

IEC 61850 於智慧型變電所之應用 及國內外案例分享

劉俊宏

105 年 7 月 15 號

PROFILE

劉俊宏

Academic Background
Ph.D. in Power & Energy

Major research
Smart grid applications
Power system protections
SCADA

Current job
Elipse Software (Brazilian based company)



OUTLINE

What is Smart Substation?

Case Study

Malaysia (Smart Substation)

Brazil (Smart Load Shedding)

Taiwan (Micro Grid Protection)

Conclusion

OUTLINE

What is Smart Substation?

Case Study

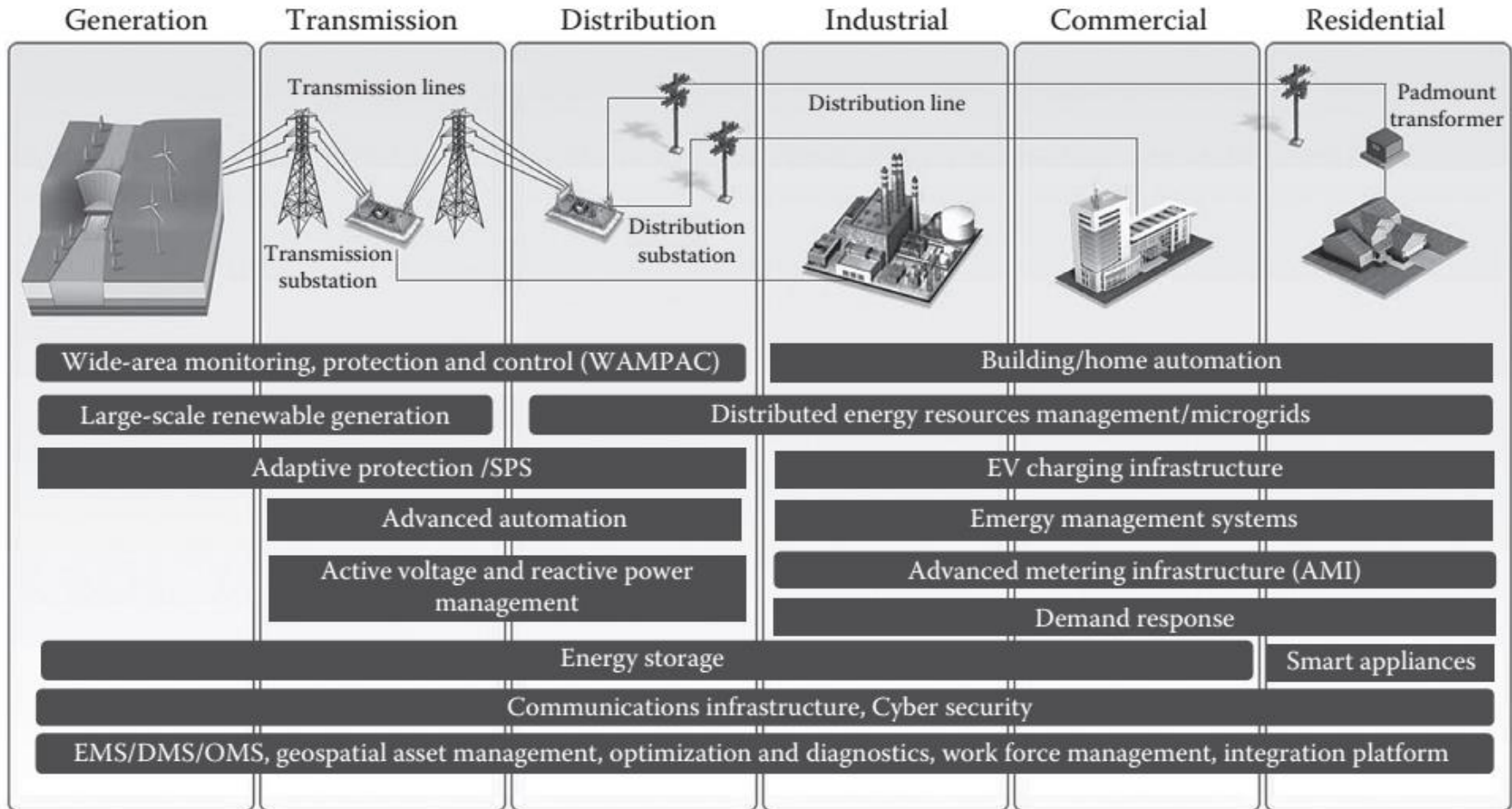
Malaysia (Smart Substation)

Brazil (Smart Load Shedding)

Taiwan (Micro Grid Protection)

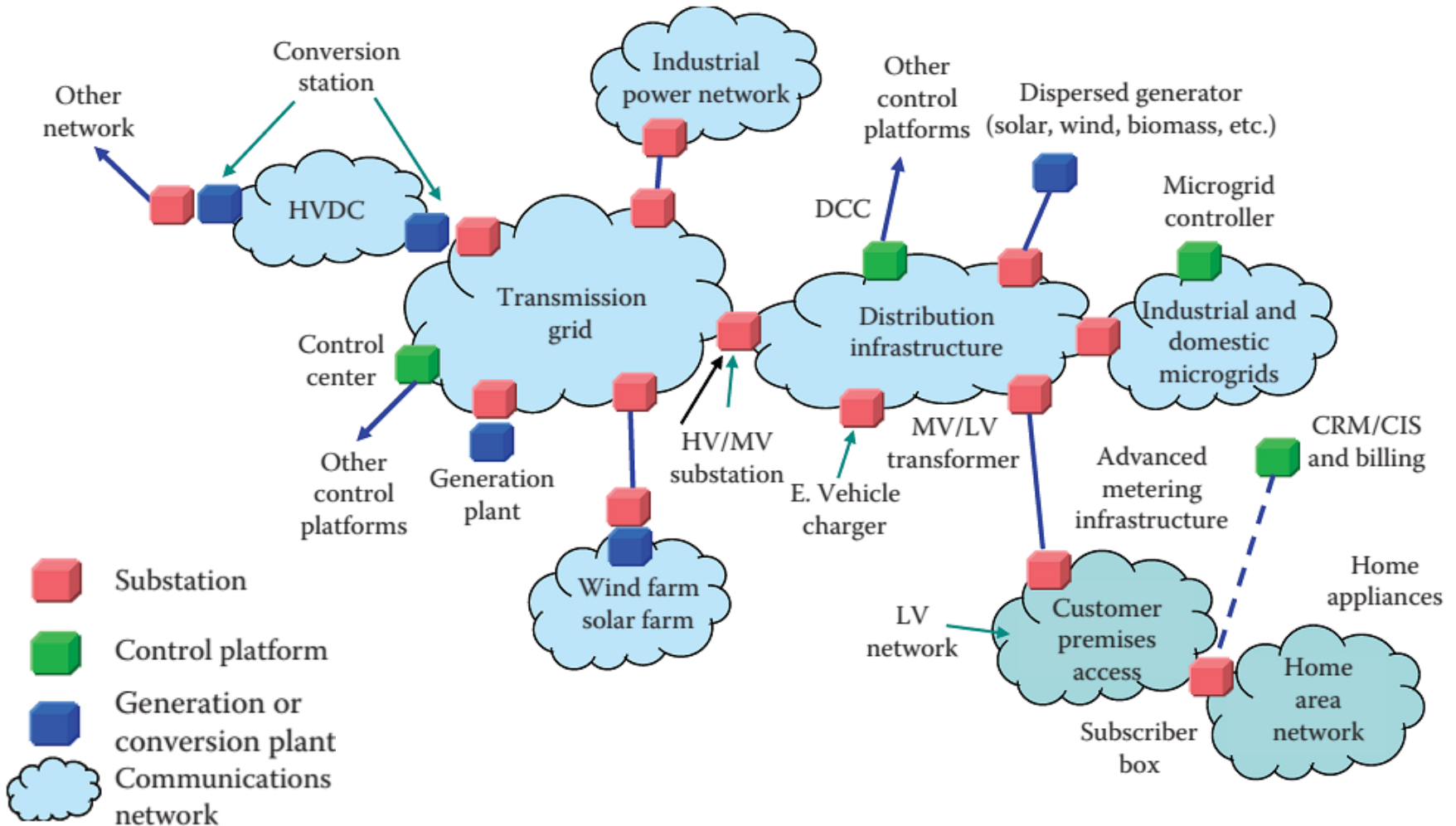
Conclusion

WHAT IS SMART SUBSTATION



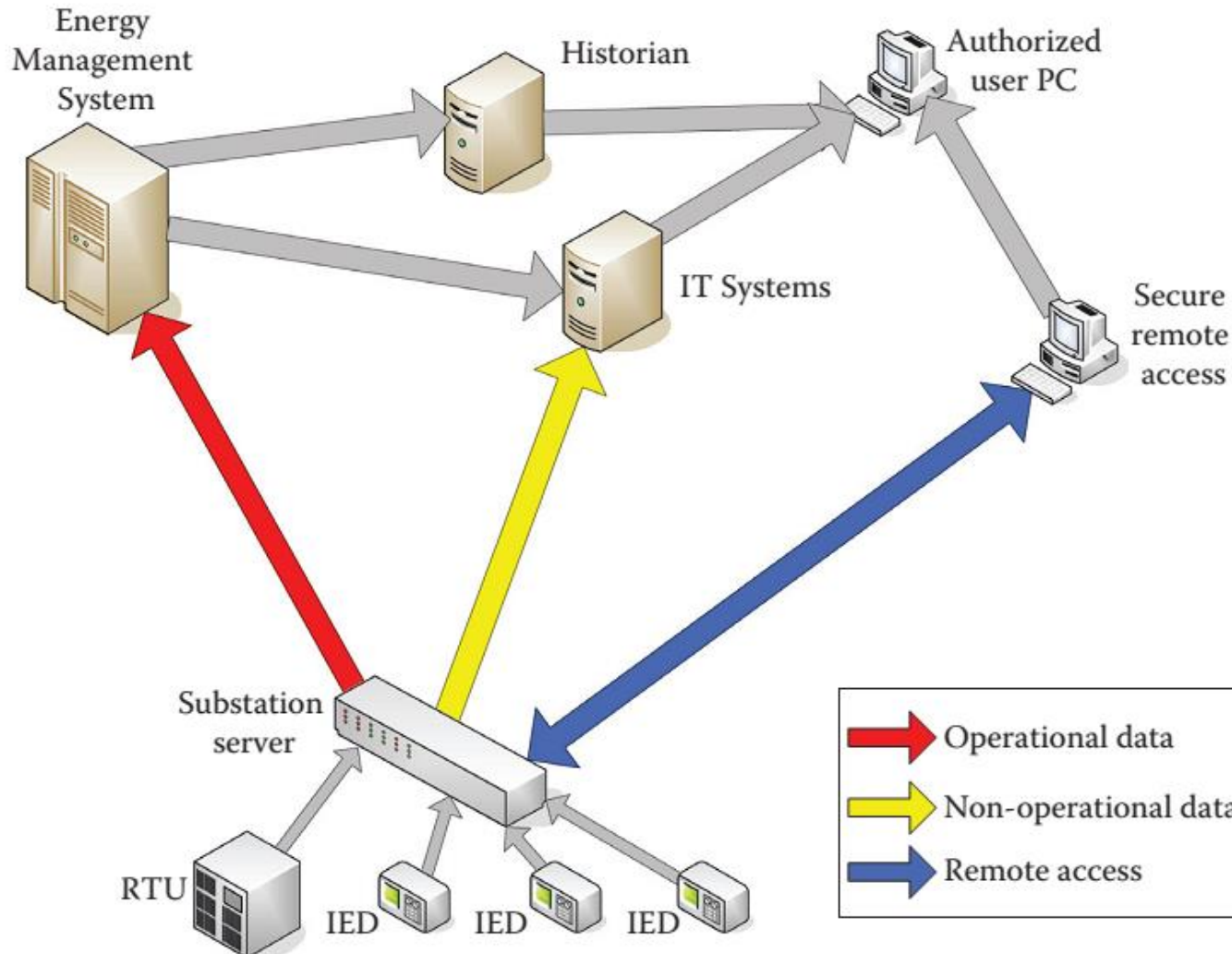
Smart grid technology span the entire grid. (from 2012 GE Energy)

WHAT IS SMART SUBSTATION



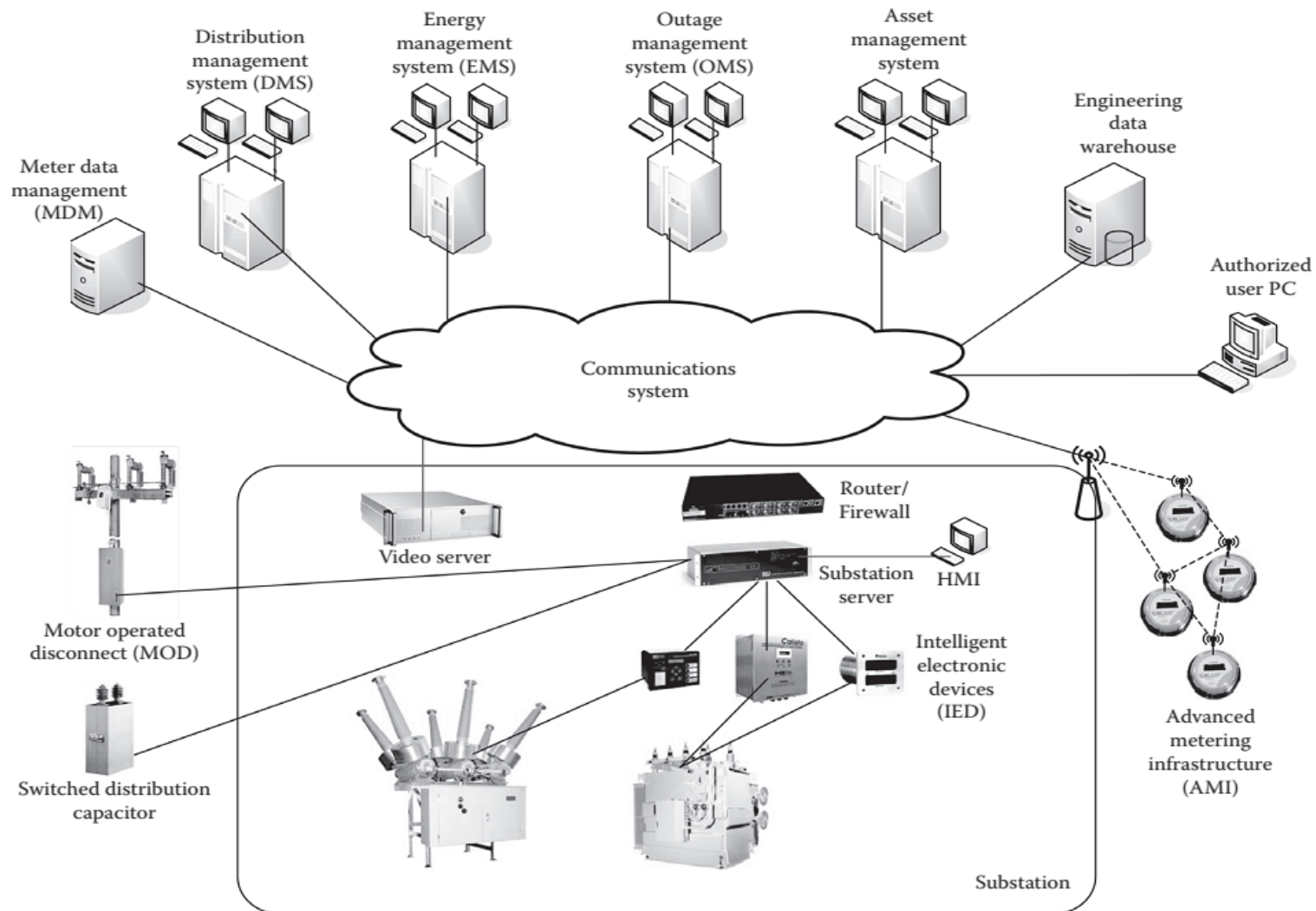
Operational communications domains in the electric utility (from 2012 Alstom)

WHAT IS SMART SUBSTATION



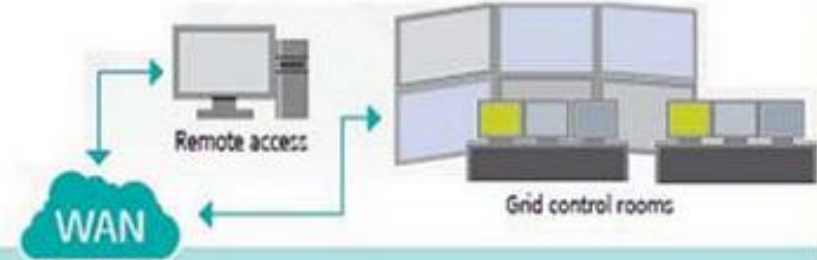
Substation data flow (Smart Grids: Infrastructure, Technology, and Solutions, *Stuart Borlase*)

WHAT IS SMART SUBSTATION



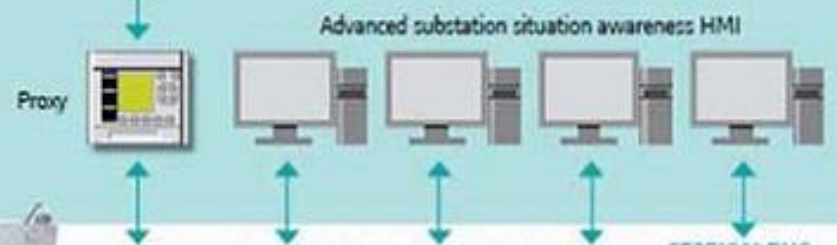
Smart substations in the smart grid architecture. (2012 Michael Pesin)

ARCHITECTURE



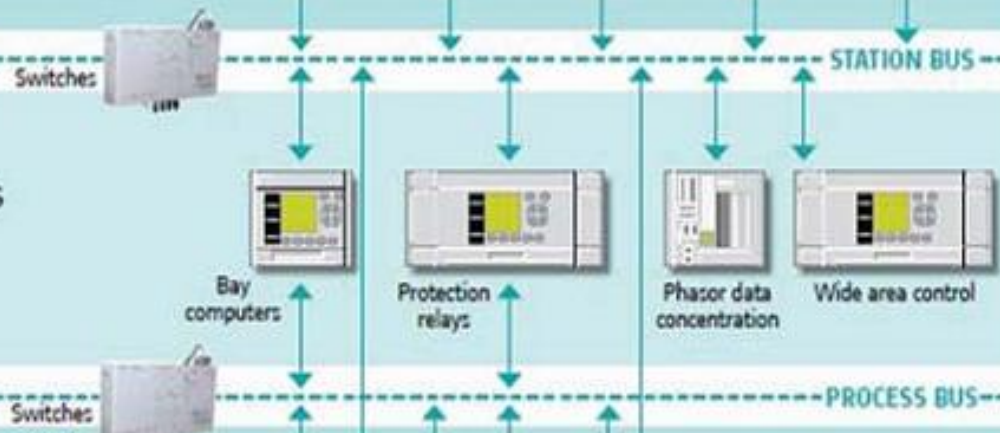
The station control area

Communication within substation and control system, coordination with the substation operational function and the station-level support function.



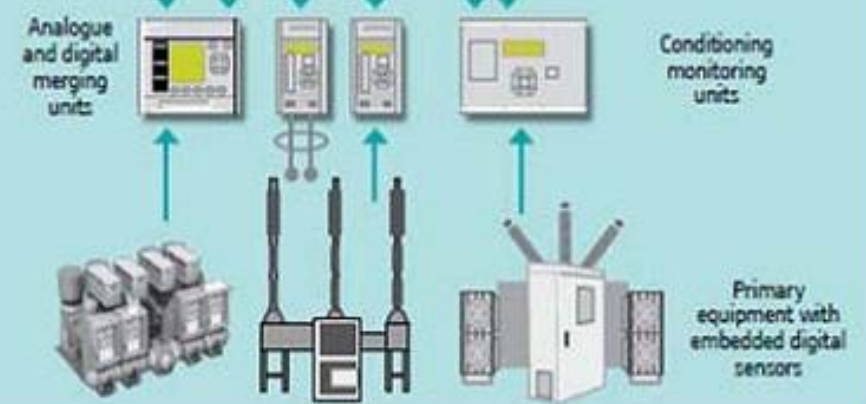
The protection and control level

Protection and control of substation equipment: includes IEDs traditionally called "secondary equipment" (protections, measurement devices, bay controllers, recorders...)



The primary equipment process level

Capture of voltage and current signals, consolidation, processing, and transmission of data via optical fibres: intelligent primary devices (electronic power and instrument transformers, circuit-breakers, disconnectors) and optic fibre have replaced traditional CT/VT systems and conventional cable wiring.



OUTLINE

What is Smart Substation?

Case Study

Malaysia (Smart Substation)

Brazil (Smart Load Shedding)

Taiwan (Micro Grid Protection)

Conclusion

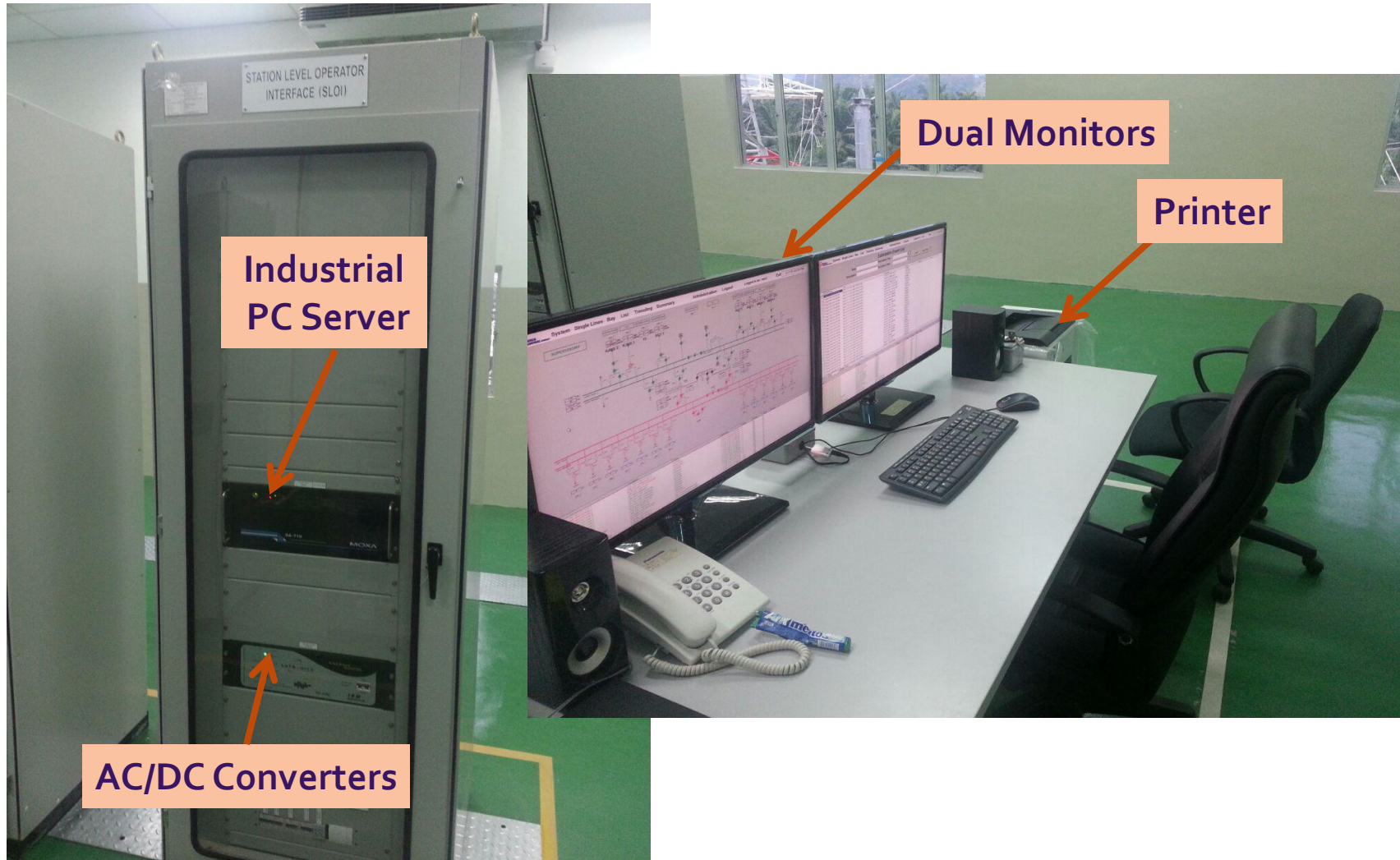
SMART SUBSTATION (TNB)

- The first Malaysia IEC 61860 Smart Substation in TNB
- 132/33KV KAJANG ESTATE
- Project completed in 2014
- Solution provided by Elipse Software

SMART SUBSTATION (TNB)

- To allow users to monitor the substation status through single line diagram at station and bay level
- To monitor and filter of fascia, alarms and events in the substation.
- To provide trending and historical information
- To communicate with DMS or EMS for power system analysis in smart grid domain

SMART SUBSTATION (TNB)



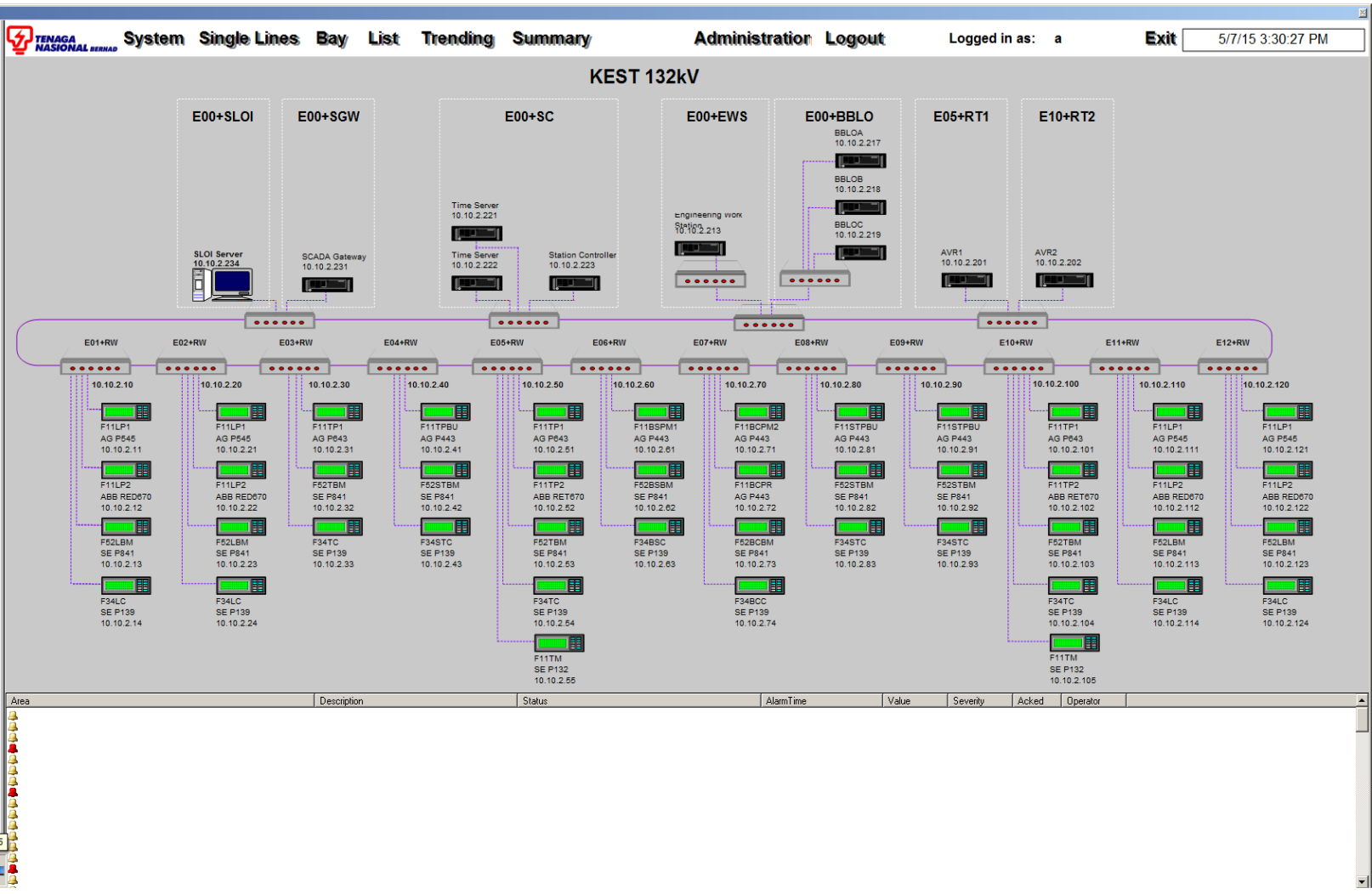
SMART SUBSTATION (TNB)

This is the CAS Switch Status shown between NLDC and STATION for substation

The button on top of the bay can navigate to the desired bay

Alarm displayed
GREEN = alarm normalized
RED = still on operated

SMART SUBSTATION (TNB)



SMART SUBSTATION (TNB)

Station Level Operator Interface - Frame Title

TENAGA NASIONAL BERHAD System Single Lines Bay List Trending Summary Administrator Logout Logged in as: a Exit 5/7/15 8:24:57 PM

STATION E01

132kV MAIN 1
132kV RESERVE

204 206 2 205 203 201A 201B KJNG2

R-Y 0 kV
Y-B 0 kV
B-R 0 kV

R 0 A
Y 0 A
0 0 A

f 0 Hz
PF 0

0 MW
0 MVAR

CONTROL FASCIA

Incoming 0.000 kV
Incoming 0.000 Hz
Running 0.000 kV
Delta V (15.29 kV) 0.000 kV
Delta f (0.125) 0.000 Hz
Delta Phase Angle (25) 0.000 degree

Autoreclose ON
Master Trip Relay NORMAL

BREAKER FAIL PROTECTION MODE
Breaker Fail Stage 1 Status ACTIVE
Breaker Fail Stage 2 Status ACTIVE

SEQUENCE CONTROL

Energize on Main Busbar for OHL
Energize on Reserve Busbar for OHL
De-Energize on OHL for Main Busbar
De-Energize on OHL for Reserve Busbar
Live Load Transfer from MBB to RBB for OHL - Single Bay
Live Load Transfer from RBB to MBB for OHL - Single Bay

Trip Counter

RESET Auto 187 Manual 187

Area	Description	Status	AlarmTime	Value	Severity	Acked	Operator
BAY IED STATUS	SC132kV	IED Connection Lost	07-May-15 05:40:22.526 PM	0	High	Yes	a
BAY IED STATUS	SC33kV	IED Connection Lost	07-May-15 05:40:22.526 PM	0	High	Yes	a
BAY H01	LOSS CLCK SYNCH	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
BAY.E02.F11LP2.LINE PROTECTION 2	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
KEST T1N1	Status Change	Intermediate	07-May-15 04:19:32.448 PM	2	Low	Yes	a
BAY.E01.F34LC.LINE BAY CONTROLLER	UNDERVOLTAGE PROT. MODE	OPERATED	07-May-15 04:19:32.448 PM	2	High	Yes	a
BAY.E10.F11TM.TRANSFORMER MONITORING	AIR BAG LEAKAGE ALARM	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
BAY.E10.F11TM.TRANSFORMER MONITORING	DLTC CONS. TANK HIGH OIL LVL	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
BAY.E01.F11LP2.LINE PROTECTION 2	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
KEST T2N1	Status Change	Intermediate	07-May-15 04:19:32.448 PM	2	Low	Yes	a
BAY.E12.F11LP2.LINE PROTECTION 2	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
BAY.E11.F11LP1.LINE PROTECTION 1	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
BAY.E01.F11LP1.LINE PROTECTION 1	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a

Start [Taskbar icons] 8:24 PM 7/5/2015

CAS Switch for bay

Master Trip Reset Button

Reset Counter

Sync Check

Control page

SMART SUBSTATION (TNB)

System **Single Lines** Bay List Trending Summary

Administration Logout
Logged in as: a
Exit
5/7/15 8:24:57 PM

STATION

E01

R-Y	0	kV
Y-B	0	kV
B-R	0	kV
R	0	A
Y	0	A
0	0	A
R-N	0	kV
Y-N	0	kV
B-N	0	kV
f	0	Hz
PF	0	
	0	MW
	0	MVAR

CONTROL
FASCIA

E01 ALARMS

LINE PROTECTION 1	LINE PROTECTION 2
<input type="checkbox"/> THERMAL OVERLOAD ALARM	<input type="checkbox"/> BACK DIST. PWR SWING BLOCK
<input type="checkbox"/> BACKUP DIST. SOTF TRIP	<input type="checkbox"/> BACKUP DIST. SOTF TRIP
<input type="checkbox"/> BACKUP DIST. VT SV ALARM	<input type="checkbox"/> BACKUP DIST. VT SV ALARM
<input type="checkbox"/> BACKUP DIST. Z1 TRIP	<input type="checkbox"/> BACKUP DIST. Z1 TRIP
<input type="checkbox"/> BACKUP DIST. Z2 TRIP	<input type="checkbox"/> BACKUP DIST. Z2 TRIP
<input type="checkbox"/> BACKUP DIST. Z3 TRIP	<input type="checkbox"/> BACKUP DIST. Z3 TRIP
<input type="checkbox"/> BACKUP DIST. Z3R TRIP	<input type="checkbox"/> BACKUP DIST. Z3R TRIP
<input checked="" type="checkbox"/> LINE DIFF COMM FAULTY	<input checked="" type="checkbox"/> LINE DIFF COMM FAULTY
<input type="checkbox"/> LINE DIFF INTER. RECEIVED	<input type="checkbox"/> LINE DIFF INTERTRIP RECEIVED
<input type="checkbox"/> LINE DIFF INTERTRIP SEND	<input type="checkbox"/> LINE DIFF INTERTRIP SEND
<input type="checkbox"/> LINE DIFF TRIP GENERAL	<input type="checkbox"/> LINE DIFF. TRIP GENERAL
<input type="checkbox"/> OVERCURRENT TRIP	<input type="checkbox"/> OVERCURRENT TRIP
<input type="checkbox"/> BACK DIST. PWR SWING BLOCK Z1	<input type="checkbox"/> THERMAL OVERLOAD ALARM
<input type="checkbox"/> BACK DIST. PWR SWING BLOCK Z2	<input type="checkbox"/> BLOCK AUTO RECLOSE
<input type="checkbox"/> BACK DIST. PWR SWING BLOCK Z3	
<input type="checkbox"/> BACK DIST. PWR SWING BLOCK Z3R	
<input type="checkbox"/> BLOCK AUTO RECLOSE	

LINE BAY CONTROLLER

<input type="checkbox"/> LCP AC MCB TRIP
<input type="checkbox"/> LCP DC MCB TRIP
<input type="checkbox"/> LINE VT MCB TRIP
<input type="checkbox"/> MASTER TRIP 1
<input type="checkbox"/> MASTER TRIP 2
<input type="checkbox"/> TRIP CIRCUIT SUPERVISION 1
<input type="checkbox"/> TRIP CIRCUIT SUPERVISION 2
<input type="checkbox"/> NULL
<input type="checkbox"/> SF6 COMPARTMENT STAGE 1
<input type="checkbox"/> SF6 COMPARTMENT STAGE 2
<input type="checkbox"/> CB SPRING UNCHARGED
<input type="checkbox"/> CRP AC MCB TRIP
<input type="checkbox"/> CRP DC MCB TRIP

LINE BREAKER MANAGEMENT

<input type="checkbox"/> AUTORECLOSE BLOCKED
<input type="checkbox"/> AUTORECLOSE IN ATTEMPTED
<input type="checkbox"/> AUTORECLOSE UNSUCCESSFUL
<input type="checkbox"/> AUTORECLOSE SYNCH FAIL
<input type="checkbox"/> NULL
<input type="checkbox"/> BREAKER FAIL STG 1 TRIP
<input type="checkbox"/> BREAKER FAIL STG 2 TRIP
<input type="checkbox"/> SYNCHRONISING CHECK FAILED
<input type="checkbox"/> BREAKER FAIL STG 2 MAIN 1 BUS TRIP
<input type="checkbox"/> BREAKER FAIL STG 2 RESERVE BUS TRIP

Area	Description	Status	AlarmTime	Value	Severity	Acked	Operator
✖ BAY E06.F34BSC.BUS SECTION BAY CONTROLLER	LCP AC MCB TRIP	OPERATED	07-May-15 00:17:01 914 PM	1	High	Yes	a
✖ BAY E06.F34BSC.BUS SECTION BAY CONTROLLER	LOSS CLK SYNCH	OPERATED	07-May-15 07:01:28 022 PM	0	Low	Yes	a
✖ BAY E12.F52LBM.LINE BREAKER MANAGEMENT	AUTORECLOSE SWITCH	OFF	07-May-15 07:01:28 022 PM	0	Low	Yes	a
✖ BAY E10.F11T2.TRANSFORMER PROTECTION 2	LOSS CLK SYNCH	OPERATED	07-May-15 05:54:36 038 PM	1	Low	Yes	a
✖ BAY IED STATUS	SC132kV	IED Connection Lost	07-May-15 05:40:22 526 PM	0	High		
✖ BAY IED STATUS	SC33kV	IED Connection Lost	07-May-15 05:40:22 526 PM	0	High		
✖ BAY H01	LOSS CLK SYNCH	OPERATED	07-May-15 04:19:32 448 PM	1	High		
✖ BAY E02.F11LP2.LINE PROTECTION 2	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32 448 PM	1	High		
✖ KEST.T1N1	Status Change	Intermediate	07-May-15 04:19:32 448 PM	2	High		
✖ BAY E01.F34LC.LINE BAY CONTROLLER	UNDERVOLTAGE PROT. MODE	OPERATED	07-May-15 04:19:32 448 PM	2	High		
✖ BAY E10.F11T1.TRANSFORMER MONITORING	AIR BAG LEAKAGE ALARM	OPERATED	07-May-15 04:19:32 448 PM	1	High		
✖ BAY E10.F11T1M.TRANSFORMER MONITORING	OLTC CONS. TANK HIGH OIL LVL	OPERATED	07-May-15 04:19:32 448 PM	1	High		
✖ BAY E01.F11LP2.LINE PROTECTION 2	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32 448 PM	1	High		
✖ KEST.T2N1	Status Change	Intermediate	07-May-15 04:19:32 448 PM	2	High		
✖ BAY E12.F11LP2.LINE PROTECTION 2	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32 448 PM	1	High		
✖ BAY E11.F11LP1.LINE PROTECTION 1	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32 448 PM	1	High		

Fascia page

SMART SUBSTATION (TNB)

Station Level Operator Interface - Frame Title

TENAGA NASIONAL BERHAD System Single Lines Bay List Trending Summary Administration Logout Logged in as: a Exit 5/7/15 8:27:31 PM

E05

STATION

R-Y	0	kV
Y-B	0	kV
B-R	0	kV
R	0	A
Y	0	A
B	0	A
R-N	0	kV
Y-N	0	kV
B-N	0	kV
f	0	Hz
PF	0	
	0	MW
	0.1	MVAR

CONTROL **FASCIA** **RTCC**

HV Winding Temperature: **32.000** °C
 LV Winding Temperature: **31.700** °C
 Oil Temperature: **32.000** °C
 Ambient Temperature: **0.000** °C

Master Trip Relay: **NORMAL**

Permissive Close CB from LV: **NOT AVAILABLE**

LOAD SHEDDING SELECTION

Underfrequency Stage 1: **NORMAL**
 Underfrequency Stage 2: **NORMAL**

SEQUENCE CONTROL

Energize on Main Busbar for Transformer
 Energize on Reserve Busbar for Transformer
 De-Energize Transformer on Main Busbar
 De-Energize Transformer on Reserve Busbar
 Live Load Transfer from MBB to RBB for Transformer - Single Bay
 Live Load Transfer from RBB to MBB for Transformer - Single Bay

Trip Counter

RESET

Auto	9
Manual	8

Area	Description	Status	AlarmTime	Value	Severity	Acked	Operator
BAY.IED STATUS	SC132kV	IED Connection Lost	07-May-15 05:40:22.526 PM	0	High	Yes	a
BAY.IED STATUS	SC33kV	IED Connection Lost	07-May-15 05:40:22.526 PM	0	High	Yes	a
BAY.H01	LOSS CLCK SYNCH	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
BAY.E02.F11LP2.LINE PROTECTION 2	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
KEST.T1N1	Status Change	Intermediate	07-May-15 04:19:32.448 PM	2	Low	Yes	a
BAY.E01.F34LC.LINE BAY CONTROLLER	UNDERVOLTAGE PROT. MODE	OPERATED	07-May-15 04:19:32.448 PM	2	High	Yes	a
BAY.E10.F11TM.TRANSFORMER MONITORING	AIR BAG LEAKAGE ALARM	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
BAY.E10.F11TM.TRANSFORMER MONITORING	OLTC CONS. TANK HIGH OIL LVL	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
BAY.E01.F11LP2.LINE PROTECTION 2	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
KEST.T2N1	Status Change	Intermediate	07-May-15 04:19:32.448 PM	2	Low	Yes	a
BAY.E12.F11LP2.LINE PROTECTION 2	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
BAY.E11.F11LP1.LINE PROTECTION 1	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a
BAY.E01.F11LP1.LINE PROTECTION 1	LINE DIFF COMM FAULTY	OPERATED	07-May-15 04:19:32.448 PM	1	High	Yes	a

RTCC Step Position

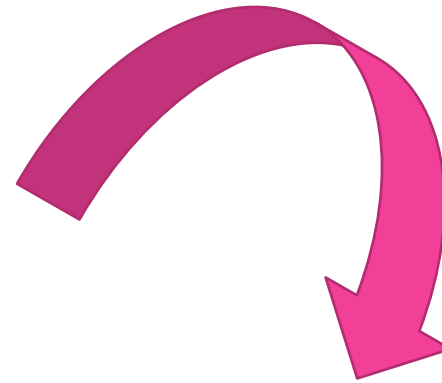
SMART SUBSTATION (TNB)

OPERATION SELECTOR:
KEST_SYS_1.E01F34LC.E01F34LCSystem.DataSets.
[LLN0\$dsSLO1_Digital].[XCBR1\$ST\$Pos]

KEST.E01.[205]

Operate **Block**

Abort



SELECT:
KEST_SYS_
1.E01F34LC.E01F34LCControl.CSWI1.CO.Pos

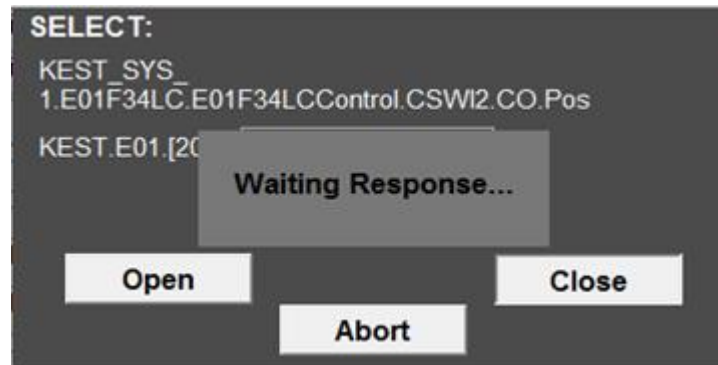
KEST.E01.[205]

Open **Close**

Abort

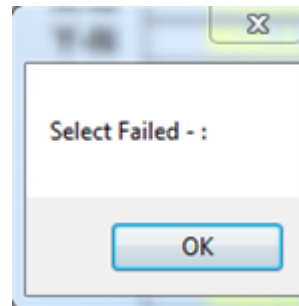
SMART SUBSTATION (TNB)

When the control command is in progress the display 'Waiting Response' will be shown below:



The timeout for Control Operation = 20s.

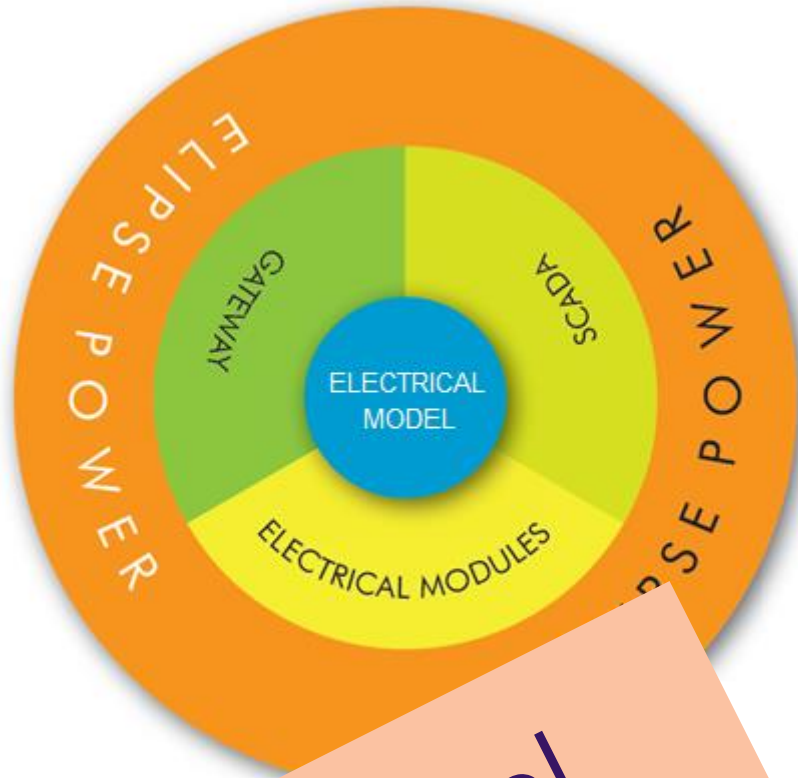
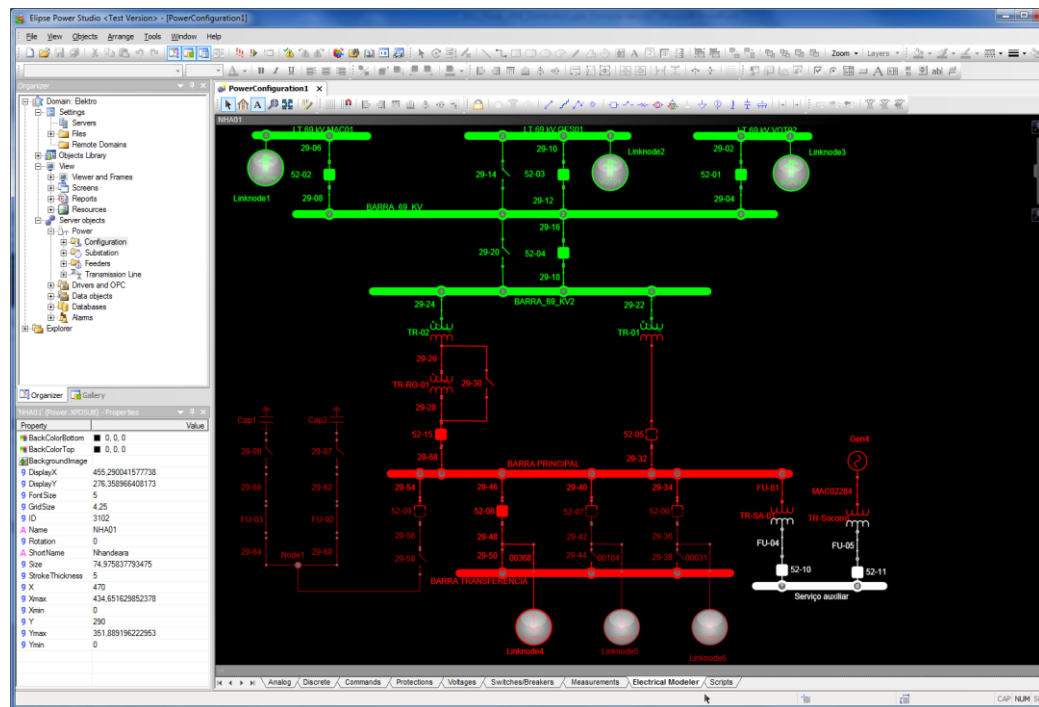
In such if the control failed, the pop up menu will show:



SMART SUBSTATION (TNB)


0 = Terminated OK	117 = AppError:AbortionByTrip
2 = Select Accepted	118 = AppError:ObjectNotSelected
3 = Select With Value Accepted	200 = WriteError:Object_invalidated
4= Cancel Accepted	201 = WriteError:Hardware_fault
5 = Operate Accepted	202 = WriteError:Temporarily_unavailable
50 = Terminate Fail	203 = WriteError:Object_access_denied
100 = AppError:Unknown	204 = WriteError:Object_undefined
101 = AppError:NotSupported	205 = WriteError:Invalid_address
102 = AppError:BlockedBySwitchingHierarchy	206 = WriteError:Type_unsupported
103 = AppError:SelectFailed	207 = WriteError:Type_inconsistent
104 = AppError:InvalidPosition	208 = WriteError:Object_attribute_inconsistent
105 = AppError:PositionReached	209 = WriteError:Object_access_unsupported
106 = AppError:ParameterChangeInExecution	210 = WriteError:Object_non_existent
107 = AppError:StepLimit	211 = WriteError:Object_value_invalid
108 = AppError:BlockedByMode	212 = WriteError:Error_unknown
109 = AppError:BlockedByProcess	213 = WriteError:Timeout
110 = AppError:BlockedByInterlocking	214 = WriteError:OutOfMemory
111 = AppError:BlockedBySynchrocheck	215 = WriteError:DecodeError
112 = AppError:CommandAlreadyInExecution	216 = WriteError:WrongParameters
113 = AppError:BlockedByHealth	217 = WriteError:CmdnotSupported
114 = AppError:1_Of_N_Control	
115 = AppError:AbortionByCancel	
116 = AppError:TimeLimitOver	

SMART SUBSTATION (TNB)



Tool

SMART SUBSTATION (TNB)

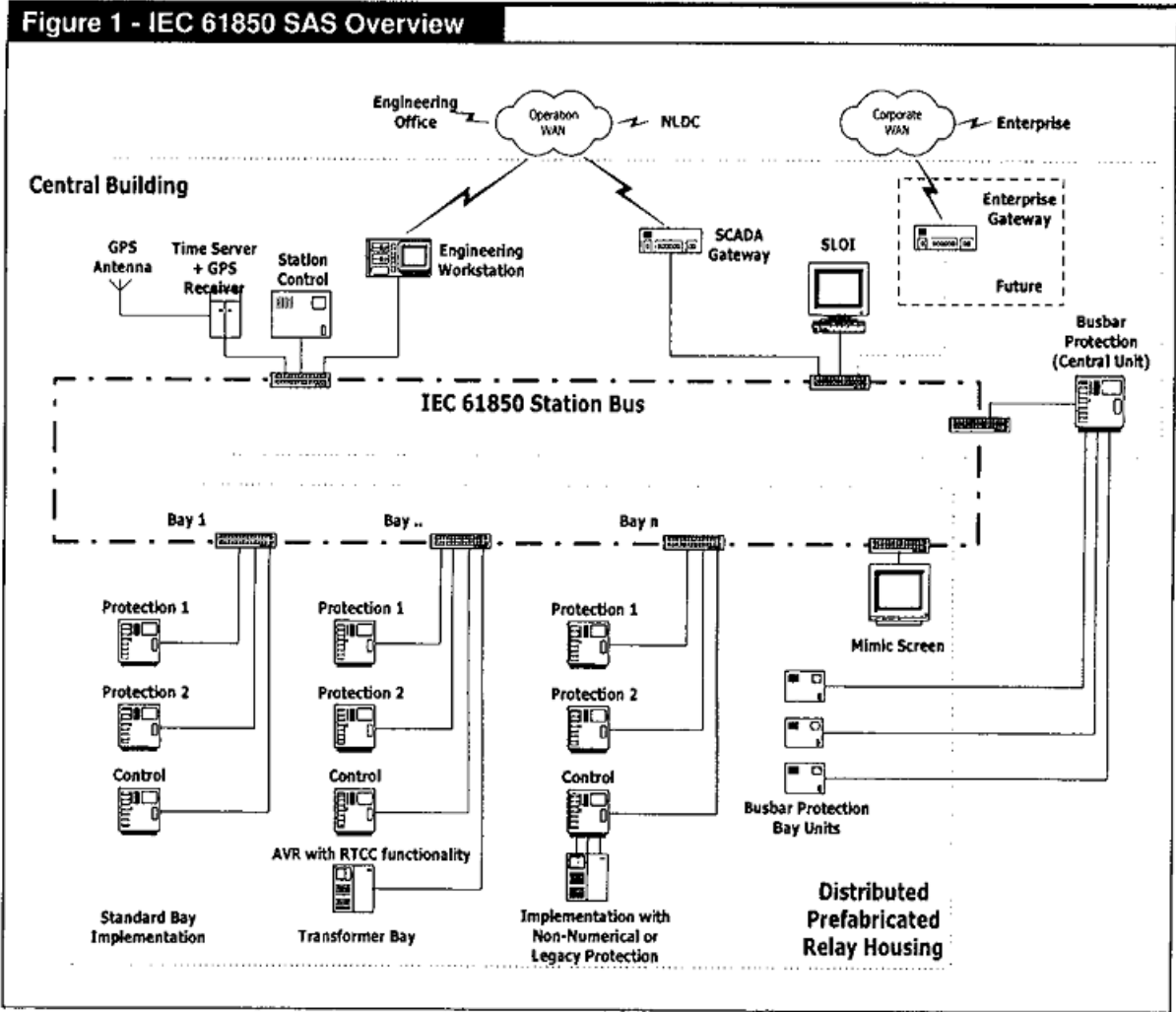
TENAGA NASIONAL BERHAD							
	Telecontrol Section Engineering Department Transmission Division Tenaga Nasional Berhad (200866-W)			IEC 61850 SUBSTATION AUTOMATION SYSTEM(SAS) STATION LEVEL OPERATOR INTERFACE (SLOI) EQUIPMENT SPECIFICATION			
	Doc. No.	TNBT-TELE-SAS-SPEC-2	Rev. No.	1	Date	30/5/2008	Page

IEC 61850 SUBSTATION AUTOMATION SYSTEM (SAS) STATION LEVEL OPERATOR INTERFACE (SLOI) EQUIPMENT SPECIFICATION



Prepared by:
 Telecontrol Section, Engineering Department
 Transmission Division

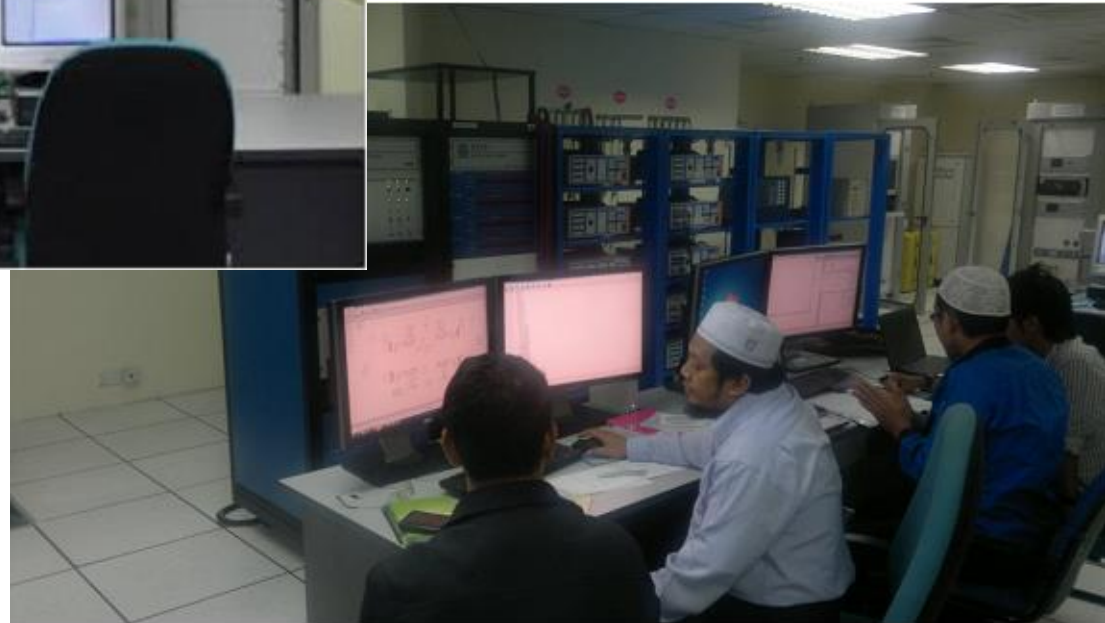
SMART SUBSTATION (TNB)



SMART SUBSTATION (TNB)



TNB SVS Lab in TNB Research Sdn Bhd.



Research and Development on Substation Automation System Based on IEC61850 for Optimal Substation Design in TNB

OUTLINE

What is Smart Substation?

Case Study

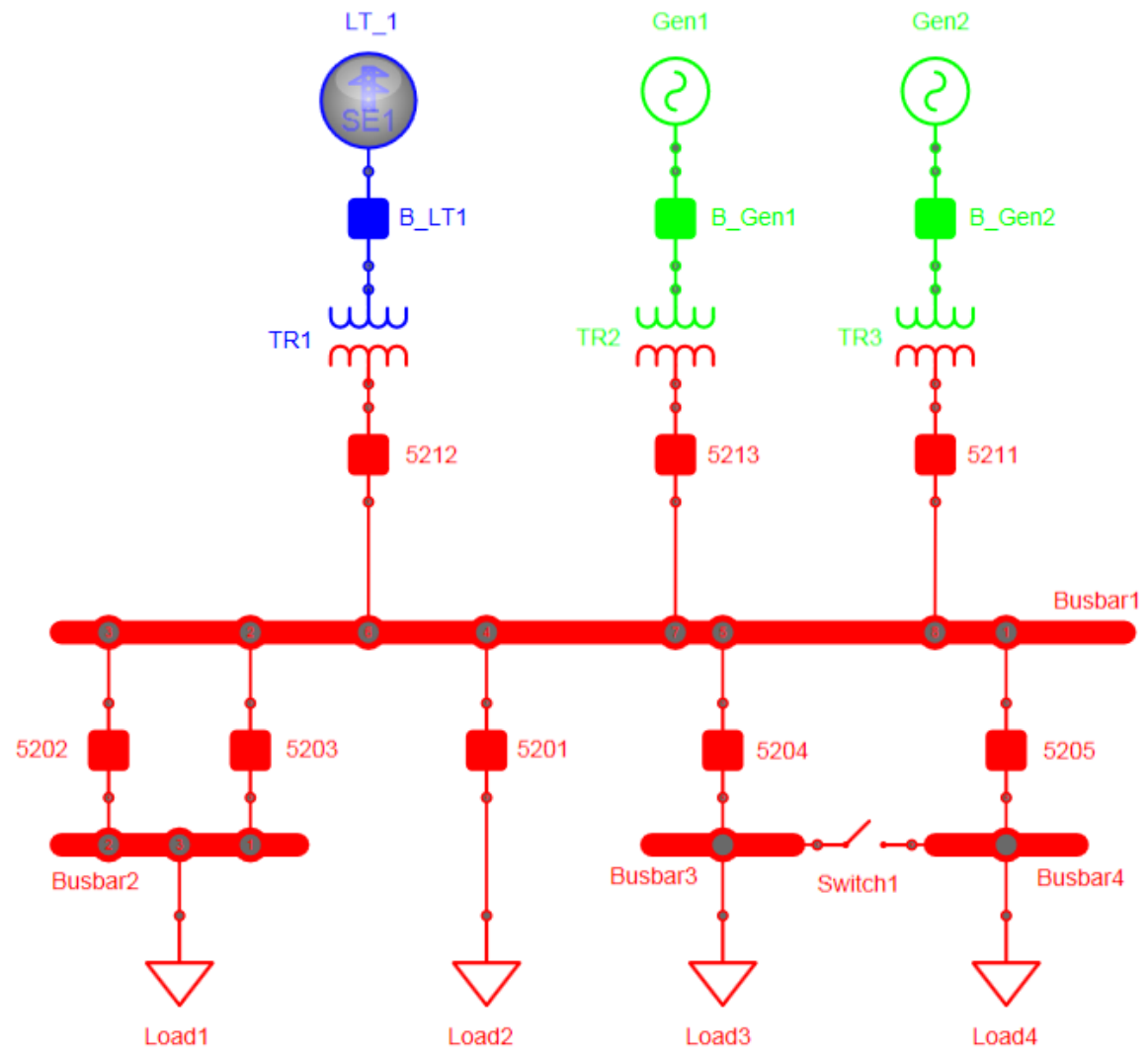
Malaysia (Smart Substation)

Brazil (Smart Load Shedding)

Taiwan (Micro Grid Protection)

Conclusion

SMART LOAD SHEDDING

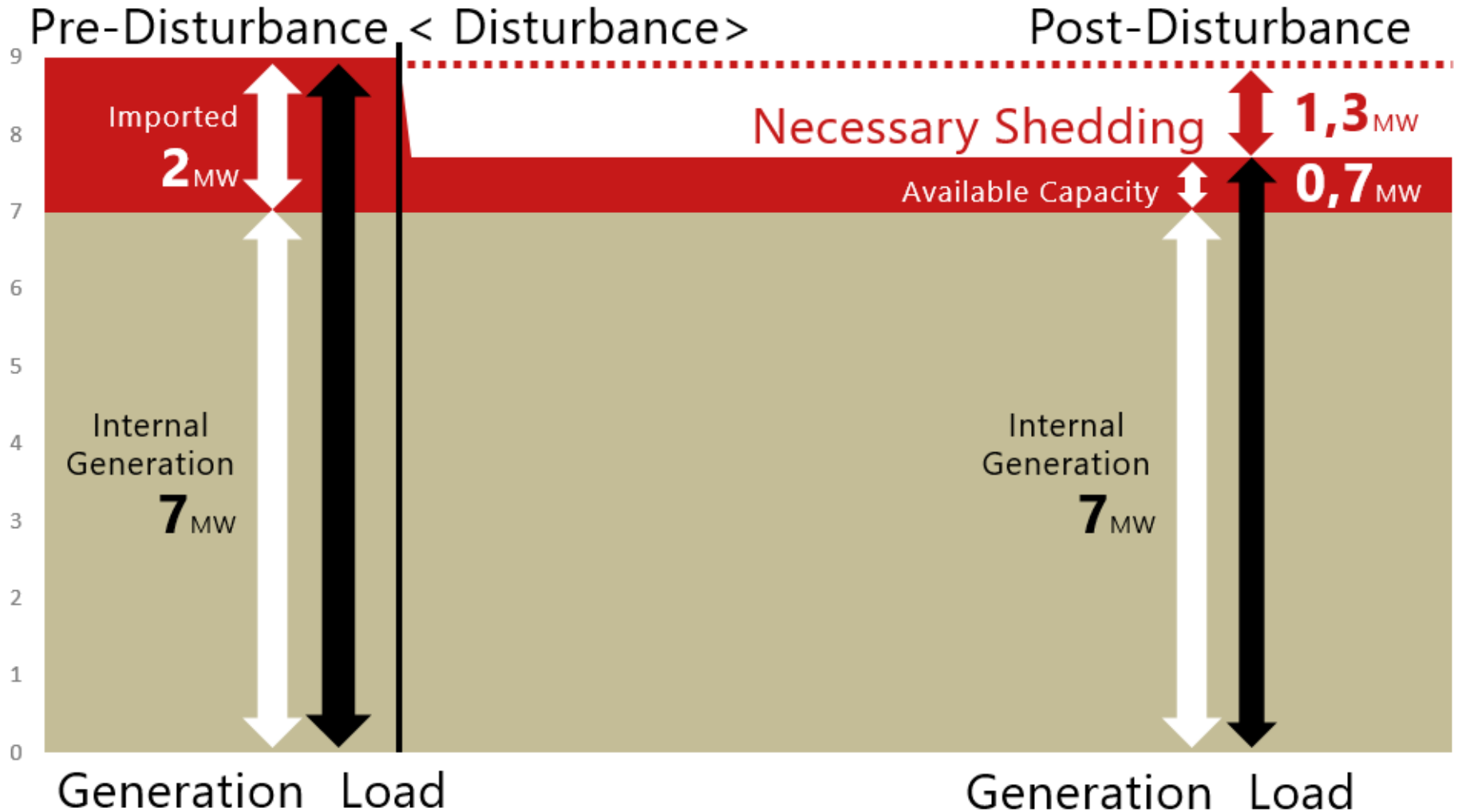


SMART LOAD SHEDDING

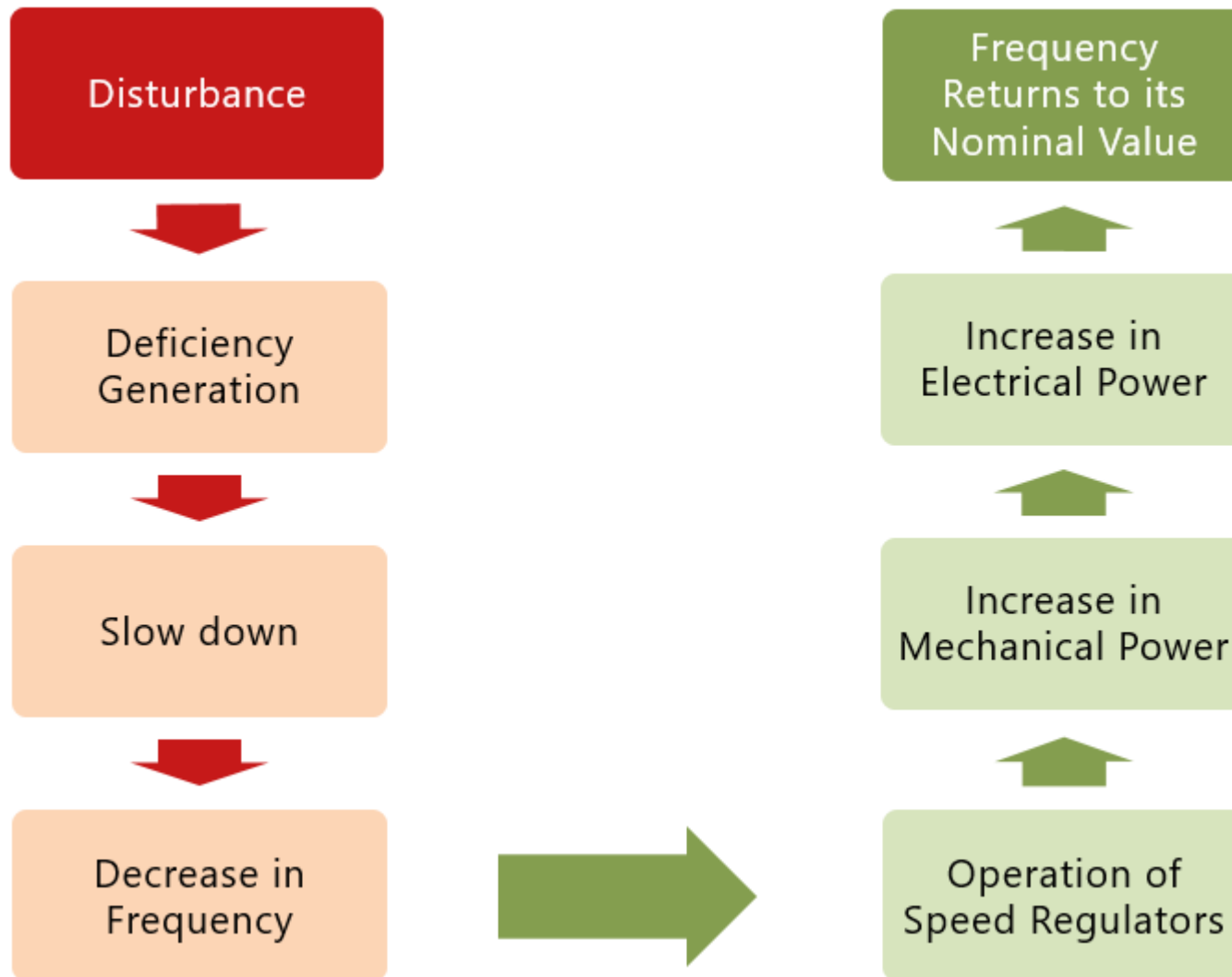
Provide power To all loads
Maintain V and F



SMART LOAD SHEDDING

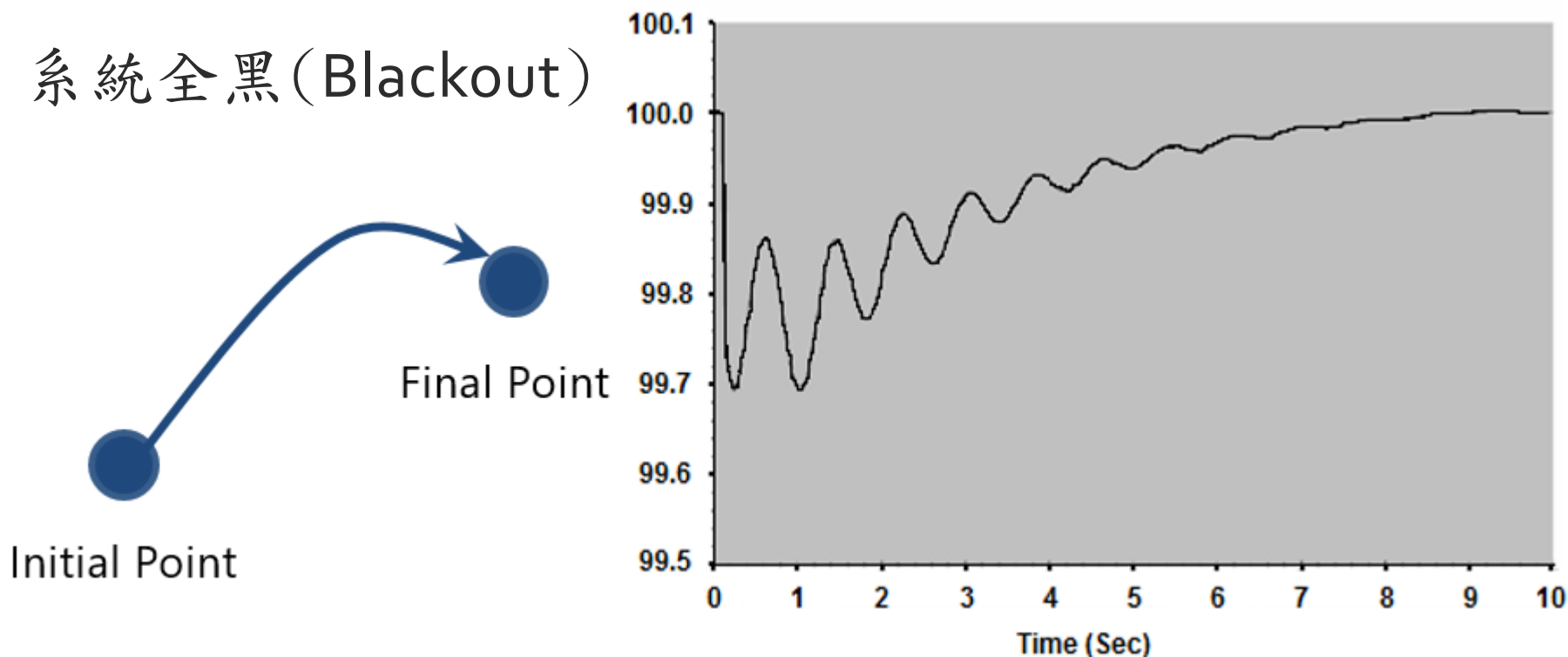


SMART LOAD SHEDDING



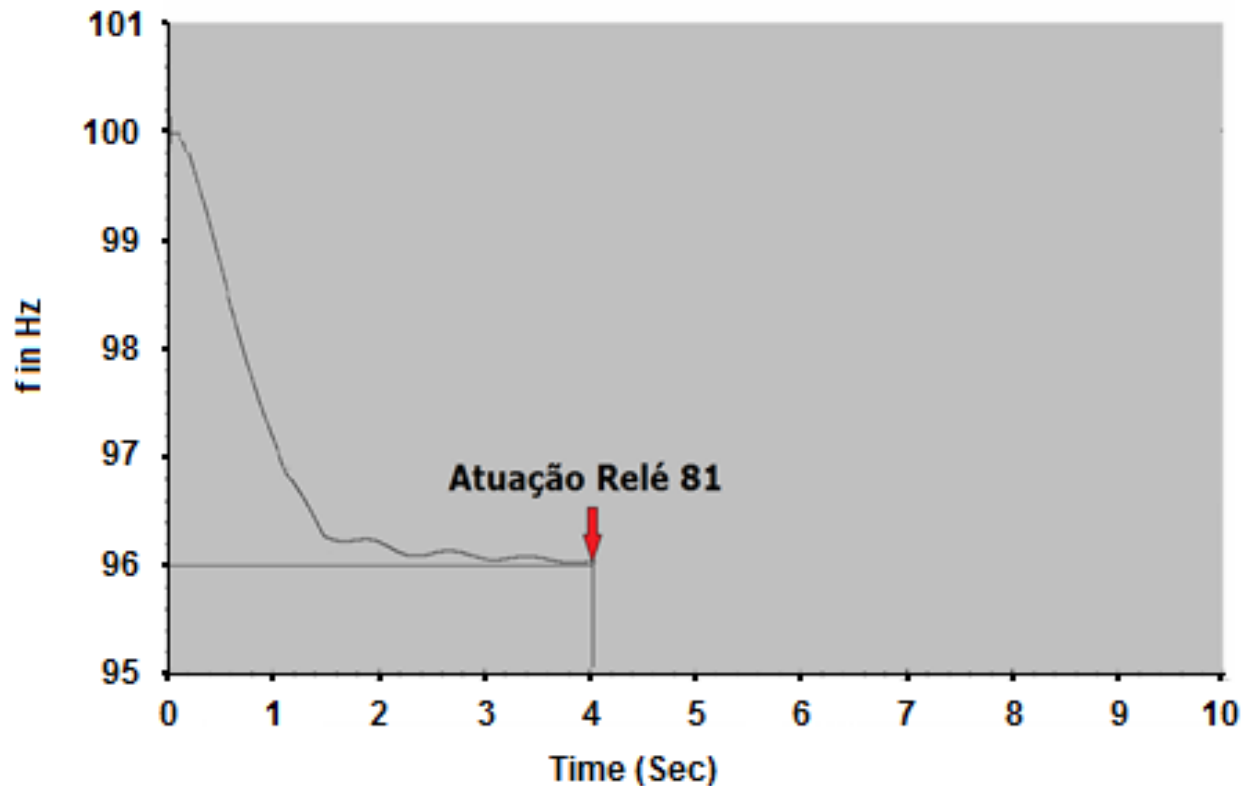
SMART LOAD SHEDDING

供電系統受到突發性干擾導致瞬間供電容量不足時，系統必須能盡速調整到穩定平衡的狀態以避免系統全黑 (Blackout)



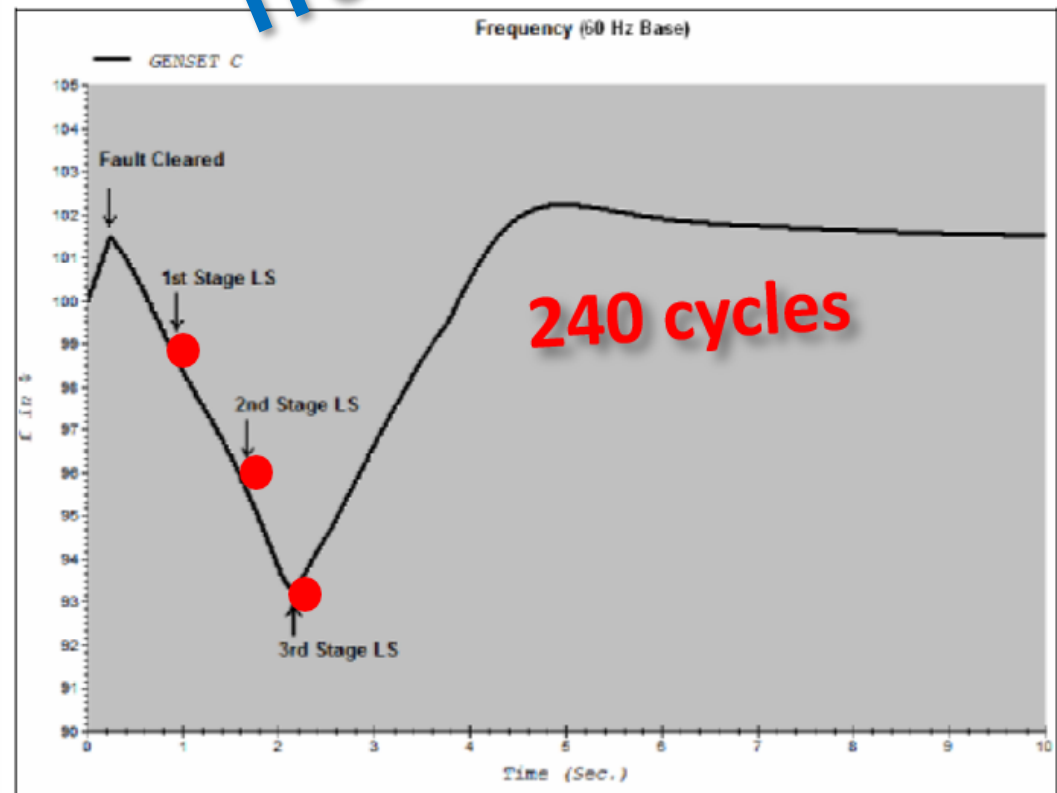
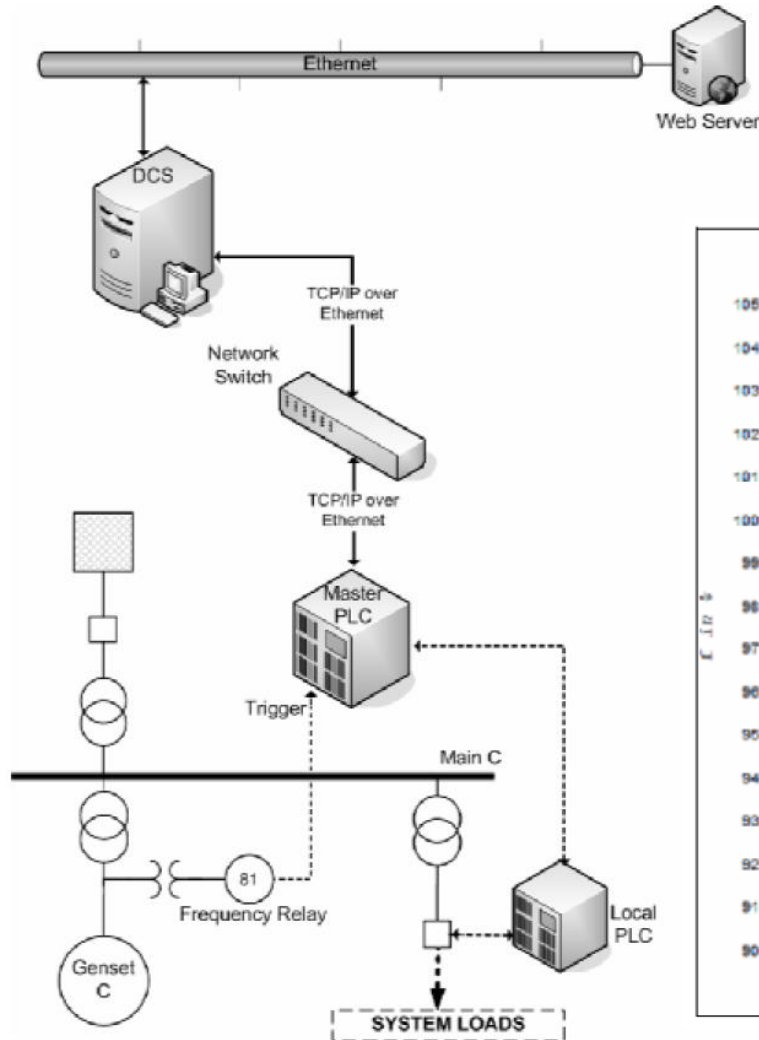
SMART LOAD SHEDDING

頻率突降可能導致發電機低頻保護跳脫，系統供電中斷。



SMART LOAD SHEDDING

Traditional

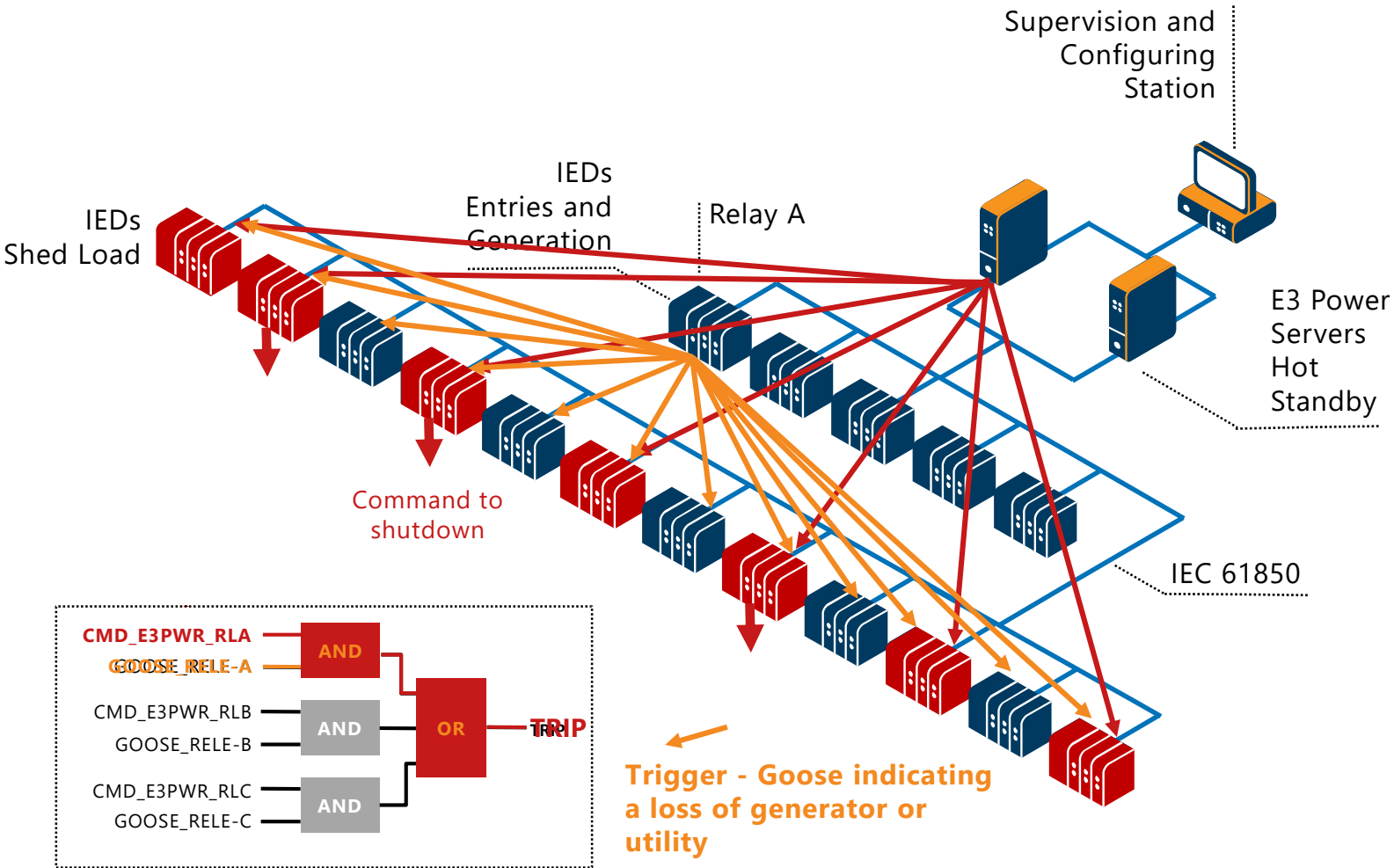


SMART LOAD SHEDDING

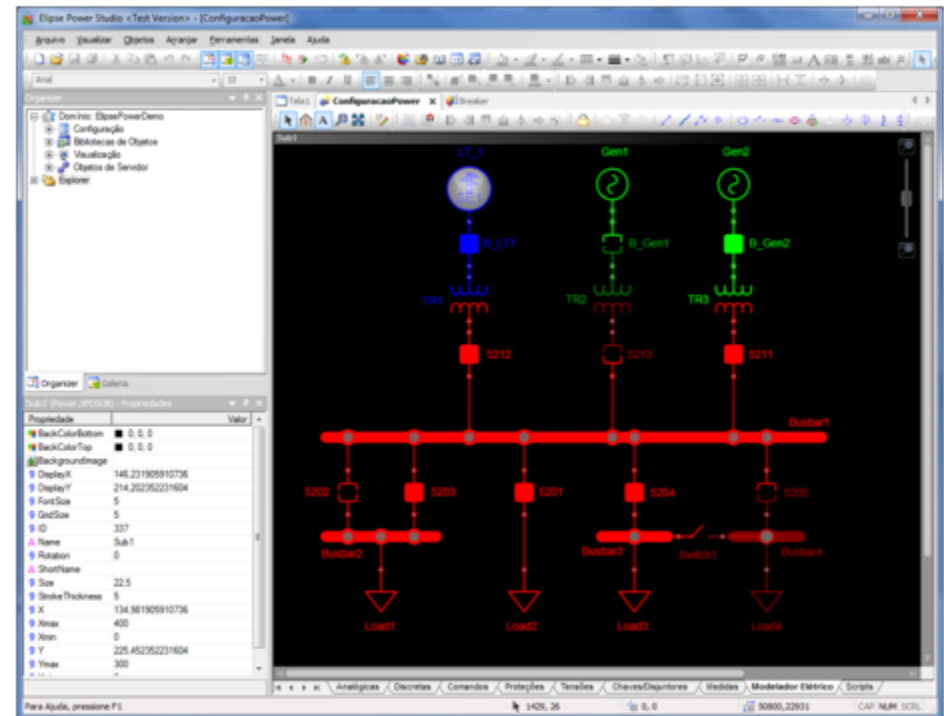
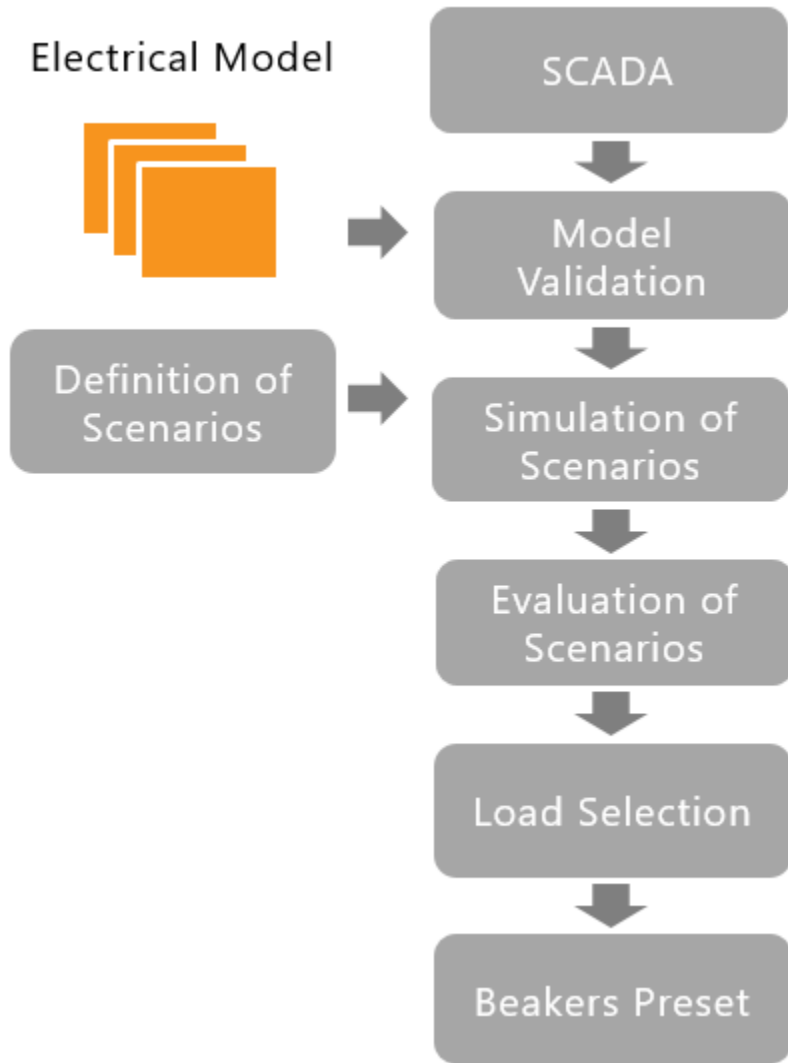
- 隔離最少化的負載 (Minimized), 降低對製程的影響
- 最佳化可使用之發電機的備載容量 (spinning reserve)
- 彈性可規劃的負載重要性的等級
- 快速動態分析電力潮流以及預先Pre-Set 要切斷的開關群及切斷的優先次序
- 100 ms 以內完成卸載, 達到系統平衡

GOOSE

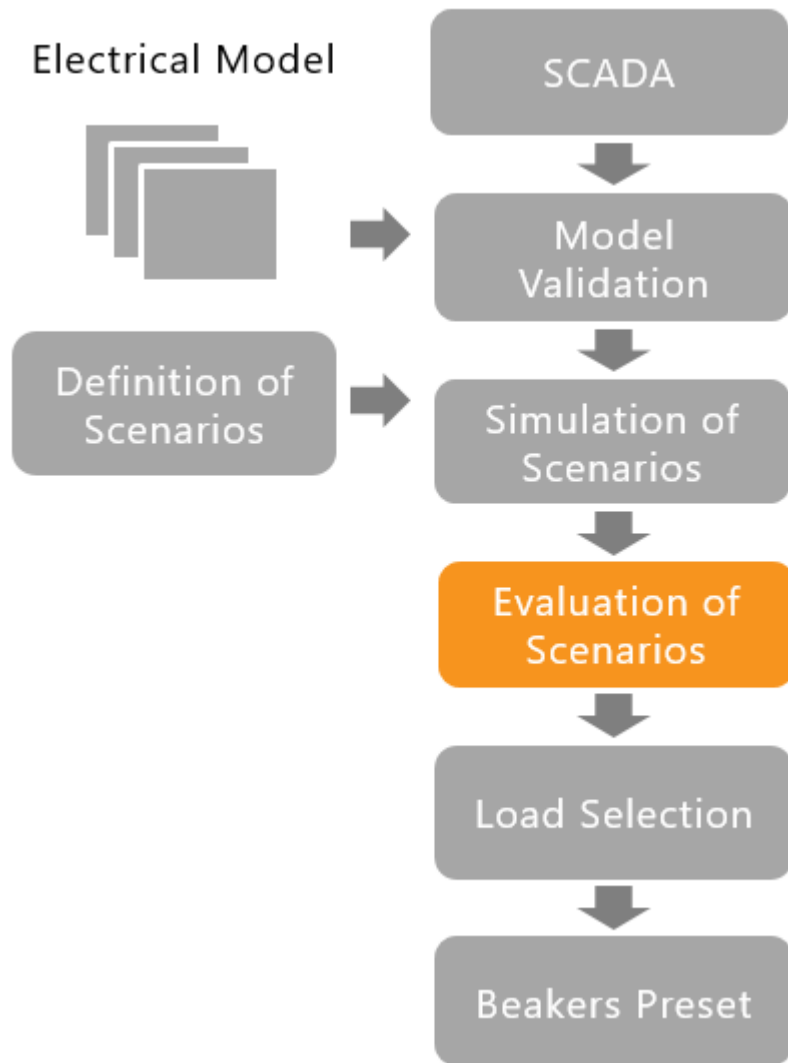
SMART LOAD SHEDDING



SMART LOAD SHEDDING

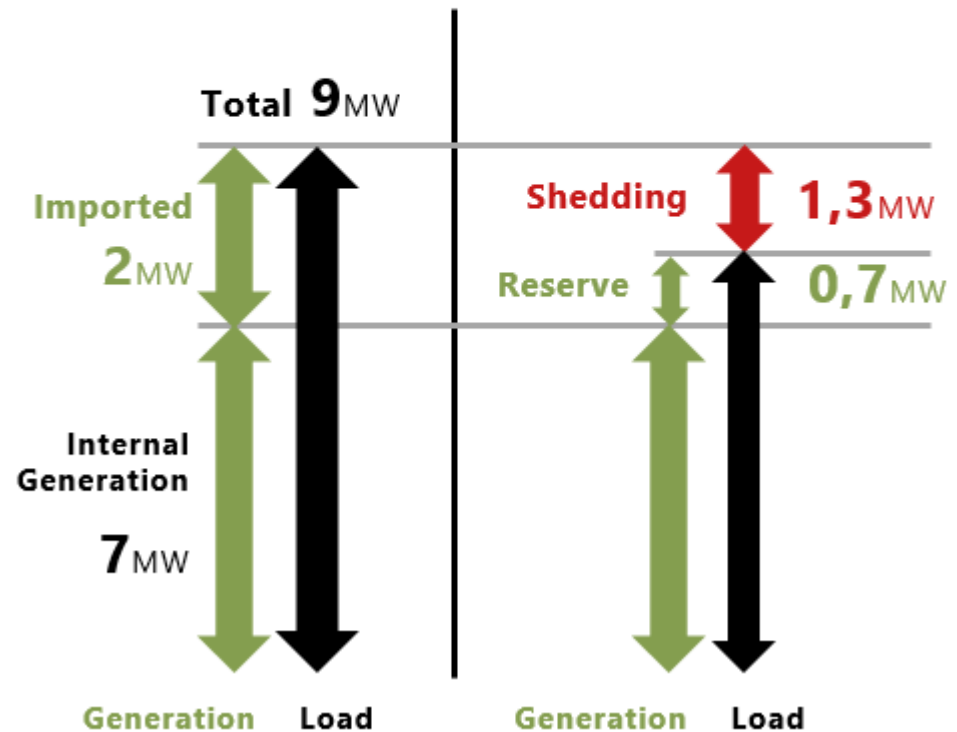


SMART LOAD SHEDDING



$$P_{shedding} = P_{simulated} - P_{reserve} - P_{measured}$$

Normal Condition < **Disturbance** > Main Supplier Loss



SMART LOAD SHEDDING

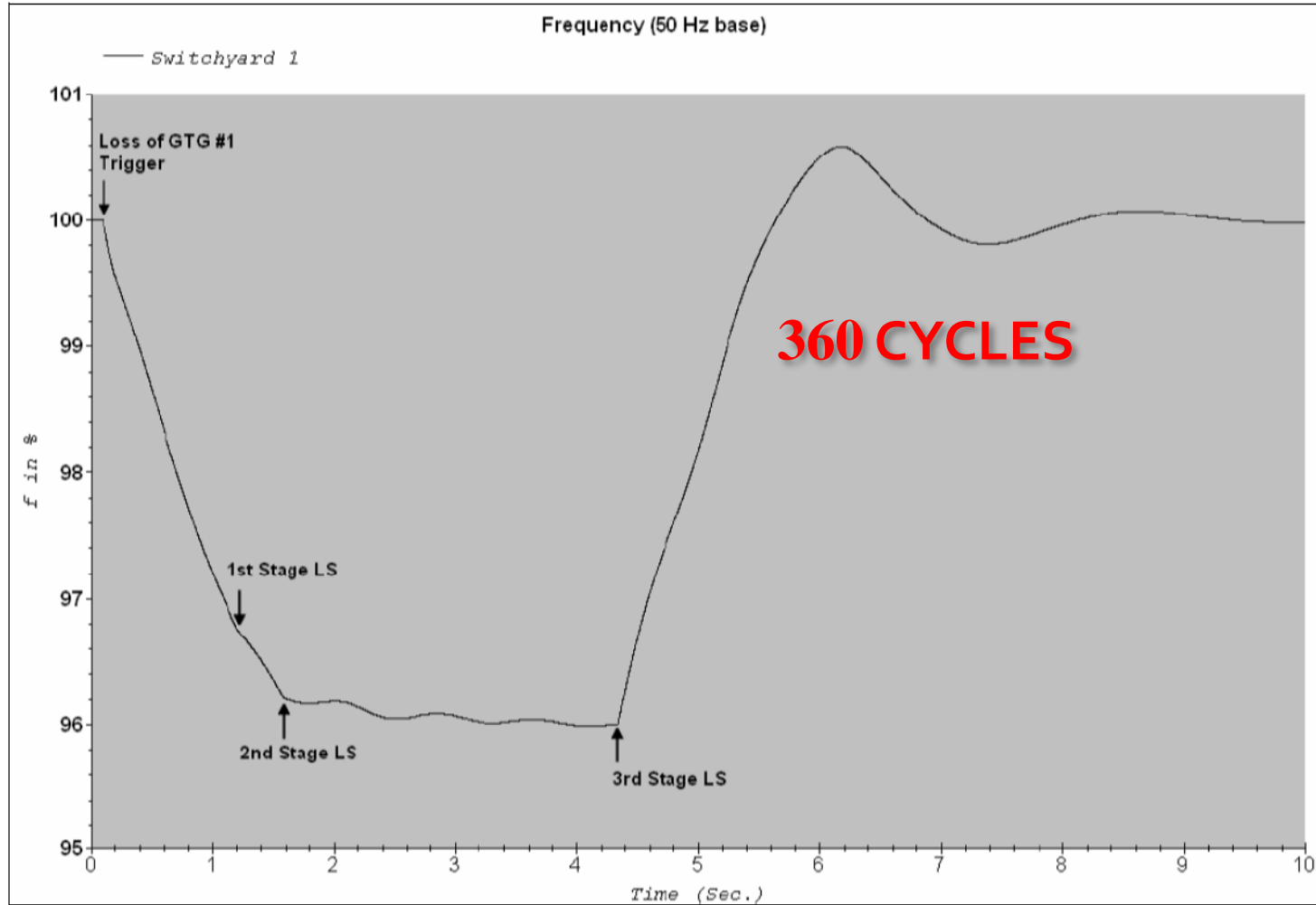


Fig. 8. Frequency Response for Load Shedding Stages

SMART LOAD SHEDDING

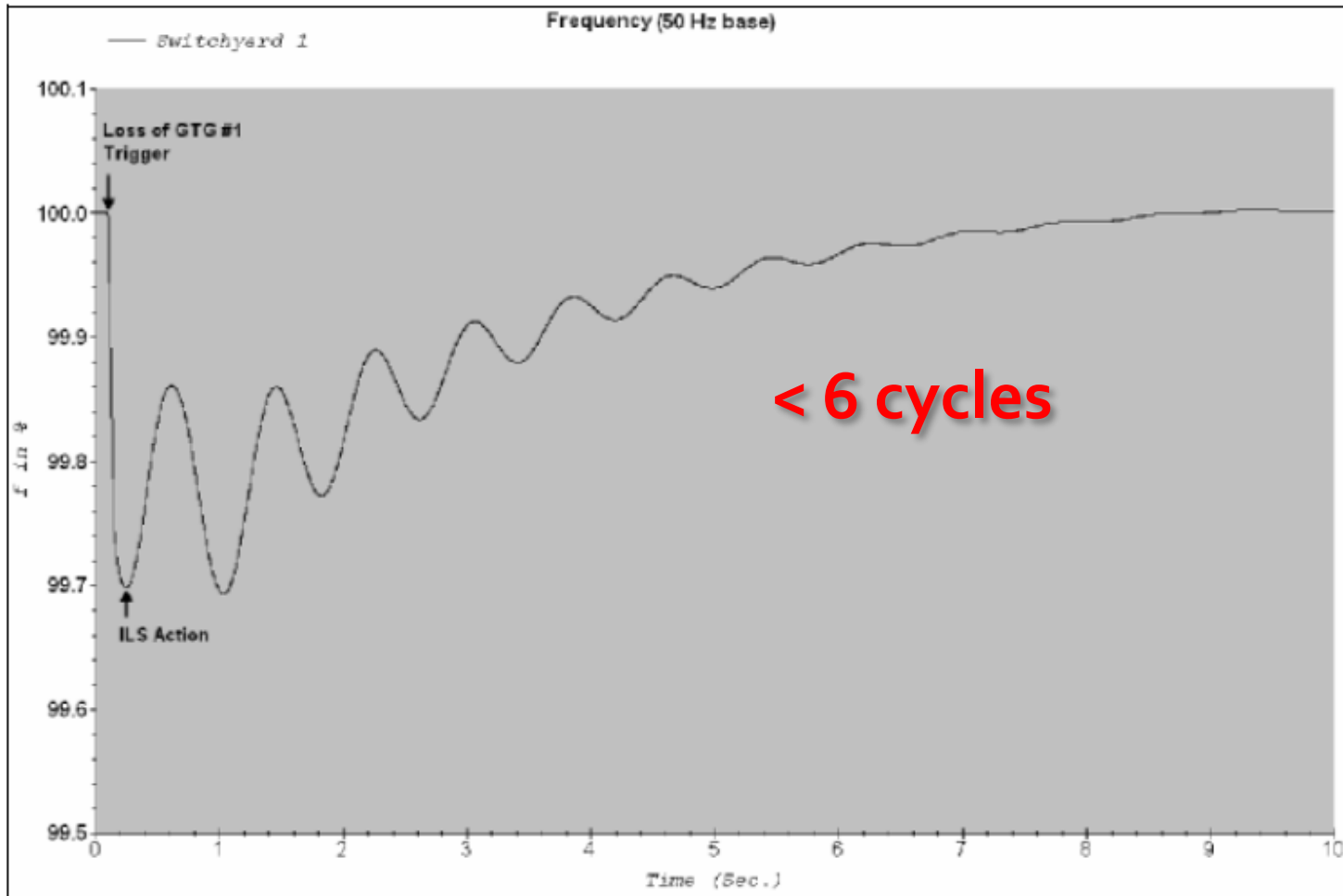


Fig. 10. Frequency Response with ILS Scheme

Reference from "Intelligent Load Shedding Need for a Fast and Optimal Solution," IEEE PCIC Europe 2005

OUTLINE

What is Smart Substation?

Case Study

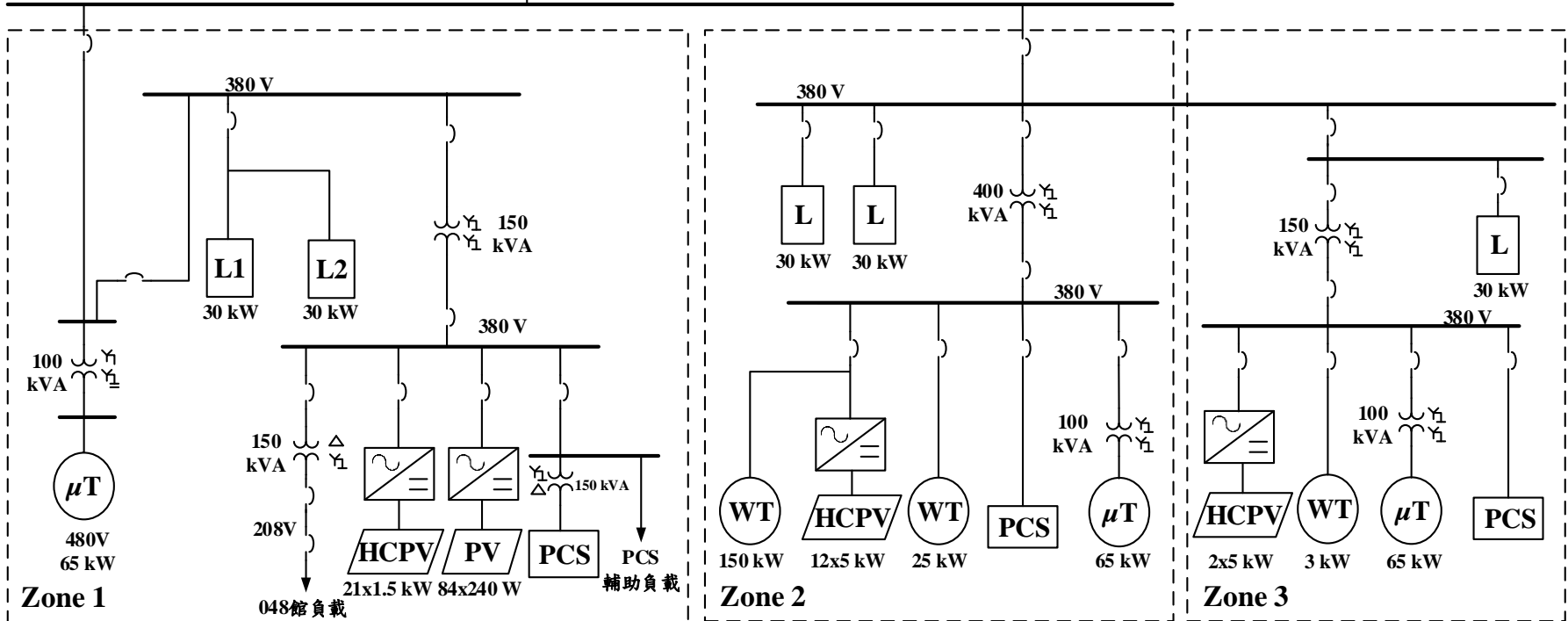
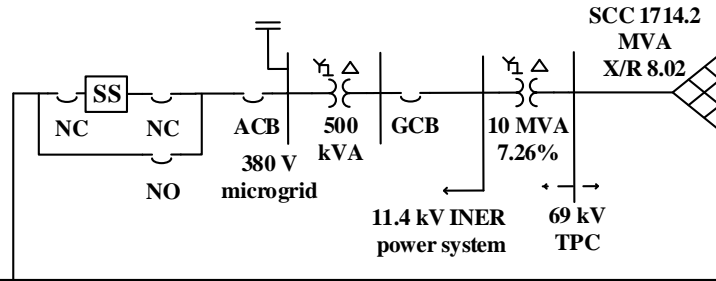
Malaysia (Smart Substation)

Brazil (Smart Load Shedding)

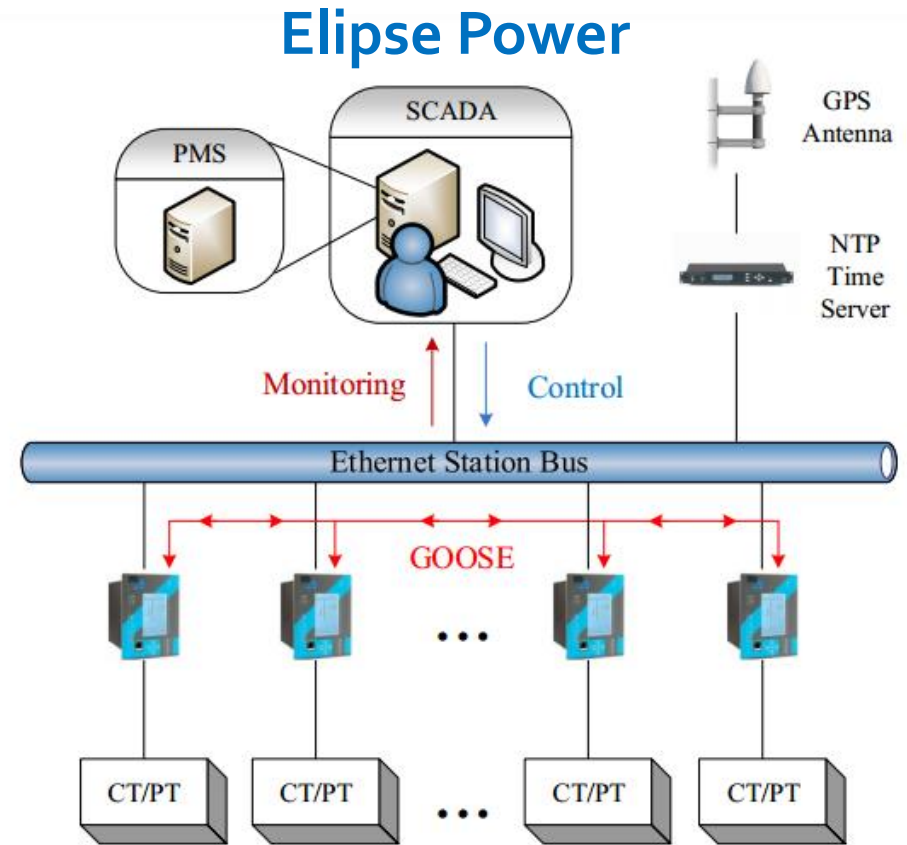
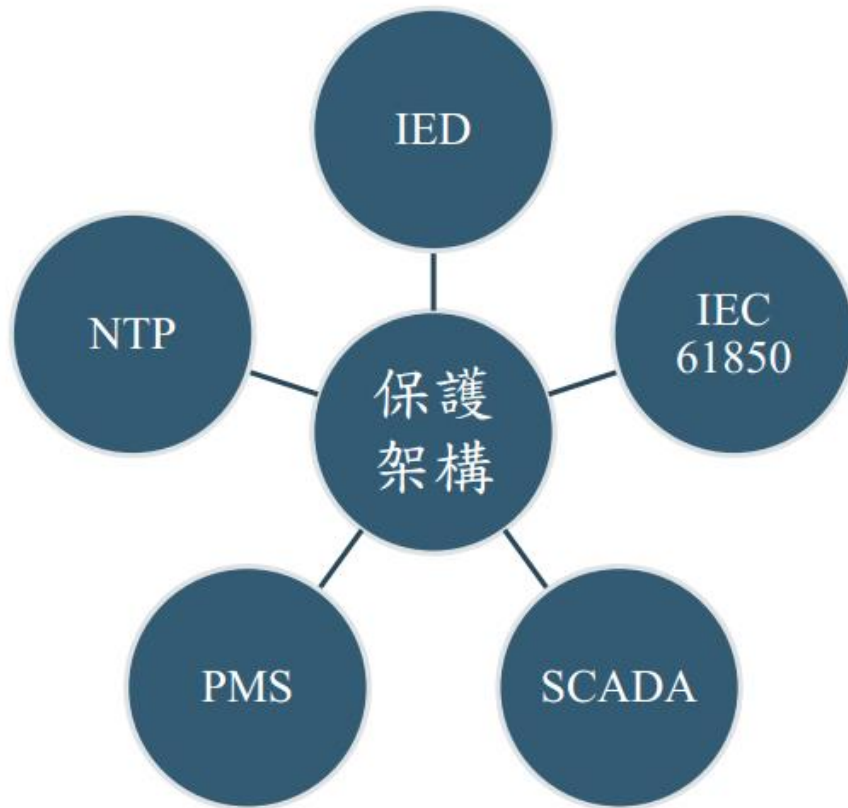
Taiwan (Micro Grid Protection)

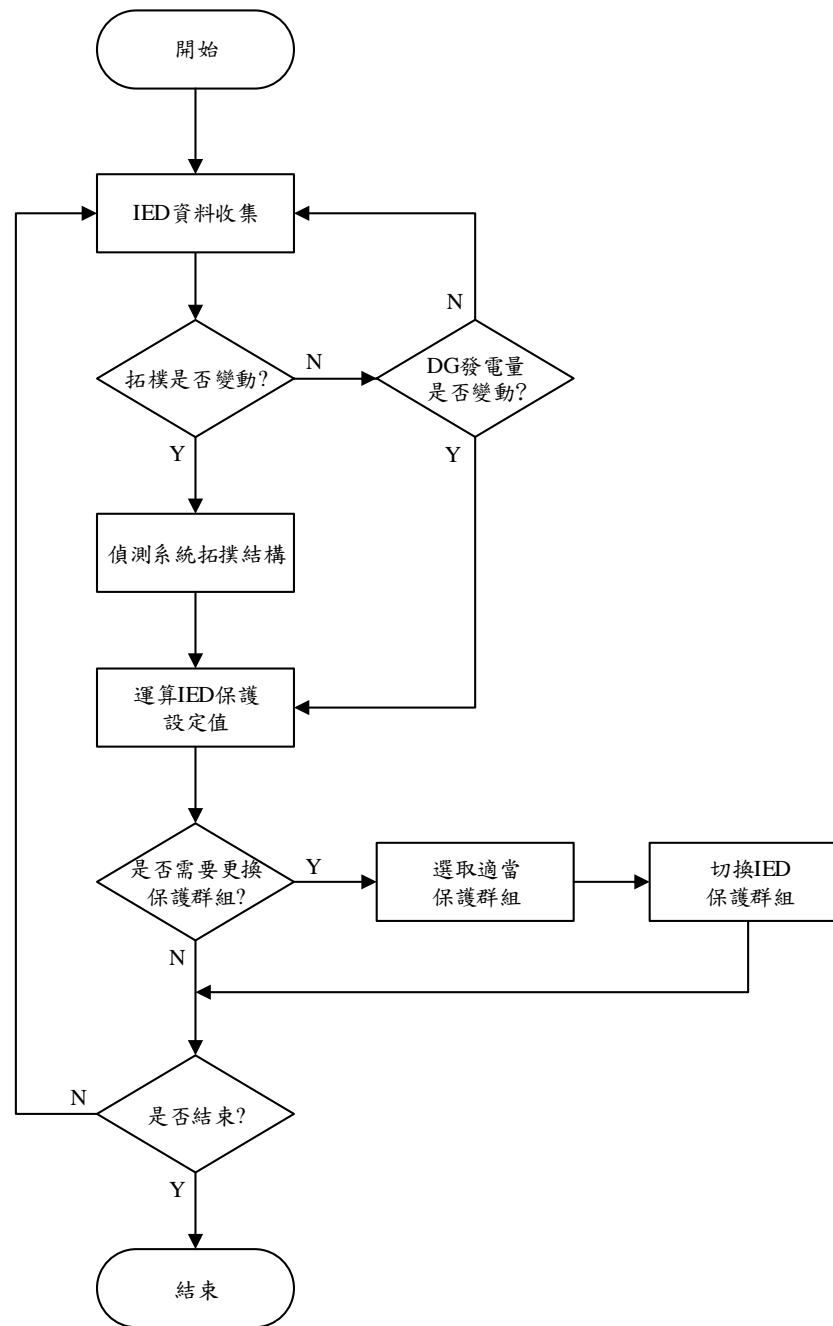
Conclusion

MICRO GRID PROTECTION

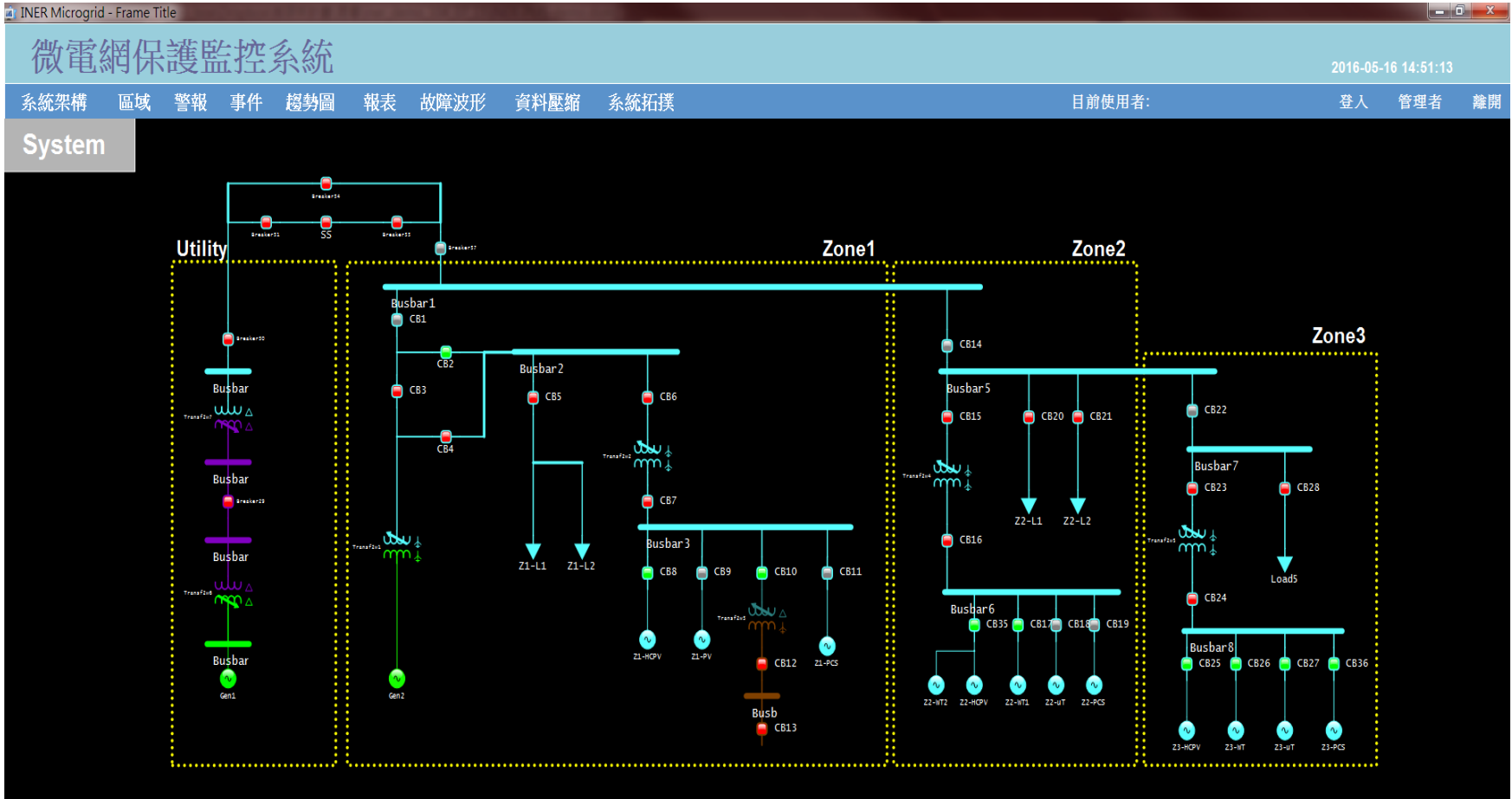


MICRO GRID PROTECTION

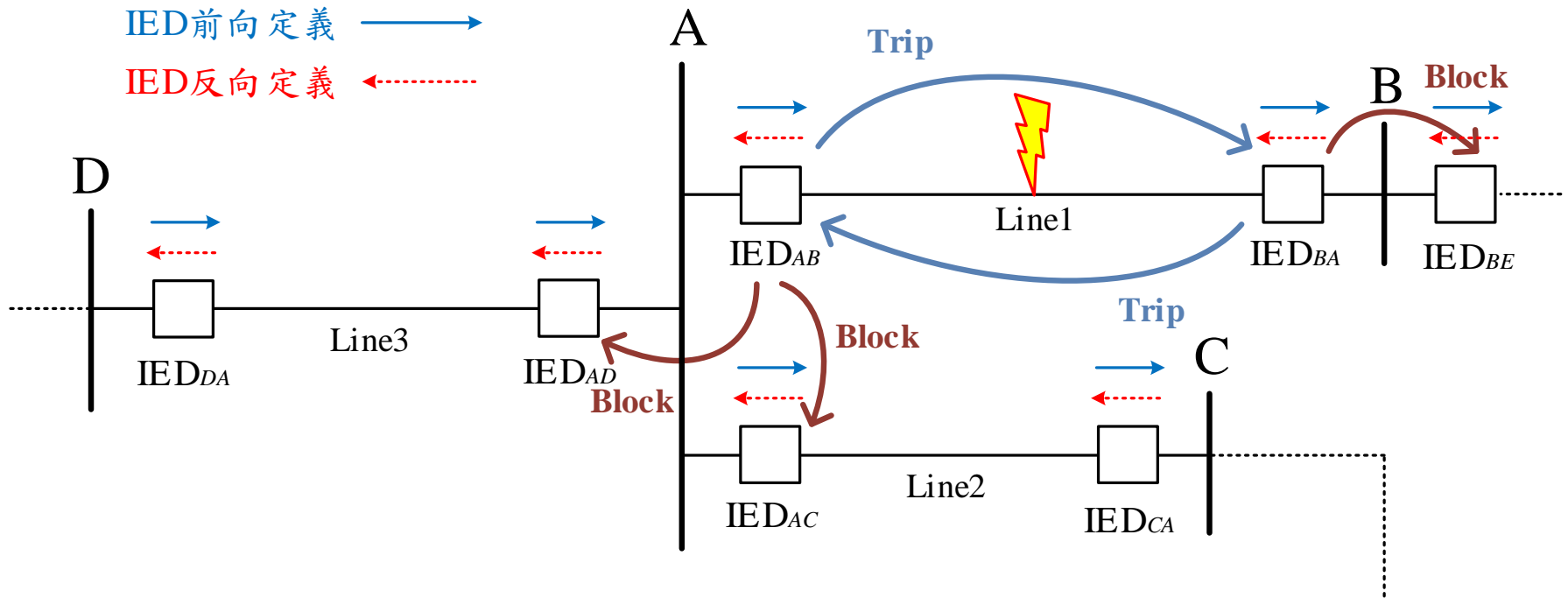




MICRO GRID PROTECTION

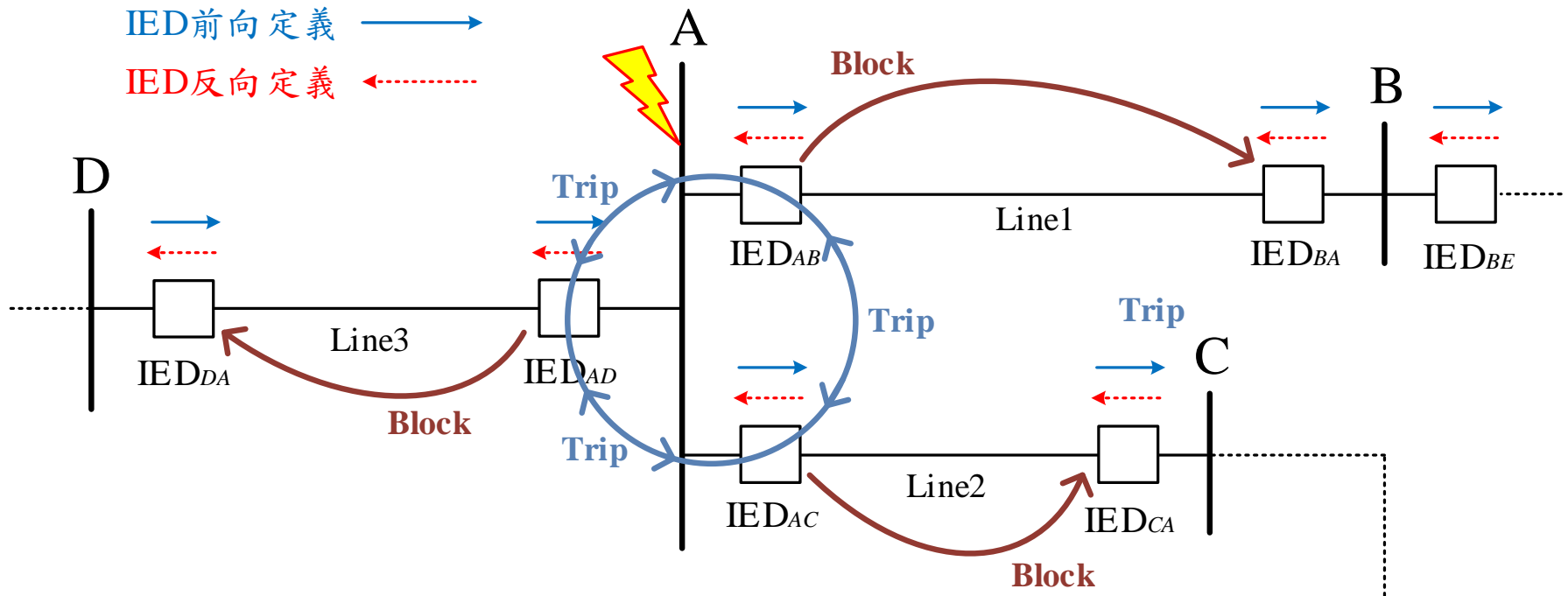


MICRO GRID PROTECTION



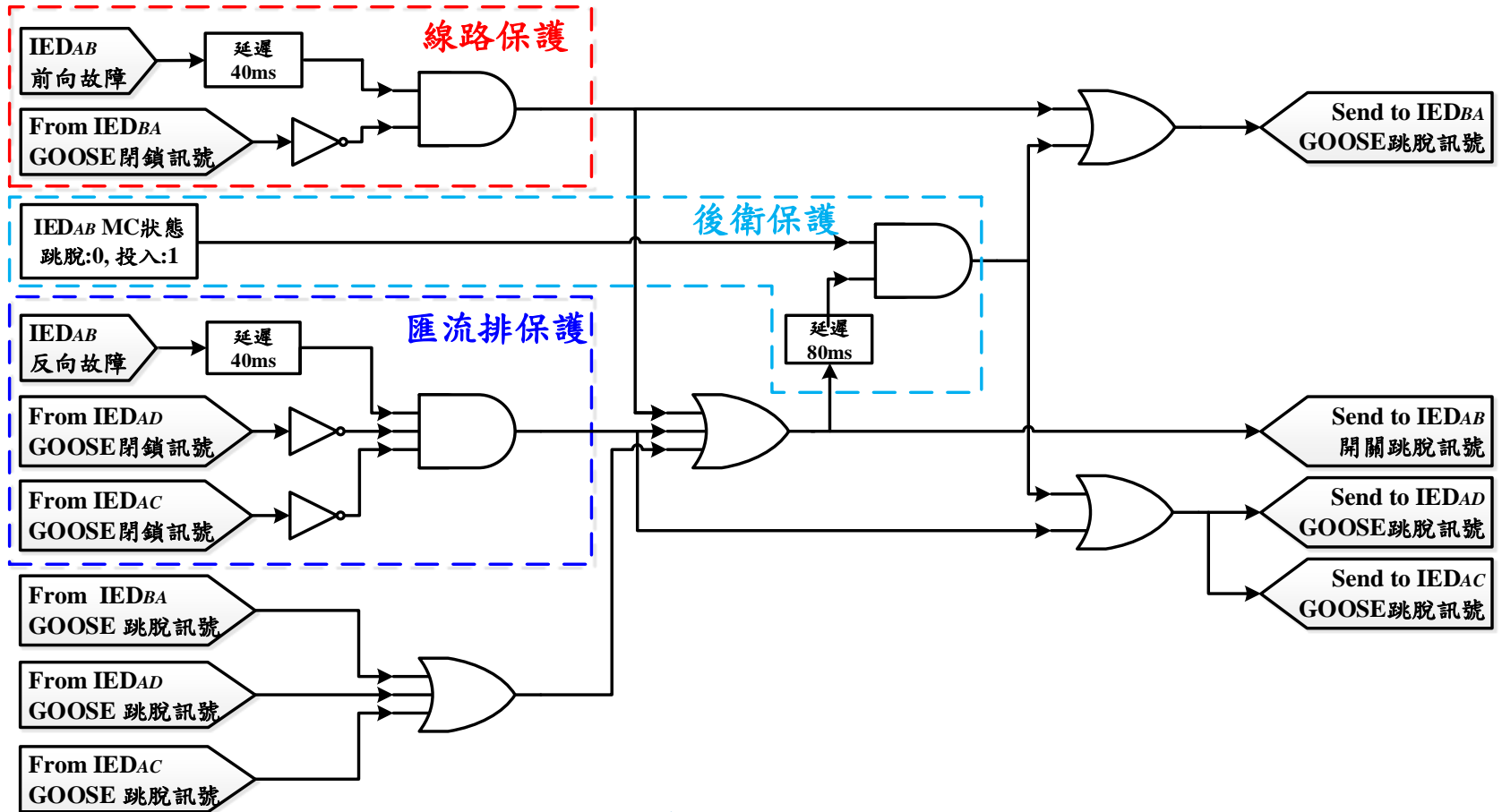
IED_{AB} 線路保護示意圖

MICRO GRID PROTECTION



IED_{AB}匯流排保護示意圖

MICRO GRID PROTECTION



範例系統IEDAB邏輯規劃圖

MICRO GRID PROTECTION

以上微電網保護系統研究資料為台灣科技大學
辜志承教授及電力系統研究室團隊提供

What is Smart Substation?

Case Study

Malaysia (Smart Substation)

Brazil (Smart Load Shedding)

Taiwan (Micro Grid Protection)

Conclusion

簡報完畢 敬請指教