대만 ESCO사업의 측정 및 검증(M&V)에 관한 사례연구

Case Study of Measurement & Verification in Taiwan ESCO

Dr. Bill H.J. Chen, 회장
대만 에너지 서비스 협회, 대만, R.O.C
Hung-Yao Chao, CMVP, PE
Jun-Yuan ㈜ 에너지 텍
Dr. Bing-Chwen Yang, 선임 연구원
친 환경 에너지연구소

Dr. Bill H.J. Chen, Chairman
Taiwan Energy Service Association, Taiwan, R.O.C
Hung-Yao Chao, CMVP, PE
Jun-Yuan Energtech Eng. Co. Ltd.
Dr. Bing-Chwen Yang, Leader Researcher
Green Energy Environment Research Lab. ITRI

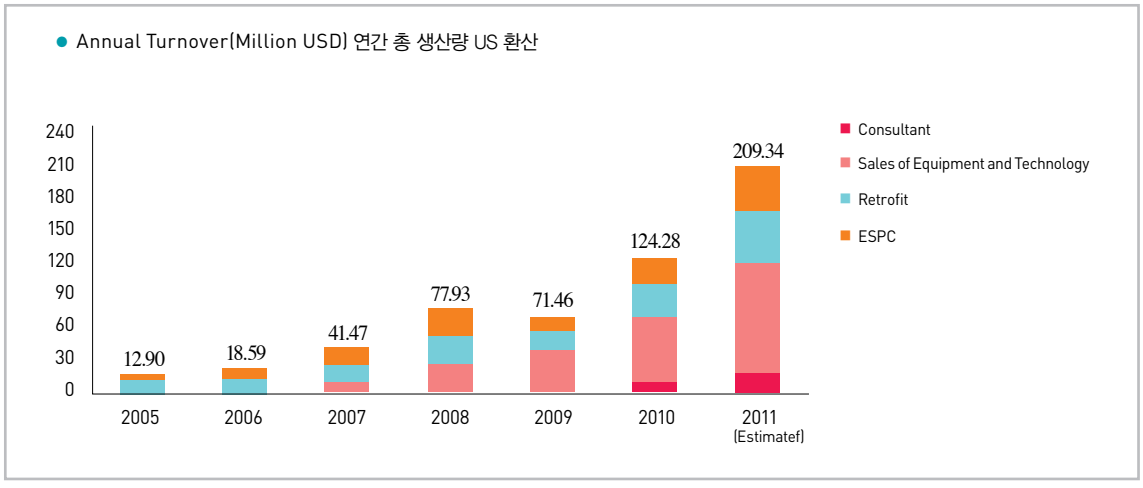
지난 9월 한국을 방문한 대만 ESCO협회 Bill Chen회장 일행을 통해 대만 ESCO협회의 역할과 대만 ESCO 사업에 있어 M&V방법에 대해 알아보았다.

대만 ESCO협회는 교육 및 세미나, 포럼 등을 전담하여 추진하는 'TAESCO'와 ESCO사업을 영위하는 기업들을 대변하는 'TESA' 두 개의 기관이 존재한다.

TAESCO는 2005년 6월 설립되었으며 143개의 기업회원과 283개의 개인회원으로 구성되어 있다. TAESCO는 ESCO산업에 대한 지식제공과 ESCO 정부 에너지사용자 상호간의 연결고리 역할, ESCO 관련 전문가 교육 등의 역할을 수행하고 있다. TESA는 2008년 8월 설립되어 144개의 회원사를 갖고 있다.

TESA는 ESCO정책제안, 사업 발굴 등 지속적으로 ESCO 사업발전을 이루기 위한 활동을 하고 있다. 대만 ESCO는 에너지절약, 에너지효율개선, 신재생에너지, 최대전력수요제어장치(기기), 타당성 검토, 설계, 제조, 설치, 관리 및 유지, 진단운영 및 측정 검증 등의 사업을 영위하고 있다.

아래 그림은 대만 ESCO산업의 현황을 나타낸 표이다.



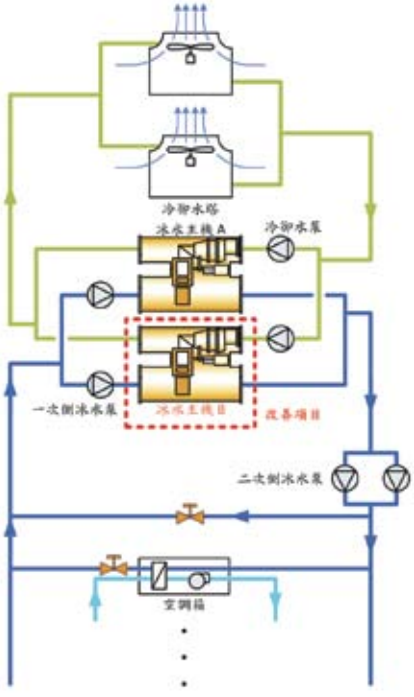
The M&V for Air-Conditioning Building (Option D)

1 A commercial building in Taipei city :

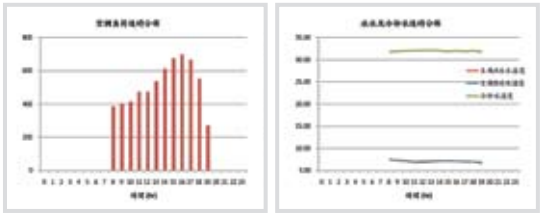
In the building, the capacity of chillers 2 sets is 350RT each. One of the chiller has operated for more than 10 years. Due to the low COP, the retrofit is to replace the chiller. The system operates from 8:00 to 20:00 per day and 252 days per year.

2 System Description

- Original design : as the right figure shows
- Chiller 1,230 kW (350RT) each
  Chilled water 12℃ in/7℃ ou
  Cooling water32℃ in/37℃ out
- Cooling tower capacity 1,587 kW each
- Primary pump 0.0588 m3/s @ 147 kPa
- Secondary pump 0.0588 m3/s @ 294 kPa
- Cooling water pump 0.0735 m3/s @ 196 kPa

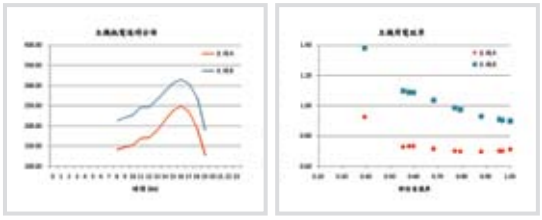


Cooling load, chiller and cooling water temperature change by hour



3 Energy Consumed Before Retrofit

- Comparison of power consumption for chillers
- Chiller B is 0.2~0.4 kW/RT higher than chiller A.



4 Energy Consumed Before Retrofit

- Baseline establishment
- Establish the power consumption model for chiller B by regression analysis.
- Baseline model:

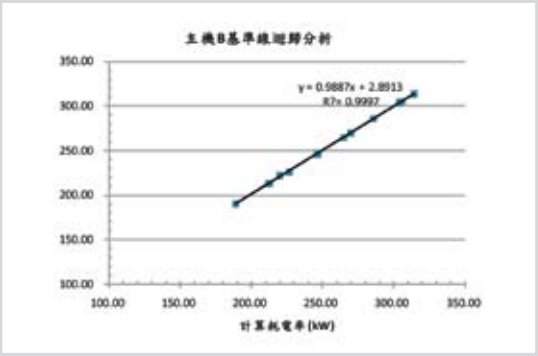
$$W=a_0+a_1\cdot(T_{cwr}-T_{chs})+a_2\cdot(T_{cwr}-T_{chs})^2+a_3\cdot Q_{ch}+a_4\cdot Q^2_{ch}+a_5\cdot(T_{cwr}-T_{chs})\cdot Q_{ch}$$

	Chiller B
a_0	0.036619
a_1	-5.905113
a_2	0.375990
a_3	0.053503
a_4	0.000024
a_5	0.002916

Where
W is Chiller power consumption
Tcwr is inlet cooling water temp.
Tchs is outlet chilled water temp.
Qch is cooling Load

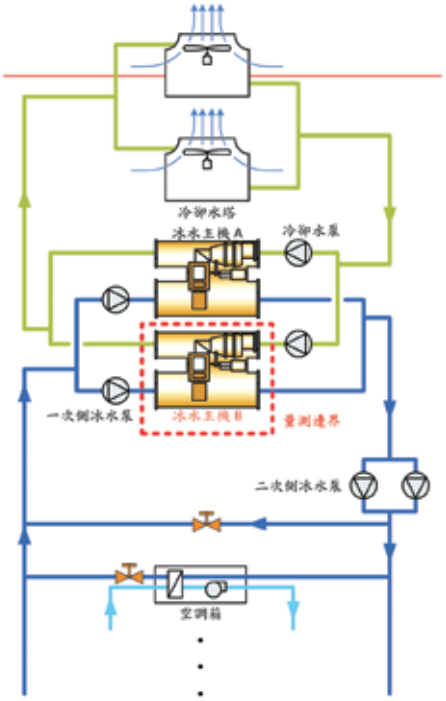
5 Energy Consumed Before Retrofit

- Result of baseline regression analysis
  - Chiller B : $R^2 = 0.9997$
  - Meet standard R2 ≧ 0.75



6 Retrofit

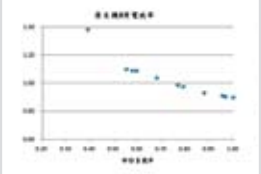
- To replace the lower efficiency chiller
  - Retrofit cost NT$ 3,000,000
  - According to the testing data provided by the manufacturer, the power consumption for the new chiller :

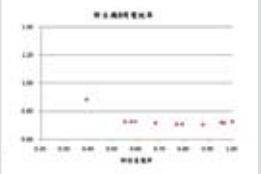


	new system B
a_0	0.035828
a_1	-1.905113
a_2	0.175990
a_3	-0.081936
a_4	0.000105
a_5	0.003201

7 Retrofit

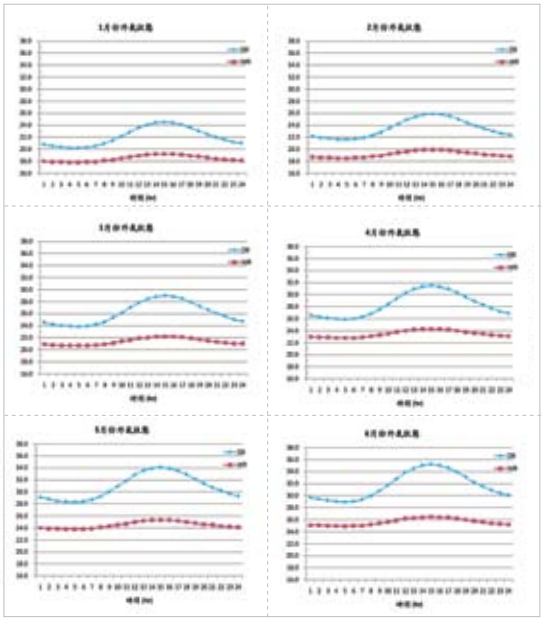
- Comparison of efficiency for chiller B before and after retrofit
  - Under different conditions, the operating efficiency of the new chiller is always higher than the old one.


Before retrofit


After retrofit

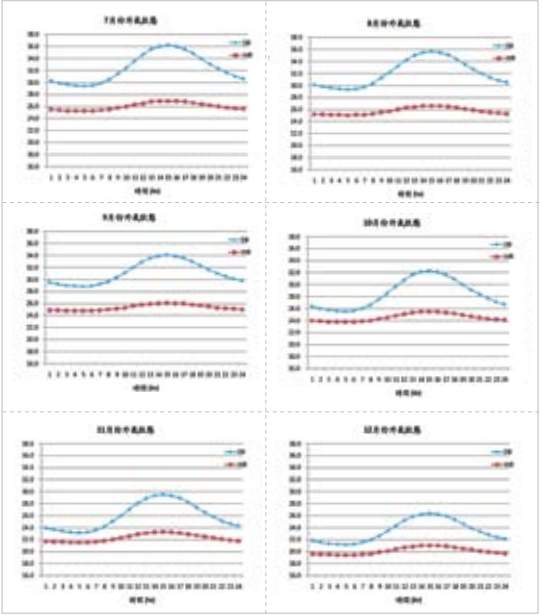
8 Weather Data (in Taiwan)

- Monthly weather data (January ~ June) Case



9 Weather Data (in Taiwan)

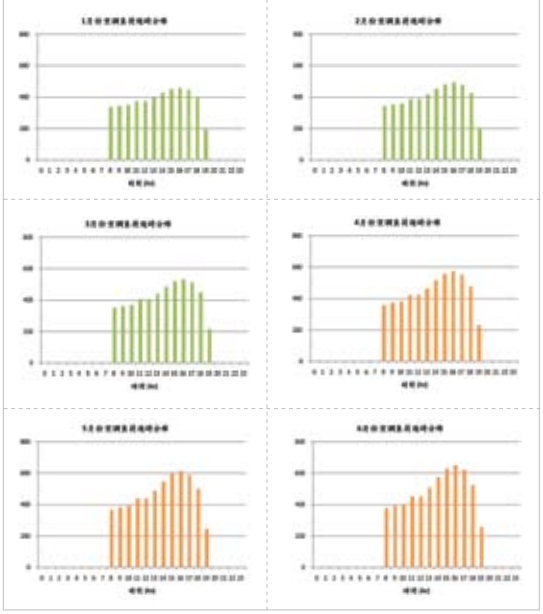
- Monthly weather data (July ~ December)



10 Cooling Load

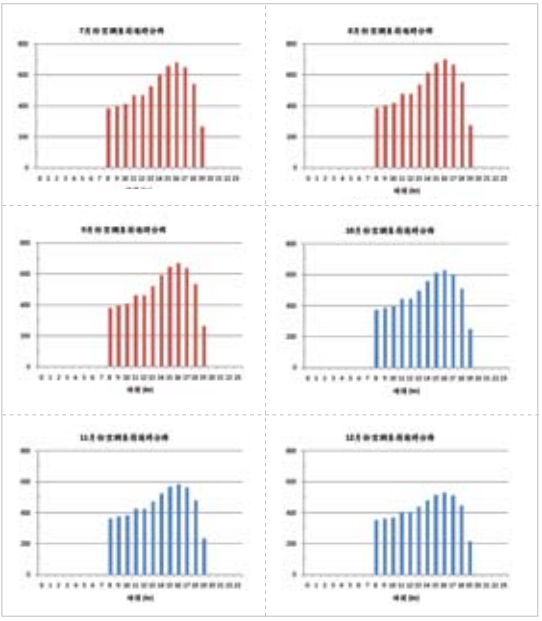
- Parameter

- Monthly cooling load profiles (January ~ June)



11 Cooling Load

- Monthly cooling load profiles (July ~ December)



12 Energy Saving Results

- Chilled water temperature : 7℃
- Cooling water temperature : 32℃
- Operation days for each month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
22	15	22	21	22	21	22	23	21	22	22	22	255

- Electricity charge : NT$1.80 /kW-h
- Inflation per year : 2%
- Interest per year : 1%

13 Energy Saving

- Analysis of monthly power consumption before and after retrofit

chiller		energy consumed (MW-h)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum (MW-h/ year)
before	old	57.9	40.5	61.1	60.1	64.7	63.2	67.7	71.7	64.1	65.4	63.3	60.9	**740.4**
after	new	38.3	27.1	41.4	41.3	45.2	44.8	48.6	51.9	45.8	45.9	43.7	41.2	**515.1**
energy saving		33.8%	33.1%	32.3%	31.2%	30.2%	29.1%	28.2%	27.6%	28.6%	29.7%	31.0%	32.3%	**30.4%**

14 Energy Saving

Case	Index	Before retrofit		After retrofit		Amount Saved Nt$	Energy saving efficiency
		MW-h/year	NT/year	MW-h/year	NT$/year	NT$/year	%
Retrofit Chiller B	Energy consumed	740.4	1,322,727	515.1	927,248	**405,479**	**30.4**
	CO_2 emission	471 Ton / year		471 Ton / year		Reduces CO_2 emission 143 Ton / year	
	SO_x emission	0.414 Ton / year		0.288 Ton / year		Reduces SO_x emission 0.126 Ton / year	
	NO_x emission	0.395 Ton / year		0.275 Ton / year		Reduces NO_x emission 0.120 Ton / year	

15 Energy Saving

- Payback
- The payback period is less than 8 years

Year	Estimated electricity consumption by old chiller(kWh)	Estimated electricity consumption by new chiller(kWh)	Electricity saved(NT$)	Profit(NT$)
0				- 3,000,000
1	1,332,727	927,248	405,479	- 2,624,521
2	1,359,381	945,793	413,588	- 2,237,178
3	1,386,569	964,709	421,860	- 1,837,690
4	1,414,300	984,003	430,297	- 1,425,770
5	1,442,586	1,003,683	438,903	- 1,001,125
6	1,471,438	1,023,757	447,681	- 563,455
7	1,500,867	1,044,232	456,635	- 112,455
8	1,530,884	1,065,117	465,767	352,188
9	1,561,502	1,086,419	475,083	830,793
10	1,592,732	1,108,147	484,585	1,323,686

16 Conclusions

- In Taiwan, ESCOs proceed energy saving services according to IPMVP which is internationally recognized.
- With M&V, the result of energy saving efficiency is accurate, complete, consistent, credible and clear. There will be no dispute about the energy saving between the energy users and ESCOs.
- There are four options for M&V. Each case adopts a different option.

※ 내용의 정확한 전달을 위하여 부득이 원문으로 표기하였습니다.