能源服務產業展望

報 告 人

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Consider

能源技術？

工程技術？

量測與驗證技術？

財物槓桿？

節能績效保證？

能源服務！

Vision

能源服務

- 新興產業
- 跨領域整合
- 產官學研合作新契機
- 創造更大利基

HVAC之外？
全方位解決方案？
技術士/技師？
能源規劃師？

能 源 服 務
ESCO內涵與發展

摘　要

- 隨著全球氣候變遷，以及京都議定書的生效，溫室氣體減量已成為世界各國的共識與致力的目標，其中節約能源乃為短期內最直接可行且最具成效的手段。
- 為進一步推廣節約能源，經濟部能源局參考國外「節約能源性能合約」(energy savings performance contracts, ESPC)，利用能源服務公司(energy service companies, ESCOs)節能績效保證之契約概念，預計推動基於節能績效予以部分補助之節約能源改善專案。
  - ✓ 促使國內長久以來推動之節能措施能找到新的著力點
  - ✓ 發揮最大的節能績效

摘　要

- 而有關提升能源效率和節約能源，雖然加強節能知識的宣導或多或少有些正面效益，但是目前已遭遇瓶頸，因此現階段最能發揮功效的應為推展「能源服務業」
  - ✓ 因為ESCO產業不但能夠透過能源效率的診斷、節能設備的安裝、相關節能措施的規劃與設計等專業技術，為業主提昇效率進而節約能源
  - ✓ 而後再從節能經濟效益中回收一定比例的投資報酬，確實發揮節能共享的精神，從而提高技術服務業的附加價值。
- 因此，發展ESCO產業，不只是能源政策中的重要一環，也是產業政策中最值得努力以赴的重點。

摘　要

- 而攸關驗收與省能費用攤還的節能性能與效果的檢驗與認定就成為計畫成敗的主要關鍵，亦即「量測與驗證」 (measurement and verification, M&V)之執行技術與程序在現階段必須儘速制訂，以確保ESPC之順利進行。
- 節能改善工程實施前、實施後之設備與系統量測、以及歸納其能源流向與所節省之效益相關工程善後與驗收，尤其是為其日後所能持續發揮之節能功效把關。
- 因此，量測與驗證(M&V)程序與技術之建立，以及其於ESCO專案中是否可以運作順暢，並發揮既有之功能，為主要重點。

背　景

- 系統之能源檢測並非易事：
  - ✓ 耗費人力資源與時間
  - ✓ 需要具專業背景之人員監督指導，甚至親自執行
  - ✓ 避免虛耗人力與各項資源，甚至導致系統診斷錯誤，使節能節約能源之美意大打折扣。
- 若欲透過系統診斷，提供節能措施以發揮出抑低空調系統耗能之具體成效，將面臨目前相關編制之人力與資源不足之窘境。

擬解決之問題

- 整合下列各項做一連串總體而完整之研究：
  - ✓ 系統之耗能原因
  - ✓ 系統診斷學理與方法
  - ✓ 節能技術落實方案
  - ✓ 系統量測檢測方法與技術
  - ✓ 各相關節能策略
  - ✓ 經濟效益
- 逐步建立各種資料庫與專家系統，最後發展出電腦輔助技術分析評估與經濟效益分析之模擬系統。
- 以更具效率、易於執行且能夠發揮更大之節能效益的作業程序，以利節能檢測改善之持續推動，進而達成為各產業能源服務之最終目標。

現階段問題點

- 在今日電子工業一日千里之進步發展下，能源技術顯得一成不變而效率不彰，其運轉能源效率比實有待進一步提升。
- 既有系統能源使用之改善才是真正具有立竿見影之效，亦能立刻顯現節約能源宣導與落實之實績。
- 以HVAC為例，根據研究指出，在既有之中央空調系統中可節能之空間非常大，若做系統整體之改善，平均可節省60%左右之電力。

現階段問題點（續）

- 系統之能源檢測並不容易，需耗費相當多之具專業背景人力資源與時間。
- 如何經由現場檢測數據，正確地診斷系統，真正發揮節能節約能源成效之後續檢討工作。
- 欲達到藉由節能改善以抑低尖峰用電量之成效，將必須投入大量具專業背景之人力與龐大之資源。
- 在現階段相關編制之人力與資源不足之狀況之下將更形困難。
- 如何以更具效率更易執行之方式進行節能技術落實，以突破現狀強化成效，是亟需進行之工作。

發展內容與項目

- 以空調系統為例，將節能效益驗證與節能改善分為下列各項目：
  - ✓ 空氣側
  - ✓ 冰水側
  - ✓ 冷媒側
  - ✓ 冷卻水側
  - ✓ 控制系統

能源服務
空調設備與系統性能量測技術

Question

- 施作節能措施(Energy Conservation Measures, ECM)後，真正節能量到底多少？
  - ✓ 今年電費與去年電費比較？
  - ✓ 口頭約定？
  - ✓ 誰說了算數？
  - ✓ 怎麼驗收？
- Performance Measurement and Verification (M&V)!

環境驗證

室內空氣品質

環保署室內空氣品質建議值

項目	建議值			單位
二氧化碳(CO_2)	8 小時值	第 1 類	600	ppm(體積濃度百萬分之一)
		第 2 類	1000	
一氧化碳(CO)	8 小時值	第 1 類	2	ppm(體積濃度百萬分之一)
		第 2 類	9	
甲醛(HCHO)	1 小時值		0.1	ppm(體積濃度百萬分之一)
總揮發性有機化合物(TVOC)	1 小時值		3	ppm(體積濃度百萬分之一)
細菌(Bacteria)	最高值	第 1 類	500	CFU/m^3(菌落數/立方公尺)
		第 2 類	1000	
真菌(Fungi)	最高值	第 2 類	1000	CFU/m^3(菌落數/立方公尺)
粒徑小於等於 10 微米(μm)之懸浮微粒(PM_{10})	24 小時值	第 1 類	60	μg/m^3(微克/立方公尺)
		第 2 類	150	
粒徑≦ 2.5 微米(μm)之懸浮微粒($PM_{2.5}$)	24 小時值		100	μg/m^3(微克/立方公尺)
臭氧(O_3)	8 小時值	第 1 類	0.03	ppm(體積濃度百萬分之一)
		第 2 類	0.05	
溫度(Temperature)	1 小時值	第 1 類	15 至 28	℃(攝氏)

- 環保署已於94.12.30公告室內空氣品質建議值
- 針對CO2、CO、甲醛、TVOC、細菌、真菌、PM10、PM2.5、O3及溫度等十種項目加以建議

註：
1. 第1類：指對室內空氣品質有特別需求場所
2. 第2類：指一般大眾聚集的公共場所及辦公大樓
3. 勞工作業場所依室內空氣污染物濃度標準，不適用本建議值

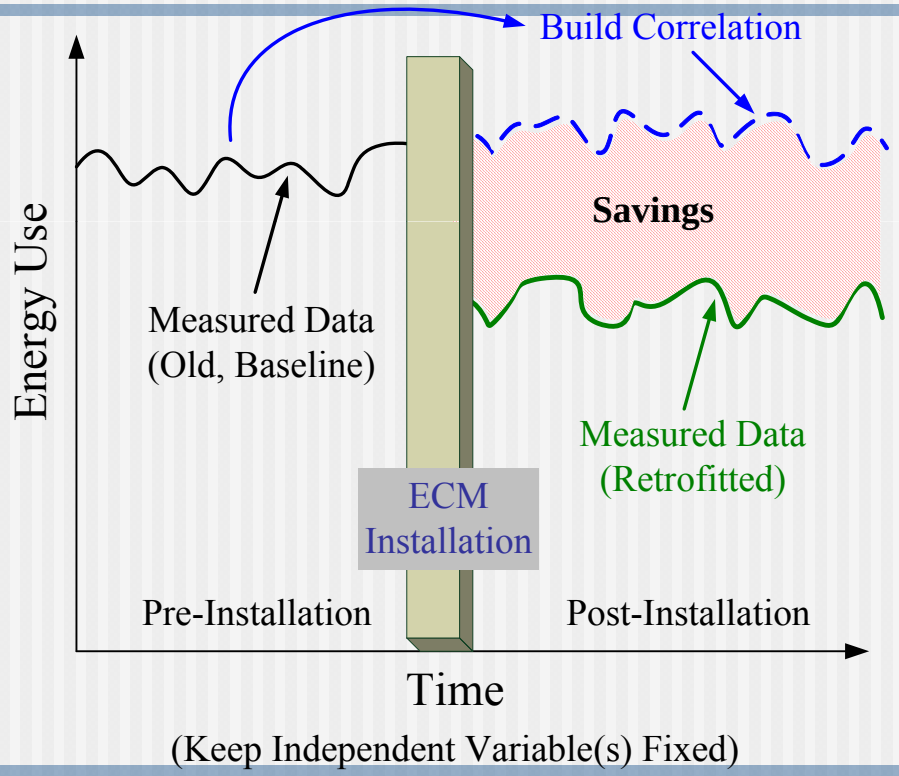
能源服務
設備與系統檢測SOP

能 源 服 務
節能效益檢測與驗證

ESPC專案之資料/整體的考量

- ✓ 風險與責任
- ✓ 電價資料
- ✓ M&V行動的時程與報告
- ✓ 操作與維修（O&M）報告之要求
- ✓ 爭議的解決方案

M&V概念



IPMVP

International **P**erformance **M**easurement and **V**erification **P**rotocol

- Volume I - *Energy Savings Concepts and Tools*
  - ✓ Defines basic M&V terminology (4 “Options”)
  - ✓ General procedures to achieve reliable and cost-effective determination of savings
  - ✓ Applicable to energy or water efficiency projects in buildings and industrial plants
- Volume II - *Indoor Environmental Quality*
- Volume III - *New Construction and Renewables*

M&V Methods

- Standard Terminology
- Four Defined "Options"
- Assigning Value to Savings

Definition: Performance

- **Performance** *n.*. (legal)
  - ✓ 1.What is required to be performed in fulfillment of a contract, promise, or obligation (substituted a new performance in novation of the contract)
  - ✓ 2.The fulfillment of a contract, promise, or obligation
- In engineering, **performance** relates to measuring some output or behaviour. Techniques for monitoring performance include
  - ✓ Sampling
  - ✓ logging
  - ✓ taking snapshots
  - ✓ testing

Performance: Examples

- Automobile - Kilometers/liter
- Lighting System - Watts/ Square Meter
- Chillers- kW/Ton (COP)
- ….

Definition: Operation

- The integrated effect of performing systems, i.e. the "energy" used over time. (kilowatt-hours)
- The contract must apportion responsibility for the long-term operation of the retrofit.

  (Who turned on/off the lights?)

Definition: Model

Model (noun)

A schematic description of a system, theory, or phenomenon that accounts for its known or inferred properties and may be used for further study of its characteristics.

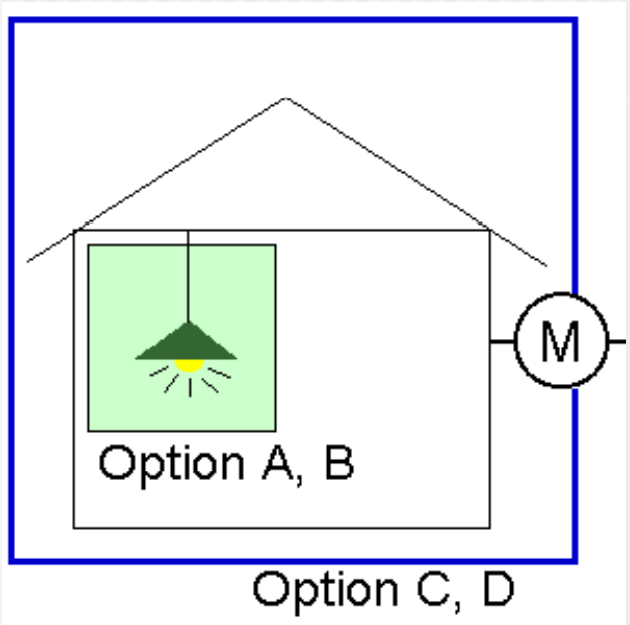
Definition: Stipulate

- **Stipulate** *v.*

a. To lay down as a condition of an agreement; require by contract.

b. b. To specify or arrange in an agreement.

M&V Options



Options A and B are retrofit-isolation methods

Options C and D are whole-facility methods

The

Which Option Is Best?

- No option not necessarily better or more/less expensive than another
- Each M&V option is applicable to different situations (particularly defined by risk-sharing)

Option A

- Simple approach (and low cost)
- Performance parameters are measured (before and after), usage parameters may be estimated and then *stipulated*
- Used where the "*potential to perform*" needs to be verified but accurate savings estimation is not necessary
- ***Option A is NOT "stipulated savings"!***

EXAMPLE of Option A

Lighting Retrofit

# or Fixtures	Before Watts	After Watts	Hours/yr	Savings
100	100.0	50.0	3000	= 15,000 kWh
200	100.0	50.0	2000	= 20,000 kWh
300	100.0	50.0	1000	= 15,000 kWh
				= 50,000 kWh

Inputs to model are based on measured data, past experiences, and facility interviews

Implications of Assumptions

- Effort is needed to get data and justify the assumption.
- Less to measure usually means lower measurement costs.
- Probable lower costs may leave more money for more accurate meters or other retrofits.

Deciding What to Assume

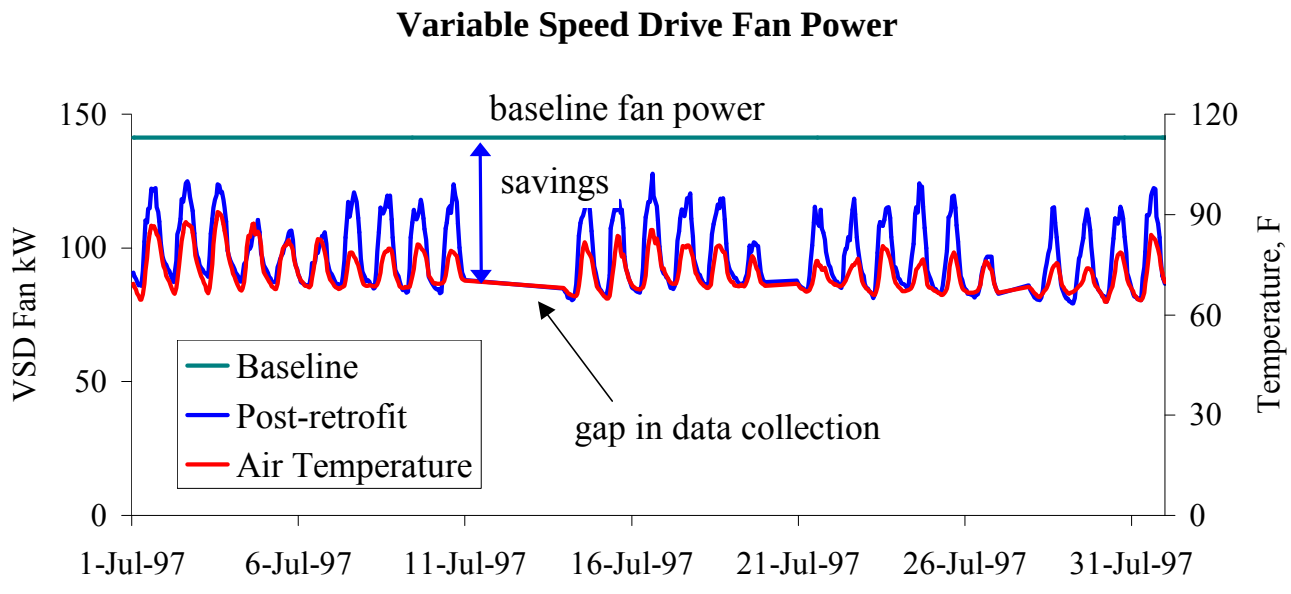
What can you assume?

- ✓ Consider plausible assumption errors.
- ✓ Make assumptions where the error is not significant, or where the parameter is not the performance item of concern.
- ✓ **IPMVP defines manufacturer specifications as assumptions** (because they are not field measurements).

Option B

- Under Option B, some or all parameters are measured periodically or continuously
- Applicable where accurate savings estimation is necessary and where long-term performance needs to be tracked
- Reduced uncertainty, but requires more effort

VSD-B-01: Monitor Fan Performance



Option B Applications

- Projects with large elements of uncertainty and/or risk ($$$)
- Variable-speed drives on fans and pumps
- Chillers and chiller plants
- Energy management & control systems
- Projects where equipment needs constant attention

Option B Benefits

Reasons to use Option B instead of A:

- “Real” M&V
- Better equipment performance
- Improved O&M
- Ongoing Commissioning
- Remote monitoring

Option C

- Option C looks at energy use and cost of entire facility, not at specific equipment
- Conceptually simple, may be difficult in practice
- Can consider weather, occupancy, etc.
- Useful where total savings need to be valued but component savings do not
- Commercial software is available that simplifies implementation

Option C Limitations

- Does not verify at component level
- Requires savings to be significant (> 10-20% of baseline consumption)
- Requires historical data (> 1 year)
- May take time to evaluate savings
- Requires building meters (not campus)
- May require baseline adjustment to account for non-project-related factors

Option C Applications

- Projects where facility usage remains constant and historical data is present
- Weather-dependent projects
- Heating projects
- Comprehensive and/or campus-wide projects (w/reservation)
- Multiple interacting measures in a single building

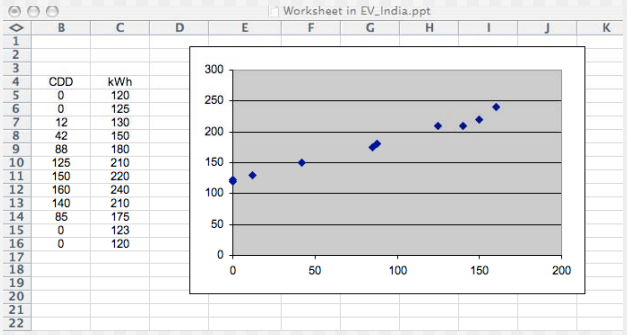
Option C Programs

(examples)

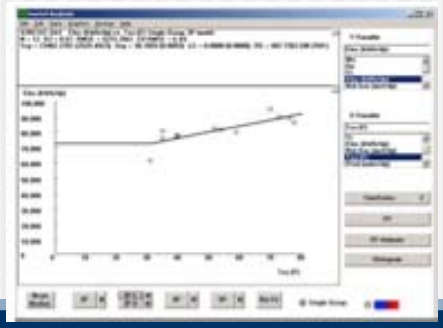
- Texas Engineering Experiment Station
  - ✓ http://ecalc.tamu.edu/gui/home/
- Metrix, Utility Manager Pro 4.0 (commerical software)
  - ✓ http://www.abraxasenergy.com/
- EZ Sim Stellar Process
  - ✓ http://ezsim.com
- University Dayton - Dr. Kelly Kissock
- Most standard statistical / regression texts

Option C Models

Regression - Simple



Regression - Change Point



Adjustments!?

An example of why we need Adjustments:

An energy retrofit was performed but plant ***production (operation) is lower*** this year than last. How much of the raw 'savings' were due to the retrofit and not the production change?

To identify the retrofit's effect we must adjust for unrelated changes. Therefore we adjust baseyear and post-retrofit energy use data to a common set of conditions.

Option D

- **Option D treats building as computer model**
- Flexible, but requires significant effort
- Applications:
  - ✓ New construction
  - ✓ Energy management & control systems
  - ✓ Building use changes
  - ✓ Building envelope modifications & additions

Option D Limitations

- Uses specialized software that requires significant experience to use
- Results vary with effort (and $$$) expended
- Requires measurements for calibration
- Still need to verify potential to perform
  - ✓ Annual inspections recommended

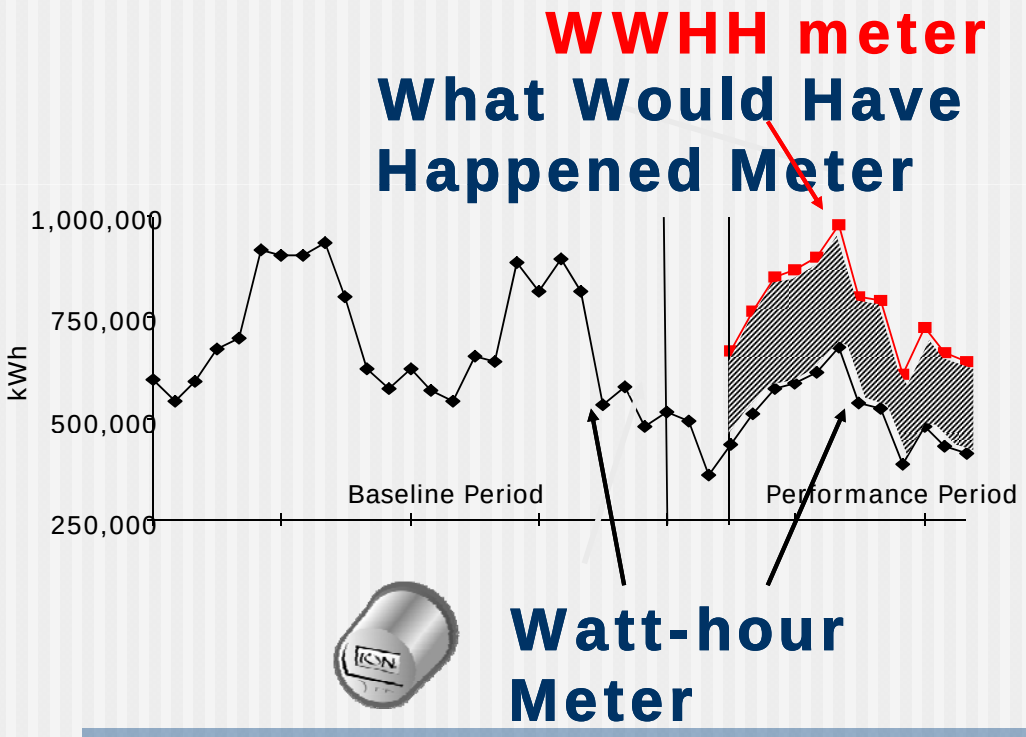
Option D Programs

- DOE-2
  J.J. Hirsch & Associates http://www.doe2.com/
- eQuest
  Energy Design Resources http://www.doe2.com/
- PowerDOE
  J.J. Hirsch & Associates http://www.doe2.com/
- EnergyPlus
  LBNL & DOE http://gundog.lbl.gov
- Visual DOE 4.0
  Eley Associates http://www.archenergy.com/
- Trace 700
  Trane http://www.trane.com/commercial/software/trace/index.asp
- Market Manager
  Optimum Energy http://www.abraxasenergy.com

Selecting An Option

- Each project is different
- Each situation must be analyzed
- Consider costs relative to savings and desired accuracy
- The following are *suggestions* of common "best fit" applications

M&V Requires TWO Meters



Converting Energy to Value

- Avoided Cost
  - ✓ Based on rates
  - ✓ Informed by futures markets
- Environmental Costs
  - ✓ Emissions Markets
    - Local
    - CDM - UNFCCC
- Hedge Value (Financial Options)
- Tradable Certificates

Avoided Cost

- Reduction in your utility bill
- Based on tariff
  - ✓ Time of use / time of savings
    - May require “savings load shape”
  - ✓ Demand charge

Emissions

- Energy Efficiency and Emissions
- World-wide SOx, NOx, GHG Verification
- Registries, Mechanisms, Schemes
- State and EPA Rules
- IPMVP activities
- Future Trends

Real Options: Theory and Application

Implications –

- Options always have some value – not negative
- Actuarial Approach will allow expansion of concept
  - ✓ Database of projects
- Fungible projects – tradable

Trading

- Trading Platforms
  - ✓ Partnering with federal, state, private sector, and international organizations
- Modeling Resources
  - ✓ Quant Shops
  - ✓ Brokerage Houses
  - ✓ Build your own trade

本土化「量測與驗證（M&V）」技術文件

- 美國能源部（DOE）的聯邦能源管理計畫（FEMP）中，制定了許多節能績效量測與驗證的參考文件。
- 因應國內推動節能績效量測與驗證機制之需要，摘錄部分參考文件翻譯及撰寫，建立符合國內應用之節能績效量測與驗證參考程序與方法。
- 提供給國內執行節能績效保證專案（ESPC）的業主及ESCO業者，做為節能績效量測與驗證的參考文件。

本土化「量測與驗證（M&V）」技術文件

A. **M&V選項總覽**：介紹4種M&V方法的綱要

B. **撰寫量測與驗證計畫綱要**：描述撰寫”量測與驗證計畫”的內容大綱，介紹量測與驗證需蒐集及準備的文件及程序

C. **M&V安裝改善後報告**：描述執行節能績效保證專案後，量測與驗證節能效益，需蒐集及準備的文件及程序

D. **M&V年度報告**：描述執行節能績效保證專案後，每個年度的量測與驗證節能效益，需蒐集及準備的文件及程序

本土化「量測與驗證（M&V）」技術文件

E. **M&V方法-選項A說明範例**：描述量測與驗證方法-選項A詳細的執行程序，包含有照明改善、更換高效率馬達、冰水主機汰換及變速控制等節能改善的量測與驗證方法及程序

F. **M&V方法-選項B說明範例**：描述量測與驗證方法-選項B詳細的執行程序，包含有照明改善、更換高效率馬達、冰水主機汰換及變速控制等節能改善的量測與驗證方法及程序

G. **M&V方法-選項C說明範例**：描述量測與驗證方法-選項C詳細的執行程序，包含有利用迴歸法公用事業帳目分析、公用事業比較法(綜合能源會計討論結果)等節能改善的量測與驗證方法及程序

本土化「量測與驗證（M&V）」技術文件

H. **M&V方法-選項D**說明範例：描述量測與驗證方法-選項D詳細的執行程序，包含有電腦模擬軟體之分析應用、模組校準的步驟等節能改善的量測與驗證方法及程序

Efficiency Valuation_protocol

- Protocols
  - **IPMVP** - International Performance Measurement and Verification Protocol
  - **IEEFP** - International Energy Efficiency Finance Protocol
  - **IPEP** - International Program Evaluation Protocol

Efficiency Valuation_physical

- **IPMVP** -
  - ✓ Measurements (and stipulations) of physical factors.
  - ✓ Global standard for creating savings quantification plans
  - ✓ Revision underway. Due Early 2006
  - ✓ CMVP certification program
  - ✓ Several thousand downloads/year

Efficiency Valuation_financial

- **IEEFP** - Int. Energy Efficiency Finance Protocol
  - ✓ *New Initiative*
  - ✓ Concept from UN Foundation / Energy Futures Coalition
  - ✓ Create standard financing terminology and applications
  - ✓ Requires IPMVP
  - ✓ Umbrella document, plus specific efforts in Europe, South Asia and South

Efficiency Valuation_financial

International Energy Efficiency *Financing* Protocol

- a "blue print" for financiers of energy efficiency projects;
- a focus on the value of savings for loan repayment and credit capacity;
- guidance on procedures for evaluating and assessing benefits and risks of energy efficiency projects;
- minimum criteria for energy efficiency project lending and use of "proven" technologies; and
- generic terms and conditions for various agreements (Loan, Security, ESCO, Construction, etc.)

Efficiency Valuation_programs

- **IPEP** - Int. Program Evaluation Protocol
  - ✓ *New Initiative*
  - ✓ Requires IPMVP
  - ✓ Applies to large programs
  - ✓ Umbrella document, plus specific efforts in Europe, California

Efficiency Valuation_regional

- European (EU) Working Group
  - ✓ Focus on EU issues
    - Emissions trading, white credits, other
    - Member Country Targets
- South Asian Working Group (?)
  - ✓ PCRA
  - ✓ India Green Buildings Program
  - ✓ Asian ESCO conference 10/05
- Taiwan Green Productivity Foundation

Efficiency Valuation_research

- Generic Energy Asset Risk Simulation (**GEARS**)
  - ✓ Model value and risk of efficiency investments
  - ✓ Explicit accounting of value, risk and responsibility in efficiency programs and contracts

Efficiency Valuation_skills

- ***Requires the full range of skills/services***
- Forecasting
  - ✓ Audits
  - ✓ Models
- Metering and Monitoring
  - ✓ Hardware
  - ✓ Energy Information Systems
- Analysis -
- Settlement -

能 源 服 務

設備與系統TAB

能 源 服 務

設備與系統效益計算與模擬

程式應用

M&V Programs

- 設備單體元件
  - ✓ Chiller/HP
  - ✓ Fan
  - ✓ Pump
  - ✓ Process Equip.
  - ✓ …
- 整合系統
- 整合SOP與熱性能分析

Energy Analysis Programs

- 設備單體元件性能
  - ✓ Chiller/HP
  - ✓ Fan/Pump
  - ✓ HX
  - ✓ Process Equip.
  - ✓ …
- 整合系統性能
- 系統最佳化
- 線上控制/自修正控制