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Verifying Savings from Existing Building Commissioning Projects

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AIA Quality Assurance

Learning Objectives

1. Understand how measurement and verification integrates with the EBCx process.

2. Understand the differences between current industry standard practice in calculating energy savings and savings validation using formal M&V approaches.

3. Identify key requirements for executing the four verification approaches detailed in the guideline: Engineering Calculations with Field Verification, System or Equipment Energy Measurement, Energy Models using Interval Data, and Calibrated Simulation.

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Agenda

California Commissioning Collaborative

Guidelines for Verifying Existing Building Commissioning Project Savings

- Background
- Formal M&V Methods vs. Standard Practice
- Key risks
- Method Selection
- Integrating M&V into EBCx
- Overview of CCC Methods

Background

- California Commissioning Collaborative project sponsored by PIER
  - Project team: PECI, QuEST, AEC
- Expansion of existing guideline
  - *www.cacx.org/meetings/...06.../Verification_of_Savings_2011-06-09.pdf*
    - Focus on interval meter data
- Now includes common industry approaches
  - Focus on practical applications and tips for best practice
  - How to integrate M&V into EBCx process

2 Key Elements of M&V

1) Operational Verification:
   - verifies that the ECMs are installed properly and have the potential to generate savings

2) Savings Verification:
   - calculates and verifies that the installed ECMs are generating the expected savings

Operational Verification

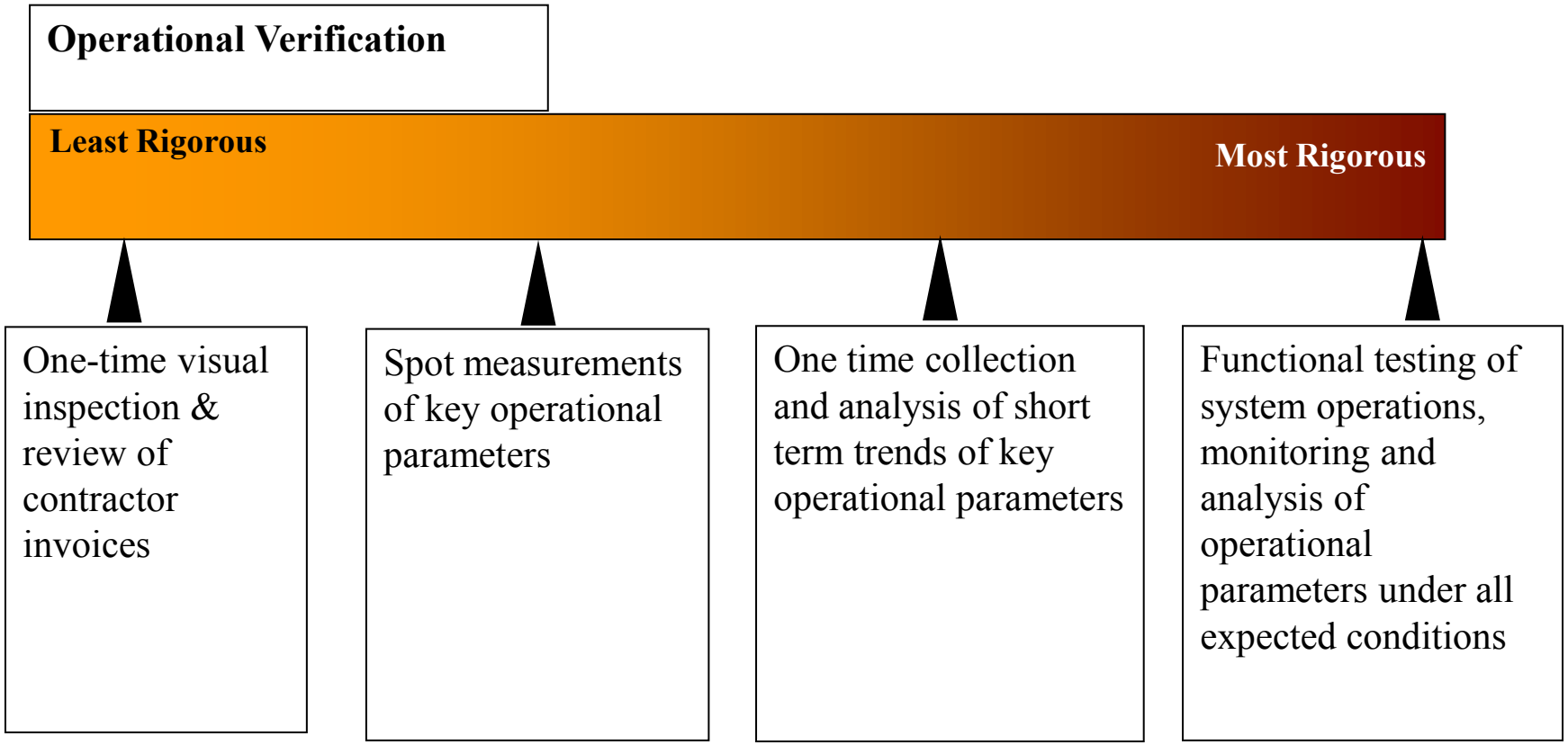
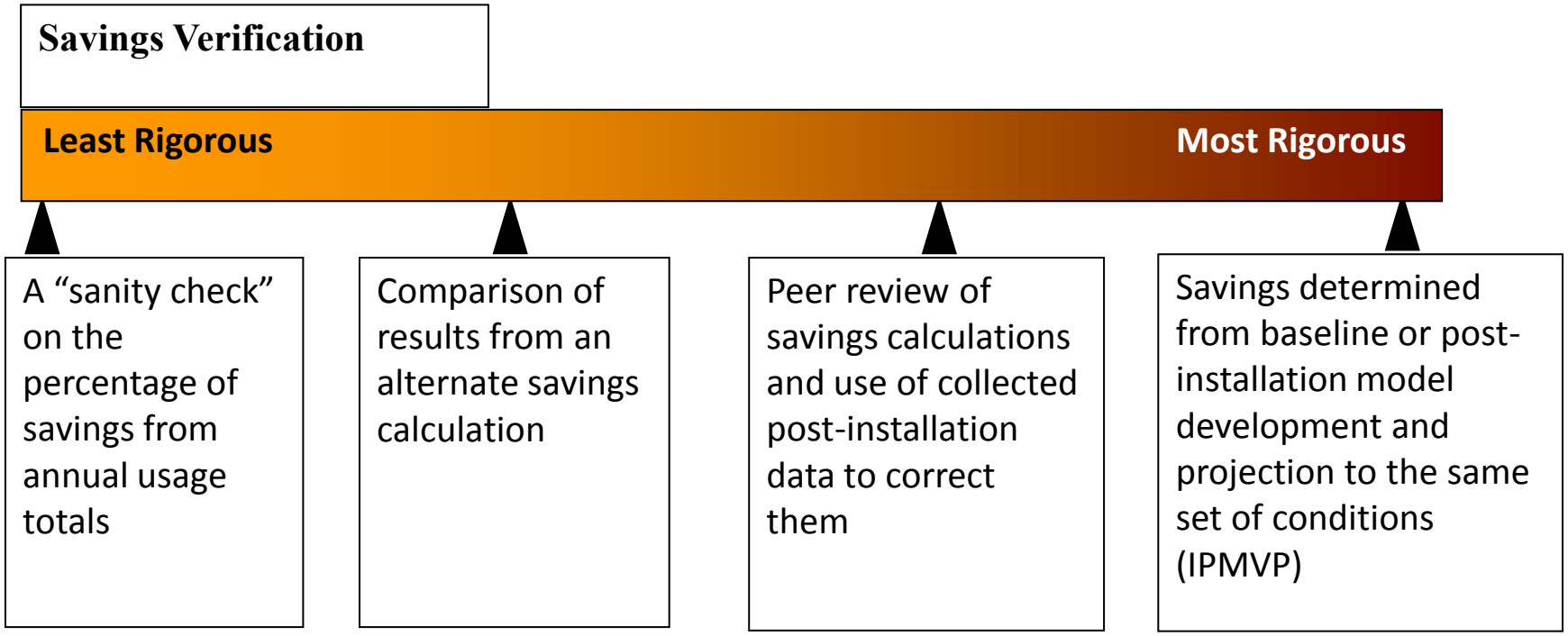


Figure from BPA Report, 2009, Research Supporting an Update of BPA's Measurement and Verification Protocols

Savings Verification



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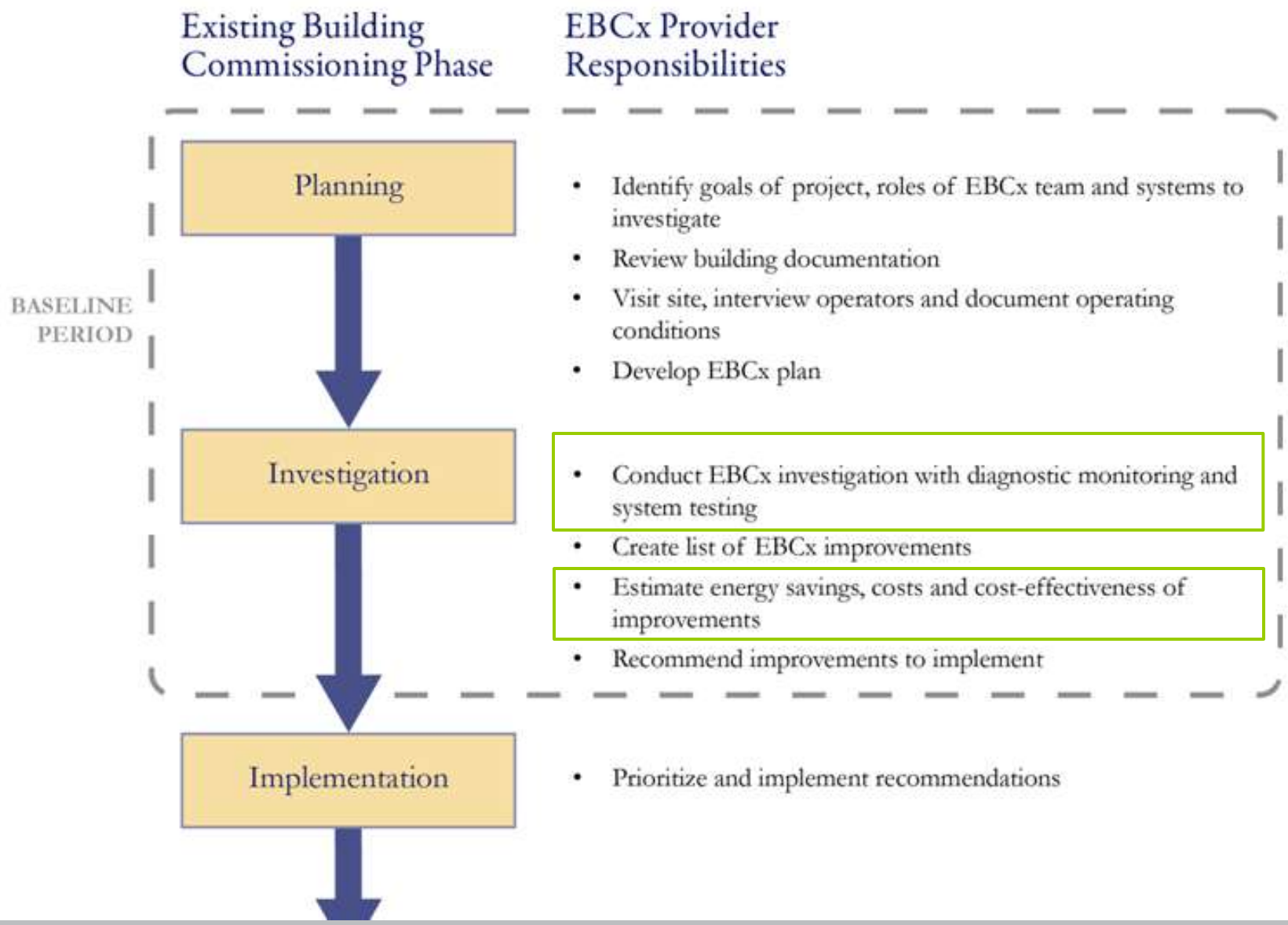

Existing Building Commissioning Phase
EBCx Provider Responsibilities
BASELINE PERIOD
Planning
Identify goals of project, roles of EBCx team and systems to investigate
Review building documentation
Visit site, interview operators and document operating conditions
Develop EBCx plan
Investigation
Conduct EBCx investigation with diagnostic monitoring and system testing
Create list of EBCx improvements
Estimate energy savings, costs and cost-effectiveness of improvements
Recommend improvements to implement
Implementation
Prioritize and implement recommendations

Existing Building Commissioning Phase	EBCx Provider Responsibilities
Hand-Off	• Conduct operational verification with functional tests • Document improved performance and develop final report • Update building documentation and systems manual • Provide operator training
Ongoing Commissioning	• Plan ongoing commissioning • Trend key system parameters • Monitor and track improved performance • Implement ongoing commissioning strategies

POST-INSTALLATION PERIOD

Formal M&V Methods

IPMVP Option	Description	ASHRAE G-14 Approach
Option A – Retrofit Isolation Key Parameter Measurement	Field measurements of key performance parameters	
Option B – Retrofit Isolation All Parameter Measurement	Field measurement of energy use or proxies	**Retrofit Isolation Metering**
Option C – Whole Facility	Analysis of utility meter data	**Whole Building Metering**
Option D – Calibrated Simulation	Simulation of whole building energy use, calibrated to measured energy data	**Whole-building Calibrated Simulation**

Overview of CCC Methods

California Commissioning Collaborative

CCC Method	May Comply with Formal Method
Method 1: Engineering Calculations with Field Verification	No
Method 2: System or Equipment Energy Measurement	•IPMVP Option A or B •GL-14 Retrofit Isolation Metering
Method 3: Energy Models with Interval Data	•IPMVP Option B or C •GL-14 Whole Building Metering •GL-14 Retrofit Isolation Metering
Method 4: Calibrated Simulation	•IPMVP Option D •GL-14 Whole-building Calibrated Simulation

Key Risks in Energy Projects

- Inaccurate or incomplete engineering assumptions, data, and analysis
- Inaccurate or incomplete physical understanding of building systems
- ECMs are quickly defeated

Method Selection

Stakeholder Objectives	Relative accuracy
	Quantification of uncertainty
	Granularity of savings
	Savings interactions captured
	Persistence
	Formal method

Constraints	Required baseline data (type)
	Required baseline data (quantity)
	Required post-ECM data (type)
	Required post-ECM data (quantity)
	Tools required
	Labor (expertise)
	Labor (level of effort)
	Requires consistent building operation?
	Requires high level of savings (>5-10% whole building)

Method 1 – Engineering Calculations w/ Field Verification

1. Collect appropriate baseline operational data for identified ECMs
2. Develop baseline energy estimates
3. Develop post-installation energy estimates to calculate savings
4. Conduct a third-party technical review
5. Execute field verification after ECMs are installed
6. Update savings if necessary
7. Conduct final peer review

Method 1 – Key Enhancements to EBCx

- **Transparency in the energy calculations**
  - Detailed documentation of assumptions and data
- **A third-party review**
  - Calculation approaches and savings are reasonable
- **Incorporate post-installation data to confirm assumptions**
  - Enhanced assurance of final savings estimates are accurate
- **Updated calculations**
  - Use post-installation data

Method 1 - Content

Analysis Methods

- Calculation Best Practices
- Summary of Calculation Approaches
  - Simple, Spreadsheet, Simulation
- Quantifying Equipment Loads and Hours using Operational Data

Purpose	Equation
Energy content of air	$Q = 1.08 * CFM * \Delta T$
Pump energy use	$BHP = (GPM * \Delta P)/(3960 * \eta_{pump})$
Fan energy use	$BHP = (CFM * \Delta P)/(6356 * \eta_{fan})$
Fan affinity laws*	$(BHP_2/BHP_1)=(CFM_2/CFM_1)^3$

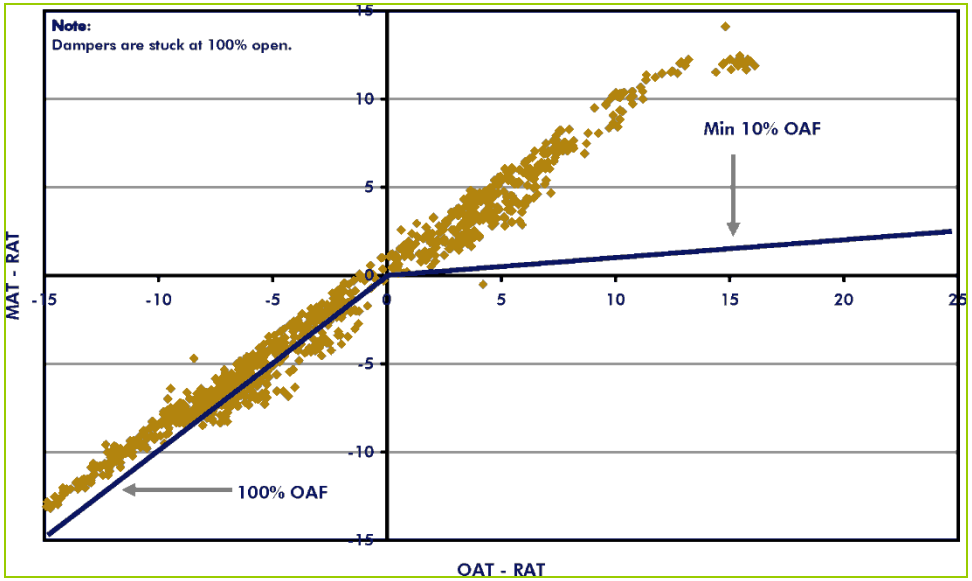
Method 1 - More Details

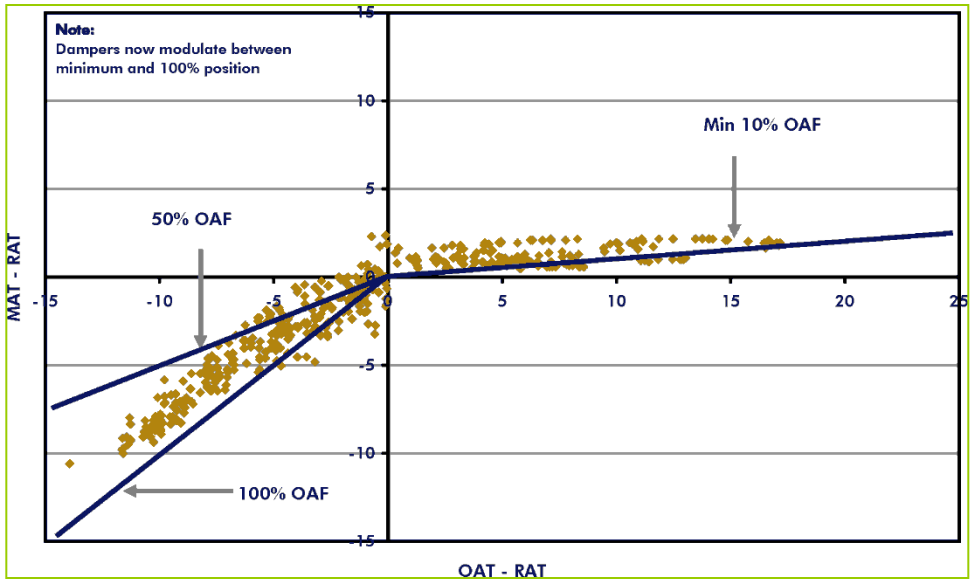
Field Verification Approaches

- Visual Verification *(Not Method 1)*
- Performance verification
- Field Verification Examples

Measure Category	Example Finding	Data Collection Options for Calculations and Verification	
		Performance Verification (High rigor – Method 1)	Visual Verification (Low rigor)
Economizer/Outside Air Loads	Inadequate use of free cooling Over-ventilation	Trend and analyze OAT, MAT, RAT during all operating modes	Provide baseline and post-implementation photos of economizer dampers

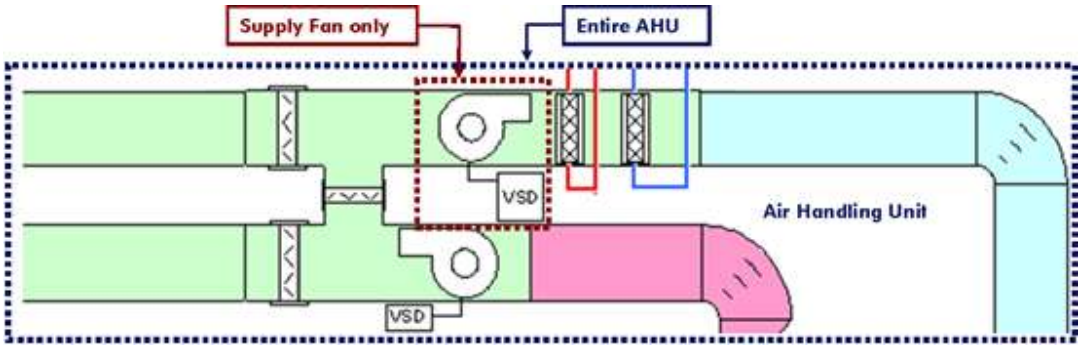
Visual vs. Performance Verification





Method 2 – System or Equipment Energy Measurement

1. Define the measurement boundary
2. Identify system characteristics



3. Develop M&V Plan
4. Measure appropriate parameters to quantify baseline load and hours of use
5. Develop baseline energy use estimate
6. Measure appropriate parameters to quantify post-installation load and hours of use
7. Develop post-installation energy use estimate
8. Calculate Savings

Method 2 – System or Equipment Energy Measurement

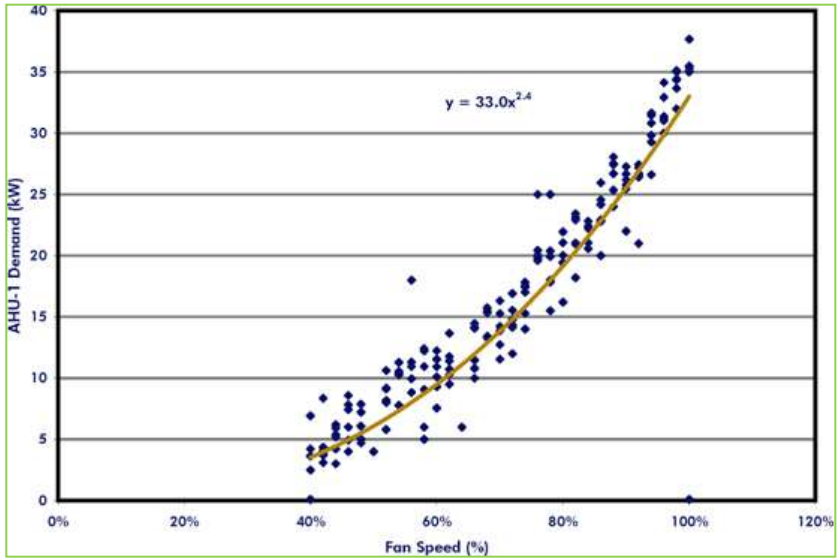
Analysis Methods

- Characterizing Load and Hours of Use

Quantifying Energy Parameters

- Confirmed Proxies
- Estimates of Energy Use Parameters

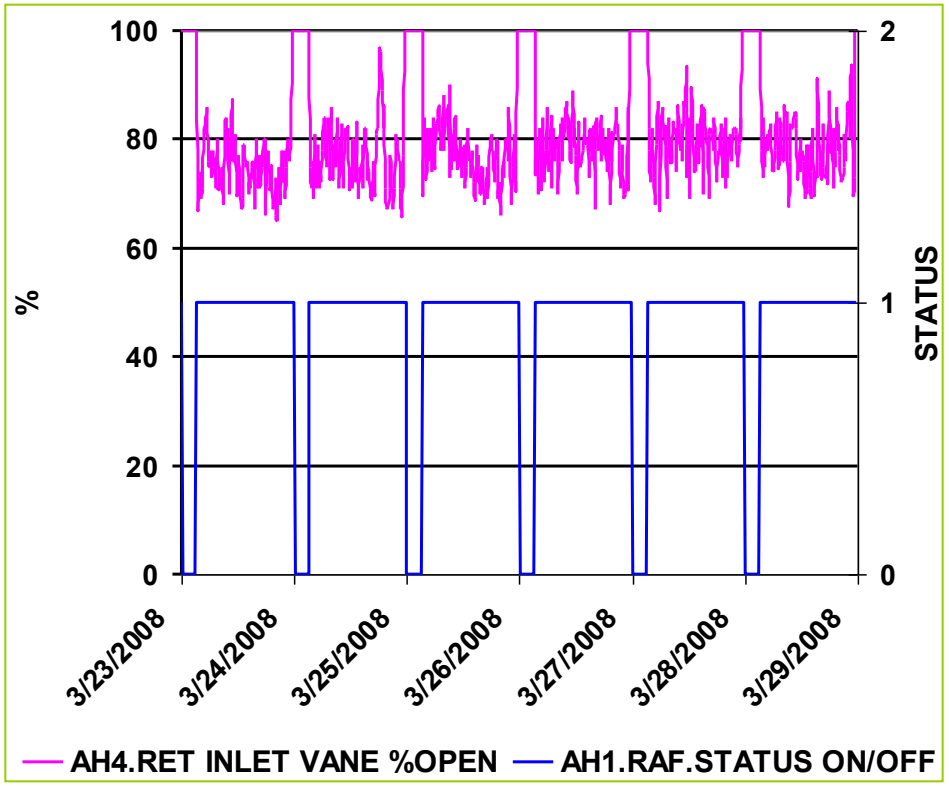
Calculation Techniques



$$kWh_{saved} = \sum\left(kW_{base} * Hours_{base}\right) - \sum\left(kW_{post} * Hours_{post}\right)$$

Notes on Method 2

- **Requires minimally more data points than Method 1**
- **May be applied as Option A or B**
- **Simple, based on direct energy measurements**
  - Less engineering modeling
- **Repeatable for checking persistence**
- **Can do uncertainty analysis if desired**



Method 3 – Energy Models w/ Interval Data

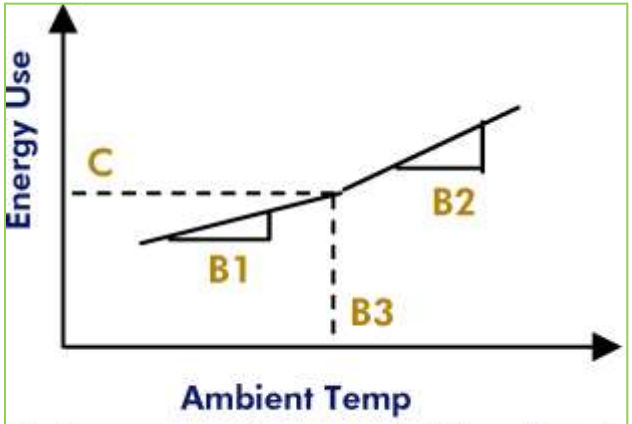
If whole building model is insufficient

1. Collect Whole Building Data
2. Develop and Assess Whole Building Baseline Model
3. Collect Building Subsystems Energy Use Data
4. Develop and Assess Systems Baseline Model
5. Document Savings Verification Requirements in the EBCx Plan
6. Collect Post-Installation Period Data
7. Develop Post-Install Model
8. Adjust Models to Uniform Conditions
9. Calculate Savings

Method 3 – Energy Models w/ Interval Data

Analysis Methods

- Modeling Techniques
- Selecting a Time Interval for Data Analysis
  - Hourly or Daily
- Amount of Data to Collect
- Developing, Assessing, and Selecting the Appropriate Model(s)



F: 4-parameter model (cooling)

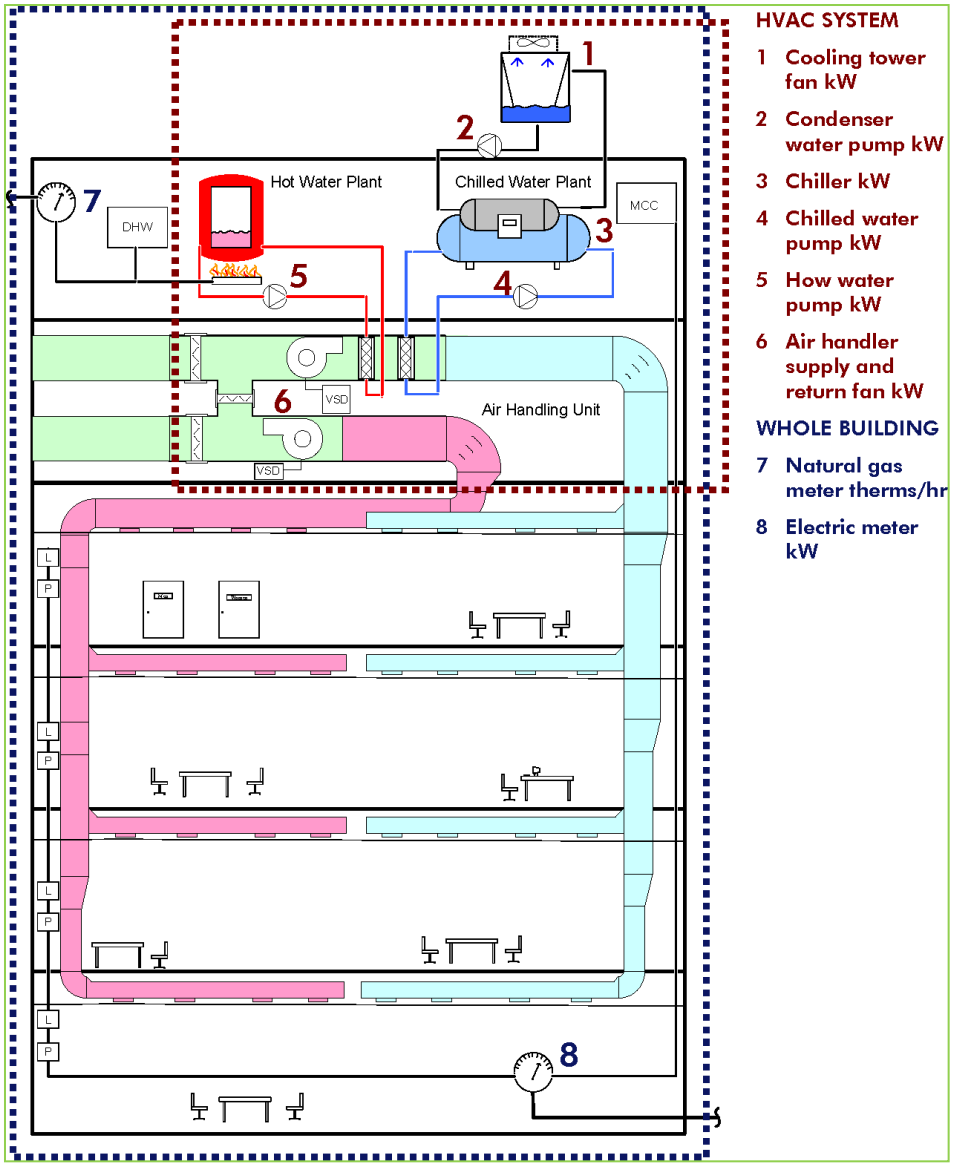
Model Development

- Model Uncertainty Assessment
- Example of Model-Development Procedure

Method 3 – Energy Models w/ Interval Data

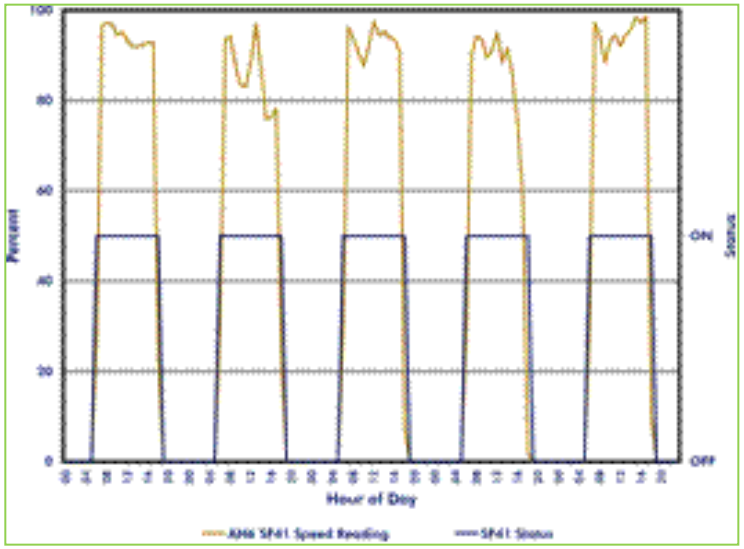
Key Elements:

- Energy use data
  - Whole building or system level
- Data management
- Model development
  - Independent variables (temperature, schedule/occupancy)
- Uncertainty analysis
  - "optional"
- Total savings



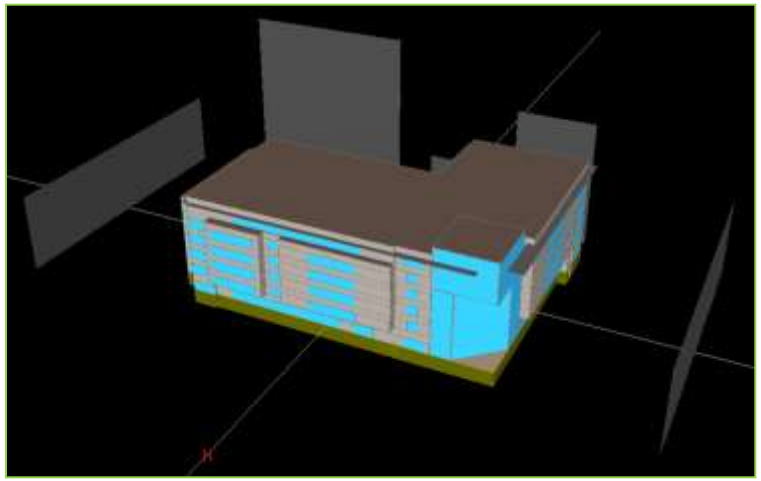
Notes on Method 3

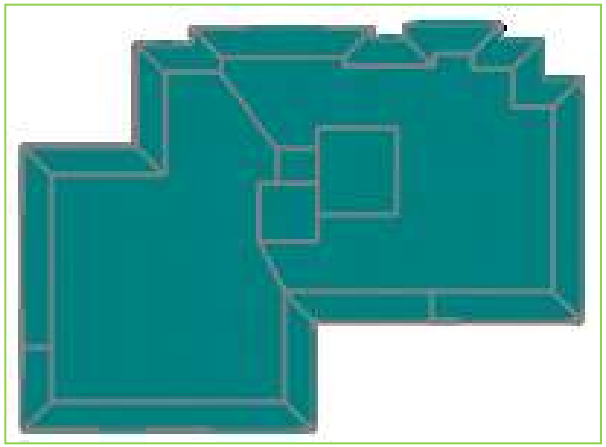
- **May be IPMVP Option C (whole building) or Option B (systems)**
- **Uncertainty analysis is possible, not always performed**
- **Provides operator feedback on energy use**
- **Useful in maintaining persistence**



Method 4 – Calibrated Simulation

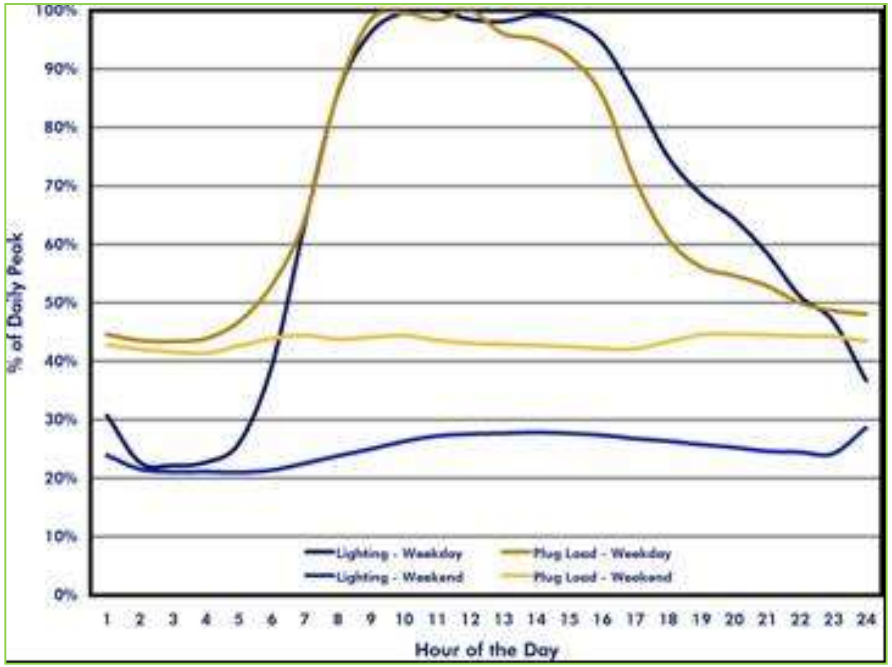
1. Collect baseline data
2. Develop baseline model
3. Develop post-install model
4. Compare models to estimate savings
5. Calibrate baseline model
6. Collect post-install data
7. Calibrate post-install model
8. Adjust models to uniform conditions
9. Compare adjusted models for normalized savings



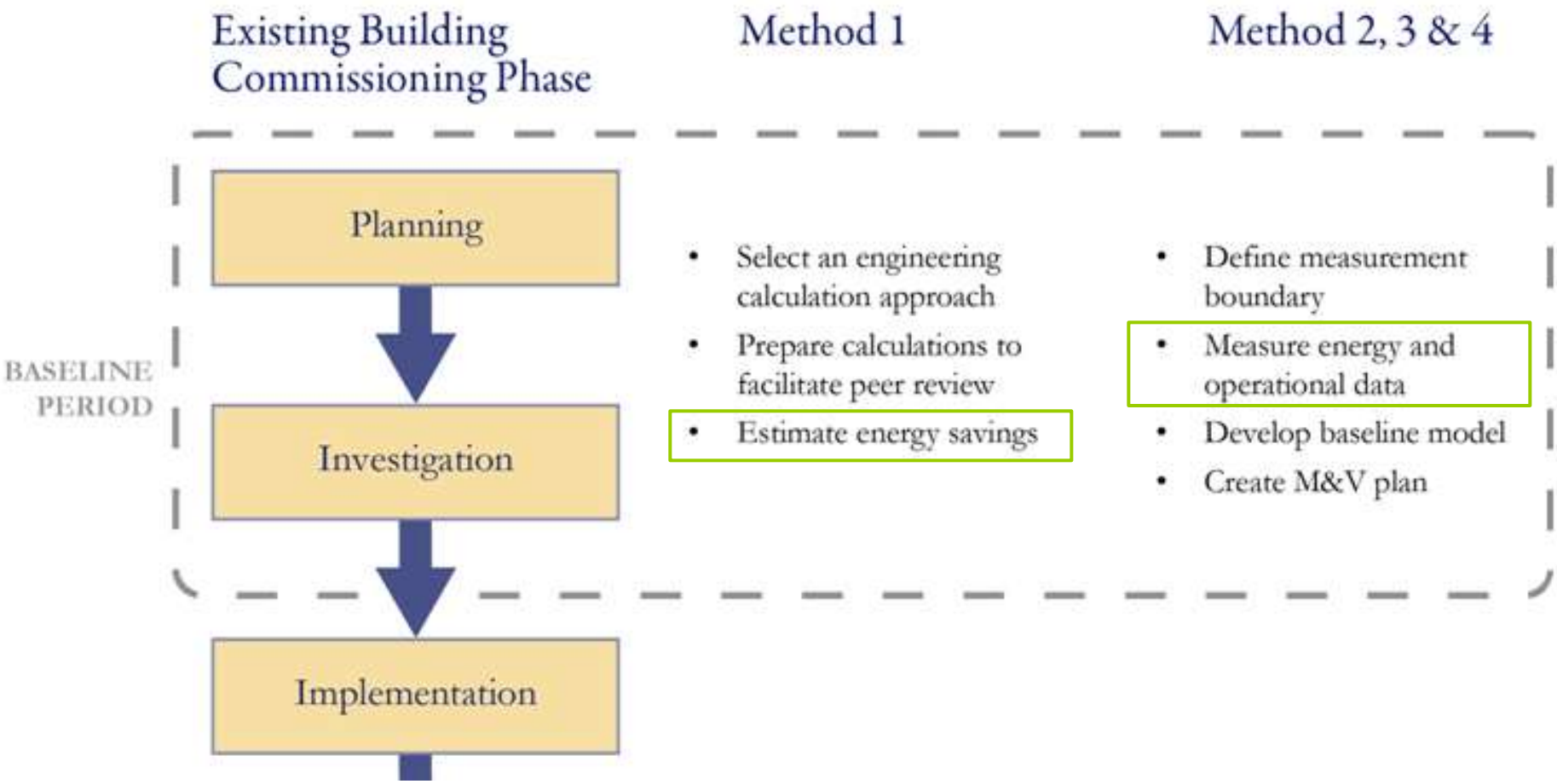


Notes on Method 4

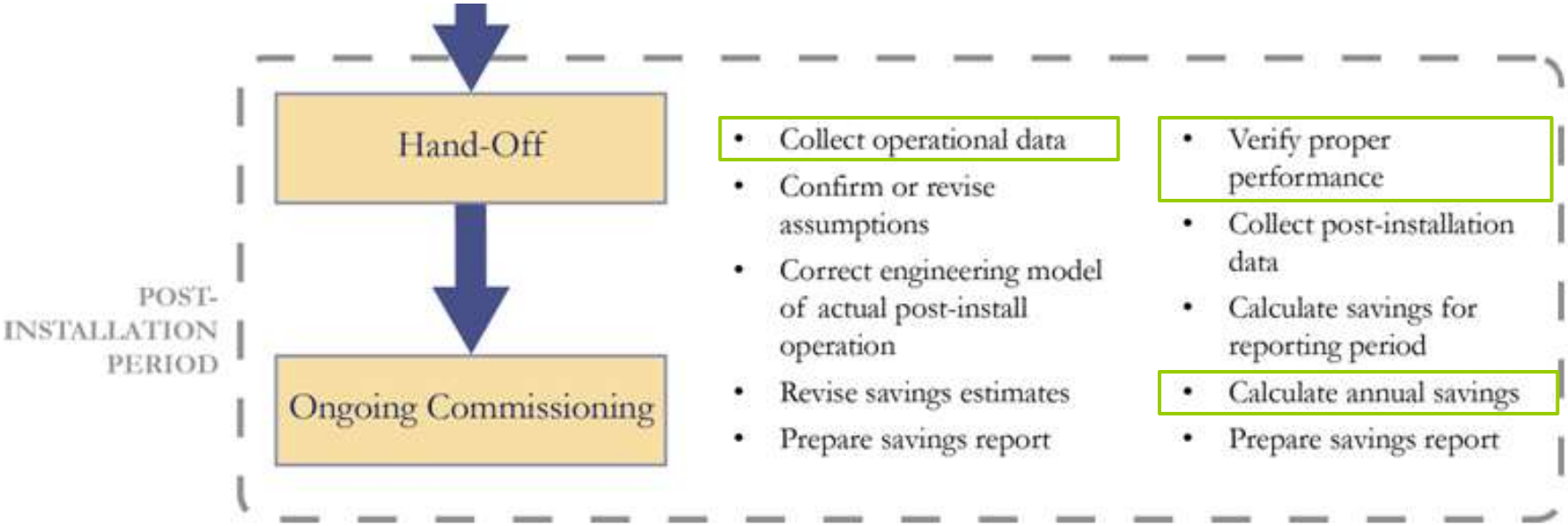
- **Requires historic utility data**
- **Qualified simulation professional required**
- **Use if model developed for other purposes**
- **Use of sub-metered data improves accuracy**



M&V in the EBCx Process



M&V in the EBCx Process, cont.



Appendices

Appendix A : List of Acronyms

Appendix B : Data Sources and Management

Appendix C : Tools

Appendix D : Data-Driven Models

Appendix E : Uncertainty Analysis

Appendix F : Algorithms for Peak-Period Demand Savings

Summary

- Guideline due out November 2011:
  - California Commissioning Collaborative www.cacx.org/
- “New” methods:
  - Engineering Calculations with Field verification
  - Energy Models with Interval Data
- Focused on “how-to” and practical applications
- Integration of M&V into EBCx

Thank-you!

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