ENRG 61 - Measurement Tools and Verification of Savings Calculations

COURSE DESCRIPTION: Measurement and verification (M&V) is a quality assurance process for energy efficiency measures that have been implemented. Course covers how M&V relates to audit process, accepted standards, M&V planning, measurement boundaries, data collection tools and methods, savings calculations.

18 Lecture Hours

LEARNING OUTCOMES:

Upon completion of this course a student will be able to:

- Describe the role of measurement and verification in the commercial building audit process
- Distinguish between different measurement boundaries, and describe the appropriate selection criteria for each
- Identify sources of data and appropriate measurement instruments
- Assess and apply different energy savings analysis methods
- Calculate actual energy savings based on data

COURSE TOPICS:

I. Role of measurement & verification (M&V) in energy efficiency (EE), renewable energy, or demand response (DR) process
   A. Normal project process
      1. Audit
      2. Implementation
      3. Verification
   B. Importance and uses of M&V
      1. Quality assurance for EE measures
      2. Basis of payments, rebates and incentives from utilities or energy service companies (ESCOs)
      3. Data for calculating true financial impact of implemented EE measures
      4. Data point for possible future EE measures

II. Concepts, guidelines and standards
   A. Concepts
      1. Savings cannot be measured, only estimated
      2. Audit savings estimates may be based on published tables, prior studies, or calculated with various levels of rigor and measured data
      3. Audit savings estimates needed for cost/benefit analysis of measures implemented
   B. Guidelines and Standards
      1. Standard M&V procedures are documented in international, and national protocols and guidelines
         a. International Performance Measurement & Verification Protocol (IPMVP) by Efficiency Valuation Organization (EVO)
         b. ASHRAE Guideline 14
         c. Various practical guidelines (list, describe, and cite sources)
   C. Savings verification
      1. Quality assurance methods
      2. IPMVP-based M&V relies on direct energy measurements before and after EE measure implementation
         a. Fundamental savings verification concept
         b. Concept of adjustments
   D. Measurement boundaries determine type & extent of data collected

III. Savings Calculation Fundamentals
   A. Energy savings = adjusted baseline energy - post implementation energy +/- non-routine adjustments
   B. Baseline energy use
   C. Adjustments to energy use
      1. Routine adjustments

a. Caused by naturally occurring influencing factors
b. Whole building level
1.) Ambient air temperature
2.) Relative humidity
3.) Building operations schedule
4.) Occupancy
c. System level
1.) Lighting (on or off)
2.) HVAC
i. Very complex
ii. Many variables
iii. Heat load is main influencing factor

2. Non-routine adjustments
a. Unanticipated events that affect energy use
b. Tenants moving in or out
c. Adding new function to building, such as a data center
d. Equipment failure

IV. Measurement boundary
A. Building level
1. Easiest to obtain, hardest to get detailed data
2. Whole building meters for gas or electricity
3. Weather data
4. Building operations schedule
B. System level
1. Requires ability to measure energy use by system
2. Separate meters
3. System control data monitoring
C. Component level
1. Requires ability to measure energy use by component
2. Component control data monitoring

V. Savings calculation methods
A. Load and schedule combinations
1. Lighting
2. HVAC
3. Other systems
B. Sampling of multiple small measures
C. Regressions
1. Whole building level
2. System level
D. Simulations
1. Whole building level
2. Retrofit isolation
E. Available software and tools

VI. Selection of measurement boundary
A. IPMVP options for data sources for different measurement boundaries
1. Retrofit isolation key parameter measurement (system level)
2. Retrofit isolation all parameter measurement (system level)
3. Whole building (empirical energy models)
4. Calibrated simulations (computer simulations)
B. Determining factors in measurement boundary selection
1. Number and diversity of energy efficiency measures
a. Single system or component = retrofit isolation
b. Multiple systems = whole building-+

2. Magnitude of savings: need large magnitude to select whole building
3. Availability of data

VII. Sources of Data and Measurement Instruments

A. Whole building
1. Electric
a. Monthly bills
b. Time-of use meters (large facilities)
c. Smart meters
d. Advanced metering or Energy Information Systems (EIS) owned by customer
2. Natural Gas
a. Monthly bills
b. Smart meters
c. Advanced metering or EIS

B. Building subsystems
1. Building automation system (controls)
2. Energy management and Information Systems
3. Typical data available
a. Submeters
b. Status/feedback signals
1.) Equipment on/off
2.) Variable speed signal
c. Sensor data:
1.) Ambient temperature (local)
2.) Indoor temperature
3.) Supply and Return temperatures (water or air)
4.) Etc.
d. Weather data
1.) Websites – NOAA, weather underground
2.) TMY data

C. Measurement devices

VIII. Developing the M&V Plan

A. Defining EEM intent
B. Select IPMVP Option and define Measurement Boundary
C. Define the baseline period and conditions
D. Savings reporting periods
E. Basis for adjustments
F. Data collection
1. Data loggers
2. Spot measurement instruments
3. Calibration issues

TYPES OF ASSIGNMENTS:

I. In-class

A. Participation in class discussions
B. Small group projects such as identifying factors required for M&V savings analysis, or developing an appropriate M&V approach for various sample EE, renewable or DR measures
C. Perform calculations from data sets such as M&V savings analyses from sample data sets

II. Out-of-class

A. Readings as assigned from M&V resources, instructor handouts
B. Perform calculations of different M&V savings methods using provided data (monthly bills, interval data, end-use data)
C. Develop a written M&V Plan for an assigned project

TEXTBOOKS & RESOURCES:
• www.evo-world.org, resource for the IPMVP • www.ashrae.org, resource for ASHRAE Guideline 14 (approx $80 – cannot require) • www.cacx.org, practical guidelines for M&V in commissioning projects • www.conduitnw.org, practical guidelines for M&V methods: end-use approach, energy modeling approach, regression guidance, sampling guidance

BEST Center Curricula, Resources & Recordings

Academic Programs
Georgia Piedmont Technical College - Building Automation Systems
Milwaukee Area Technical College - Sustainable Facilities Operations
Laney College - Commercial HVAC Systems
City College San Francisco - Commercial Building Energy Analysis & Audits

Professional Development Materials, Presentations & Videos
National Institutes
Building Automation Systems Instructor Workshops
Webinars (e.g., BEST Talks)

Faculty Profile Videos
Reports & Case Studies
Marketing Resources

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