Measurement & Verification – LEED EA Credit 5 Requirements

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Providing Technical & Business Solutions

Presented To:

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LEED

BCxA Building Commissioning Association

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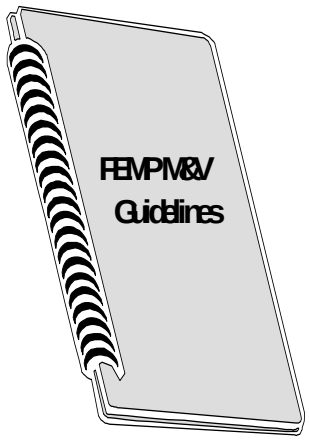
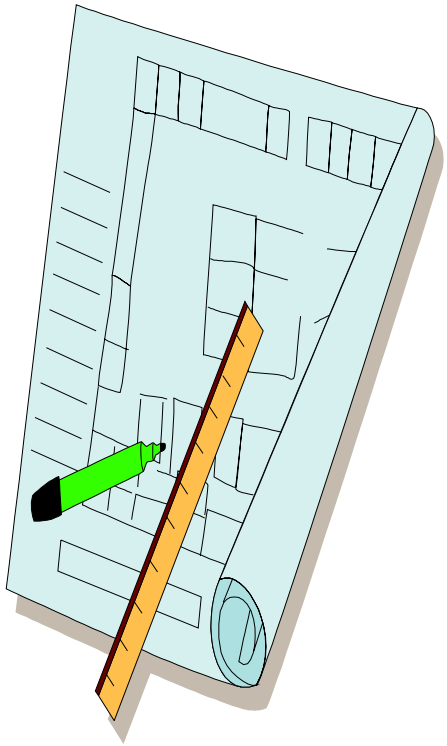
Learning Objectives



- Learn the fundamentals of measurement and verification (M & V) for energy and water conservation projects
- Recognize the four M & V methodologies described under the International Performance Measurement & Verification Protocol (IPMVP)
- Grasp guidelines for meeting the requirements of LEED Energy and Atmosphere Credit 5

Overview of Presentation

- Objectives of Performance Measurement and Verification
- Overview of IPMVP Measurement & Verification Options
- Examples of When Application of Option A is Suitable
- Example Applications of Option B
- Examples of When Application of Option C is suitable
- Comments On Option D
- Combining Option B and Option D
- Role of Commissioning in the M & V Plan
- Development of a Measurement & Verification Plan
- Conclusions and Recommendations



Objectives of Performance Measurement and Verification

- Assure owners and the design team that what was planned would actually meet performance and economic objectives;
- Optimize operation of equipment and systems by fine-tuning energy efficiency measures to maximize savings;
- Meet contractual requirements in an Energy Saving Performance Contract (ESPC) arrangement;
- Enhance the effectiveness of green building and systems design by minimizing energy use.

LEED EA Credit 5 Requirements

- Develop and implement a measurement and verification plan consistent with IPMVP Option B or Option D;
- The M & V shall cover a period of no less than one year post-installation.

Overview of IPMVP M & V Options

- **Option A: Savings are calculated based on:**
  - **spot or short term measurement or metering, and engineering spread sheet calculations, or**
  - **manufacturer's catalogue, and engineering spread sheet calculations, or**
  - **un-calibrated computer simulation, with or without spot or short term measurement or metering.**

Sources of Stipulations

Option A | Option B | Option C | Option D

Acceptable

- Engineering analysis
- Spot measurement-based models
- Manufacturer's data
- Standard tables
- TMY or TRY weather
- ANSI/ARI/ASHRAE
- Actual facility logs

Unacceptable

- Undocumented assumptions
- Proprietary algorithms
- Unsupported handshake agreements
- Guesses at parameters
- Models based on questionable data
- Other buildings (w/ some exceptions)

Overview of IPMVP M & V Options (Cont.)

- **Option B: Savings are based on:**

- **Actual metering of operating hours of lighting and constant load motors,**
- **Spot metering of lighting circuits and of constant load motor kW,**
- **Continuous long term metering of variable load motor kW and related controlled variables, and**
- **Continuous long term metering of heating and cooling plants, including chillers and boilers.**

Overview of IPMVP M & V Options (Cont.)

- **Option C: Savings are determined based on:**

- **building metered utility energy consumption, including natural gas, district steam or high temperature hot water, district chilled water, and electricity; and**

- **multivariate regression analysis is performed to correct for variations in pertinent variables that affect energy consumption, such as weather, operating hours, occupancy patterns, and industrial production level.**

Overview of IPMVP M & V Options (Cont.)

- **Option D; Savings are determined based on:**

- **measured equipment and system performance,**

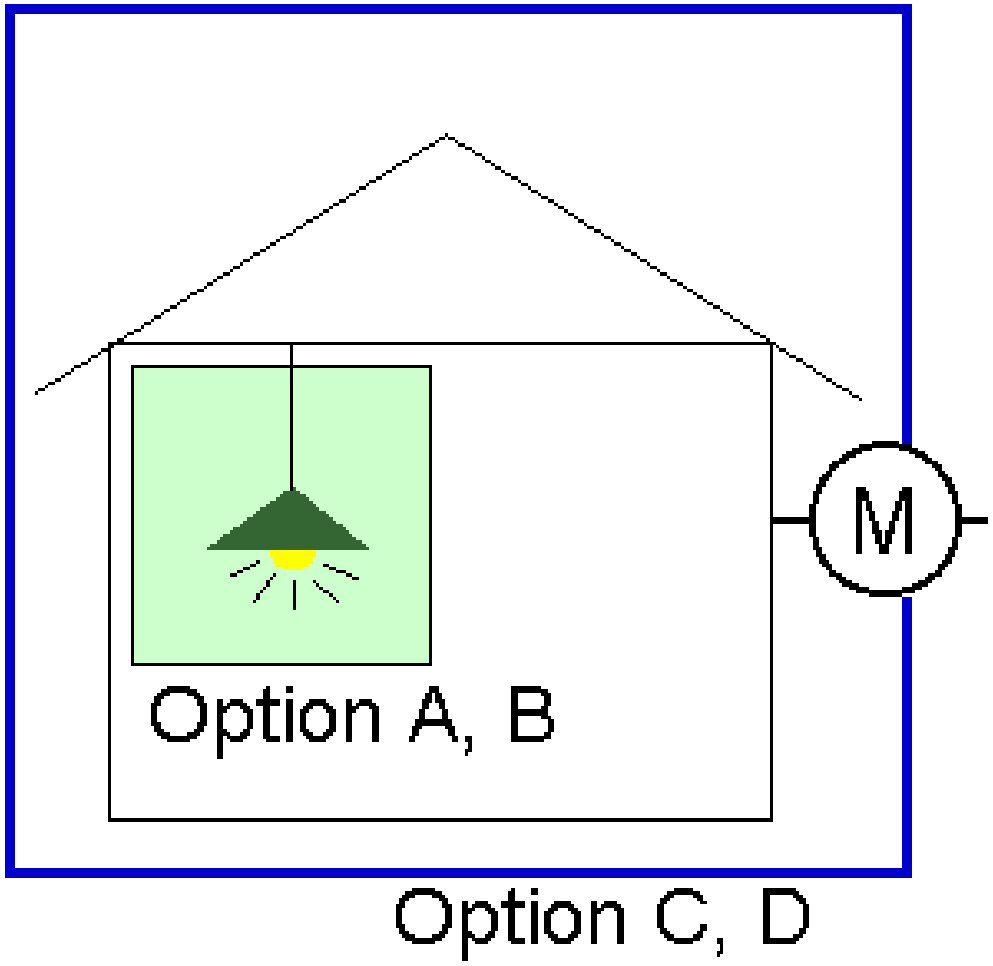
- **calibrated energy analysis computer simulation model of the building as a whole or of a sub-metered area of the building;**

- **calibration of the computer simulation model is performed on the basis of rigorous comparison:**

  - **between predicted and actual measured system and equipment performance, and**

  - **between simulated and actual metered energy consumption.**

Options A and B vs. Options C and D



Options A and B are retrofit-isolation methods

Options C and D are whole-facility methods

The difference is where the boundary lines are drawn

Example Application of Option A

Lighting Fixture Upgrade in Private Offices:

- **Savings are stipulated by spot checking fixture wattage of a sample of lighting fixtures, before- and post-installation, and**
- **Estimating number of on-time hours based on field survey;**
- **for new construction, post-installation is compared to ASHRAE 90.1 maximum lighting power density for type of occupancy;**
- **Illumination levels (foot-candles) are spot checked to ensure they have not been adversely affected.**

Example Application of Option A (cont.)

Re-insulation of Overhead Steam Piping:

- **Savings are calculated using surface temperature measurement at selected locations, before- and after- installation,**
- **rigorous heat transfer analysis is used to predict pipe heat loss reduction and annual energy savings;**
- **the set of on-site measurements are repeated periodically (e.g., once every three months);**
- **wind conditions, outside air temperature, and test locations are recorded.**

Example Application of Option B

Lighting Fixture and Control Upgrade in Open Offices:

- **Multi-channel programmable control panel with on-time data logging feature is used for switching area lighting;**
- **Fixture wattage of a sample of lighting fixtures is spot checked, before- and post-installation,**
- **Numbers of on-time hours are obtained from the programmable controller and used in calculating energy savings.**

Example Application of Option B (Cont.)

Replacement of Constant Load Motors:

- **Savings resulting from replacement of constant load standard efficiency motors with high efficiency motors are calculated using short term metering of power draw (kW) of all or a sample of motors to be replaced, before- and after- installation; and**

- **the building automation system is used to obtain run-time hours of individual motors.**

Example Application of Option B (Cont.)

Conversion of Constant Volume Systems to Quasi-VAV:

- **Quasi-VAV: Variable speed drive is operated at a reduced speed during unoccupied hours;**
- **Savings from conversion of constant volume systems to Quasi-VAV is calculated by on-line monitoring of power (kW) draw of variable frequency drive, and**
- **comparison of post-installation data with baseline data before installation of ECM; and**
- **Obtaining number of hours at reduced speed from the building automation system.**

Suitable Applications of Option C

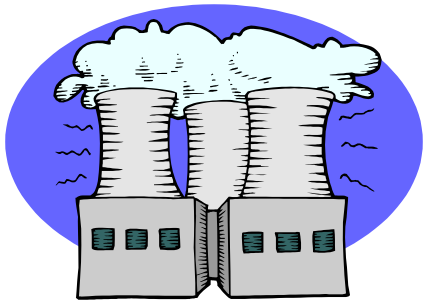
1. If it is anticipated that Energy Conservation Measure (ECM) will likely result in more than 20% energy saving;
2. If calculations do not necessitate developing a comprehensive building energy simulation model;
3. Sites where at least twelve (preferably 24) months worth of pre-installation metered consumption data are available;
4. Sites where a correlation between metered utility data and a set of variables that affect energy consumption, have been established with high degree of confidence;
5. The correlation can be modeled as a multi-variable regression equation with a high R^2 value.

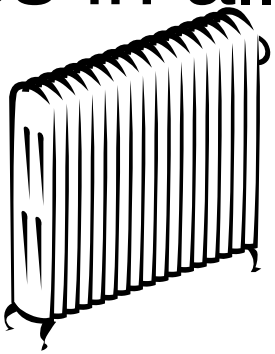
Heating Project w/ Option C

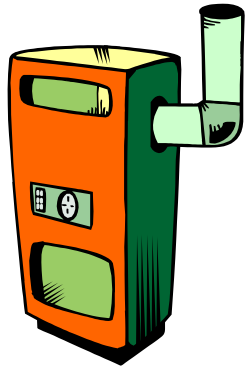
Option A	Option B	**Option C**	Option D

Consider heating system upgrade in a building within a complex

- Baseline: Gas-fired boilers with central steam plant provide heat to buildings
- New System: Shut down steam plant, install gas furnaces in all buildings







Option C Programs

Option A | Option B | **Option C** | Option D

- EnergyCAP, FASER (discontinued)

  Good Steward Software

  http://www.goodstewardsoftware.com/
- EEM Suite

  Silicon Energy http://www.siliconenergy.com
- EZ Sim

  Stellar Process http://ezsim.com
- Metrix, Utility Manager Pro 4.0

  Abraxas Energy Consulting

  http://www.abraxasenergy.com/products.php

  Optimum Energy Products Ltd

  http://www.optimumenergy.com/software/

This list is not complete. Listing here does not imply endorsement.

Comments on Option D

- **Option D can be the most cost effective method to implement a measurement and verification plan;**
- **A comprehensive and accurate hourly energy simulation model can be feasibly developed, using proven public domain programs;**

Comments on Option D (Cont.)

- **New high efficiency electrical equipment, such as variable frequency drives and chillers, can be bought, at relatively small incremental cost, with energy monitoring features, to allow continual monitoring of power draw (kW), amperage, voltage, power factor, and motor speed;**
- **The building automation system can be readily utilized to continually monitor variables that affect energy use; these variables include liquid and air static pressure, supply air flow rate, water flow rate, supply and mixed air temperature, and valve and damper positions.**

Steps to Combine Option B and Option D

1. Develop a comprehensive hourly energy simulation model;
2. Specify major electrical equipment to have power monitoring capability; control system should allow for trend logging of electrical consumption, motor speed, and related variables;
3. Specify, in the M & V plan, how system predicted performance will be validated against actual measured data, post-installation;
4. Provide for water and air flow measuring stations for measuring heating and cooling loads of individual systems;

Combining Options B and D (Cont.)

5. Provide for on-line monitoring of energy produced by the heating and cooling plants;
6. Implement procedure to validate predicted performance over time against actual measured performance;
7. Go back and modify equipment performance curves originally used in the simulation, to be consistent with actual equipment performance derived from on-line measurement;
8. Re-run the model and compare simulated energy consumption with actual metered energy consumption;
9. Reconcile major differences, pin-point their causes, and modify the simulation model according to the findings derived from the comparison.

Role of Commissioning in the M &V Plan

- **Conceptual design should be commissioned to ensure it has been truly optimized;**
- **Preferably, development and evaluation of conceptual design and energy conservation measures, and development of a comprehensive energy simulation model should constitute the first step in the commissioning process;**

Role of Commissioning in the M &V Plan (Cont.)

- **Design phase commissioning should ensure that energy performance can be thoroughly verified;**
- **Controls sequence of operation should be clearly defined and the plan should delineate how the sequence should be verified;**
- **Commissioning authority (CA) should oversee that comprehensive documentation is being provided for maintenance and operation of energy conservation measures (ECM);**
- **CA should oversee training of operating staff on how to continually verify and optimize system performance.**

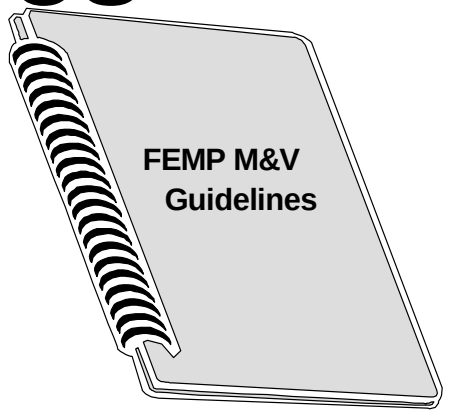
Development of a Measurement & Verification Plan

- **M & V plan should cover at least one year of stable operation post-installation;**
- **Estimate resources required for analysis of measured and metered data and for calibration of energy simulation model;**
- **Validation scheduling should allow for testing at least once every three months within the first year;**
- **Identify factors likely to affect significant variations between actual system performance and energy consumption and predicted system performance and simulated energy consumption;**
- **Inspect operating conditions that may affect model calibration.**

Conclusions and Recommendations

1. **Measurement and verification using Option B coupled with Option D is the most cost effective method for validating HVAC and lighting energy conservation projects;**
2. **Efficient use of resources for accurate and comprehensive energy modeling of the building will be cost effective in the long run;**
3. **Selection of hardware with M & V enhancing features will likely be cost effective (e.g., chillers, VFD, programmable lighting panels);**
4. **In some cases, option A is your only option;**
5. **Careful planning and diligent effort are necessary to establish a valid baseline before retrofits are implemented;**
6. **Be mindful of the resources required for M & V activities during the warranty phase of the project;**
7. **Going forward, M & V will substantially enhance the cause of sustainability and green building design; most often, what is good for the environment is also good for the pocket book.**

FEMP M&V Guidelines



- Derived from IPMVP
- For federal energy projects
- Step-by-step procedural guide
- Defines M&V methods by project type
- Available at

  http://www.eere.energy.gov/femp/financing/superespcs_mvresources.cfm

  http://ateam.lbl.gov/mv/

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THANK YOU

This concludes the ASHRAE & AIA
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Please go to the website for the course evaluation
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Questions or Comments??

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