California Commissioning Collaborative

# Guidelines for Verifying Savings from Commissioning Existing Buildings

## Overview and Method Selection

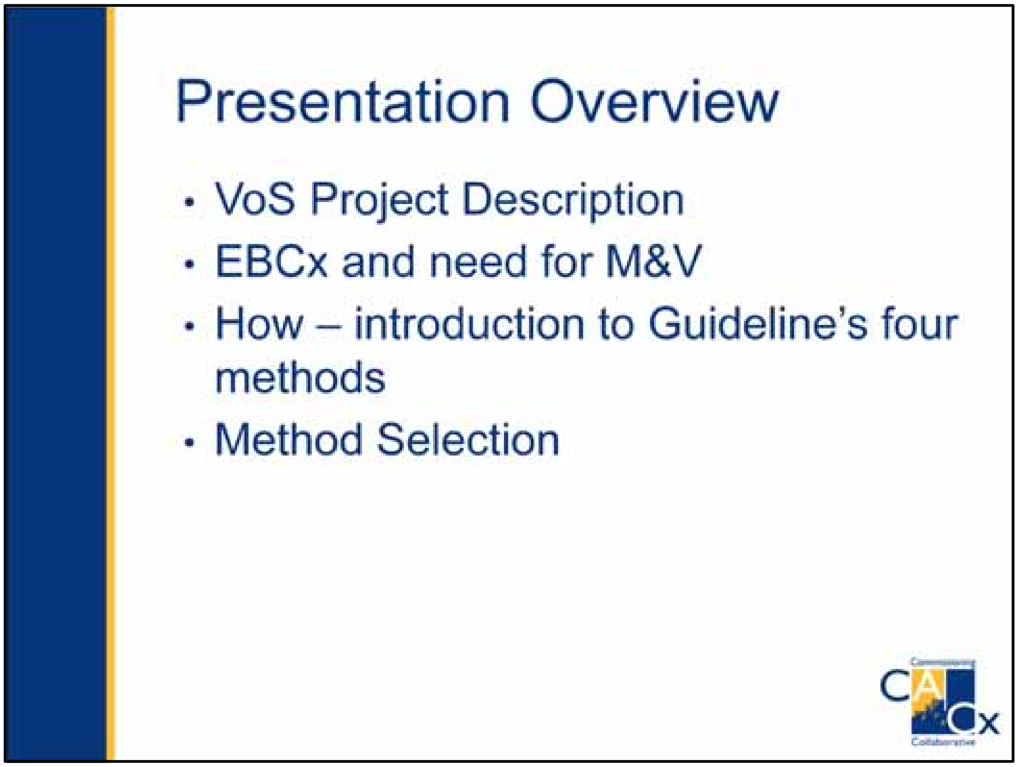
David Jump, Ph.D., P.E.

August 30, 2012

# Welcome!

Web-Meeting Notes

- All participant lines are muted
- Please submit questions via the Chat feature to Host
  - Find the Chat button at the top center of your screen (menu will expand down when hovered over)




This presentation covers the first 3 chapters of the VoS guidelines

It reviews the need for savings verification in EBCx projects

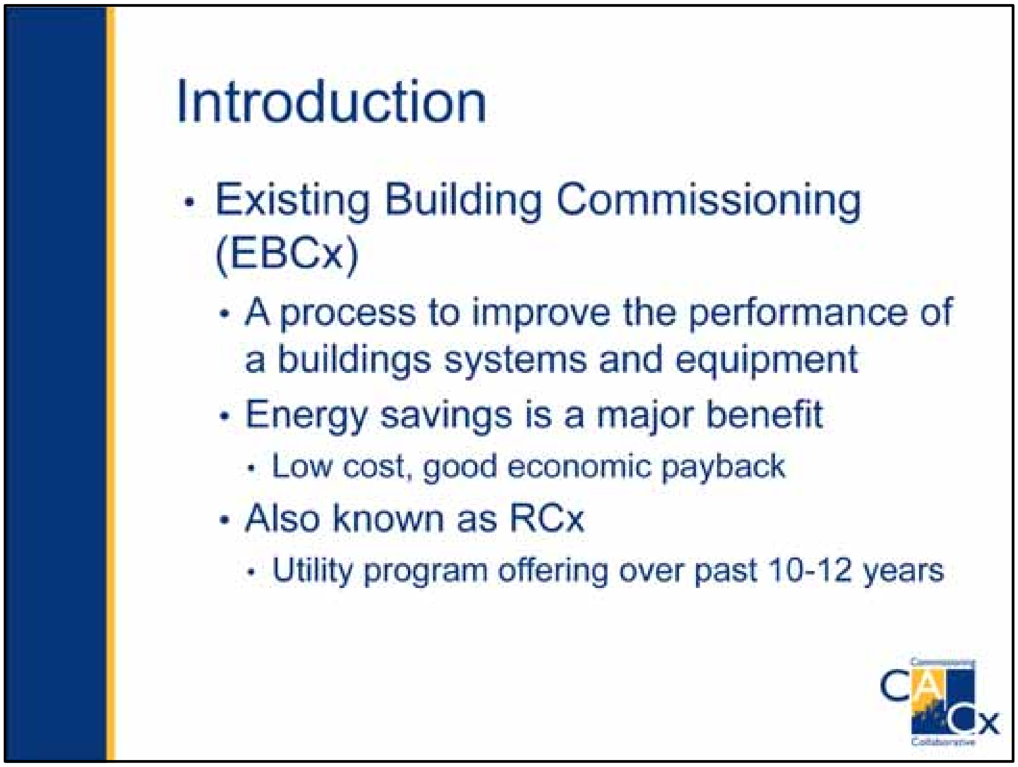
It compares the EBCx and M&V processes and shows how they can be integrated

The four methods are briefly described

A framework for evaluating the verification methods is described

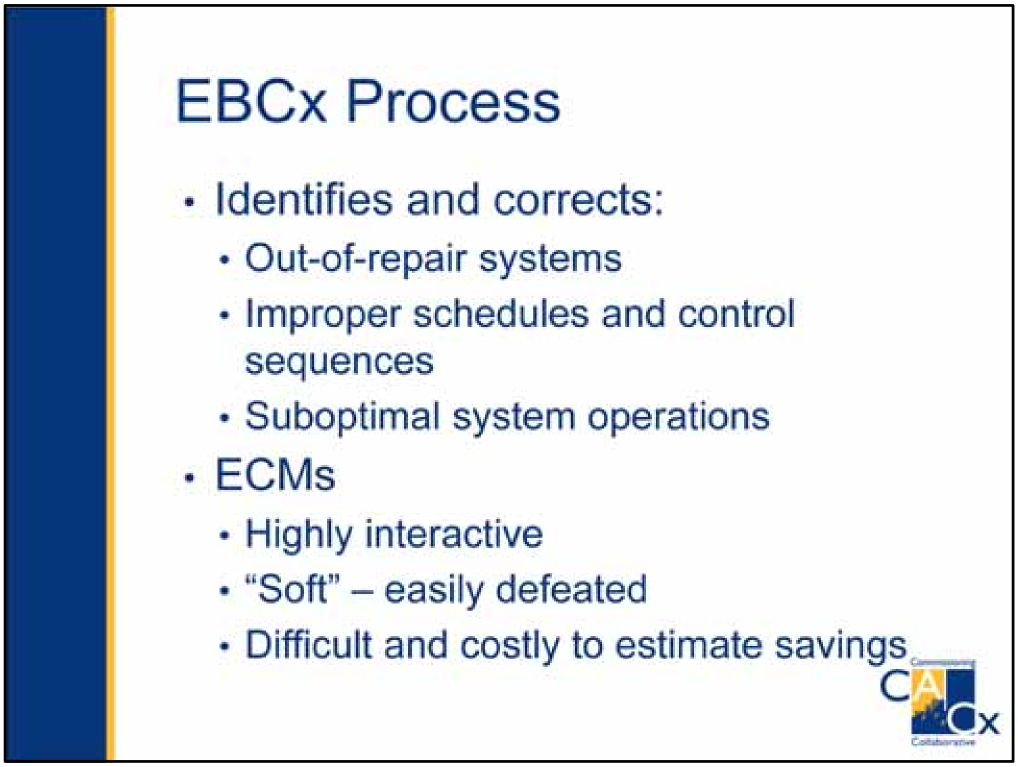

There was an initial CCC project completed in 2008 in which stakeholders were surveyed, and current methods were identified. An evaluation framework was developed to help assess the merits of these methods. Reports are available on the CCC website.  This project recognized that there were various methods to verify savings, but determined to produce a guideline describing a Option C Whole Building / Option B Retrofit Isolation method based on developing regression-based energy models.  This guideline was updated for this project (Method 3).

Pilot demonstrations are for Method 3. Energy modeling method.




Most EBCx projects are performed with a goal to improve systems operations without investing in capital-intensive equipment replacements and retrofits. The goal is energy savings.

EBCx is also used to improve building comfort, indoor air quality, and system reliability, but these goals are not addressed here.



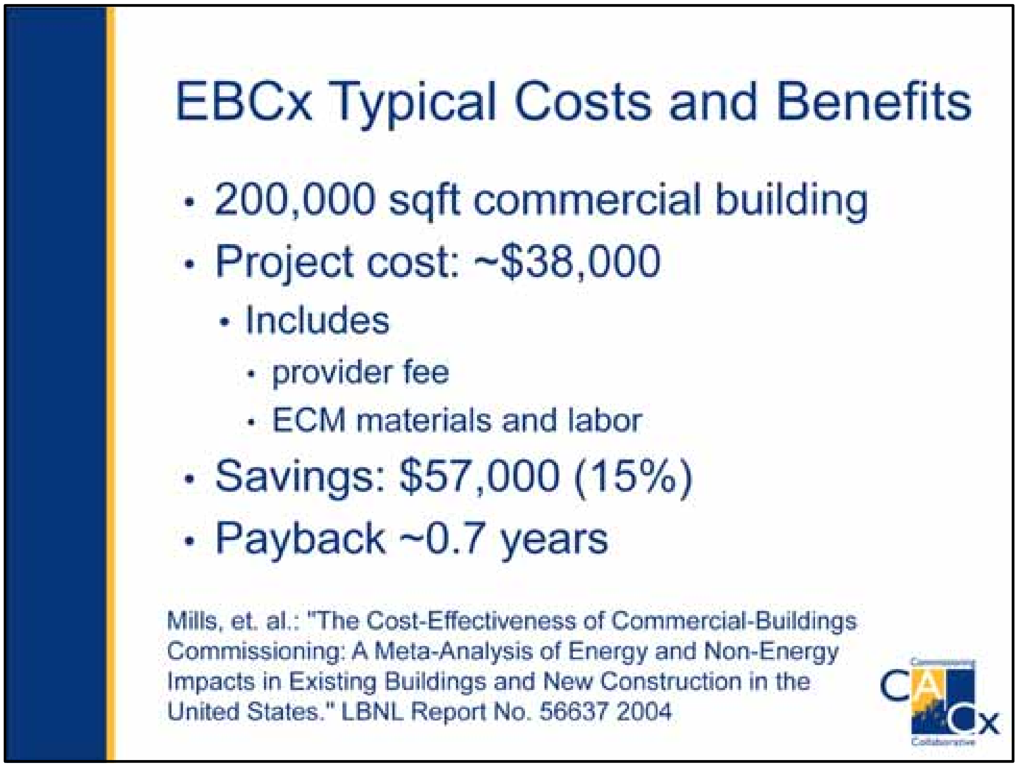

The main point here about the nature of the energy savings in building systems from EBCx is that the 'findings' or ECMs are highly interactive – ECMs implemented in one system may generate savings in another system, or ECMs indirectly affect energy using systems within a building.

For example, a repair to a building economizer saves energy at the chiller, not necessarily at the air handler where it is located.

Many ECMs are improvements controls systems sequences of operations. Often these can be as quickly removed as they are installed.

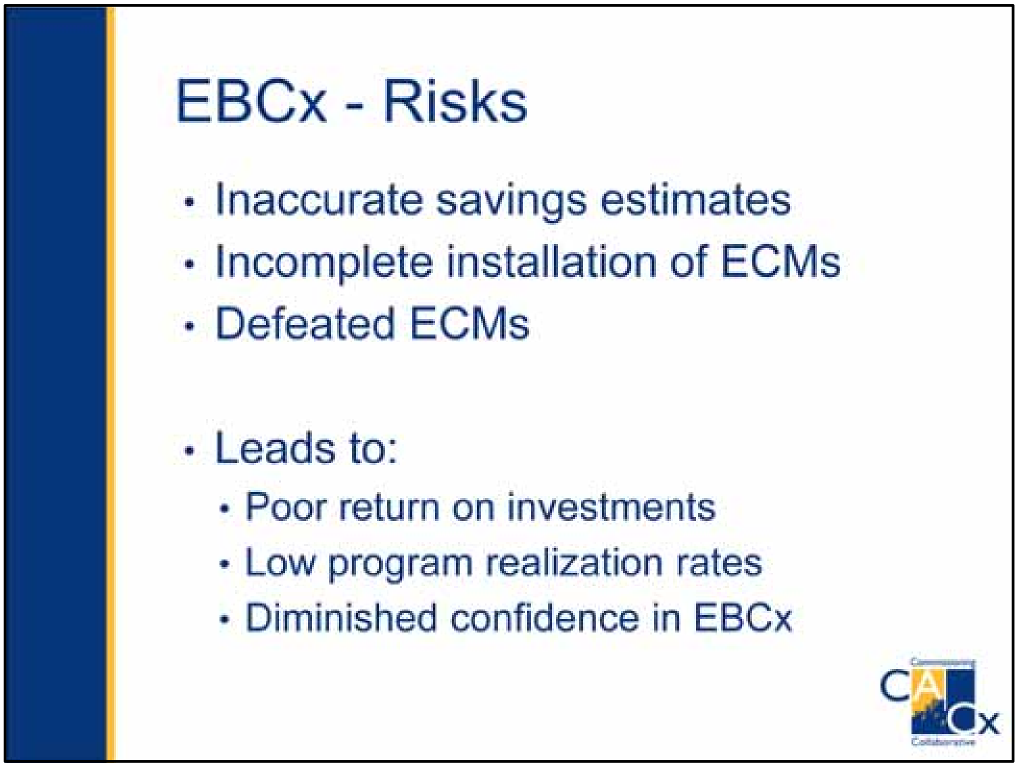
It is not uncommon if settings are too aggressive and cause problems in other places – rather than being dialed back, they are switched off.

ECM savings are difficult to quantify – they require data and analysis for good estimations, project resources may not always support this.




While EBCx projects have good economic benefits, they may cost a lot up front.

They may be susceptible to poor follow-through when measures are not implemented, or not implemented correctly. This can strand much needed funds, and yield poor returns on investments




A few years ago, for the 2006-08 program cycles in CA, some RCx programs were determined through evaluation to generate only 60% realization rates.

Review of these evaluations showed that savings estimates were poor, ECMs were not installed consistently with savings estimates, and ECMs were easily defeated.

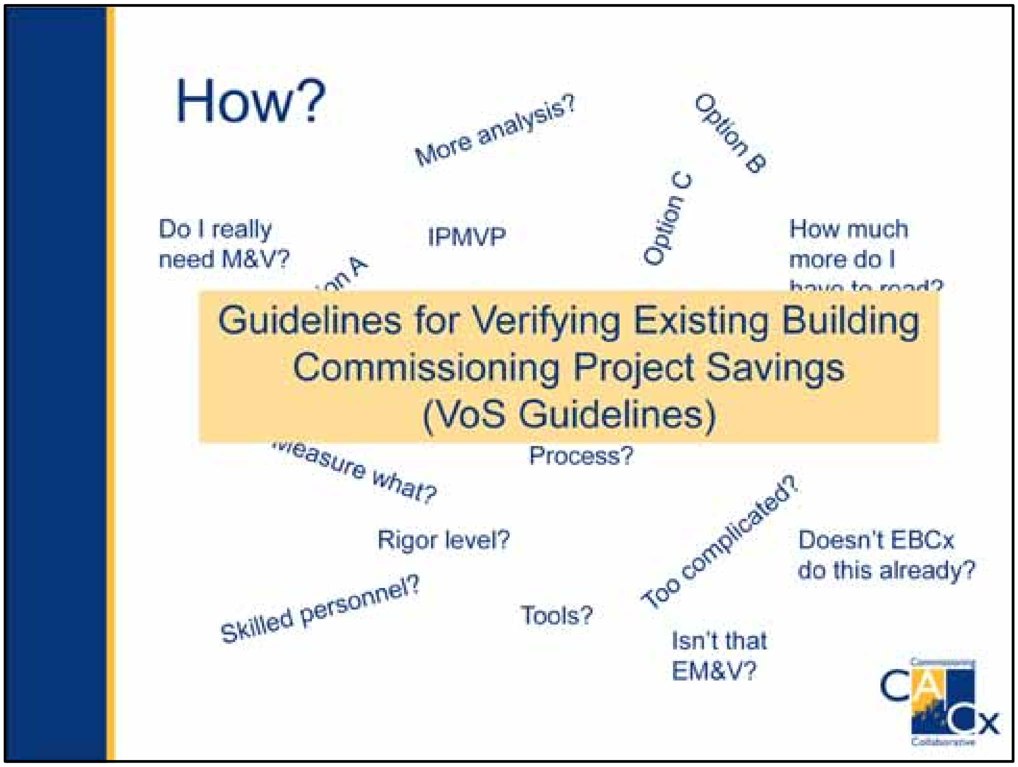
It was noted however, that projects with high realization rates were projects with good definition of baselines supported by data, and had good analysis of savings supported with post-implementation data.

Programs that included these practices generally had much more acceptable overall realization rates.


In response, the California Energy Commission sponsored the CCC on this project to develop methods for verifying savings in EBCx projects.

Proper verification of savings mitigates the savings risks described earlier.

Verification can also promote savings persistence




M&V has different meanings to different people. Part of the problem is the industry standard guideline, IPMVP, is not specific in describing adherent methodologies.

Service providers, utilities, and project sponsors are left on their own to develop proper verification methods. Given constraints on project budgets and available resources, conducting a fully adherent method is not always possible.

The VoS Guideline describes practical methods and best practices to implement verification methods in EBCx projects.

# Guidelines Purpose

- Properly prepare for M&V
- Select appropriate method
- Integrate with EBCx process
- Minimize M&V costs
- Verify return on investment
- Promote standardization

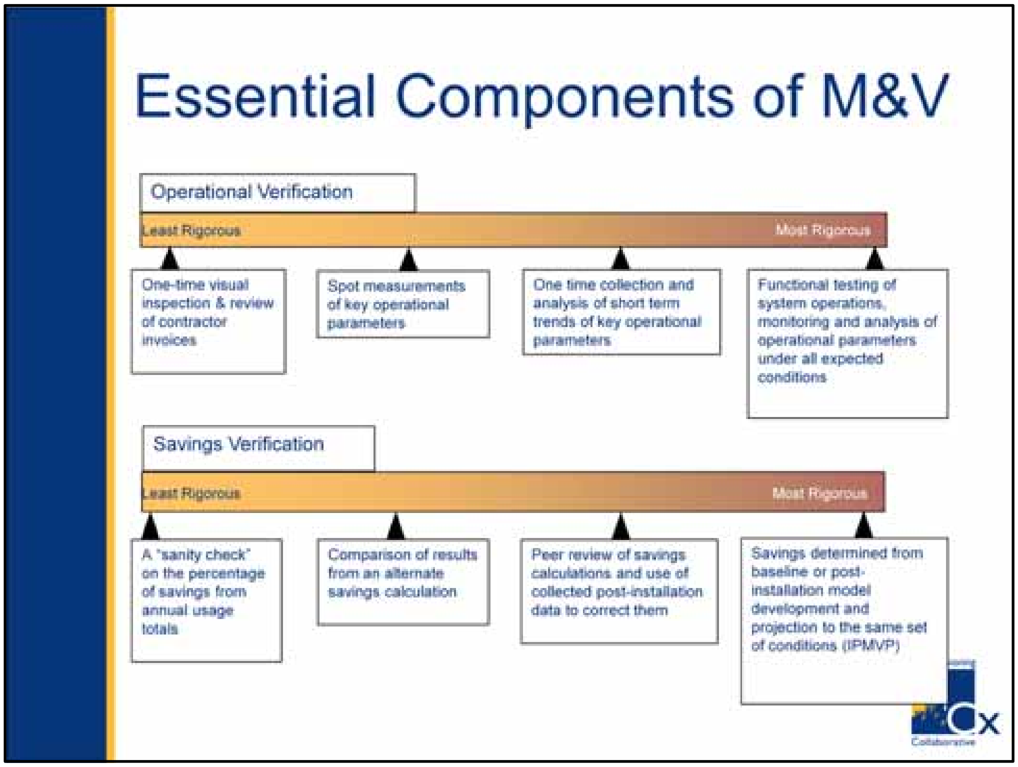
# Purpose, continued

- Define technical requirements
- Define common terminology
- Identify useful tools
- Provide examples

## Common Verification Practices

- Sanity check
- Alternate savings calculations
- Peer review
- Engineering estimates corrected with post-install data
- Measurement & Verification

Methods described in this guideline

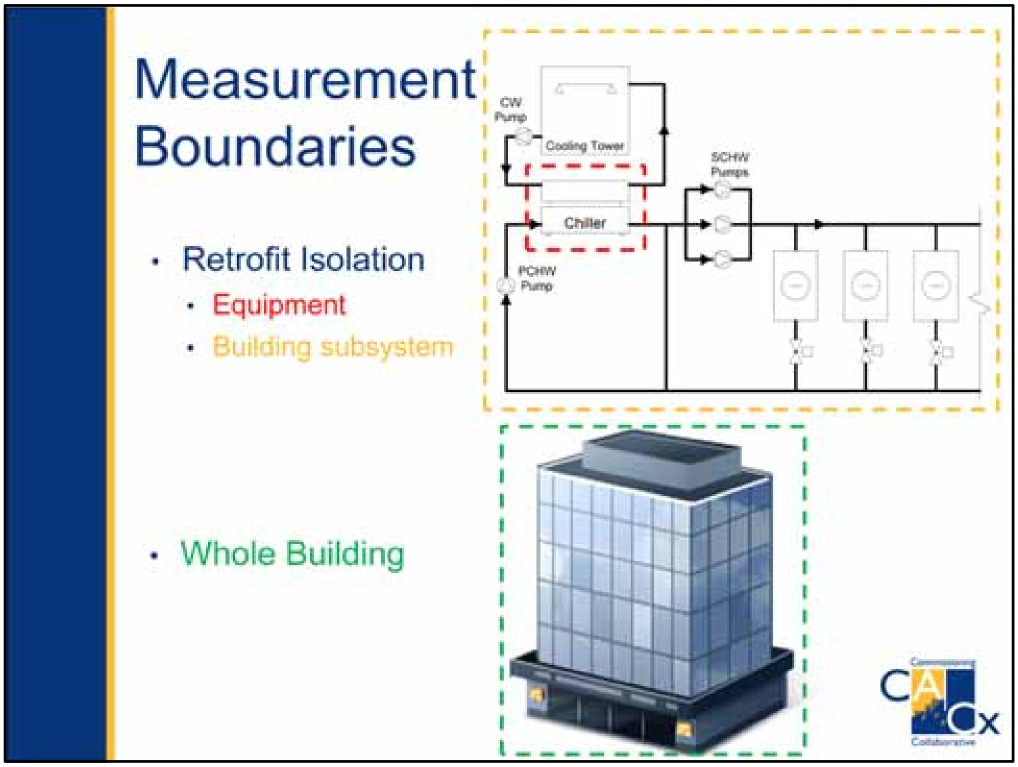



There are two key components of M&V: operational verification and savings verification.

Understanding these elements helps to understand how EBCx and M&V are related

Operational verification: verifies an ECM's *potential to generate savings* . It can be applied with various levels of rigor, as the chart shows.

Savings verification: *accounts* for the amount of savings actually achieved. It may also be applied with increasing levels of rigor, with the most rigorous methods being adherent with IPMVP principles.




The guideline's methods may be applied to specific measurement boundaries. Generally these boundaries are drawn around a specific piece of equipment, a building subsystem, or the whole building.

A way to measure energy use of the components inside the measurement boundary must be determined. Often the measurement boundaries are determined by the availability of data sources.

## Method 1: Engineering Calculations & Field Verification

- Verifies individual ECM savings
- Applies to equipment or systems
- Mirrors industry practice
- Recommends best practices
- Describes use of post-installation operational verification in "truing up" savings estimates
- Not IPMVP adherent

# Method 1 Example

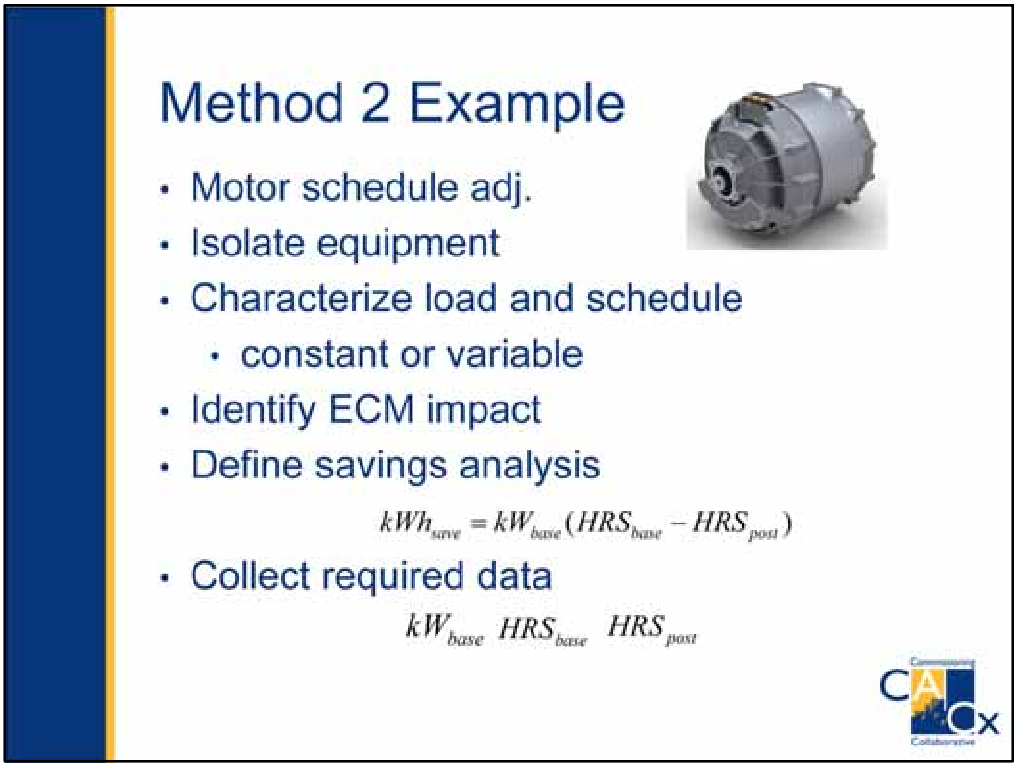
| A<br>Baseline Operation<br>w/ IGV | | | | | D<br>Proposed Operation<br>w/o IGV, w/ VFD High Limit & w/ VFD Modulation | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Air Volume Flow Rate Profile<br>% | Speed<br>% | IGV Power Ratio [Note 1]<br>% | Power<br>kW | Annual Energy Use<br>kWh/Yr | Air Volume Flow Rate Profile<br>% | Speed w/ VFD Modulation<br>% | VFD Power Ratio [Note 2]<br>% | Power w/ VFD Modulation<br>kW | Annual Energy Use<br>kWh/Yr |
| 100% | 100% | 109% | 12.8 | 51 | 100% | 89.3% | 71% | 9.1 | 36 |
| 98% | 100% | 105% | 12.3 | 74 | 98% | 87.6% | 68% | 8.4 | 50 |
| 96% | 100% | 102% | 12.0 | 96 | 96% | 85.9% | 64% | 7.7 | 62 |
| 94% | 100% | 99% | 11.6 | 267 | 94% | 84.2% | 63% | 7.3 | 168 |
| 92% | 100% | 96% | 11.3 | 362 | 92% | 82.6% | 60% | 6.8 | 218 |
| 91% | 100% | 93% | 10.9 | 436 | 91% | 80.9% | 57% | 6.2 | 248 |
| 89% | 100% | 90% | 10.6 | 244 | 89% | 79.2% | 56% | 5.9 | 136 |
| 87% | 100% | 87% | 10.2 | 602 | 87% | 77.5% | 53% | 5.4 | 319 |
| 85% | 100% | 85% | 10.0 | 750 | 85% | 75.8% | 50% | 5.0 | 375 |
| 83% | 100% | 84% | 9.9 | 782 | 83% | 74.1% | 49% | 4.9 | 387 |
| 81% | 100% | 83% | 9.7 | 1,358 | 81% | 72.5% | 46% | 4.5 | 630 |
| 79% | 100% | 81% | 9.5 | 1,055 | 79% | 70.8% | 44% | 4.2 | 466 |
| 77% | 100% | 80% | 9.4 | 808 | 77% | 69.1% | 43% | 4.0 | 344 |
| 75% | 100% | 78% | 9.2 | 1,003 | 75% | 67.4% | 40% | 3.7 | 403 |
| 74% | 100% | 77% | 9.0 | 801 | 74% | 65.7% | 38% | 3.4 | 303 |
| 72% | 100% | 76% | 8.9 | 454 | 72% | 64.0% | 37% | 3.3 | 168 |
| 70% | 100% | 74% | 8.7 | 835 | 70% | 62.3% | 34% | 3.0 | 288 |
| 68% | 100% | 73% | 8.6 | 774 | 68% | 60.7% | 32% | 2.8 | 252 |
| 66% | 100% | 73% | 8.6 | 697 | 66% | 59.0% | 30% | 2.6 | 211 |
| 64% | 100% | 71% | 8.3 | 1,212 | 64% | 57.3% | 28% | 2.3 | 336 |
| 62% | 100% | 70% | 8.2 | 869 | 62% | 55.6% | 26% | 2.1 | 223 |
| 60% | 100% | 69% | 8.1 | 1,013 | 60% | 53.9% | 24% | 1.9 | 238 |
| 58% | 100% | 68% | 8.0 | 1,048 | 58% | 52.2% | 23% | 1.8 | 236 |
| 57% | 100% | 67% | 7.9 | 840 | 57% | 50.5% | 21% | 1.7 | 202 |
| 55% | 100% | 66% | 7.8 | 562 | 55% | 48.9% | 19% | 1.5 | 108 |
| 53% | 100% | 65% | 7.6 | 1,284 | 53% | 47.2% | 19% | 1.4 | 237 |
| 51% | 100% | 65% | 7.6 | 958 | 51% | 45.5% | 17% | 1.3 | 164 |
| 50% | 100% | 65% | 7.6 | 1,041 | 50% | 44.7% | 16% | 1.2 | 164 |
| 50% | 100% | 65% | 7.6 | 1,487 | 50% | 44.7% | 16% | 1.2 | 232 |
| 50% | 100% | 65% | 7.6 | 631 | 50% | 44.7% | 16% | 1.2 | 100 |
| 50% | 100% | 65% | 7.6 | 509 | 50% | 44.7% | 16% | 1.2 | 80 |
| 50% | 100% | 65% | 7.6 | 456 | 50% | 44.7% | 16% | 1.2 | 72 |
| 50% | 100% | 65% | 7.6 | 319 | 50% | 44.7% | 16% | 1.2 | 50 |
| 50% | 100% | 65% | 7.6 | 152 | 50% | 44.7% | 16% | 1.2 | 24 |
| 50% | 100% | 65% | 7.6 | 122 | 50% | 44.7% | 16% | 1.2 | 19 |
| 50% | 100% | 65% | 7.6 | 122 | 50% | 44.7% | 16% | 1.2 | 19 |
| 50% | 100% | 65% | 7.6 | 84 | 50% | 44.7% | 16% | 1.2 | 13 |
| 50% | 100% | 65% | 7.6 | 122 | 50% | 44.7% | 16% | 1.2 | 19 |
| 50% | 100% | 65% | 7.6 | 23 | 50% | 44.7% | 16% | 1.2 | 4 |
| | | | 12.8 | 24,379 | | | | 9.1 | 7,603 |

Savings = 24,379 – 7,603 = 16,776 kWh annually

(?)

## Method 2: Equipment or System Energy Measurement

- Verifies individual ECM savings
- Applies to equipment or systems
- Methodology framework based on
  - Baseline load and schedule characteristics
    - constant or variable
  - Impact of ECM
  - Post-install load and schedule characteristics
- IPMVP adherent




Method 2 may be implemented in an Option A approach, or an Option B approach.

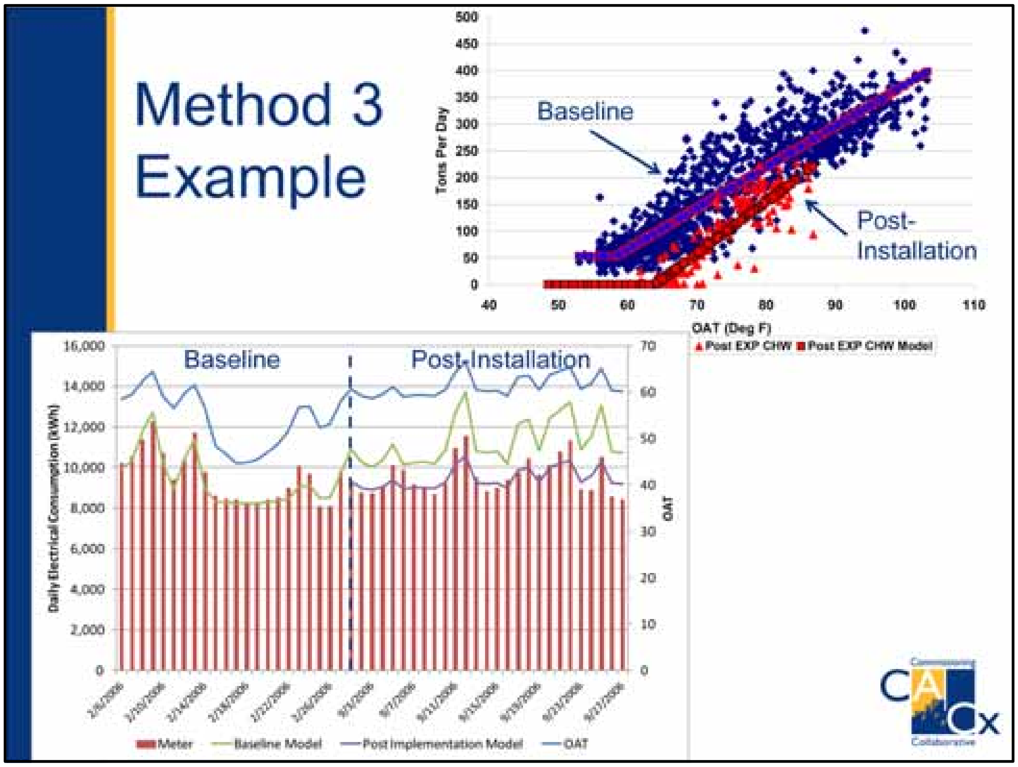
Under Option A, *key parameter measurement*, the key parameter in this example is the hours of operation, so a measurements of hours of operation  in baseline and post-installation are required.

The baseline kW may be estimated by one spot measurement, or use of the nameplate rating plus good load factor estimation.

Under Option B, all parameters must be measured, including baseline kW.

## Method 3: Energy Models using Interval Data

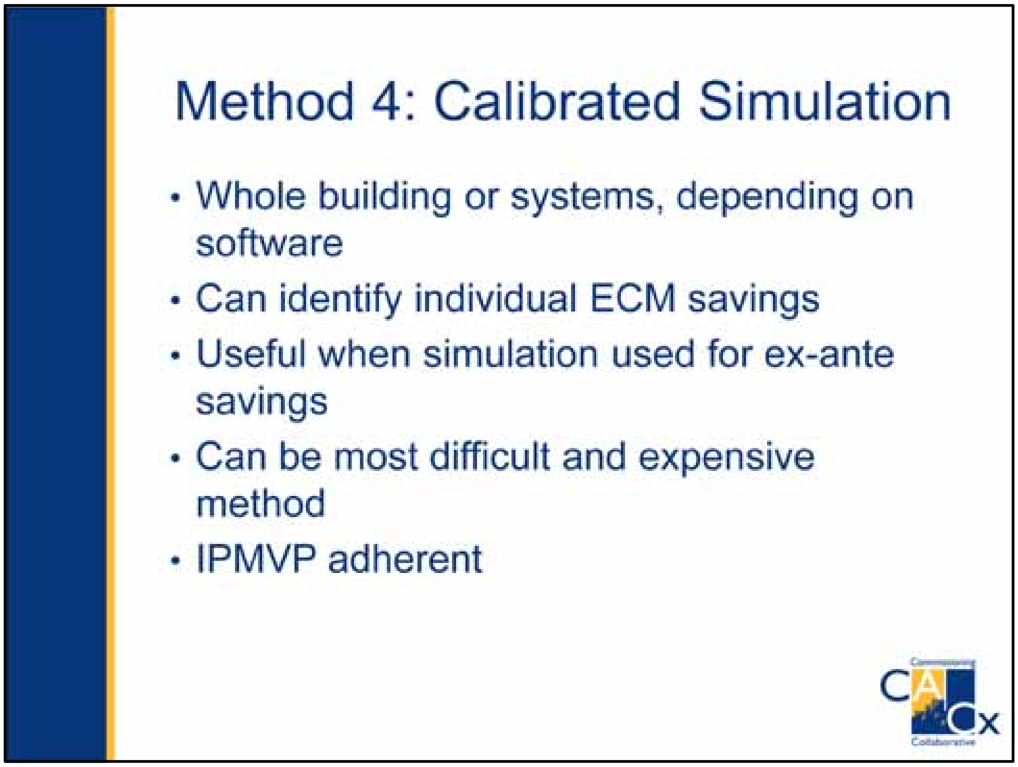
- Verifies system or whole building total savings
- Regression-based methodology
  - ASHRAE RP1050 change-point models
- Hourly or daily time intervals
- Improved based on feedback from pilots, previous guideline comments
- IPMVP adherent




The charts show the data collected and used to develop baseline and post-installation regression models.

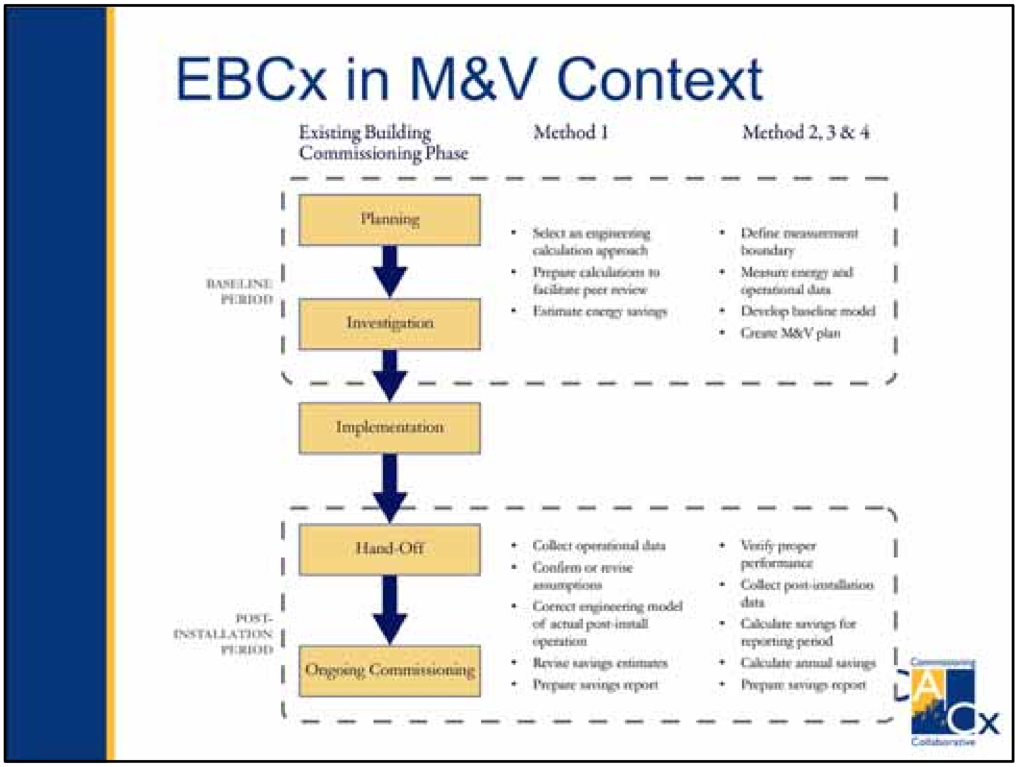
Baseline model may be 'adjusted' to post-installation energy use conditions to determine savings, or both baseline and post-installation models may be adjusted to other conditions (such as TMY weather conditions) to determine savings.

Both scatter charts and time-series charts are useful to show that savings is being realized.

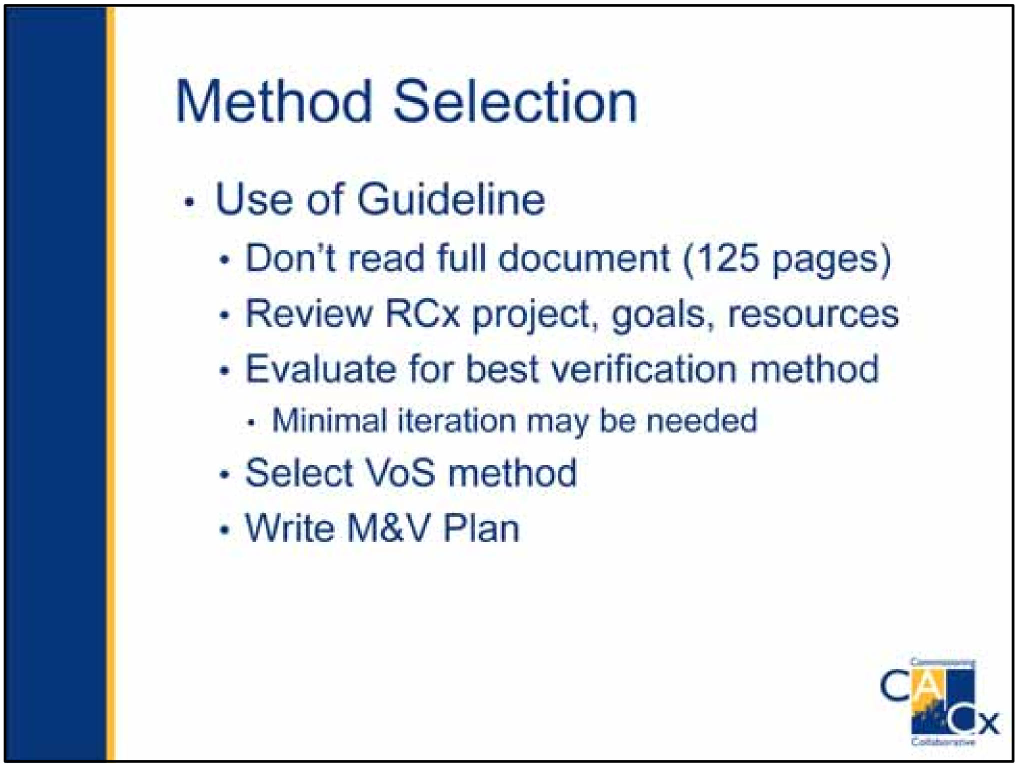



Calibrating a simulation model requires specialized skill and experience, requires much measured data, and requires that the simulation be able to model poor building operations well.

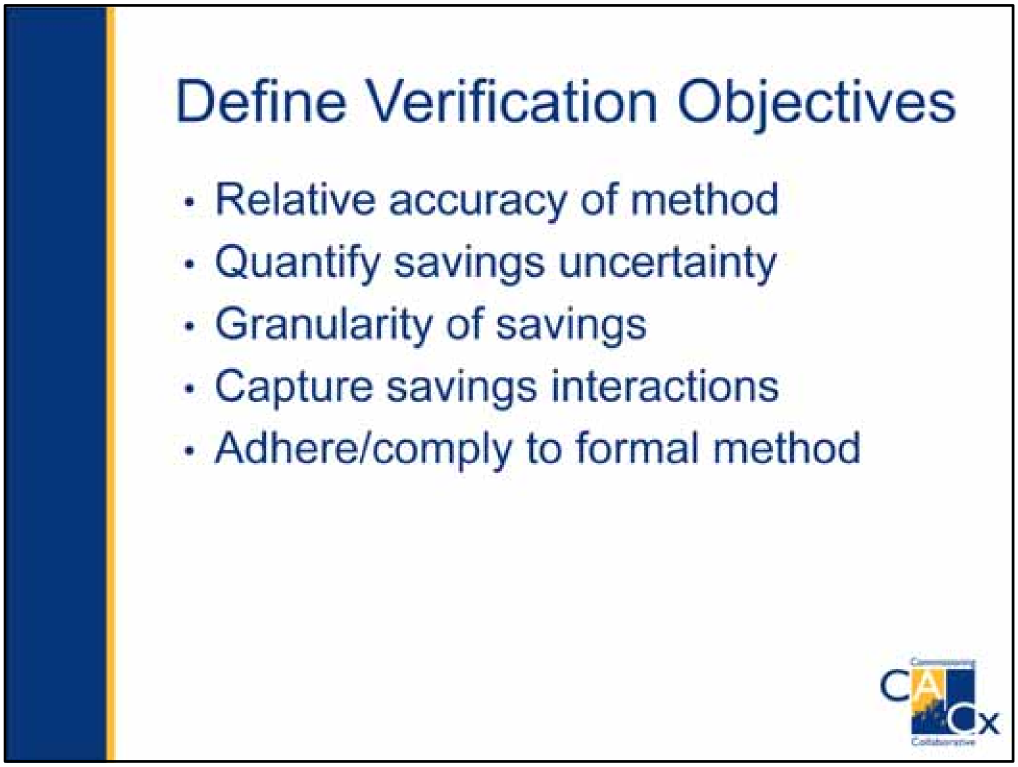
This method is highly technical and is only recommended for projects where an existing simulation is already in place, or where the service provider has the necessary skills and experience.




This chart shows how the EBCx process aligns with the M&V process, and when each of the activities of the individual methods are conducted.




We intended to provide enough information for readers to select the verification method when planning their EBCx project so that readers would only have to read about that particular method and not have to read the entire guideline before getting started.

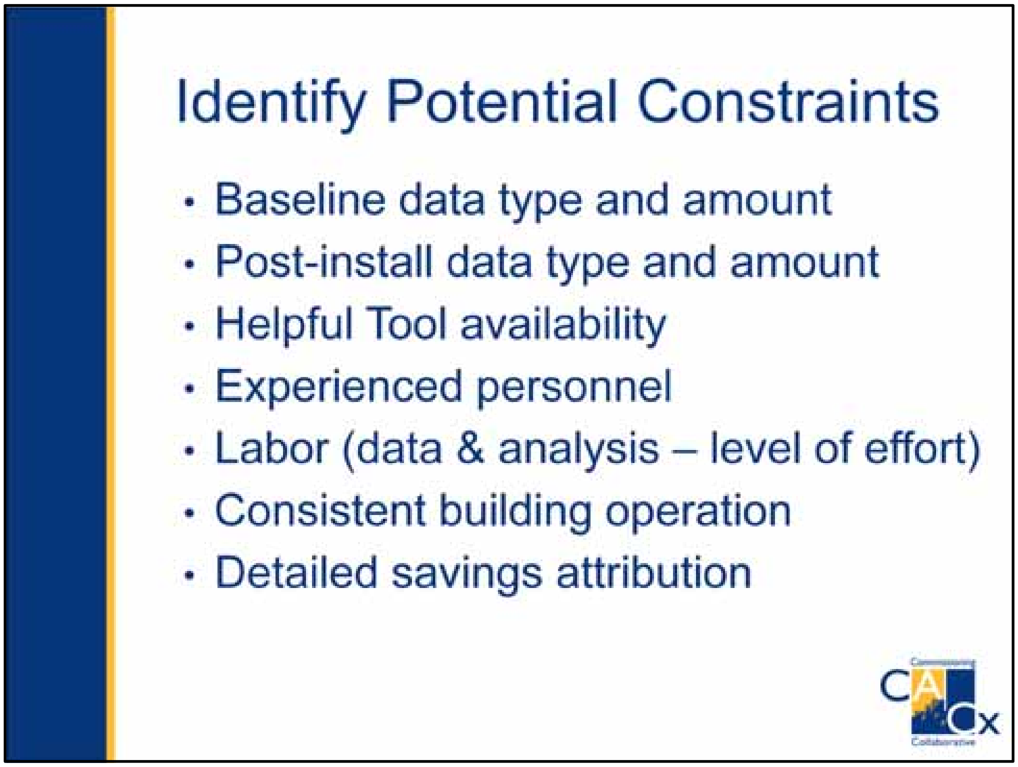



Define the verification objectives and match them up with what each method provides (see table).

# Evaluation Framework - Objectives

| Method | Sub-Method | Objectives | | | | | |
|---|---|---|---|---|---|---|---|
| | | Accuracy (1-5) 1 = Low 5 = High | Quantified Uncertainty (yes/no) | Granularity of Savings (whole building, system, measure) | Savings Interactions Captured (yes/no) | Persistence assurance (Repeat, continuous, no) | Formally accepted method (IPMVP, ASHRAE) |
| Method 1: Engineering Calcs with Field Verification | Engineering Calcs & Visual Verification | 1-3 | No | System<br>Measure | No | Repeat | No |
| | Engineering Calcs & Performance Verification | 2-4 | No | System<br>Measure | No | Repeat | No |
| Method 2: Equipment or End-use Energy Measurement | Key Parameter Measurement | 2-4 | No | System<br>Measure | No | Repeat | IPMVP - Option A |
| | All Parameter Measurement | 4 | Yes | System<br>Measure | No | Repeat | IPMVP - Option B<br>ASHRAE GL-14 |
| Method 3: Energy Models Using Interval Data | System Approach | 4-5 | Yes | System | No | Continuous | IPMVP - Option B<br>ASHRAE GL-14 |
| | Whole Building Approach | 4-5 | Yes | Whole building | Yes | Continuous | IPMVP - Option C<br>ASHRAE GL-14 |
| Method 4: Calibrated Simulation | System Approach | 4 | Yes | System<br>Measure | No | No | IPMVP - Option D<br>ASHRAE GL-14 |
| | Whole Building Approach | 4-5 | Yes | Whole building<br>Measure | Yes | No | IPMVP - Option D<br>ASHRAE GL-14 |

This table is also shown in the Guideline.



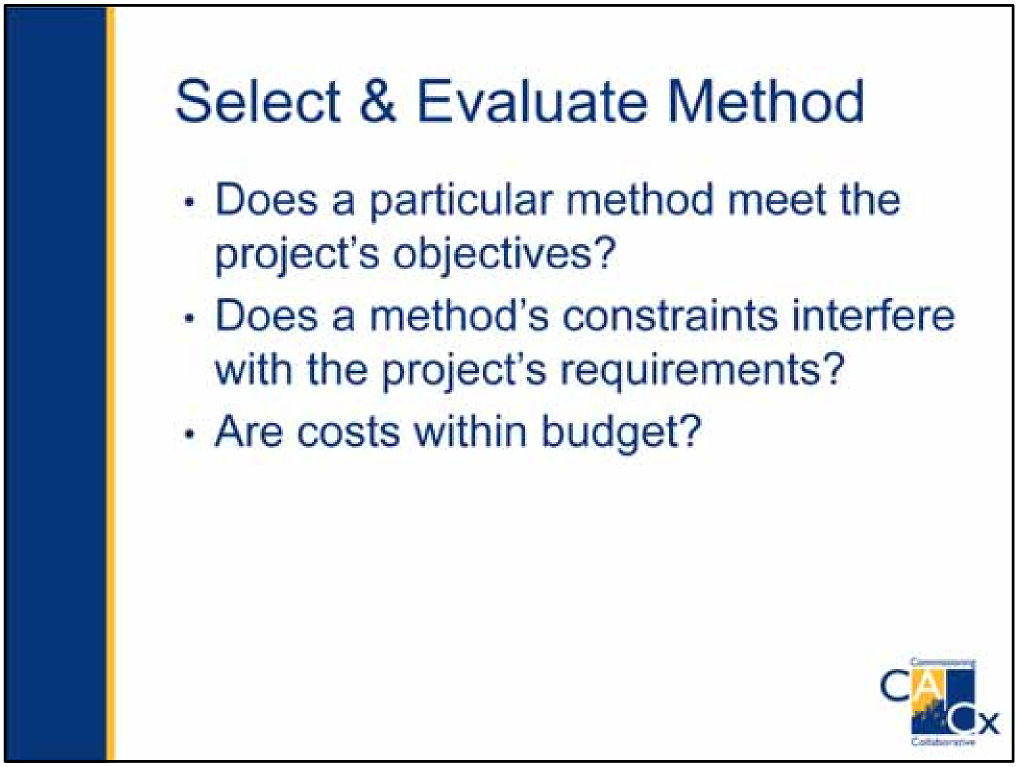

Identify a projects potential requirement/constraints and compare them to a methods requirements.

# Evaluation Framework - Constraints

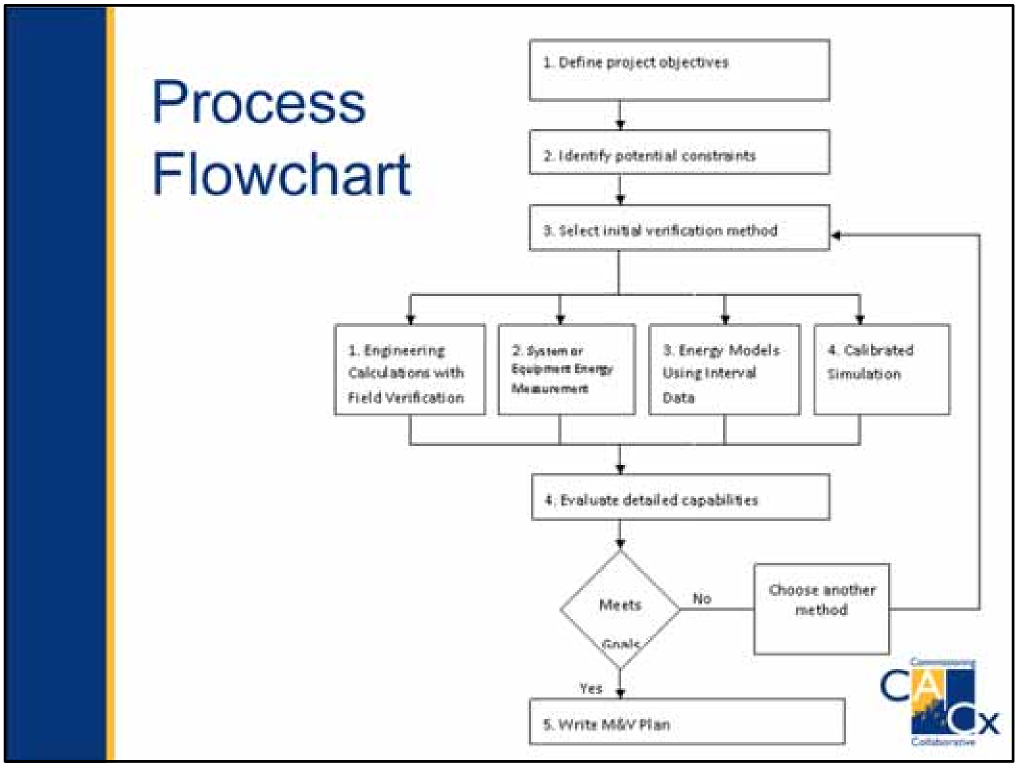
| Method | Sub-Method | Constraints | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Required Baseline Data (Type) | Required Baseline Monitoring Time (Quantity) | Required Post-ECM Data (type) | Required Post-ECM Monitoring Time (Quantity) | Basic tools required (type) | Labor - Expertise required (type) | Labor Level of effort (1-5) | Consistent building operation required (Yes/No) |
| Method 1: Engineering Calcs with Field Verification | Engineering Calcs & Visual Verification | Nameplate, Physical inputs and/or Performance data | spot measurement or up to 1-4 weeks | Snapshots | spot measurement | Logging tools Spreadsheet or Simulation software | Engineer | 2-3 | No |
| | Engineering Calcs & Performance Verification | Nameplate, Physical inputs and/or Performance data | spot measurement or up to 1-4 weeks | Performance data | spot measurement or up to 1-4 weeks | Logging tools Spreadsheet or Simulation software | Engineer | 3 | No |
| Method 2: Equipment or End-use Energy Measurement | Key Parameter Measurement | Measured physical inputs and Energy performance data | spot measurement or up to 1-4 weeks | Energy performance data | spot measurement or up to 1-4 weeks | Equipment performance curves Spreadsheet | Engineer | 3 | No |
| | All Parameter Measurement | Measured physical inputs and Energy performance data | 1-4 weeks | Energy performance data | 1-4 weeks | Logging tools Spreadsheet or Simulation software | Engineer | 4 | No |
| Method 3: Energy Models Using Interval Data | System Approach | Sub-metered or logged consumption data, energy driving variable | characterize cycle of operation: 1-6 months | Sub-metered or logged consumption data, energy driving variable | characterize cycle of operation: 1-6 months | Spreadsheet or Regression analysis tool | Engineer | 4-5 | No |
| | Whole Building Approach | Main meter interval data Energy driving variable | 6-12 months | Main meter interval data | 6-12 months | Spreadsheet or Regression analysis tool | Engineer | 3-4 | Yes |

Collaborative

Method 4 is cut off in this slide, but it is included in the Guideline.




Keep in mind the costs required to carry out the verification method. If too expensive, you may have to select a less expensive method, or reduce the level of effort in other areas of the EBCx project.


Process Flowchart
1. Define project objectives
2. Identify potential constraints
3. Select initial verification method
1. Engineering Calculations with Field Verification
2. System or Equipment Energy Measurement
3. Energy Models Using Interval Data
4. Calibrated Simulation
4. Evaluate detailed capabilities
Meets Goals
No
Choose another method
Yes
5. Write M&V Plan

# Develop M&V Plan

- Goals of EBCx project
- Identify & describe verification method
- Describe data requirements
- Identify responsible parties
- Explain analysis procedures
- Describe required baseline adjustments
- Describe savings reports and frequency

# Where to find the Guideline

- http://cacx.org/resources/vos-guidelines/

# Q&A

- Please submit questions via the Q&A box
  - Look for menu at the top center of your screen (it will expand down when you move your mouse over it) and select Chat box
  - Send questions to "Host"

## 2012 Meeting Dates

| Date | Format |
|---|---|
| October 18, 2012 | Webinar |
| December 6, 2012 | In-person, host TBD |

## Verification of Savings Guidelines Webinar Series

| Topic | Speaker | Date | Time |
|---|---|---|---|
| Guidelines Overview and Selecting a Method | David Jump, QuEST | Aug. 30 | 12:00-1:00 Pacific |
| Method 1: Engineering Calculations with Field Verification | Lia Webster, PECI | Sept.6 | 12:00-1:00 Pacific |
| Method 2: System or Equipment Energy Measurement | Mark Effinger, PECI | Sept. 13 | 12:00-1:00 Pacific |
| Method 3: Energy Models Using Interval Data | David Jump, QuEST | Sept. 20 | 12:00-1:00 Pacific |

*Thank you for participating!*

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Let us know what you thought of the meeting.

Please respond to the post-meeting survey. A link will be emailed to you.