{KV^2}{MVA \text{ base}} = 6.667 \text{ Ohm}$

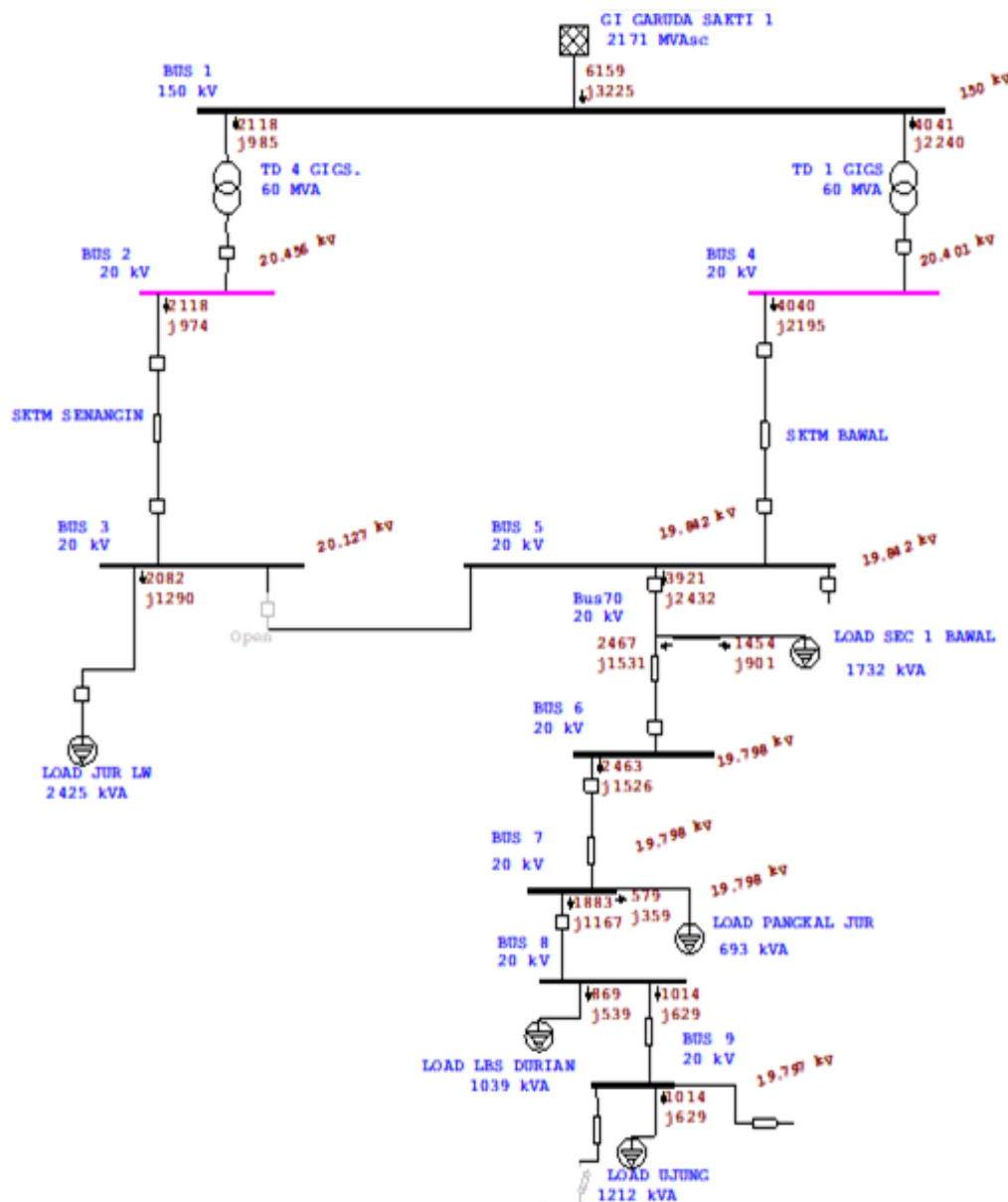


Figure 4: Single Line Diagram (SLD) configuration of the Senangin Feeder and Bawal Feeder

3.0 RESULTS AND DISCUSSION

The existence of a service program from PT PLN (Persero) to support business progress for Medium Voltage customers, which continues to grow, a premium service program has been created. This was the basis of the contract between PT PLN and the customer, namely PT 328 (*Living World*) in the Premium Services installation category Silver. So, the electricity distribution system was supplied from 2 different feeders and different power transformers as in the simulation in Figure 5. It can be seen in Figure 5, the customer supply located at GH 328 comes from 2 feeder supplies with different power transformers but was still in the same substation because customer of 328 of a premium silver category of customer.

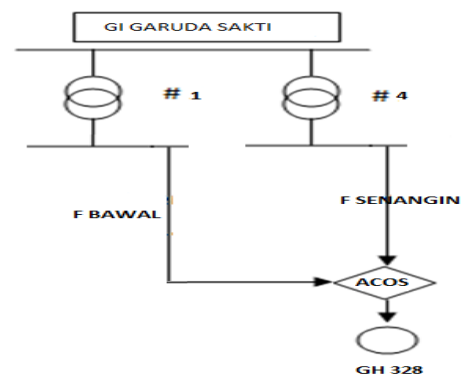


Figure 5: The 328 customer premium silver service supply simulation

3.1 Value Calculation Energy Not Supplied (ENS) dan Average Energy Not Supplied (AENS)

The value of Energy Not Supplied (ENS) on the Senangin feeder during outages in 2018 can be computed using formula equation (1) and referring to Table 1, as follows:

$$\begin{aligned} \text{Energy Not Supplied (ENS)} &= \sqrt{3} * I * v * \cos \phi * t \\ &= \sqrt{3} * 109 * 20 * 0,97 * 75 \\ &= 4,572.822 \text{ kWh} \end{aligned} \quad (1)$$

With the same calculation results (disturbance data in Table 2), the value of Energy Not Supplied (ENS) during load outages during 2018 as outlined in Table 3 and load outages during 2019 to November as outlined in Table 4.

Table 3: Calculation results ENS based on feeder disturbance data of Senangin feeder in 2018

No	Date	Feeder	Load (A)	Duration (s)	ENS (kWh)
1	4-Jan-18	Senangin	109	75	4,572.82
2	11-Feb-18	Senangin	123	11	756.82
3	15-May-18	Senangin	179	13	1,301.65
4	7-Jul-18	Senangin	128	84	6,014.31
5	9-Jul-18	Senangin	212	42	4,980.60
6	13-Jul-18	Senangin	167	1	93.41
7	14-Jul-18	Senangin	178	1	99.57
8	14-Jul-18	Senangin	152	13	1,105.31
9	26-Sep-18	Senangin	113	9	568.88
10	26-Sep-18	Senangin	81	4	181.23
11	5-Oct-18	Senangin	194	29	3,147
12	31-Dec-18	Senangin	202	97	10,960.23
Total					33,781.83

Table 4: Calculation results ENS based on Senangin feeder disturbance data in 2019

No	Date	Feeder	Load (A)	Duration(S)	ENS(Kwh)
1	26/03/19	Senangin	242	37	5,008.57
2	10/5/2019	Senangin	23	9	115.79
Total					5,124.36

Meanwhile, to find out the average value Energy Not Supplied (ENS) for Senangin feeder during the 2018 and 2019 periods can be calculated using formula (2):

$$\text{Average Energy Not Supplied (AENS)} = \frac{\text{ENS}}{N_T} \quad (2)$$

Average Energy Not Supplied (AENS) 2018 = $\frac{33,781,83}{3586} = 9.42$ kWh/customer

Average Energy Not Supplied (AENS) 2019 = $\frac{5,124,36}{3586} = 1.42$ kWh/customer

3.2 Calculation of SAIDI and SAIFI Values at the Senangin Feeder

The calculation of SAIDI and SAIFI values was only calculated for the Senangin feeder as the main feeder supply for

Premium 328 Customer. The calculations were carried out before and after installation on incoming customers at Substation 328 whose implementation was carried out in December 2018 (referring to the 2018 Senangin feeder disruption data in Table 1). Table 1 was data on Senangin feeder disruptions for 1 year in 2018. The number of outages was 12 outages with the number of customers experiencing outages of 32,077 customers out of a total of 5386 customers (after the process maneuver from Bawal feeder as many as 42 substations). The types of interference consist of 9 times air line interference, 1 time network protection interference, and 2 times interference sympathetic trip. To find out the number of times a customer has had outages per years. It was calculated by the total number of outages a year times the number of customer outages during the year. Hence, the result was obtained from Table 1 of 18,540 outages hours/customer a year. The SAIDI and SAIFI standard in a feeder can be calculated using the average blackout frequency index calculation was based on the output number. The outgoing number component data can be seen in Table 5. The average blackout frequency index value based on the exit number on the Senangin feeder can be calculated using formula below:

$$f = \sum_{i=1}^n C_i \cdot x_i \lambda_i \frac{\text{blackout}}{\text{year}} \quad (3)$$

The component data calculation results for the average blackout frequency index based on exit numbers at the Senangin feeder in 2018 can be seen in Table 5. The Table 5 shows component data for calculating the average blackout frequency index based on output numbers. In data on Senangin feeder disruptions in 2018, the cause of outages was due to 3 types of unit components, namely air ducts, network protectors and power breakers.

Table 5: Average outage frequency index component data based on Senangin feeder output figures for 2018

No	Component Type	Components (units, km)	Numbers come out	Pu system that comes out	Outage frequency
i	x	l	c	f	
1	Air duct	31.75	0.2	1	6.35
2	Network protector	1	0.005	1	0.005
3	Energy breaker	2	0.004	1/2	0.004
Amount					6.359

The results of the average blackout frequency index based on the number of component outages on the Senangin feeder in 2018 were 6.359 blackouts/years. The average blackout frequency index was the number of customers who experience blackouts in one year divided by the number of customers served, and can be calculated using formula:

$$f = \frac{\sum_{i=1}^m C_i \text{ blackout}}{N \text{ year}} \quad (4)$$

Hence, the average value of customer outages was:
 $= \frac{32077}{5386} \cdot 12$
 $= 71.467 \text{ outages/year}$

Therefore, the result of average value of customer outages at the Senangin feeder in 2018 experiencing was 71.467 outages/years.

To find out the reliability index, it can be calculated from the outage number of components that cause blackouts. The value of reliability index was the blackout frequency index on Table 5, which presented in Table 6. The calculation for the average outage duration index based on the component exit numbers $f(i)$ was the result of calculating the average blackout frequency index per year, meanwhile t_{ij} was the timeliness required for service restoration. Calculation of the average blackout duration index can be calculated using formula:

$$d = \sum_{i=1}^n x_i \lambda_i \left(\sum_{j=1}^n c_{ij} t_{ij} \right) \frac{\text{Hours}}{\text{year}} \quad (5)$$

From the results of calculating the average blackout duration index data based on the type of Senangin feeder component in 2018, was 19.14 hours/years, it can be seen in Table 6.

Table 6: Average blackout duration index data based on component type and on exit numbers
Components of the 2018 Senangin Feeder

No	Component Type	Frequency of outages	Time (hour)	Duration outage
i		f	t_{ij}	d
1	Air duct	6.35	3	19.05
2	Network protector	0.005	10	0.05
3	Energy breaker	0.004	10	0.04
Amount				19.14

3.3 Electrical Conditions for Premium 328 Customers After Installation ACOS

After the installation is carried out ACOS in December 2018, based on data from January to November 2019, customer outages have never occurred again due to the ACOS worked fine, and only experienced it 2 times change over at the Senangin Feeder with an ENS value of 5,124.36 kWh. Contrast, before ACOS installation the ENS value was 33,781.83. It can be said ACOS never experienced any problems and worked as expected.

Data from the calculation of the short circuit current of the Senangin feeder based on the results of data collection that has been carried out during observations can be used in the process of searching and tracking the location of the fault point, so that it can make it easier to localize the fault point and can influence the SAIDI value due to the recovery time can be reduced.

Large Short Circuit Current of 3 Phase Senangin Feeder

The magnitude of the 3-phase short circuit fault current on the Senangin feeder can be found by calculating formula (6), as follows:

$$I_{f3\phi} = \frac{E_a}{(Z_{s1} + Z_{L1})} \quad (6)$$

$$I_{f3\phi} = \frac{\frac{20}{\sqrt{3}}}{(0,1005+j4,60359)+(0,40741+j),1629)}$$

$$I_{f3\phi} = 2.4 \text{ kA for a distance of 10.25 km from the main substation output.}$$

Large Short Circuit Current of 2 Phase Senangin Feeder

The magnitude of the 2-phase short circuit fault current on the Senangin feeder can be found by calculating formula (7), as follows:

$$I_{f2\phi} = \frac{\sqrt{3} \cdot E_a}{2 \cdot (Z_{s1} + Z_{L1})} \quad (7)$$

$$I_{f2\phi} = \frac{\sqrt{3} \cdot \frac{20}{\sqrt{3}}}{2 \cdot (0,1005 + j4,60359) + (0,40741 + j),1629)}$$

$$I_{f2\phi} = 2.083 \text{ kA for a distance of 10.25 km from the main Substation output.}$$

One (1) Phase Short Circuit Current to Senangin Feeder ground

The magnitude of the 1 phase short circuit fault current to ground on the Senangin feeder can be found by calculating formula (8), as follows:

$$I_{f1\phi \text{ to ground}} = \frac{3 \cdot \frac{20}{\sqrt{3}}}{2 \cdot (Z_{s1} + Z_{L1}) + Z_{S0} + Z_{L0}} \quad (8)$$

$$I_{f1\phi \text{ to ground}} = \frac{3 \cdot \frac{20}{\sqrt{3}}}{2 \cdot (0.50791 + j4.76649) + (45.5106 + j60.9842) + (1.2223 + j0.4074)}$$

$$I_{f1\phi \text{ to ground}} = 0.405 \text{ kA for a distance of 10.25 km from the main substation output.}$$

From the results of the same short circuit current calculations above, the results of the short circuit current per fault distance are obtained which are outlined in Table 7 for the Senangin Feeder data. The creation of Short Circuit (SC) current fault values per distance in Table 7 was intended to make it easier for officers in the field when looking for fault locations, especially faults caused by short circuit faults. Therefore, the officers only match the table with the numbers on the recording, which was read in the distribution control center.

3.3 Short Circuit Fault Simulation with ETAP 12.6

The simulation uses ETAP 12.6 software with IEC standards and a frequency of 50 Hz. The simulation was used for 3 phase short circuit currents that occur in the network at the Senangin feeder. The Senangin feeder conductor used Medium Voltage Cable Channel. Hence the short circuit current disturbances were often experienced of 3 phase faults. The aim of using ETAP Software was to validate the results of calculations that calculated by manually. The simulation result of a 3-phase short circuit fault at the Senangin feeder using ETAP software presents in Figure 6.

The ETAP simulation of short circuit faults, as depicted in Figure 6, reveals the impact on busbar 3. Specifically, the peak 3-phase short circuit current on busbar 3 correlates directly with the fault location. This location is identified as 10.25 km from the source, aligning with the area near the load center. The short-circuit (SC) analysis yielded an approximate result of 2.4 kA. This value aligns closely with the manual calculation, which produced a result of 2.40531 kA, demonstrating a high degree of accuracy.

Table 7: Short circuit current data for Senangin feeder with Conductors XLPE 150 mm²

No	Distance (km)	Network Length (%)	Short Circuit Current Calculation		
			SC current 3 Phases (kA)	SC current 2 Phases (kA)	SC current 1 phase ground (kA)
1	1	10	2.49480	2.160557396	0.412117546
2	2	20	2.48551	2.152516188	0.411290831
3	3	29	2.47612	2.144382812	0.410466492
4	4	39	2.46663	2.136161724	0.409644527
5	5	49	2.45704	2.127857342	0.408824931
6	6	59	2.44736	2.119474019	0.408007702
7	7	68	2.43759	2.111016048	0.407192837
8	8	78	2.42774	2.102487664	0.406380331
9	9	88	2.41782	2.093893031	0.405570182
10	10	98	2.40782	2.085236245	0.404762386
11	10.25	100	2.40531	2.083062811	0.404560805

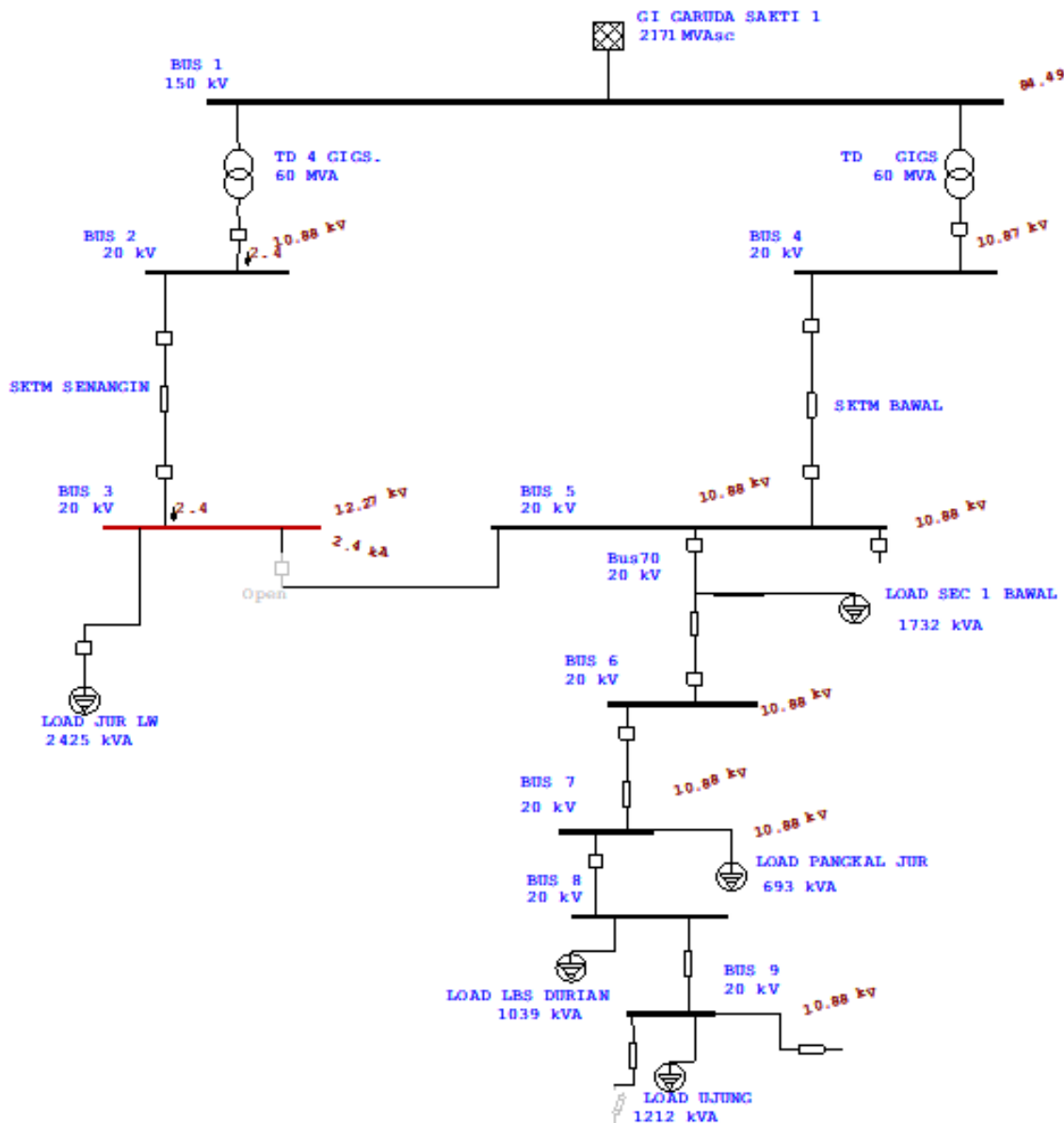


Figure 6: Simulation of a 3 phase short circuit fault for Senangin feeder

The results of the analysis showed that after installing ACOS, there was a significant decrease in the SAIFI and SAIDI indices. The SAIFI value, which previously reached 71.647 outages per year, decreased to 45.32 outages per year after the installation of ACOS. This shows that the frequency of power outages among premium customers was reduced, which is a positive indication of increased reliability of the electricity system. The SAIDI value was decreased from 3.44 hours per year to 1.75 hours per year, which the duration of power outages were also reduced significantly.

The decrease in ENS value was also clearly visible, where the total ENS in 2019 fell to 5,124.36 kWh compared to 33,781.83 kWh in 2018. This shows that less energy was not distributed to customers due to power outages. This data supports the argument that ACOS installation contributes positively to the reliability of electricity supply for premium customers. This ENS reduction also has implications for reducing economic losses experienced by customers, especially in the industrial sector, which is highly dependent on continuity of electricity supply. Overall, the results of this analysis show that installing ACOS can increase the reliability of the electricity system for premium customers. However, PLN must continue to monitor and evaluate the effectiveness of ACOS and make continuous improvements in infrastructure and human resource management to achieve better reliability.

4.0 CONCLUSION

This paper aim is to analysis of electrical system reliability for premium customers after installation of Automatic Change Over Switch (ACOS). The case study was conducted in a premium customer code 385. Before the Automatic Change Over Switch (ACOS) was installed, the SAIFI value was 71,647 outages/year and the SAIDI value was 3.44 hours/year and in 2019. Hence, it can be assumed that the SAIDI SAIFI value was 0 because ACOS worked as expected. The Energy Not Supplied (ENS) value of the Senangin Feeder in 2018 was 33,781.83 kWh, while in 2019 the ENS value was 5,124.36 kWh. It can be said that ACOS works well so that when outages occur, whether planned or unplanned, customers do not experience outages and the ENS is not too large. The results of calculating the magnitude of the short circuit fault current per fault distance for either 3 phases, 2 phases or 1 phase to ground on the Senangin feeder can be used in searching and tracking fault locations, so that the SAIDI of short circuit faults can be minimized. This calculation is very useful when the 20 kV conductor type uses Medium Voltage Cable Channels because it is difficult to find the location of the fault. Therefore, ACOS installation has a positive impact on the reliability of the electricity system for premium customers. The significant decreased in the SAIFI and SAIDI indices, as well as the reduction in ENS values indicated that ACOS is effective in reducing the frequency and duration of power outages. Further research utilizing advanced technology such as the Internet of Things (IoT) and data analytics can help in monitoring system performance in real-time and identifying problems before they become bigger disruptions. In this way, PLN can provide better service to premium customers and increase customer satisfaction.

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