

核能研究所委託研究計畫

優化饋線開關長期操作序列之研究
Study on Optimizing the
Long-term Operation Sequence of Feeder Switch

執行單位：國立彰化師範大學

計畫主持人：黃維澤 教授

參與人員：林韋辰、蕭權賢

05/24/2023

大綱

計畫目標

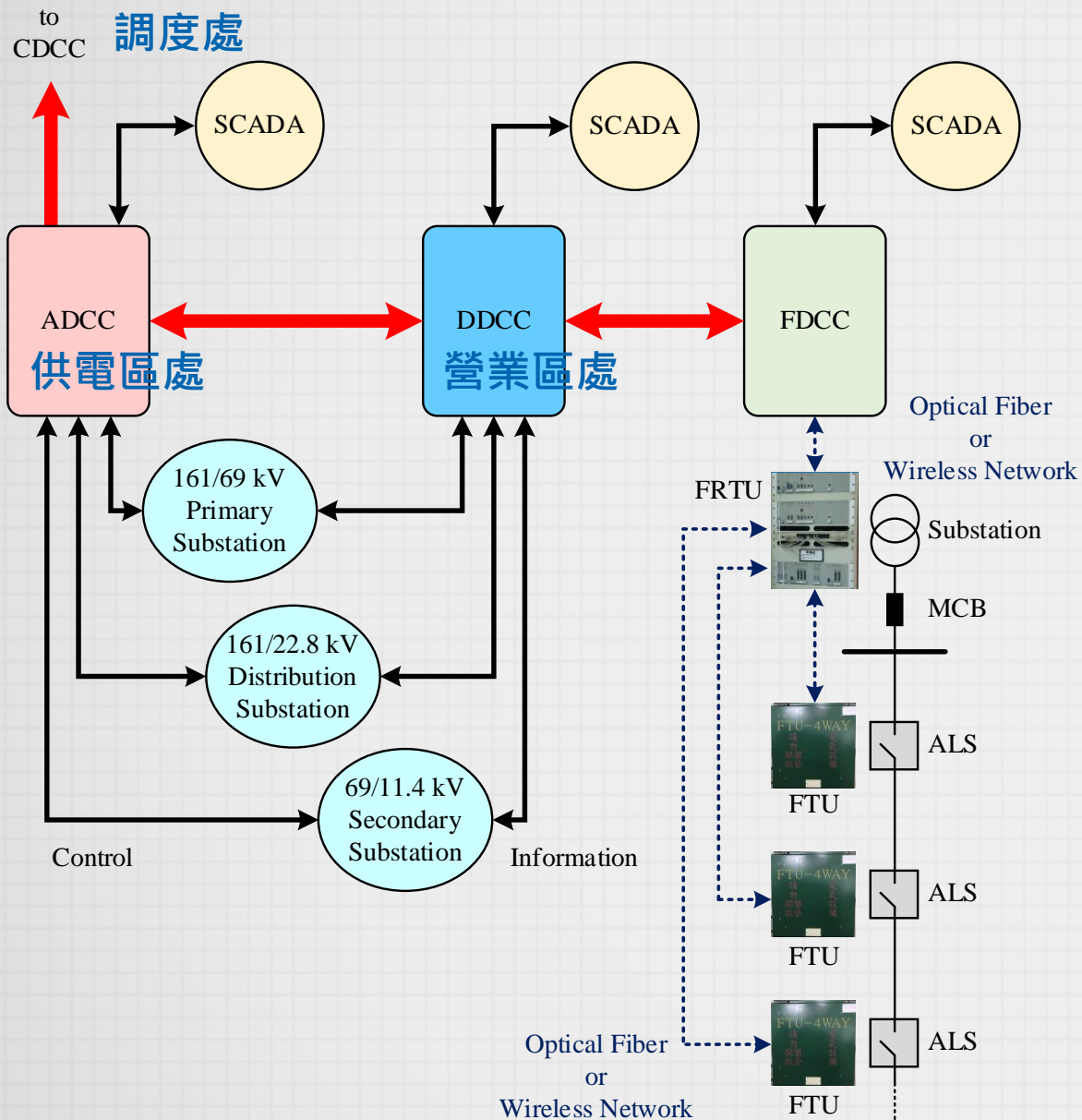
研究方法

重要成果

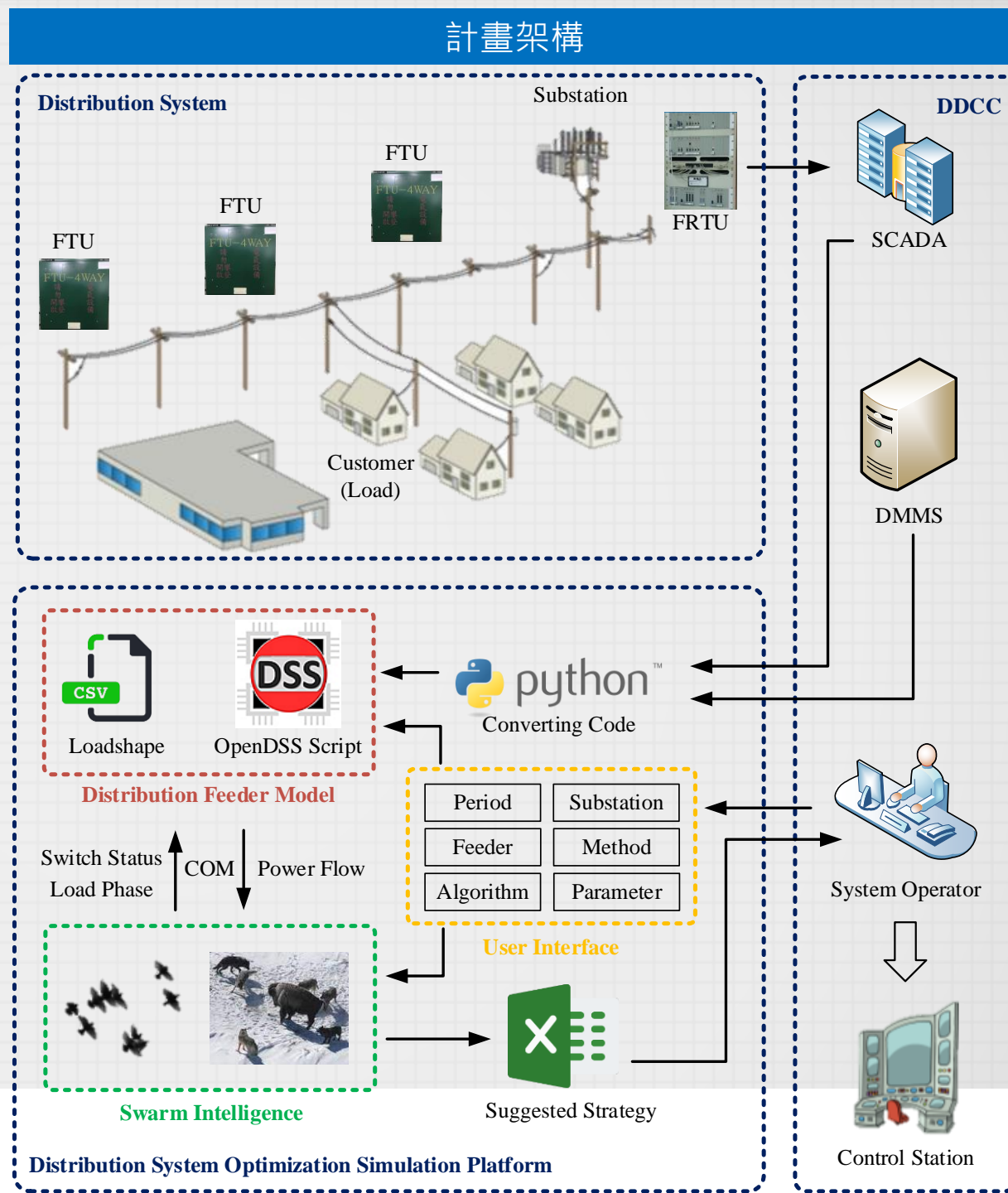
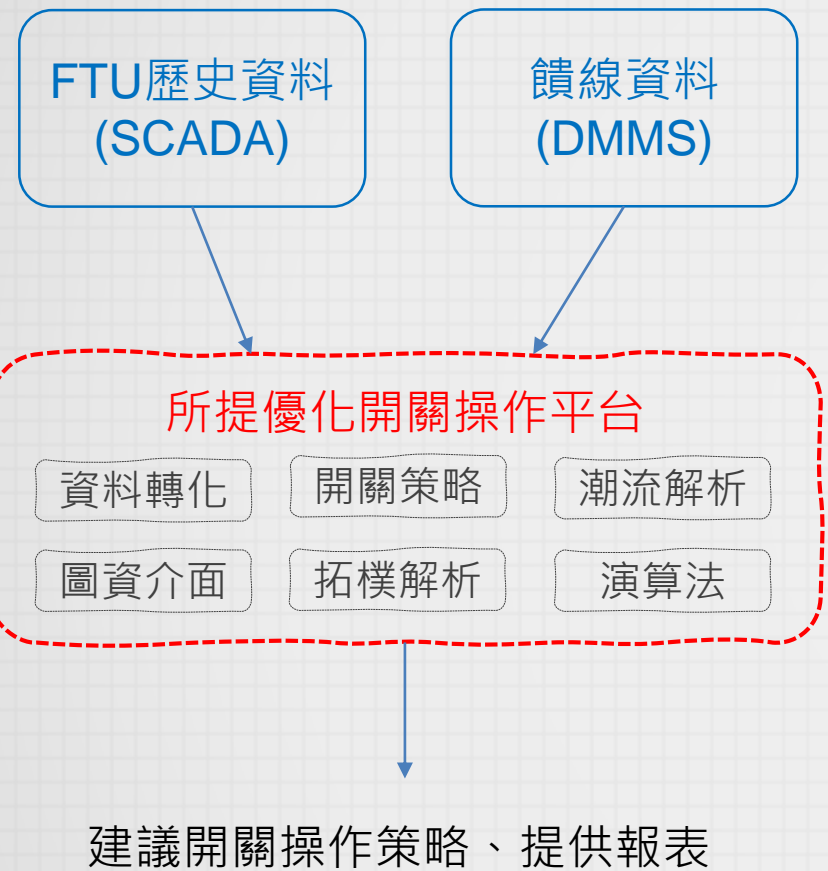
結論

計畫目標

階層式調度控制中心 (HDCCS)

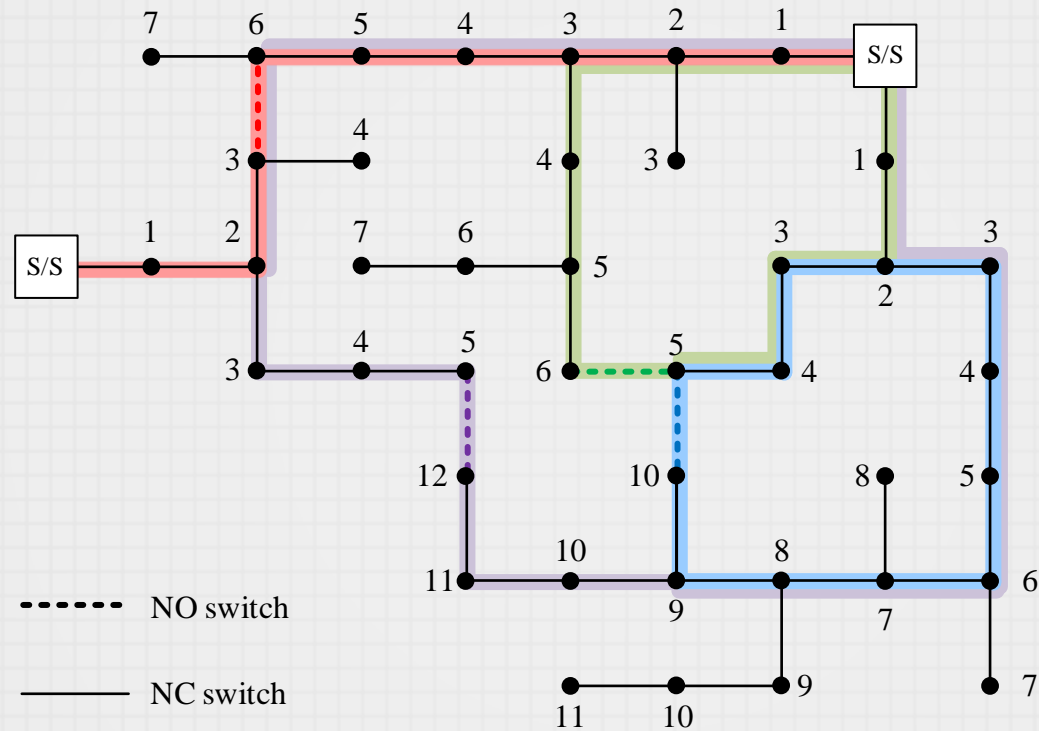


- 故障偵測、隔離、恢復 (FDIR)
- V / Q 控制
- 主變壓器監控
- 11.4 kV/22.8 kV 饋線監控
- 停電管理
- 圖資系統
- 開關操作

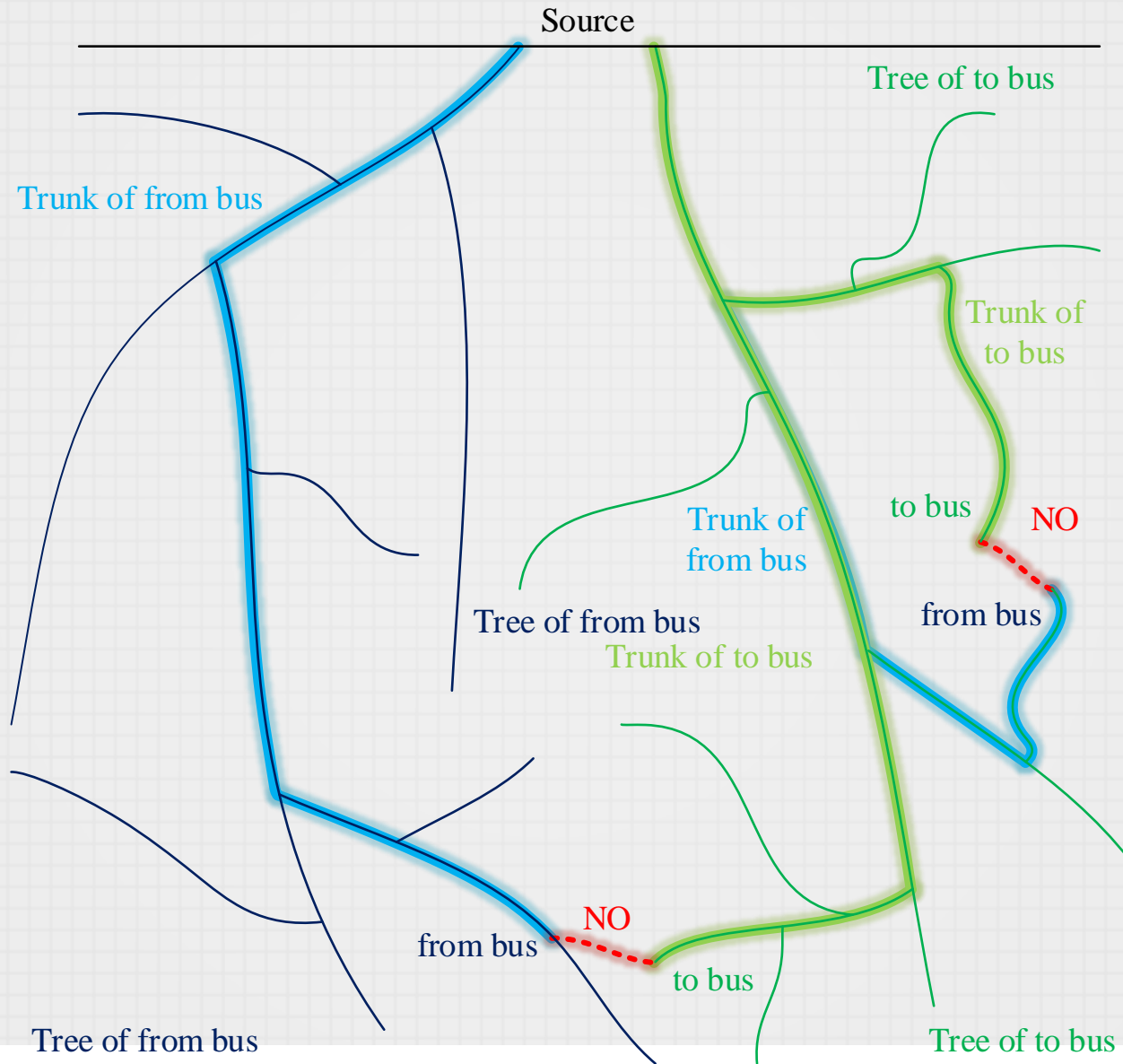


研究方法

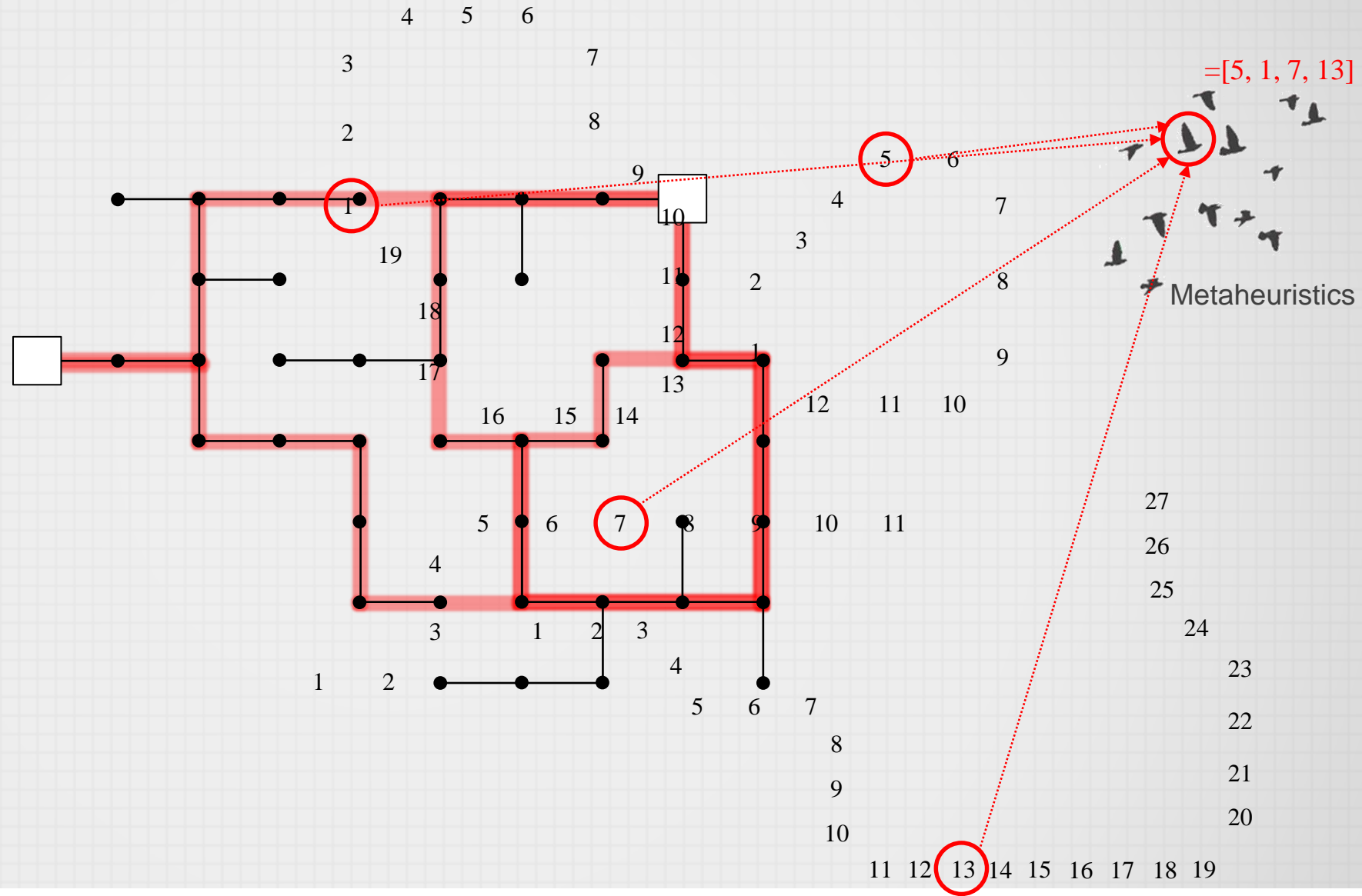
開關操作策略 — 饋線拓樸上下游關係 & 環路說明



開關操作策略 — 環路形成



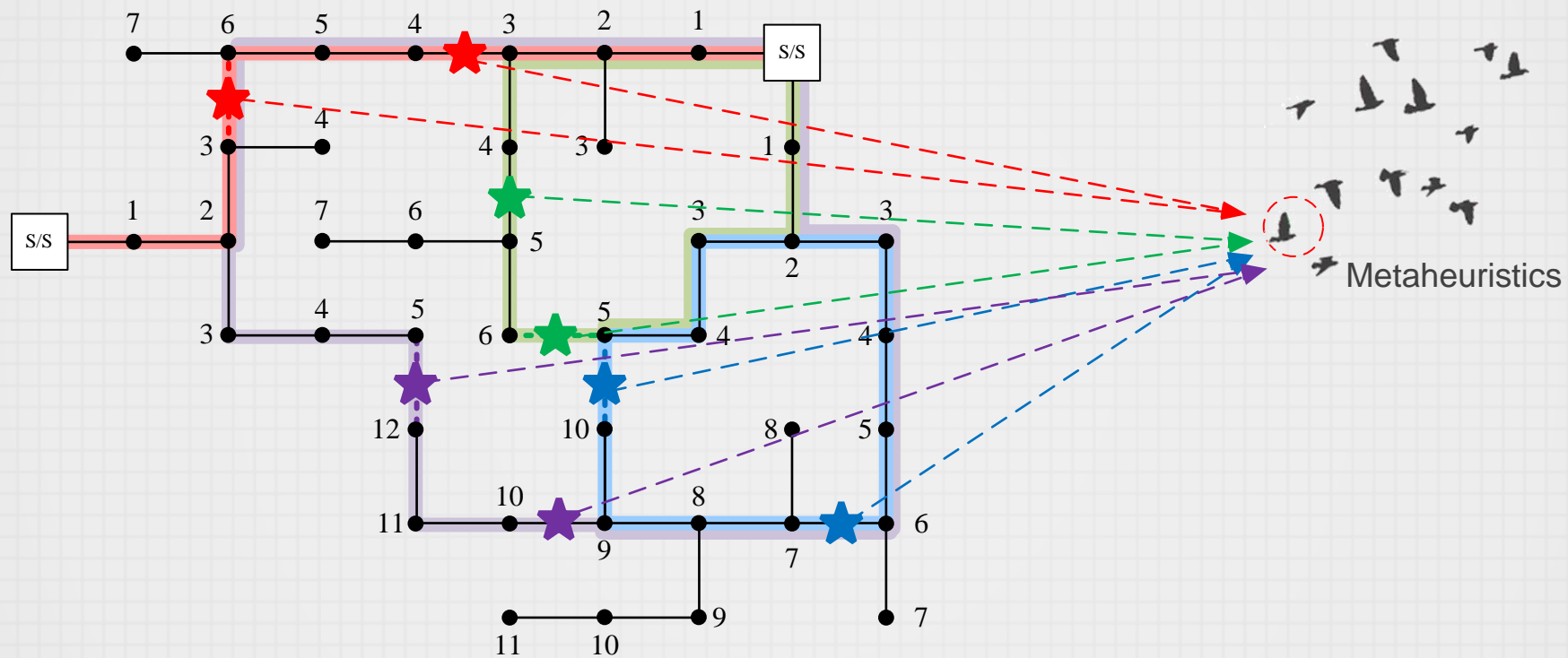
開關操作策略 — 應用啟發式演算法



所提之開關操作策略 VS 其他常見策略

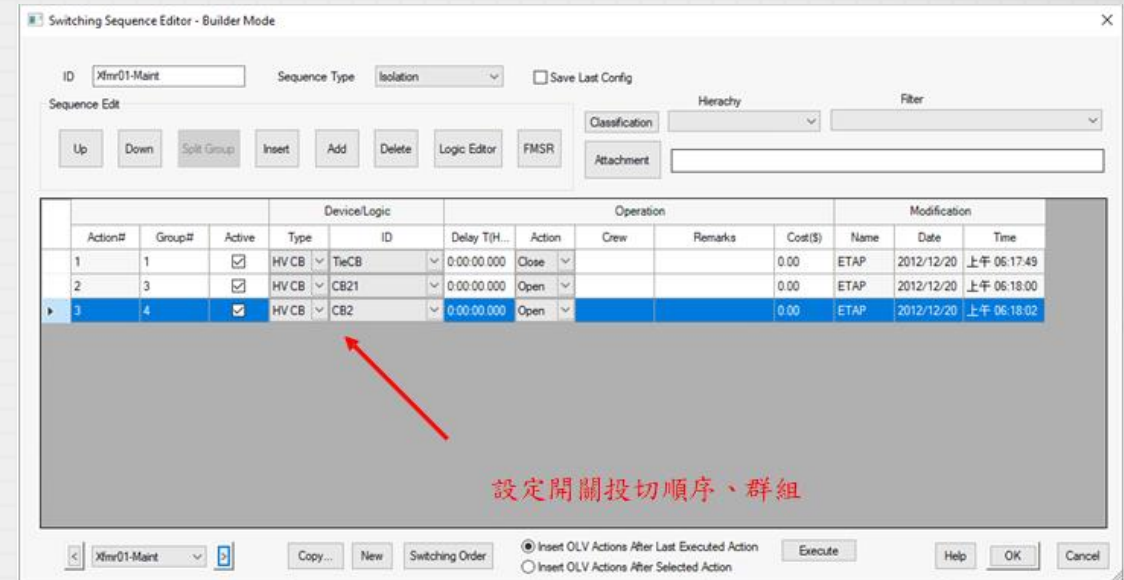
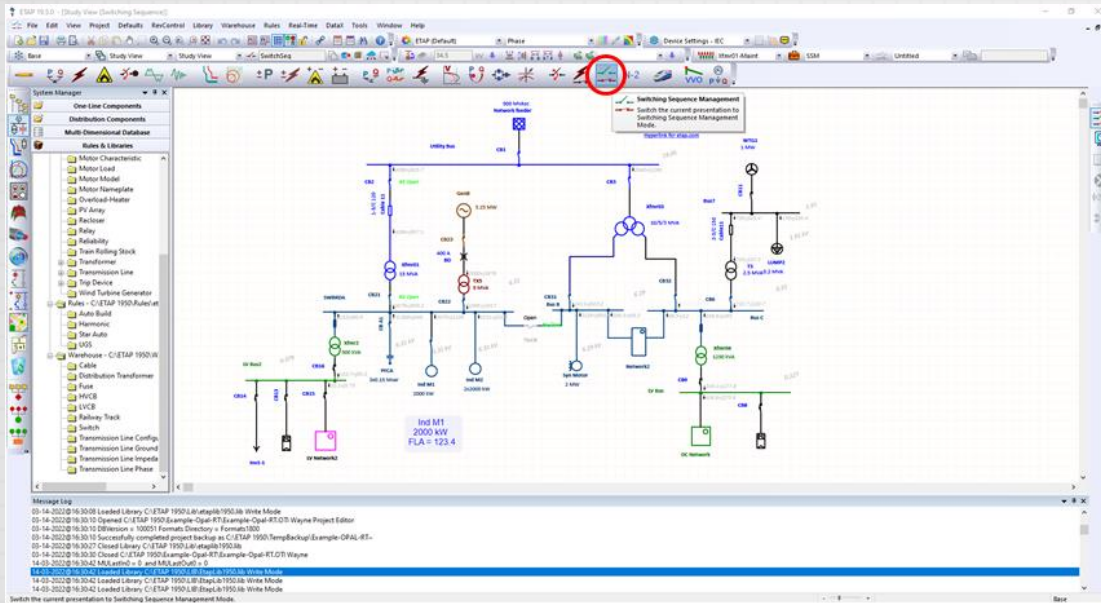
特性	策略	限制法	資料集法	圖論法	所提之策略
計算時間		最快	最慢	較慢	較快
可行解		最不可行	較可行	較可行	最可行
電網大小		小	小	小	無限大
前置作業		不需要	需要	需要	不需要

開關操作序列策略



電力模擬軟體之開關操作序列功能探討

Electrical Transient Analyzer Program (ETAP)



設定開關投切順序、群組

電力模擬軟體之開關操作序列功能探討

Electrical Transient Analyzer Program (ETAP)

Switching Sequence View

Sequence List

Action #	Group #	Time	Action Status	Device/Logic	Original	Current	End	Crew	Remarks	Cost	
1	1	0:00:00.001		TieCB	HV CB	Open	Close	Open	0:00:00.000	0:00:00.000	0.00
2	3	0:00:00.001		CB21	HV CB	Open	Closed	Open	0:00:00.000	0:00:00.000	0.00
3	4	0:00:00.001		CB2	HV CB	Closed	Open	Closed	0:00:00.000	0:00:00.000	0.00

執行開關投切
(自動執行、單步執行)

Execution Control

Auto Start Step Start Restart Manual Confirm

Switching Order

SO#: [] Rev # []

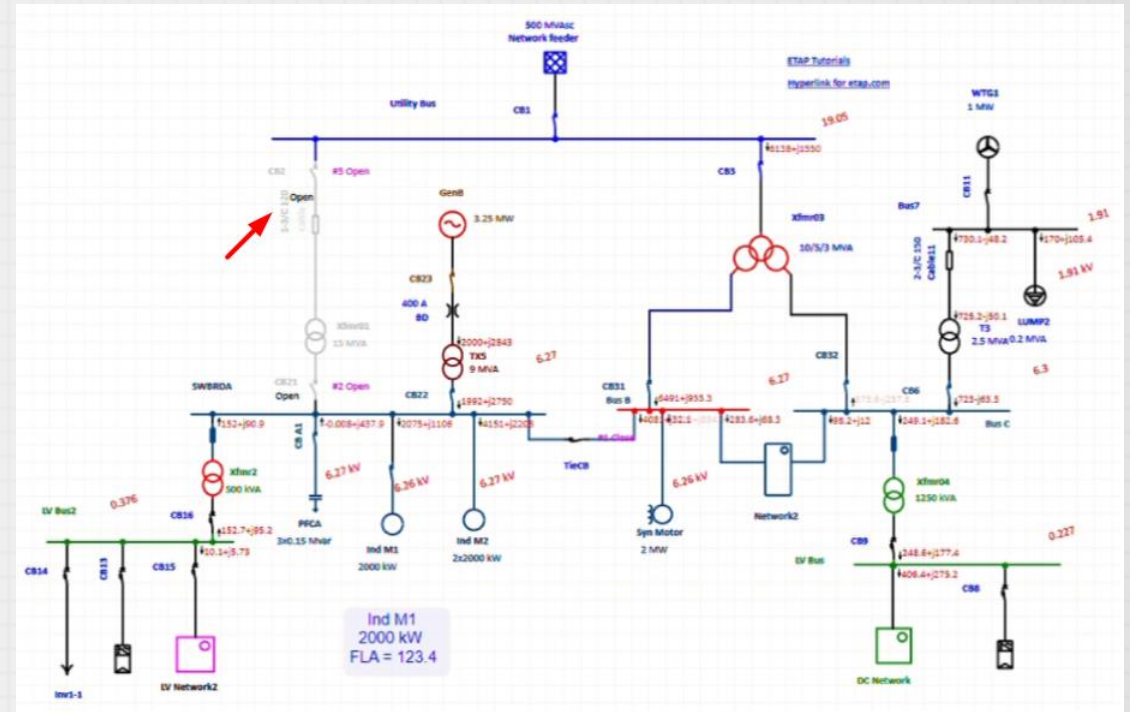
Alert

Action #	Time	Device	Status	Action	Type	Condition	Alert ID	Device Type	Required	Actual	A	B	C
0:00:00.000		Bus LOC B			Critical	Under Vol	Bus LOC B	Bus	0.65 kV	Opera...	0.355	0.365	0
0:00:00.000		Bus 780			Critical	Under Vol	Bus 780	Bus	0.11 kV	Opera...	0.06	0.061	0
0:00:00.000		Bus 781			Critical	Under Vol	Bus 781	Bus	0.11 kV	Opera...	0.06	0.061	0
0:00:00.000		Bus 782			Critical	Under Vol	Bus 782	Bus	0.11 kV	Opera...	0.06	0.06	0
0:00:00.000		Bus 783			Critical	Under Vol	Bus 783	Bus	0.11 kV	Opera...	0.06	0.06	0
0:00:00.000		LIUR (Po			Critical	LIUR (Po	Cable Main	Cable	11.84	Opera...	5.923	5.923	11.847
0:00:00.000		IUF 2 (Ne			Critical	IUF 2 (Ne	Cable Main	Cable	10.25	Opera...	10.259	10.259	10.259
0:00:00.000		LIUR (Po			Critical	LIUR (Po	T2	2W XFMR	145.1	Opera...	30.13	18.159	11.971
0:00:00.000		IUF 2 (Ne			Critical	IUF 2 (Ne	T2	2W XFMR	144.1	Opera...	26.226	26.226	26.226
0:00:00.000		IUF 0 (Ze			Critical	IUF 0 (Ze	T2	2W XFMR	144.1	Opera...	6.069	6.069	6.069
0:00:00.000		LIUR (Po			Critical	LIUR (Po	Xfmr2	2W XFMR	158.5	Opera...	4.77	5.139	9.908

潮流超過設定值之告警
(電壓標么值、設備承載率)

Show All Alerts Show Alerts on Not-Required Actions

Xfmr01-Maint Sequence Type Isolation



電力模擬軟體之開關操作序列功能探討

Open Distribution System Simulator (OpenDSS)

透過文字檔Script & API獲取潮流解果，適合演算法開發

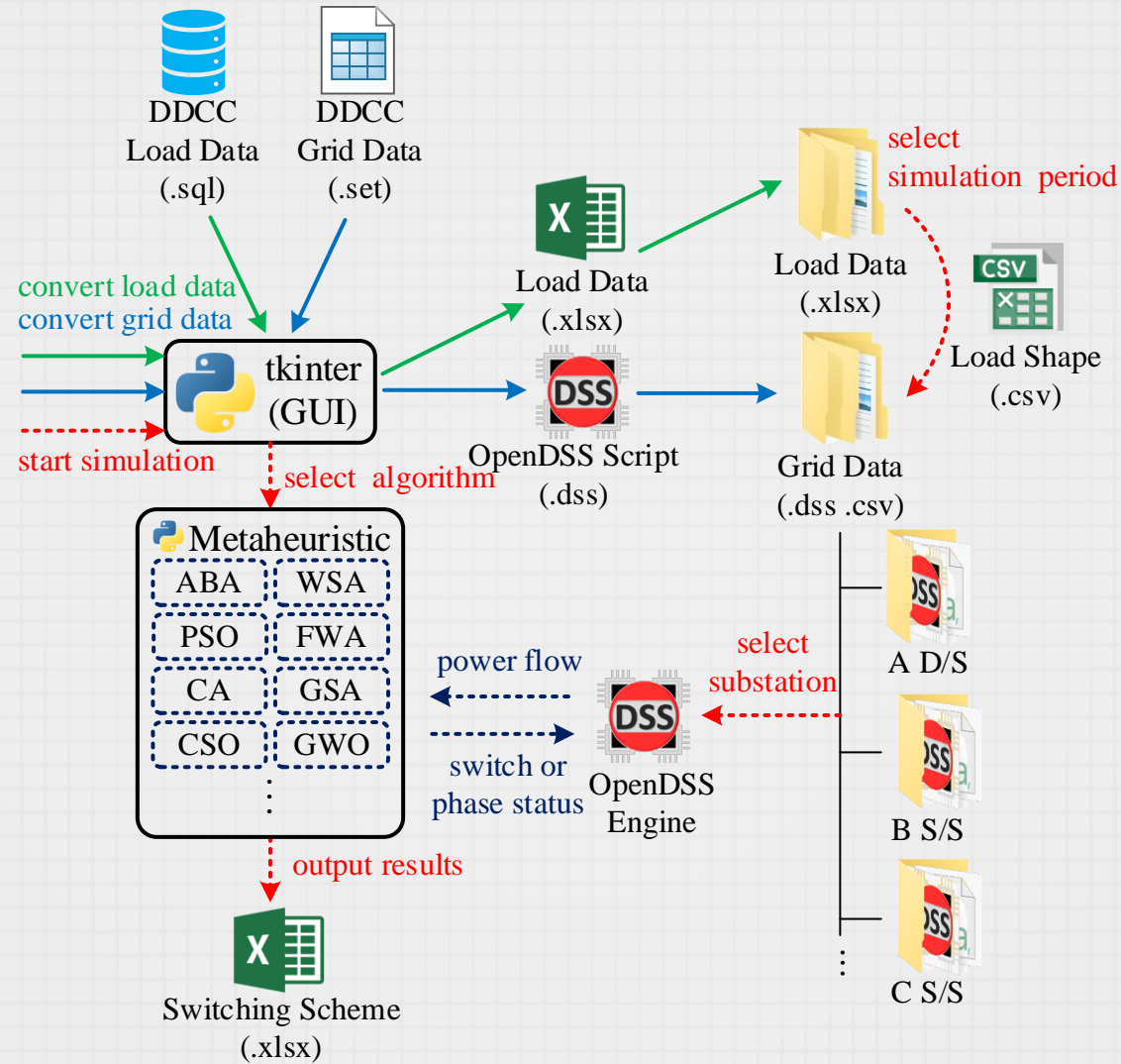
```
File Edit Do Set Make Export Show Visualize Plot Reset Help
Source/Fault Vsource
D:\SVN\SGTALab_Public\0931009\INER2020\TPCdata\XD\master.dss

enable line.K3338EC31-S01
enable line.K3633AE74-S01
enable line.K4132AE33-S01
enable line.K4332DA08-S01
enable line.K4232FD87-S01
enable line.K4229DC07-S01
enable line.K4932FB06-F01
enable line.K4045BC47-S01
enable line.K4044AE62-S06
enable line.K4235GC10-S01
enable line.K4038AA64-S01
disable line.K4331AE44-S01_NO
disable line.K4425GC71-S04_NO
disable line.K4033GA3645-S06_NO
disable line.K3830GC17-S01_NO
disable line.K4227AB28-S01_NO
disable line.K3926DC36-F01_NO
disable line.K4025DC82-S01_NO
disable line.K4139GE00-S01_NO
disable line.K4039AA42-S01_NO
disable line.K4034GB31-S01_NO
disable line.K4341FA36-S01_NO
```

```
RUN_VLN.Txt Notepad
File Edit Format View Help

SYMMETRICAL COMPONENT VOLTAGES BY BUS (for 3-phase buses)
Bus      Mag:  V1 (kV)  p.u.  V2 (kV)  %V2/V1  V0 (kV)  %V0/V1
source161  97.6    1.05  4.576E-008  4.688E-008  6.349E-009  6.505E-009
source69   41.83   1.05  2.297E-006  5.491E-006  2.721E-009  6.505E-009
xm#2       6.633   1.008  0.009206  0.1388  0.009537  0.1438
xm21       6.633   1.008  0.009206  0.1388  0.01077  0.1624
xm22       6.633   1.008  0.009206  0.1388  0.009756  0.1471
xm23       6.633   1.008  0.009206  0.1388  0.01287  0.194
xm24       6.633   1.008  0.009206  0.1388  0.01417  0.2136
xm25       6.633   1.008  0.009206  0.1388  0.007092  0.1069
k5057bb01-j02  6.586   1.001  0.01311  0.1991  0.02008  0.3049
k5057aa32-j01  6.586   1.001  0.013  0.1974  0.01985  0.3014
k4958ha69-f01  6.609   1.004  0.01017  0.1538  0.01333  0.2016
k5058ac14-j01  6.61    1.004  0.01016  0.1537  0.01343  0.2032
k4858hd22-s01  6.607   1.004  0.01092  0.1653  0.01534  0.2322
k4957fa48-s01  6.591   1.001  0.01244  0.1888  0.01952  0.2962
k4957hb04-j09  6.587   1.001  0.01325  0.2011  0.02126  0.3228
k4957hb04-j12  6.587   1.001  0.01325  0.2011  0.02126  0.3227
k5057ee52-j01  6.58    0.9998  0.01622  0.2465  0.02617  0.3977
k5057ee52-j03  6.58    0.9998  0.01622  0.2465  0.02618  0.3978
k4957hb04-s03  6.587   1.001  0.01325  0.2012  0.02127  0.3229
k4956ge7352-s01  6.589   1.001  0.01283  0.1948  0.02071  0.3143
k4957hb04-s04  6.587   1.001  0.01325  0.2012  0.02127  0.3229
k4859bc48-s01  6.614   1.005  0.01044  0.1579  0.01406  0.2126
k4859ea3580-s01  6.614   1.005  0.01045  0.158  0.01407  0.2127
k5057cc21-j01  6.582   1  0.01536  0.2333  0.02451  0.3723
k5057cc21-j03  6.582   1  0.01536  0.2333  0.02451  0.3723
k5057hb87-i01  6.584   1  0.01477  0.2243  0.02365  0.3593
```

本計畫軟體架構

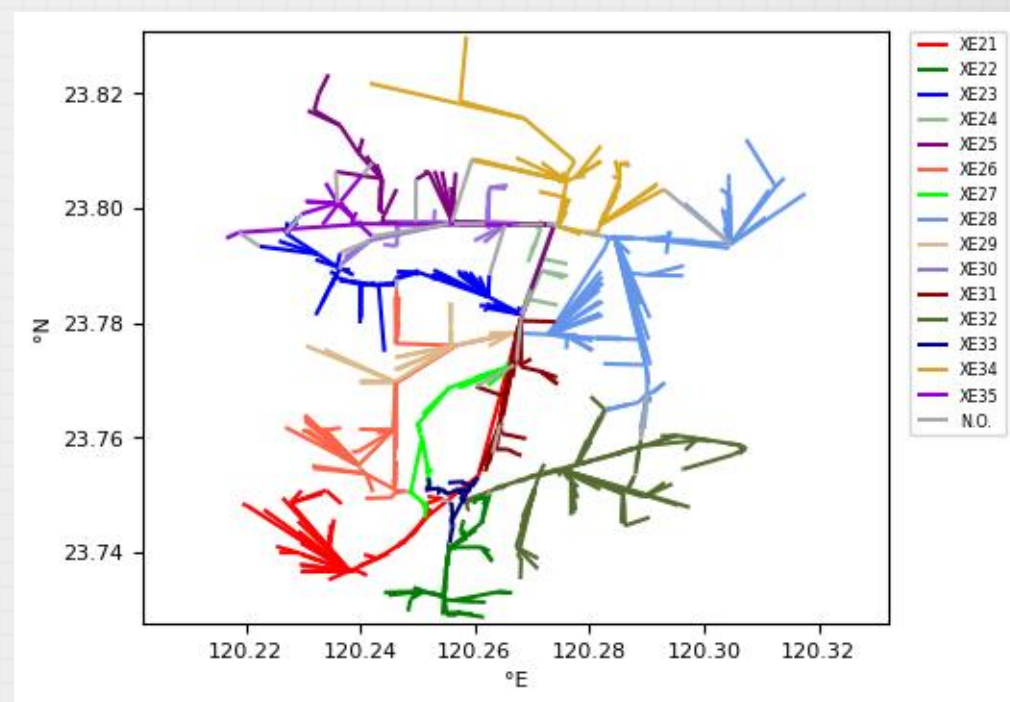
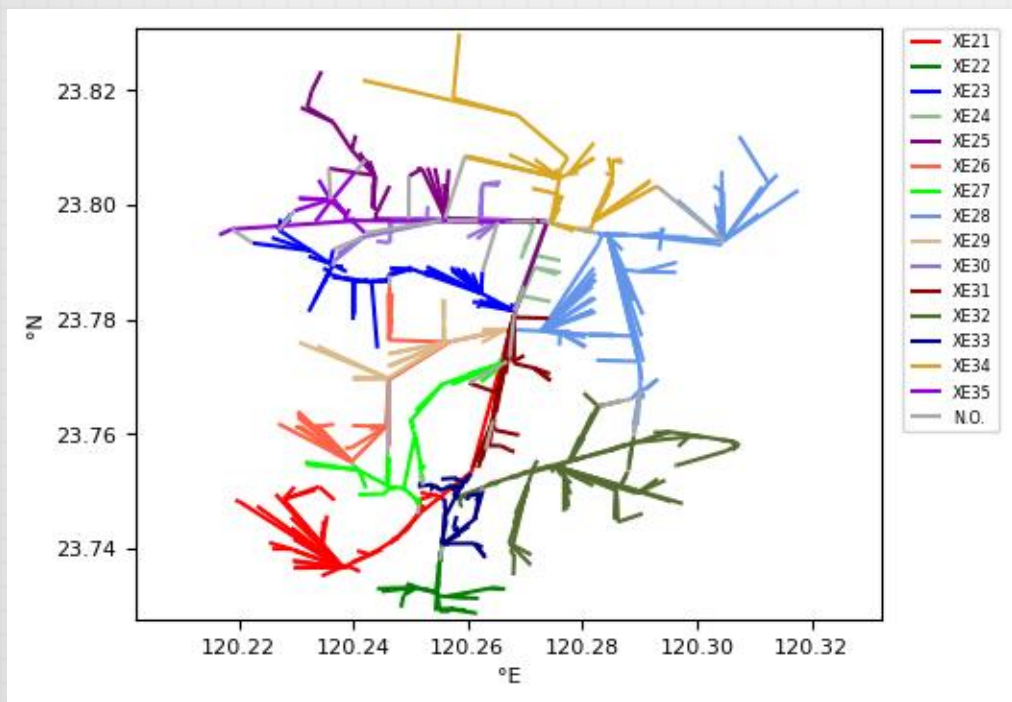


重要成果

模擬案例 – 開關操作策略

單一變電所：

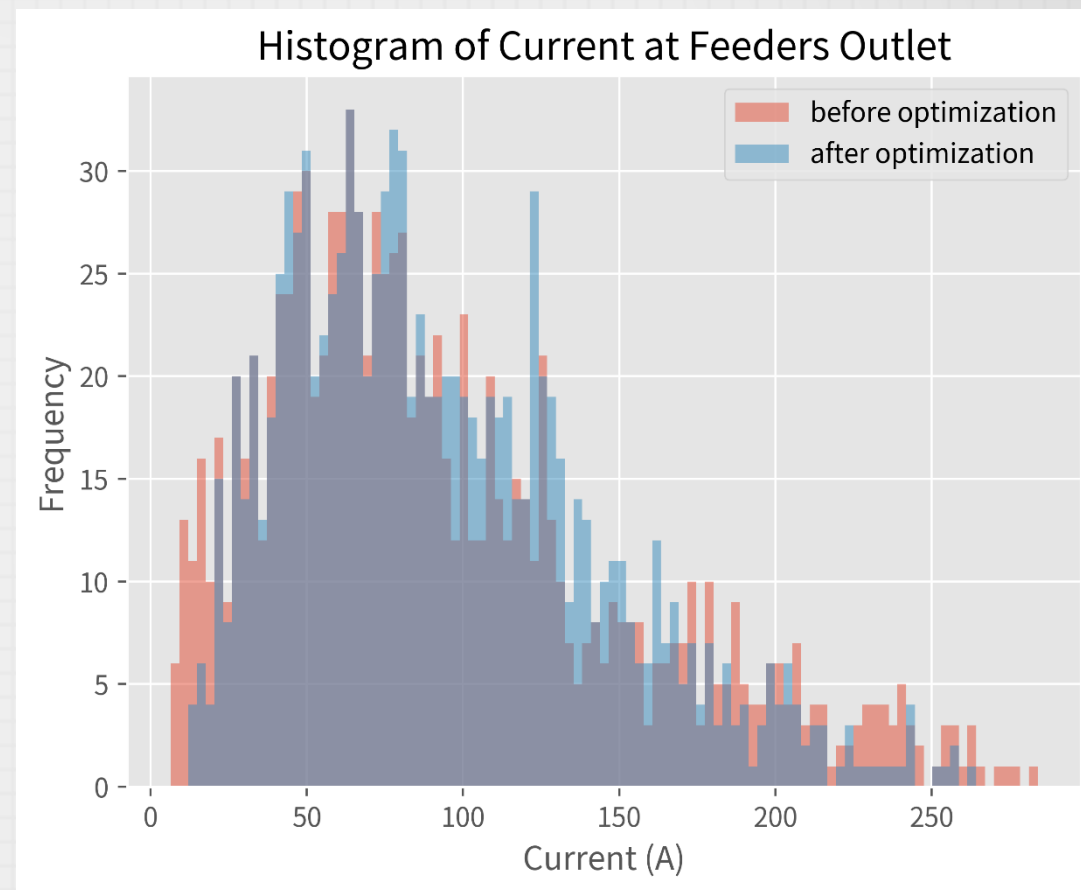
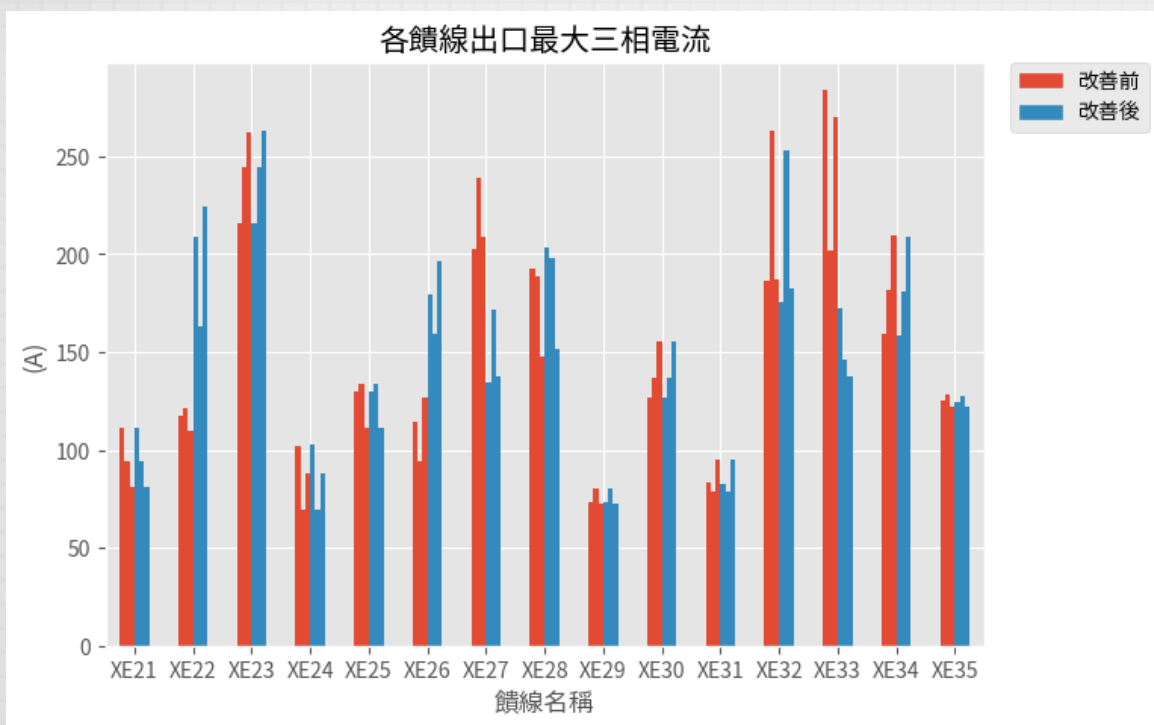
- 標的系統：橋村(XE) S/S
- 演算法：灰狼演算法(50隻灰狼、50次迭代)
- 模擬資料：2021年七月平均24小時日負載
- 目標函數：總線路損失最小化



模擬案例 — 開關操作策略

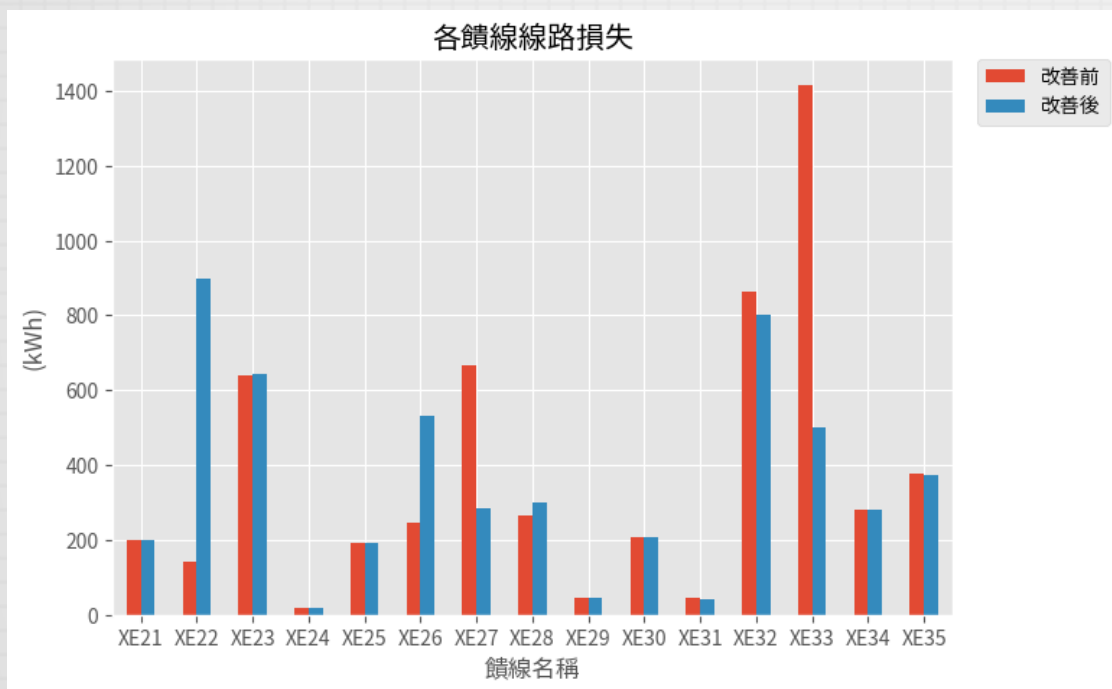
IV

283 A → 262A



模擬案例一 開關操作策略

5596 kWh → 5318 kWh (4.9%)



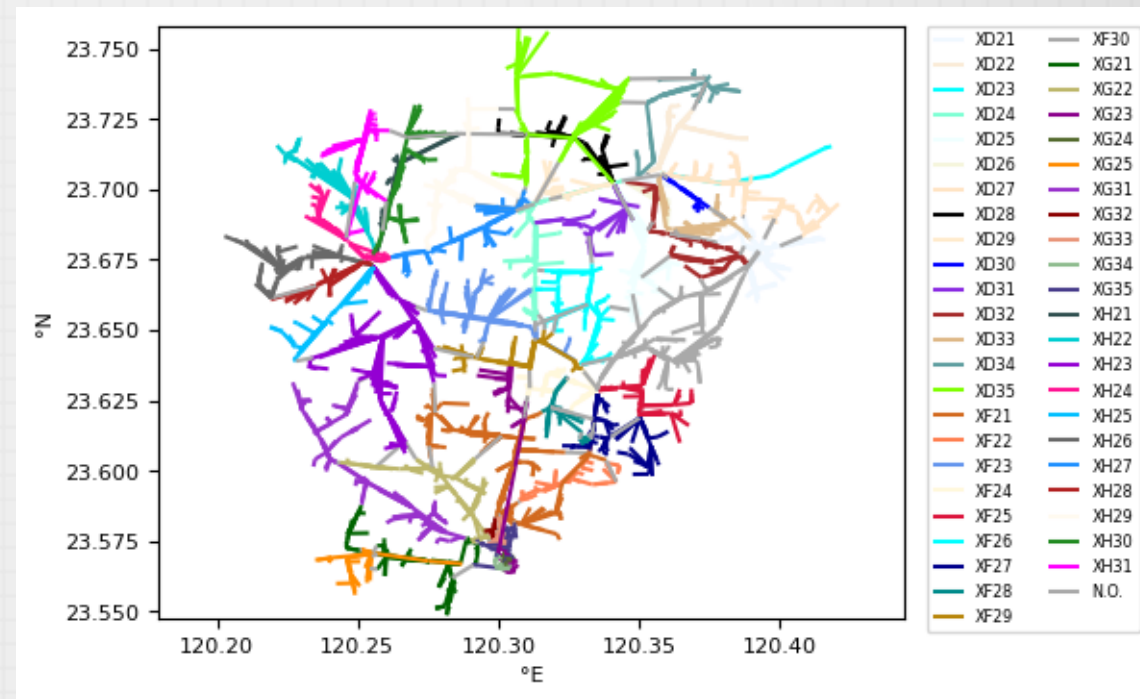
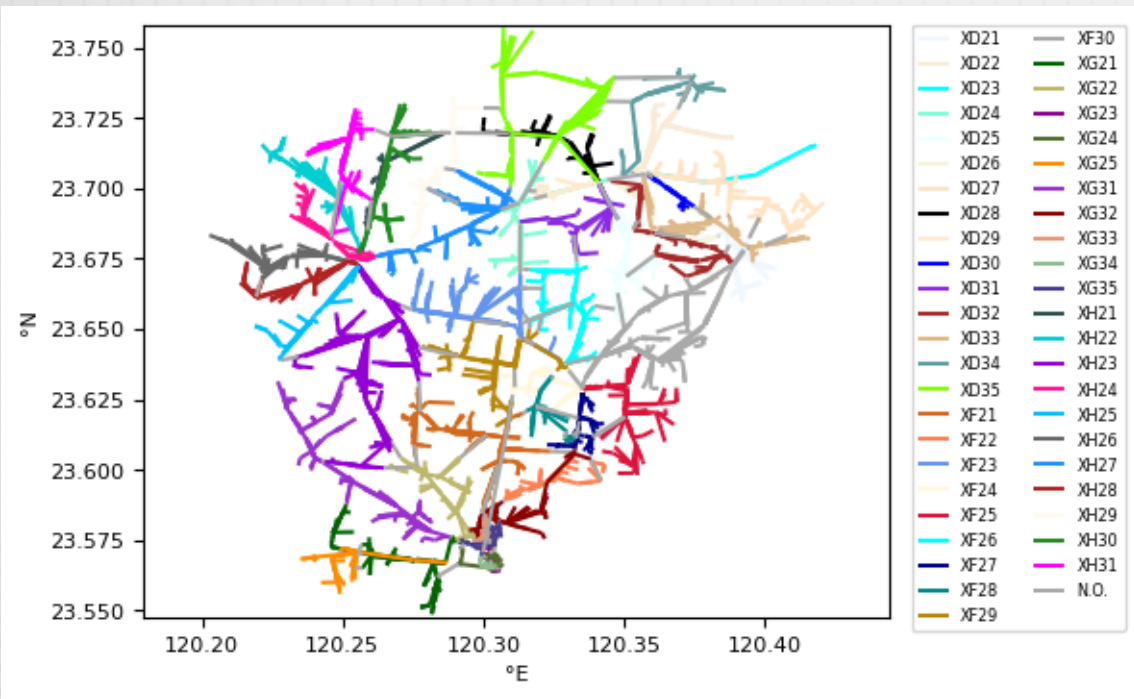
開關操作順序列表

操作順序	切開開關	投入開關	切開開關所屬饋線	投入開關所屬饋線	最大饋線出口電流變動率
1	K0455BA17-S06_NO	K0355HB4748-J01	XE21, XE33	XE21	XE33: 29.1% (64.9 A → 77.0 A)
2	K0354EC49-S06_NO	K0354EC49-J05	XE21, XE27	XE21	XE24: 0.0% (19.6 A → 19.6 A)
3	K0256BC06-S01_NO	K0255HD8050-S04	XE26, XE27	XE27	XE27: 12.1% (56.7 A → 56.0 A)
4	K0565FE46-S01_NO	K0465BE08-S01	XE24, XE30	XE30	XE24: 407.2% (19.6 A → 74.9 A)
5	K0164FE72-S01_NO	K0263BD40-S01	XE23, XE30	XE23	XE23: 12.5% (151.5 A → 170.5 A)
6	K0167FE09-S01_NO	K0268DB56-F01	XE25, XE35	XE25	XE21: 0.0% (52.3 A → 52.3 A)
7	K0860EB03-S01_NO	K1060HB50-S01	XE32, XE28	XE32	XE21: 0.0% (52.3 A → 52.3 A)
8	K0860EC72-S01_NO	K0859EB18-S01	XE32, XE28	XE32	XE21: 0.0% (52.3 A → 52.3 A)
9	K0765DE84-S01_NO	K0867HB32-S01	XE34, XE28	XE28	XE21: 0.0% (52.3 A → 52.3 A)
10	K0468FC22-S01_NO	K0665EE32-S01	XE25, XE34	XE34	XE21: 0.0% (52.3 A → 52.3 A)
11	K0355FD44-S08_NO	K0355GD87-J01	XE33, XE27	XE33	XE21: 0.0% (52.3 A → 52.3 A)
12	K0265DC33-S01_NO	K0565EE36-S01	XE35, XE30	XE30	XE21: 0.0% (52.3 A → 52.3 A)
13	K0267BE72-F01_NO	K0266EC83-S01	XE25, XE35	XE25	XE30: 100.0% (37.8 A → 0.0 A)

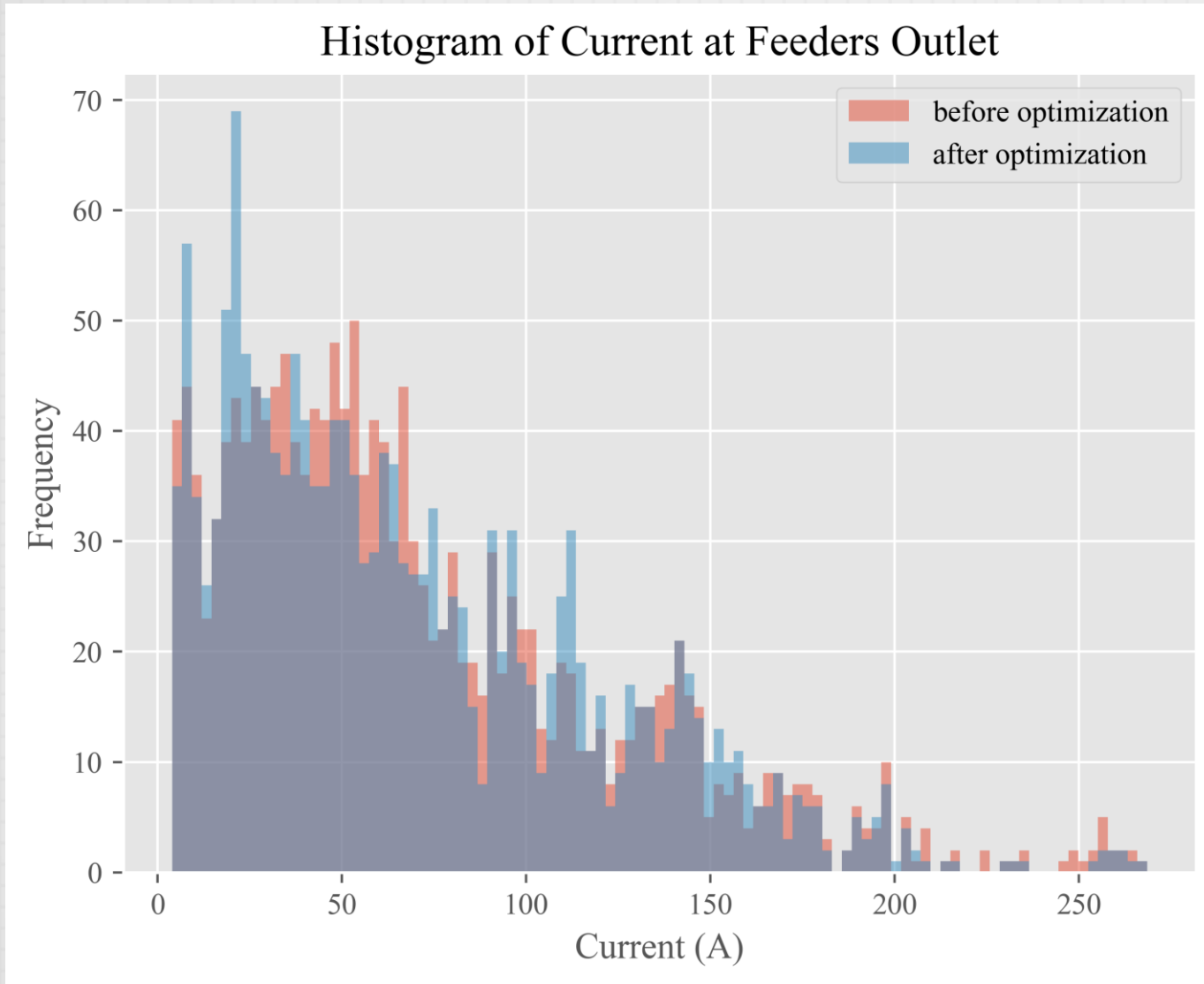
模擬案例 – 開關操作策略

多變電所：

- 標的系統：土庫(XD) S/S、元長(XF) S/S、雲港(XG) S/S、東北(XH) S/S
- 演算法：鯨群演算法(50隻鯨魚、50次迭代)
- 模擬資料：2021年七月平均12小時白天日負載
- 目標函數：饋線電流標準差最小化



模擬案例 — 開關操作策略



降低損失
6627 kWh → 6501 kWh (1.9%)

結論

- 本計畫依據所擬定目標與工作項目，以台電雲林區處實際運轉資料，開發配電網最佳開關操作、開關序列策略。
- 本計畫提供饋線運轉者一套較具系統性之模擬工具，除了饋線電流均化，改善饋線裕度、損失等，亦提供清晰之報表、拓樸繪製等，供饋線運轉者判斷策略之合理性與可行性等，具實務應用之價值。