23RD ANNUAL PQSYNERGY™ INTERNATIONAL CONFERENCE & EXHIBITION 2025

A VOLTAGE IMPROVEMENT STRATEGY TO MITIGATE TECHNICAL LOSSES AT THE 22 KV SAI YOK SUBSTATION

PRESENT BY

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PROVINCIAL ELECTRICITY AUTHORITY

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Introduction

This framework uses data analysis to resolve power quality issues from small power producers (SPP/VSPP).

The collaborative approach provides technical support, aiming to enhance grid reliability and stability through effective assessment and mitigation.

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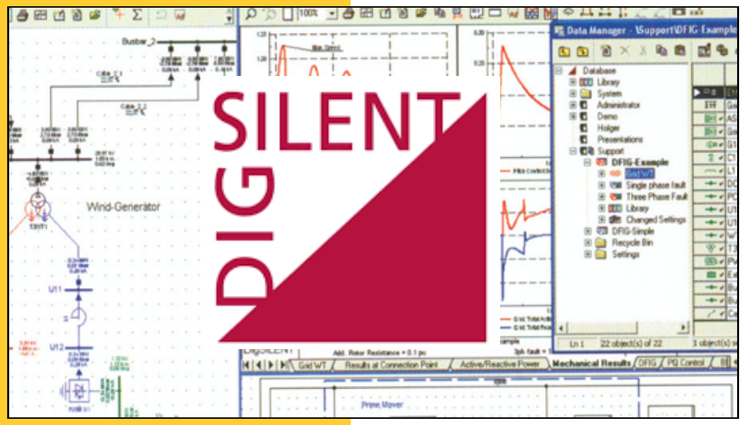
Electrical Engineering

Power Quality and Small Power Plant Division

AGENDA



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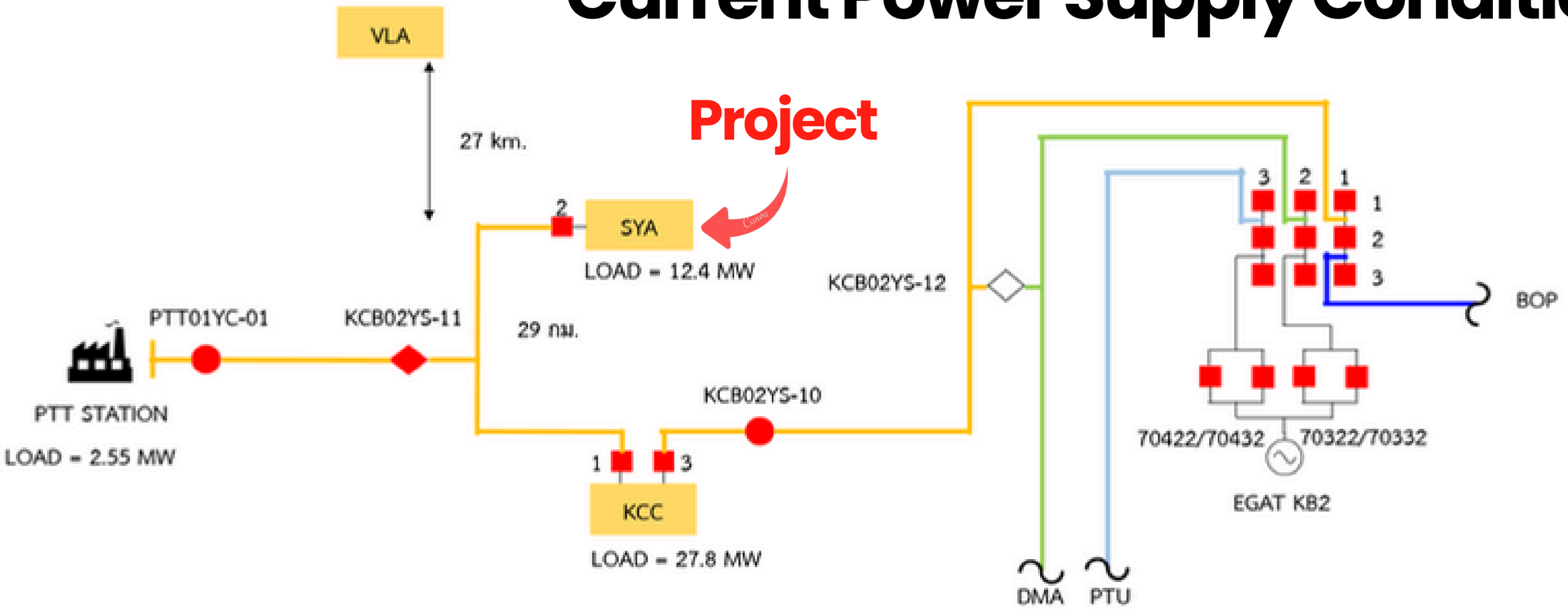
Overview of Power Supply at Sai Yok Substation

Current Power Supply Condition at 115 kV



VLA	115 /22 kV Substation "Vajiralongkorn Dam "
SYA	115 /22 kV Substation "Sai Yok"
KCC	115 /22 kV Substation "Kanchanaburi 3"

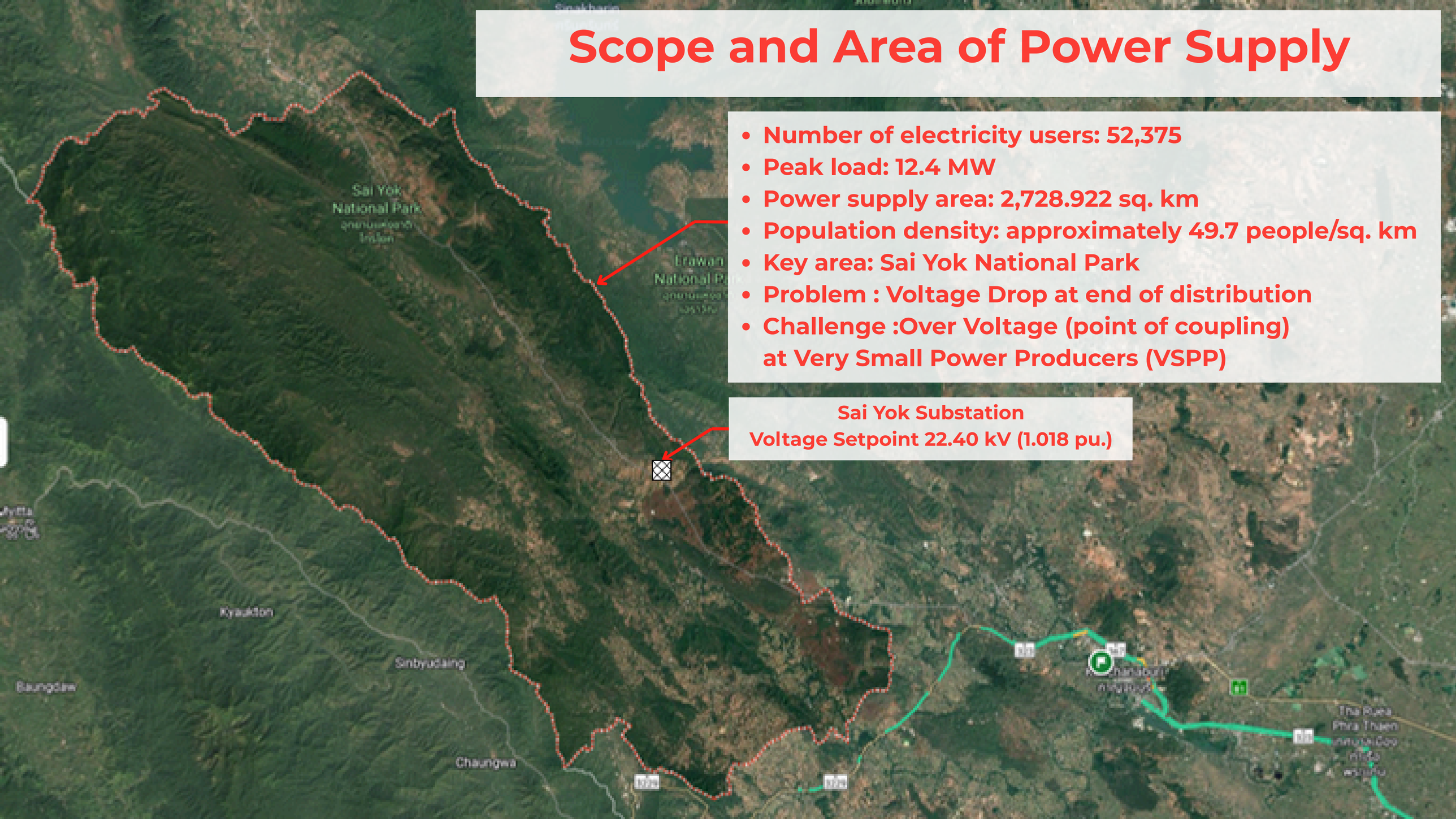
115 kV Substation "Customer"

115 kV Substation "Electricity Generating Authority of Thailand"

Consideration Conditions

- The load group of Sai Yok Substation consists of residential households and small-scale industrial facilities, which are suitable for operation.
- Sai Yok Substation is located in a remote area and supplies electricity over long distances, making it suitable for implementing voltage improvement

Scope and Area of Power Supply



- Number of electricity users: 52,375
- Peak load: 12.4 MW
- Power supply area: 2,728.922 sq. km
- Population density: approximately 49.7 people/sq. km
- Key area: Sai Yok National Park
- Problem : Voltage Drop at end of distribution
- Challenge :Over Voltage (point of coupling) at Very Small Power Producers (VSPP)

Sai Yok Substation
Voltage Setpoint 22.40 kV (1.018 pu.)

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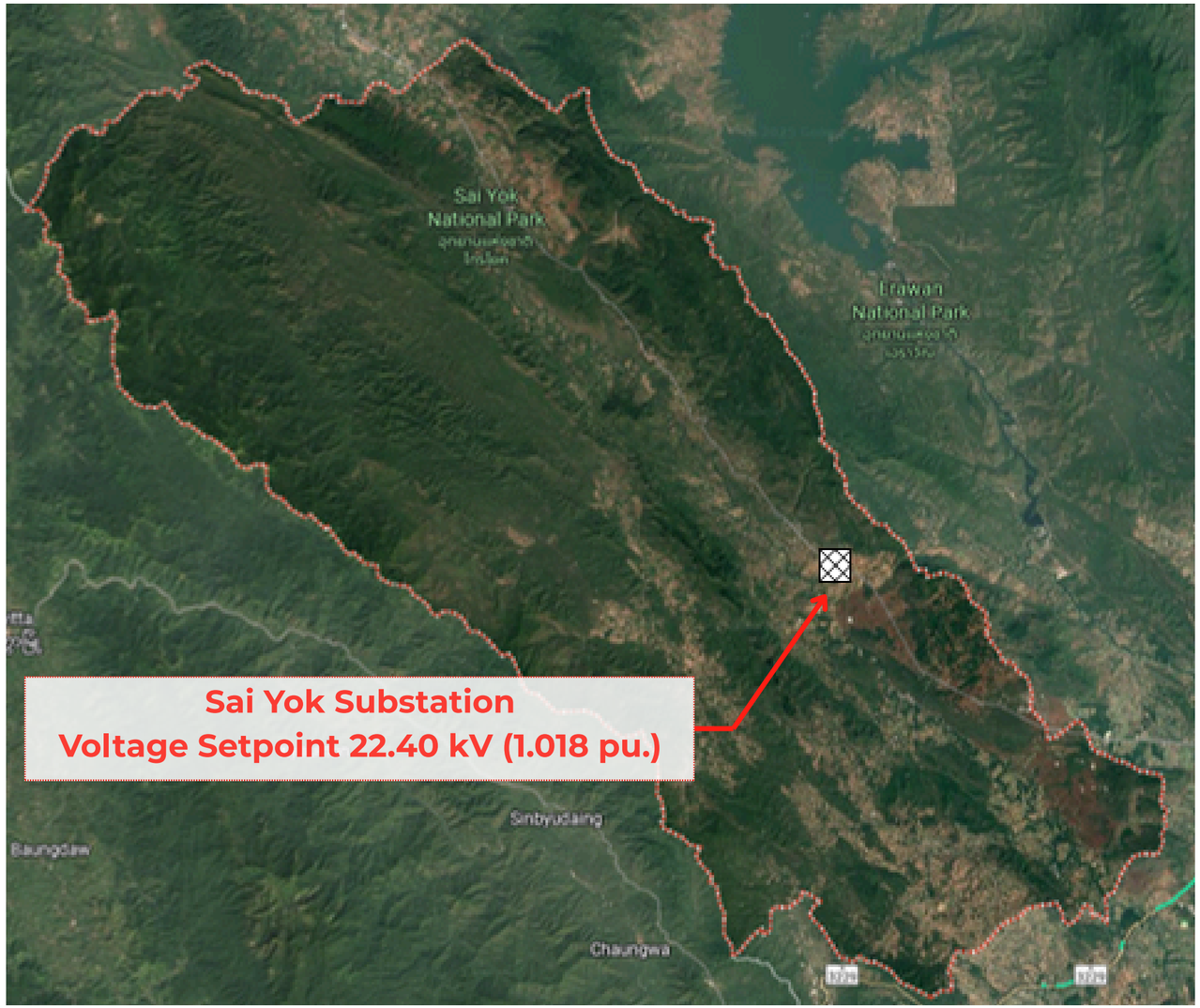
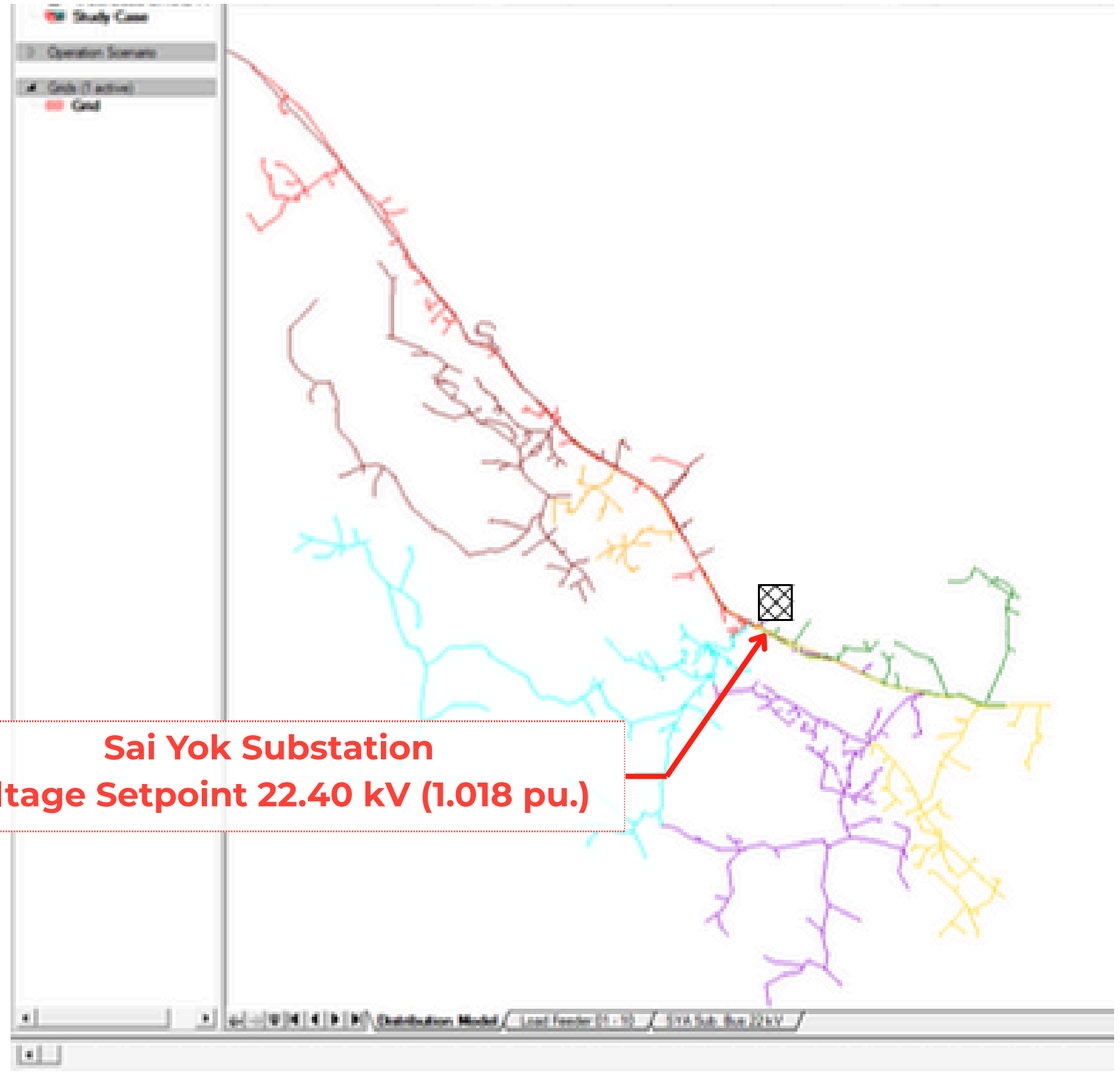
Analysis of Technical Losses Following the Voltage Improvement Plan and Simulation with Power factory Programing

Simulation with Power factory Programing

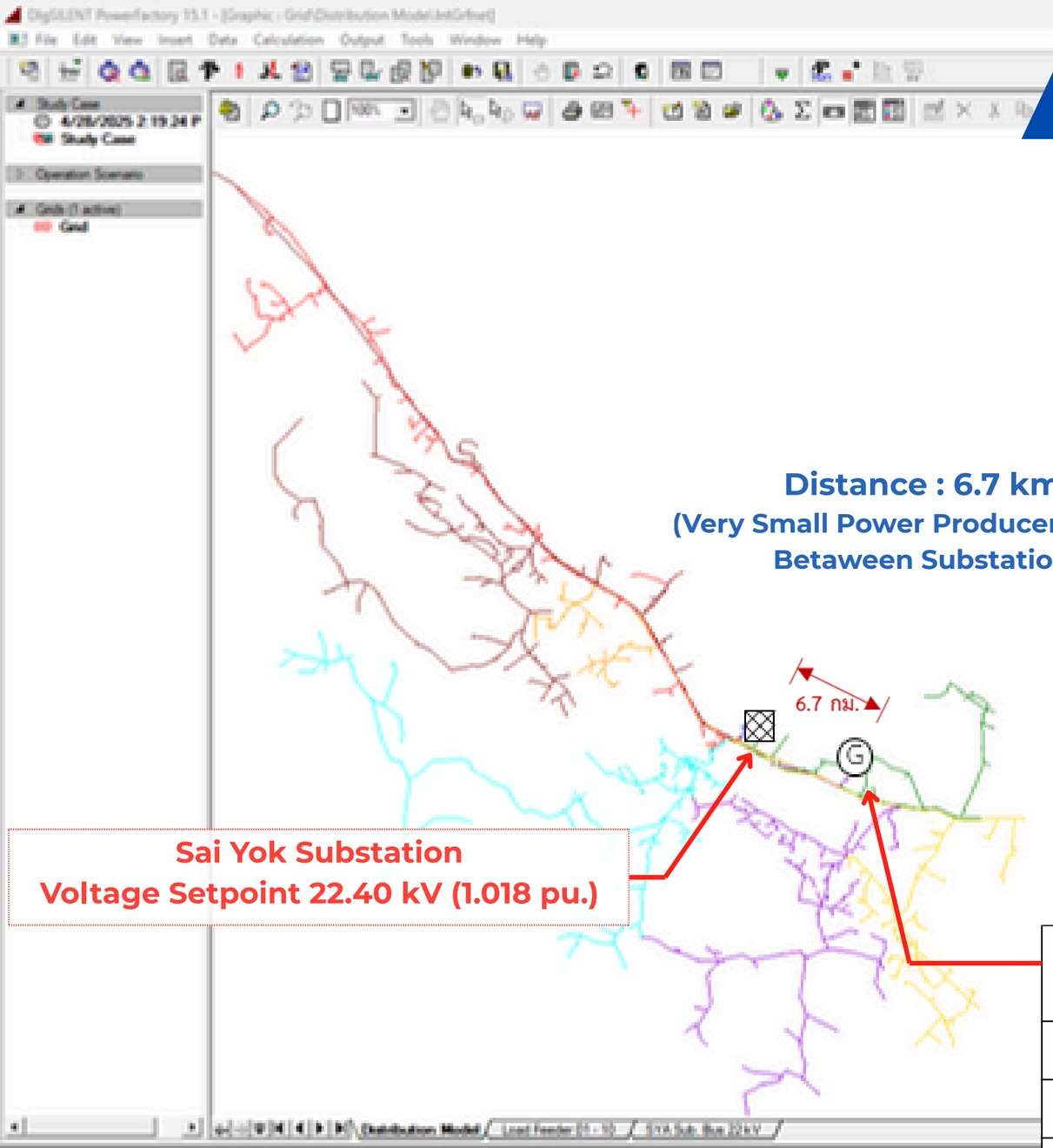
ArcGIS



Model in Programming



Model in Power factory Programing

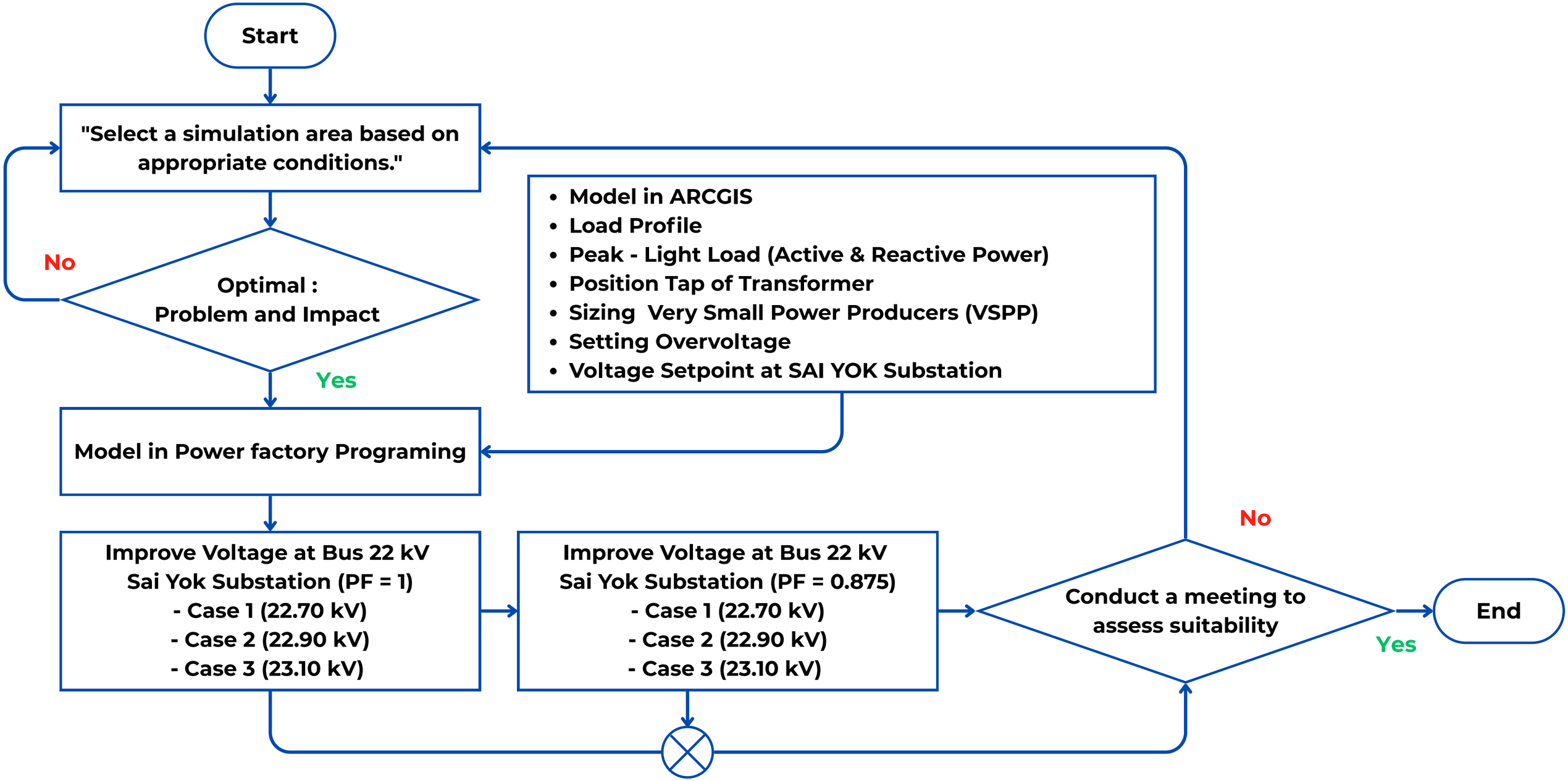


Feeder	Peak Load		Light Load	
	P (MW)	Q (MVAR)	P (MW)	Q (MVAR)
1	2.4	0.6	0.8	0.2
2	1.6	0.3	0.2	0.1
3	0.1	0.01	0.01	0
4	Out of Service			
5	3.0	0.6	1.5	0.4
6	1.4	0.2	0.01	0.00
7	0.3	0.03	0.1	0.01
8	Out of Service			
9	2.5	0.5	0.6	0.1
10	3.6	0.8	1.7	0.3

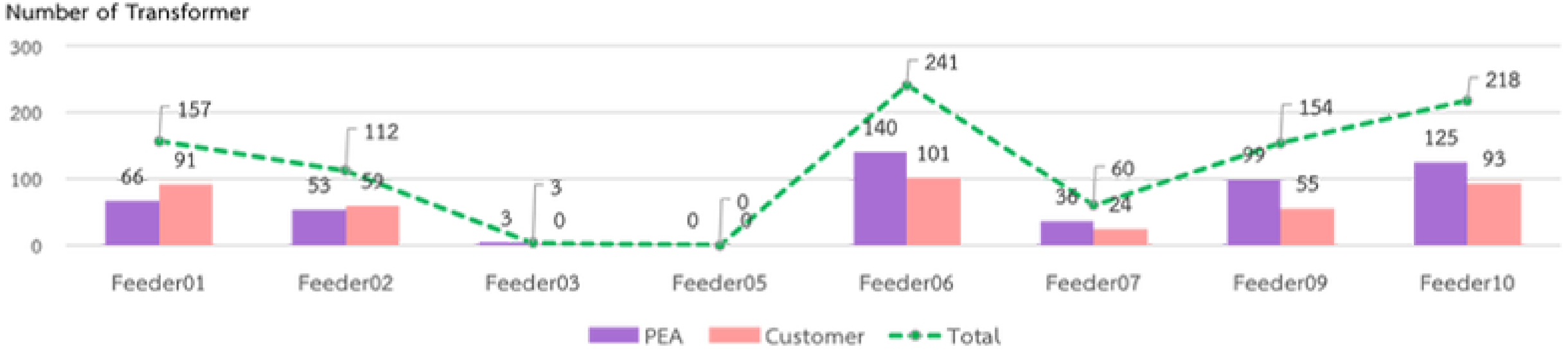
	Name	Type	Contract (MW)	Parallel Feeder
1	Conservation of Energy co.,ltd	Solar (PV)	6.00	Feeder02
2	Conservation of Energy co.,ltd	Solar (PV)	6.00	Feeder06
3	Conservation of Energy co.,ltd	Solar (PV)	6.00	Feeder09

Flow Chart Analysis

Model in Power factory Programing



Basic information (22 kV distribution transformer)

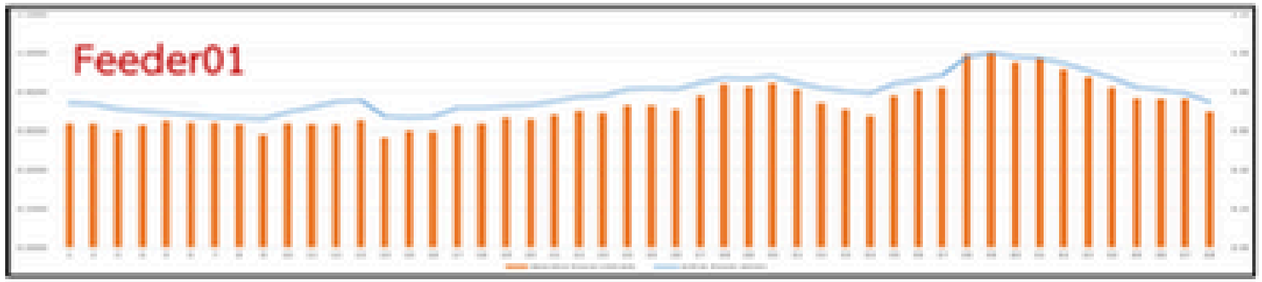


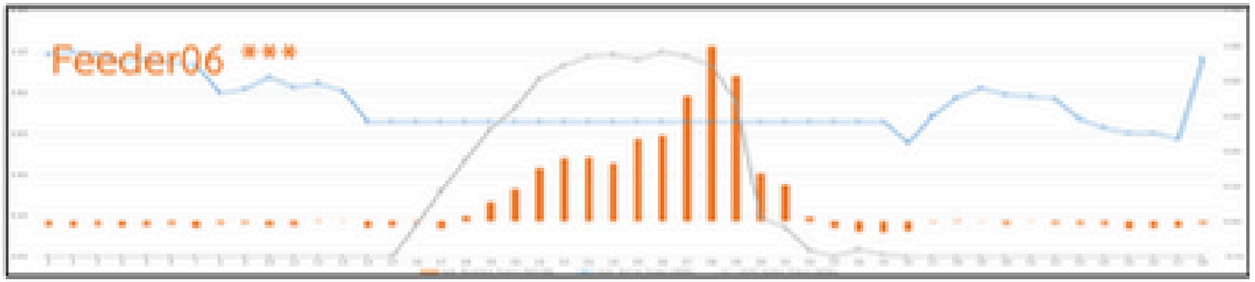
รหัส TAG	ระบบเฟส	PEANO	เฟสที่ติดตั้ง	ค่าพิกัด kVA หม้อแปลง	รูปแบบ Winding	เจ้าของหม้อแปลง	ค่าแหน่งการ TAP	ประเภทผู้ใช้ไฟ	สถานที่	รหัสสายป้อนที่ 1
33XFIA000123435	หม้อแปลง 3 Phase	41-006243	ABC	100 kVA	Dyn11 (Default)	Customer	Tap 3	อื่นๆ	ค่ายฝึกไทรโยค	DMA06
33XFIA000171826	หม้อแปลง 1 Phase	67-108495	AB	30 kVA	Don't Apply	Customer	Tap 3	อื่นๆ	CUS.TR.แขวงทางหลวงกาญจนบุรี กรมทางหลวง จุดที่10 โค	DMA06
33XFIA000011537	หม้อแปลง 3 Phase	21-003737	ABC	250 kVA	Dyn11 (Default)	Customer	Tap 3	อุตสาหกรรม	โรงเลื่อยจักรป่าไม้พัฒน์ ต.ท่าเสา	SYA01
3371XF000006924	หม้อแปลง 1 Phase	22-002541	BC	10 kVA	Don't Apply	PEA	Tap 3	ที่อยู่อาศัย	DCC_บ.พุดระเดียน	SYA01
3371XF000007143	หม้อแปลง 3 Phase	22-003538	ABC	50 kVA	Dyn11 (Default)	Customer	Tap 3	อื่นๆ	ที่ทำการหมวดการทางไทรโยค	SYA01
33XFIA000011535	หม้อแปลง 3 Phase	22-004829	ABC	250 kVA	Dyn11 (Default)	Customer	Tap 3	อุตสาหกรรม	โรงแรมหมู่บ้านแม่น้ำแคว ต.ท่าเสา ไทรโยค	SYA01
33XFIA000013523	หม้อแปลง 3 Phase	24-006110	ABC	100 kVA	Dyn11 (Default)	Customer	Tap 3	อื่นๆ	กกส.สทพ.นทพ.(1) ต.ท่าเสา อ.ไทรโยค	SYA01
3371XF000007146	หม้อแปลง 3 Phase	25-001079	ABC	50 kVA	Dyn11 (Default)	Customer	Tap 3	ธุรกิจ	นายประสิทธิ์ มณีกาญจน์ ปั๊มไทรโยคน้อย	SYA01
33XFIA000166873	หม้อแปลง 1 Phase	28-003990	CA	20 kVA	Don't Apply	PEA	Tap 3	ที่อยู่อาศัย	ปากทางวังใหญ่ ต.ท่าเสา	SYA01
3371XF000007042	หม้อแปลง 1 Phase	28-006169	CA	20 kVA	Don't Apply	PEA	Tap 3	ที่อยู่อาศัย	DCC_บ้านหนองตามัวง ม.10 ต.ท่าเสา	SYA01
3371XF000006898	หม้อแปลง 1 Phase	28-010804	CA	10 kVA	Don't Apply	PEA	Tap 3	ที่อยู่อาศัย	DCC_หน้า รร.บ้านหาดงิ้ว อ.ไทรโยค	SYA01
3371XF000007029	หม้อแปลง 1 Phase	28-011849	CA	30 kVA	Don't Apply	PEA	Tap 3	ที่อยู่อาศัย	DCC_หน้าวัดพุทธิวิมุต ต.ท่าเสา	SYA01
33XFIA000056280	หม้อแปลง 1 Phase	29-004158	BC	30 kVA	Don't Apply	PEA	Tap 3	ที่อยู่อาศัย	DCC_บ้านเขาโทน ม.3 ต.ท่าเสา อ.ไทรโยค	SYA01
3371XF000007276	หม้อแปลง 3 Phase	29-015408	ABC	50 kVA	Dyn11 (Default)	Customer	Tap 3	ธุรกิจ	บ้านไร่ไทรโยค บ้านพุเตย ต.ท่าเสา อ.ไทรโยค	SYA01
33XFHA000054685	หม้อแปลง 1 Phase	33-001287	CA	20 kVA	Don't Apply	PEA	Tap 3	ที่อยู่อาศัย	หน้าวัดหาดงิ้ว	SYA01
33XFIA000011534	หม้อแปลง 3 Phase	33-005521	ABC	500 kVA	Dyn11 (Default)	Customer	Tap 3	อุตสาหกรรม	โรงแรมหมู่บ้านแม่น้ำแคว ต.ท่าเสา ไทรโยค	SYA01
3371XF000006917	หม้อแปลง 1 Phase	34-000966	AB	20 kVA	Don't Apply	Customer	Tap 3	อื่นๆ	สำนักกรมป่าไม้ ต.ท่าเสา อ.ไทรโยค	SYA01
3371XF000006938	หม้อแปลง 3 Phase	34-004316	ABC	50 kVA	Dyn11 (Default)	Customer	Tap 3	ธุรกิจ	ธนาคารกรุงไทย ต.ท่าเสา อ.ไทรโยค	SYA01
33XFHA000047808	หม้อแปลง 3 Phase	34-005749	ABC	100 kVA	Dyn11 (Default)	Customer	Tap 3	อื่นๆ	กองการเกษตรและสหกรณ์หน่วยทหารพัฒนา	SYA01
3371XF000006929	หม้อแปลง 1 Phase	34-009813	BC	30 kVA	Don't Apply	Customer	Tap 3	ธุรกิจ	ที่พักผ่อนนายบุญเลิศ ต.ท่าเสา .ไทรโยค	SYA01
3371XF000006942	หม้อแปลง 3 Phase	35-001199	ABC	50 kVA	Dyn11 (Default)	Customer	Tap 3	ธุรกิจ	บ้านพักพนักงานโรงแรมหมู่บ้านแม่น้ำแคว อ.ไทรโยค	SYA01
33XFIA000144768	หม้อแปลง 1 Phase	35-005522	BC	30 kVA	Don't Apply	PEA	Tap 3	ที่อยู่อาศัย	บ้านเขาโทนบน ต.ท่าเสา	SYA01
3371XF000006914	หม้อแปลง 3 Phase	35-015719	ABC	50 kVA	Dyn11 (Default)	Customer	Tap 3	ธุรกิจ	สถานีโทรคมนาคมเขาวังเขมร ต.ท่าเสา ไทรโยค	SYA01

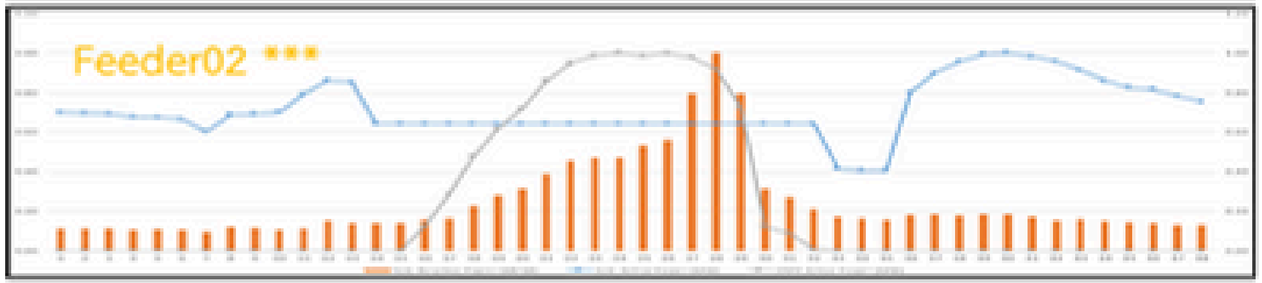
Total number of transformers in the area Sai Yok Power Station:

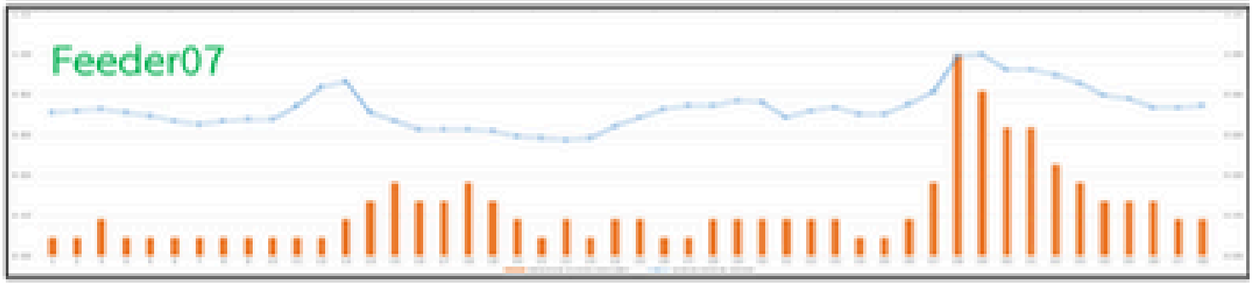
945 units

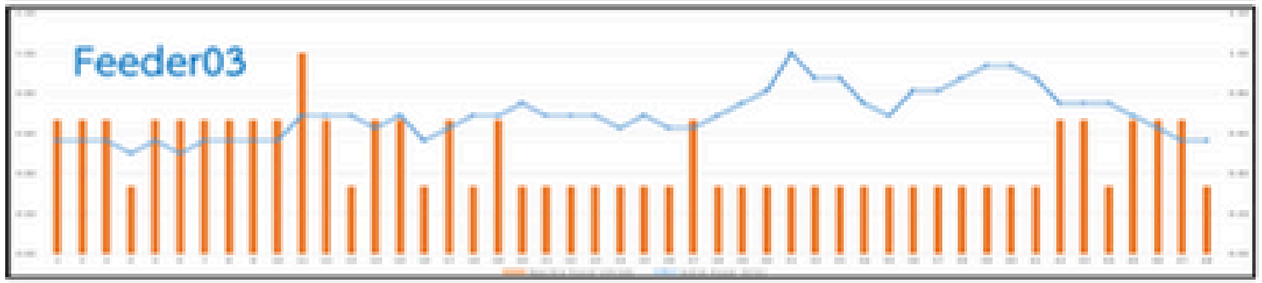
Basic information
(Peak - Light Load, Period : Year)

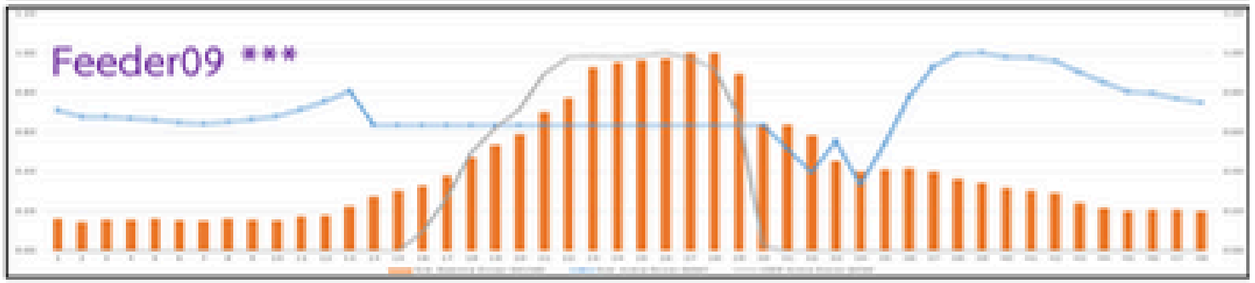


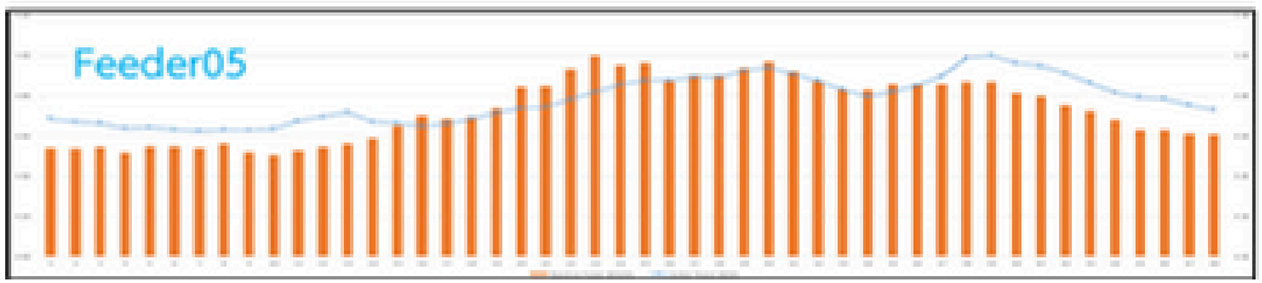


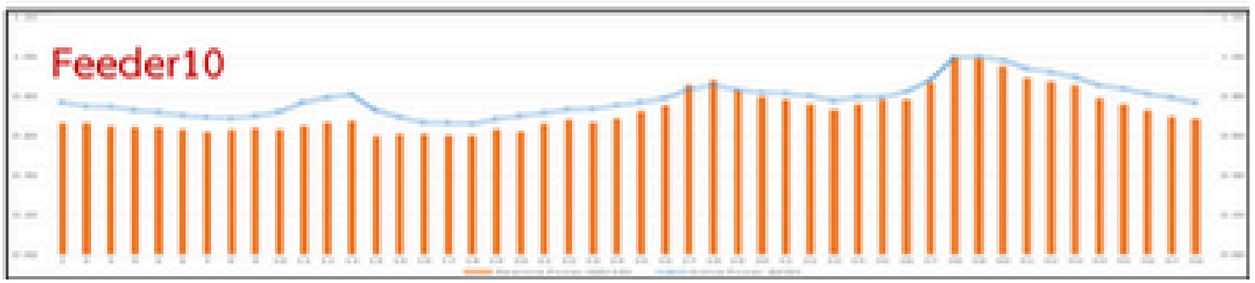




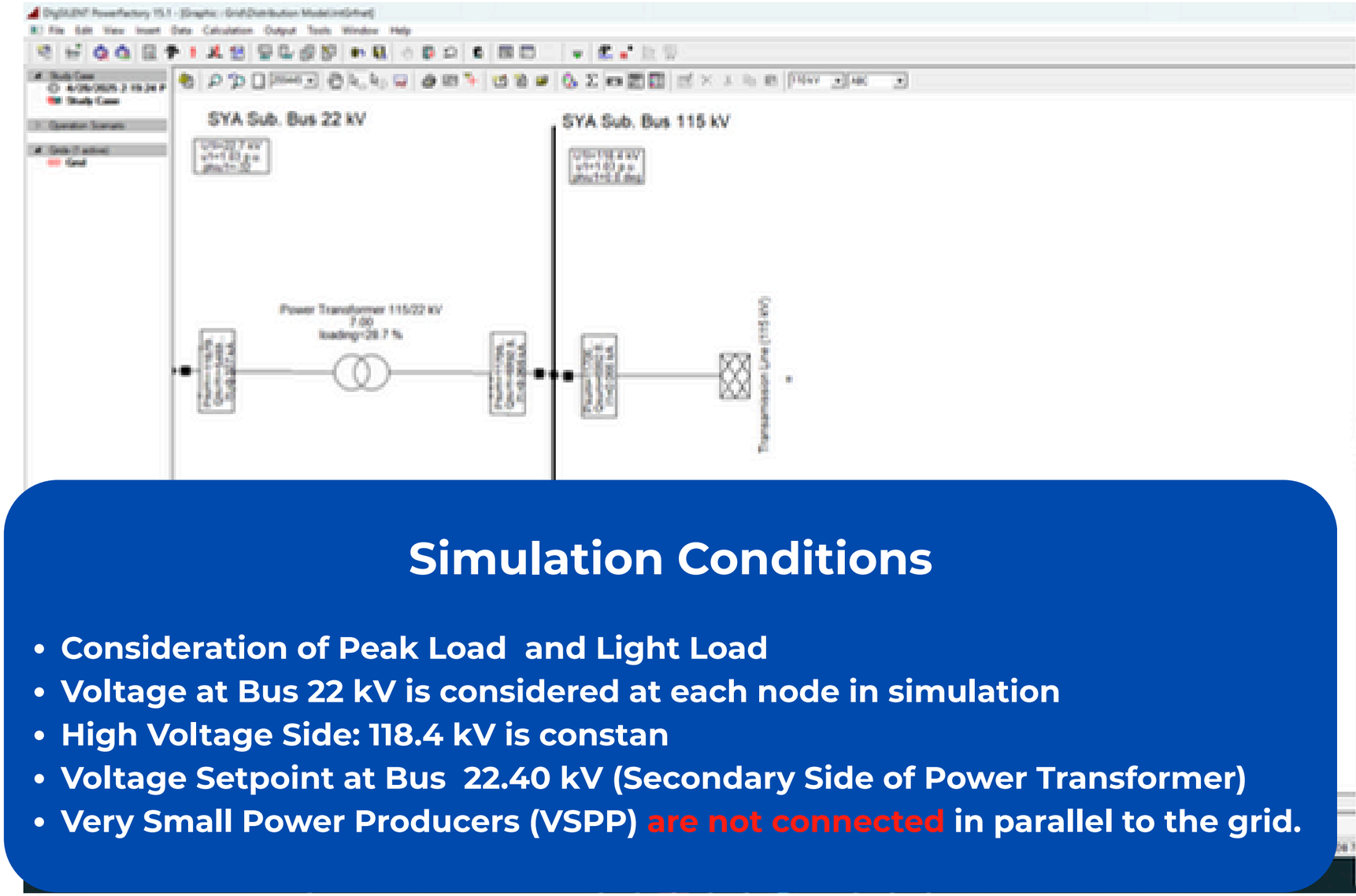


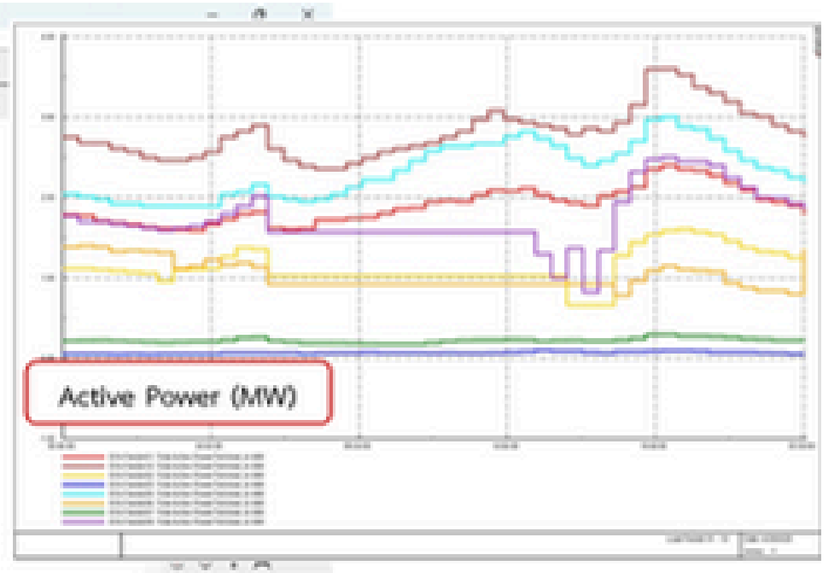


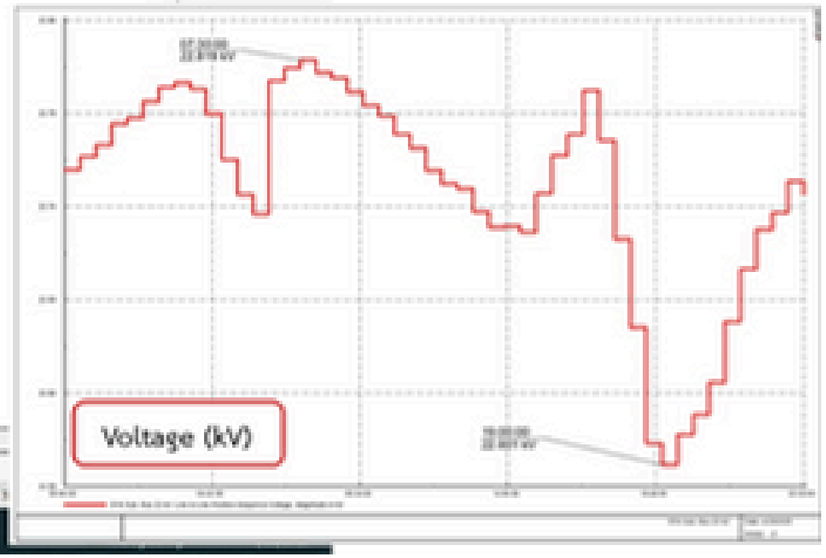




Simulation with Power factory



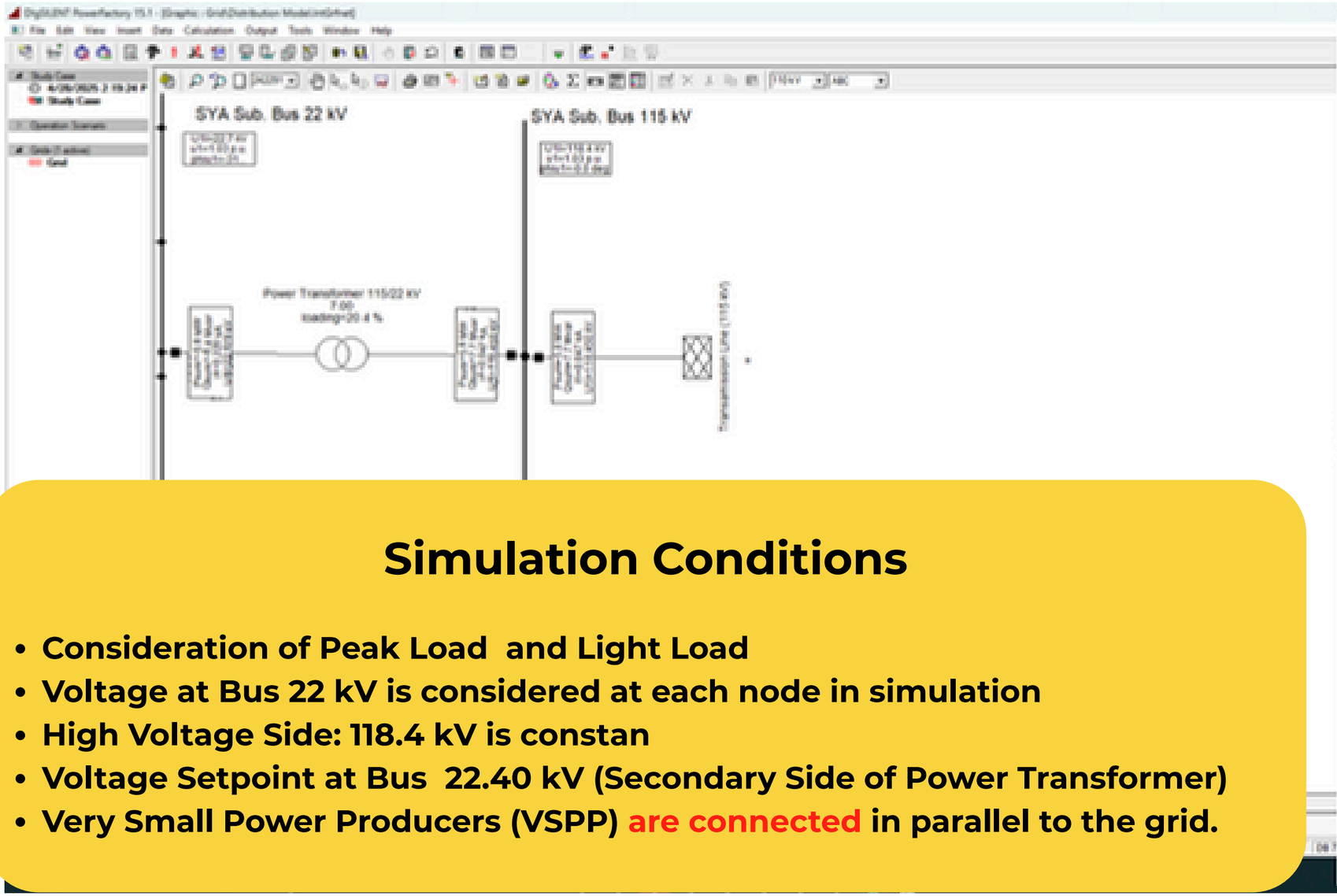


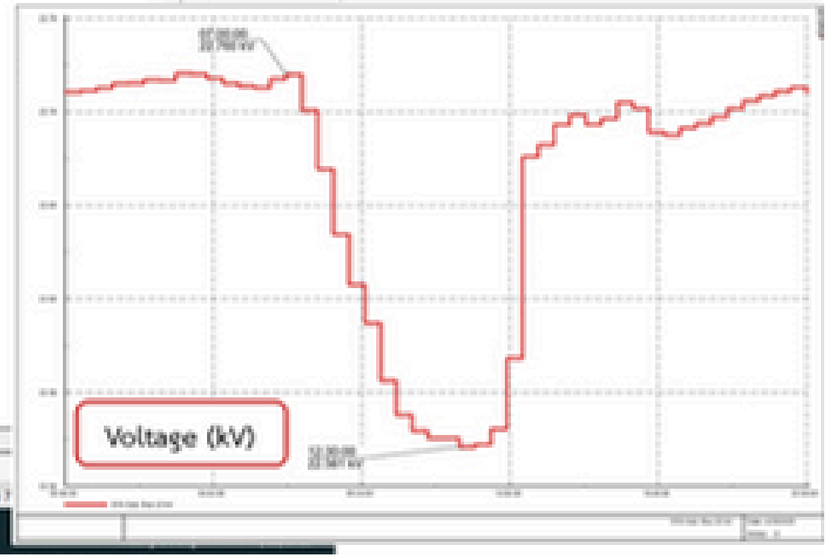


Simulation Conditions

- Consideration of Peak Load and Light Load
- Voltage at Bus 22 kV is considered at each node in simulation
- High Voltage Side: 118.4 kV is constan
- Voltage Setpoint at Bus 22.40 kV (Secondary Side of Power Transformer)
- Very Small Power Producers (VSPP) are not connected in parallel to the grid.

Simulation with Power factory





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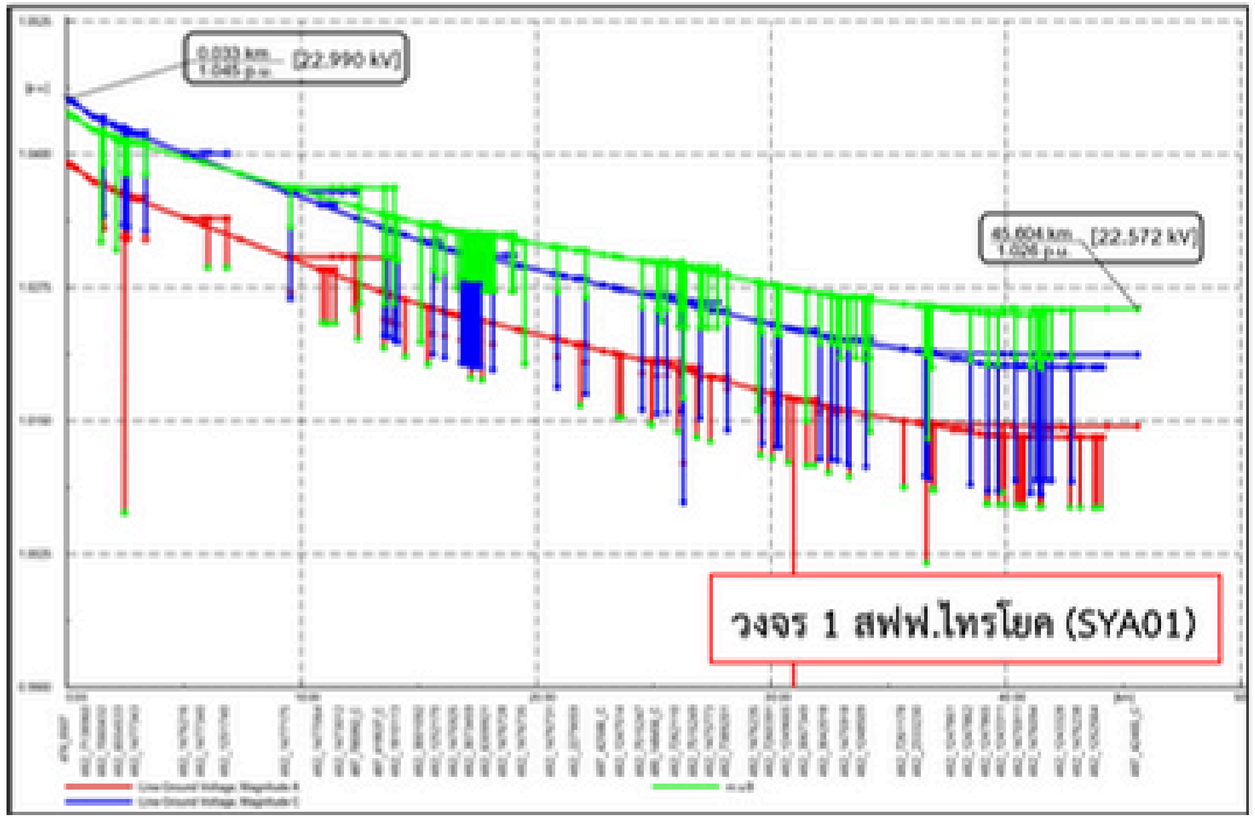
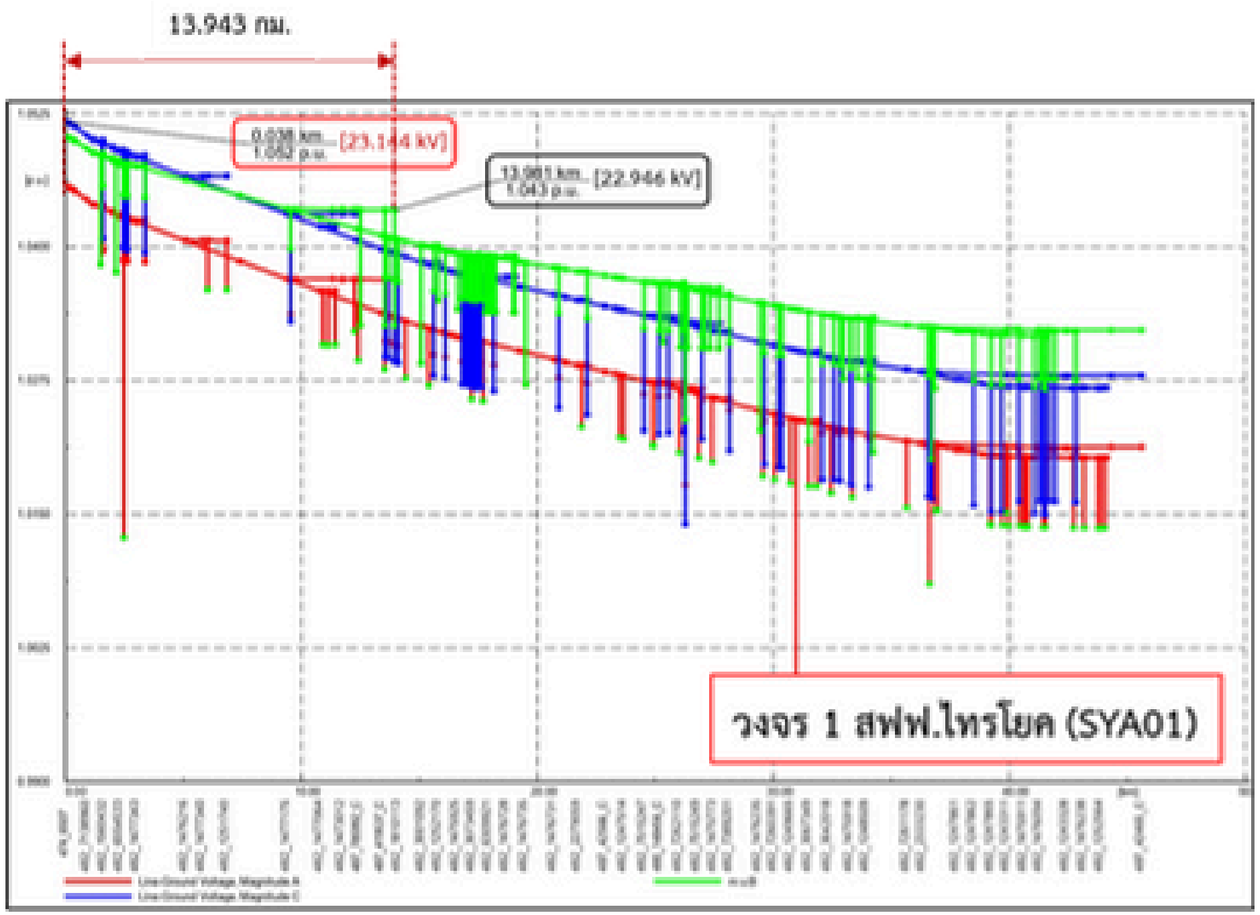
- Very Small Power Producers (VSPP) are connected in parallel to the grid.

Feeder01 Sai Yok Substation

Result of Simulation with Power factory



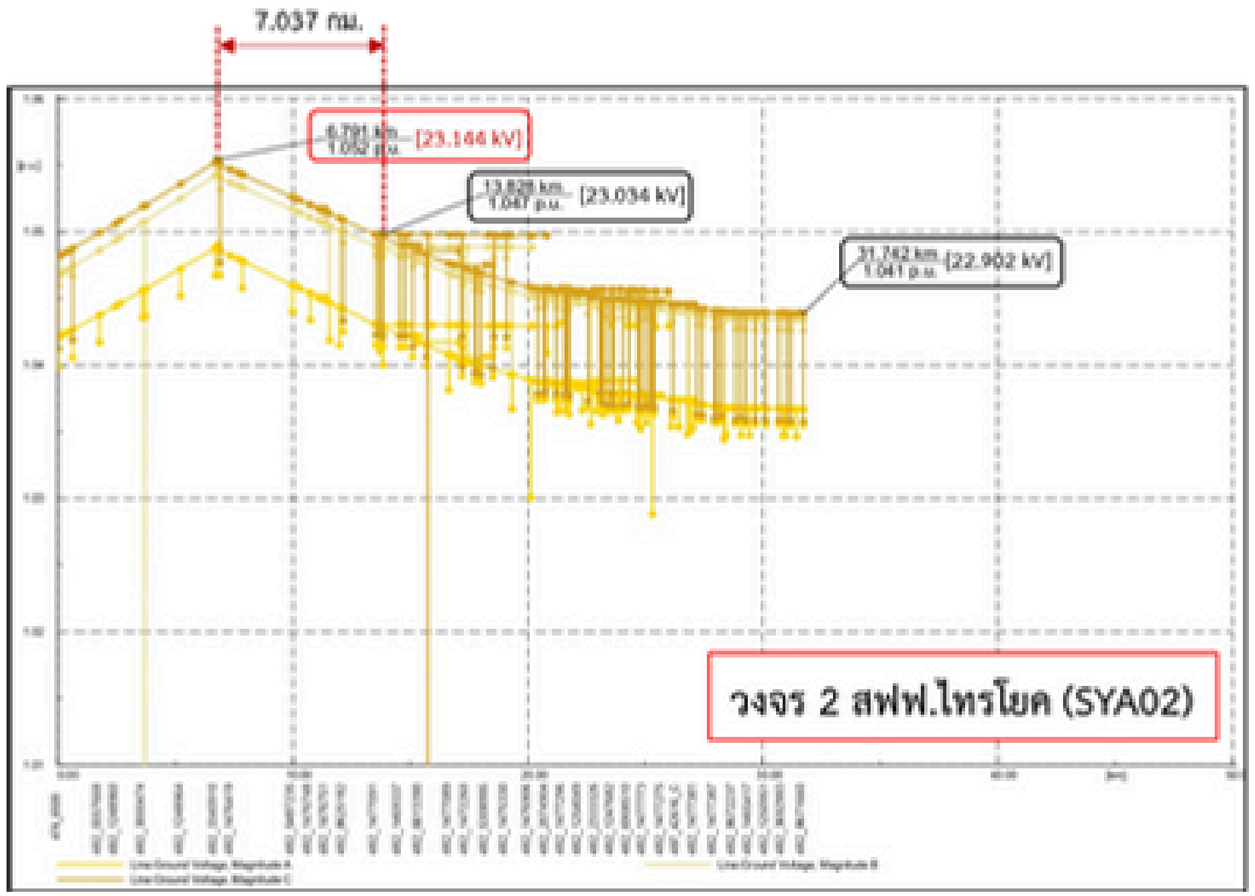


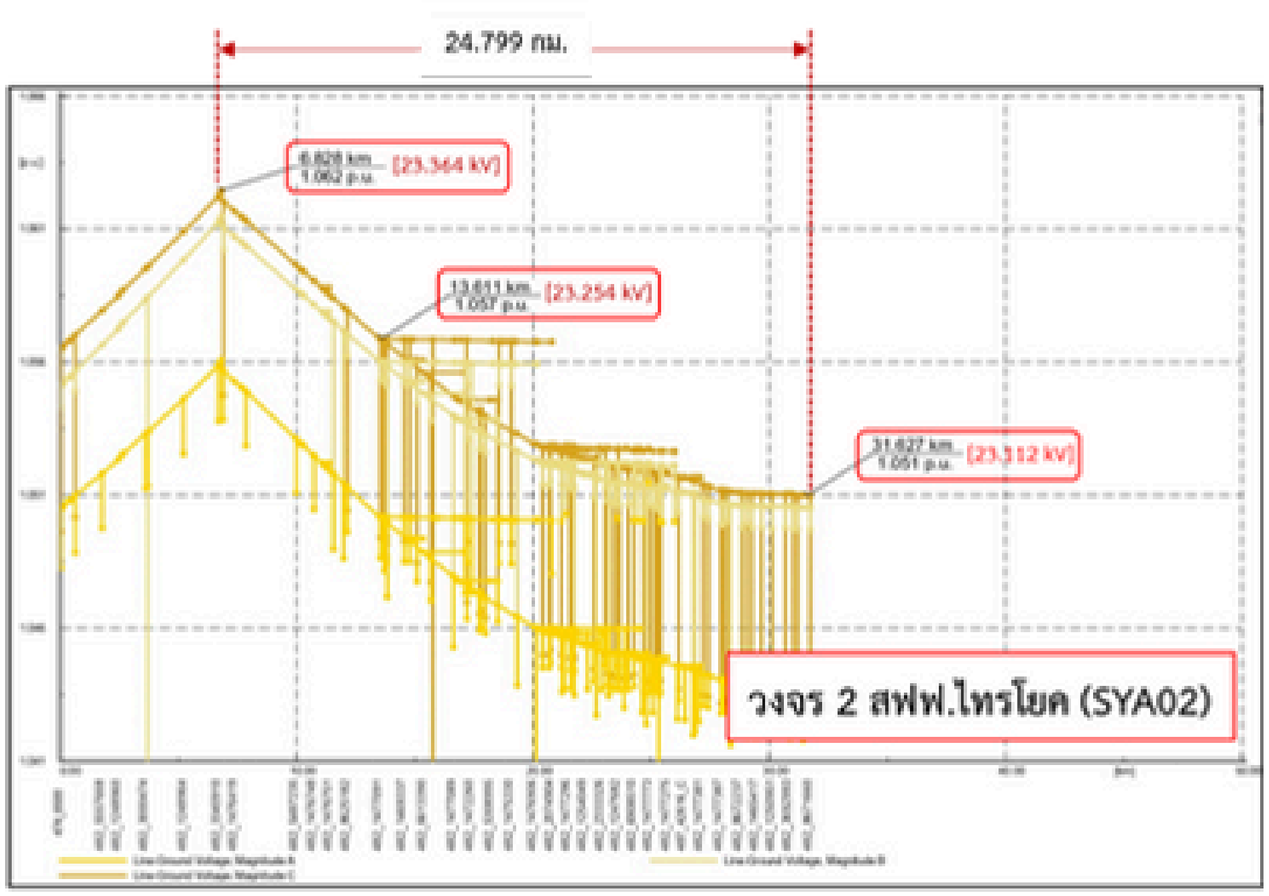
At 22.90 kV, the power transformer is not affected in terms of voltage.

The 23.10 kV voltage level of the transformer is affected by the voltage conditions, with a distance of approximately 13.943 km from the Very Small Power Producer (VSPP)

Result of Simulation with Power factory

Feeder02 Sai Yok Substation



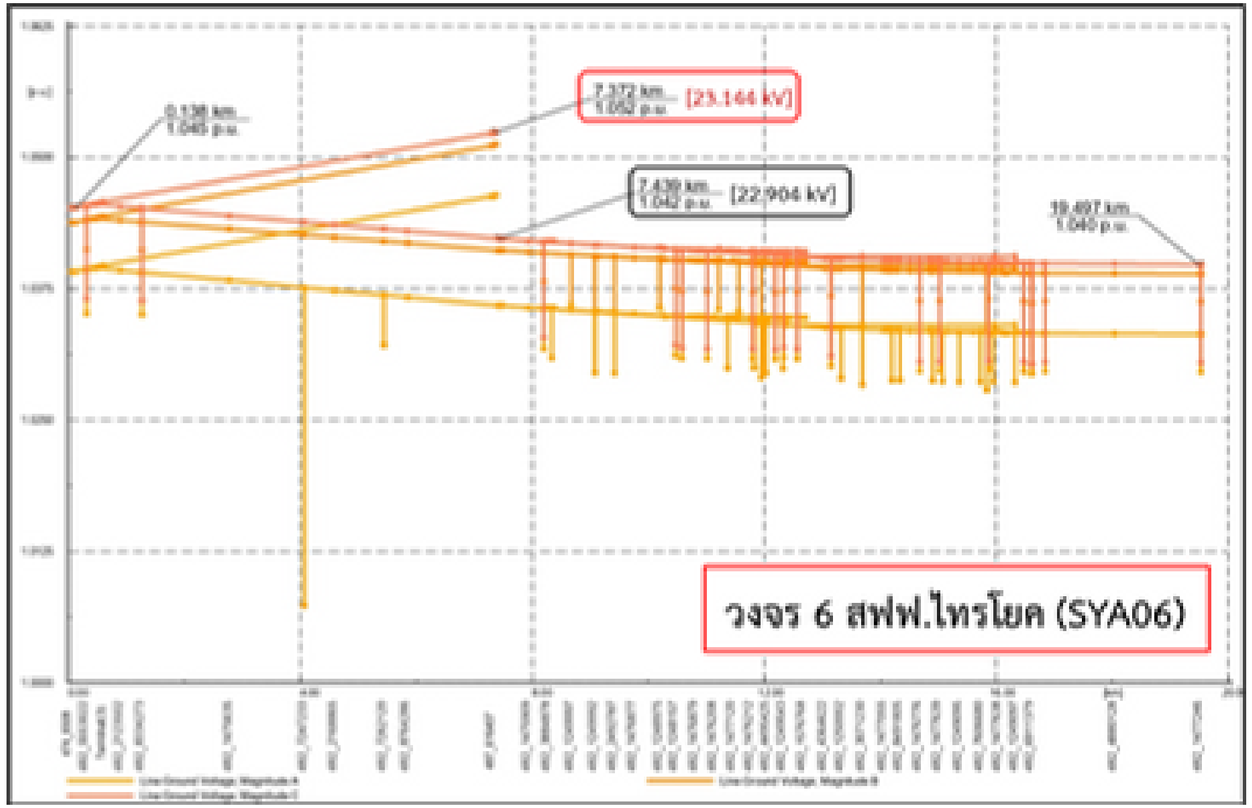


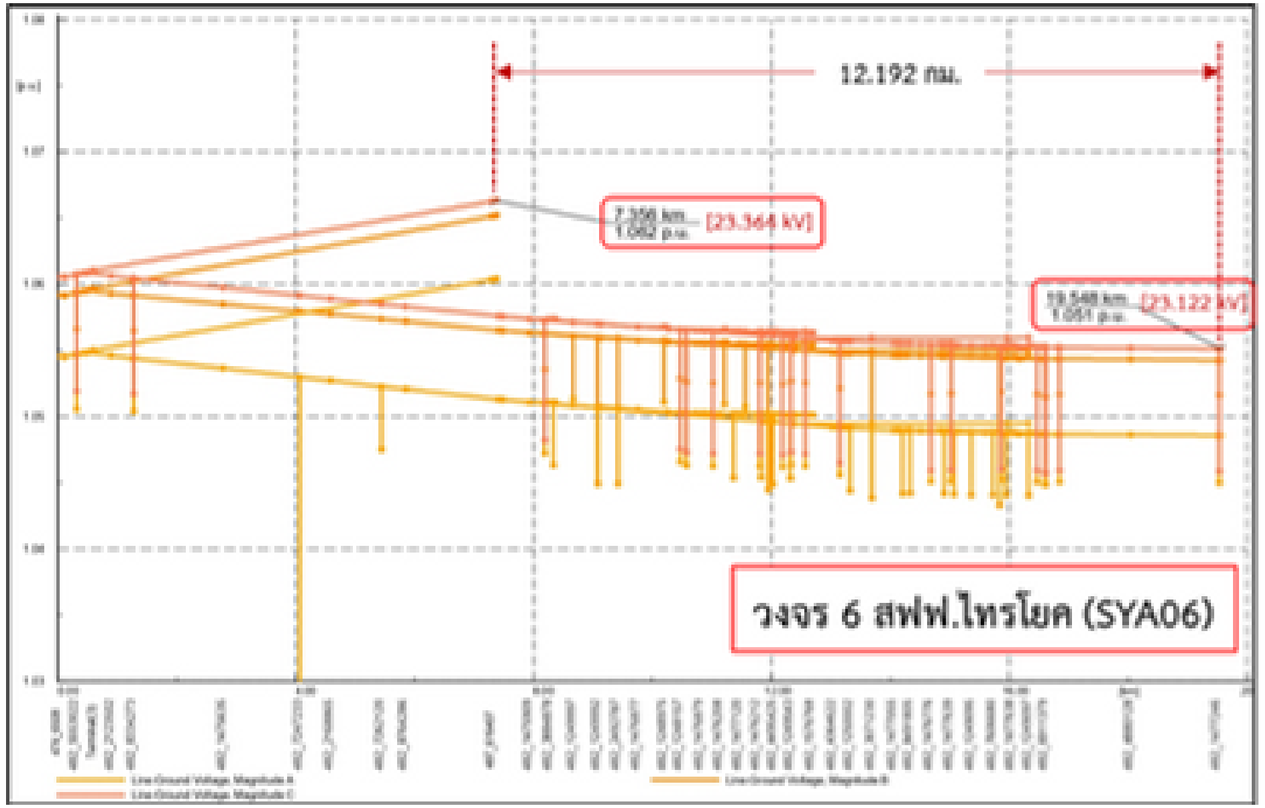
The 22.90 kV voltage level of the transformer is affected by the voltage conditions, with a distance of approximately 7.037 km from the Very Small Power Producer (VSPP)

The 23.10 kV voltage level of the transformer is affected by the voltage conditions, with a distance of approximately 24.799 km from the Very Small Power Producer (VSPP)

Feeder06 Sai Yok Substation

Result of Simulation with Power factory



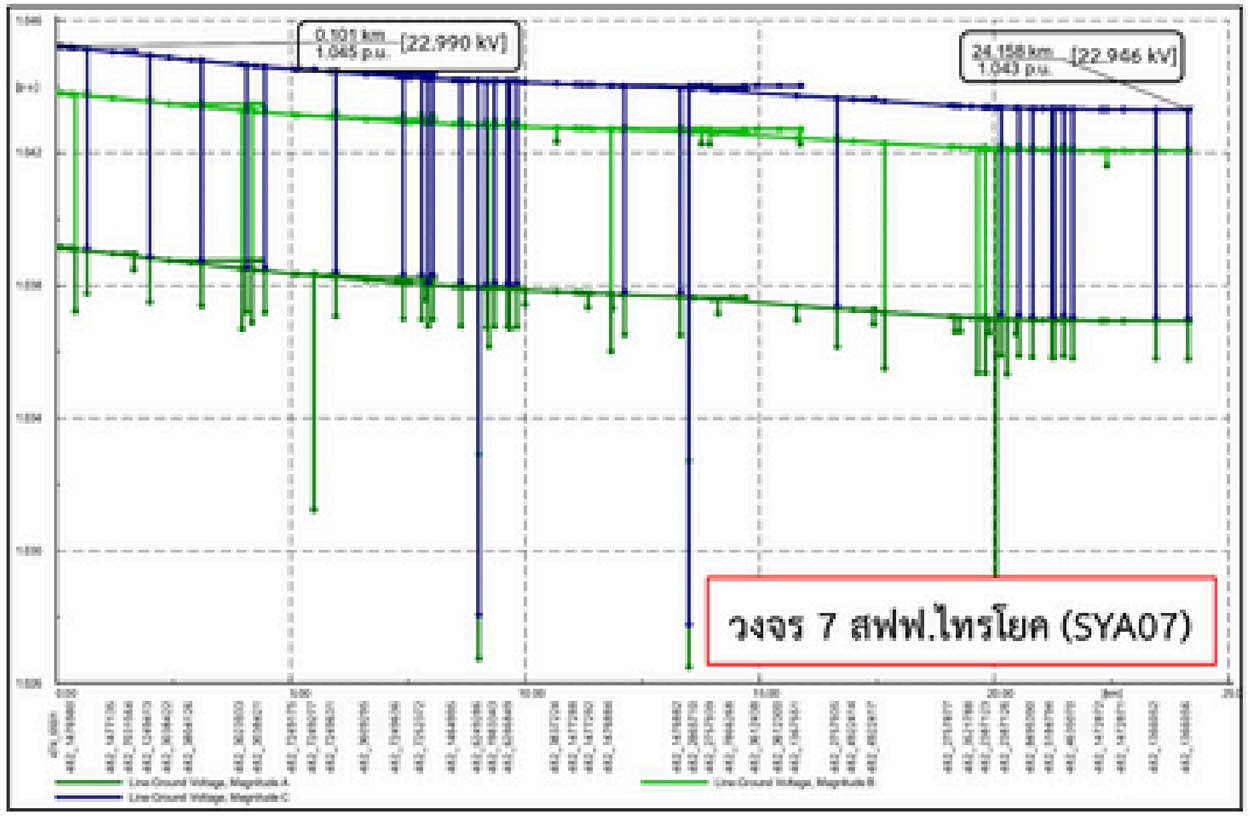


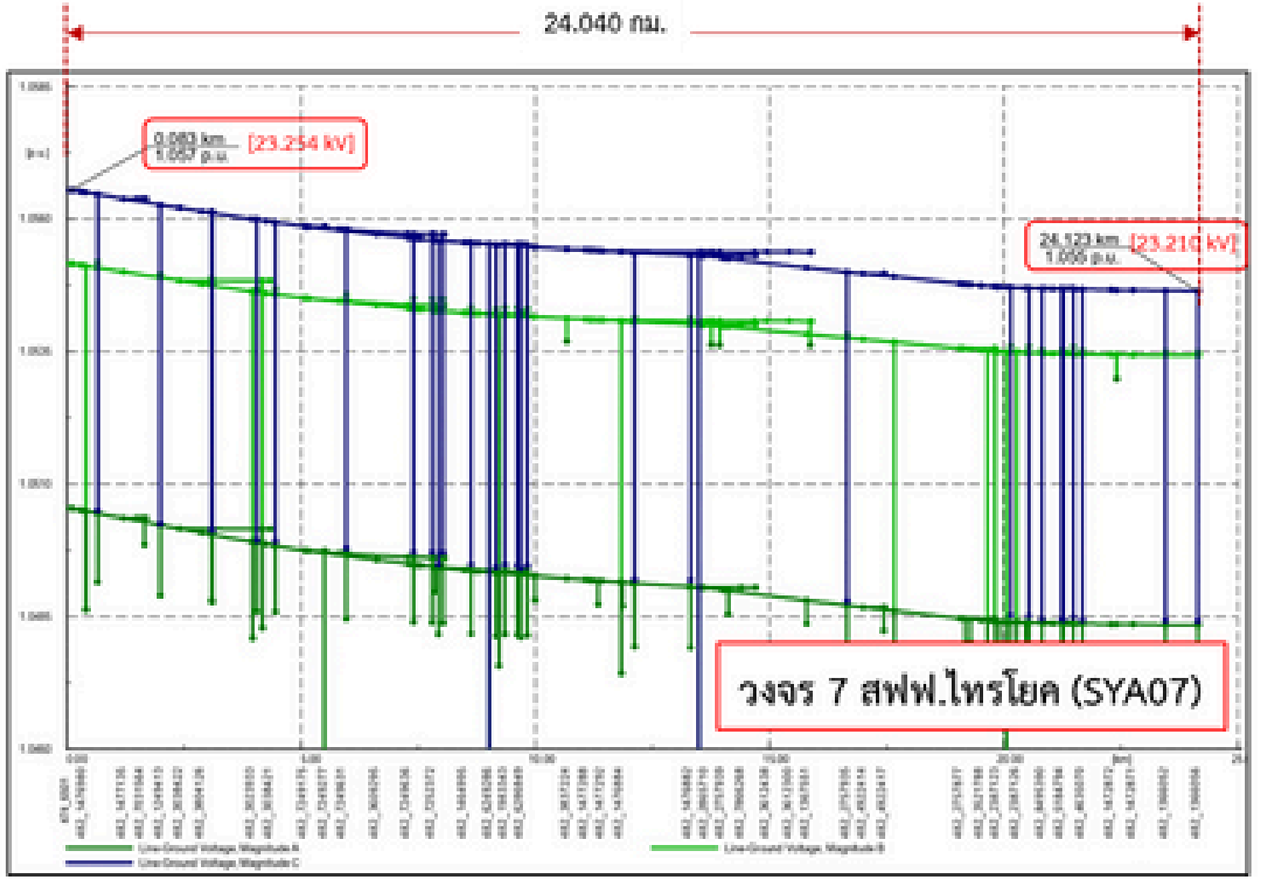
The 22.90 kV voltage level of the transformer is affected by the voltage conditions, with a distance of approximately 0.067 km from the Very Small Power Producer (VSPP)

The 23.10 kV voltage level of the transformer is affected by the voltage conditions, with a distance of approximately 12.192 km from the Very Small Power Producer (VSPP)

Feeder07 Sai Yok Substation

Result of Simulation with Power factory



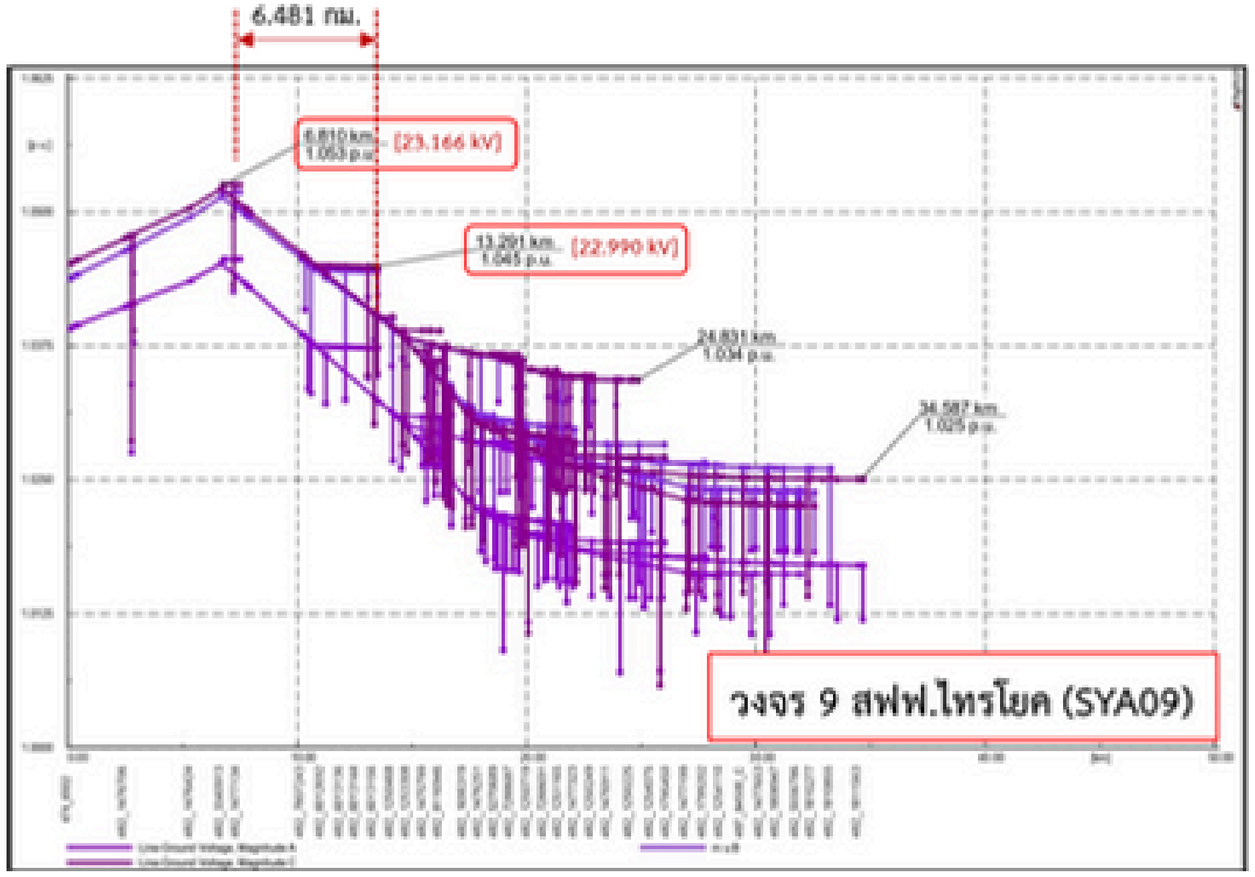


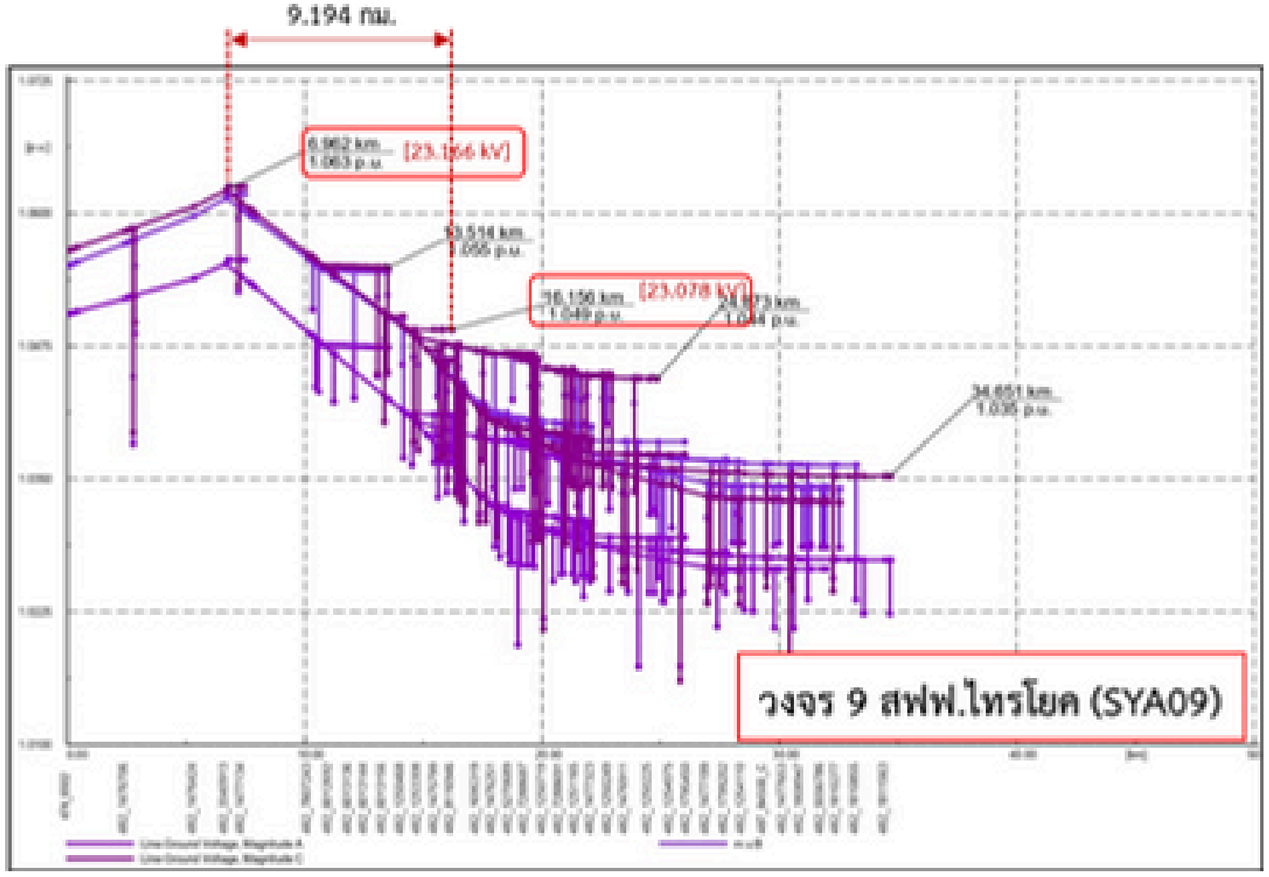
At 22.90 kV, the power transformer is not affected in terms of voltage.

The 23.10 kV voltage level of the transformer is affected by the voltage conditions, with a distance of approximately 24.040 km from the Very Small Power Producer (VSPP)

Result of Simulation with Power factory

Feeder09 Sai Yok Substation



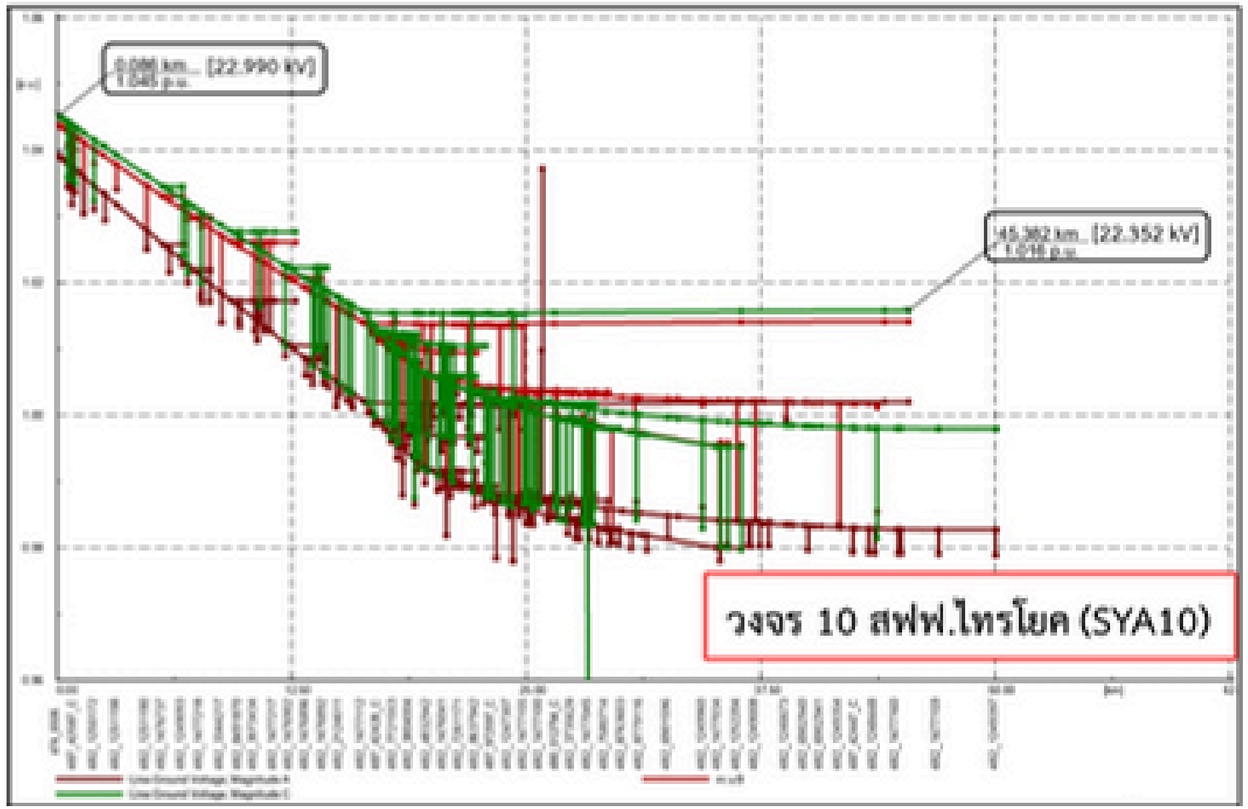


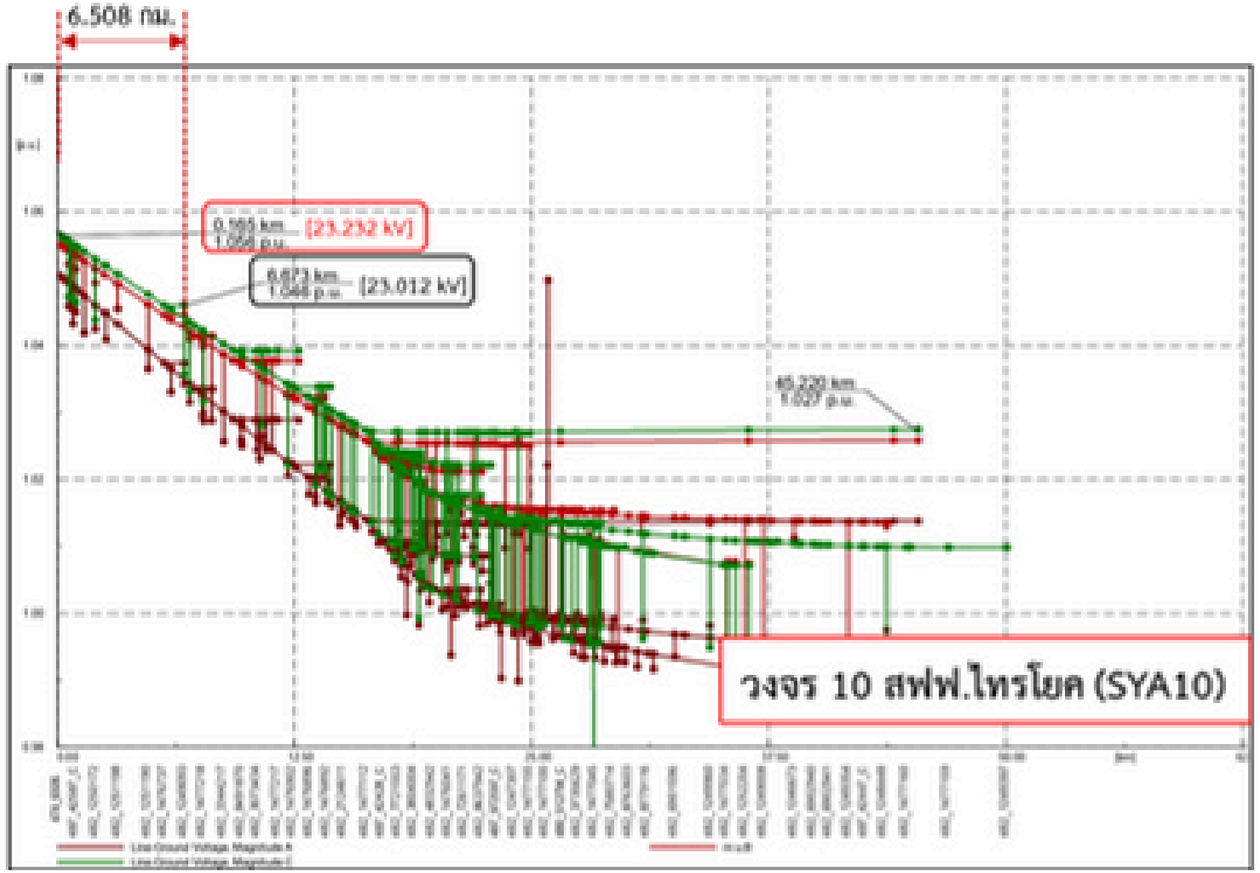
The 22.90 kV voltage level of the transformer is affected by the voltage conditions, with a distance of approximately 6.481 km from the Very Small Power Producer (VSPP)

The 23.10 kV voltage level of the transformer is affected by the voltage conditions, with a distance of approximately 9.194 km from the Very Small Power Producer (VSPP)

Feeder10 Sai Yok Substation

Result of Simulation with Power factory



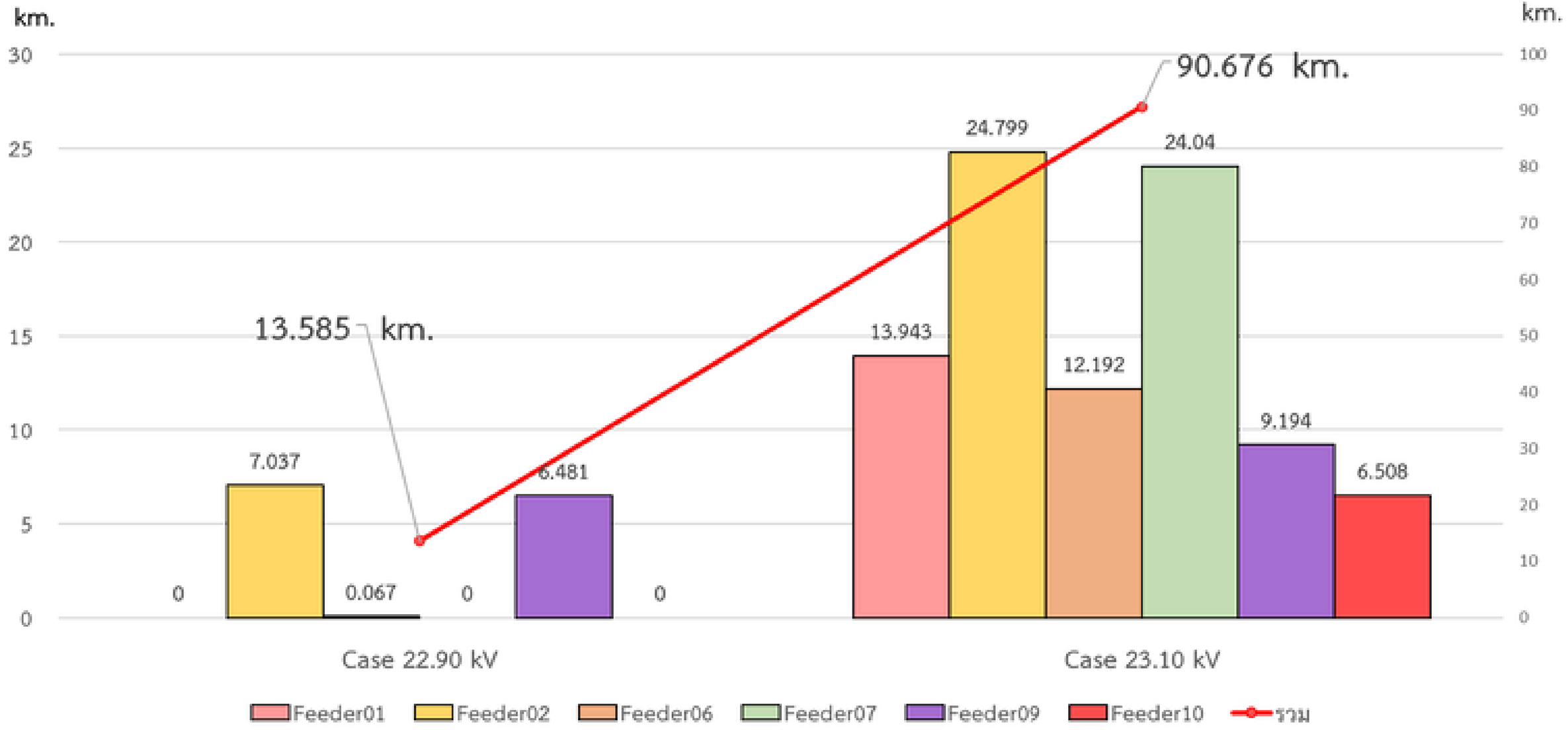


At 22.90 kV, the power transformer is not affected in terms of voltage.

The 23.10 kV voltage level of the transformer is affected by the voltage conditions, with a distance of approximately 6.508 km from the Very Small Power Producer (VSPP)

Voltage Profile Feeder 1 - 10 and Total Distance

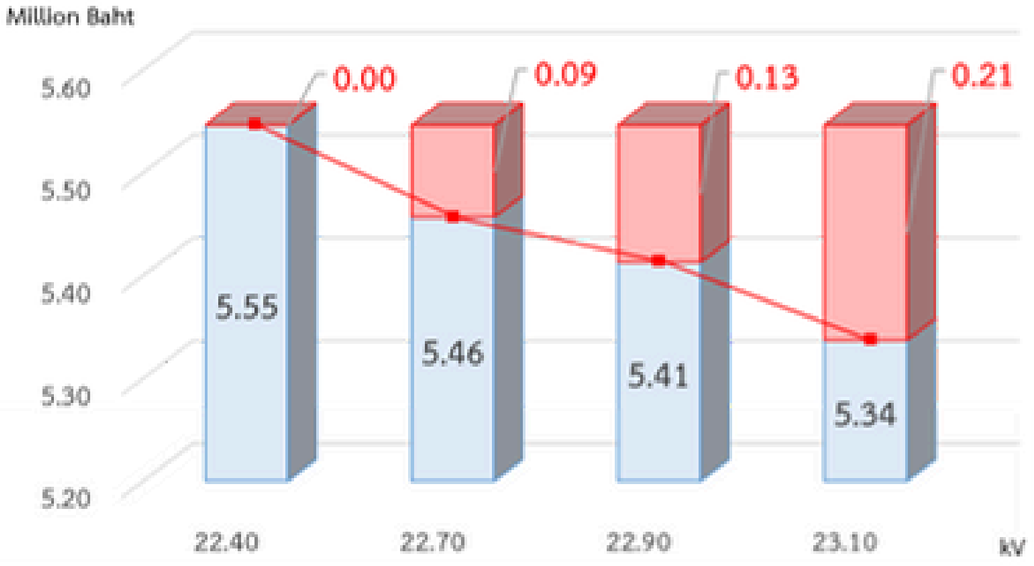
Result of Simulation with Power factory



Technical Losses /Year
(kW-hr)/Year

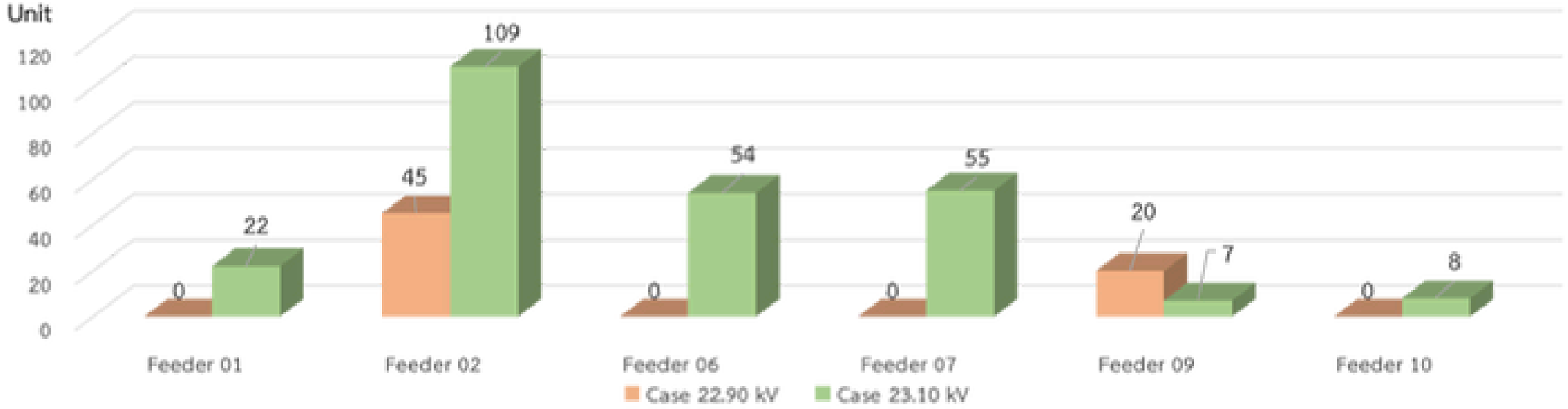
Result of Simulation with Power factory

	Case	Total Energy Loss (kW.hr)	Cost of Energy Loss (Bath)	Decrease		
				Total Energy Loss (kW.hr)	Cost of Energy Loss (Bath)	%
1	22.40 kV	1,949,589.75	5,546,287.14	-	-	-
2	22.70 kV	1,918,081.48	5,456,650.90	31,508.27	89,636.24	1.62
3	22.90 kV	1,902,694.93	5,412,878.51	46,894.82	133,408.63	2.41
4	23.10 kV	1,876,040.24	5,337,049.94	73,549.51	209,237.20	3.78

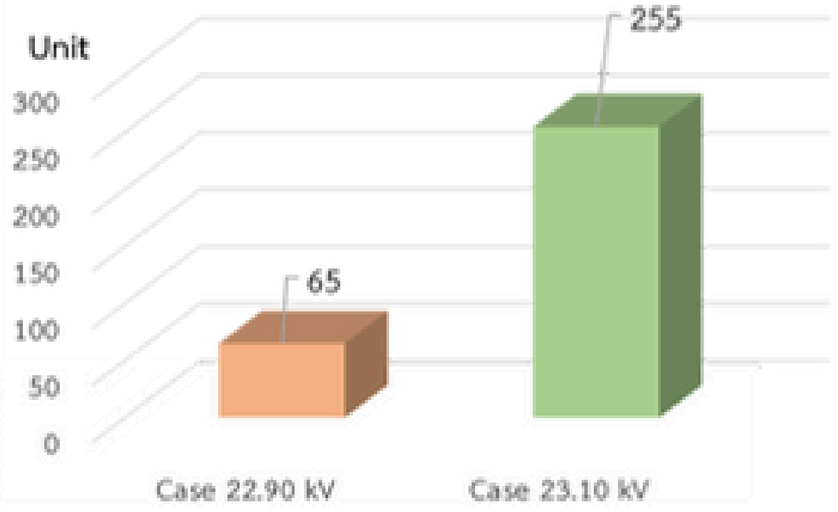


Number of Transformers That Require Tap Adjustment

Result of Simulation with Power factory

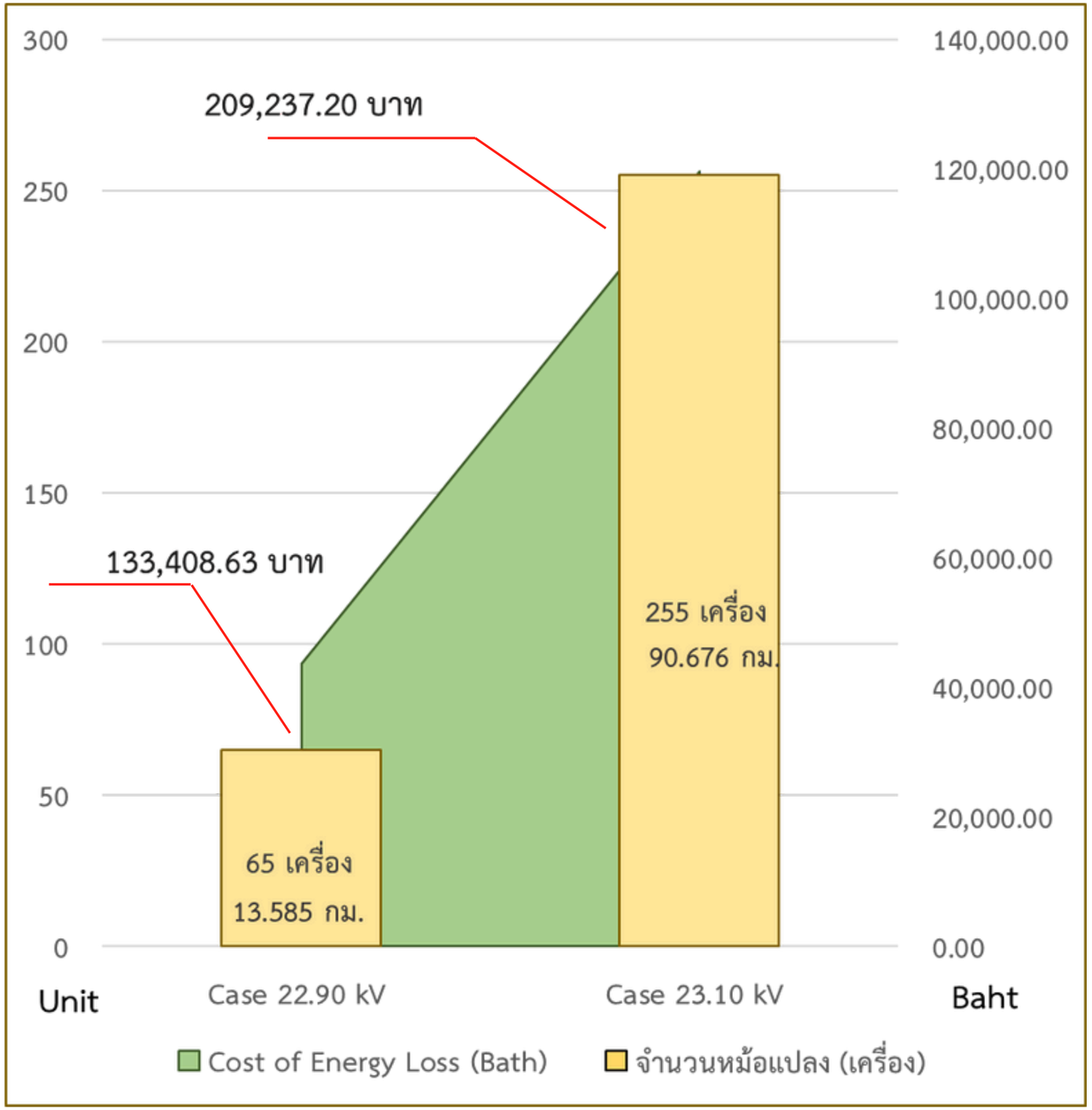


	Case 1 22.70 kV	Case 1 22.90 kV	Case 1 23.10 kV	Case 2 22.70 kV	Case 2 22.90 kV	Case 2 23.10 kV	Case 3 22.70 kV	Case 3 22.90 kV	Case 3 23.10 kV	Match Data For Foreign Key	
Xf-680_566759	0.995882	1.026895	1.060153	1.028665	1.061852	1.058153	1.087987	1.059658	1.071789	58-107734	Xf-680_566759
Xf-680_1567408	0.992014	1.023401	1.33771	1.027829	1.060415	1.053713	1.085658	1.057685	1.0696	42-006308	Xf-680_1567408
Xf-680_148574	0.989174	1.020913	1.034885	1.026211	1.059059	1.05218	1.085058	1.056884	1.069003	52-011577	Xf-680_148574
Xf-680_844279	0.991059	1.022184	1.054294	1.027432	1.06042	1.05352	1.084727	1.056543	1.068487	42-006307	Xf-680_844279
Xf-680_459044	0.992407	1.023562	1.071947	1.028282	1.0991	1.05223	1.083858	1.055699	1.067833	56-008305	Xf-680_459044
Xf-680_1615142	0.989367	1.020325	1.034854	1.027775	1.060572	1.053682	1.083683	1.055491	1.067627	39-002813	Xf-680_1615142
Xf-680_844279	0.988249	1.019103	1.033045	1.027247	1.060039	1.053142	1.082937	1.05479	1.066931	42-006306	Xf-680_844279
Xf-680_148855	0.987916	1.018807	1.033012	1.027144	1.060362	1.053474	1.082698	1.054715	1.066699	59-108898	Xf-680_148855
Xf-680_1519435	0.987910	1.018852	1.033004	1.027143	1.060362	1.053473	1.082695	1.054711	1.066696	44-112801	Xf-680_1519435
Xf-680_1441127	0.987897	1.018784	1.032942	1.027117	1.060356	1.053467	1.082654	1.054711	1.066657	55-444777	Xf-680_1441127
Xf-680_508841	0.987838	1.018765	1.032921	1.027114	1.060353	1.053465	1.082641	1.054698	1.066643	58-014977	Xf-680_508841
Xf-680_148599	1.008907	1.040474	1.029231	1.028444	1.057687	1.050948	1.082575	1.054627	1.066567	33-001755	Xf-680_148599
Xf-680_1464499	0.987623	1.018578	1.032737	1.02714	1.060359	1.053451	1.082526	1.054585	1.066532	28-015240	Xf-680_1464499
Xf-680_285743	0.987616	1.01857	1.03273	1.02714	1.06036	1.053452	1.082522	1.054581	1.066528	56-009638	Xf-680_285743
Xf-680_148743	1.012187	1.039234	1.053281	1.028674	1.061467	1.054573	1.082503	1.05456	1.066504	56-007255	Xf-680_148743
Xf-680_147454	0.987549	1.018524	1.032698	1.027544	1.060363	1.053454	1.082497	1.054554	1.066503	51-005605	Xf-680_147454
Xf-680_968550	0.987512	1.018464	1.032626	1.02714	1.06036	1.053453	1.082461	1.05452	1.066469	43-002914	Xf-680_968550
Xf-680_302937	0.987329	1.018474	1.032636	1.027114	1.060353	1.053425	1.082401	1.054518	1.066461	56-115530	Xf-680_302937
Xf-680_147452	0.987497	1.018452	1.032615	1.02714	1.06036	1.053452	1.082455	1.054515	1.066461	44-008569	Xf-680_147452
Xf-680_986250	1.01229	1.038994	1.052602	1.027114	1.059907	1.053012	1.082323	1.054182	1.066329	53-000117	Xf-680_986250
Xf-680_1441128	1.009729	1.036465	1.050087	1.024377	1.057214	1.050368	1.081935	1.053794	1.065946	55-123044	Xf-680_1441128
Xf-680_1345014	1.009513	1.036445	1.05087	1.024327	1.057167	1.05032	1.081939	1.053699	1.065847	43-002144	Xf-680_1345014
Xf-680_148585	0.986428	1.017986	1.031561	1.027347	1.060168	1.053282	1.081759	1.053624	1.065779	43-001052	Xf-680_148585
Xf-680_148405	1.010263	1.038322	1.050525	1.028444	1.061261	1.054371	1.081909	1.05318	1.065341	57-007240	Xf-680_148405

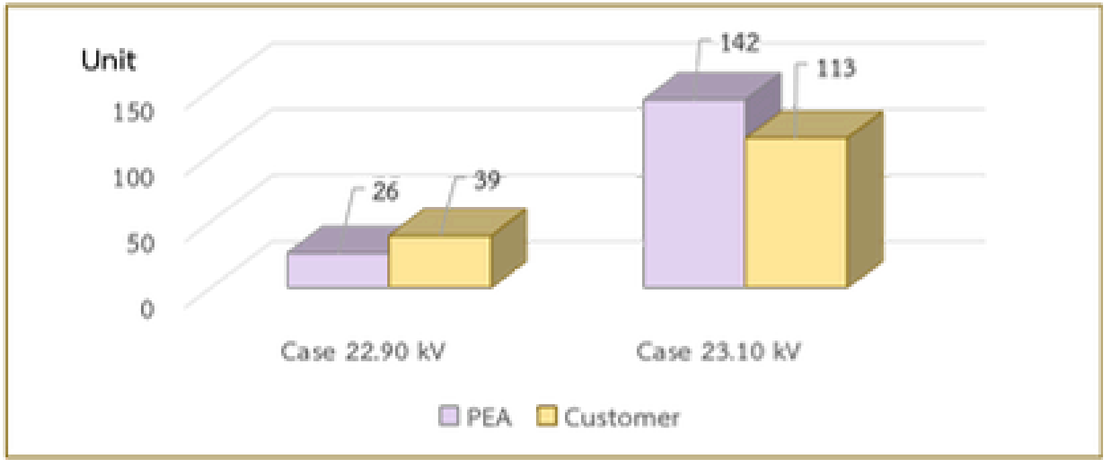


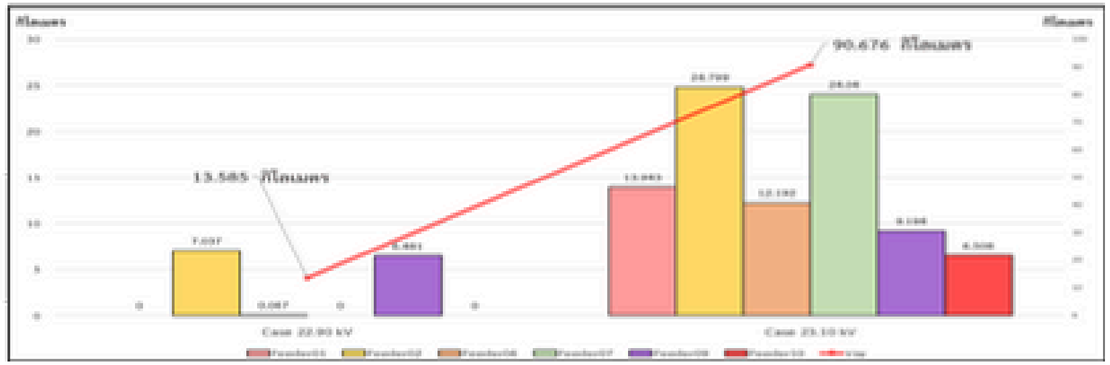
Result of Simulation with Power factory

Summary of Results



	Case	Total Energy Loss (kW.hr)	Cost of Energy Loss (Bath)	Decrease		
				Total Energy Loss (kW.hr)	Cost of Energy Loss (Bath)	%
1	22.40 kV	1,949,589.75	5,546,287.14	-	-	-
2	22.70 kV	1,918,081.48	5,456,650.90	31,508.27	89,636.24	1.62
3	22.90 kV	1,902,694.93	5,412,878.51	46,894.82	133,408.63	2.41
4	23.10 kV	1,876,040.24	5,337,049.94	73,549.51	209,237.20	3.78

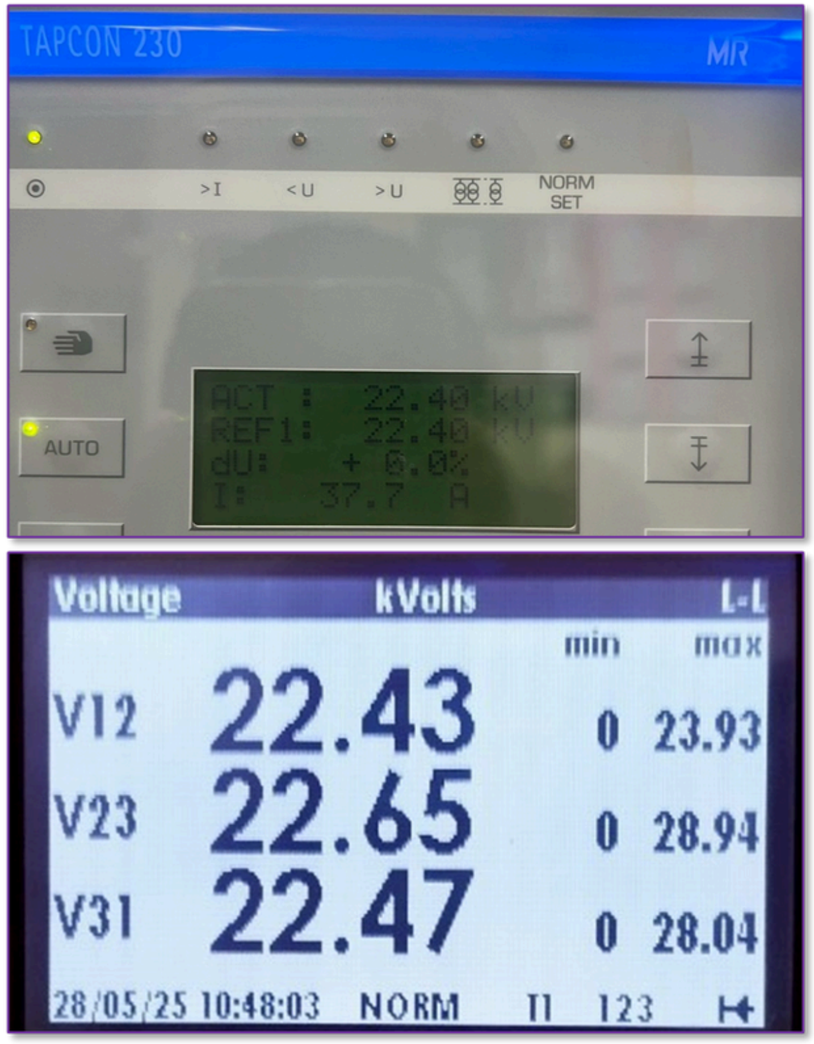




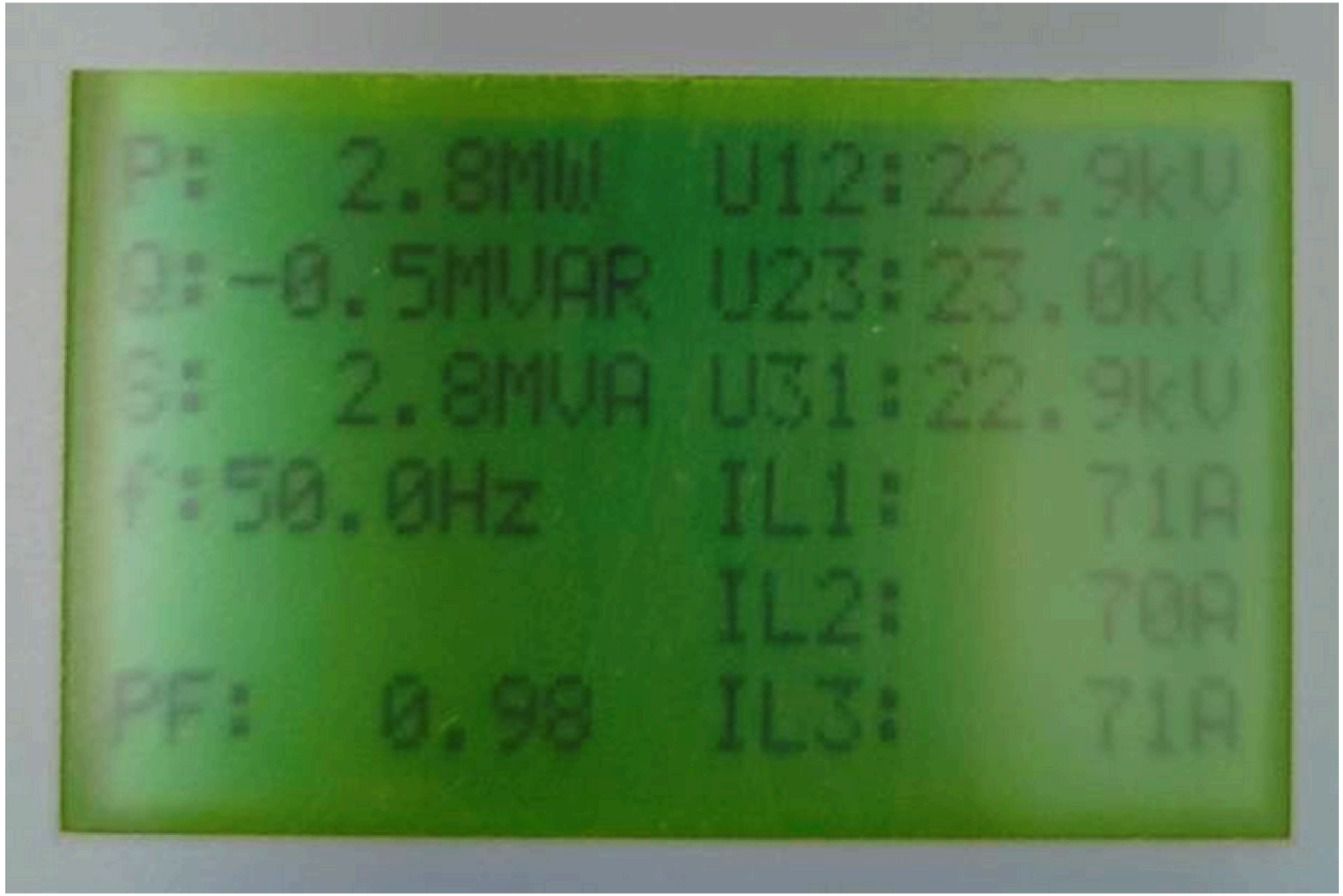
PEA
PROVINCIAL ELECTRICITY AUTHORITY

Impact Analysis and Problem-Solving Approaches for the Voltage Improvement Project

Impact Analysis and Problem-Solving

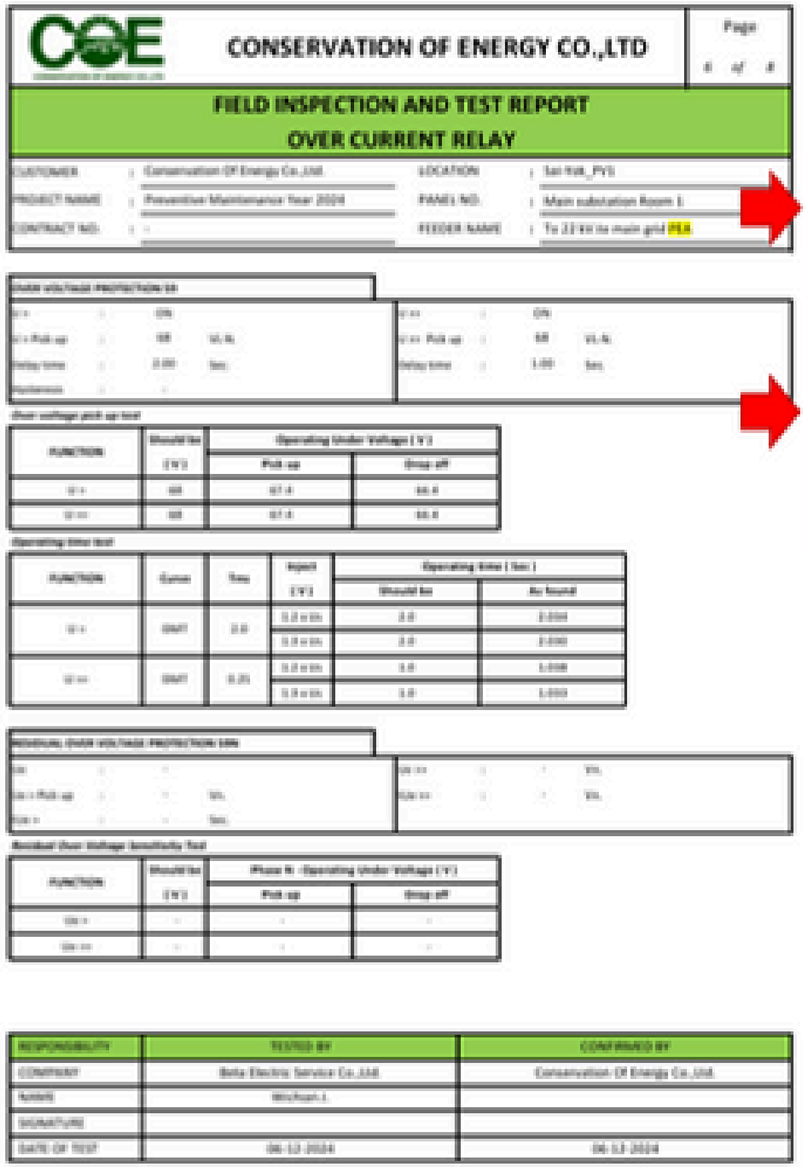


Voltage Bus
SAI YOK Substation



Voltage Bus
Very Small Power Producers (SPP/VSPP).

Impact Analysis and Problem-Solving



CONSERVATION OF ENERGY CO.,LTD

Page 4 of 8

FIELD INSPECTION AND TEST REPORT

OVER CURRENT RELAY

CUSTOMER	: Conservation Of Energy Co.,Ltd.	LOCATION	: Sai Yok_PYI		
PROJECT NAME	: Preventive Maintenance Year 2024	PANEL NO.	: Main substation Room 1		
CONTRACT NO.	: -	FEEDER NAME	: To 22 kV to main grid PEA		

SETTING PARAMETER						
CT Pri.	:	300	A.	Voltage input	:	4W3M HV
CT Sec.	:	1	A.	Current input	:	4W3M HV
VT Pri.	:	22000	V.			
VT Sec.	:	110	V.			

OVER VOLTAGE PROTECTION 59						
U >	:	ON		U >>	:	ON	
U > Pick up	:	68	VL-N.	U >> Pick up	:	68	VL-N.
Delay time	:	2.00	Sec.	Delay time	:	1.00	Sec.
Hysteresis	:	-					

Over voltage pick up test

FUNCTION	Should be (V)	Operating Under Voltage (V)	
		Pick up	Drop off
U >	68	67.4	66.4
U >>	68	67.4	66.4

Setting Over Voltage (Line – Line Voltage, U >)

$$U> = \sqrt{3} \times 68 \times \frac{22000}{110} = 23.56 \text{ kV (1.071 pu.)}$$

Impact Analysis and Problem-Solving

VSPP, Power Factor = 1

Details	Base Case	Case 1	Case 2	Case 3
Magnitude Voltage (kV)	22.40	22.70	22.90	23.10
Technical Losses (kW-Hr/Year)	1,949,589.75 kW.Hr 5,546,287.14 Baht	1,918,081.48 kW.Hr 5,456,650.90 Baht	1,902,694.93 kW.Hr 5,412,878.51 Baht	1,876,040.24 kW.Hr 5,337,049.94 Baht
Technical Losses Decrease (kW-Hr/Year, Baht)	-	31,508.27 kW.Hr 89,636.24 Baht	46,894.82 kW.Hr 133,408.63 Baht	73,549.51 kW.Hr 209,237.20 Baht
Percent (%) of Decrease	-	1.62 %	2.41 %	3.78 %
Number of Transformers	-	-	65 unit	255 unit
Total Distance	-	-	13.585 km.	90.676 km.
PF Control (1.000) at (PCC) Feeder 02 Feeder 06 Feeder 09	Reactive Power (MVar) 0.000 0.000 0.000	Reactive Power (MVar) 0.000 0.000 0.000	Reactive Power (MVar) 0.000 0.000 0.000	Reactive Power (MVar) 0.000 0.000 0.000
Voltage at (PCC) Feeder 02 Feeder 06 Feeder 09	 22.561 22.641 22.378	 22.851 22.930 22.670	 23.148 23.227 22.969	 23.452 23.560 23.276
Voltage Setting at Bus VSPP	23.56 kV (1.071 pu.)			

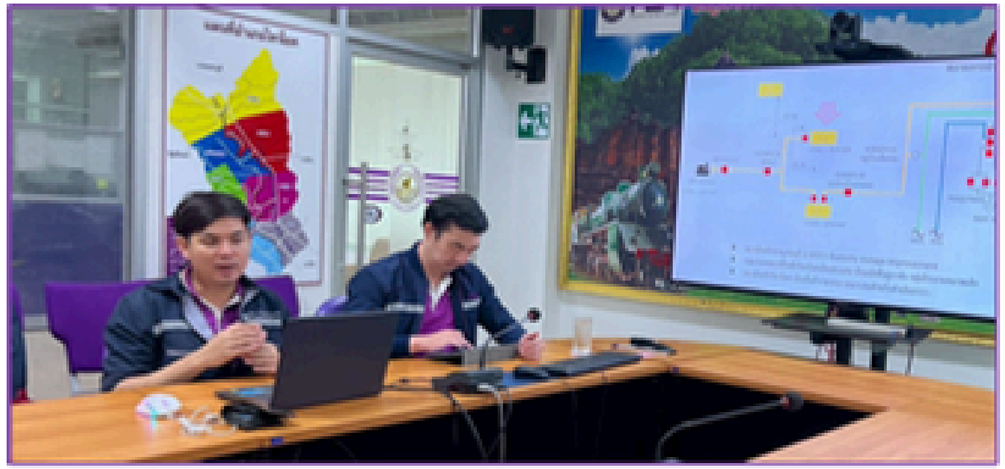
Impact Analysis and Problem-Solving

VSPP, Power Factor = 0.875

Details	Base Case	Case 1	Case 2	Case 3
Magnitude Voltage (kV)	22.40	22.70	22.90	23.10
Technical Losses (kW-Hr/Year)	1,949,589.75 kW.Hr 5,546,287.14 Baht	1,918,081.48 kW.Hr 5,456,650.90 Baht	1,902,694.93 kW.Hr 5,412,878.51 Baht	1,876,040.24 kW.Hr 5,337,049.94 Baht
Technical Losses Decrease (kW-Hr/Year, Baht)	-	31,508.27 kW.Hr 89,636.24 Baht	46,894.82 kW.Hr 133,408.63 Baht	73,549.51 kW.Hr 209,237.20 Baht
Percent (%) of Decrease	-	1.62 %	2.41 %	3.78 %
Number of Transformers	-	-	65 unit	255 unit
Total Distance	-	-	13.585 km.	90.676 km.
PF Control (0.875) at (PCC) Feeder 02 Feeder 06 Feeder 09	Reactive Power (MVar) 3.320 3.320 3.320	Reactive Power (MVar) 3.320 3.320 3.320	Reactive Power (MVar) 3.320 3.320 3.320	Reactive Power (MVar) 3.320 3.320 3.320
Voltage at (PCC) Feeder 02 Feeder 06 Feeder 09	 22.856 22.960 22.647	 23.113 23.216 22.906	 23.376 23.378 23.171	 23.645 23.747 23.443
Voltage Setting at Bus VSPP	23.56 kV (1.071 pu.)			

Impact Analysis and Problem-Solving

First Meeting



Meeting on the Voltage Upgrade Project at Sai Yok Substation with the Provincial Electricity Authority (PEA) on-site team to provide clarification and gather feedback on issues related to the project

Impact Analysis and Problem-Solving

Second Meeting

"A meeting on the voltage upgrading plan was convened, inviting relevant stakeholders to provide their feedback."

PEA
PROVINCIAL ELECTRICITY AUTHORITY

Thank You For Your Attention

Mr. Churit Pansakul