Energy Modeling for Measurement & Verification

Linda Morrison, PE, CEM, GBE, LEED-AP
Building Performance Engineer Team Lead

Renee Azerbegi, CEM, LEED-AP
President

Andy Walker, PE, PhD
Senior Engineer

Agenda

- Background
- M&V Option D Calibrated Simulation
- The Team
- The M&V Process
- Financial Impact
- Conclusions

Background on IPMVP

- **I**nternational **P**erformance **M**easurement and **V**erification **P**rotocol
- Funded by US DOE Federal Energy Management Program
- Originally targeted towards existing buildings
- Used to prove savings / project funding for Energy Savings Performance Contracting industry

LEED-NC and M&V

- LEED-NC EAc1, Optimize Energy Efficiency
- LEED-NC EAc5 Measurement and Verification
  - Intent: “provide for the ongoing accountability of building energy consumption over time”
  - IPMVP Option B, Energy Conservation Measure Isolation
  - IPMVP Option D, Whole Building Calibrated Simulation

Energy Savings for New Buildings =
Projected Baseline Energy Use – Post-Construction Energy Use

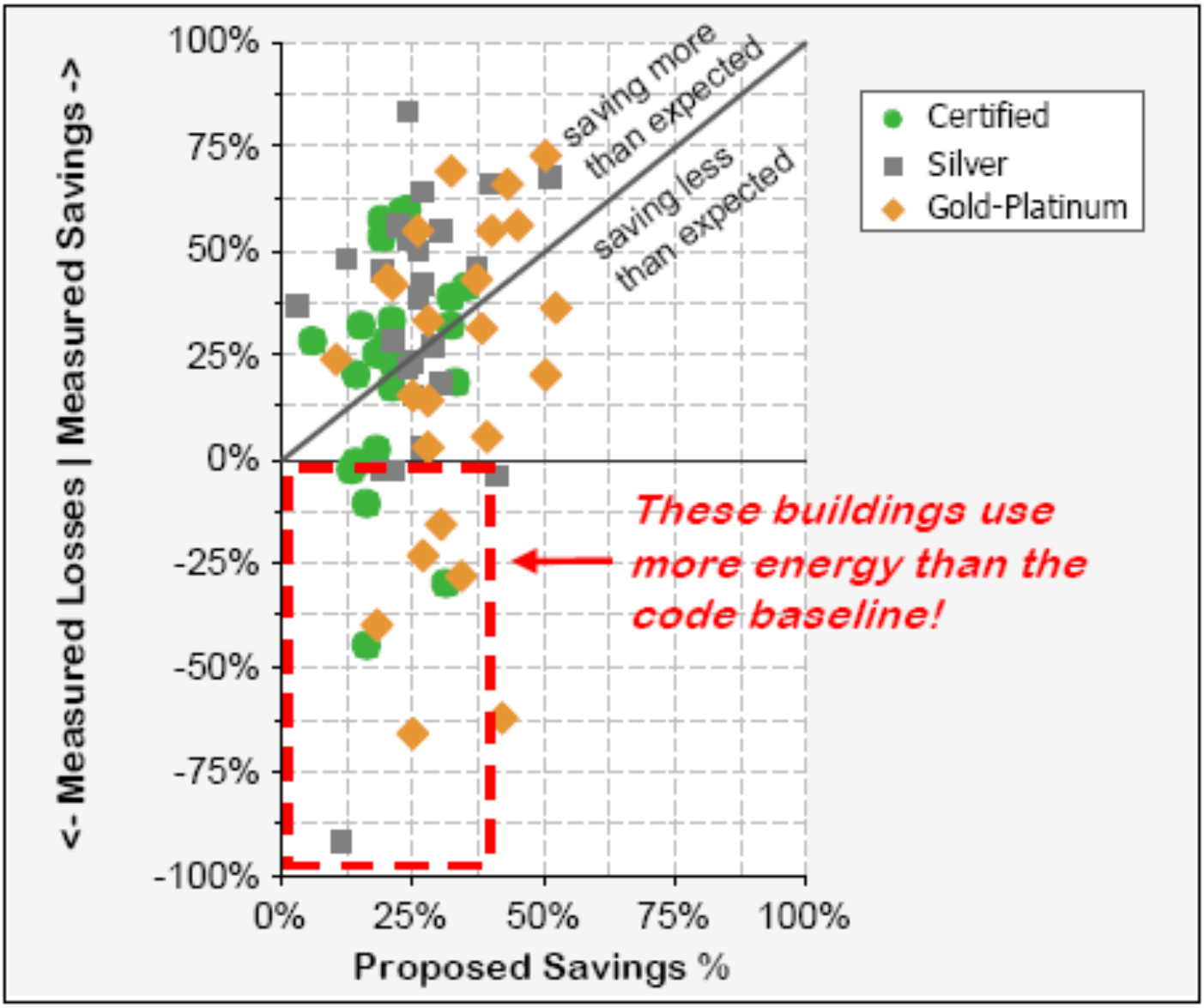
When to Use Option D

- Whole Building Calibrated Simulation:

"Option D is most suited to *buildings with numerous ECMs that are highly interactive or where building design is integrated and holistic*, rendering isolation and M&V of individual ECMs impractical or inappropriate" (IPMVP 2006).

Measured vs Proposed Savings

Measured versus Proposed Savings Percentages
(NBI, Turner, Frankel, 2008)



Measured vs Proposed Savings

Measured versus Proposed Savings Percentages
(NBI, Turner, Frankel, 2008)

"More feedback is needed from actual building performance results to design phase energy modeling. The current variability between predicted and measured performance has significant implications for the accuracy of the prospective life cycle cost evaluations for any given building. Better feedback to the design community is needed to help calibrate energy modeling results."

Benefits of M&V

- Tool for facility management
- Allocate operating costs among programs or tenants in a building
- Demonstrate performance of a new technology
- Demonstrate compliance with energy reduction regulations
- Confirm or calibrate analytical tools
- Educate students and visitors
- Earn green building rating points

Cost of M&V

- Size of project
- Type of building
- Number of metered systems
- Utility costs for the facility
- Utility cost risk
- Time period between calibrations

Cost of M&V

- Project design fees:
  - Whole building simulation
  - Data gathering / energy assumptions
  - Commissioning
- Infrastructure:
  - Building automation system
  - Incoming utility meters
  - Submeters included with equipment
  - Additional submetering
  - Trends and graphics
- Professional Services during M&V Period:
  - M&V period data collection
  - Model calibration
  - M&V report

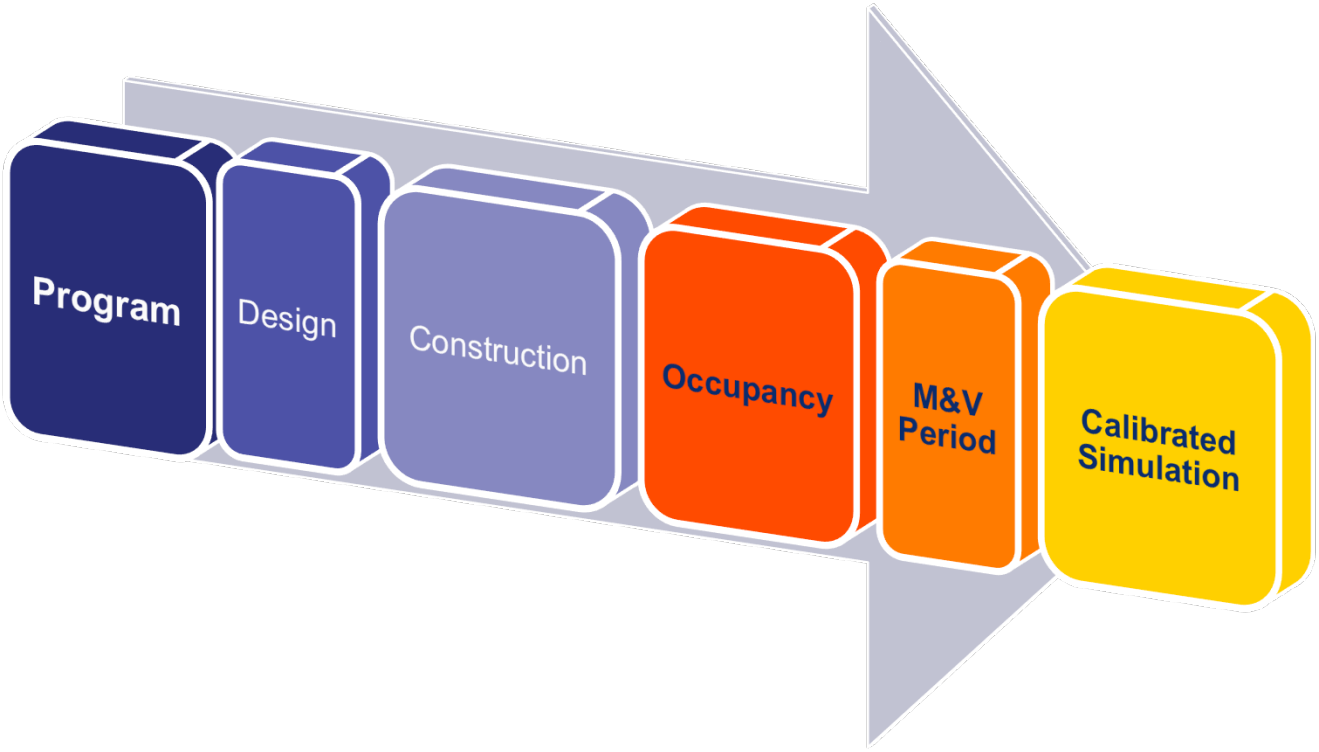
Cost of M&V

- A rule of thumb for M&V of 4% to 10% of the typical project cost savings based on IPMVP Option B (Walker, et al 1999).
- Cost for the meters for measurement and verification can add $2 to $4 per square foot to the cost of a project. In addition, the cost of the studies can range from $50,000 to $200,000 (Morris and Matthiessen 2008).

The Team

- Owner
- Architect
- Sustainability Consultant
- Energy Modeler
- Commissioning Agent
- Mechanical Engineer
- Electrical Engineer
- Controls Contractor
- Building Engineer
- Facility Manager

The M&V Process



Programming

- Define facility marketing goals
  - Low utility costs
  - Lease type
- Facility management goals
  - Utility cost risk management
  - Level of facility staff sophistication
- Determine team for M&V
  - Commissioning agent
  - Energy modeler
  - Controls contractor
    - General contractor selection
    - Negotiated with RFQ for previous experience with M&V projects

Design Development

- Develop savings strategies over ASHRAE Standard 90.1-2004
- Energy modeler determines savings amount, independent variables, risk, and sensitivity
- Identify data collection platform
  - Building automation
  - Other IT platform
- Identify gaps in instrumentation
- Cost estimate for instrumentation
- Fee estimate for professional services for M&V period

Construction Documents

- Write M&V plan
- Specify instrumentation details
  - Metering devices
  - Signal conditioning
  - Communication equipment
  - Data storage
  - Long term data storage
- Assign data collection outside of building automation (events, occupancy, etc.)

During Construction

- Controls contractor and commissioning agent commission the sub-metering, data collection, and trends
- Verify operation of energy saving strategies
- Review and test trend data

At Occupancy

- Turn over User's Manual with M&V to facility management staff
  - M&V plan
  - Instrumentation
  - Trends and reports from BAS
  - The energy simulation results
  - Demonstrate the building performance feedback tool

The M&V Period

- Starts after stable occupancy and operation
- Lasts for one year or longer
- Pull M&V data and write to long term storage
- Sanity check on M&V data
  - Schedules / temperatures
  - VFD fan and pump profiles
  - Cooling plant performance
  - Boiler plant performance
- Proactively tune equipment performance

Calibrated Simulation

- After one year of M&V or on an interim basis
- Calibrate as-built and baseline energy models
  - Normalize weather
  - Actual schedules – occupancy, equipment, lighting
  - Incorporate custom part load curves
- Compare to original EAc1 savings predictions
- Communicate results and have on-going actions

Conclusion

- LEED-NC projects with energy simulation already include significant investment in M&V

- Improved energy modeling techniques validated with actual building performance

- Create a tool for facility management with calibrated savings

Conclusion

- Who benefits from measurement and verification?

- The owner with *better performance*
- The facility manager with *troubleshooting tools*
- The energy modeler for *more accurate model*
- The design team for *proof of concept*

Thank You!

Q&A

Linda Morrison

Renee Azerbegi

Andy Walker

ambient energy