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The Study of Medium Voltage Source Change Effect to Voltage Sag in Low Voltage Customer in Distribution System

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Objective

- Study Number of Sag (NOS.)
- Prepare power quality information for customer

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Scope of work

- ***Compare voltage sag characteristic between substation CMC and CMU***
- ***One substation constructed with 5 feeders 22 kV 10 km. / feeder (185Sq.mm.SAC)***
- ***Faults are 4 types (SP-G, PP-G,PP and 3P)***
- ***Study voltage sag at customer low voltage side, when fault occur in medium voltage network***

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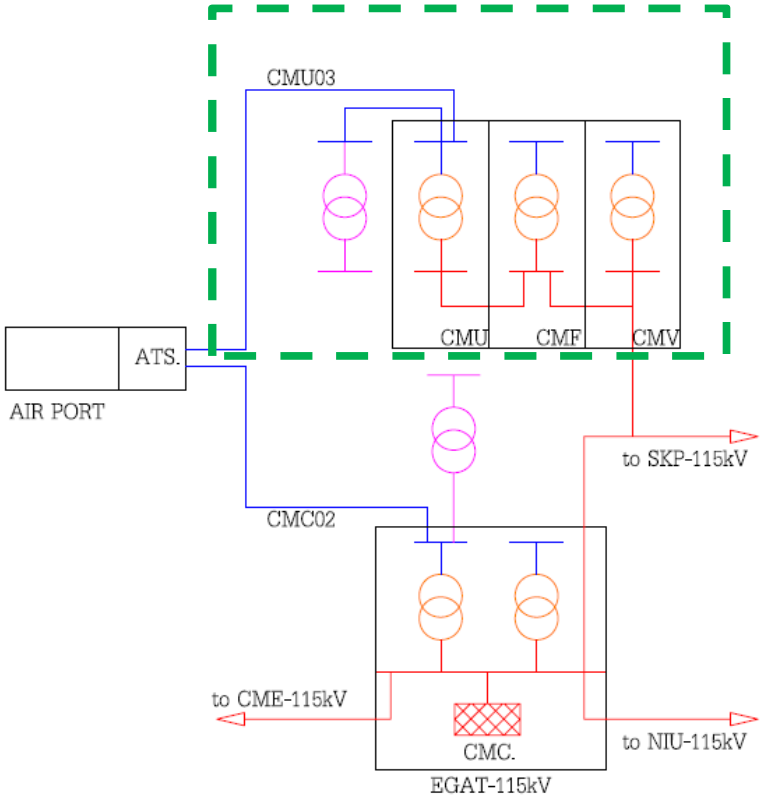
Introduction

- *When load increase , PEA. construct new substation and transmission line*
- *New substation contains shorter distribution system ,smaller outage area , increase reliability ,solve voltage drop problem and losses*
- ***There is no consideration about voltage sag and harmonic.***
- ***There is no power quality data to make customer understand***

New installation



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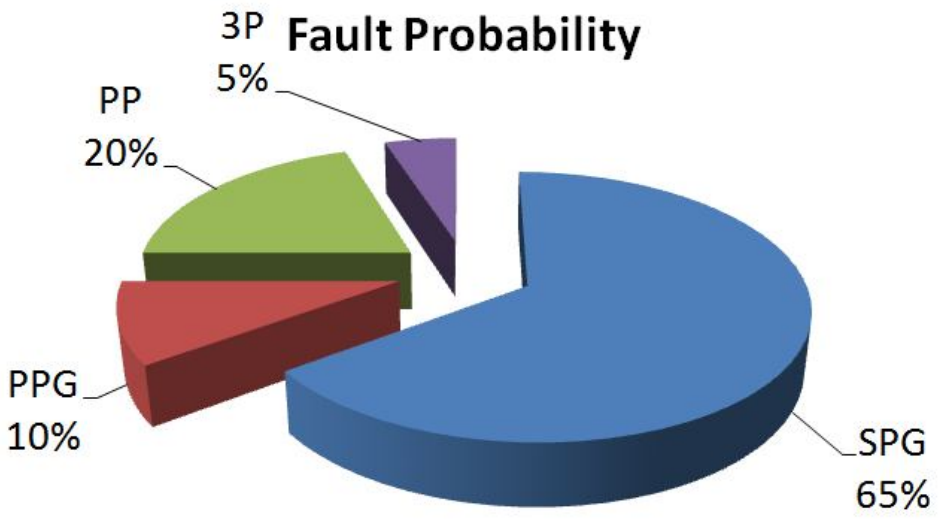
Theory

❑ Fault Probability



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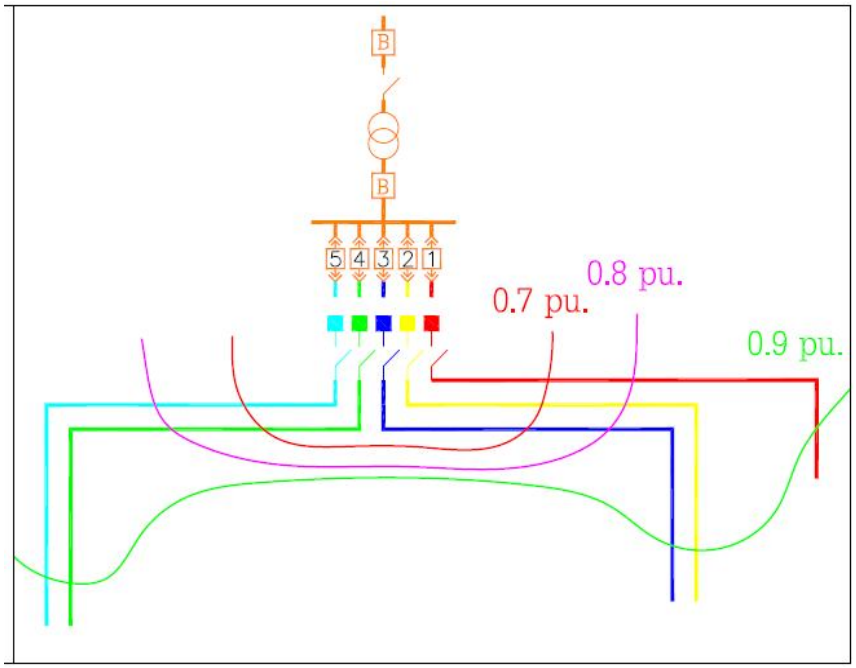
Theory

- NOS = LFP x AOV.
- LFP = FR / total circuit-km.



- FR. :Fault rate (fault/year)
- total circuit-km. (circuit-km.)
- LFP :Line Fault Performance (fault/km/year)
- AOV.: Area of Vulnerability (circuit-km.)
- NOS. :Number of Sag event (event/year)

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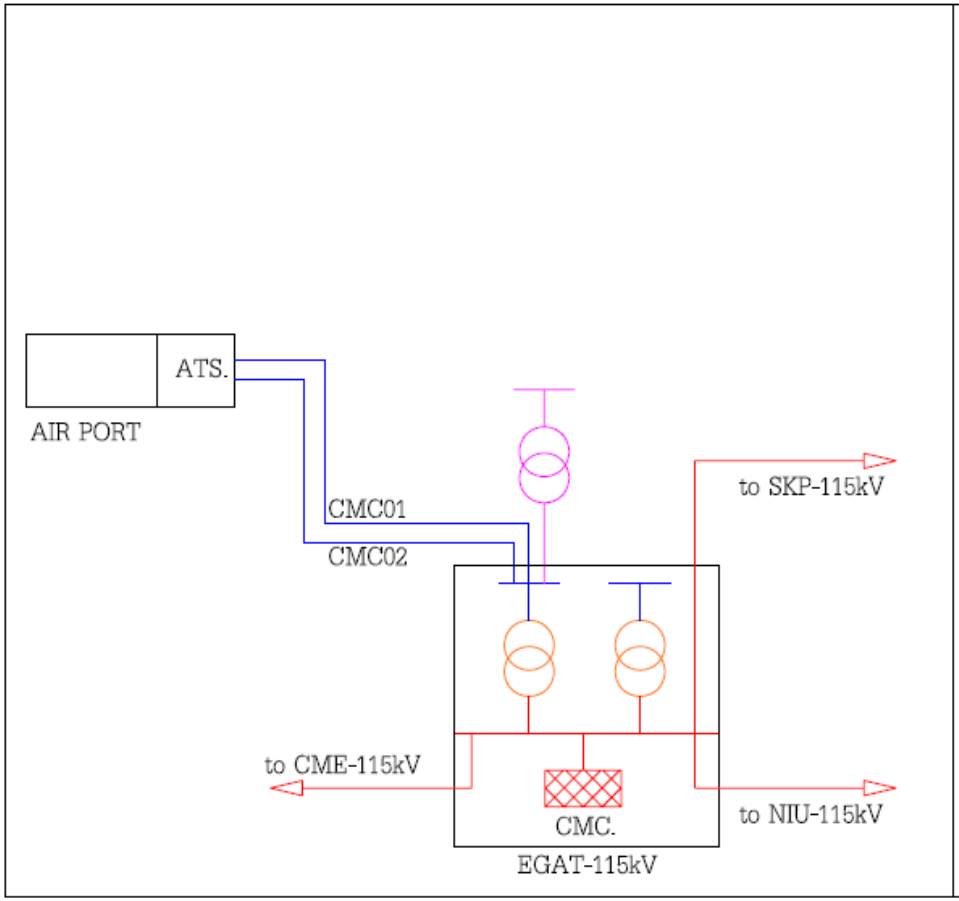
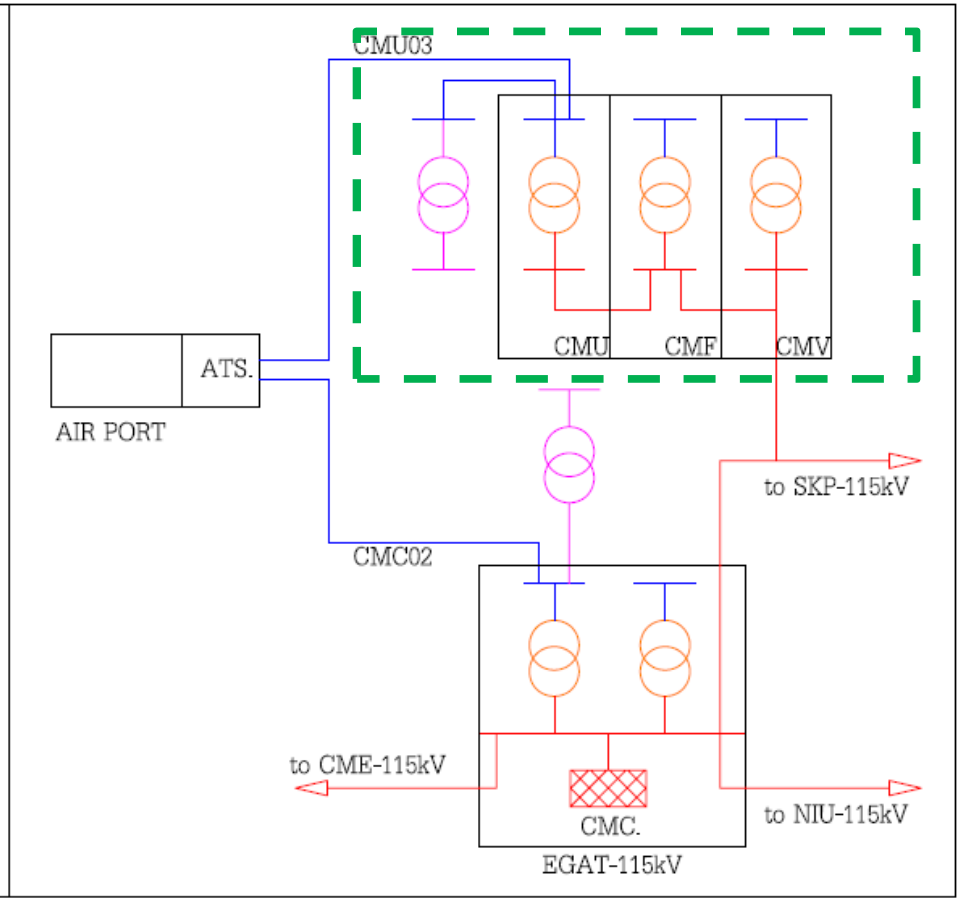
Existing system and New dispatch



New substation



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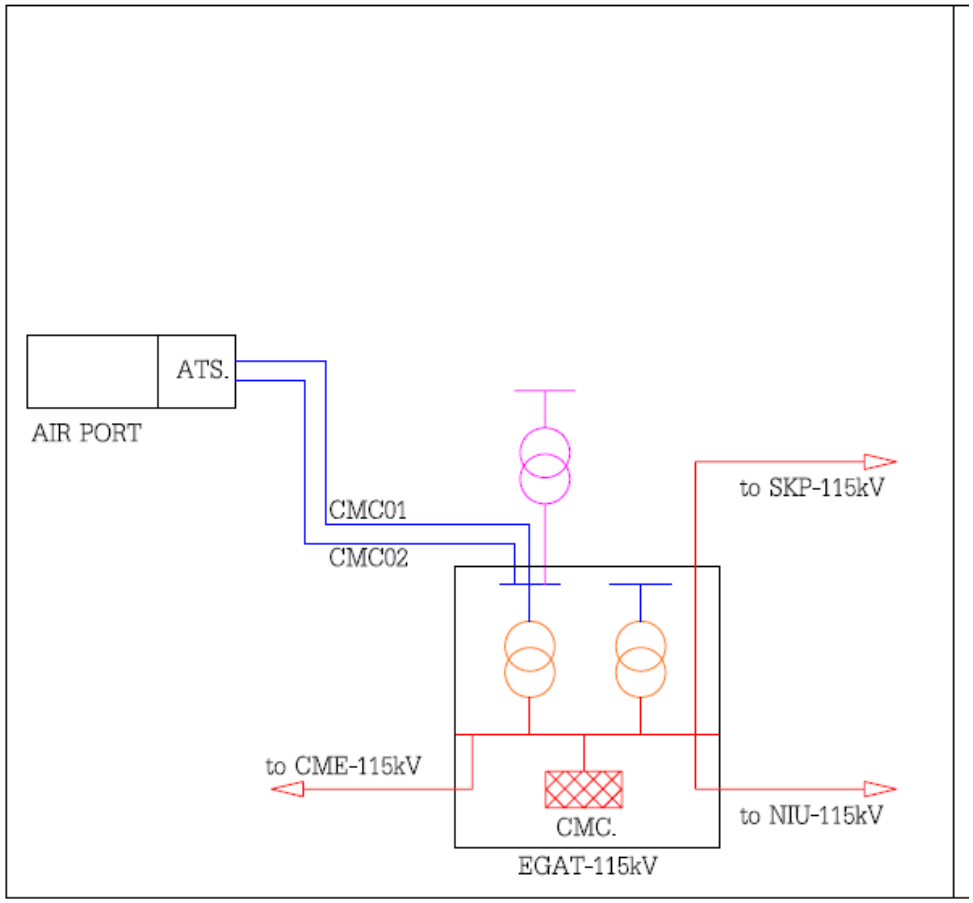
Existing distribution system



- CMC. Connected to **EGAT substation**
- **CMC 50 MVA** Power Transformer
- three phase fault = **8.795 kA.** At 22 kV bus
- MVAsc = **335.12 MVA.** At 22 kV bus
- customer connected to **CMC01 or CMC02**

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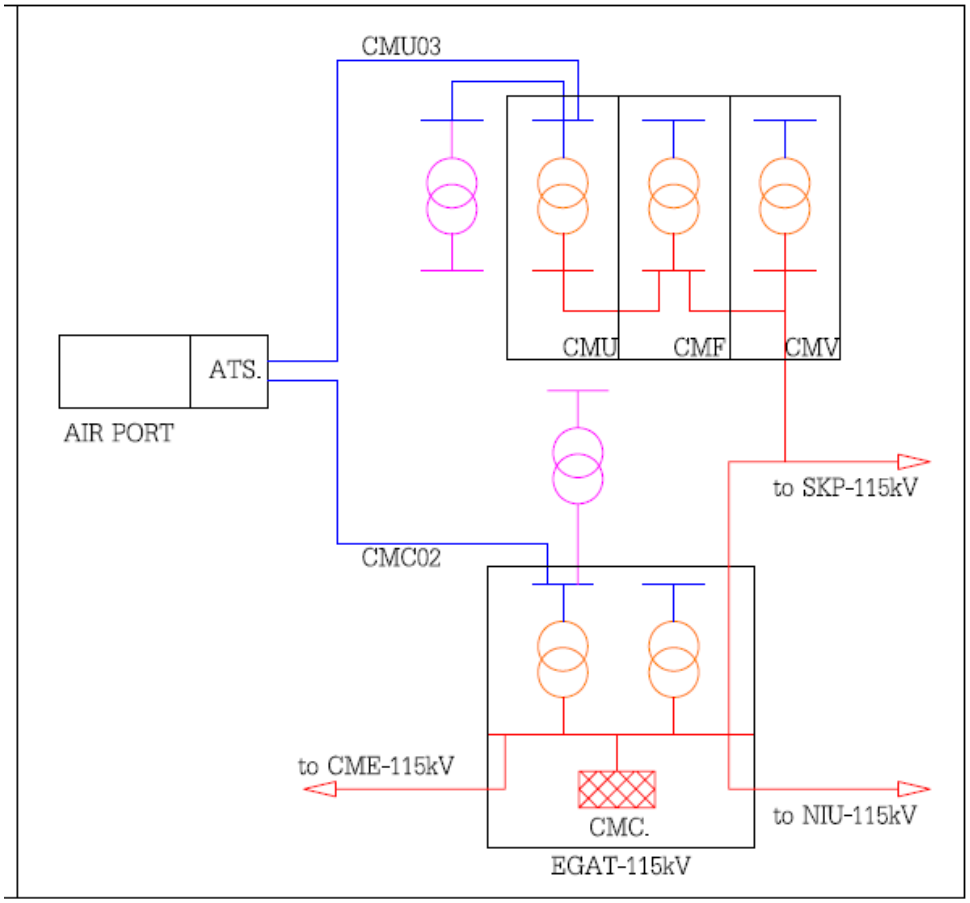
New Substation



- CMU. Connected to **115 kV line cable 2x400 Sq.mm. 23.19 km to CMC EGAT substation**
- **CMU 25 MVA** Power Transformer
- three phase fault = **6.206 kA.** At 22 kV bus
- MVAsc = **236.49 MVA.** At 22 kV bus
- customer connected to CMC02 or CMU03

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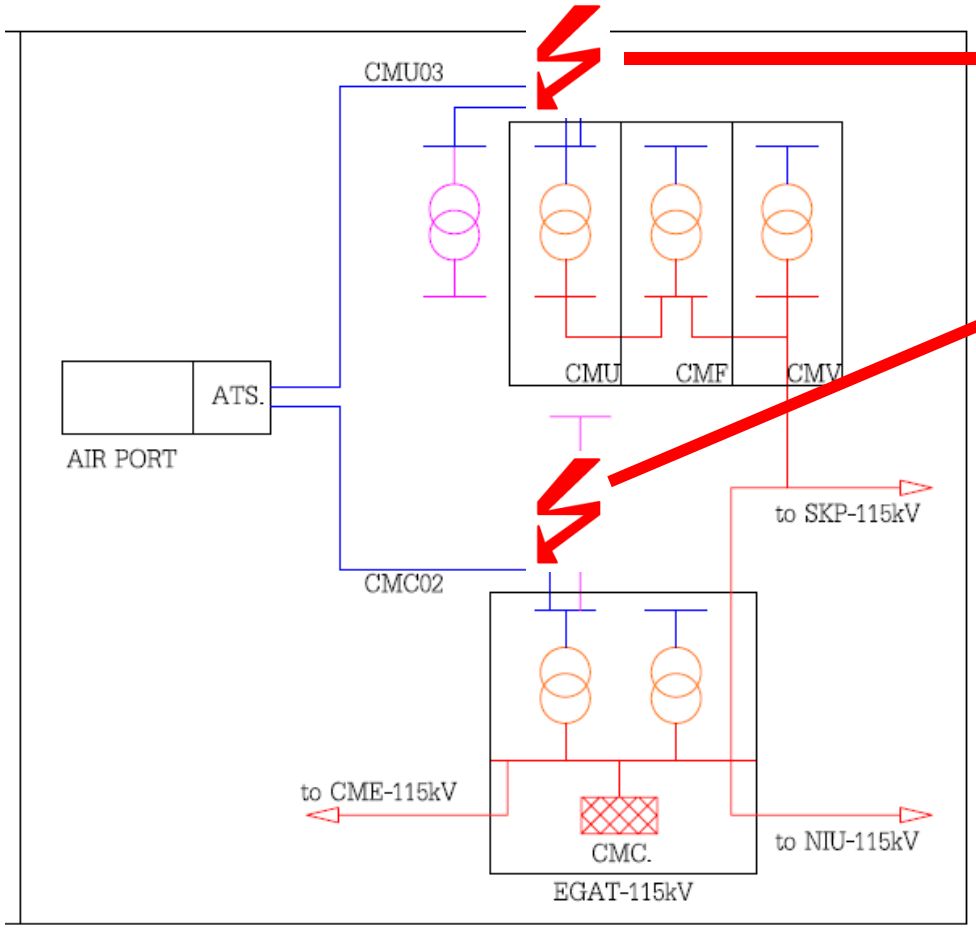
Existing system and New system



- ***CMU. (NEW SUBSTATION)***
  *MVAsc = **236.49 MVA.** At 22 kV bus*
  *Zs2= **2.0466 Ohm** at 22 kV*
- ***CMC. (OLD SUBSTATION)***
  *MVAsc = **335.12 MVA.** At 22 kV bus*
  *Zs1= **1.4443 Ohm** at 22 kV*
- *impedance at pcc. 22 kV substation CMU. Is high because of **transmission line 115 kV impedance และ power transformer impedance 25 MVA.***

Ztr 50 MVA.=1.1616 Ohm %Z = 12%

Ztr 25 MVA.=1.5488 Ohm %Z = 8%

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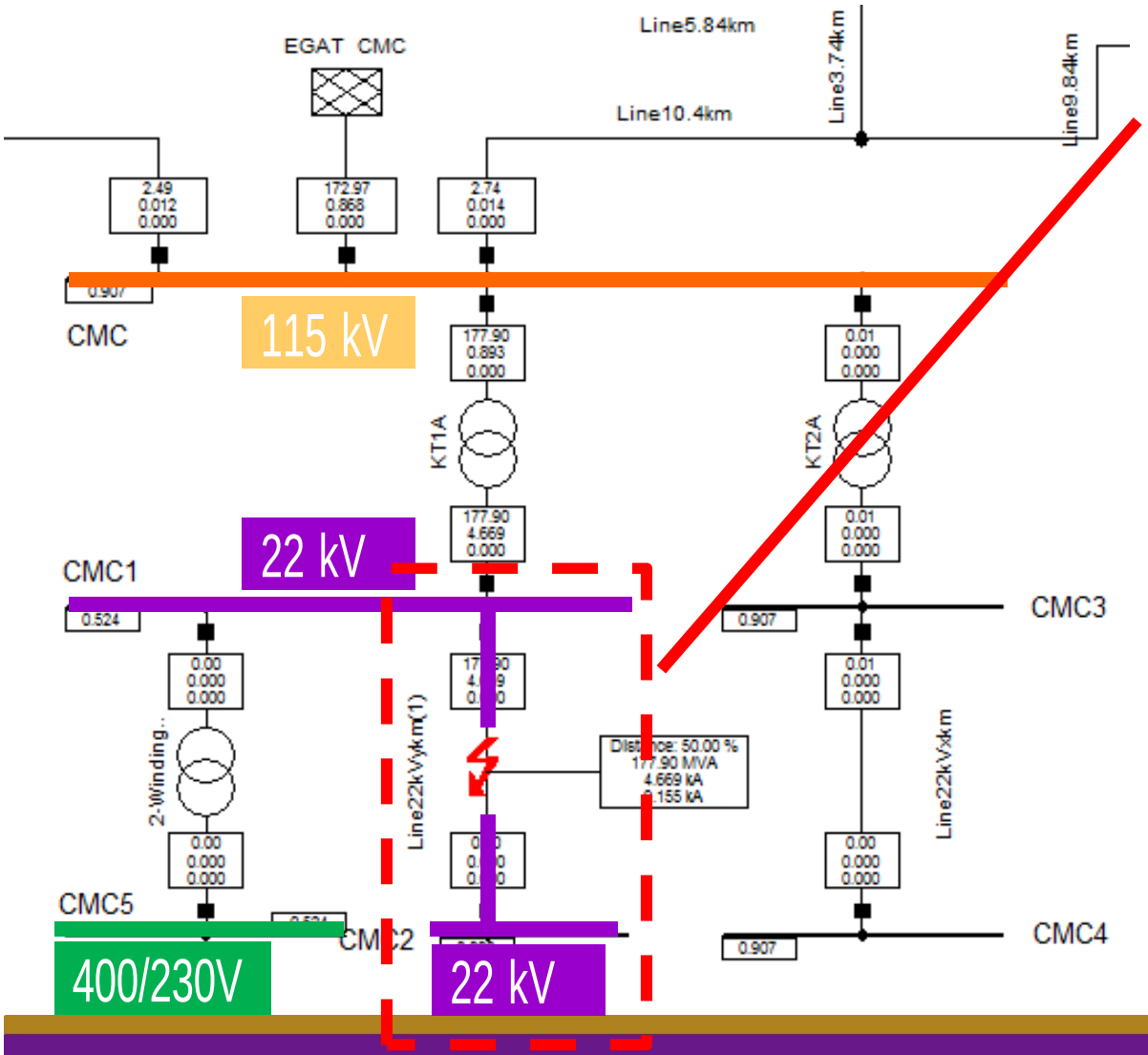
Determine AOV.



- *Draw 22 kV line model 185 Sq.mm. SAC.*
- *Vary fault distance from substation 0-10 km.*
- *Short circuit analysis for 4 types SP-G PP PP-G 3P fault*

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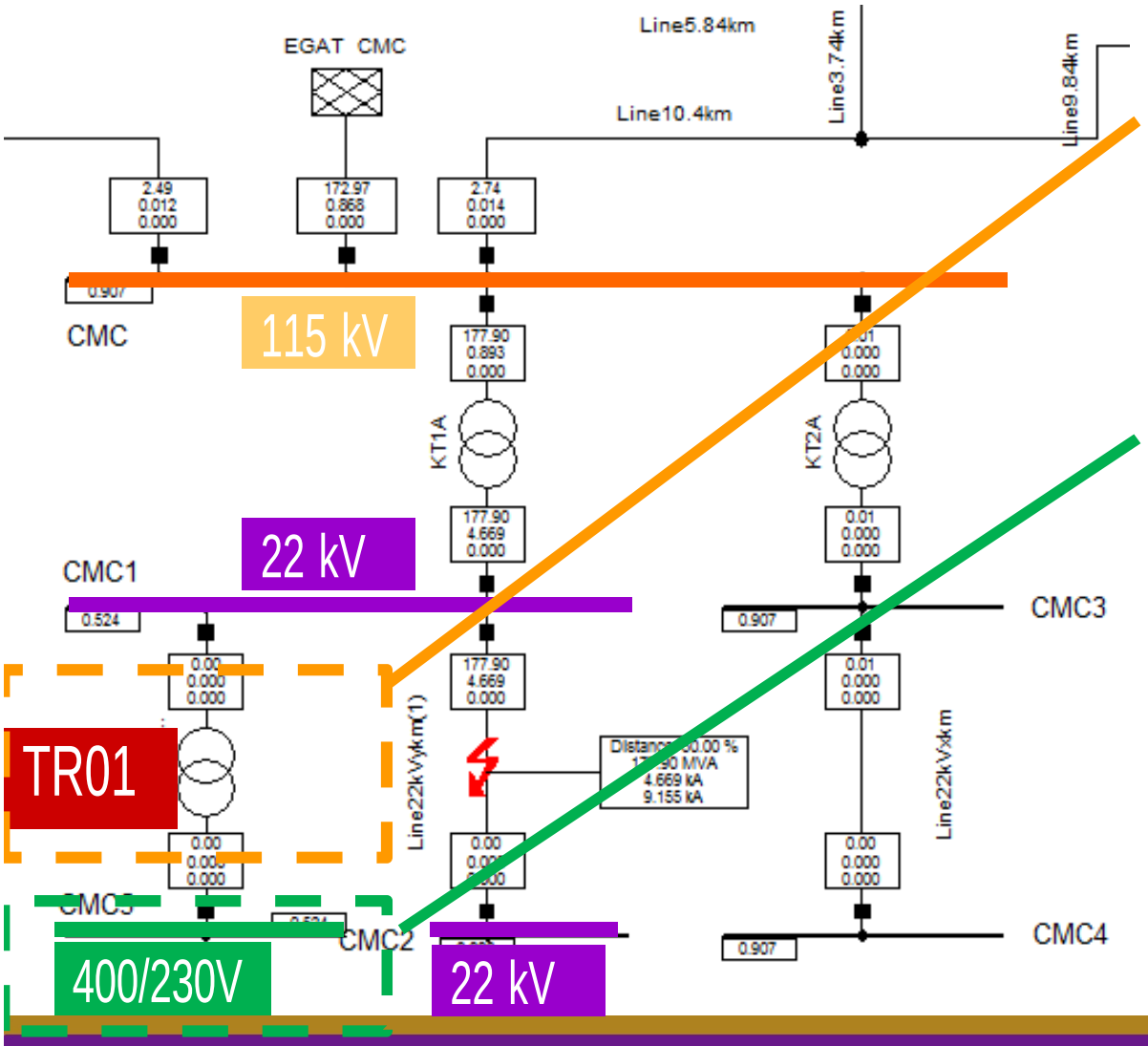
Determine AOV.



- *Model **TR1** DYn11 22kV/400V at substation to measure 230V side*
- *Voltage at this bus is voltage that all customer in substation will meet during short circuit.*

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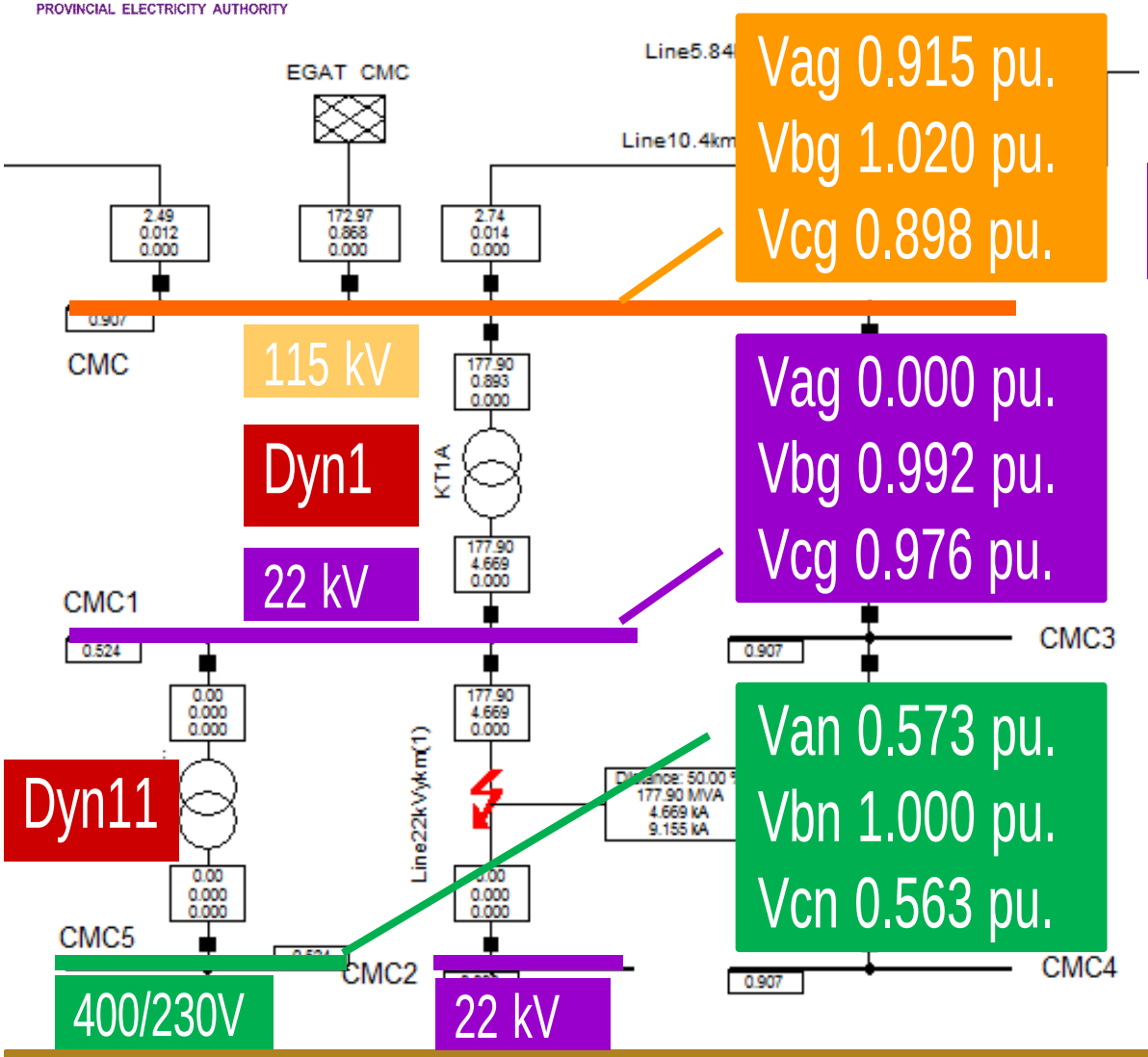
Determine AOV.



Vag 0.915 pu.
Vbg 1.020 pu.
Vcg 0.898 pu.

Vag 0.000 pu.
Vbg 0.992 pu.
Vcg 0.976 pu.

Van 0.573 pu.
Vbn 1.000 pu.
Vcn 0.563 pu.

Single line to ground Fault

- *short circuit calculation at 22kV*
  A-G
- *affect customer 230 V side*
  phase A-N and C-N

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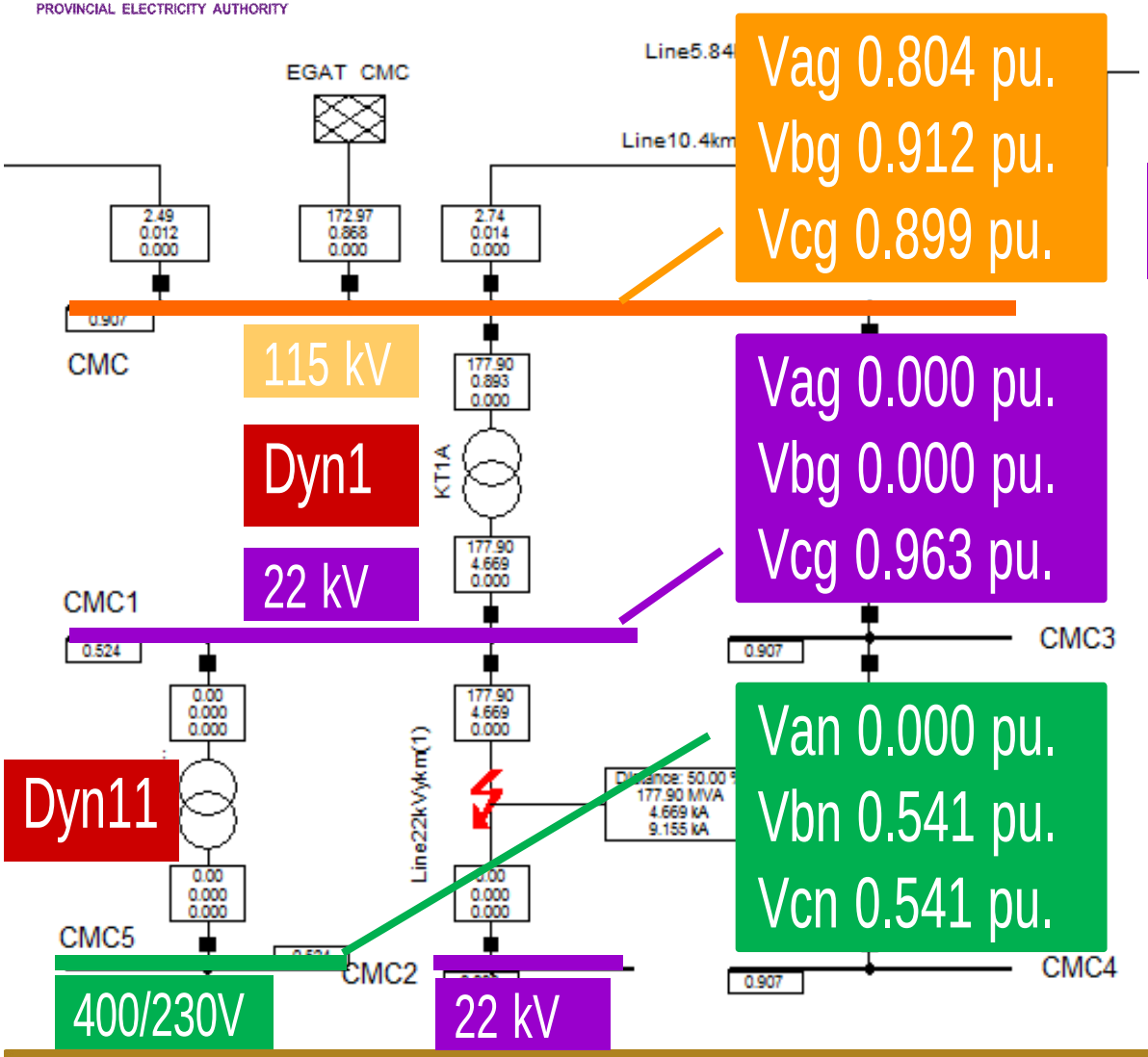
Determine AOV.



Vag 0.804 pu.
Vbg 0.912 pu.
Vcg 0.899 pu.

Vag 0.000 pu.
Vbg 0.000 pu.
Vcg 0.963 pu.

Van 0.000 pu.
Vbn 0.541 pu.
Vcn 0.541 pu.

Double line to ground Fault

- *short circuit calculation at 22kV*
  AB-G
- *affect customer 230 V side*
  phase A B and C
  phase A-N is the lowest value

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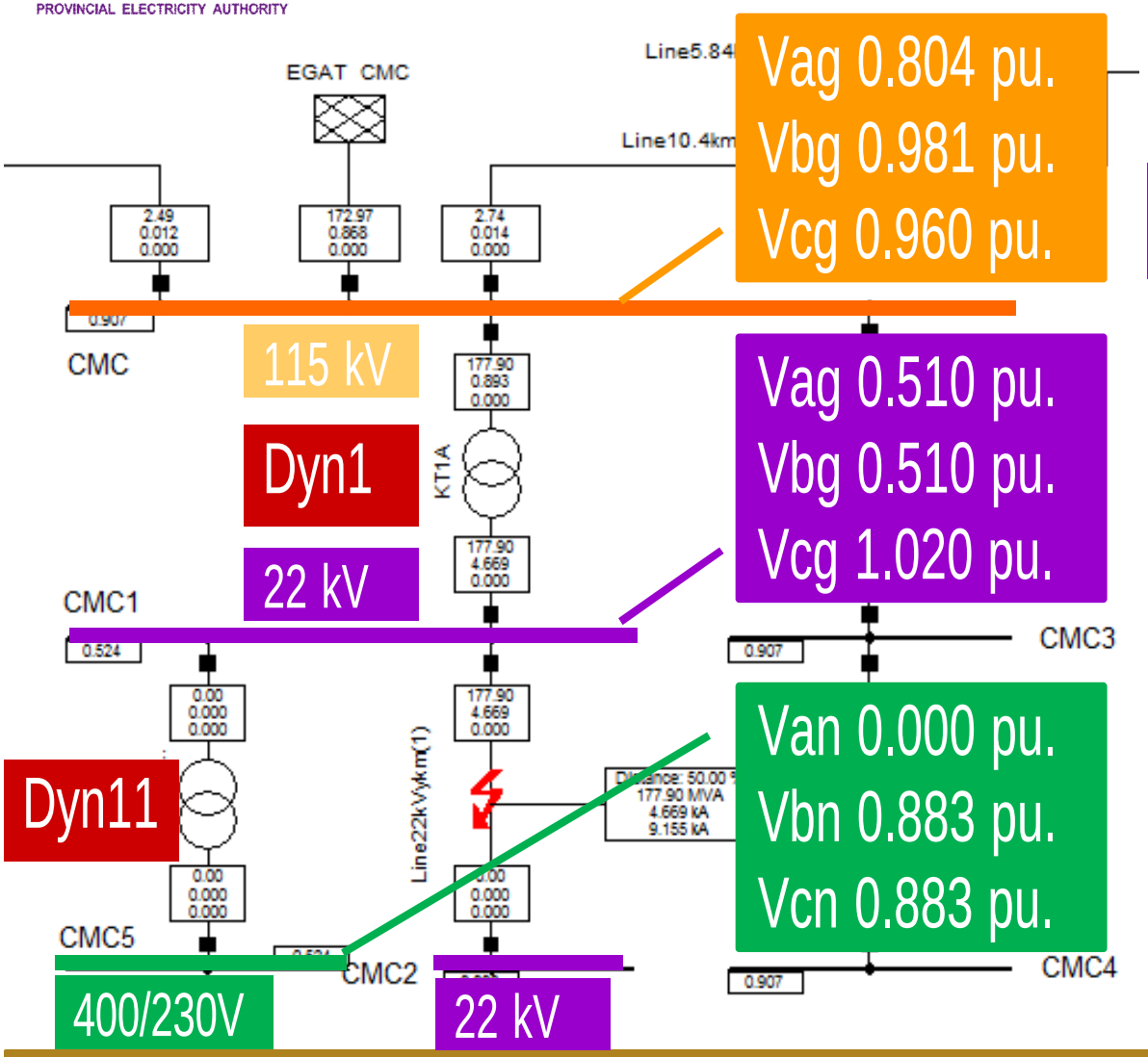
Determine AOV.



Vag 0.804 pu.
Vbg 0.981 pu.
Vcg 0.960 pu.

Vag 0.510 pu.
Vbg 0.510 pu.
Vcg 1.020 pu.

Van 0.000 pu.
Vbn 0.883 pu.
Vcn 0.883 pu.

Double line Fault

- *short circuit calculation at 22kV*
  A-B
- *affect customer 230 V side*
  phase A B and C
  phase A-N is the lowest value

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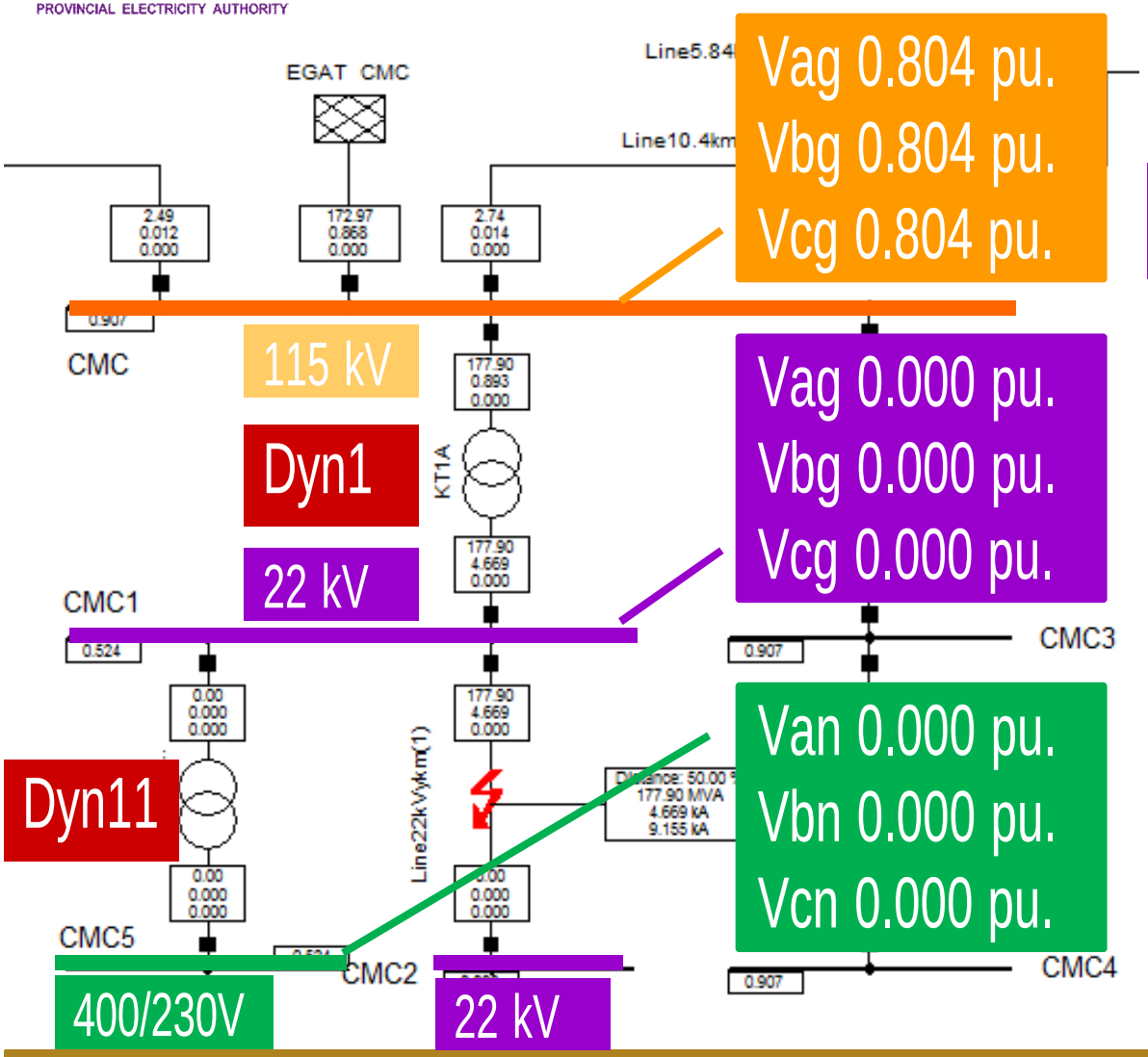
Determine AOV.



Three phase Fault

- *short circuit calculation at 22kV*
  ABC
- *affect customer 230 V side*
  phase A B and C

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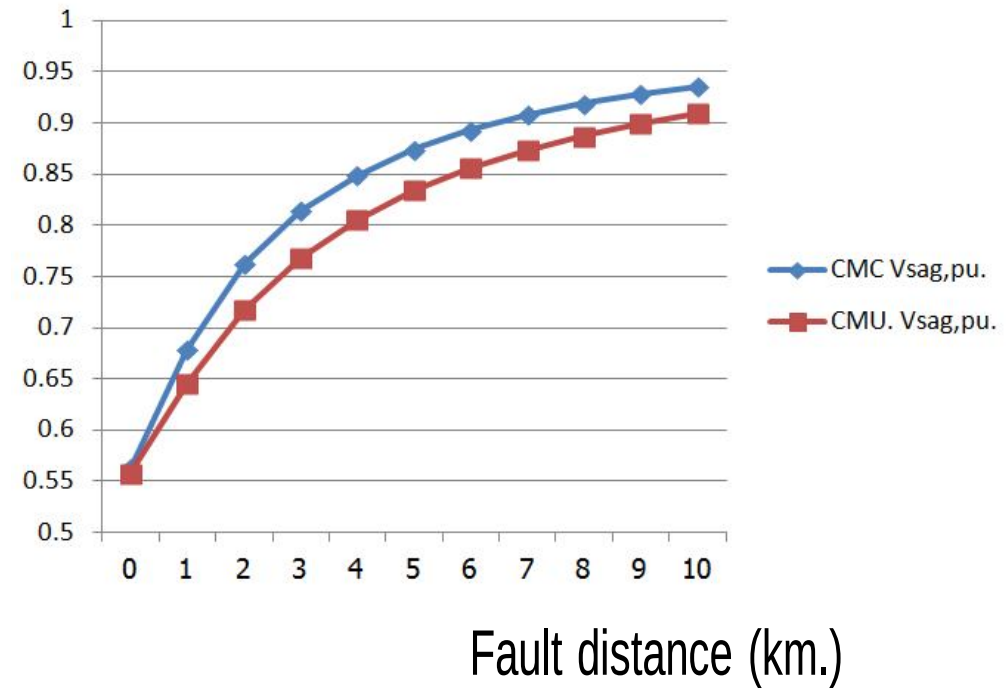
Voltage sag at low voltage customer side

Single line to ground Fault

fault distance km.	CMC Vsag,pu.	CMU. Vsag,pu.
0	0.563	0.558
1	0.679	0.645
2	0.762	0.717
3	0.814	0.768
4	0.849	0.806
5	0.874	0.834
6	0.893	0.856
7	0.908	0.873
8	0.919	0.887
9	0.928	0.899
10	0.936	0.909



At the same fault distance from substation: CMC Grid is stronger than CMU Grid. Voltage sag (customer side) at CMU is lower than CMC.

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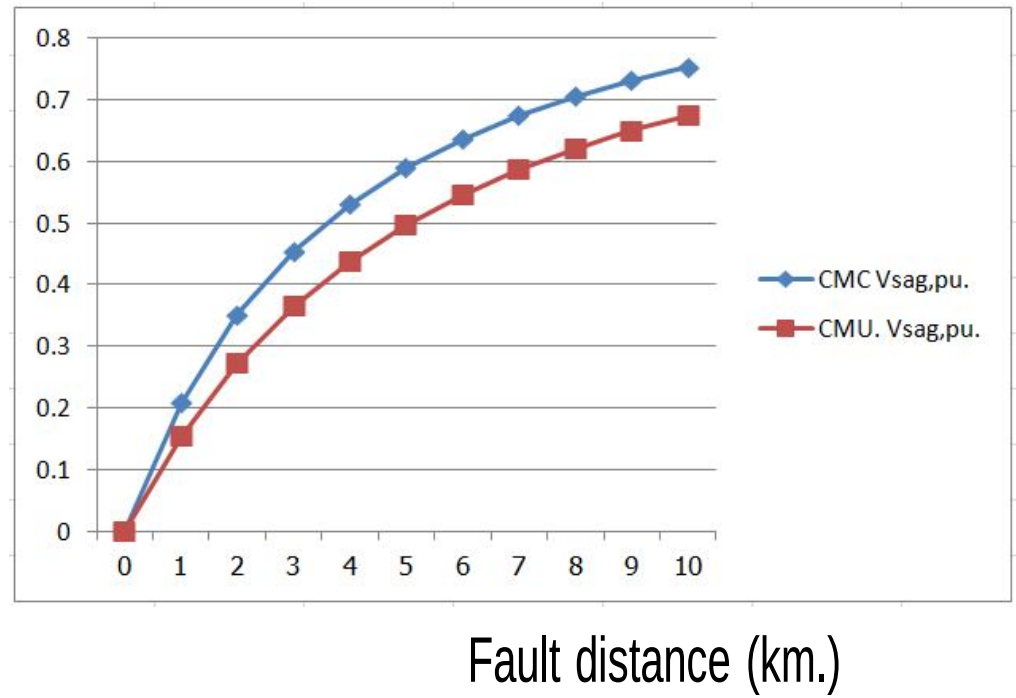
Voltage sag at low voltage customer side

PP-G, PP, 3P FAULT

fault distance km.	CMC Vsag,pu.	CMU. Vsag,pu.
0	0	0
1	0.208	0.155
2	0.351	0.273
3	0.454	0.365
4	0.531	0.438
5	0.589	0.497
6	0.636	0.545
7	0.674	0.586
8	0.705	0.62
9	0.731	0.65
10	0.753	0.675



At the same fault distance from substation: CMC Grid is stronger than CMU Grid. Voltage sag (customer side) at CMU is lower than CMC.

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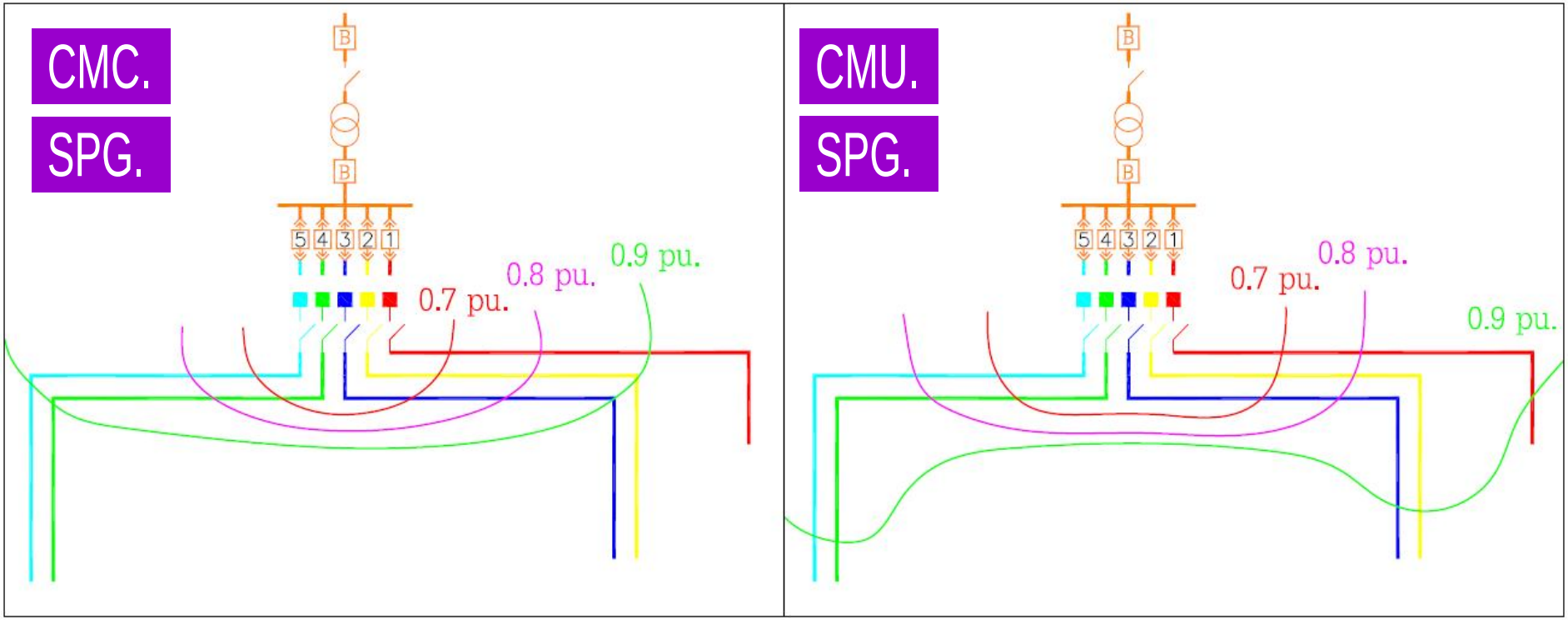
Area of Vulnerability for SPG fault



Vsag,pu.	CMC.		CMU.		delta AOV.	increasing %
	fault distance km.	AOV circuit-km.	fault distance km.	AOV circuit-km.		
0.70	1.2	6.00	1.8	9.00	3.00	50.00
0.80	2.7	13.50	3.8	19.00	5.50	40.74
0.90	6.6	33.00	9	45.00	12.00	36.36

Single line to ground Fault

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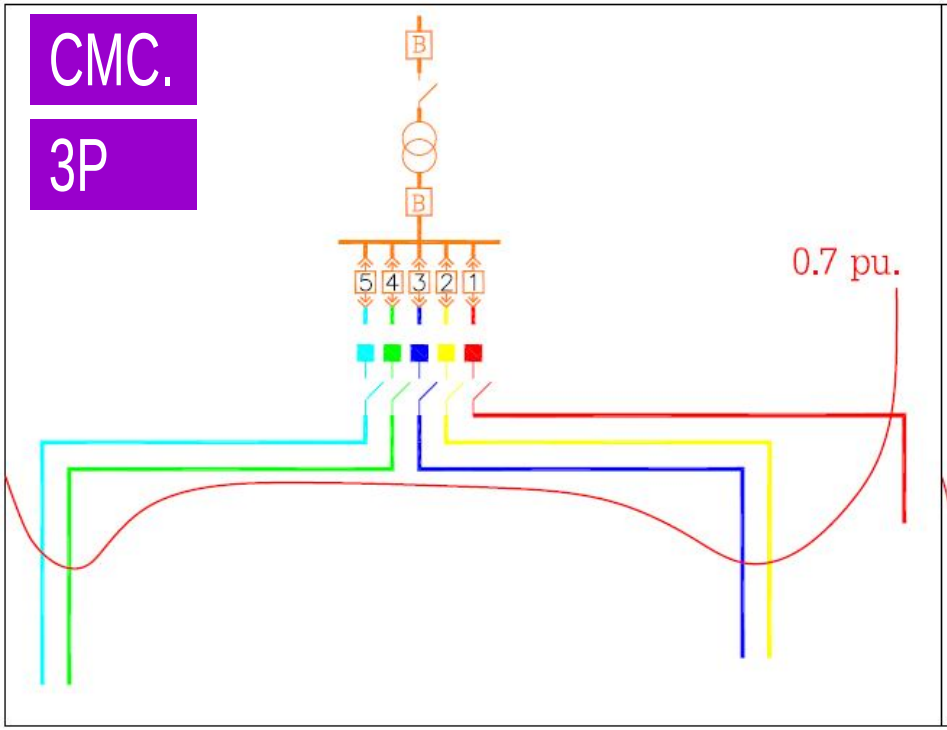
Area of Vulnerability for 3PG fault

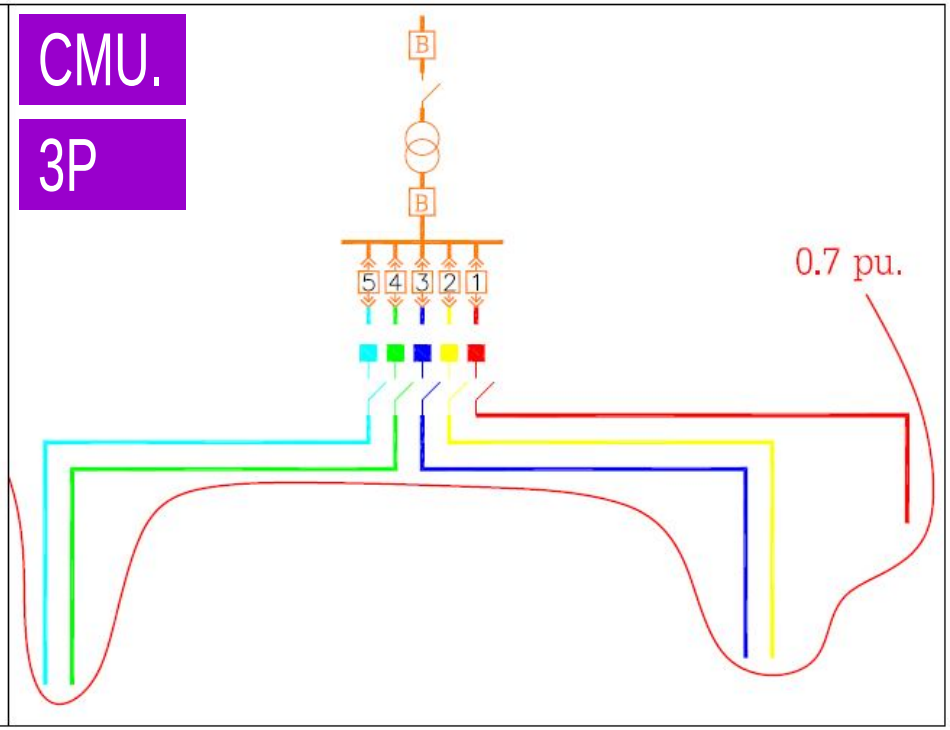
CMC.

3P



CMU.

3P



Vsag,pu.	CMC.		CMU.		delta AOV.	increasing %
	fault distance km.	AOV circuit-km.	fault distance km.	AOV circuit-km.		
0.70	7.8	39.00	10	50.00	11.00	28.21

3P Fault

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Number of Voltages Sag event

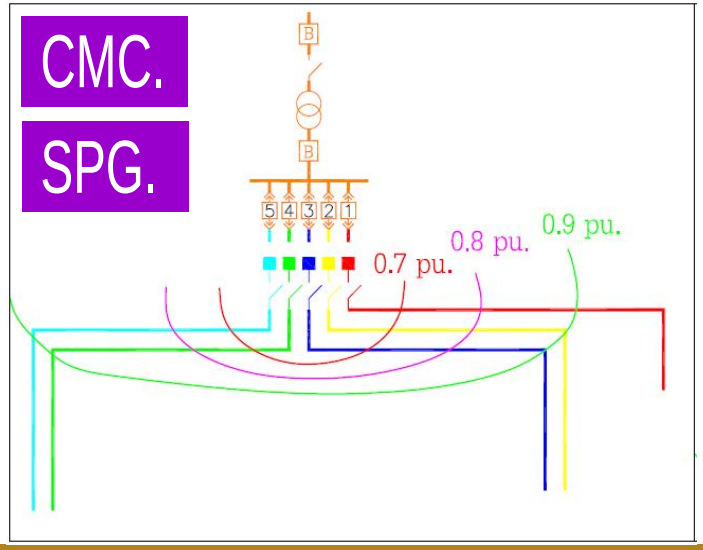
fault type	Prob.	Fault rate fault/year	total circuit-km. circuit-km.	LFP. fault/km./year	AOV. circuit-km.	NOS. events
SPG	0.65	39.98	50.00	0.7995	6	4.8
PPG	0.10	6.15	50.00	0.1230	39	4.8
PP	0.20	12.30	50.00	0.2460	39	9.6
3P	0.05	3.08	50.00	0.0615	39	2.4
total	1.00	61.50				21.6

61.50 fault/year

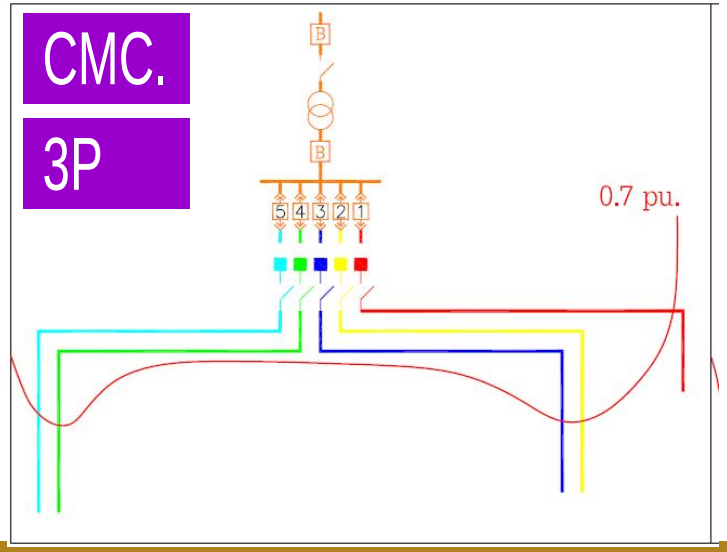
Sag ,impact to customer
21.6 event/year

35%

CMC.
SPG.



CMC.
3P



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Number of Voltages Sag event

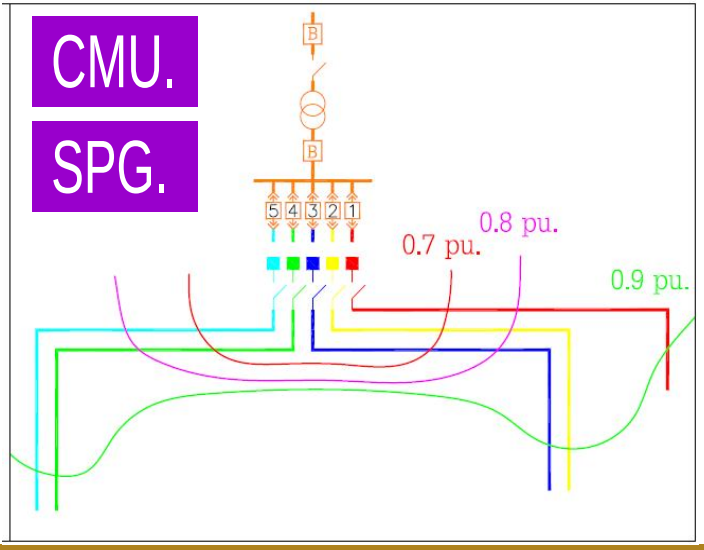
fault type	Prob.	Fault rate fault/year	total circuit-km. circuit-km.	LFP. fault/km./year	AOV. circuit-km.	NOS. events
SPG	0.65	23.40	50.00	0.4680	9	4.2
PPG	0.10	3.60	50.00	0.0720	50	3.6
PP	0.20	7.20	50.00	0.1440	50	7.2
3P	0.05	1.80	50.00	0.0360	50	1.8
total	1.00	36.00				16.8

36 fault/year

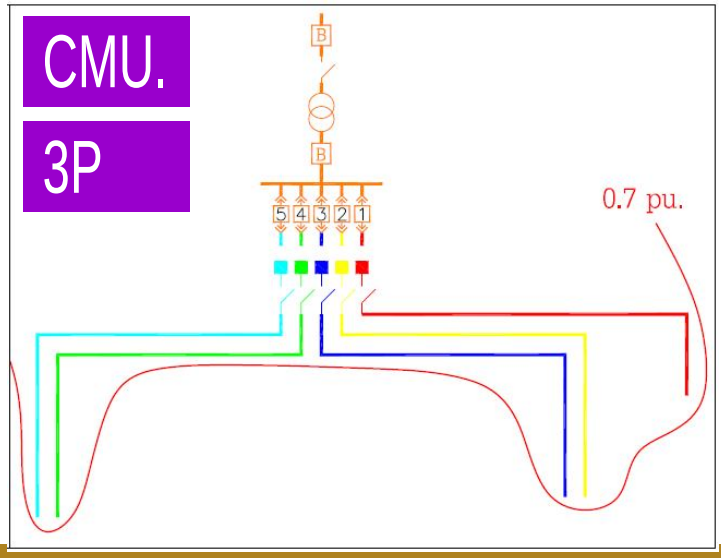
Sag ,impact to customer
16.8 event/year

46%

CMU.
SPG.



CMU.
3P



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Result

	unit	CMC	CMU
Fault Rate	fault/year	61.5	36
AOV. Vsag 0.7PU. SPG	km.-circuit	6	9
AOV. Vsag 0.7PU. PPG PP 3P	km.-circuit	39	50
Number of Sag	event/year	21.6	16.8

- ***CMU Substation (NEW) ; Fault Rate is less than old substation.***
- ***CMU Substation (NEW) ; AOV. is greater old substation.***
- ***CMU Substation (NEW) ; NOS. (number of sag that make low voltage equipment (customer side) stop or mul-function.) NOS. is less than old substation.***

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Conclusion

- *Number of Voltage Sag (NOS) is an easy parameter to predict number of sag that make low voltage equipment (customer side) stop or mul-function and easy for customer to understand*
- *Other power quality indices such as SARFIx and Reliability indices should be considered.*