



# MATLAB based 植物工廠燈光控制

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# 背景

- 電費的費率有尖峰與非尖峰時段的價差。
  - 預設值：離峰電價：1.8 NT\$/kWh, 平時電價：4.44 NT\$/kWh
  - 離峰時段：22:30 ~ 07:30
- 冷氣的效能 (性能係數, COP) 隨著室外溫度升高而降低, 因為散熱變得較困難。反之, COP 隨著室外溫度降低而升高, 因散熱變得較容易。
  - 預設值： $COP_o = 3$ , 量測 COP 的基準室外與室內溫度為 25 °C 與 20 °C。
  - 定義  $dT = T_o - T_i$
  - 假設  $dCOP = (dT - 5) * 0.1$
  - $COP_{actual} = COP_o - dCOP$
- 電費會隨著開燈時段的不同而有變化

# 室外溫度影響冷氣COP

## 舊版軟體使用數值

- `hrs1=[1,2,5,8,9,11,14,17,20,21,23,24];`
- `Tdb1=[25.8,25.8,25.1,28.9,30.2,32.5,35.7,33.8,30,29.3,28.1,28.1];`
- `t=1:1:24;clk=mod(t,24);`
- `Tout=interp1(hrs1,Tdb1,clk,'spline');`
  
- `subplot(2,2,1); plot(t, Tout,'-*');`
- `ylabel('Temperature_{outdoor} (T_o, ^oC) ');`
- `xlabel('hrs elapsed in a day');`

# Defaults

Ti=20; % indoor Temperature

COP0=3; dT0=5;

% Coefficient Of Performance (COP) measured at  $dT0 = T_o - T_i = 5$ ;

noLamp=1000;

pcperlamp=20; % power consumption per lamp, in W

ligperiod=16; % duration of light period, in hrs per day

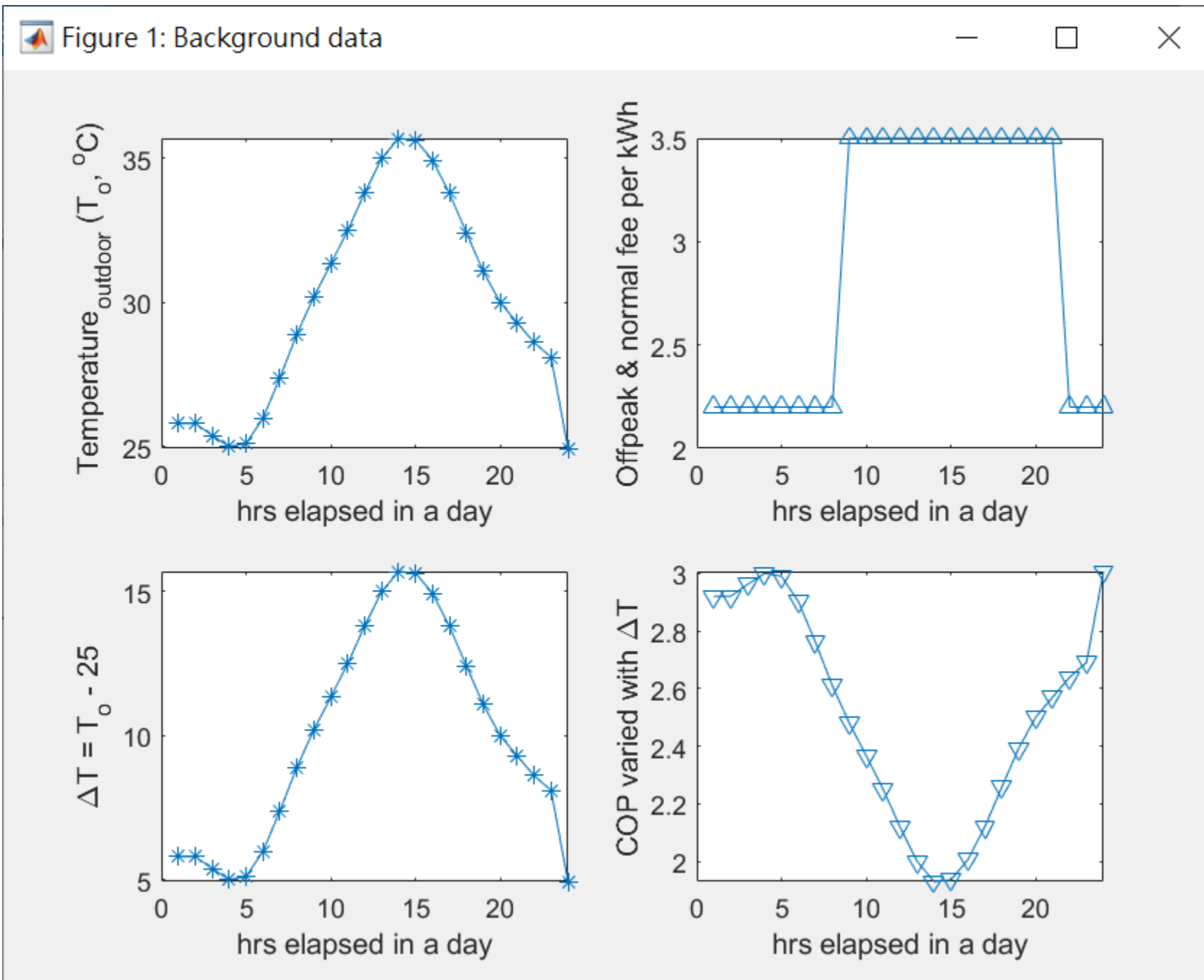
offpeakstart=22.5; offpeakend=7.5; % offpeak period

offpeakfee=2.2; normalfee=3.5; % fee per kWh

noA=noLamp/2; noB=noLamp-noA; % no. of lamps in group A and B

pcoflampA=noA\*pcperlamp; pcoflampB=noB\*pcperlamp;

- % assuming COP increase/drop 0.1 when dT drop/increase by 1 deg.C;
- for i=1:1:24
- dT(i)=Tout(i)-Ti;
- dCOP(i)=(dT(i)-dT0)\*0.1; % dCOP(i) = Tout(i)-20=5 = Tout(i) - 25
- COP(i)=COP0-dCOP(i);
- if i<=offpeakend || i>=offpeakstart
- fee(i)=offpeakfee;
- else
- fee(i)=normalfee;
- end
- end
- subplot(2,2,2); plot(t,fee,'-^');
- ylabel('Offpeak & normal fee per kWh'); xlabel('hrs elapsed in a day');
- subplot(2,2,3); plot(t,dT,'-\*');
- ylabel('\DeltaT = T\_o - 25'); xlabel('hrs elapsed in a day');
- subplot(2,2,4); plot(t,COP,'-v');
- ylabel('COP varied with \DeltaT'); xlabel('hrs elapsed in a day');



subplot(2,2,1);

subplot(2,2,2);

subplot(2,2,3);

subplot(2,2,4);

# 新版軟體允許使用者輸入

10個氣象測站的20筆室外溫度擇1做後續計算

- 前十筆為有最高平均日溫當天的室外溫度
- 後十筆為有最高平均時溫當天的室外溫度

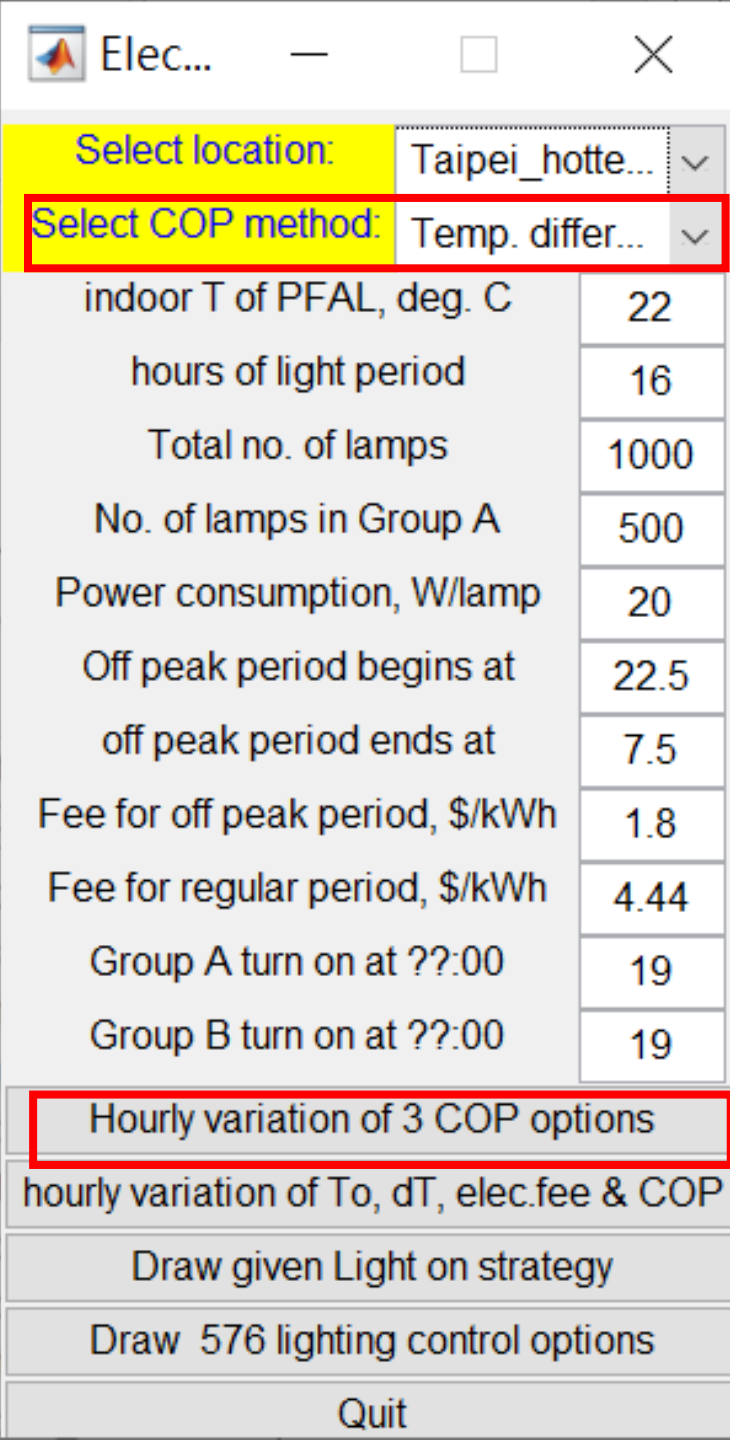
The screenshot shows a software window titled 'Elec...' with a yellow highlight on the 'Select location:' and 'Select COP method:' dropdown menus. The 'Select location:' menu is currently set to 'Taipei\_hotte...'. Below these menus is a table with various input parameters and their values.

indoor T of PFAL, deg. C	22
hours of light period	16
Total no. of lamps	1000
No. of lamps in Group A	500
Power consumption, W/lamp	20
Off peak period begins at	22.5
off peak period ends at	7.5
Fee for off peak period, \$/kWh	1.8
Fee for regular period, \$/kWh	4.44
Group A turn on at ??:00	19
Group B turn on at ??:00	19

Below the table are several buttons: 'Hourly variation of 3 COP options', 'hourly variation of To, dT, elec.fee & COP', 'Draw given Light on strategy', 'Draw 576 lighting control options', and 'Quit'.

This screenshot shows the same software window as the first, but with the 'Select COP method:' dropdown menu open. The menu lists 20 options, with 'Wuchi\_hottest\_hr' selected at the bottom. The options are:

- Taipei\_hottest\_day
- Hualien\_hottest\_day
- ilan\_hottest\_day
- Tainan\_hottest\_day
- Kaohsiung\_hottest\_day
- Chiayi\_hottest\_day
- Taichung\_hottest\_day
- Alishan\_hottest\_day
- Taitung\_hottest\_day
- Wuchi\_hottest\_day
- Taipei\_hottest\_hr
- Hualien\_hottest\_hr
- ilan\_hottest\_hr
- Tainan\_hottest\_hr
- Kaohsiung\_hottest\_hr
- Chiayi\_hottest\_hr
- Taichung\_hottest\_hr
- Alishan\_hottest\_hr
- Taitung\_hottest\_hr
- Wuchi\_hottest\_hr



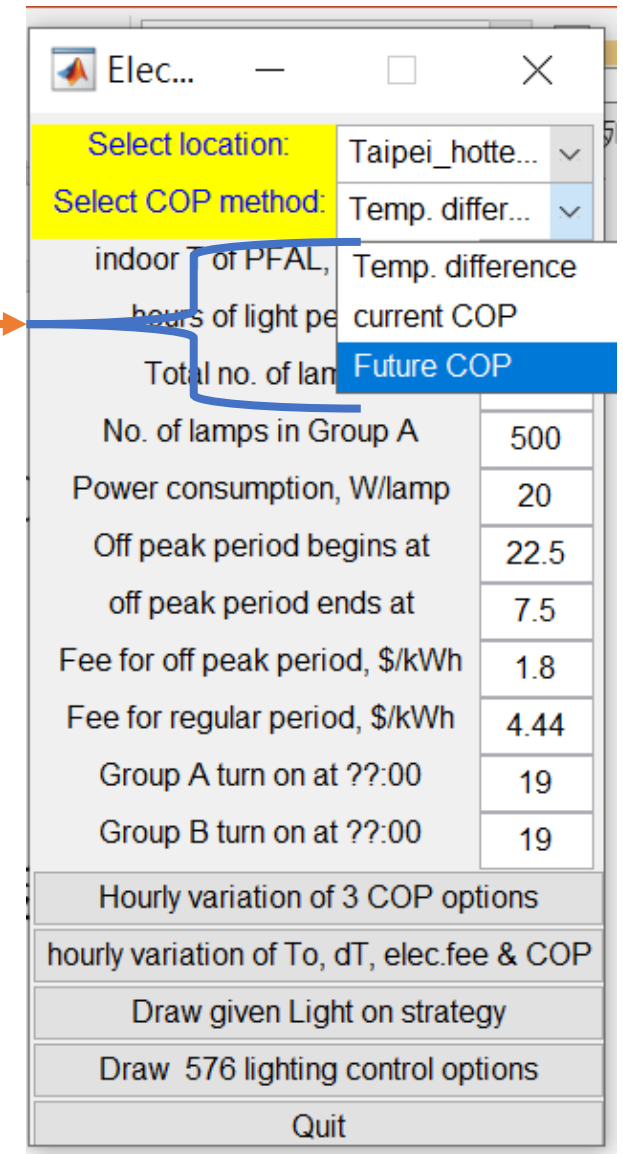
3個 COP 計算方式擇1

舊版軟體只有第一個選項

11 個參數輸入值

3個 COP 計算方式的差異

5個 pushbuttons



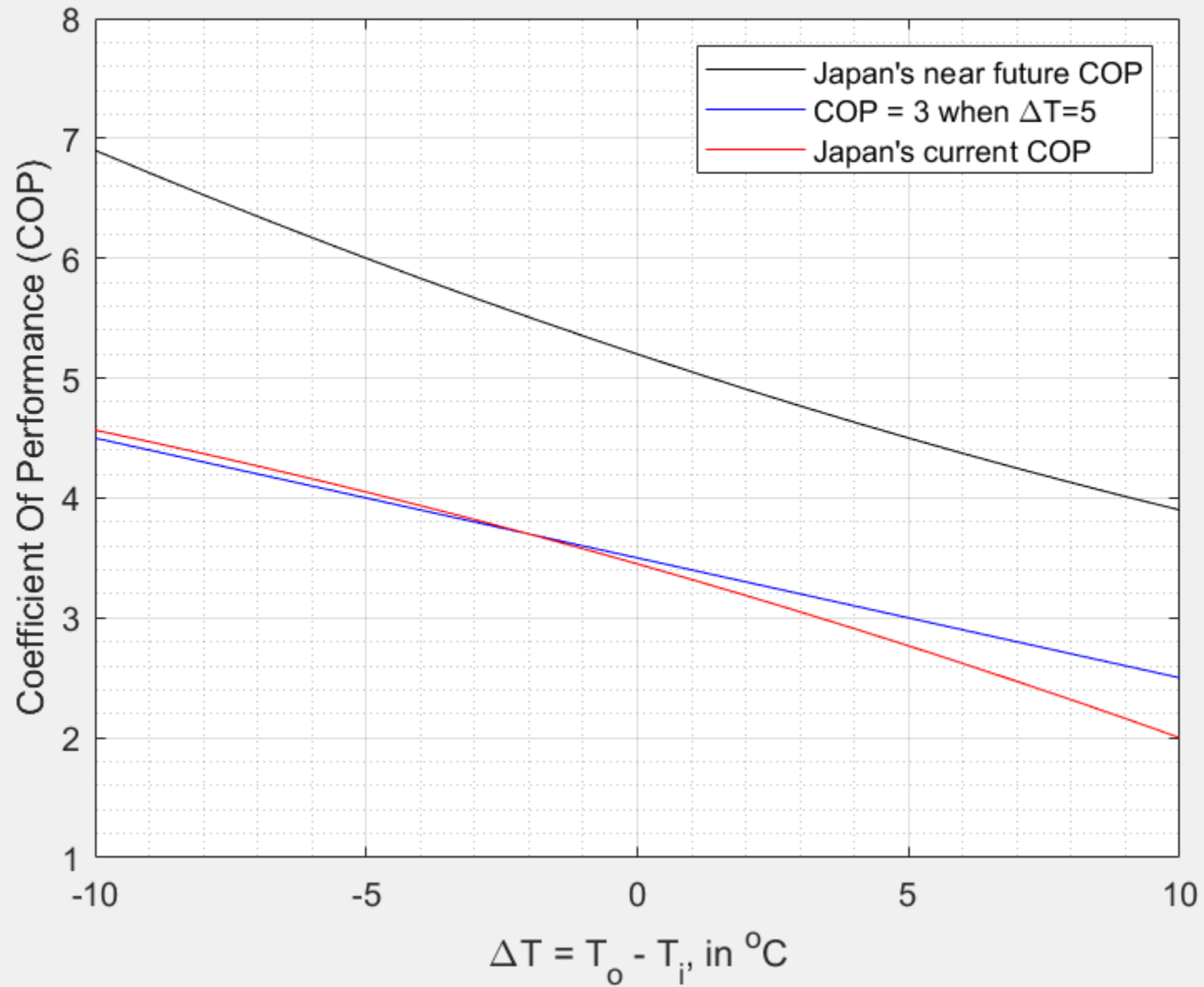


# 1<sup>st</sup> pushbutton

Hourly variation of 3 COP options

**Fig. 1, 2**

Fig. 1: Based on 3 COP calculation methods



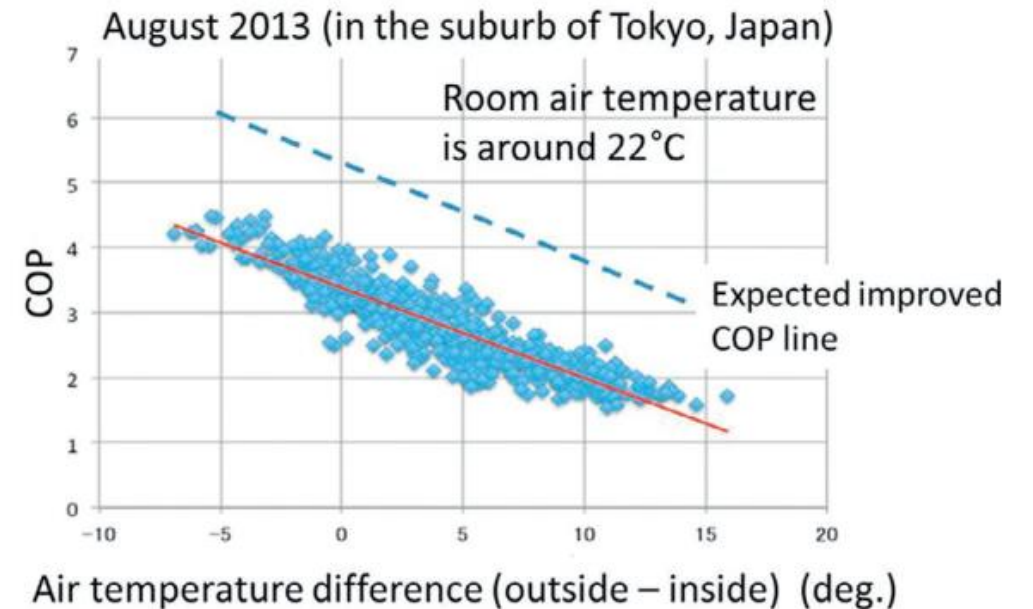
# COP as function of $(T_o - T_i)$

三個策略的  $T_i$  稍有不同

```
function COP=COPtdif(Tout)
Ti=20; dT0=5;
dT=Tout-Ti;
COP0=3; % at dT0=5
COP=COP0-(dT-dT0)*0.1;
```

```
function COP=COPpresent(Tout)
Ti=22;dT=[-5 0 10];
COPpresent=[4.05 3.45 2.0];
COP=interp1(dT,COPpresent,(Tout-Ti),'spline');
```

```
function COP=COPimproved(Tout)
Ti=22;dT=[-5 0 10];
COPpresent=[6 5.2 3.9];
COP=interp1(dT,COPimproved,(Tout-Ti),'spline');
```



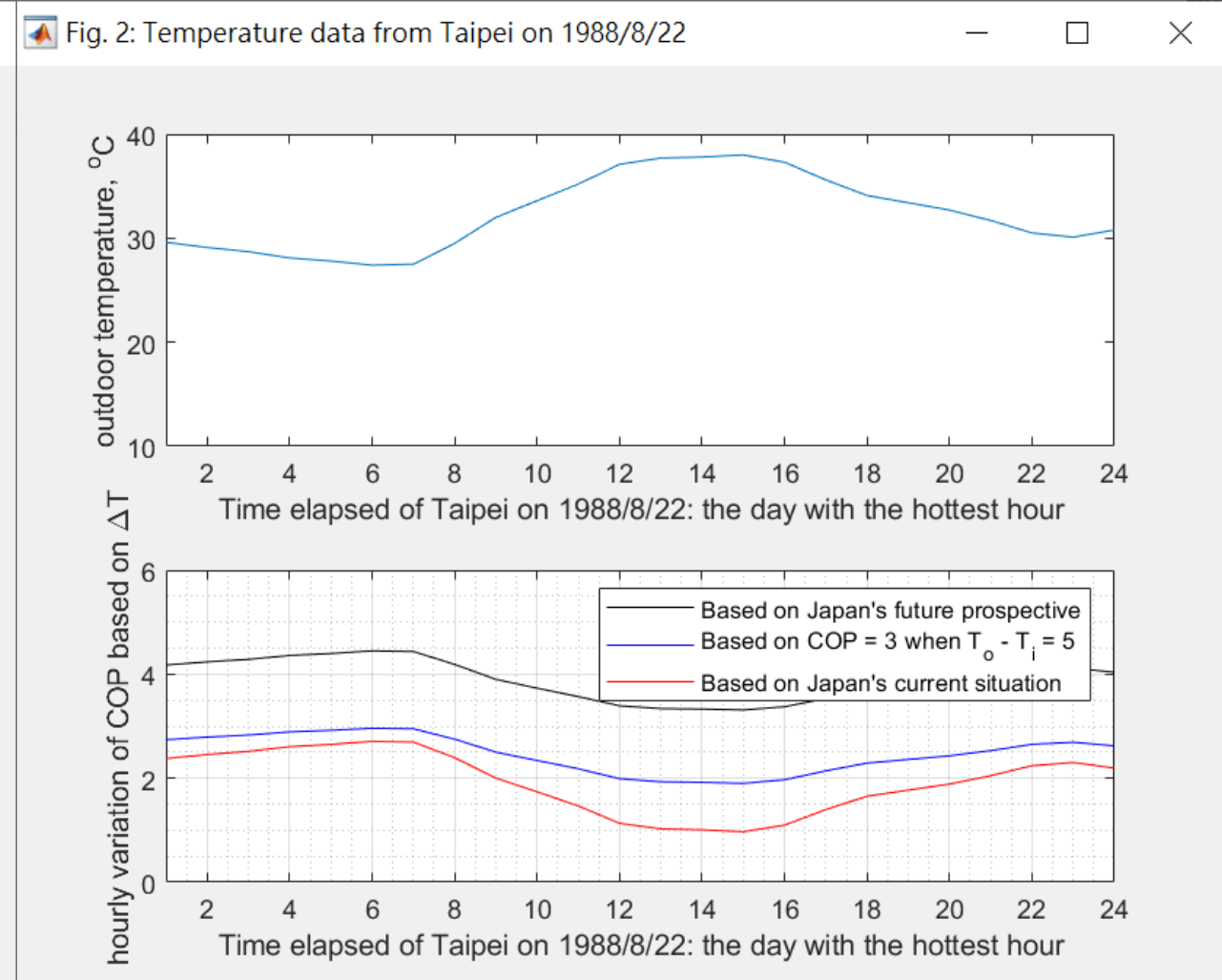
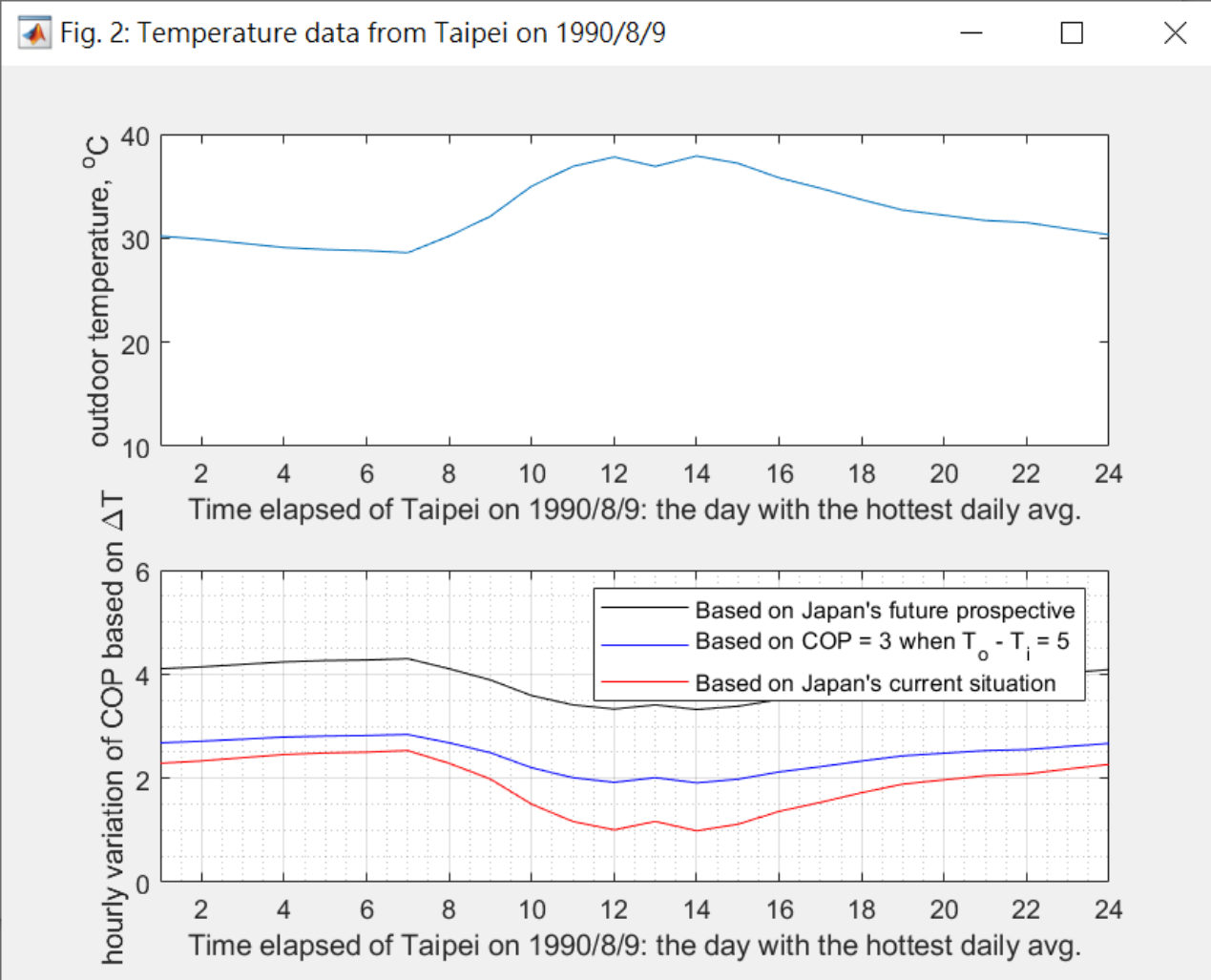
# 選擇 City 中第 1 選項

## 最熱的一天

台北

# 選擇 City 中第 11 選項

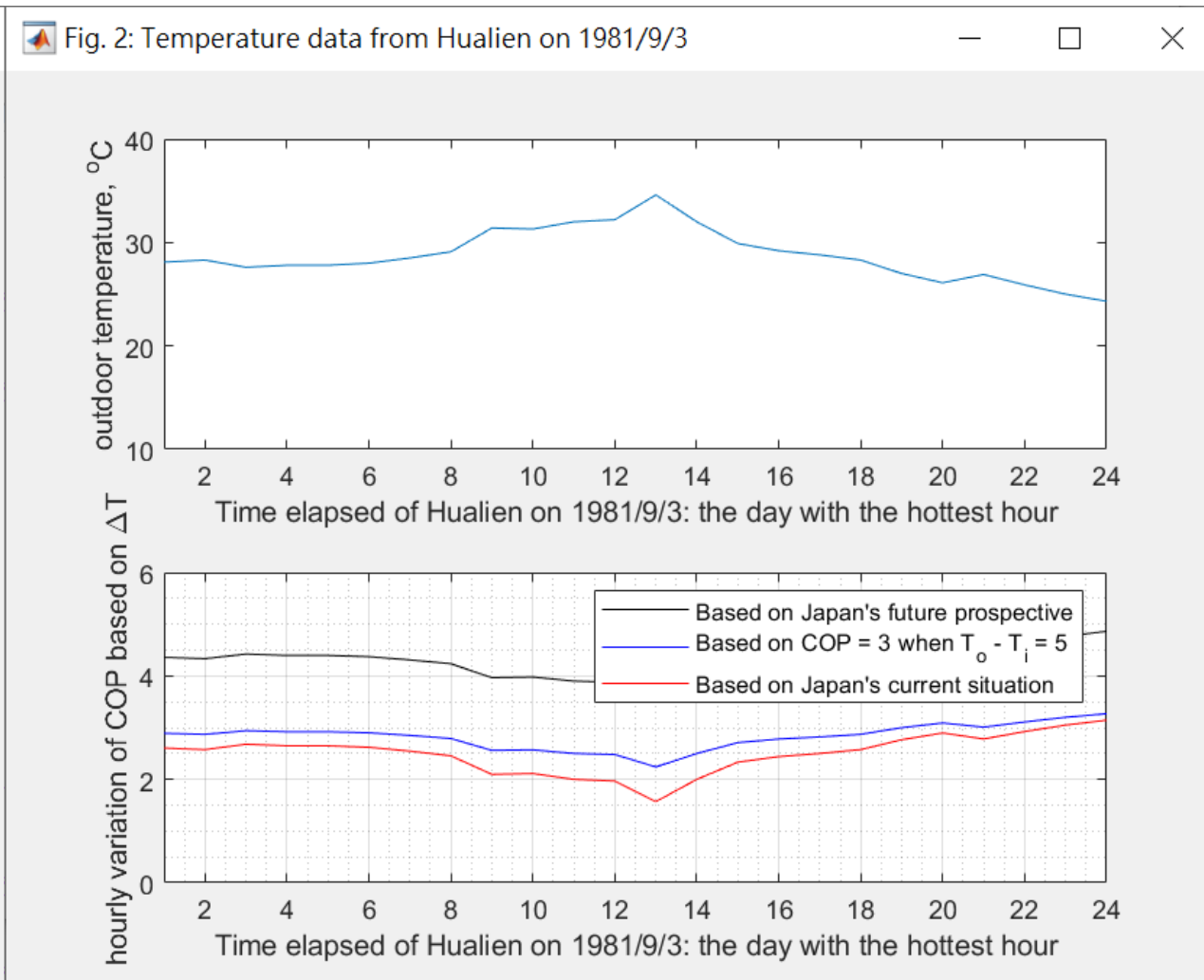
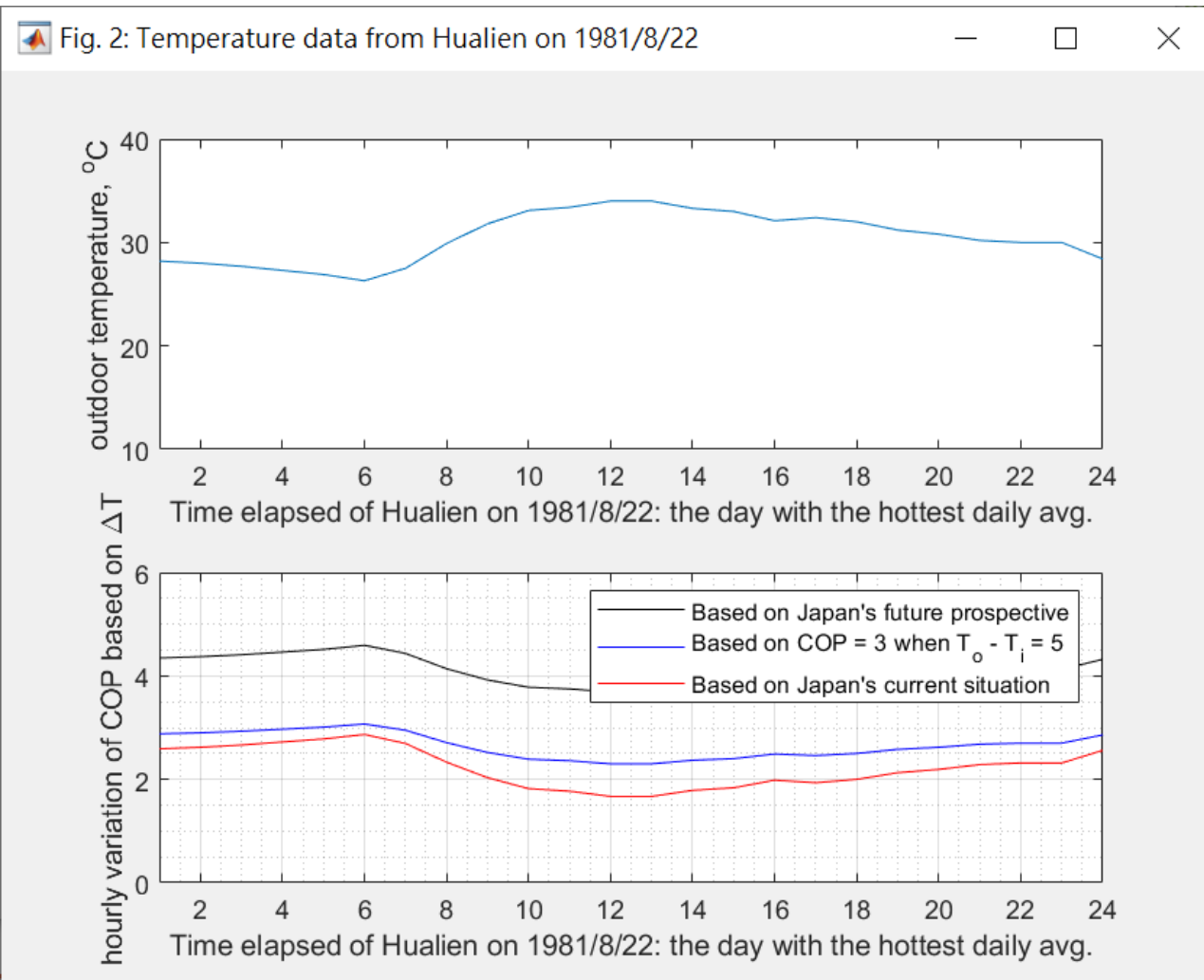
## 有最熱的一小時那天



# 選擇 City 中第 2 選項 最熱的一天

花蓮

# 選擇 City 中第 12 選項 有最熱的一小時那天



# 選擇 City 中第 3 選項

## 最熱的一天

# 宜蘭

# 選擇 City 中第 13 選項

## 有最熱的一小時那天

Fig. 2: Temperature data from Ilan on 1991/7/27

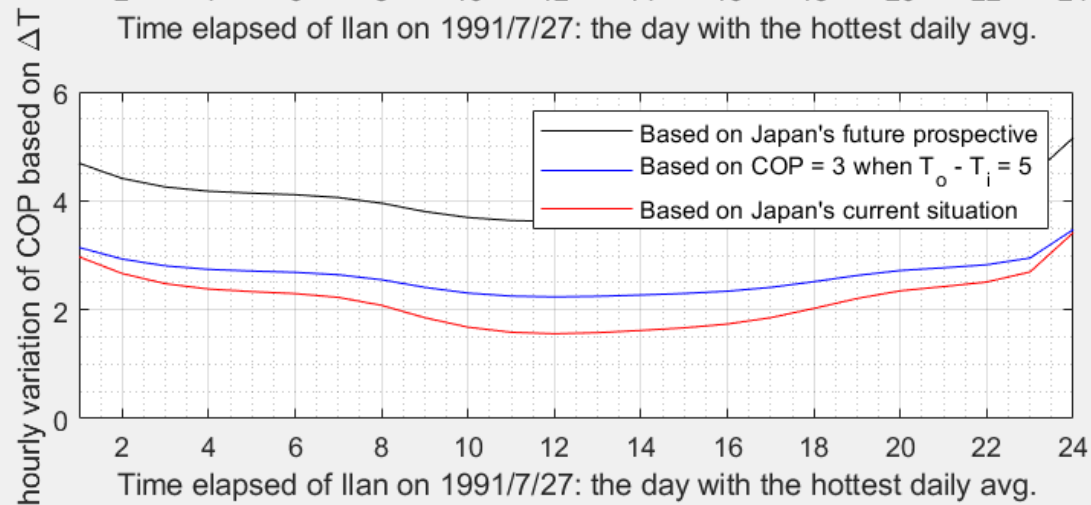
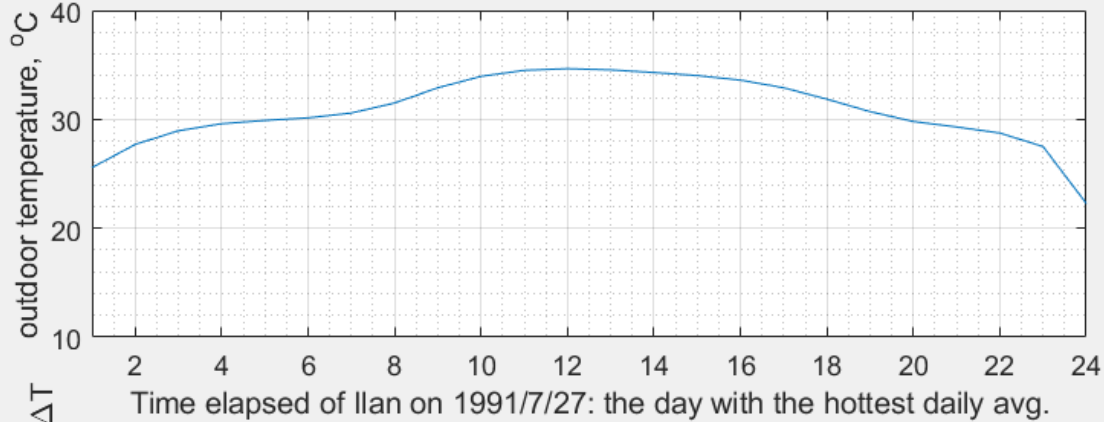
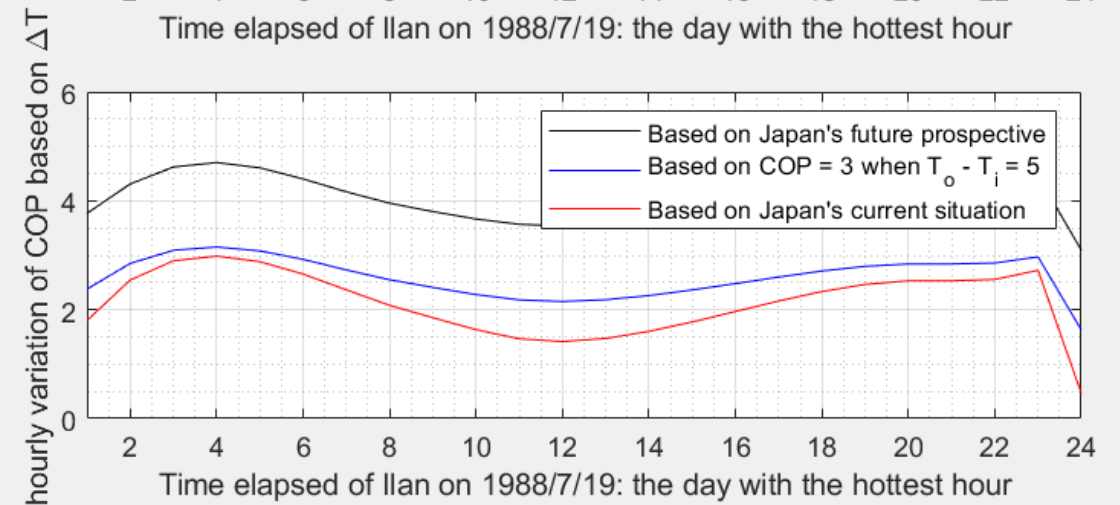
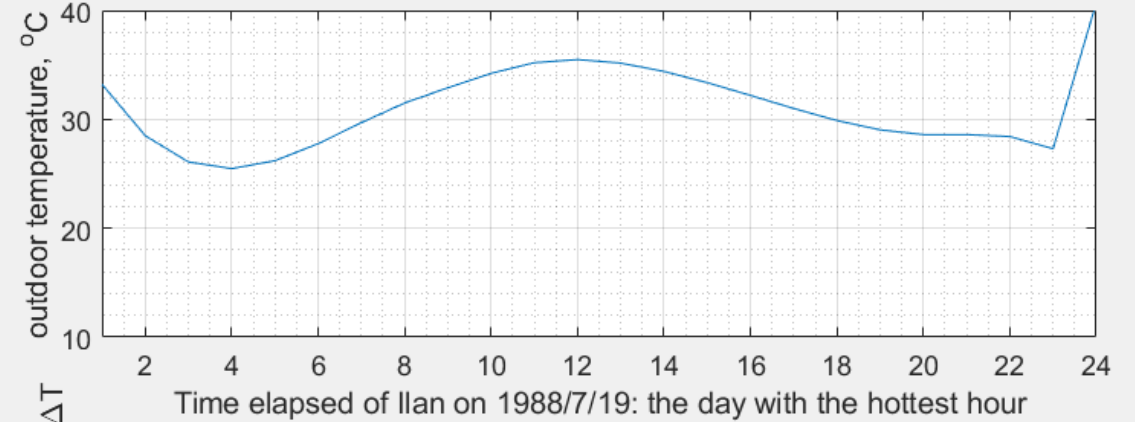


Fig. 2: Temperature data from Ilan on 1988/7/19



# 選擇 City 中第 4 選項

## 最熱的一天

台南

# 選擇 City 中第 14 選項

## 有最熱的一小時那天

Fig. 2: Temperature data from Tainan on 1986/6/23

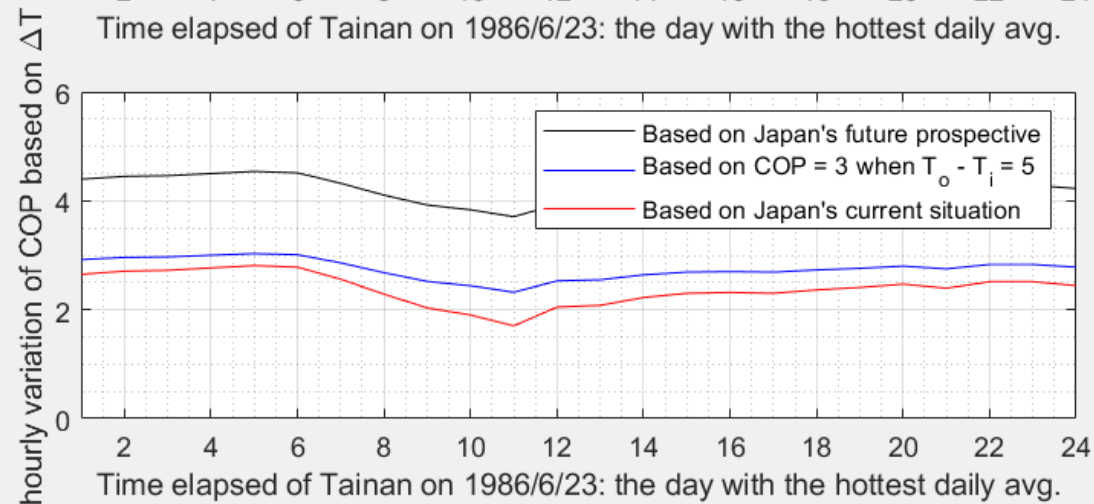
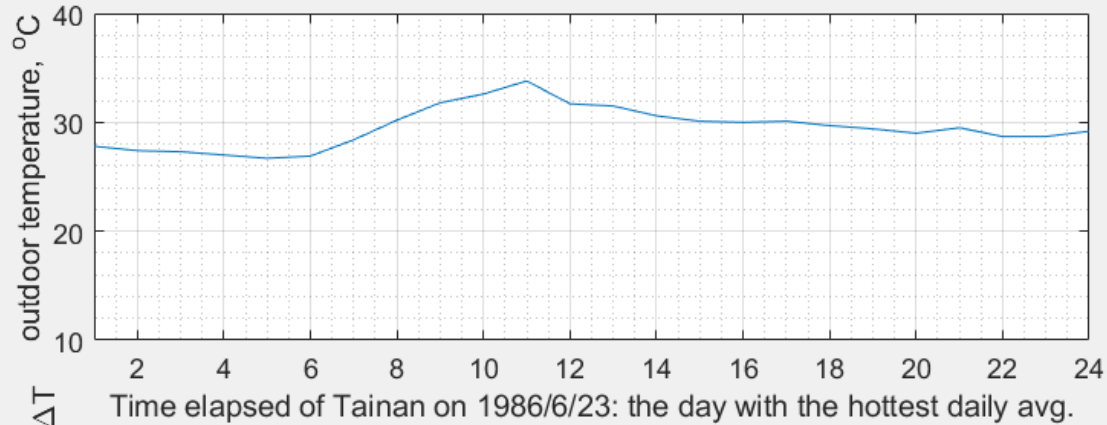
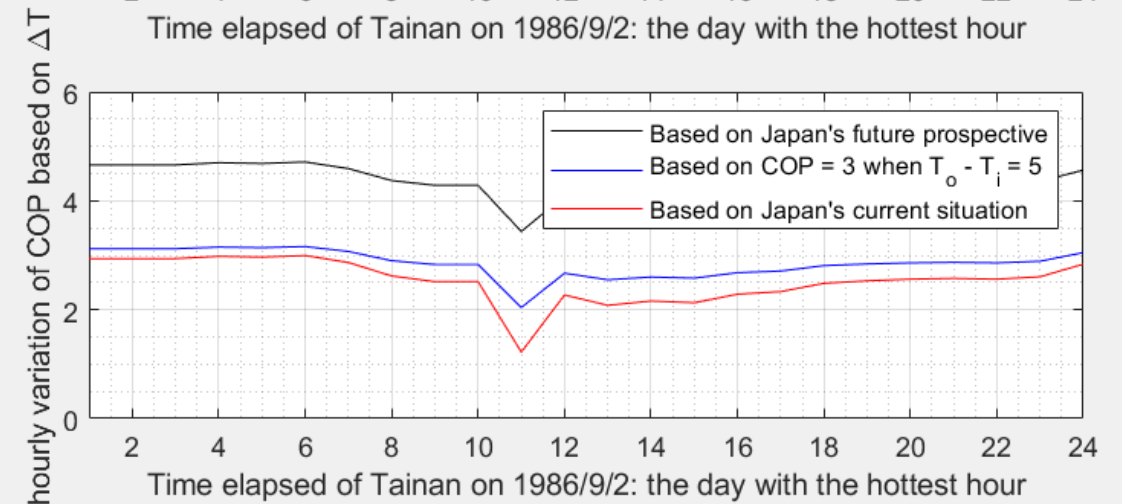
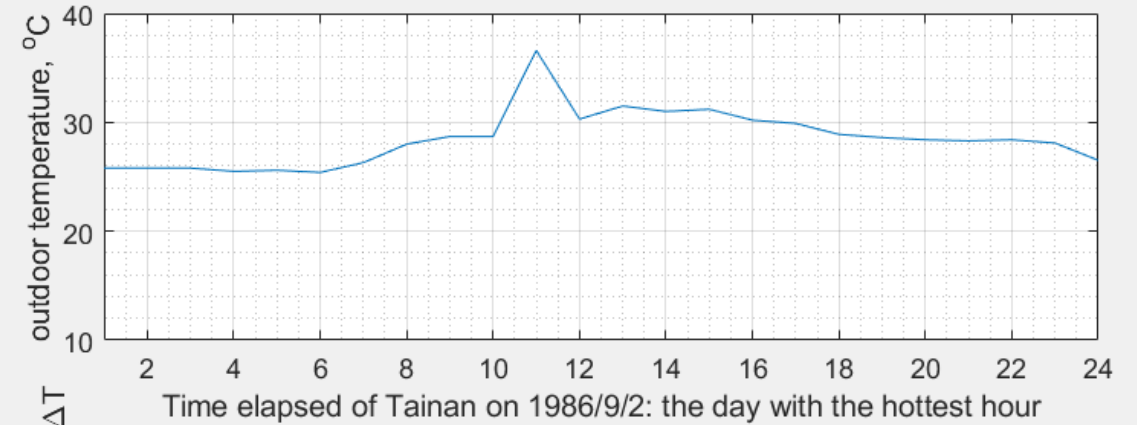


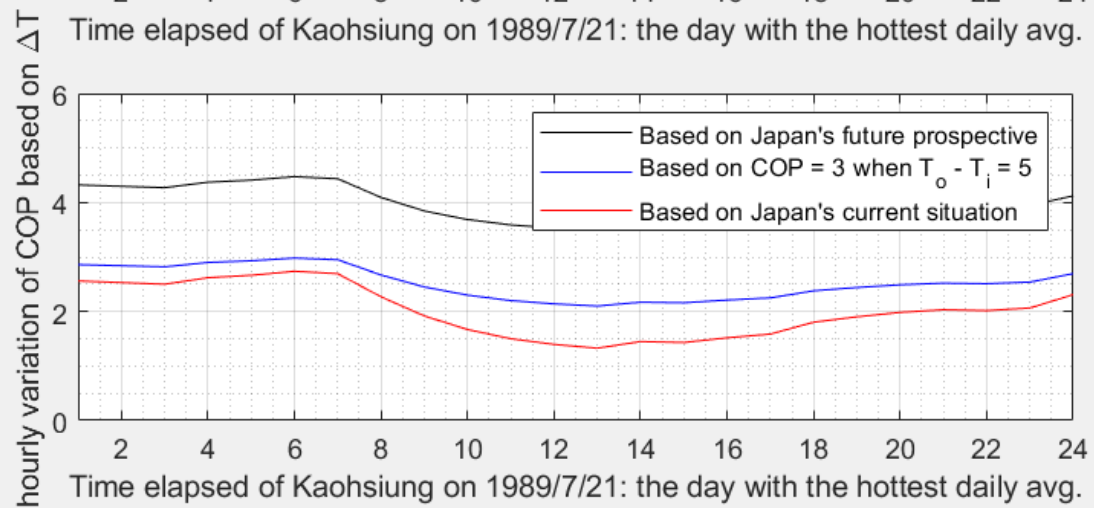
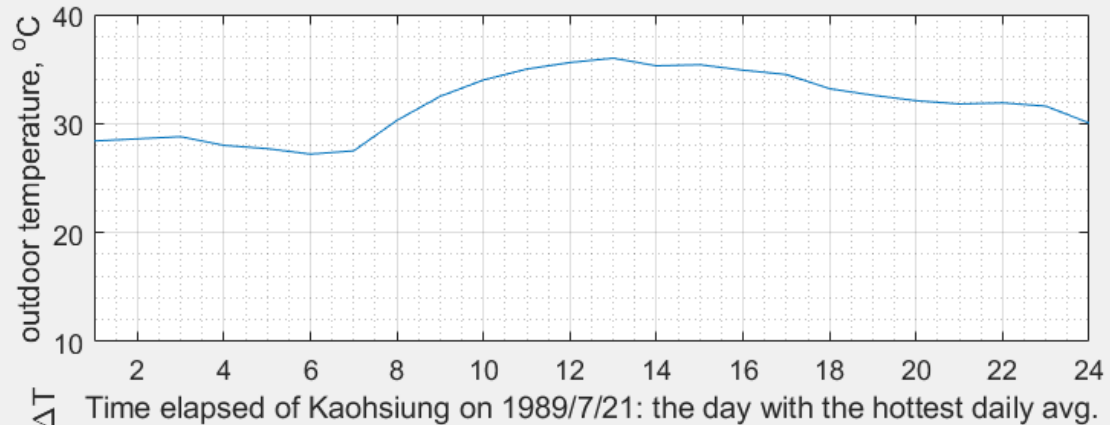
Fig. 2: Temperature data from Tainan on 1986/9/2



# 選擇 City 中第 5 選項

## 最熱的一天

Fig. 2: Temperature data from Kaohsiung on 1989/7/21

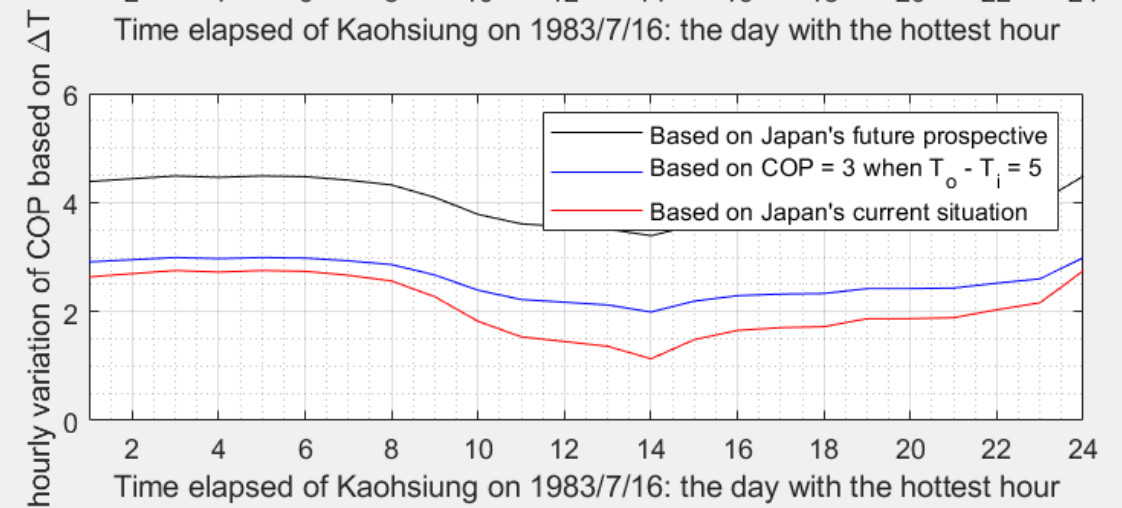
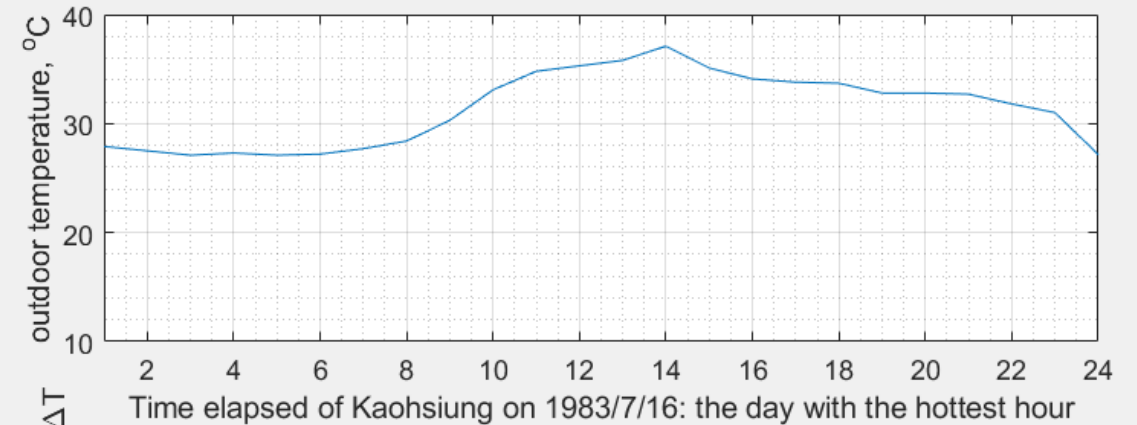


# 高雄

# 選擇 City 中第 15 選項

## 有最熱的一小時那天

Fig. 2: Temperature data from Kaohsiung on 1983/7/16





# 選擇 City 中第 7 選項 最熱的一天

台中

# 選擇 City 中第 17 選項 有最熱的一小時那天

Fig. 2: Temperature data from Taichung on 1983/7/2

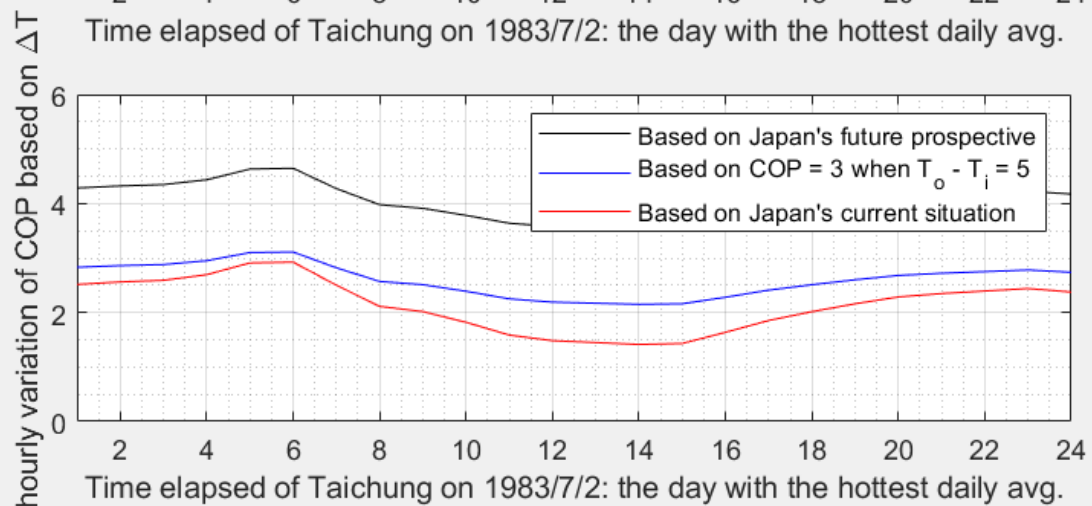
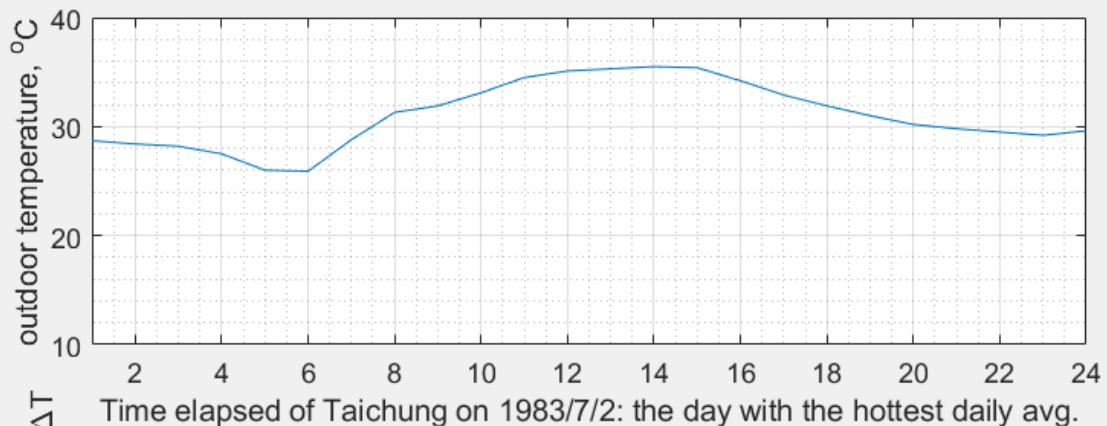
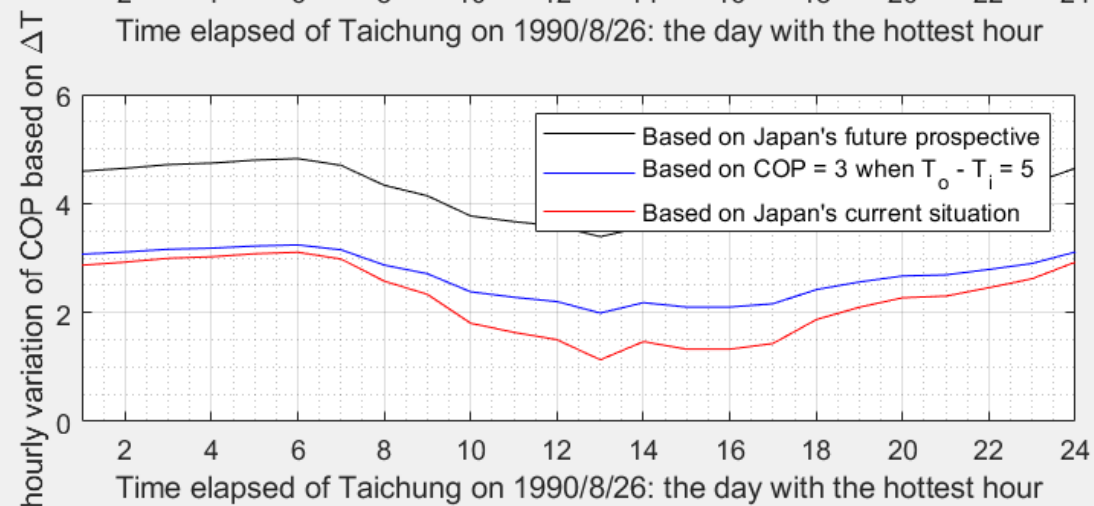
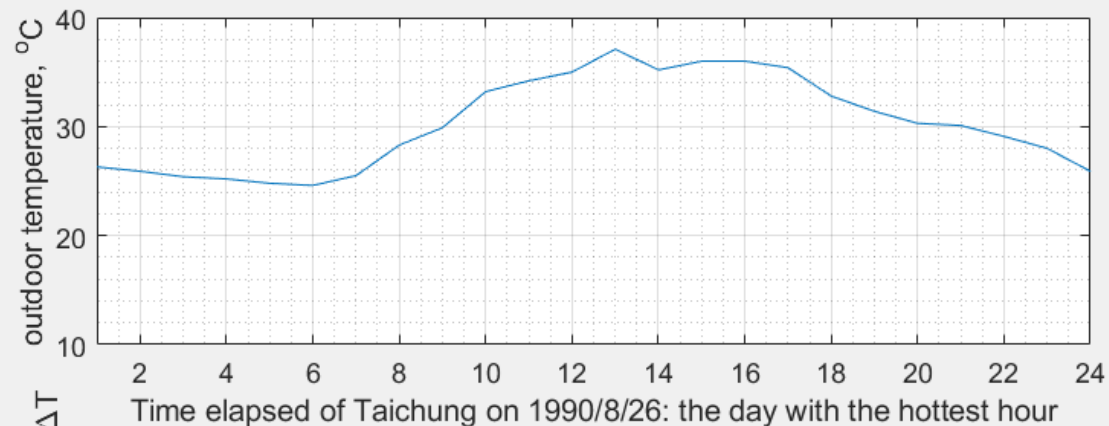


Fig. 2: Temperature data from Taichung on 1990/8/26



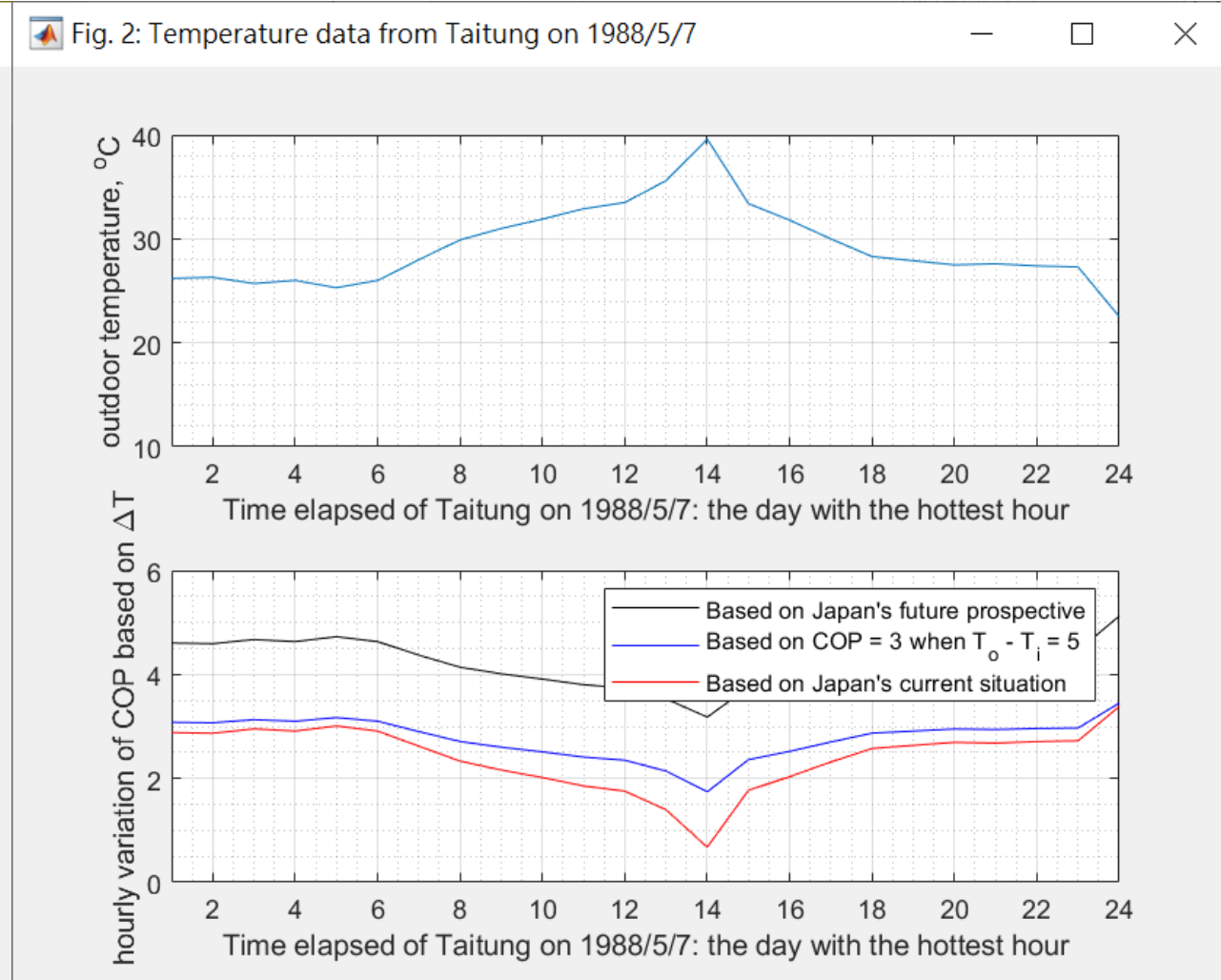
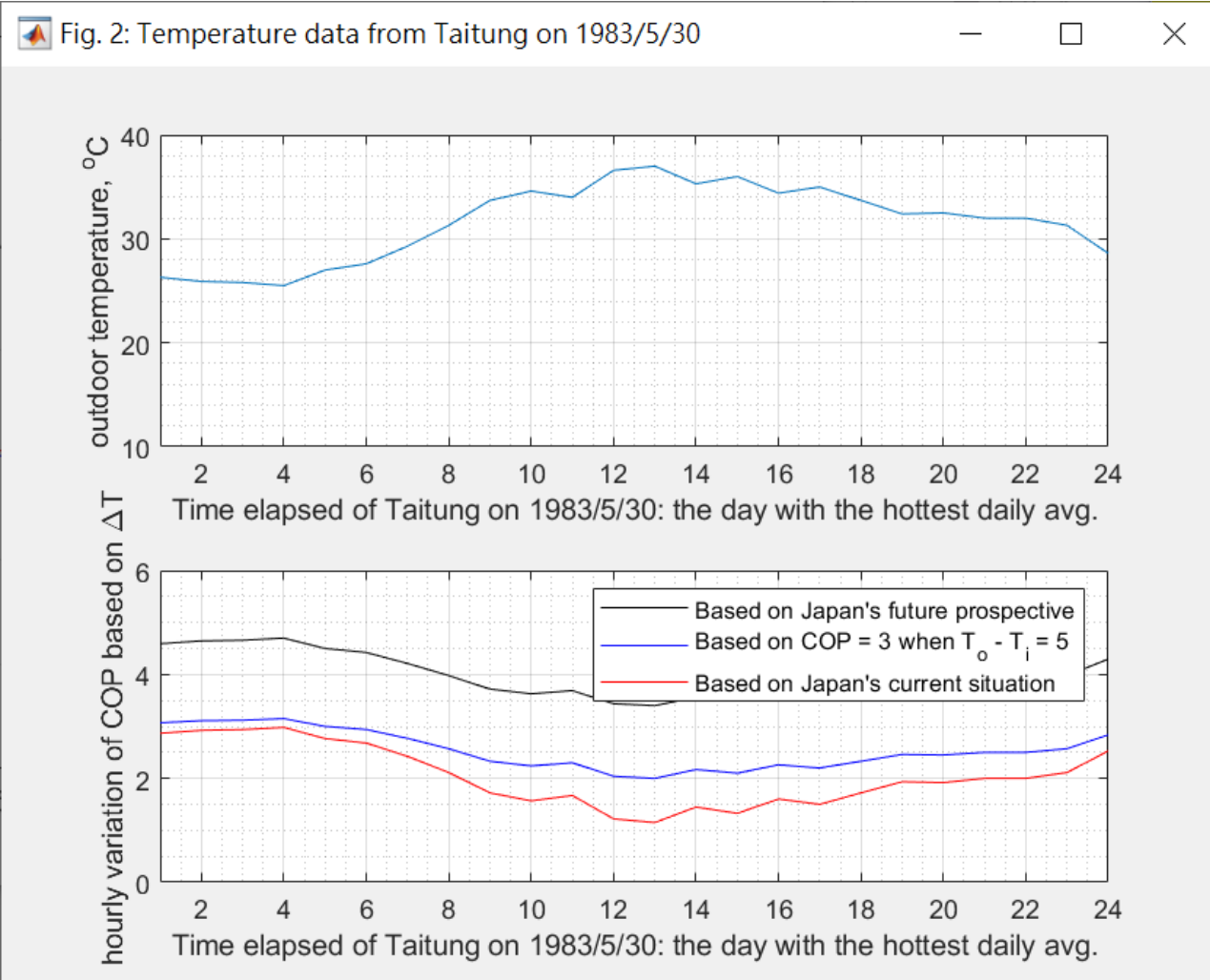
# 選擇 City 中第 9 選項

## 最熱的一天

台東

# 選擇 City 中第 19 選項

## 有最熱的一小時那天



## 2<sup>nd</sup> pushbutton

Hourly variation of 3 COP options

hourly variation of  $T_o$ ,  $dT$ , elec.fee & COP

Fig. 1, 2

**Fig. 3**

Fig. 3: Temperature data from Taipei on 1990/8/9

# 台北，最熱的一天

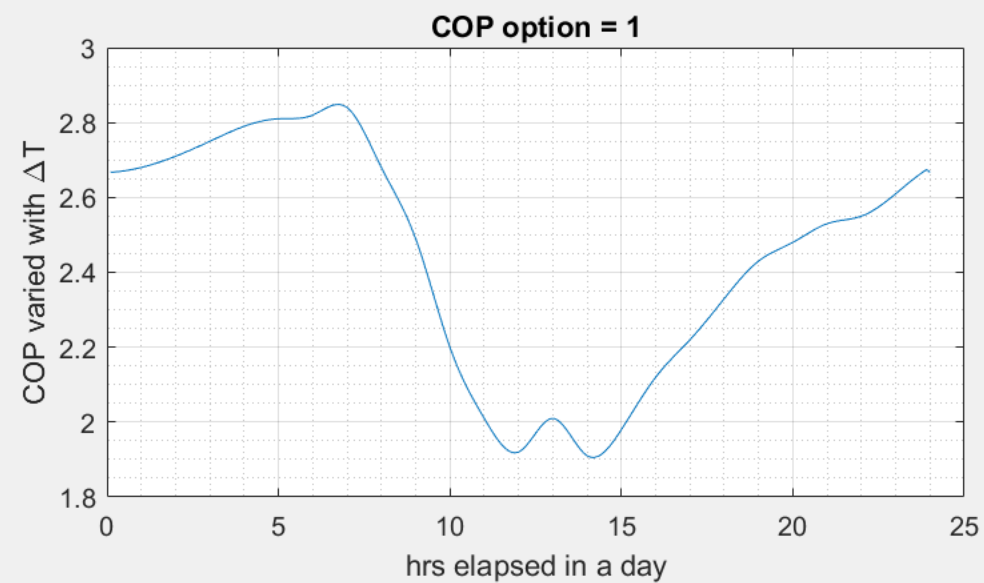
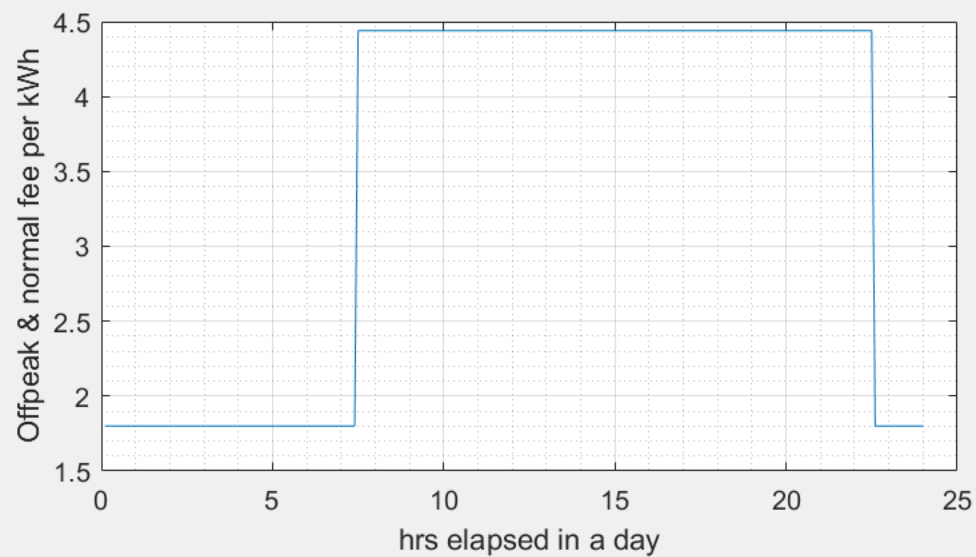
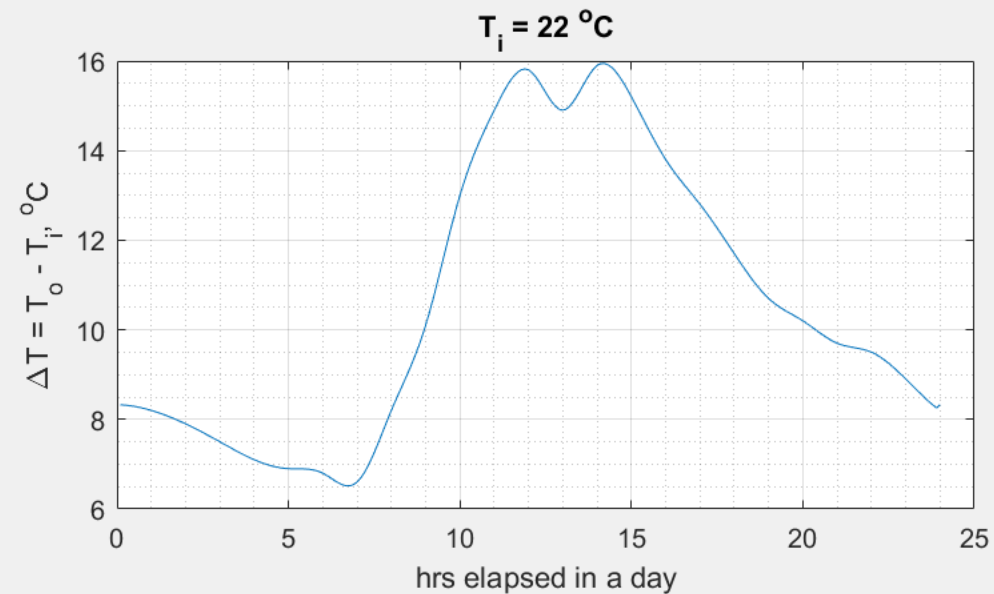
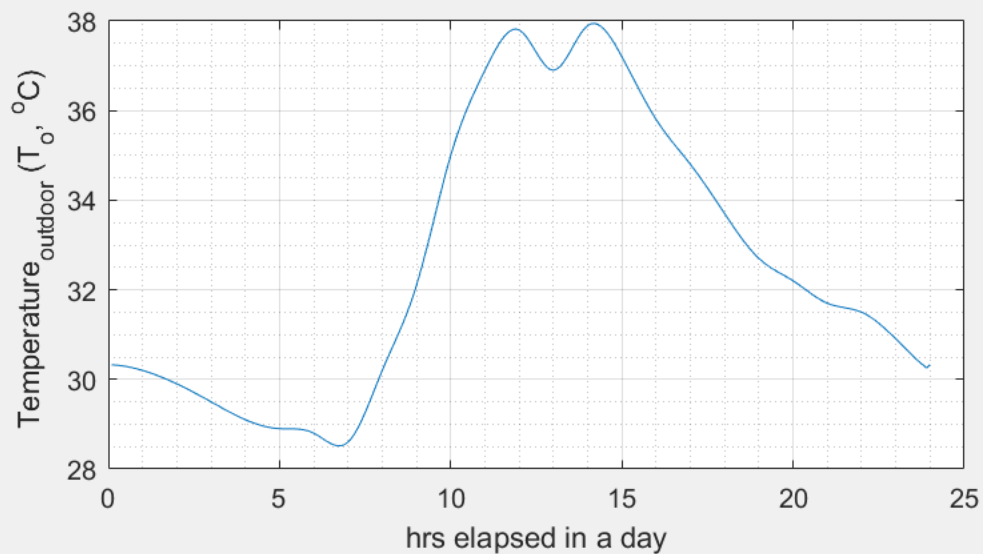


Fig. 3: Temperature data from Taipei on 1988/8/22

# 台北，當天有最熱的一小時

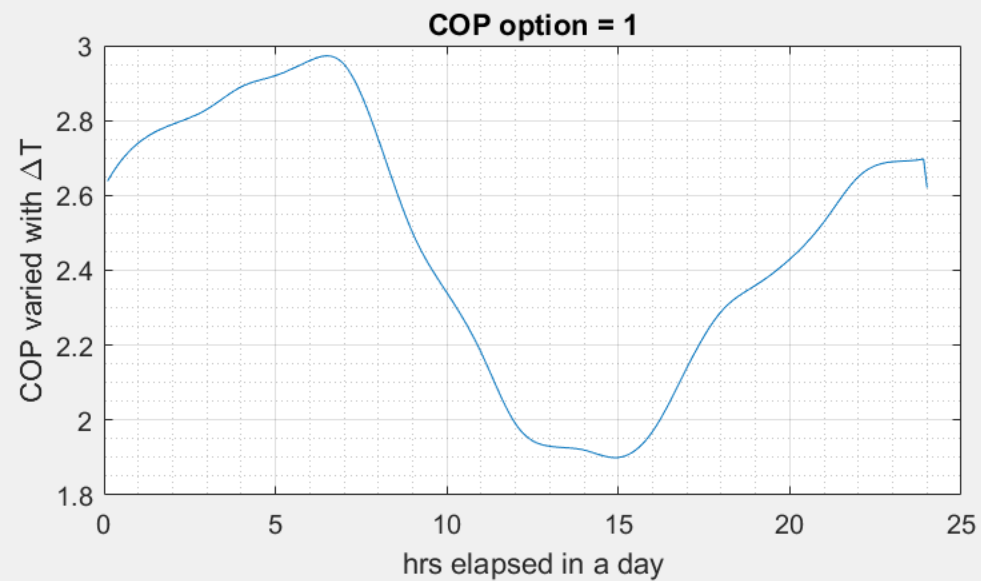
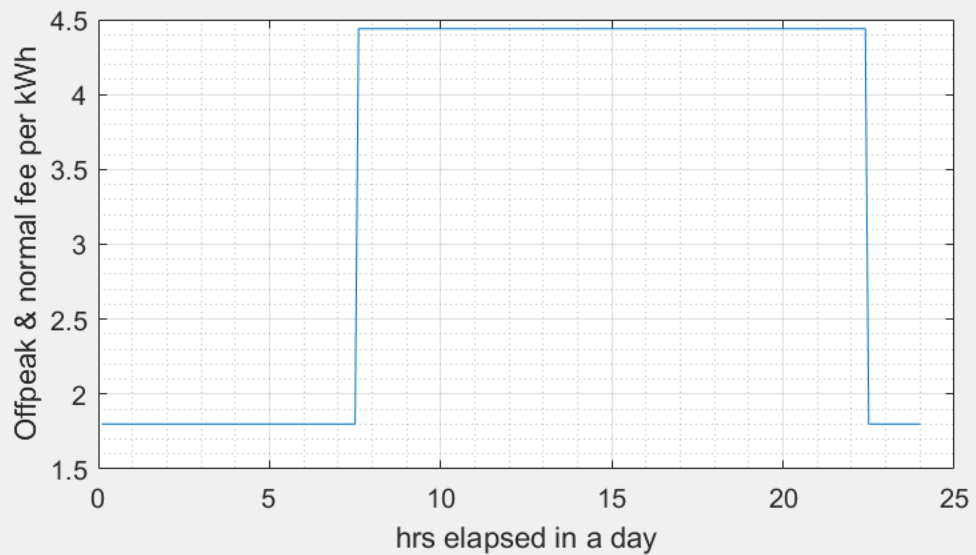
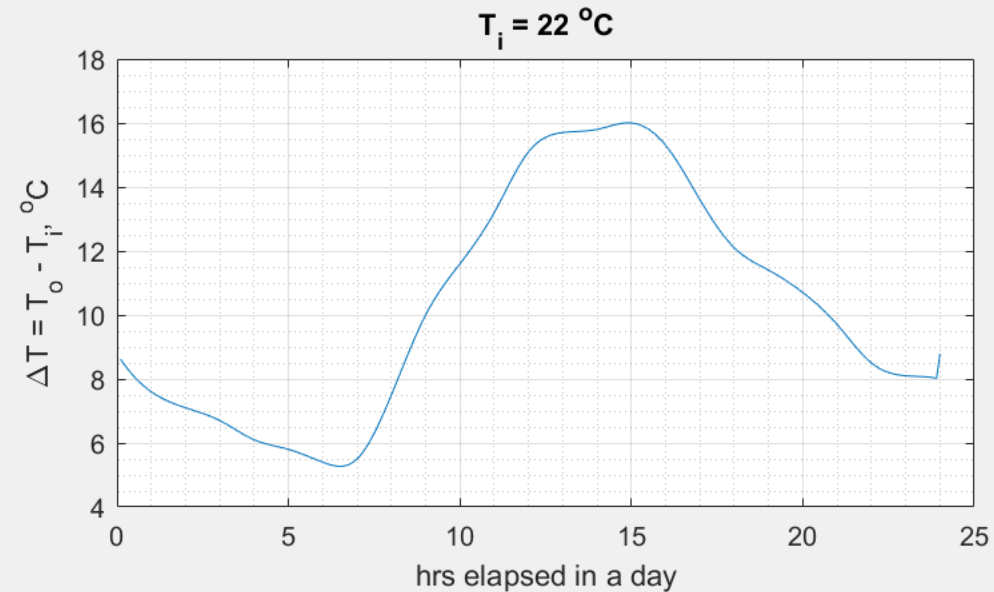
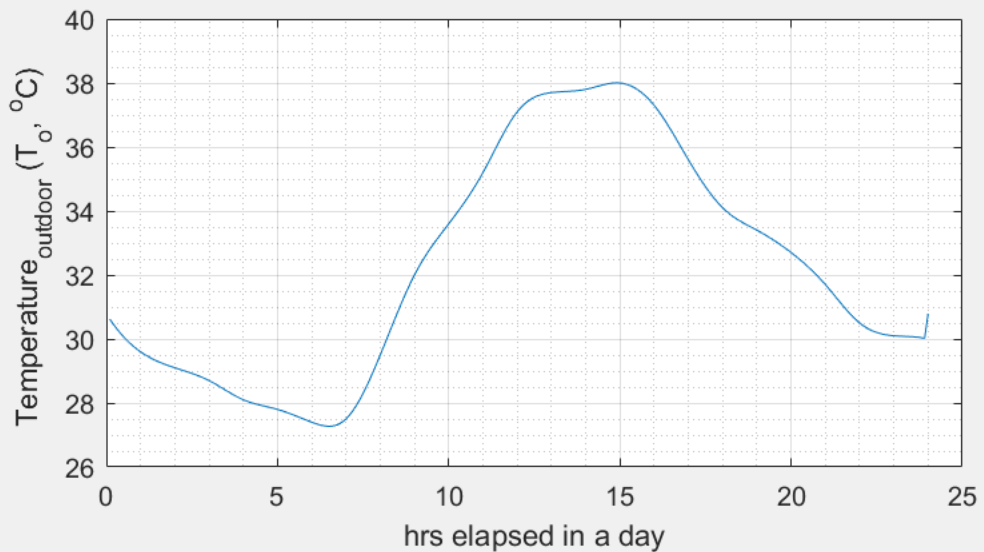


Fig. 3: Temperature data from Taichung on 1983/7/2

# 台中，最熱的一天

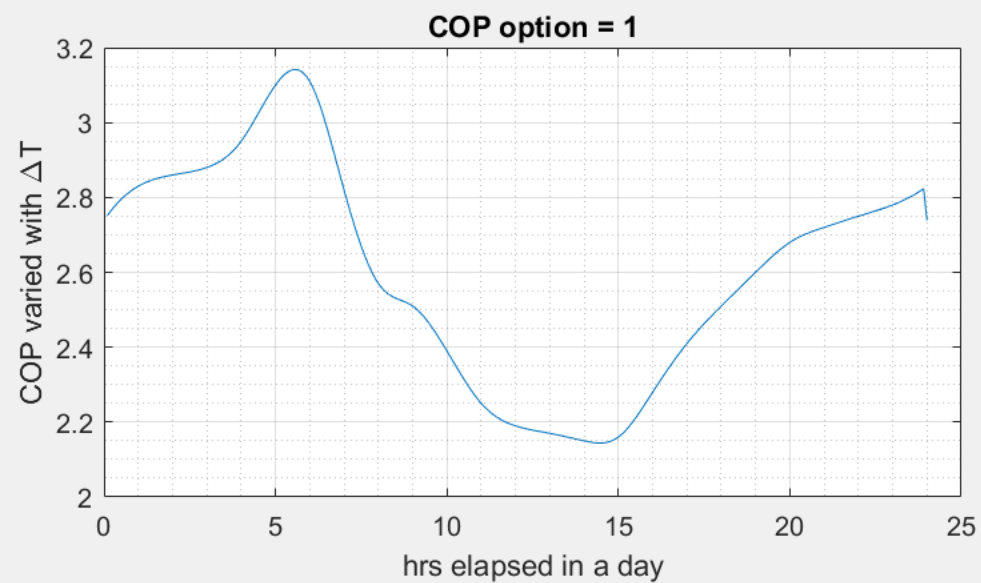
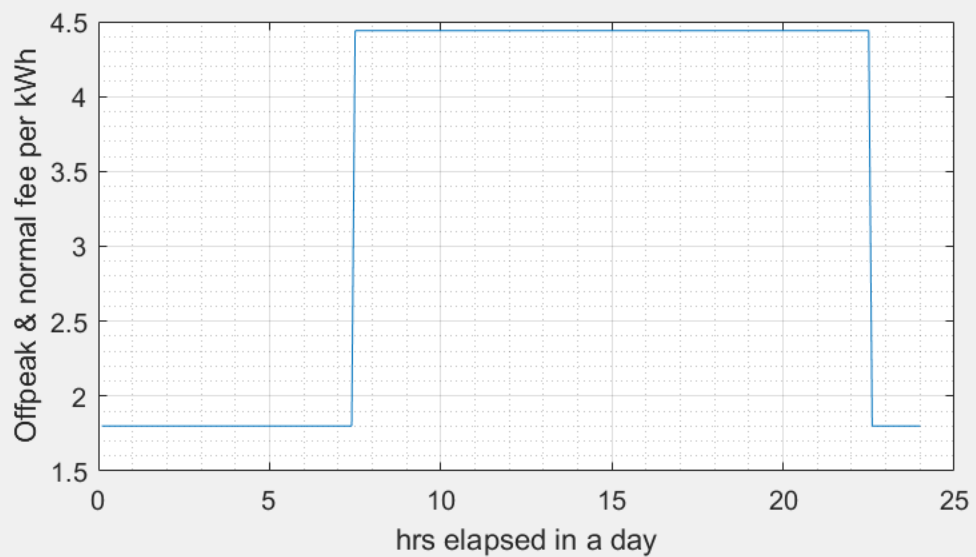
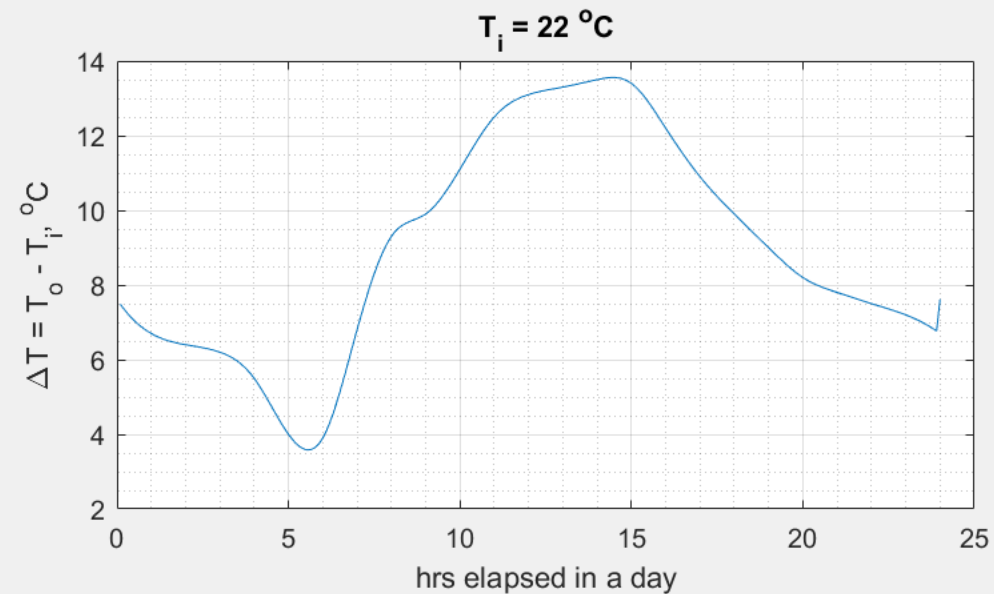
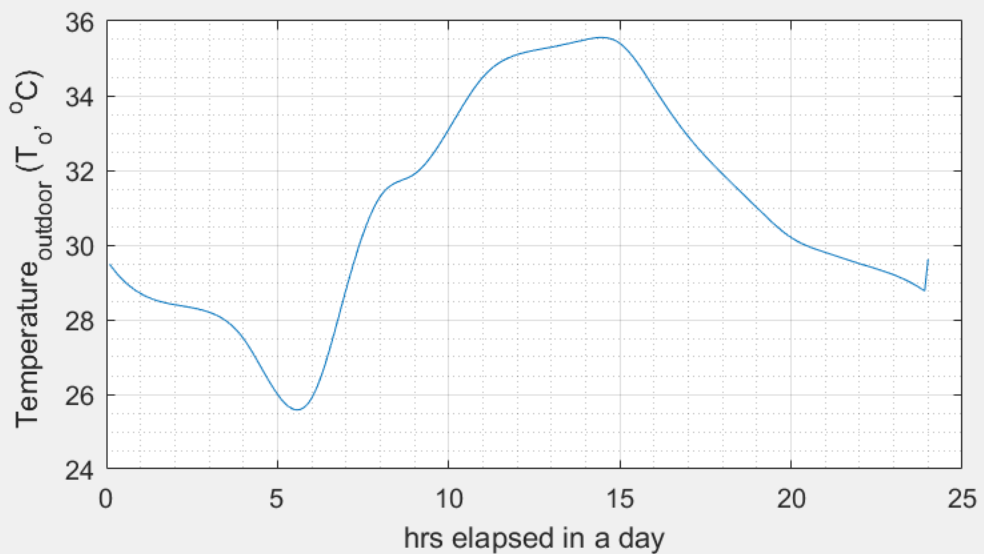


Fig. 3: Temperature data from Taichung on 1990/8/26

# 台中，當天有最熱的一小時

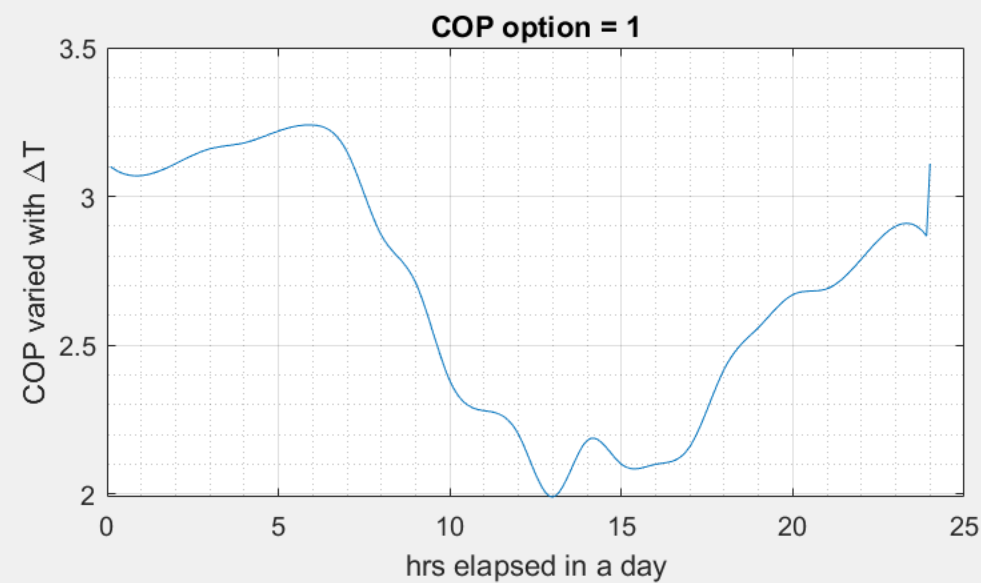
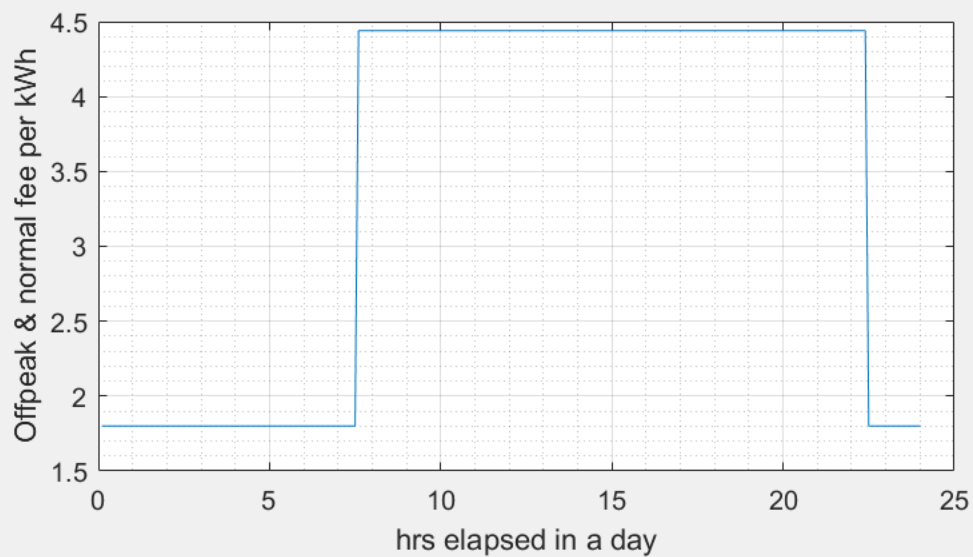
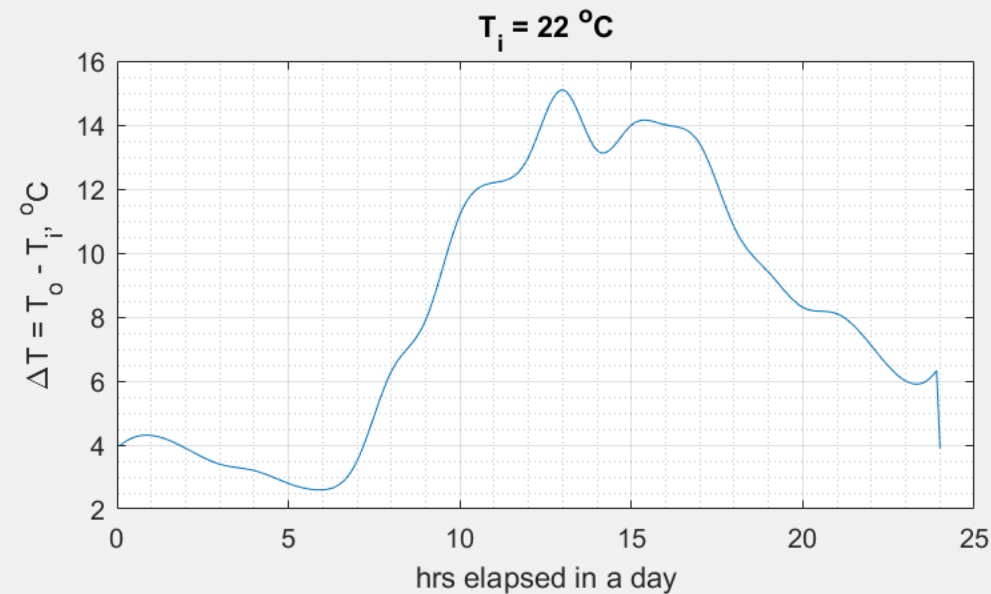
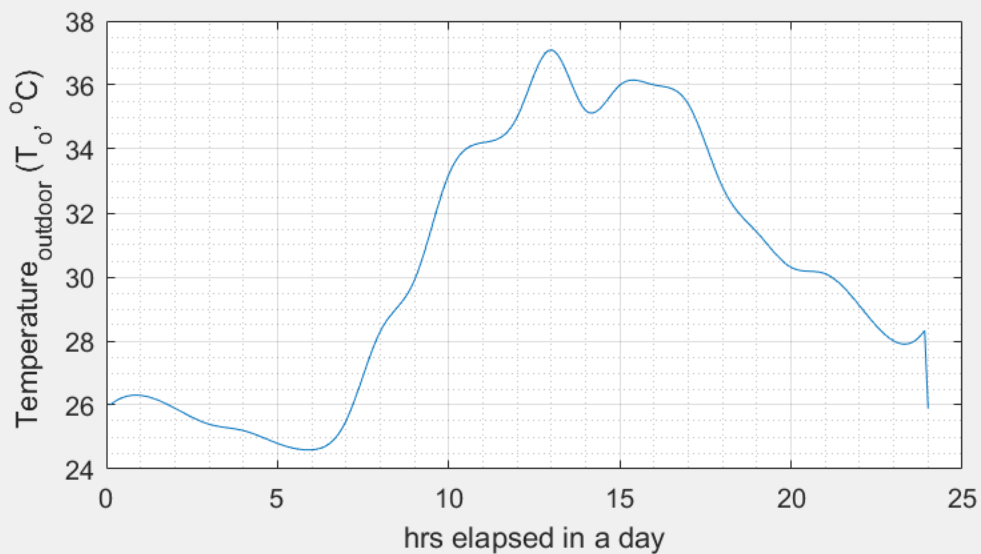


Fig. 3: Temperature data from Tainan on 1986/6/23

# 台南，最熱的一天

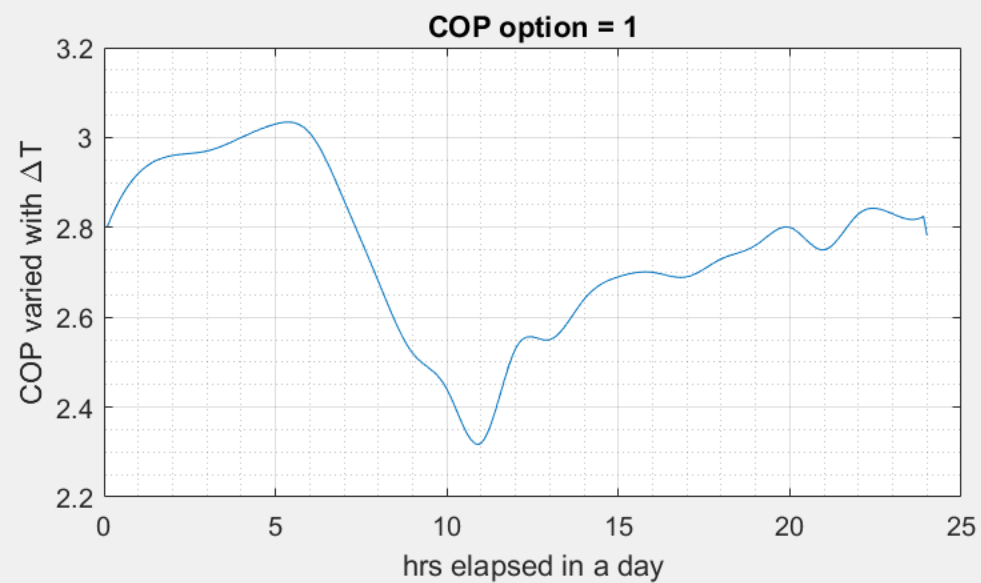
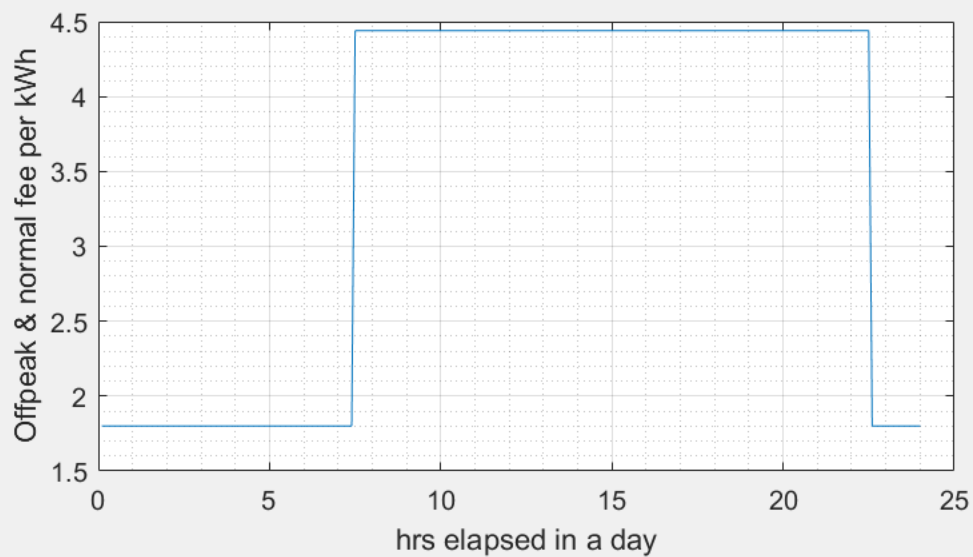
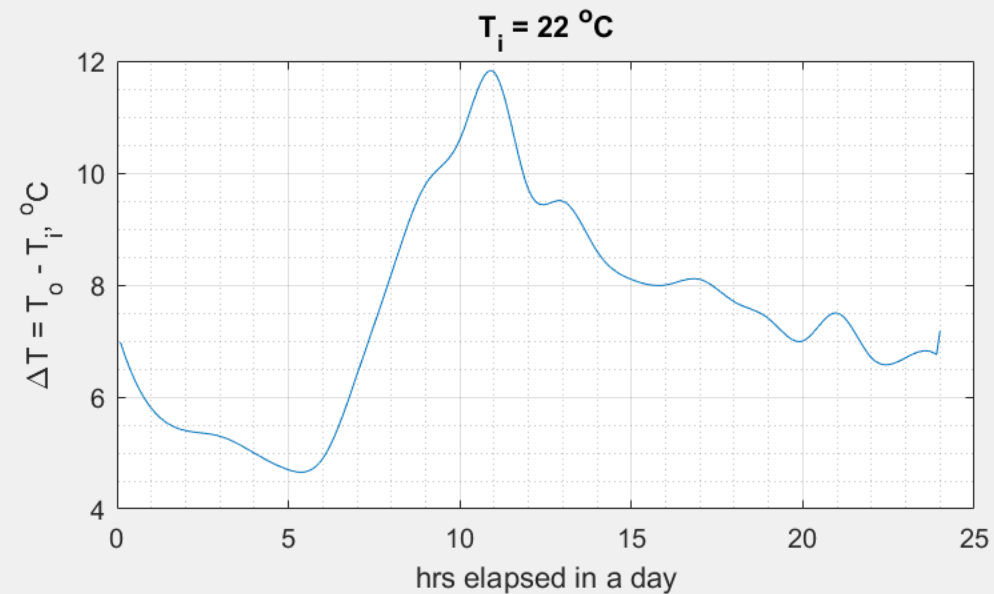
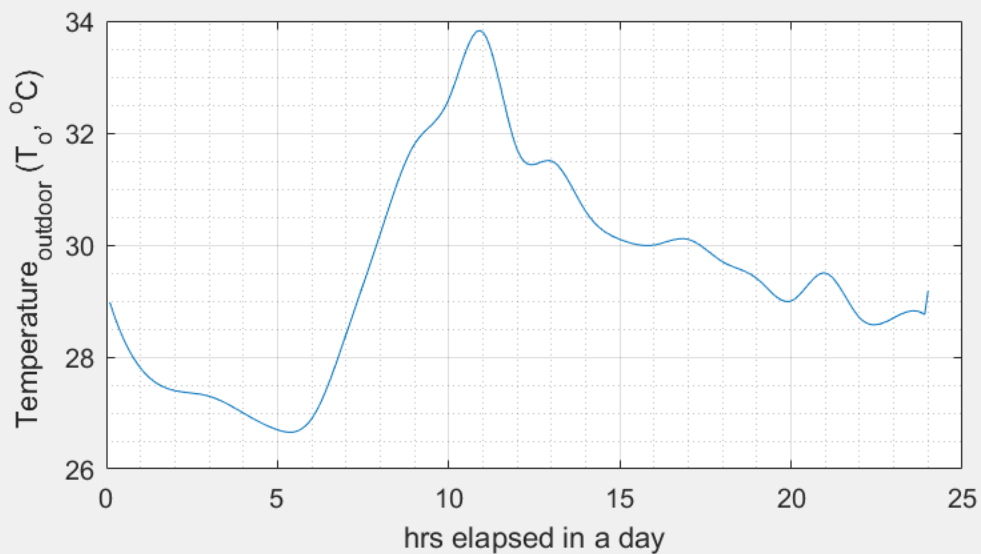




Fig. 3: Temperature data from Tainan on 1986/9/2

# 台南，當天有最熱的一小時

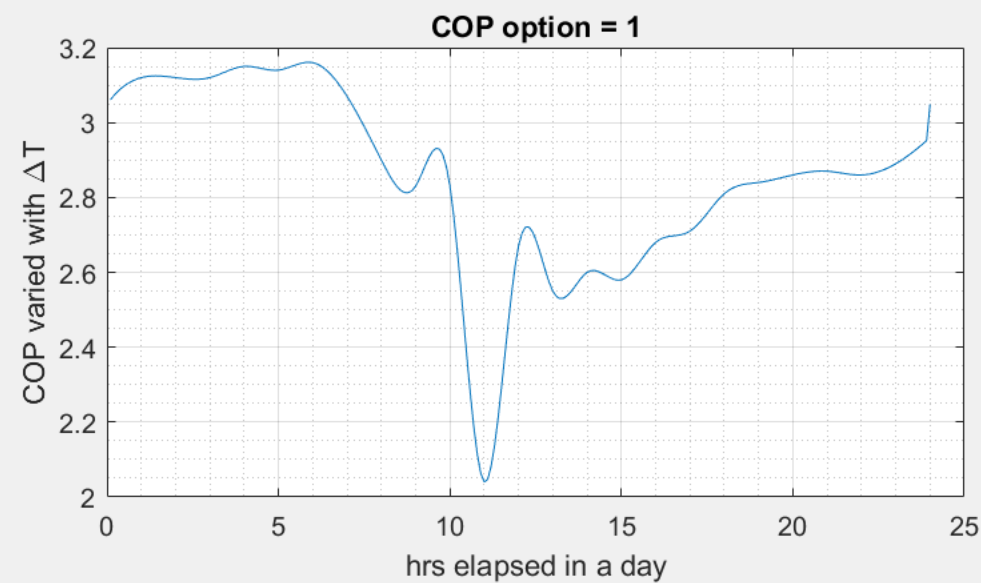
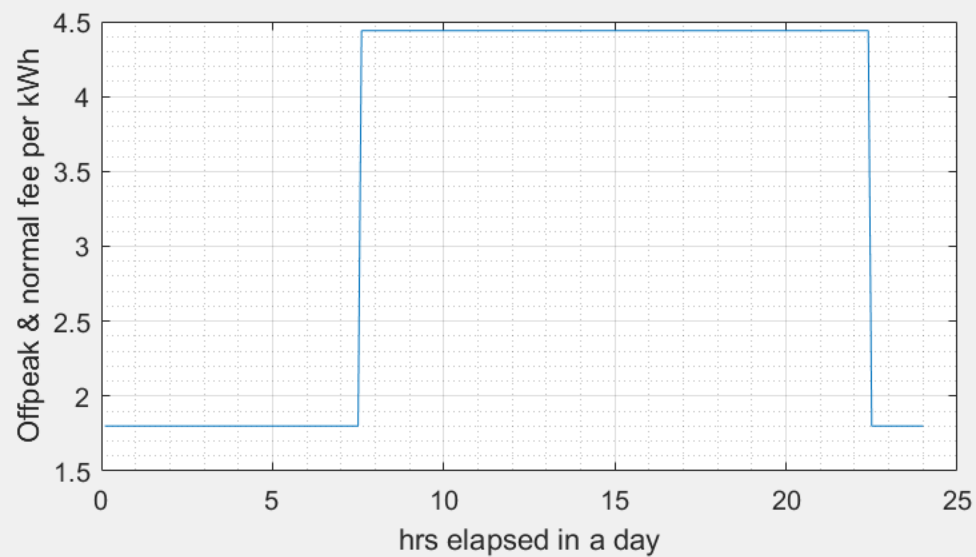
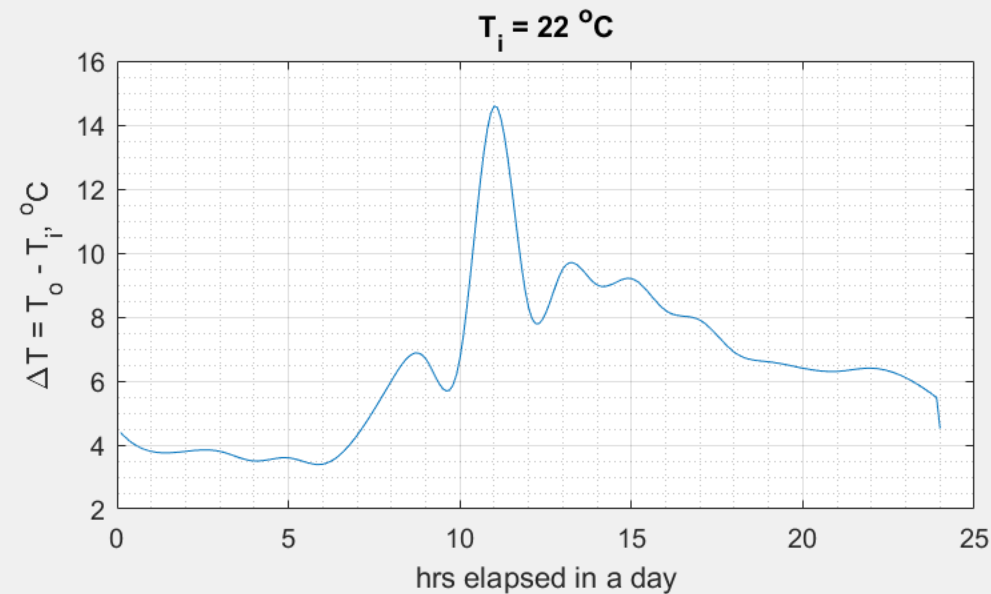
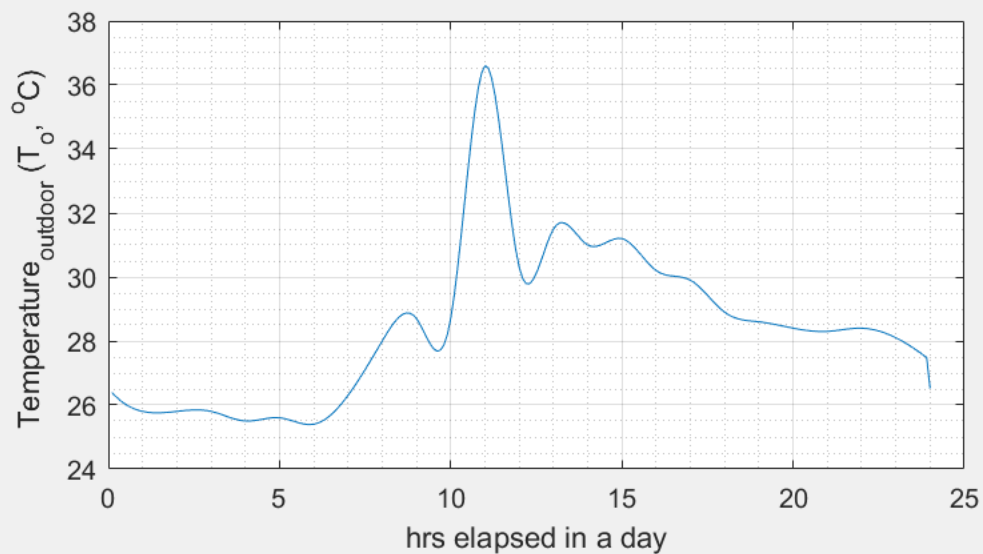


Fig. 3: Temperature data from Kaohsiung on 1989/7/21

# 高雄，最熱的一天

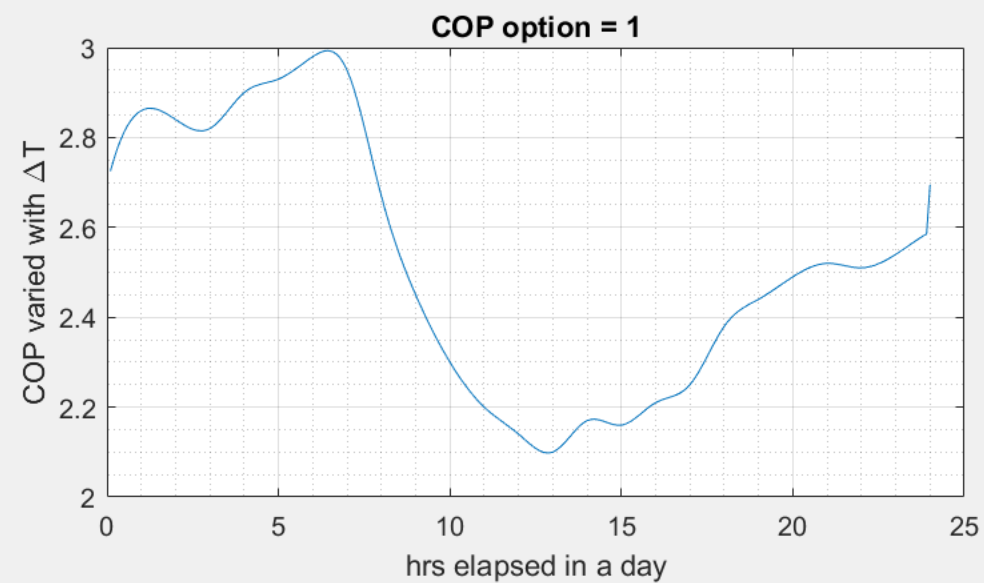
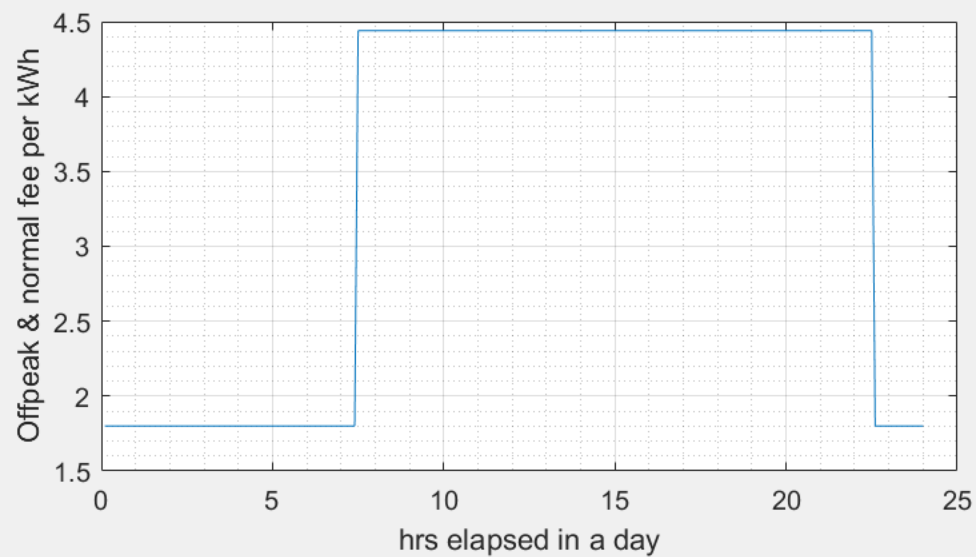
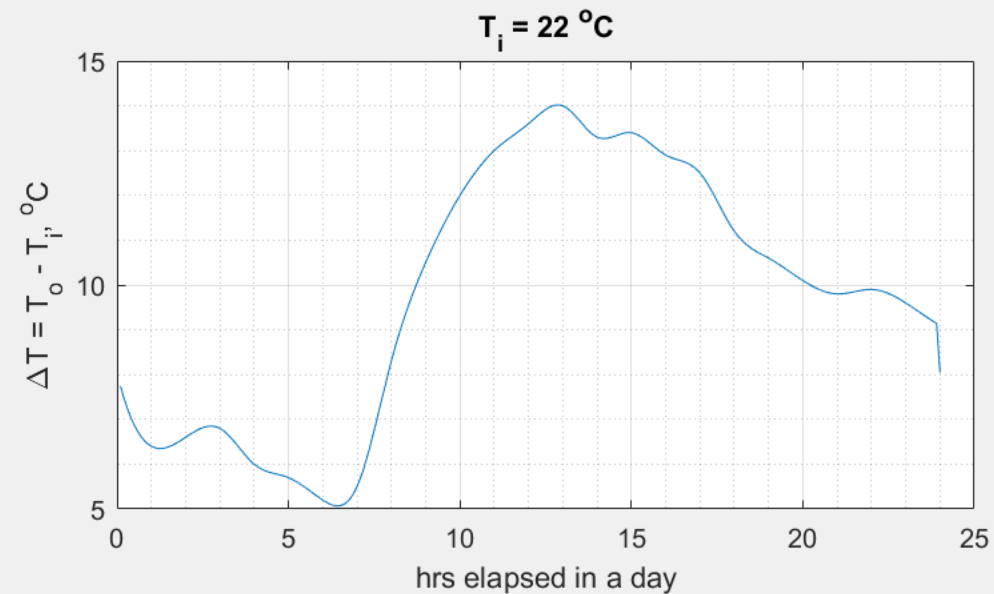
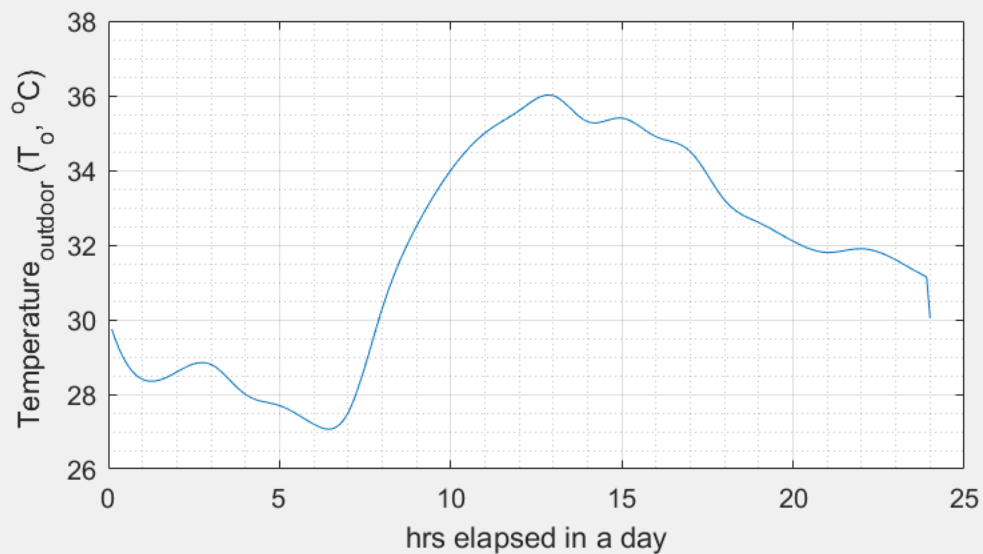
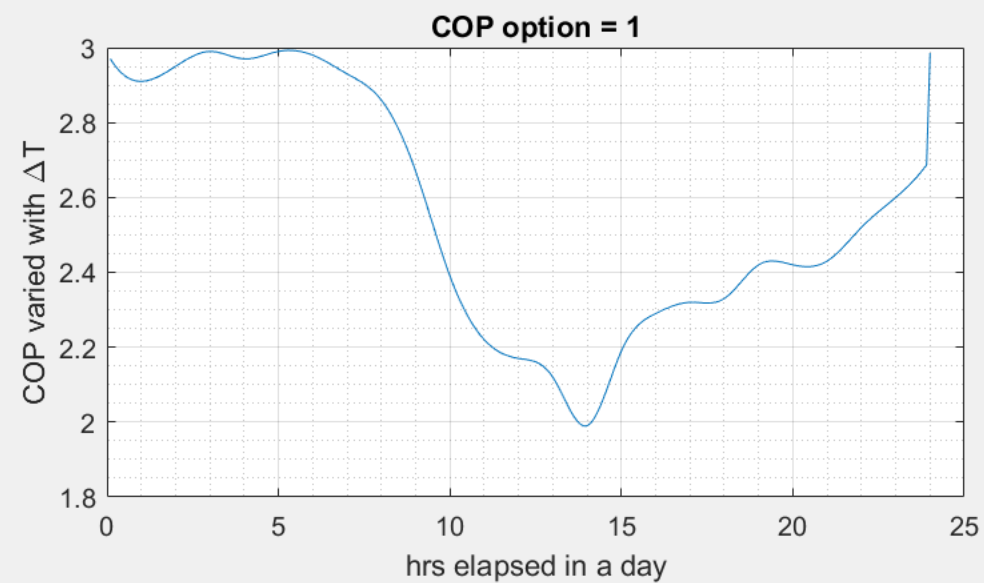
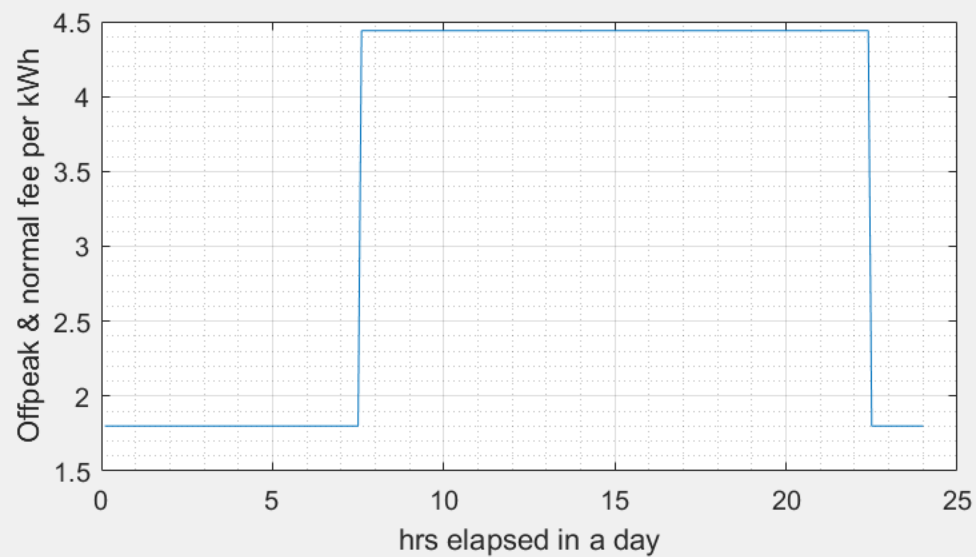
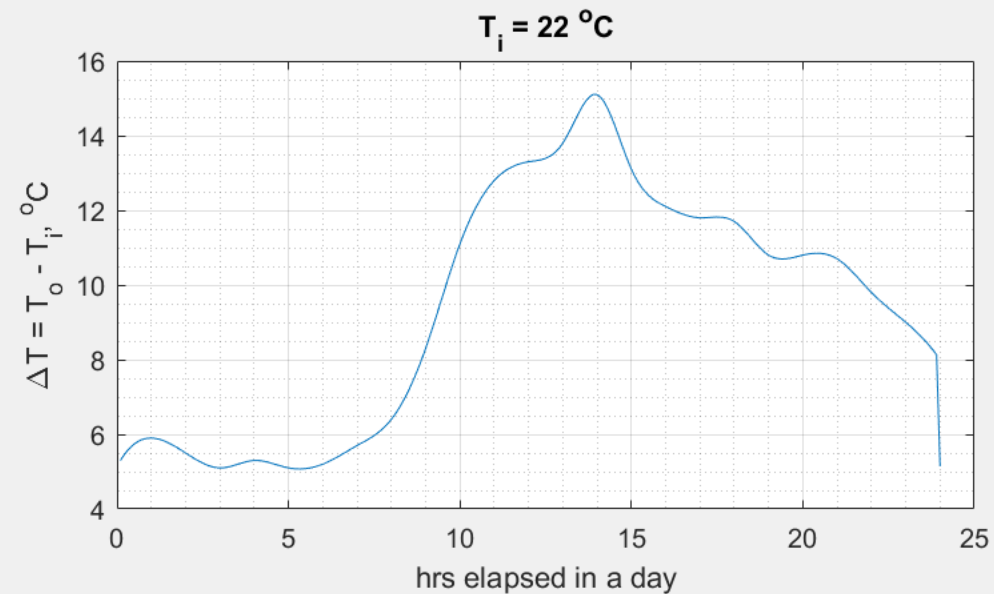
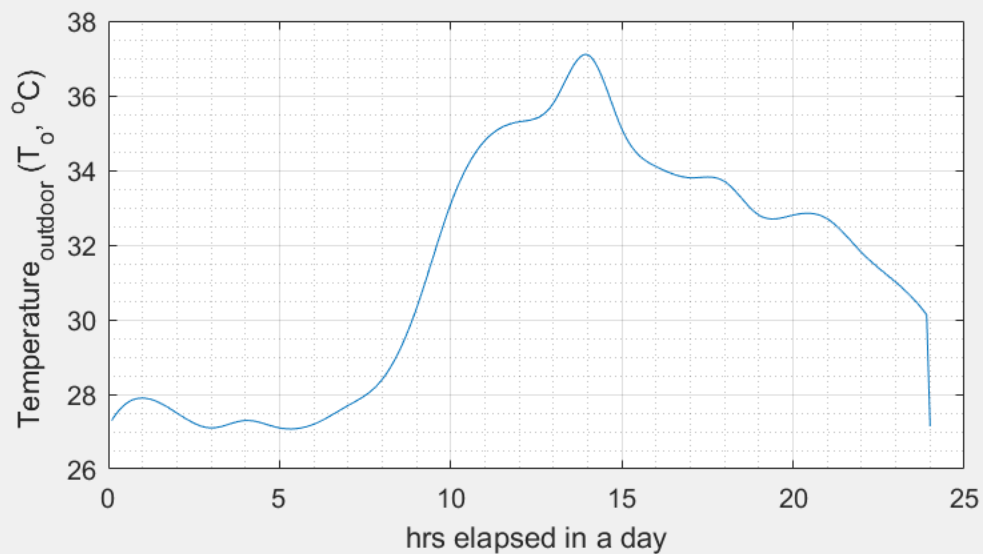


Fig. 3: Temperature data from Kaohsiung on 1983/7/16

# 高雄，當天有最熱的一小時



# 3<sup>rd</sup> pushbutton

Hourly variation of 3 COP options

Fig. 1, 2

hourly variation of  $T_o$ ,  $dT$ , elec.fee & COP

Fig. 3

Draw given Light on strategy

**Fig. 4, 5, 6**

Fig. 4: Group A & B turns on at 8 & 8, Light period = 16 hrs

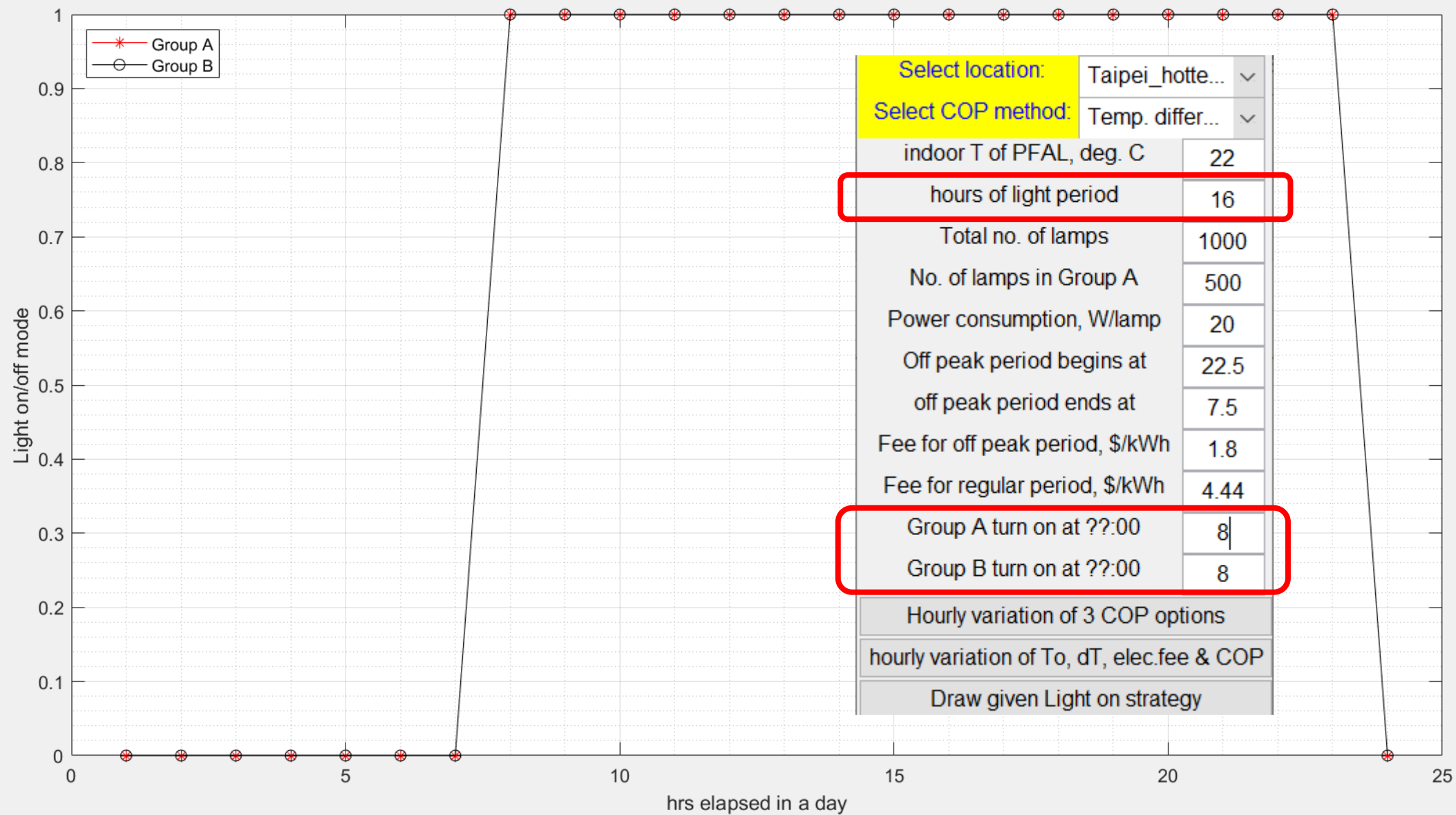


Fig. 5: Group A & B turns on at 8 & 8, Light period = 16 hrs

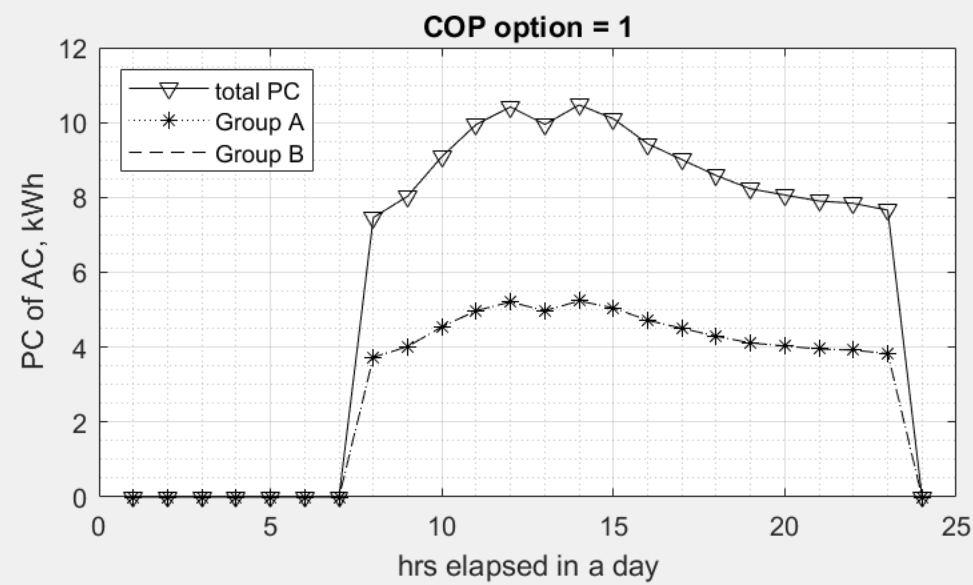
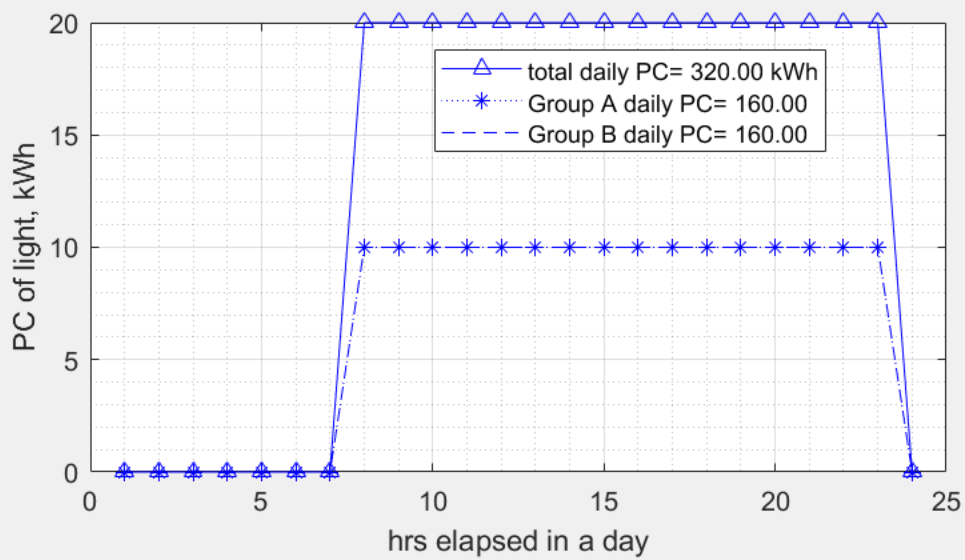
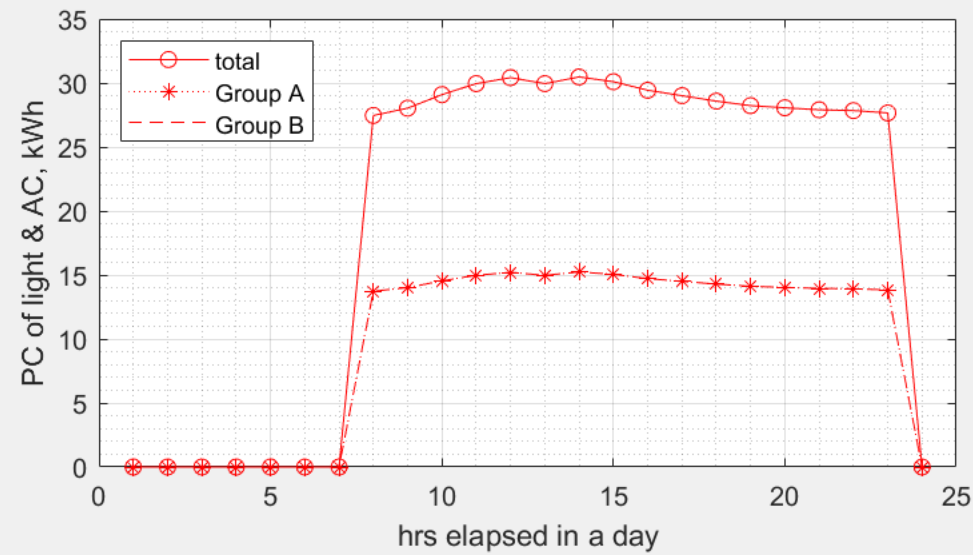
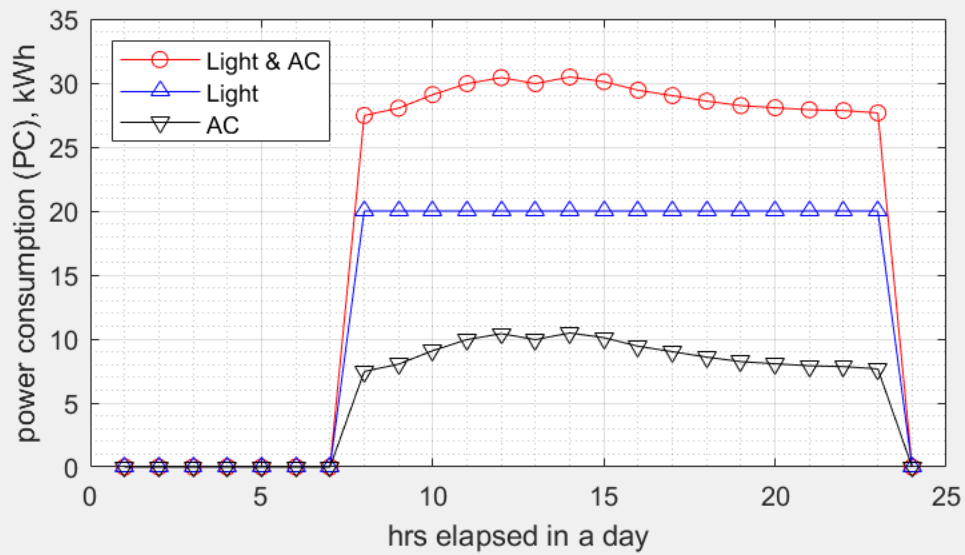


Fig. 6: Group A & B turns on at 8 & 8, Light period = 16 hrs

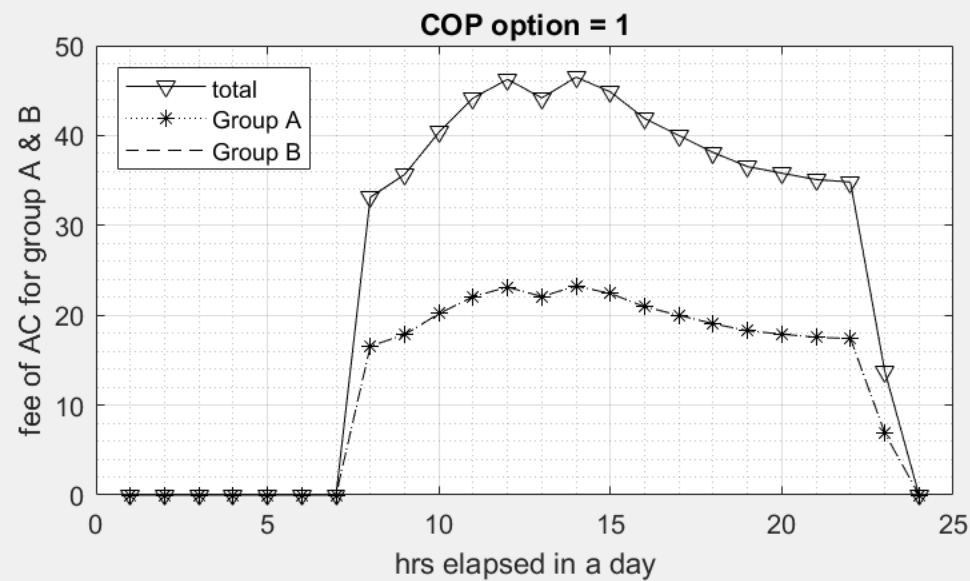
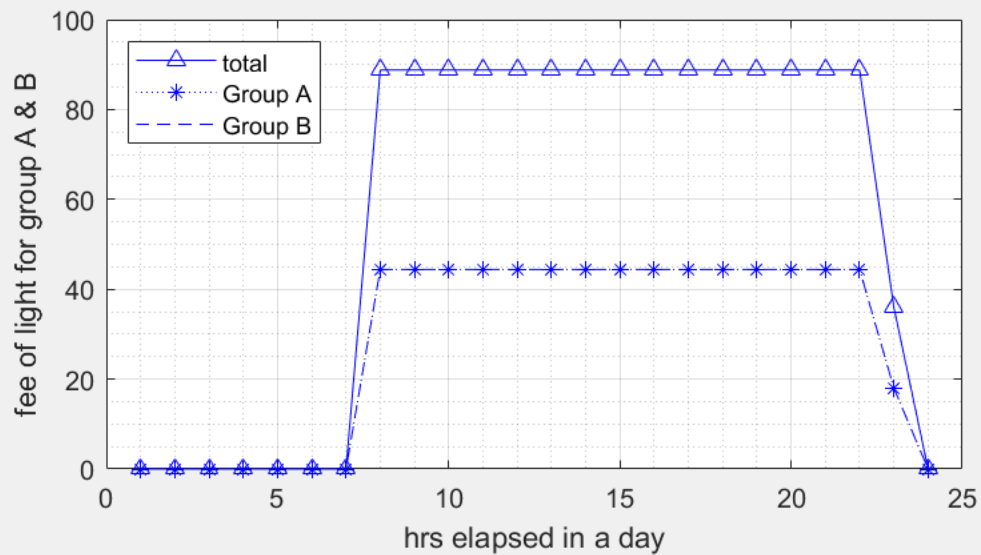
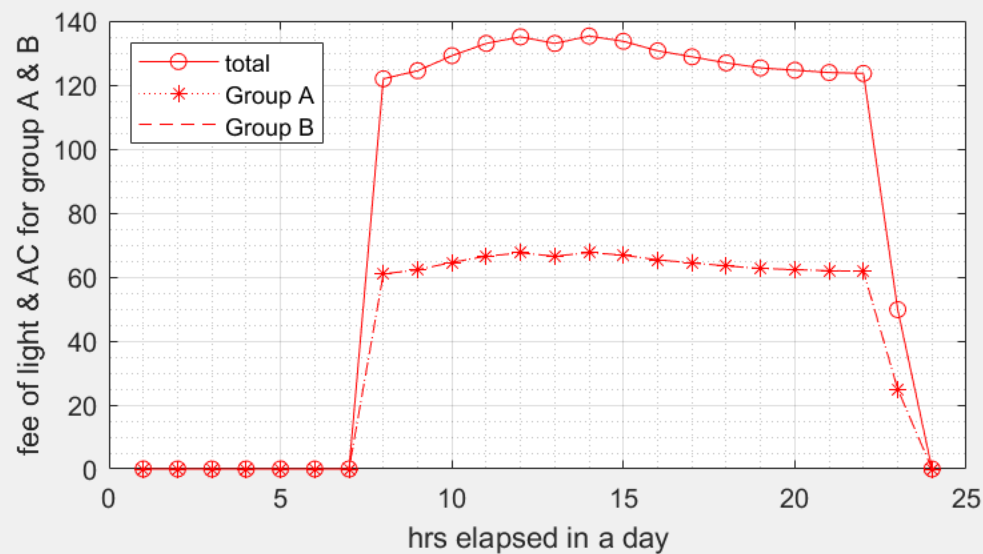
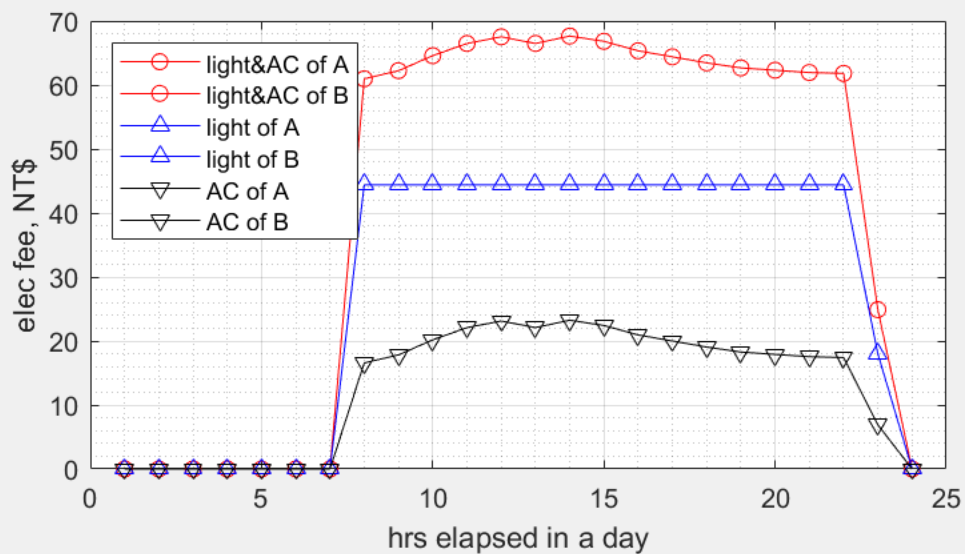


Fig. 4: Group A & B turns on at 17 & 17, Light period = 16 hrs

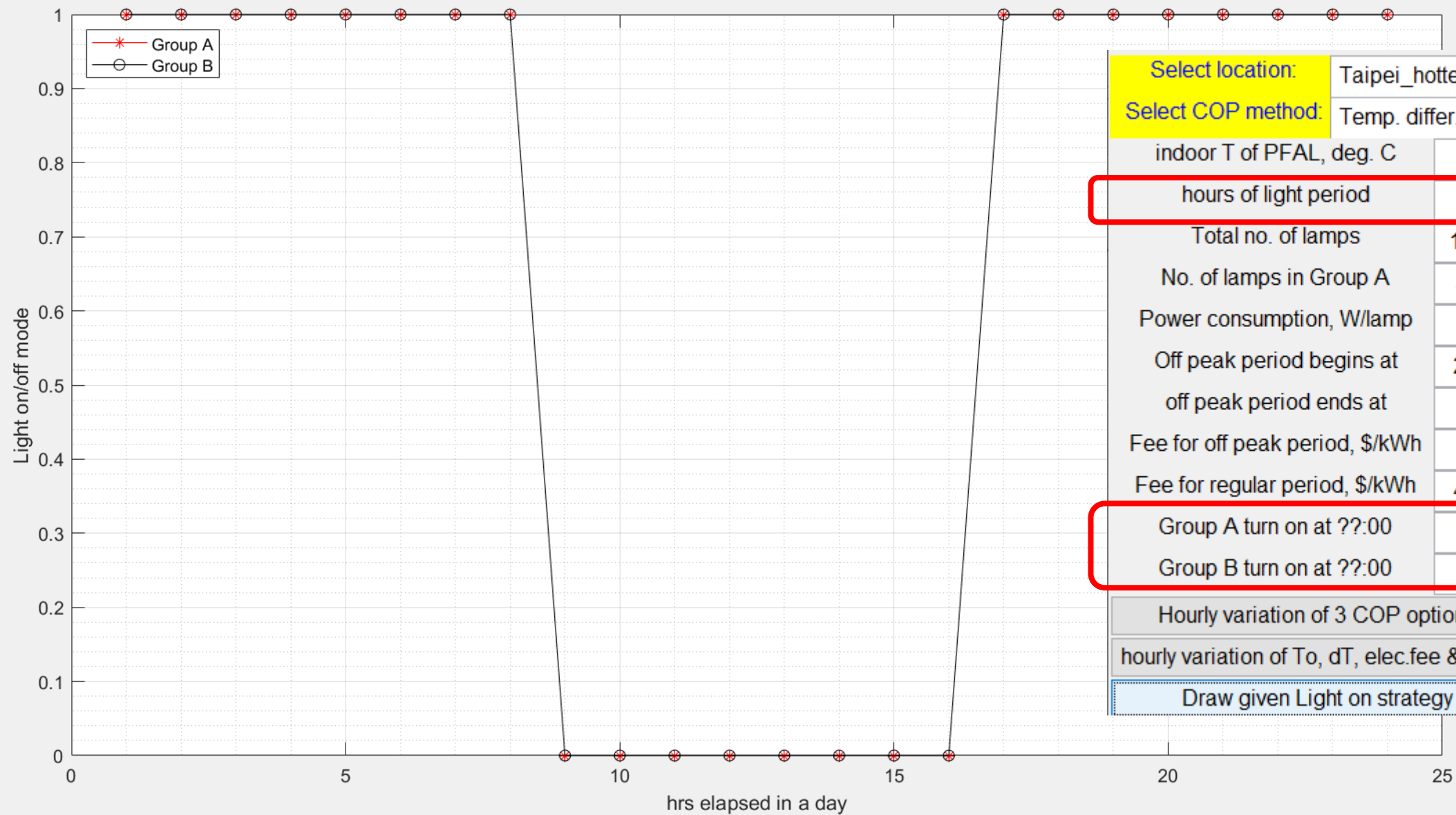




Fig. 5: Group A & B turns on at 17 & 17, Light period = 16 hrs

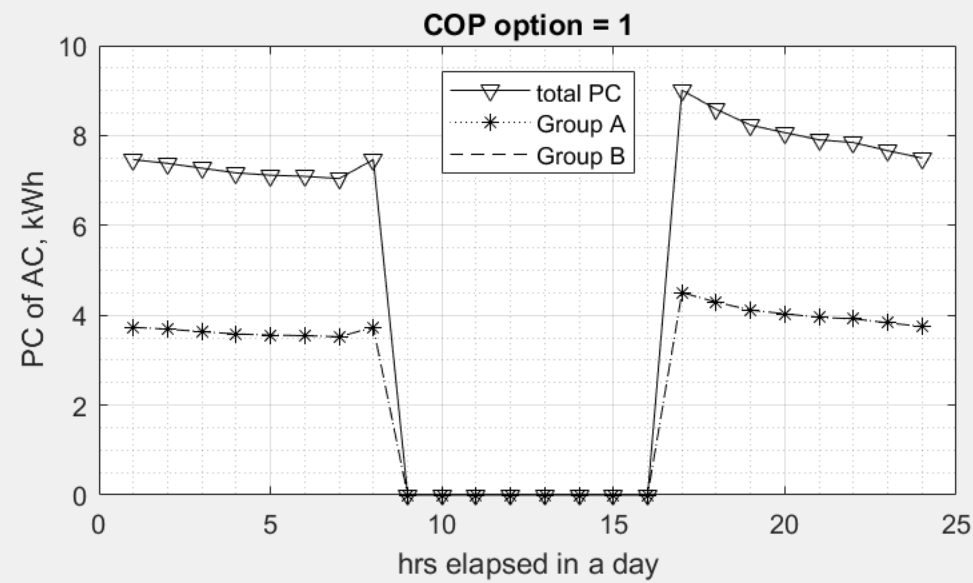
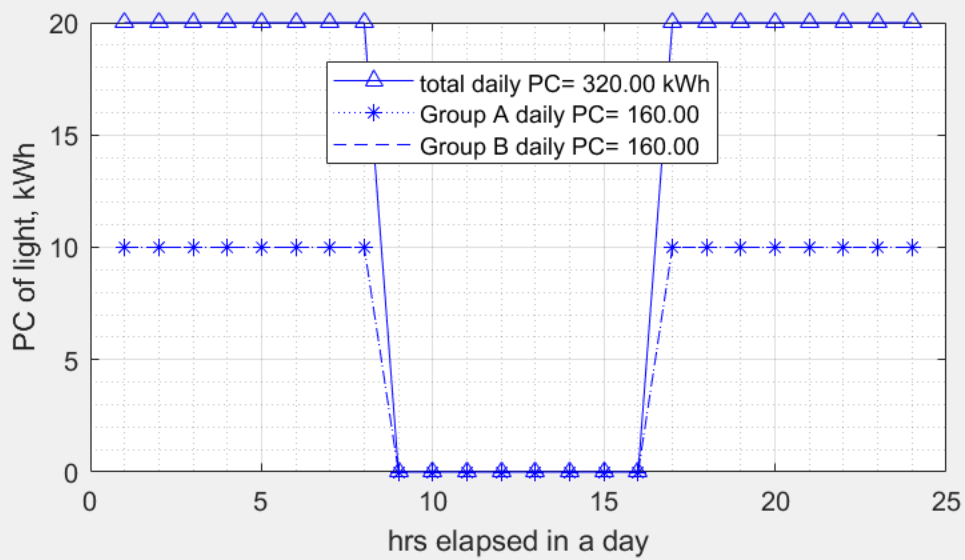
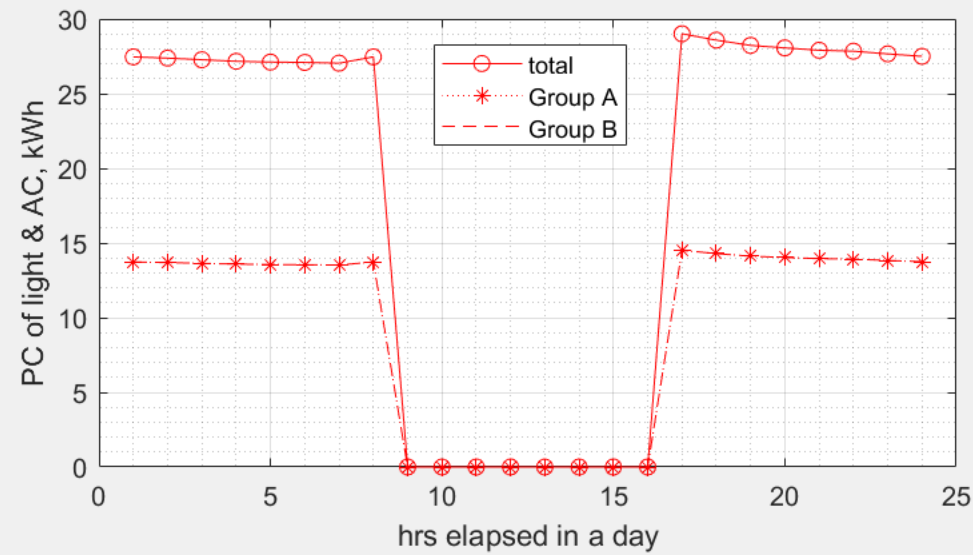
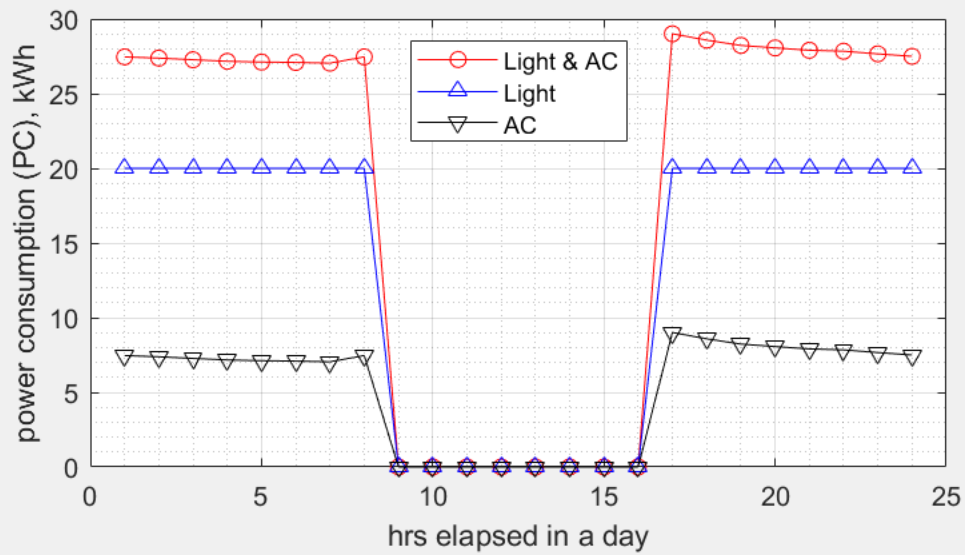


Fig. 6: Group A & B turns on at 17 & 17, Light period = 16 hrs

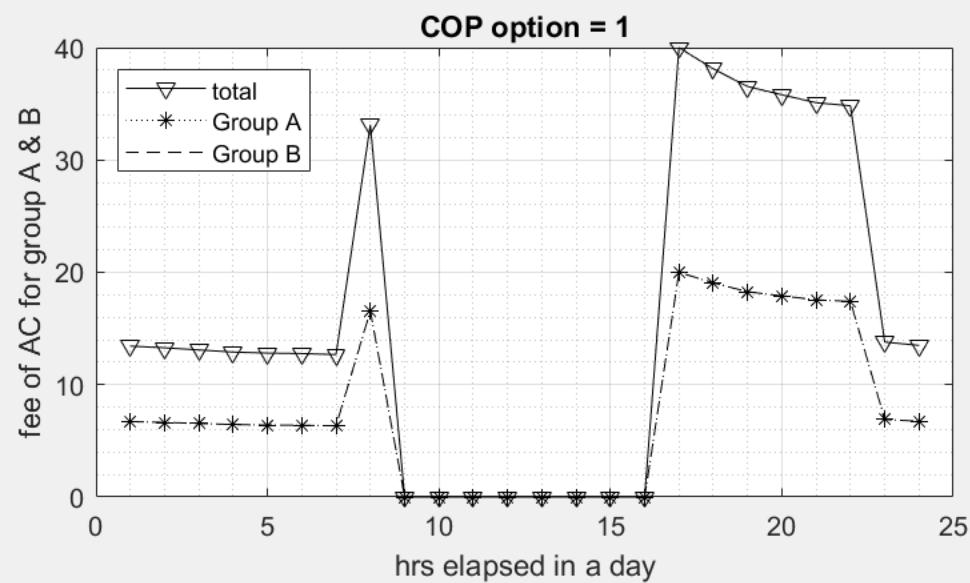
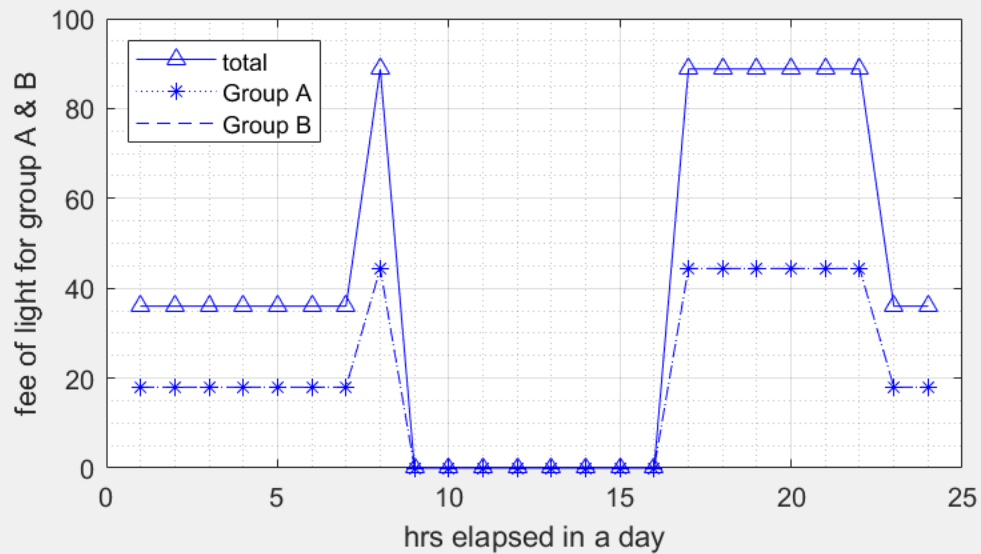
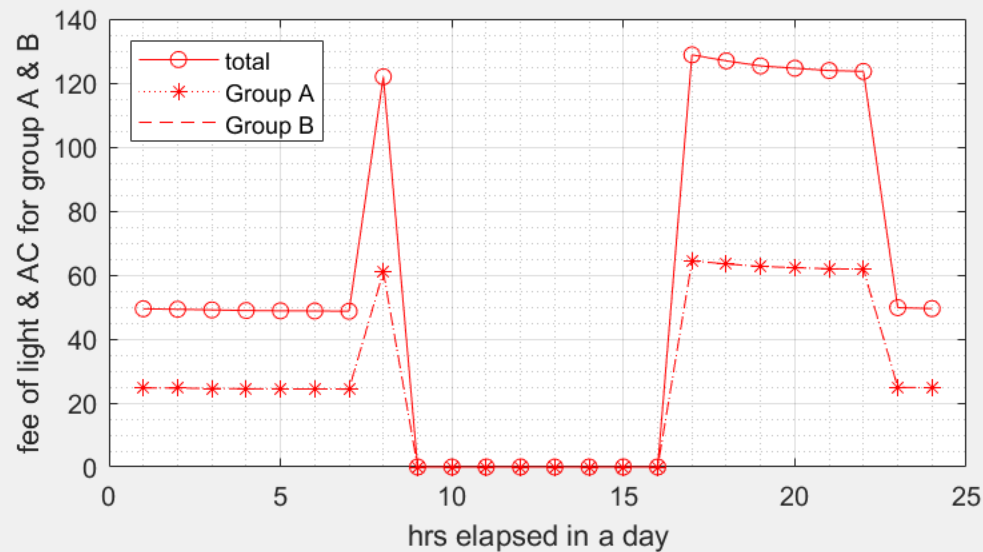
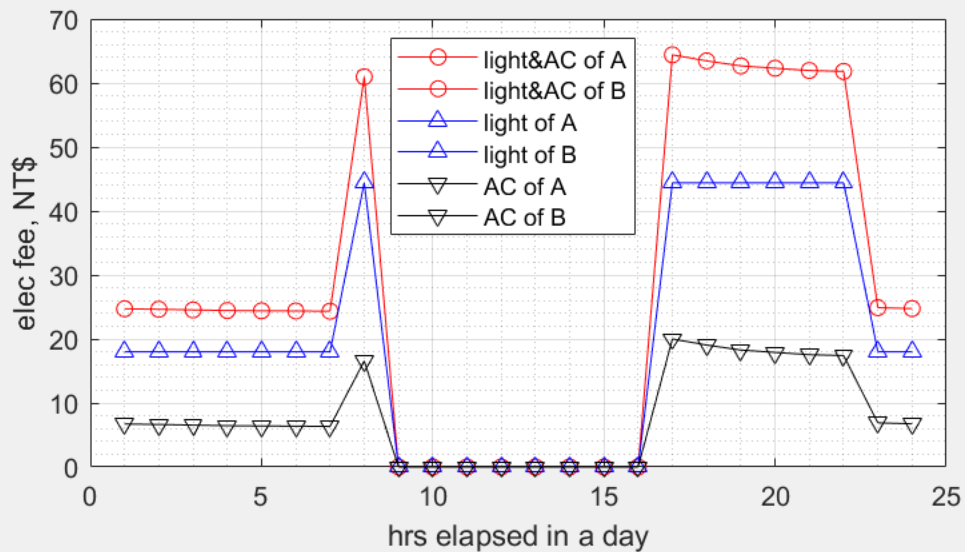
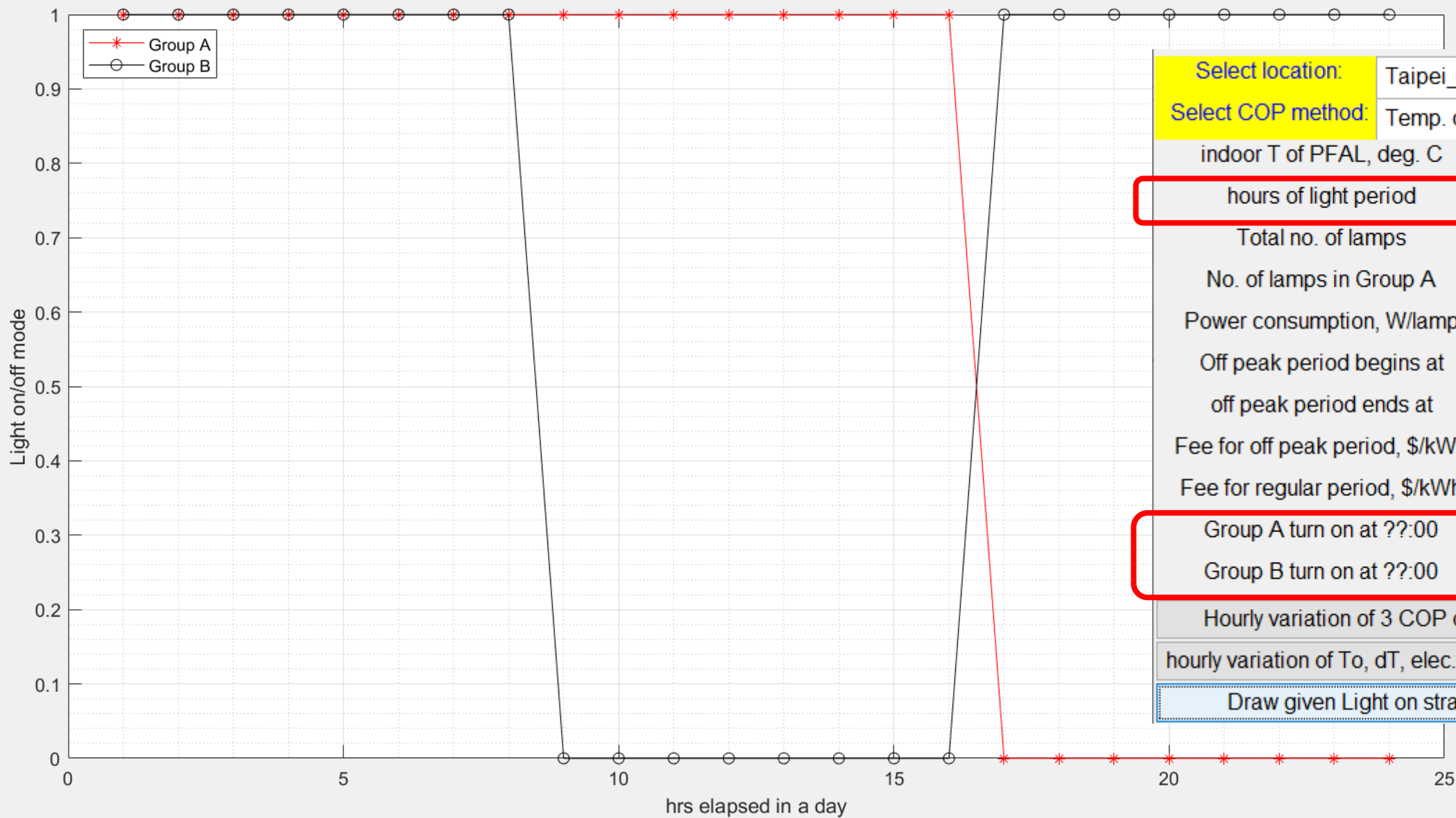


Fig. 4: Group A & B turns on at 1 & 17, Light period = 16 hrs



Select location: Taipei\_hotte... ▾

Select COP method: Temp. differ... ▾

indoor T of PFAL, deg. C	22
hours of light period	16
Total no. of lamps	1000
No. of lamps in Group A	500
Power consumption, W/lamp	20
Off peak period begins at	22.5
off peak period ends at	7.5
Fee for off peak period, \$/kWh	1.8
Fee for regular period, \$/kWh	4.44
Group A turn on at ??:00	1
Group B turn on at ??:00	17
Hourly variation of 3 COP options	
hourly variation of To, dT, elec.fee & COP	
Draw given Light on strategy	

Fig. 5: Group A & B turns on at 1 & 17, Light period = 16 hrs

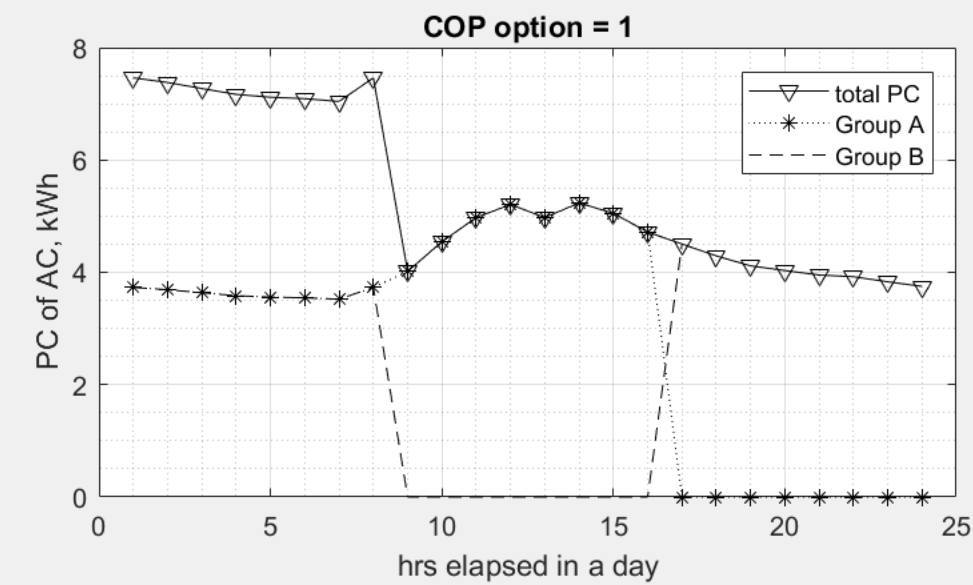
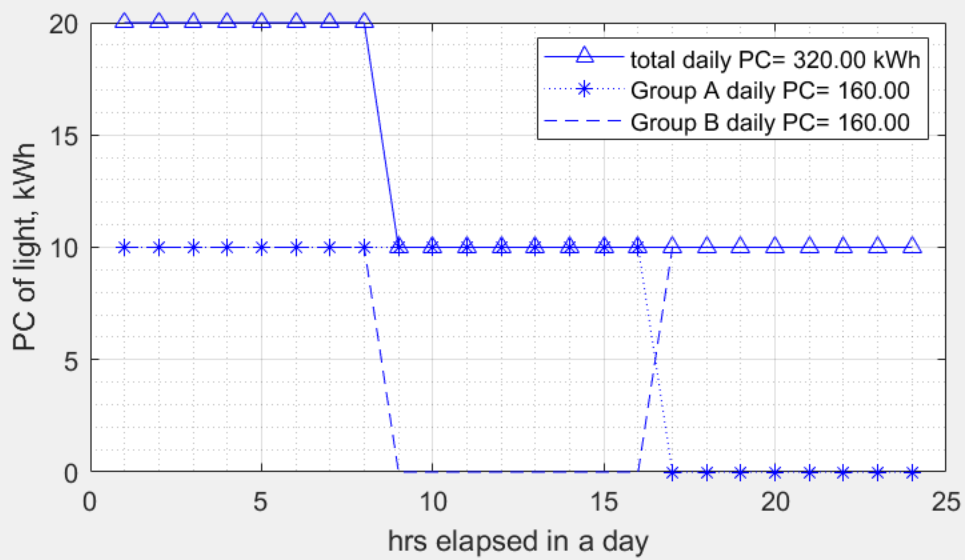
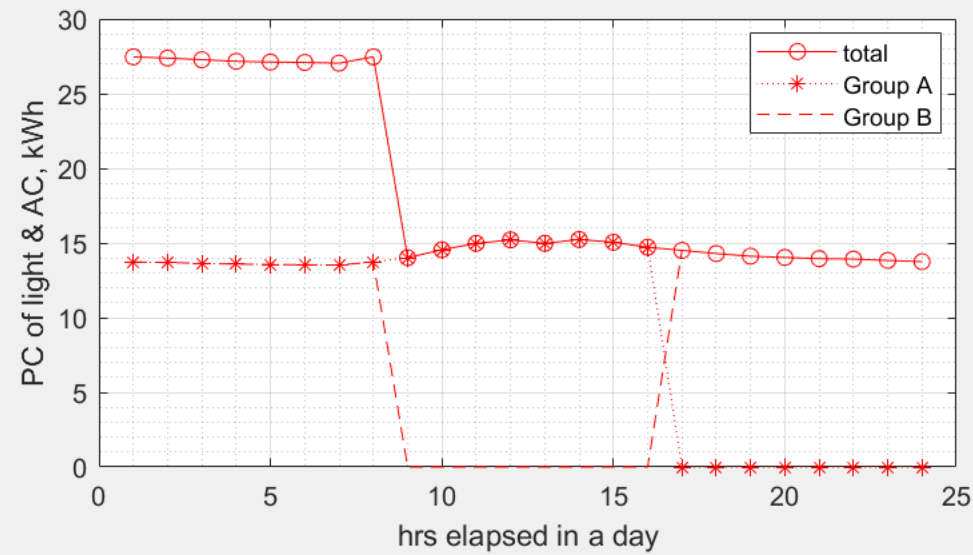
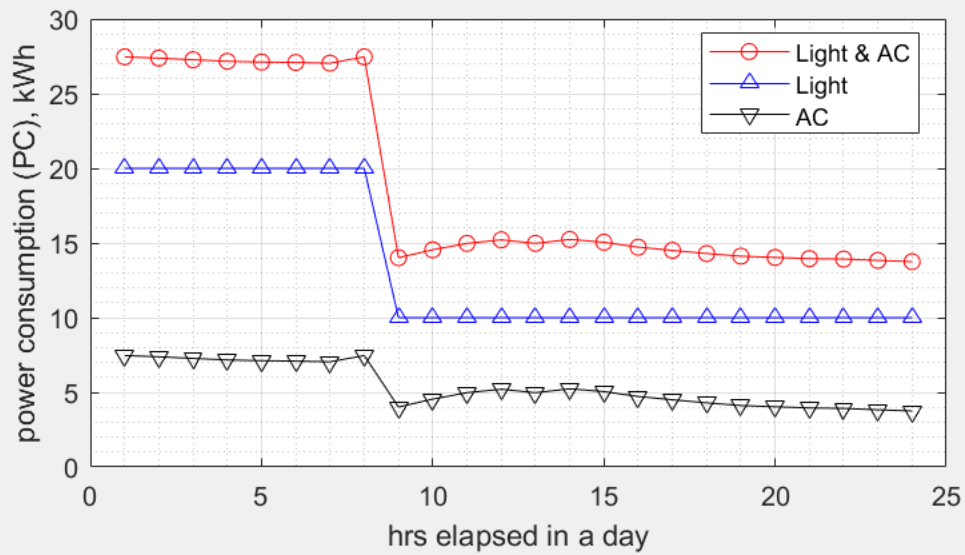
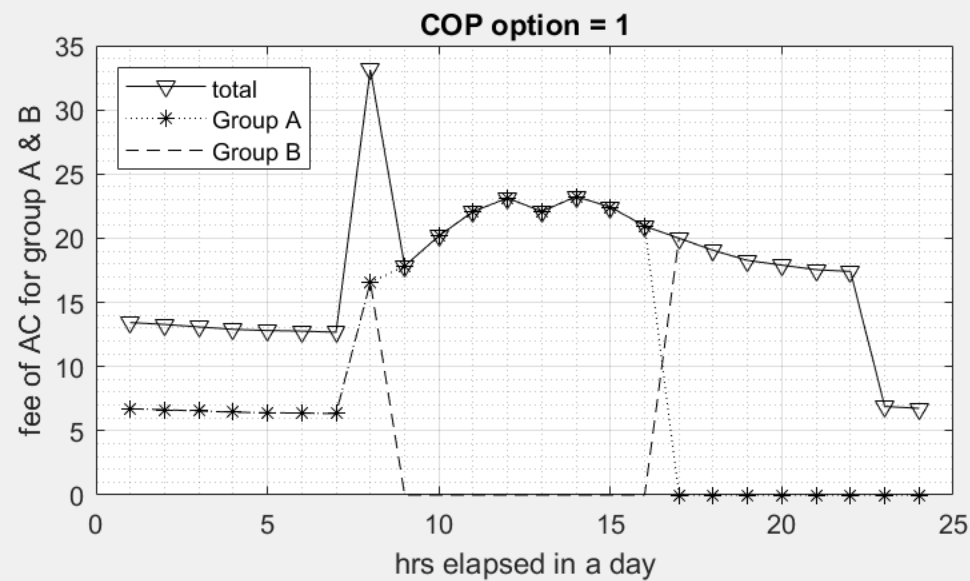
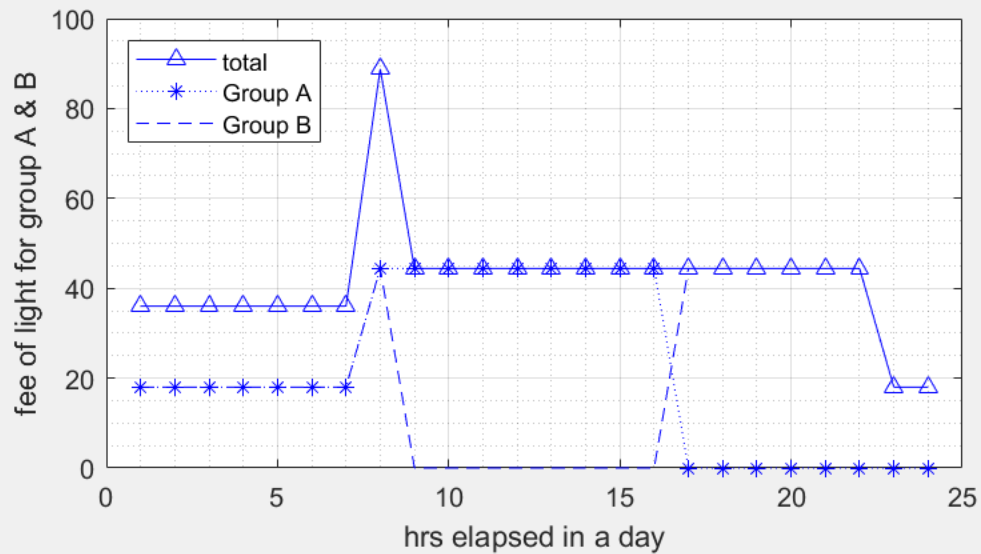
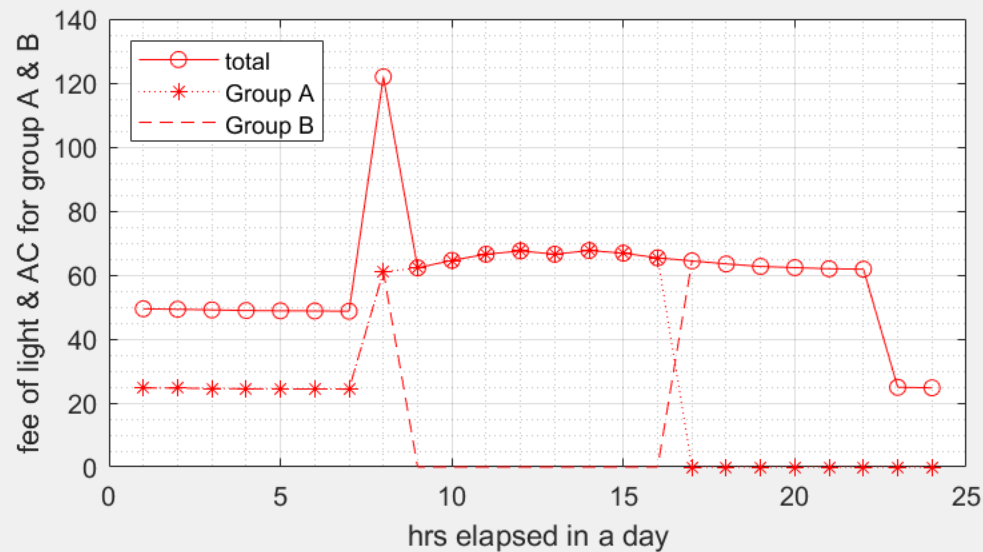
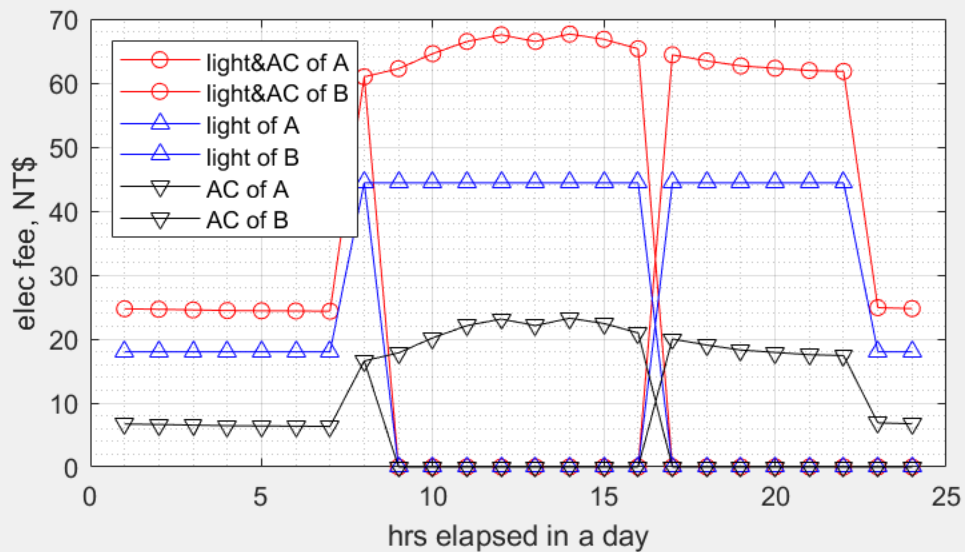


Fig. 6: Group A & B turns on at 1 & 17, Light period = 16 hrs



# 電費計算

$$LF_t = n w f_t \frac{m_t}{1000}$$

$$Lfee = \sum_{t=1}^{t=24} LF_t$$

$$AF_t = LF_t / COP_t$$

$$Afee = \sum_{t=1}^{t=24} ACF_t$$

$$Tfee = Lfee + Afee$$

$n$  : 燈管數 NT\$/kWh

$w$  : 單支W數

$f_t$  :  $t$ 時刻電價 (elec. Fee at  $t$ ) , NT\$/kWh

$m_t$  :  $t$ 時刻燈光開啟狀態 (mode at  $t$ )

開燈 : 1, 關燈 : 0

$LF_t$  :  $t$ 時刻燈光電費

$AF_t$  :  $t$ 時刻空調電費

$Lfee$  : 24小時燈光電費

$Afee$  : 24小時空調電費

$Tfee$  : 24小時總電費

# 4<sup>th</sup> pushbutton

Hourly variation of 3 COP options

hourly variation of  $T_o$ ,  $dT$ , elec.fee & COP

Draw given Light on strategy

Draw 576 lighting control options

Fig. 1, 2

Fig. 3

Fig. 4, 5, 6

**Fig. 7, 8 &  
options with  
extreme cost**

# Lighting control options

- 以1000支 20 W LED 燈管為例，分成 A， B 兩區
- 每區 500 支燈管，各 10 kW
- 假設開燈時段可以是24小時中的任一準點的時刻
  - A區 = 1:1:24
  - B區 = 1:1:24
- 合計共有  $24 \times 24 = 576$  個選擇



# Arrangement on lighting control

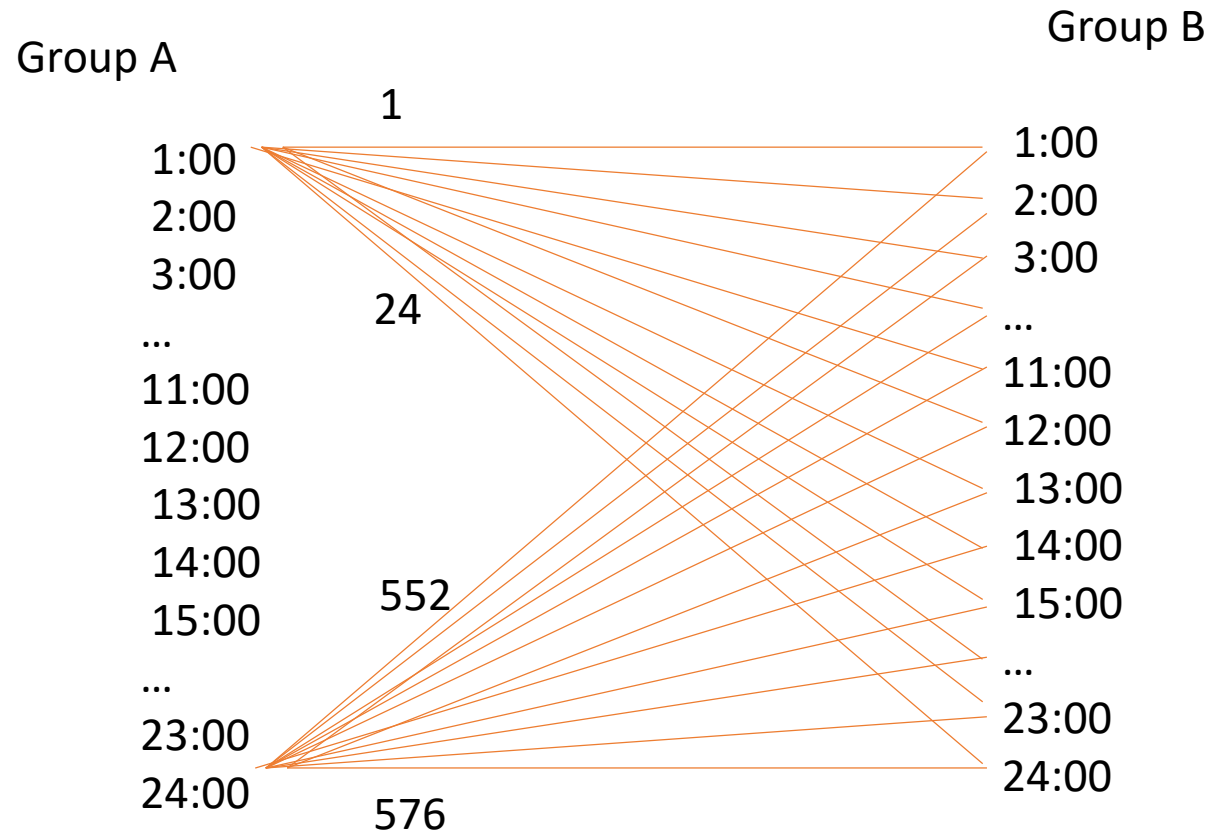


Fig. 7: Unsorted data of 576 options

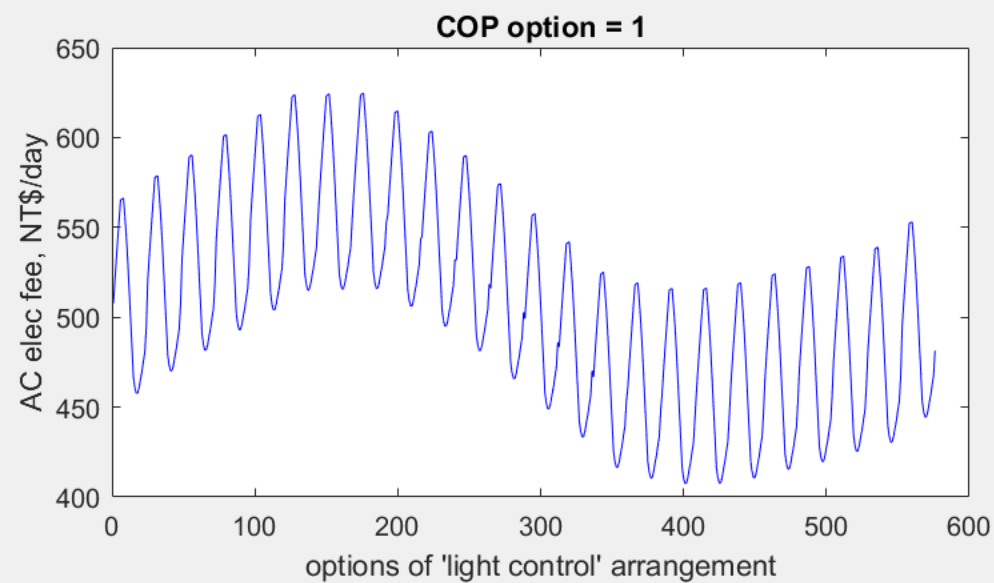
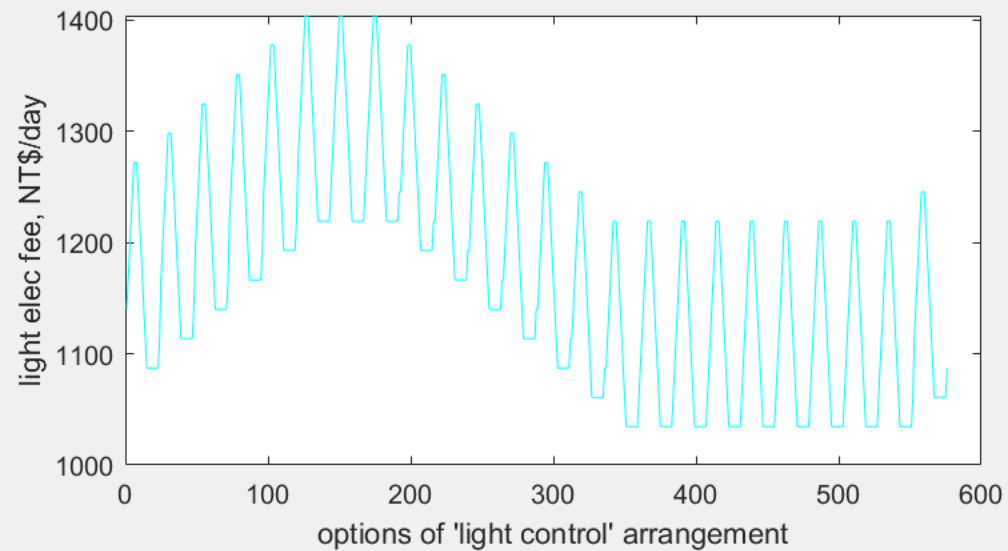
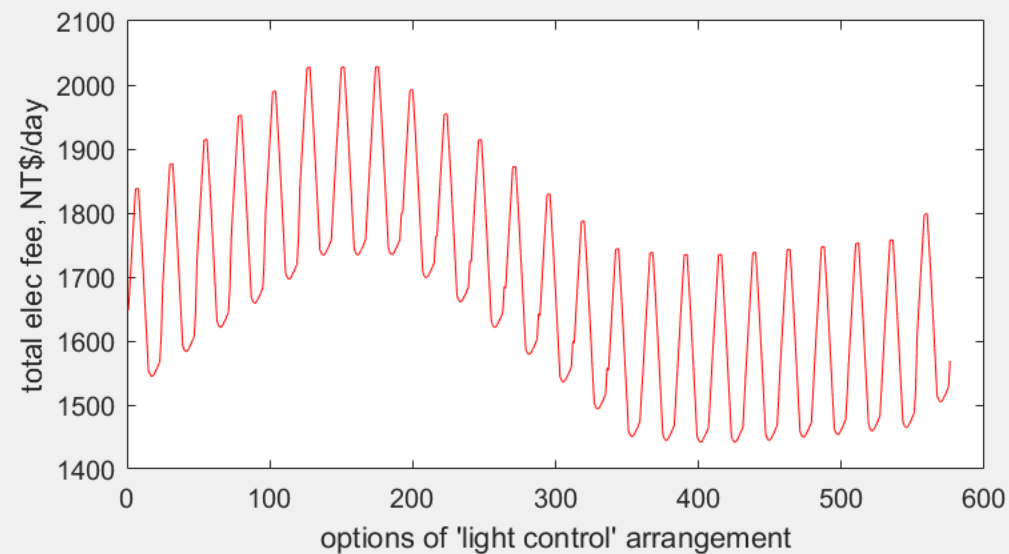
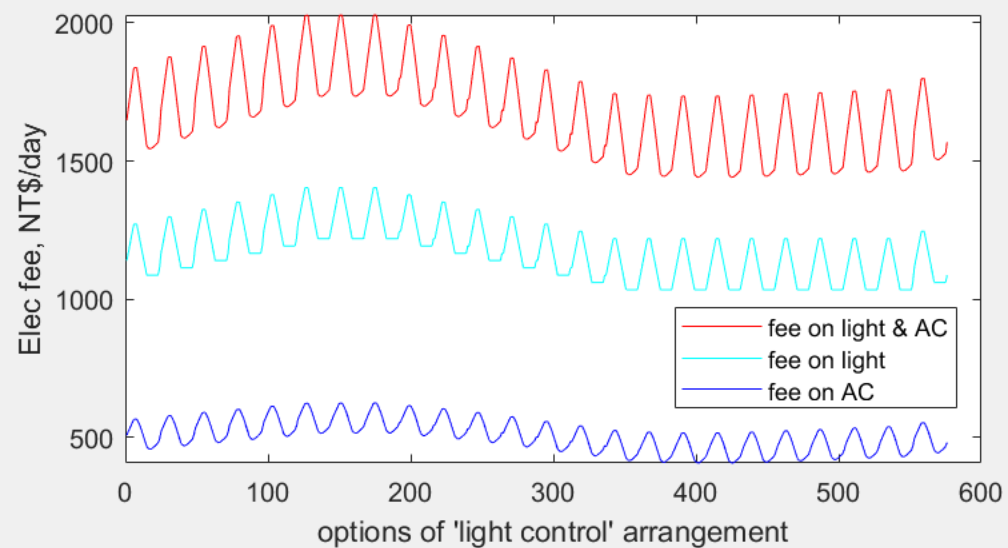
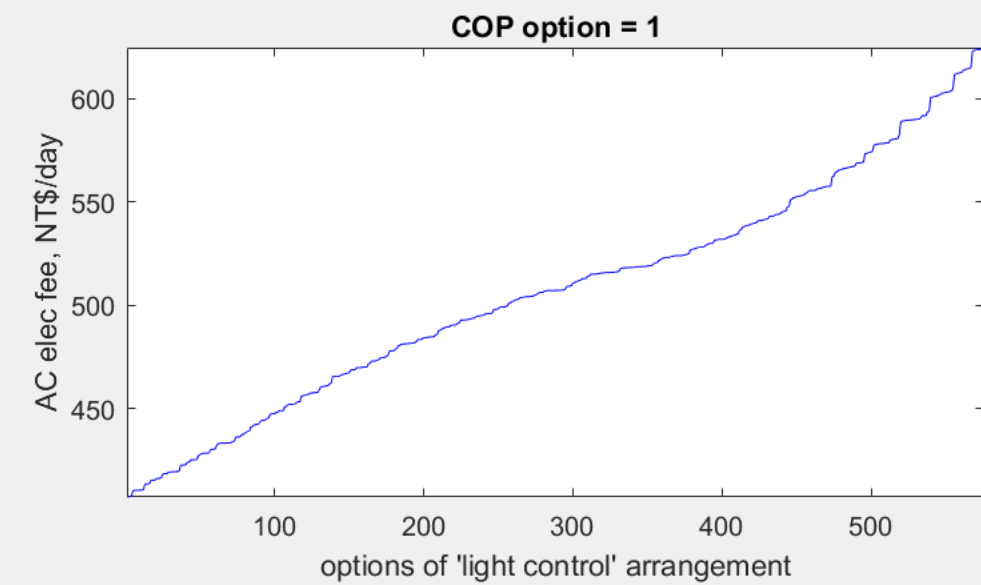
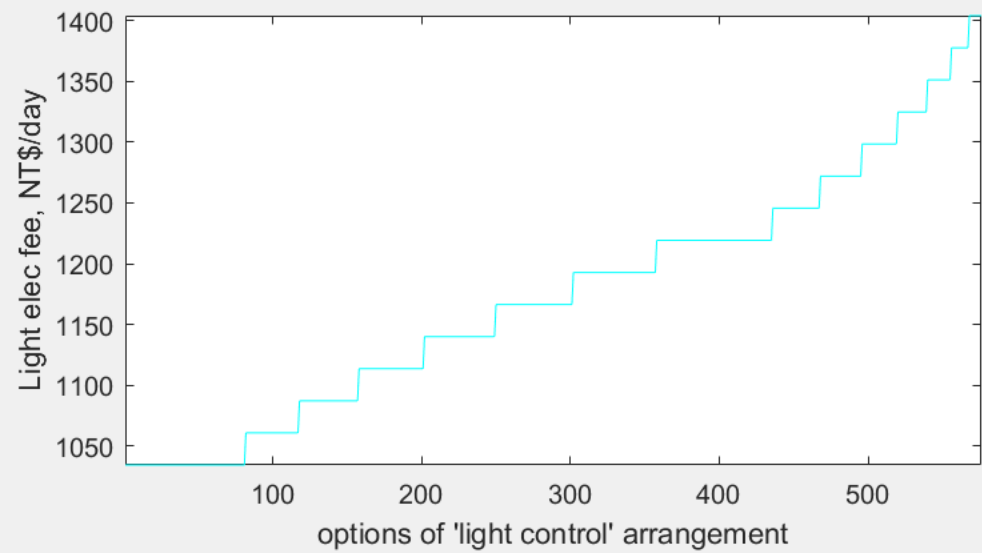
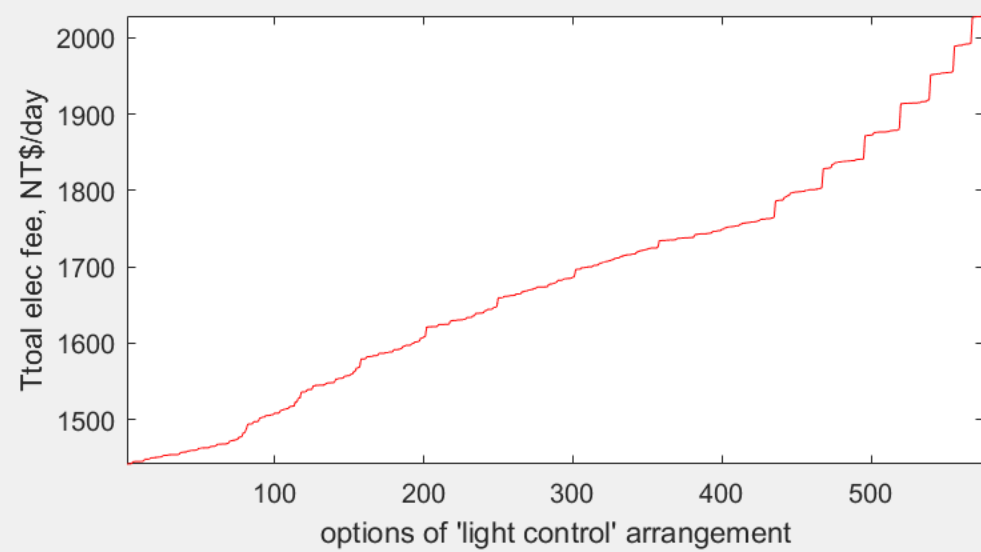
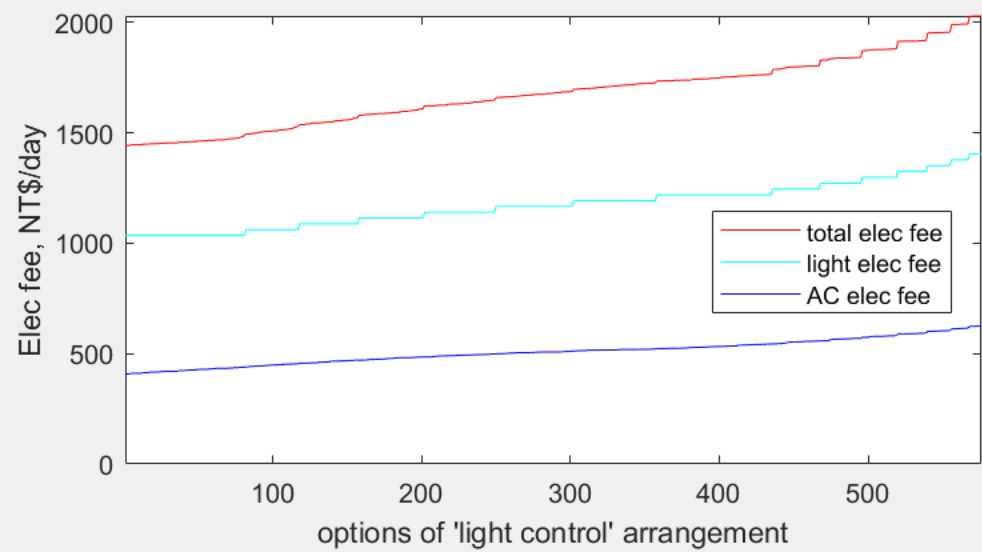


Fig. 8: Sorted data of 576 options



Elec...

Select location: Taipei\_hotte...

Select COP method: Temp. differ...

indoor T of PFAL, deg. C	22
hours of light period	16
Total no. of lamps	1000
No. of lamps in Group A	500
Power consumption, W/lamp	20
Off peak period begins at	22.5
off peak period ends at	7.5
Fee for off peak period, \$/kWh	1.8
Fee for regular period, \$/kWh	4.44
Group A turn on at ??:00	8
Group B turn on at ??:00	8

Hourly variation of 3 COP options

hourly variation of To, dT, elec.fee & COP

Draw given Light on strategy

Draw 576 lighting control options

Quit

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Given:

City: Taipei on 1990/8/9, COP option = 1  
 light period = 16.0 hrs  
 Total number of Lamps = 1000 tubes, divided into group A = 500 and group B = 500  
 Assuming all lamps are equal, power consumption per lamp = 20.00  
 Off peak rate = 1.8 NT\$/kWh and normal rate = 4.4 NT\$/kWh  
 Off peak period starts at 22:30 and ends at 7:30  
 group A-Light turns on at 8:00 and group B turns on at 8:00

---

Results:

Max daily lighting elec fee = 1404.0 NT\$, group A turns on at 7:00, Group B on at 7:00  
 Max daily AC elec fee = 624.7 NT\$, group A turns on at 8:00, Group B on at 8:00  
 Max daily total elec fee = 2028.7 NT\$, group A turns on at 8:00, Group B on at 8:00

Min daily lighting elec fee = 1034.4 NT\$, group A turns on at 15:00, Group B on at 15:00  
 Min daily AC elec fee = 407.4 NT\$, group A turns on at 17:00, Group B on at 17:00  
 Min daily total elec fee = 1441.8 NT\$, group A turns on at 17:00, Group B on at 17:00

Max - Min lighting elec fee = 369.6 NT\$  
 Max - Min AC elec fee = 217.2 NT\$  
 Max - Min total elec fee = 586.8 NT\$

fx >>

最高成本  
 最低成本  
 的照明設計

# 5<sup>th</sup> pushbutton

Hourly variation of 3 COP options	Fig. 1, 2
hourly variation of To, dT, elec.fee & COP	Fig. 3
Draw given Light on strategy	Fig. 4, 5, 6
Draw 576 lighting control options	Fig. 7, 8 & extreme cost
Quit	<b>Save defaults, close all &amp; exit</b>

# 燈具設計的探討

- 假設 DLI 相同時，植物的成長就會相同
- 光源耗電功率與PPFD 正相關
- $20\text{ W} \times 16\text{ hr} = 35.555\text{ W} \times 9\text{ hr} = 40\text{ W} \times 8\text{ hr}$   
 $= 13.333\text{ W} \times 24\text{ hr} = 26.666\text{ W} \times 12\text{ hr} = 320\text{ W.hr per LED tube}$

燈光設計	20 x 16	35.55 x 9	40 x 8	13.33 x 24	26.66 x 12
燈光耗電成本	1034.4	733.9	648.0	1104.0	905.7
空調耗電成本	407.4	269.1	236.5	477.1	342.7
總耗電成本	1441.8	1003.0	884.5	1581.1	1248.4

**minimum**

Elec... — □ ×

Select location: Taipei\_hotte... ▾

Select COP method: Temp. differ... ▾

indoor T of PFAL, deg. C	22
hours of light period	16
Total no. of lamps	1000
No. of lamps in Group A	500
Power consumption, W/lamp	20
Off peak period begins at	22.5
off peak period ends at	7.5
Fee for off peak period, \$/kWh	1.8
Fee for regular period, \$/kWh	4.44
Group A turn on at ??:00	8
Group B turn on at ??:00	8

Hourly variation of 3 COP options

hourly variation of To, dT, elec.fee & COP

Draw given Light on strategy

Draw 576 lighting control options

Quit

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Given:

```

City: Taipei on 1990/8/9, COP option = 1
light period = 16.0 hrs
Total number of Lamps = 1000 tubes, divided into group A = 500 and B = 500 tubes
Assuming all lamps are equal, power consumption per lamp = 20.00 W
Off peak rate = 1.8 NT$/kWh and normal rate = 4.4 NT$/kWh
Off peak period starts at 22:30 and ends at 7:30
group A-Light turns on at 19:00 and group B turns on at 19:00

```

---

Results:

```

Max daily lighting elec fee = 1404.0 NT$, group A turns on at 7:00, Group B on at 7:00
Max daily AC elec fee = 624.7 NT$, group A turns on at 8:00, Group B on at 8:00
Max daily total elec fee = 2028.7 NT$, group A turns on at 8:00, Group B on at 8:00

Min daily lighting elec fee = 1034.4 NT$, group A turns on at 15:00, Group B on at 15:00
Min daily AC elec fee = 407.4 NT$, group A turns on at 17:00, Group B on at 17:00
Min daily total elec fee = 1441.8 NT$, group A turns on at 17:00, Group B on at 17:00

Max - Min lighting elec fee = 369.6 NT$
Max - Min AC elec fee = 217.2 NT$
Max - Min total elec fee = 586.8 NT$

```

*fx* >> |

Elec... — □ ×

Select location: Taipei\_hotte... ▾

Select COP method: Temp. differ... ▾

indoor T of PFAL, deg. C	22
hours of light period	9
Total no. of lamps	1000
No. of lamps in Group A	500
Power consumption, W/lamp	35.55
Off peak period begins at	22.5
off peak period ends at	7.5
Fee for off peak period, \$/kWh	1.8
Fee for regular period, \$/kWh	4.44
Group A turn on at ??:00	8
Group B turn on at ??:00	8

Hourly variation of 3 COP options

hourly variation of To, dT, elec.fee & COP

Draw given Light on strategy

Draw 576 lighting control options

Quit

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Given:

```

City: Taipei on 1990/8/9, COP option = 1
light period = 9.0 hrs
Total number of Lamps = 1000 tubes, divided into group A = 500 and B = 500 tubes
Assuming all lamps are equal, power consumption per lamp = 35.55 W
Off peak rate = 1.8 NT$/kWh and normal rate = 4.4 NT$/kWh
Off peak period starts at 22:30 and ends at 7:30
group A-Light turns on at 19:00 and group B turns on at 19:00

```

---

Results:

```

Max daily lighting elec fee = 1578.6 NT$, group A turns on at 8:00, Group B on at 8:00
Max daily AC elec fee = 751.7 NT$, group A turns on at 10:00, Group B on at 10:00
Max daily total elec fee = 2330.4 NT$, group A turns on at 10:00, Group B on at 10:00

Min daily lighting elec fee = 733.9 NT$, group A turns on at 22:00, Group B on at 22:00
Min daily AC elec fee = 269.1 NT$, group A turns on at 23:00, Group B on at 23:00
Min daily total elec fee = 1003.0 NT$, group A turns on at 23:00, Group B on at 23:00

Max - Min lighting elec fee = 844.8 NT$,
Max - Min AC elec fee = 482.6 NT$,
Max - Min total elec fee = 1327.4 NT$,

```

*fx* >> |



Elec... — □ ×

Select location: Taipei\_hotte... ▾

Select COP method: Temp. differ... ▾

indoor T of PFAL, deg. C	22
hours of light period	24
Total no. of lamps	1000
No. of lamps in Group A	500
Power consumption, W/lamp	13.33
Off peak period begins at	22.5
off peak period ends at	7.5
Fee for off peak period, \$/kWh	1.8
Fee for regular period, \$/kWh	4.44
Group A turn on at ??:00	8
Group B turn on at ??:00	8

Hourly variation of 3 COP options

hourly variation of To, dT, elec.fee & COP

Draw given Light on strategy

Draw 576 lighting control options

Quit

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Given:

City: Taipei on 1990/8/9, COP option = 1  
 light period = 24.0 hrs  
 Total number of Lamps = 1000 tubes, divided into group A = 500 and B = 500 tubes  
 Assuming all lamps are equal, power consumption per lamp = 13.33 W  
 Off peak rate = 1.8 NT\$/kWh and normal rate = 4.4 NT\$/kWh  
 Off peak period starts at 22:30 and ends at 7:30  
 group A-Light turns on at 19:00 and group B turns on at 19:00

---

Results:

Max daily lighting elec fee = 1104.0 NT\$, group A turns on at 1:00, Group B on at 1:00  
 Max daily AC elec fee = 477.1 NT\$, group A turns on at 1:00, Group B on at 1:00  
 Max daily total elec fee = 1581.1 NT\$, group A turns on at 1:00, Group B on at 1:00

Min daily lighting elec fee = 1104.0 NT\$, group A turns on at 1:00, Group B on at 1:00  
 Min daily AC elec fee = 477.1 NT\$, group A turns on at 1:00, Group B on at 1:00  
 Min daily total elec fee = 1581.1 NT\$, group A turns on at 1:00, Group B on at 1:00

Max - Min lighting elec fee = 0.0 NT\$  
 Max - Min AC elec fee = 0.0 NT\$  
 Max - Min total elec fee = 0.0 NT\$

*fx* >>

Elec... — □ ×

Select location: Taipei\_hotte... ▾

Select COP method: Temp. differ... ▾

indoor T of PFAL, deg. C	22
hours of light period	12
Total no. of lamps	1000
No. of lamps in Group A	500
Power consumption, W/lamp	26.6666
Off peak period begins at	22.5
off peak period ends at	7.5
Fee for off peak period, \$/kWh	1.8
Fee for regular period, \$/kWh	4.44
Group A turn on at ??:00	19
Group B turn on at ??:00	19

Hourly variation of 3 COP options

hourly variation of To, dT, elec.fee & COP

Draw given Light on strategy

Draw 576 lighting control options

Quit

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Given:

City: Taipei on 1990/8/9, COP option = 1  
 light period = 12.0 hrs  
 Total number of Lamps = 1000 tubes, divided into group A = 500 and B = 500 tubes  
 Assuming all lamps are equal, power consumption per lamp = 26.67 W  
 Off peak rate = 1.8 NT\$/kWh and normal rate = 4.4 NT\$/kWh  
 Off peak period starts at 22:30 and ends at 7:30  
 group A-Light turns on at 19:00 and group B turns on at 19:00

---

Results:

Max daily lighting elec fee = 1539.2 NT\$, group A turns on at 8:00, Group B on at 8:00  
 Max daily AC elec fee = 705.9 NT\$, group A turns on at 9:00, Group B on at 9:00  
 Max daily total elec fee = 2245.1 NT\$, group A turns on at 9:00, Group B on at 9:00

Min daily lighting elec fee = 905.6 NT\$, group A turns on at 19:00, Group B on at 19:00  
 Min daily AC elec fee = 342.6 NT\$, group A turns on at 21:00, Group B on at 21:00  
 Min daily total elec fee = 1248.2 NT\$, group A turns on at 21:00, Group B on at 21:00

Max - Min lighting elec fee = 633.6 NT\$  
 Max - Min AC elec fee = 363.3 NT\$  
 Max - Min total elec fee = 996.9 NT\$

*fx* >>

Elec... — □ ×

Select location: Taipei\_hotte... ▾

Select COP method: Temp. differ... ▾

indoor T of PFAL, deg. C	22
hours of light period	8
Total no. of lamps	1000
No. of lamps in Group A	500
Power consumption, W/lamp	40
Off peak period begins at	22.5
off peak period ends at	7.5
Fee for off peak period, \$/kWh	1.8
Fee for regular period, \$/kWh	4.44
Group A turn on at ??:00	8
Group B turn on at ??:00	8

Hourly variation of 3 COP options

hourly variation of To, dT, elec.fee & COP

Draw given Light on strategy

Draw 576 lighting control options

Quit

MATLAB R2020b - academic use

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Given:

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City: Taipei on 1990/8/9, COP option = 1
light period = 8.0 hrs
Total number of Lamps = 1000 tubes, divided into group A = 500 and B = 500 tubes
Assuming all lamps are equal, power consumption per lamp = 40.00 W
Off peak rate = 1.8 NT$/kWh and normal rate = 4.4 NT$/kWh
Off peak period starts at 22:30 and ends at 7:30
group A-Light turns on at 19:00 and group B turns on at 19:00

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Results:

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Max daily lighting elec fee = 1598.4 NT$, group A turns on at 8:00, Group B on at 8:00
Max daily AC elec fee = 772.6 NT$, group A turns on at 10:00, Group B on at 10:00
Max daily total elec fee = 2371.0 NT$, group A turns on at 10:00, Group B on at 10:00

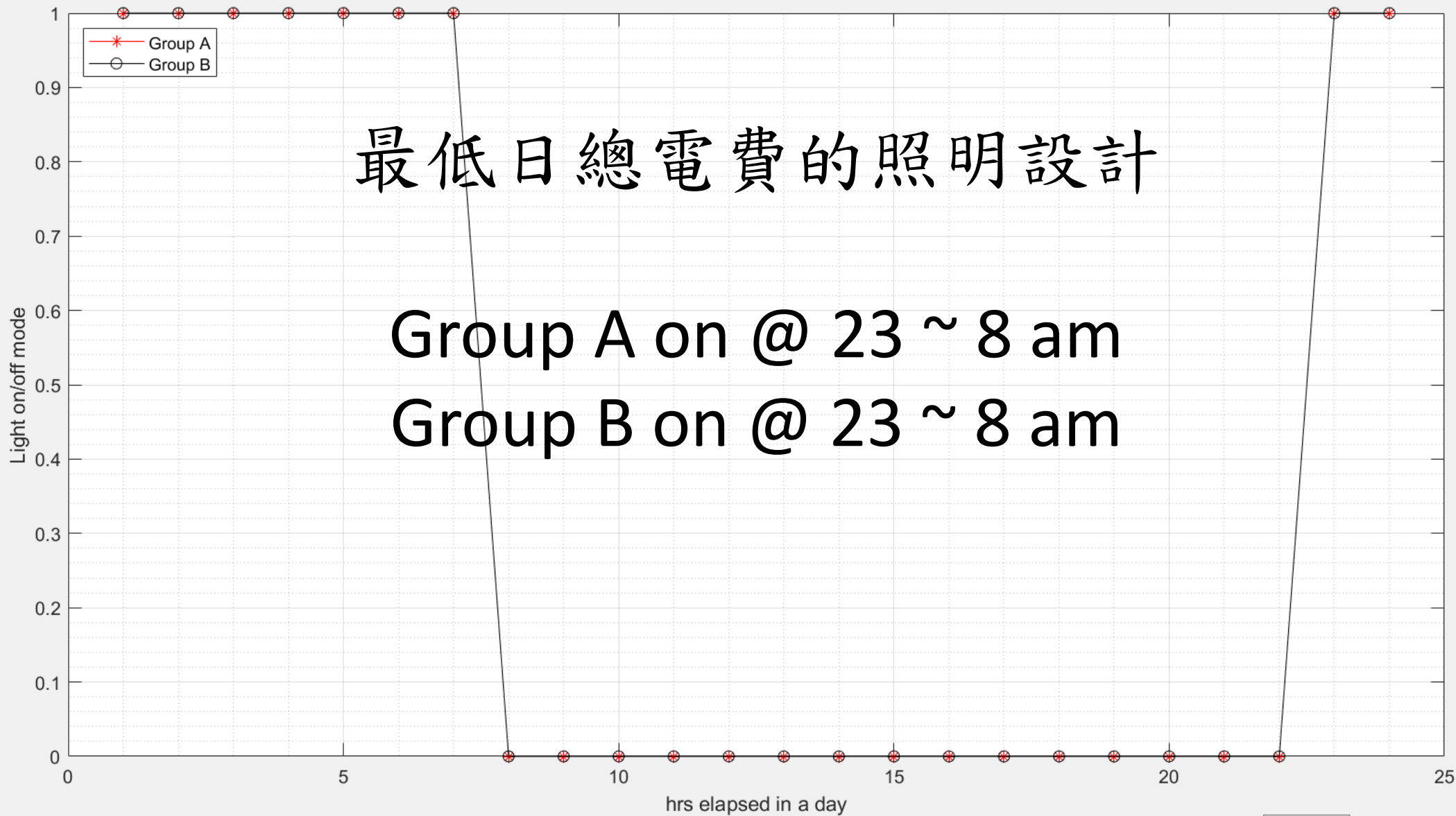
Min daily lighting elec fee = 648.0 NT$, group A turns on at 23:00, Group B on at 23:00
Min daily AC elec fee = 236.5 NT$, group A turns on at 23:00, Group B on at 23:00
Min daily total elec fee = 884.5 NT$, group A turns on at 23:00, Group B on at 23:00

Max - Min lighting elec fee = 950.4 NT$
Max - Min AC elec fee = 536.1 NT$
Max - Min total elec fee = 1486.5 NT$

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*fx* >>

Fig. 4: Group A & B turns on at 23 & 23, Light period = 9 hrs



# 最低日總電費的照明設計

Group A on @ 23 ~ 8 am

Group B on @ 23 ~ 8 am

Fig. 5: Group A & B turns on at 23 & 23, Light period = 9 hrs

# 最低日總電費時的逐時燈光與空調耗電 (kWh)

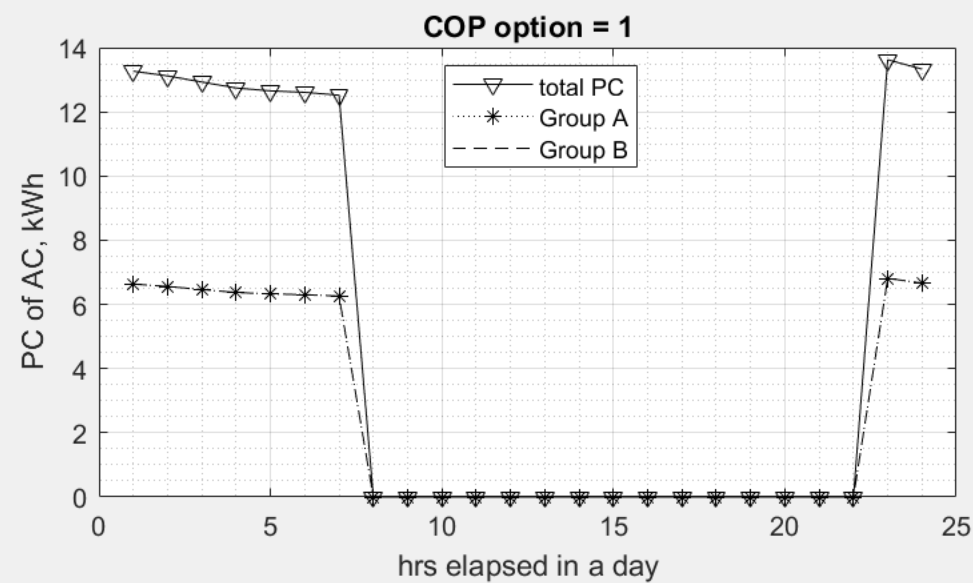
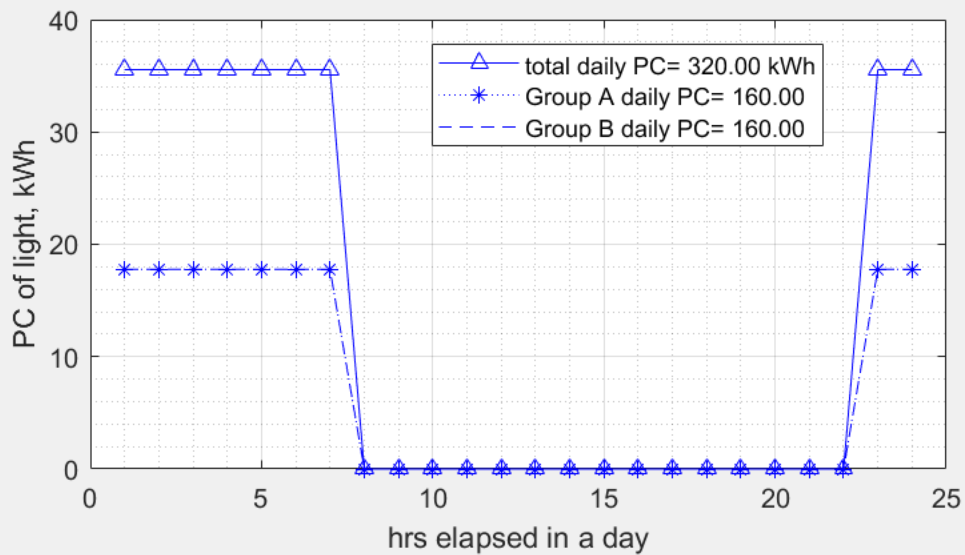
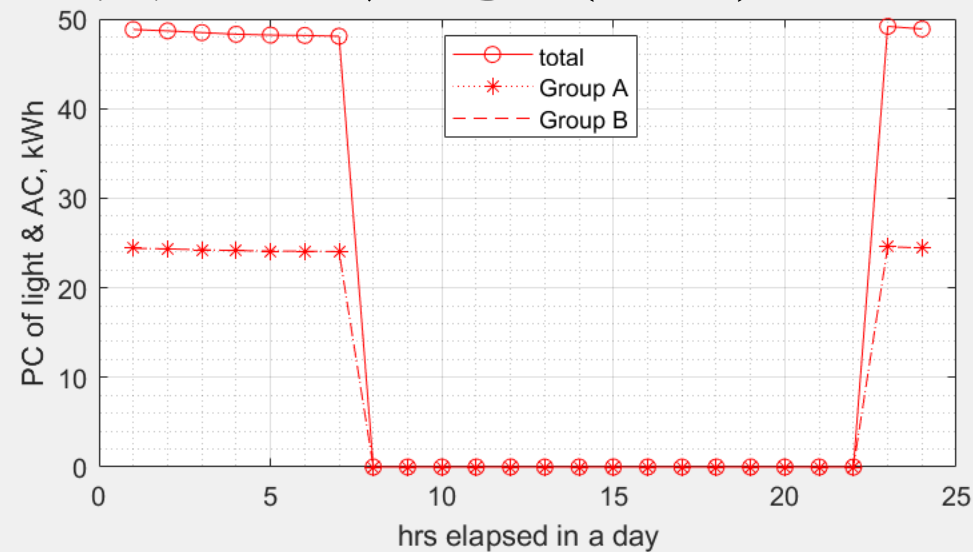
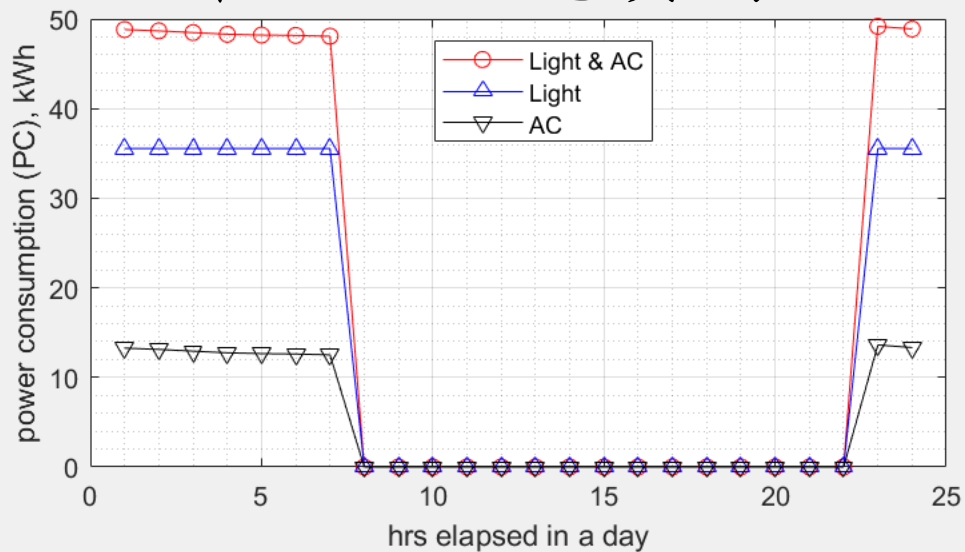
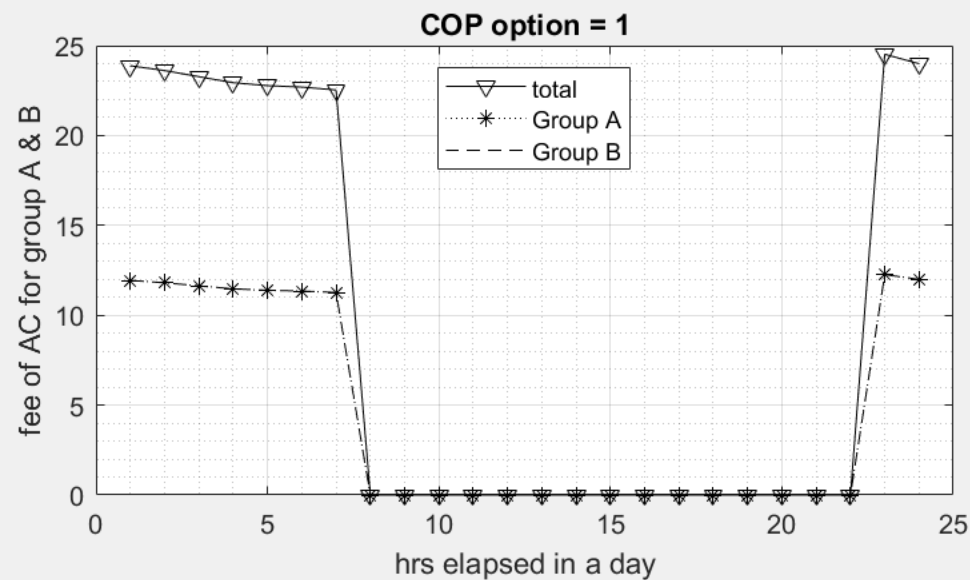
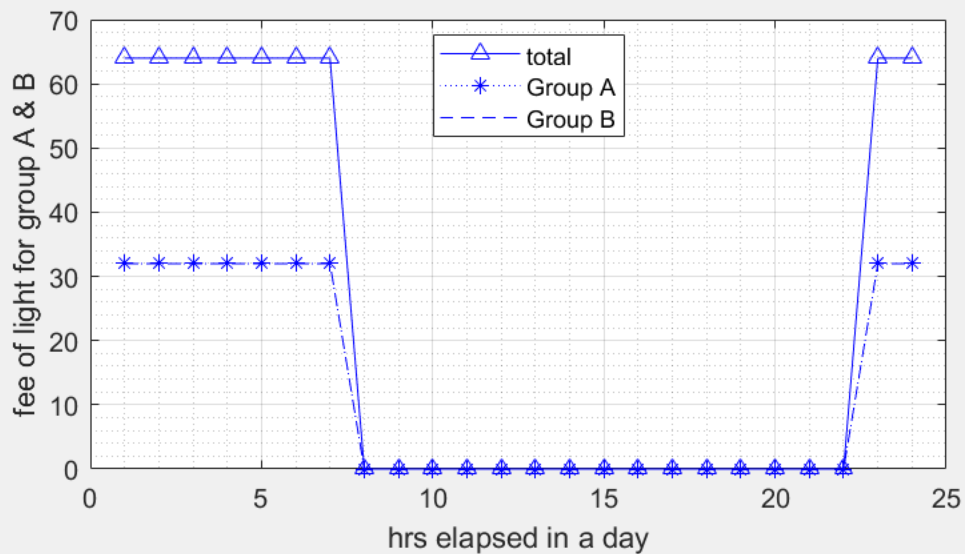
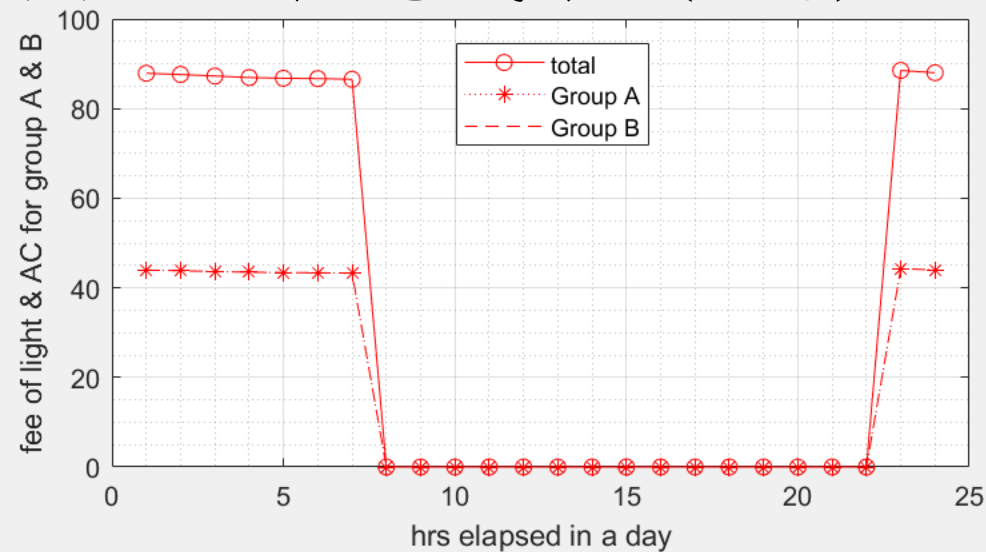
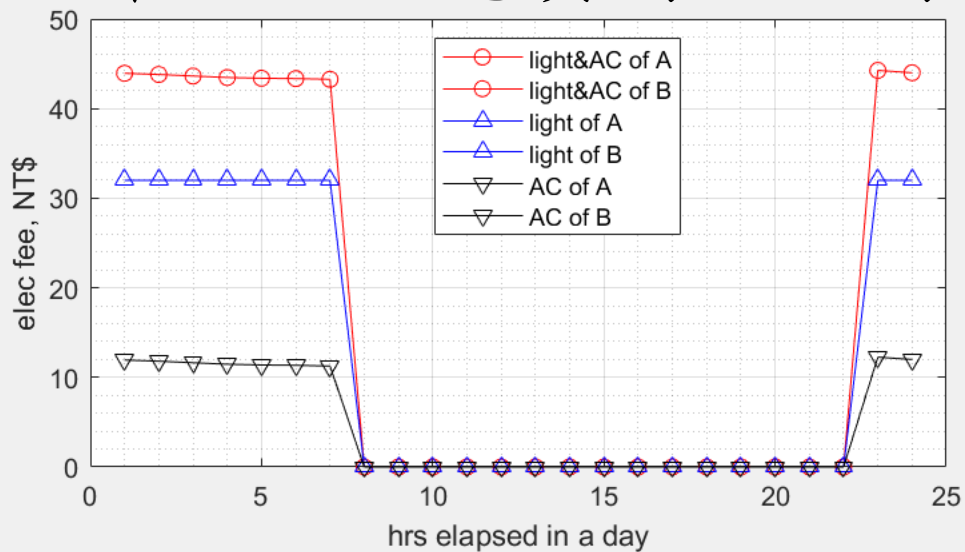
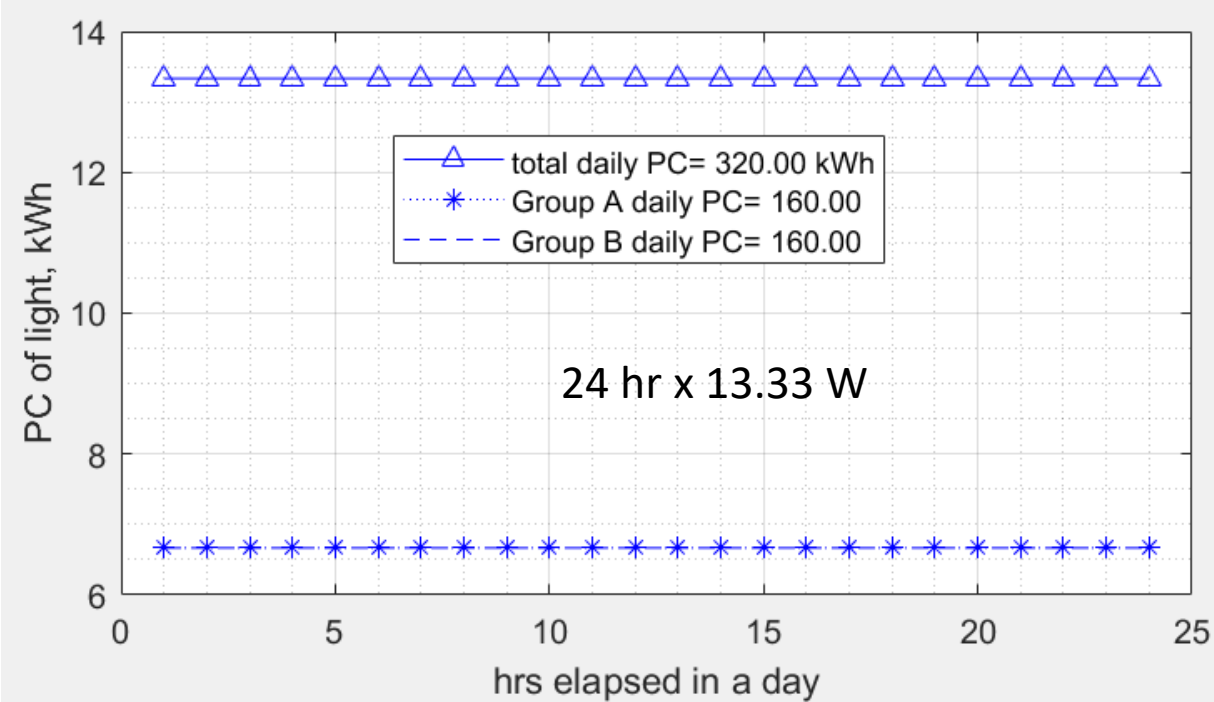
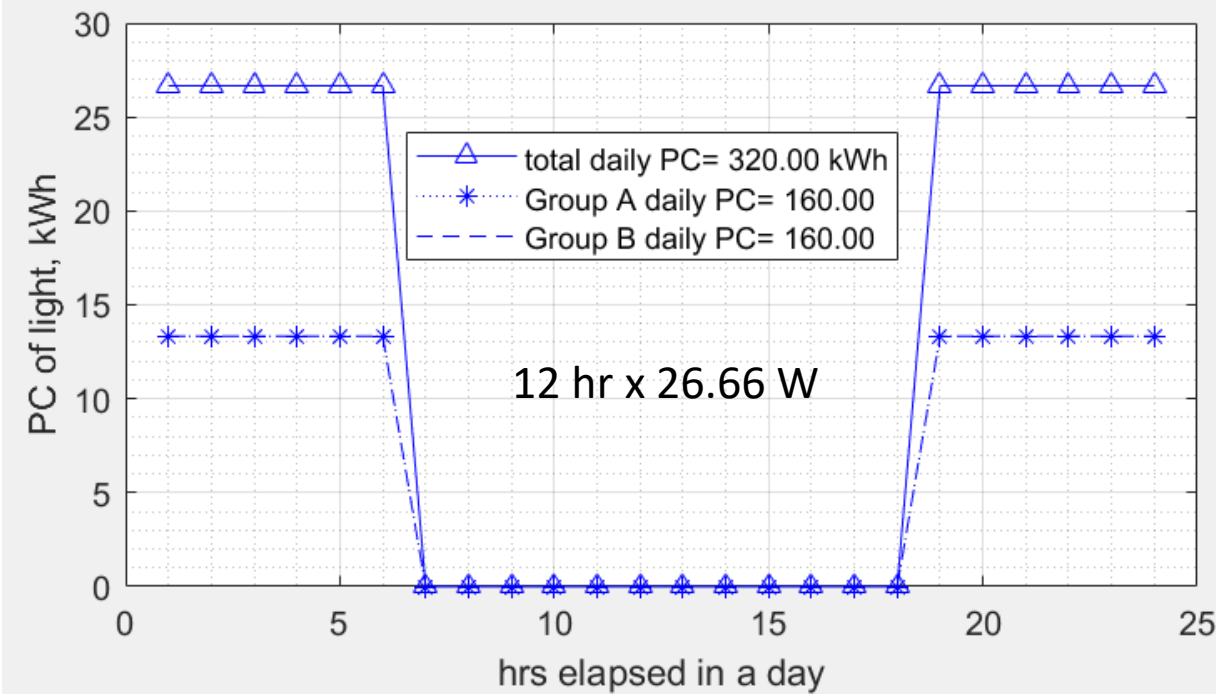
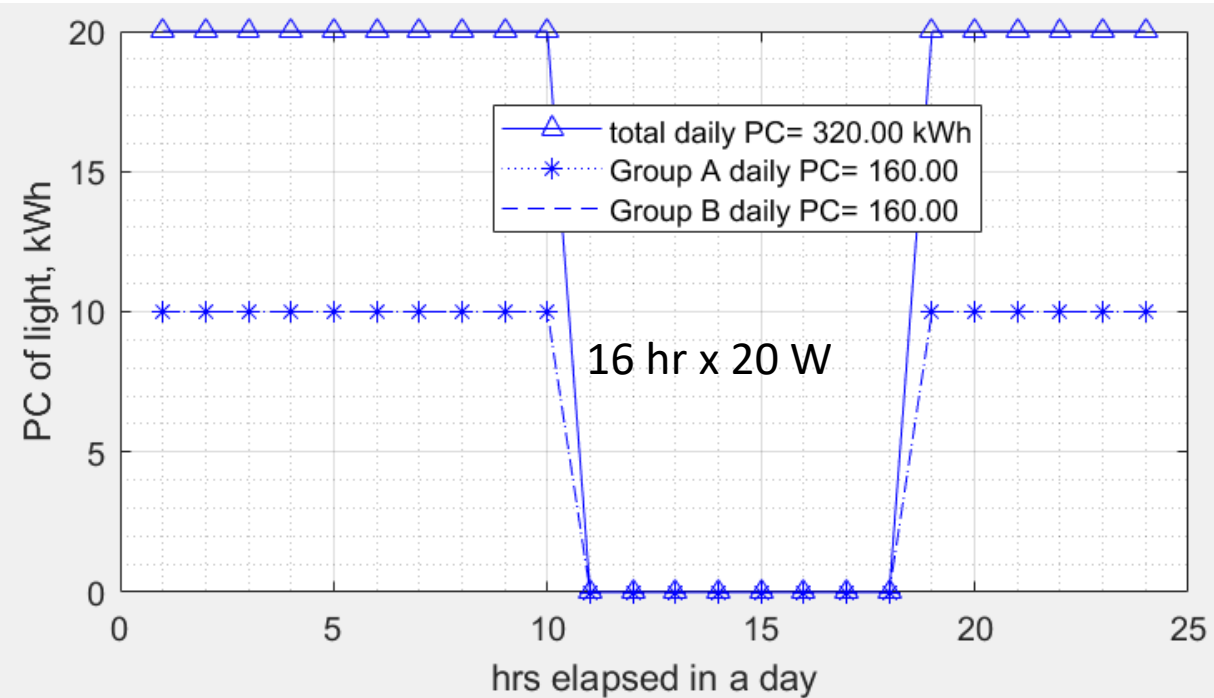
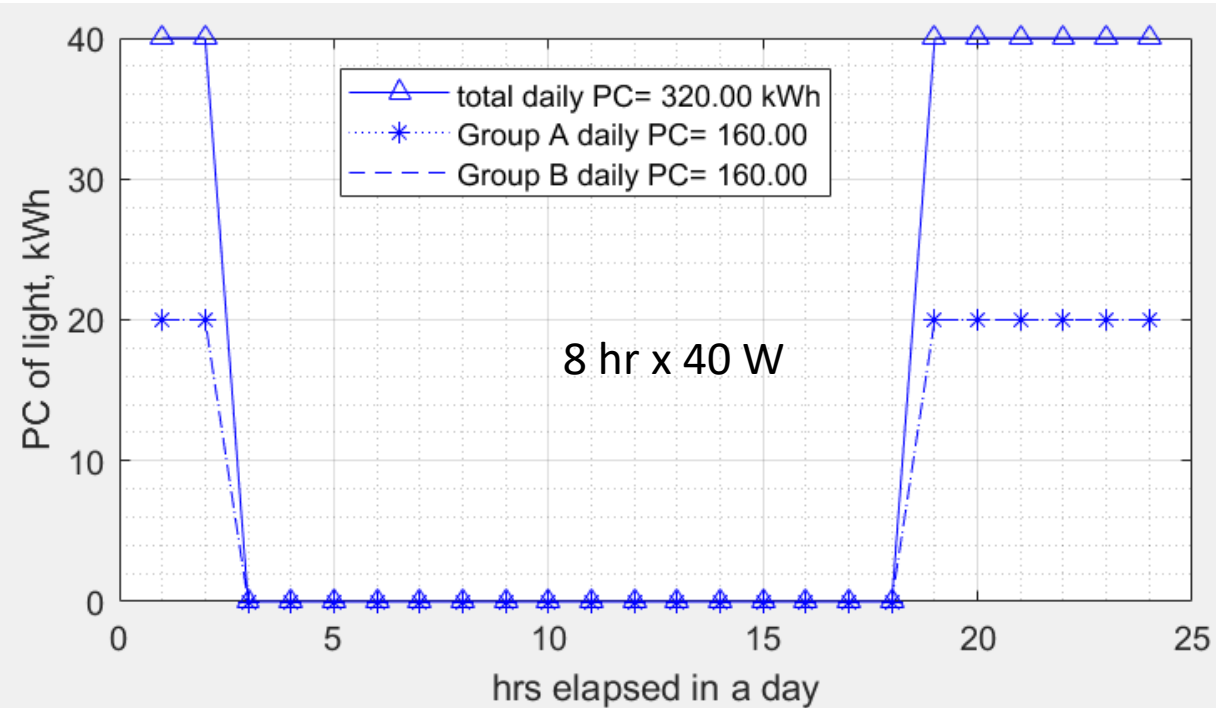


Fig. 6: Group A & B turns on at 23 & 23, Light period = 9 hrs

# 最低日總電費時的逐時燈光與空調耗電成本 (NT\$)





# Daily harvested Fresh Weight, in gFW

- Daily power consumption (**DPC**) of light in kWh was calculated
- Assuming **EY** (in gFW/kWh) of the cultural practice also given
- The daily harvested FW can be calculated as follows:
  - Daily harvested (**DH** in kg/day) = **DPC \* EY / 1000**
  - **Assuming EY is 100 ~ 125 g/kWh (10 ~ 8 kWh/kg FW)**
  - DPC = 320 kWh/day derived from previous page for 1000 LED tubes
  - The DH =  $320 * 100$  (or  $125$ ) /  $1000 = 32$  or  $40$  kg/day
  - Monthly production (30 days) =  $0.96$  or  $1.20$  ton/month



# Affordable Price

Max / Min daily elec. fee = 1441 ~ 2028 NT\$/day

Month fee (30 days) = 43230 ~ 60840 NT\$/month

Assuming elec. fee is 30 ~ 50 % of the total operating cost

OP cost per month = 86460 ~ 121680 NT\$ @ 50%

= 144100 ~ 202800 NT\$ @ 30%

Monthly harvest = 0.96 ~ 1.20 tons of produce

Minimum price  $\geq 121680 / (0.96 * 1000 * 10) = 12.675$  NT\$/100 g @50%

or  $86460 / (1.20 * 1000 * 10) = 7.205$  NT\$/100 g @50%

$\geq 202800 / (0.96 * 1000 * 10) = 21.125$  NT\$/100 g @30%

or  $144100 / (1.20 * 1000 * 10) = 12.008$  NT\$/100 g @30%