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Recloser system technology on middle voltage transmission of electric energy

Recloser system technology on middle voltage transmission of electric energy

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Abstract. The Needed of Power Electricity in Indonesia always increase every year to year. The demand of development power electricity is needed to be balance with increasing of electric power plant, transmission and distribution line, and infrastructure capabilities, so that distribution of power electricity to consumer go in good manner. One problem that often in distribution and transmission of power electricity is occurred faults in transmission and distribution line system. Our research method is doing observation and interview in collect data, and handling electricity the faults in the fields. the faults occurred in work area of PT PLN (Persero) UP3 Tegal divided by internal and external faults. Internal fault is the occurred faults in equipment of supporting power electricity transmission system like electricity components, electricity equipment, electricity substations, and electricity poles. Meanwhile, external faults divided faults by tree, faults by nature, faults by third party, and faults by kite. The faults are handled by PLN using work procedure (SOP). The contribution of the results of this study to science in the field of energy transmission is an analysis technique to minimize faults of middle voltage transmission of electric energy.

1. Introduction

The Needed of Power Electricity in Indonesia always increase every year to year. In 2015, Power electricity is distributed to consumer as much as 204.279,97 GWh, and in 2017 as much as 226.014,06 GWh. Increasing electrical load demand rise in electrical generation capacity [1]. One problem that often in distribution and transmission of power electricity is occurred faults in transmission and distribution line system. The obstruction of the transmission and distribution system causes to obstructed of transmission and distribution process of electricity to consumer. The Effort to provide the obstruction of the transmission and distribution system is give a protection in that system, so that transmission and distribution process of electricity not have long term damaged.

The transmission and distribution system are managed by PT PLN (Persero), it has divided to be two main units according to region in Indonesia. One the main unit in Indonesia is PT PLN (Persero) Distribusi Jawa Tengah & DIY, it has provided to assurance the quality of power electricity, in order to distributed power electricity to consumer. In 2017, power electricity is distributed in Jawa Tengah (Central Java) as much as 7.223,07 GWh and DIY as much as 240,07 GWh. PT. PLN (Persero) UP3 Tegal is the sub unit of PT. PLN (Persero) Distribusi Jawa Tengah & DIY. Function of UP3 to manage distribution of power electricity to region Tegal and the surroundings.

Our research is studies of several equipment to protect distribution line system (middle voltage transmission line) 20KV. One of the protection devices is recloser, the function of recloser is protect a distribution line. Recloser is one of several devices who used to analyse a temporary faults and permanent faults. Function of recloser to isolate a region is affected by faults. The Classification of recloser divided by voltage source, i.e. single phase and three phase line recloser. single phase recloser used to protect single phase line source, because the single phase supplied most of electronics device.

Three phase recloser used to protect distribution line 20KV (middle voltage transmission 20KV). Optimization of recloser setting in the network to improve structural reliability of electrical service, including in the sense of reliability index [2]. Usage of recloser in distribution line is supported to reduce a continuous blackout, because in distribution line almost 80% until 95% faults is temporary faults and over voltages.

Recent studies discuss about coordination time GARD (Grid Automatic Reclosing Time), [3] Studied to analyse the effect power plant location to protecting's reclosing in the distribution line. Reference of [4] presented an automatic safety device based on weak feeder protection methods to solve coordination with reclosing. reference [5] studies a method to setting auto recloser and over current relay in distribution line. in 2019, This study discussed recloser, like work principal, and analysis faults when recloser tripped. The Analysed method is used to know causes recloser trip during operation recloser in distribution lines 20kV.

Much research has been conducted on recloser work time analysis as done [6] which explains the efficiency analysis of recloser functions and [7] examines optimization of fuse coordination with reclosers. There is no research focused on analysis techniques to minimize the faults that cause recloser trip. Therefore, this research facuses on analysis technique to minimize the faults, analysis of the type of faults that often occure, analysis factor that cause faults, analysis of the factors that cause of faults, analysis of recloser capacity as a protective device, and analysis of the impact of frequent disturbances on middle voltage transmissions of electric energy.

2. Method

In this study, several methods used to collect data, such as method literature review and field review. Literature review, the theories used to analyze research objects, and field review, the method observation with participate on faults solving.

2.1. Faults on Distribution Line 20KV

There is two classification of faults based on characteristic of faults, such as faults because internal factor and external factor. Internal factors concern faults occurred from the system itself. i.e. faults that occurs in equipment that supports the electrical energy transmission and distribution line system such as components, substations, poles, life time of components, overhaul and so on. External factors concern faults occurred from environment around the system. i.e. fault by trees, weather, lighting strikes, natural disasters, beside that possibility faults occurred by animals, i.e. rats, bird, snake, and so on. Based on study from [8], temporary faults is a faults with a small time duration with not damaged a distribution line, and permanent faults is a faults with damaged permanently a distribution line until it handled.

2.2. Type of Faults o Distribution Line 20KV

Based on PT. PLN (Persero) there is several types of faults divided into internal factor and external factors. Table 1 shows the type of faults.

Table 1. The types of faults

No	Factor Faults (Internal/External)	Faults Code	Type of Faults
1	Component (I1)	41d-3	Disconnected FCO (Caused by Unknown)
		44a	Disconnected Middle Voltage Transmission Line (MVTL)/ SUTM
		44b	Damaged MVTL's Jumper
		44c	MVTL a parted from Isolator
		41d-4	Decomposed JTM's wires
		51	Faults on SKTM cable
		53	Damaged Connection Box SKTM

No	Factor Faults (Internal/External)	Faults Code	Type of Faults
		54	Damaged
		59	Failed Isolation of Power Cables (Break Down)
2	Equipment (I2)	45	Damaged Isolator
		41d-2	Damaged CT/PT
		46	Damaged Cut Out
		47	Damaged Pole Switch
		47-1	Operated Equipment
		48	Damaged Lighting Arrester
3	Substation (I3)	41d-1	Damaged Transformers
		56	Sympathetic Tripping
		49-1	Over Load
4	Poles (I4)	35	Collapsed Electric Poles (vehicles)
		36	Collapsed Electric Poles (ages)
		37	Collapsed Electric Poles (other reason)
		38	Damaged Poles except Isolator dan conductor
5	Trees (E1)	41a	Faults by trees
		49	Faults not found
6	Environment (E2)	41c	Lightning
		81	Strong winds (tornado)
		82	Heavy rains
		83	Flood
		84	Landslip
		85	Earthquake
		86	Fire
		87	And So on (mass riots)
7	Third Party/Animals (E3)	41b	Animals (Bird, snake, and so on)
		52	Faults SKTM because PDAM Excavation,and so on.
		49-2	Electrocuted
8	Kite (E4)	41d	Kite (Billboard, and so on)

2.3. Capability Recloser as Protection

Recloser will work when the distribution network 20KV disruption is to cut off the power and then recloser analyze the disorder is permanent or temporary. If interference is temporary, the recloser will cut off the power and re-entry up to setting limits that have been programmed. If the disorder is considered permanent, then recloser will cut off the power until the clerk eliminate, such interference and recloser inserted back [9].

The relationship between the amount of fault current and tripping time is shown in figure 1 below. From the picture shows that the greater the fault current flowing, it will cause the breakdown time/trip on the recloser faster, and if the smaller the fault current flowing, the slower the breakdown time/trip on the recloser. Breakdown for large fault currents occurs very quickly because in large fault currents the heating that arises due to the fault currents iv very large. Manufacturers have standardized maximum of four operation time trip before lock-out occurs [10].

After a predefined time, enough for the fault clearance, the recloser reenergises the feeder and restores the power supply. Since 50% to 80% of faults occurring in electrical distribution networks have transient nature, the fuse saving strategy can improve the system security and reliability [11].

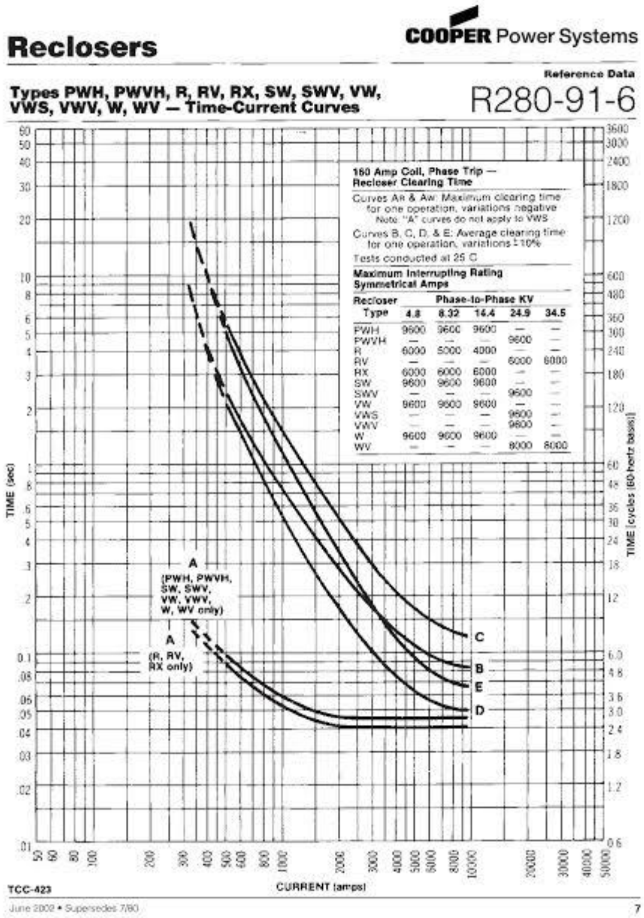

Figure 1. Current Characteristic – time

3. Result and Discussion

3.1. Sub unit (ULP) PT PLN (Persero) UP3 Tegal

The scope of work area of PT PLN (Persero) UP3 Tegal which included 10 ULP spreads across Tegal city, Tegal regency, Brebes regency, and Pemalang regency. The ULP description shown in table 2.

Table 2. Work areas of UP3

No	Names ULP	City/Regency
1.	Tegal City	Tegal City
2.	East Tegal	Tegal City
3.	Pemalang	Pemalang Regency
4.	Slawi	Tegal Regency
5.	Brebes	Brebes Regency
6.	Bumiayu	Brebes Regency
7.	Comal	Pemalang Regency
8.	Jatibarang	Brebes Regency
9.	Balapulang	Tegal Regency
10.	Randudongkal	Pemalang Regency

3.2. Middle Voltage Transmission Line Faults

PT PLN (Persero) UP3 Tegal handled faults that occurs on middle voltage transmission line, causing recloser trip. The faults are recapped and collected by type of faults, location of faults, and reason of faults. In 2018, The faults are mostly caused by external factors (Graph. 1). Based on table 3. The faults are caused by trees have percentages 45.6% with 195 incident cases, and 34.4% caused by other factors (Graph. 2). This mostly faults occurred, because of locations Tegal and surround dominated with trees and not densely populated urban areas.

Table 3. Faults cases is divided by regions

ULP	I1	I2	I3	I4	E1	E2	E3	E4	Total
Tegal City	5	10	0	1	6	1	12	4	39
East Tegal	2	1	0	0	11	1	3	3	21
Pemalang	3	3	2	0	45	6	9	7	75
Slawi	1	6	1	0	18	3	9	6	44
Brebes	9	5	0	1	8	5	5	5	38
Bumiayu	8	4	0	1	27	1	11	3	55
Comal	3	3	1	0	13	2	2	4	28
Jatibarang	4	11	3	0	33	5	2	4	62
Balapulang	3	6	1	0	9	1	2	1	23
Randudongkal	4	1	0	3	25	4	4	2	43
Totals	42	50	8	6	195	29	59	39	428
Persentages (%)	9.8	11.7	1.9	1.4	45.6	6.8	13.8	9.1	

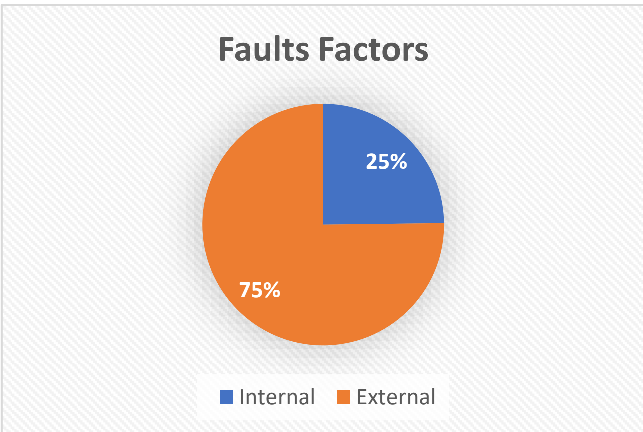

Figure 2. Comparison of internal between external factors

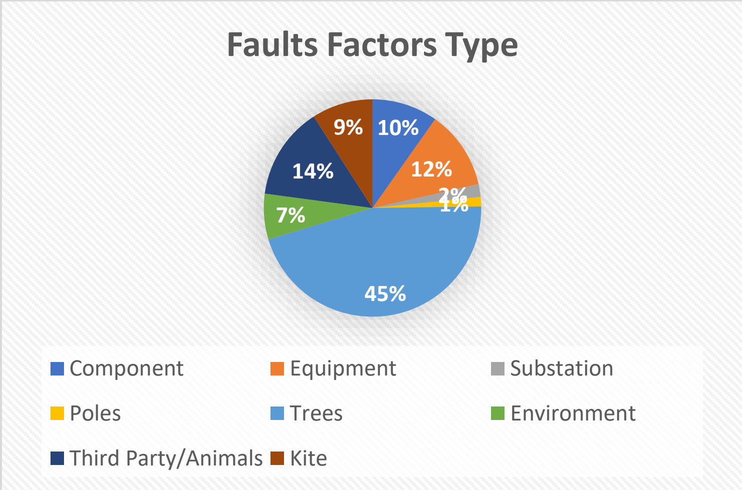

Figure 3. Comparison of several type factors

3.3. Effect of Faults
The faults occurred in MVTL, it effected to obstruct a distribution of electricity energy to consumer. So that, the needed of electricity distribution must be protect to reduce loss of energy and other, protection electric energy distribution using device have function to disconnected a line with the fault location. The faults like external factor affected to rise over current or over voltage in distribution line. If the faults occure continuously, it will be reduced reliability and lifespan of network component (Transformers, isolator, fuse cut-off, and so on.)

The most faults occurred in PT PLN (Persero) UP3 Tegal, that is dominated by presence of trees around the distribution line. Impact of presence of trees, recloser in distribution line will be trip because the distribution line occure fault with effect of over current or over voltage. The area which fault needs to solve as soon as possible to reduce loss energy distribution.

3.4. Reason Often Faults Occure
Faults to the middle voltage transmissions of electric energy system are recapped based on the number month in 2018. The following is a quantity of the number of faults that occur for each ULP in 2018 which is designated tables 4, 5, 6, 7, 8, 9, 10, 11.

Table 4. Internal faults caused by component

ULP	Faults by component												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Des	
Tegal City	1	0	1	1	0	0	0	0	0	1	1	0	5
East Tegal	0	0	0	0	0	0	0	0	0	1	0	1	2
Pemalang	0	0	0	0	0	0	1	0	1	0	0	1	3
Slawi	0	0	0	0	0	1	0	0	0	0	0	0	1
Brebes	0	1	2	0	0	1	2	0	1	1	1	0	9
Bumiayu	1	0	0	1	0	0	0	0	0	0	4	2	8
Comal	0	0	0	2	0	1	0	0	0	0	0	0	3
Jatibarang	0	1	1	0	1	0	0	0	0	0	0	1	4
Balapulang	0	2	0	0	0	0	0	0	0	1	0	0	3
Randudongkal	0	0	0	0	0	0	0	1	1	1	1	0	4
Total	2	4	4	4	1	3	3	1	3	5	7	5	42

Table 5. Internal faults caused by equipment

ULP	Faults by equipment												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des	
Tegal City	0	2	2	0	0	0	3	1	1	0	0	1	10
East Tegal	0	0	0	0	0	0	0	0	0	0	0	1	1
Pemalang	0	0	0	0	0	0	1	0	0	0	0	2	3
Slawi	1	0	0	1	0	0	0	0	2	2	0	0	6
Brebes	1	0	0	1	0	0	1	0	0	0	1	1	5
Bumiayu	0	0	0	0	0	1	1	0	0	0	1	1	4
Comal	0	0	0	0	0	2	0	0	0	1	0	0	3
Jatibarang	0	1	0	2	1	3	0	2	0	0	1	1	11
Balapulang	0	0	0	0	0	0	0	0	2	0	4	0	6
Randudongkal	0	0	0	0	0	0	1	0	0	0	0	0	1
Total	2	3	2	4	1	6	6	3	5	3	7	7	50

Table 6. Internal faults caused by substations

ULP	Faults by substation												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des	
Tegal City	0	0	0	0	0	0	0	0	0	1	0	0	1
East Tegal	0	0	0	0	0	0	0	0	0	0	0	0	0
Pemalang	0	0	0	0	0	0	0	0	0	0	0	0	0
Slawi	0	0	0	0	0	0	0	0	0	0	0	0	0
Brebes	0	0	0	0	0	0	0	0	0	0	1	0	1
Bumiayu	0	0	0	0	0	0	0	0	0	0	1	0	1
Comal	0	0	0	0	0	0	0	0	0	0	0	0	0
Jatibarang	0	0	0	0	0	0	0	0	0	0	0	0	0
Balapulang	0	0	0	0	0	0	0	0	0	0	0	0	0
Randudongkal	0	0	0	1	0	0	0	0	0	0	2	0	3
Total	0	0	0	1	0	0	0	0	0	1	4	0	6

Table 7. Internal faults caused by poles

ULP	Faults by poles												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des	
Tegal City	0	0	0	0	0	0	0	0	0	0	0	0	0
East Tegal	0	0	0	0	0	0	0	0	0	0	0	0	0
Pemalang	0	0	0	0	0	0	2	0	0	0	0	0	2
Slawi	0	0	0	0	0	0	0	0	0	0	0	1	1
Brebes	0	0	0	0	0	0	0	0	0	0	0	0	0
Bumiayu	0	0	0	0	0	0	0	0	0	0	0	0	0
Comal	1	0	0	0	0	0	0	0	0	0	0	0	1
Jatibarang	0	0	0	0	0	0	1	0	2	0	0	0	3
Balapulang	0	0	0	0	0	0	0	0	0	0	1	0	1
Randudongkal	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	0	0	0	0	0	3	0	2	0	1	1	8

Based on table 4, table 5, table 6 and table 7 known internal fault that often occur are due to the reliability of components and equipment, age restrictions on components and equipment. Components and equipment that can be used at PT. PLN have an age limit only 15 years. This limitation becomes the maximum periodic verification requirement of components which can be stated to be reused as a middle voltage transmissions of electric energy system. However, in practice there are still many components and equipment that are still operating with more than 15 years of age, so that the reliability of the components and equipment has been greatly reduced from the first time it is used. The PUIL 2011 regulation explains that periodic verification must be carried out after the installation age reaches 15 years, if the installation is changed or reconditioned before 15 years, then it must be verified before it is declared to be feasible for operation (PUIL, 2011).

Table 8. External faults caused by trees

ULP	Faults by trees												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dec	
Tegal City	0	0	1	2	0	1	0	0	1	0	0	1	6
East Tegal	3	1	0	0	1	0	1	0	1	0	1	3	11
Pemalang	4	2	6	5	2	2	1	3	4	3	7	6	45
Slawi	2	1	3	1	3	1	0	0	1	0	2	4	18
Brebes	2	1	0	0	1	1	1	0	0	2	0	0	8
Bumiayu	3	0	4	1	1	1	1	6	4	0	3	3	27
Comal	1	2	0	0	1	0	0	1	3	0	2	3	13
Jatibarang	1	1	2	1	3	3	4	3	1	3	3	8	33
Balapulang	1	0	0	1	1	0	1	1	0	2	0	2	9
Randudongkal	2	3	1	1	2	1	1	0	1	2	8	3	25
Total	19	11	17	12	15	10	10	14	16	12	26	33	195

Table 9. External faults caused by environment

ULP	Faults by environment												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dec	
Tegal City	0	0	0	0	0	0	0	0	0	0	0	1	1
East Tegal	0	0	0	0	0	0	0	0	0	0	0	1	1
Pemalang	0	0	2	1	0	0	0	0	1	0	2	0	6
Slawi	0	2	1	0	0	0	0	0	0	0	0	0	3
Brebes	0	4	1	0	0	0	0	0	0	0	0	0	5
Bumiayu	0	0	0	0	1	0	0	0	0	0	0	0	1
Comal	0	0	0	0	0	0	0	0	0	0	1	1	2
Jatibarang	0	2	0	0	0	0	0	0	0	1	2	0	5
Balapulang	0	1	0	0	0	0	0	0	0	0	0	0	1
Randudongkal	1	0	1	1	0	0	0	0	0	0	1	0	4
Total	1	9	5	2	1	0	0	0	1	1	6	3	29

Table 10. External faults caused by third party/animals

ULP	Faults by third party/animals												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dec	
Tegal City	0	1	1	1	0	0	0	1	1	1	2	4	12
East Tegal	0	0	0	0	0	2	0	0	0	1	0	0	3
Pemalang	0	1	0	1	1	1	0	1	1	1	0	2	9
Slawi	0	0	1	2	1	1	1	0	0	1	2	0	9
Brebes	1	0	0	0	2	0	0	0	0	0	0	2	5
Bumiayu	2	3	0	1	2	1	2	0	0	0	0	0	11
Comal	0	0	0	1	0	1	0	0	0	0	0	0	2
Jatibarang	0	0	0	0	0	0	0	0	2	0	0	0	2

ULP	Faults by third party/animals												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dec	
Balapulang	0	0	0	0	1	0	0	0	0	1	0	0	2
Randudongkal	0	0	1	0	0	2	1	0	0	0	0	0	4
Total	3	5	3	6	7	8	4	2	4	5	4	8	59

Table 11. External faults caused by kite

ULP	Faults by kite												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nov	Dec	
Tegal City	1	0	2	0	0	0	0	0	1	0	0	0	4
East Tegal	1	0	0	1	0	0	0	0	0	0	0	1	3
Pemalang	0	0	1	1	0	0	0	2	1	1	0	1	7
Slawi	2	0	0	1	0	0	1	0	0	0	2	0	6
Brebes	1	0	1	1	1	0	0	0	0	1	0	0	5
Bumiayu	0	1	0	0	0	0	0	2	0	0	0	0	3
Comal	0	1	0	1	0	2	0	0	0	0	0	0	4
Jatibarang	0	1	0	0	0	0	0	1	0	1	1	0	4
Balapulang	0	0	0	0	0	0	0	1	0	0	0	0	1
Randudongkal	0	0	0	1	0	0	0	0	1	0	0	0	2
Total	5	3	4	6	1	2	1	6	3	3	3	2	39

Based on table 8, table 9, table 10 and table 11 known that external faults that occur more dominated by disturbance due to trees. In tree fault which is divided into two, namely due to trees and not found, as many as 100 cases were caused by trees and 45 cases were not found the source of the fault. Many tree fault are caused by natural influences such as rain and strong winds. In the rainy season which starts from October to March and the dry season starts from April to September, tree fault caused by the rainy season as many as 118 cases (60%) and the dry season as many as 77 cases (77%). More natural distruptions are caused by lightning in 25 cases, strong winds (3), and heavy rain (1). In the drdddy season 4 (14%) cases were caused by natural factors, and 25 (86%) cases were caused by the rainy season. In the third party fault and kites can aoccur at any time not affected due to seasonal factors in Innonesia.

3.5 Solution Managing Faults

The solution to handle faults is caused by internal factor, must be carried out with the inspection and maintenance of component which supported electricity energy distribution. The faults from internal factors can be predicted using reliability analysis, the analysis is about how much capability of component will be used to a next few times. If reliability analysis can be done, the fault can be known and controlled.

The faults are caused by external factor, it has very difficult to handle because it depends in other factor (environment). The faults by environment can be happed for a moment following a condition of environment itself and It can’t be predict using any method. To reduce faults by external factors, must be carried out with the inspections the location along distribution line network. This inspection is used to reduce faults by tree, in other reason like natural disaster, or natural phenomenon needs to improve protections in the distribution line using recloser and other device like over current relay and over voltage relay. The improved protections reduced the loss factor of loses energy when faults occurred.

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4. Conclusions

In this study, when occurred faults, recloser function to divide disturbed areas from other areas, it will reduce loss factor of electricity energy distribution. Recloser trips divided by two type of faults such as internal faults and external faults, internal faults such as component, equipment, substation, and poles, external faults such as trees, environment, third party/animals, and kite. The faults are caused by trees have percentages 45.6% with 195 incident cases, and 34.4% caused by other factors. This mostly faults occurred, because of locations Tegal and surround dominated with trees and not densely populated urban areas. Otherwise, the number of cases of tree-related fault is due to the presence of the rainy season factor with a percentage of (60%) and the dry season with a precentage (40%),factors related to the season are natural disruption which is mostly dominated by lightning and heavy rain in the rainy season in 25 cases (86%), strong winds in the dry season (14%). More internal fault occur due to the reliability of components and equipment due to age that reduces the ability of components and equipment to support middle voltage transmission of electric energy system. The recloser's ability to handle any disruption is already said to be good, because the recloser can separate disrupted networks as a result of internal and external fault. Recloser work sensitivity is also very high to distinguish the fault is temporary or permanent in the middle voltage transmission of electric energy system.

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