M&V Guidelines
for Colorado PC projects

"You cannot manage what you do not measure"

Rebuild Colorado

Focus on performance contracting in state and local governments

Governor's Office of Energy Management and Conservation

Rebuild Colorado Team

Governor's Office of Energy Management & Conservation

Staff

- Rick Grice, Director
- Linda Smith, Sr. Program Manager

Consultants under contract

- Peter Oatman, P.E.
- Lia Webster, P.E.
- John Canfield

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Partnering with ESCOs

ESCOs selected for working group:

- Chevron
- Long
- Ameresco
- Siemens
- Johnson Controls

Experienced in Rebuild Colorado processes and Colorado projects

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Working Group is an Activity of the Energy Services Coalition (ESC)

Public/Private Partnership
to promote performance contracting

- State energy offices
- ESCOs
- Financing institutions
- Vendors
- Others

www.escperform.org

Goals

- Joint marketing
- Unify marketing efforts of state energy offices and industry
- Increase customer awareness of performance contracting
- Break down barriers to performance contracting
- Colorado Chapter
  - Improve program effectiveness (ESCOs as sounding board)

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5 Steps to Success AND Free Services

1. **Decide if performance contracting is right for you**
   (Assess needs & potential benefits)
   Services: Free engineering study, Board presentation, meetings
2. **Select an Energy Service Company, ESCO**
   (Develop an RFP)
   Services: RFP development, advisor
3. **ESCO identifies energy-saving opportunities**
   (Develop an audit contract)
   Services: Audit contract development, negotiating tips, engineering review of audit
4. **ESCO implements projects**
   (Negotiate an Energy Performance Contract)
   Services: Contract development, negotiating tips, engineering & process advisor
5. **Verify savings and enjoy the benefits**
   (Monitor long-term performance)
   Services: Engineering review of results and basic follow-up monitoring

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Colorado Legislation

for State & Local Governments

- Term limited by equipment lifetime or 25 years
  (typically recommend 12-15 years)
- Energy, water, maintenance, other savings allowed
  (labor savings discouraged)
- Guarantee required
  (customer can cancel guarantee after 3 years)
- Annual guarantee
  (savings must be met EVERY year)
- Clear cost itemization

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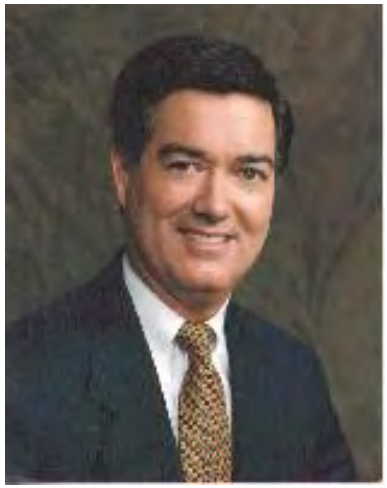
Governor's Endorsement



Governor Bill Owens

Executive Order

- State departments are required to investigate feasibility of performance contracting and issue an RFP where opportunity exists
- Higher education institutions are encouraged to do the same.

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M&V Goals

- Ensure savings are achieved
- Ensure savings can be measured
- Ensure savings can be verified (by legislators, etc.)
- Increase use and acceptance of pc

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Developing M&V Guidelines for Colorado

Facilitator: Peter Oatman, P.E., Consultant

- Lead performance contracting specialist for Rebuild Colorado
- Lead consultant for state departments/institutions (setting the stage for other Colorado projects)

Key Contributor: Lia Webster, P.E., Consultant

- Developed preliminary Colorado guidelines based on FEMP work
- Conducting M&V implementation of a major state project

This is a team effort – we want your participation!

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Measurement & Verification

- Energy savings cannot be measured!
- You cannot measure something that is not there - NegaWatt
- Can only estimate what energy would have been used in absence of the ECM

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International M&V Standards

- International Performance Measurement & Verification Protocol (IPMVP), March 2002
- FEMP Guidelines
- ESCO practices

- Http://www.ipmvp.org
  Http://ateam.lbl.gov/mv/

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International M&V Standards

- IPMVP scope includes:
  - Techniques for calculating whole-facility savings
  - Consistent procedures across all similar projects
  - Procedures that are internationally accepted, impartial, reliable
  - Methods of varying levels of accuracy and cost
  - Method of risk allocation between ESCO and customer and for investigating & resolving disputes

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International M&V Standards

- **Volume I:** Concepts and Options for Determining Energy and Water Savings
  - Four options for verifying savings
    - Option A - Partially measured retrofit isolation
    - Option B - Retrofit isolation
    - Option C - Whole facility
    - Option D - Calibrated Simulation
  - Significantly changed from 1997 version - Option A & B redefined and includes some field measurements

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M&V Methods

- Engineering Calculations
- Metering
- Billing Analysis
- Calibrated Simulation

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M&V Methods

- Determine appropriate level of M&V
  - Value of ECM in projected savings
  - Complexity of ECM
  - Number of ECMs at an individual site and degree of interactions
  - Uncertainty of savings
  - Allocation of risk for achieving savings
  - Other uses for M&V data and equipment

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M&V Methods

- Factors affecting M&V accuracy and cost
  - Level of effort required to verify baseline and post-installation characteristics
  - Size of sample required
  - Duration and accuracy of metering
  - Number of variables that must be verified
  - Contract duration
  - Required levels of confidence and precision

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Basic Concept

Energy Savings = Baseline Energy Use - Post-Retrofit Energy Use +/- Adjustments

- Adjustments - brings energy use in the two time periods to the same set of conditions
- Adjust for weather, occupancy, plant throughput, equipment operations
- Adjustments must be derived from identifiable physical facts and typically applied to baseline

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Basic Concept

- Routine Adjustments
  - Expected changes throughout the post retrofit period with good relationship to energy use/demand
    - Weather
    - Occupancy
- Non- Routine Adjustments
  - Changes which cannot be predicted
    - Increase/decrease of facility size
    - Change in operation/process/tenants
  - Based on known and agreed to changes to facility

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Selecting an Option

- Consider the facilities energy use pattern
  - Constant load without changes in operating hours
  - Operating hour reductions without changing load
  - Both load and hours of operation are reduced
- Who assumes what risk?
  - ESCO may assume equipment performance risk and Customer may assume operation hours risk
- Cost vs. Accuracy

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Option A:
Partially Measured Retrofit Isolation

- Savings determined by partial field measurement of the energy use of ECM
- Separate from the whole facility energy use
- Measurement is either short-term or continuous
- Partial measurement means SOME but not all parameters may be “stipulated”
- Stipulated parameters must not contribute significantly to overall error in calculations

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Option A:
Partially Measured Retrofit Isolation

- Stipulate - “to make an agreement or covenant to do or forbear something”
- In M&V - to stipulate a parameter is to hold its value constant regardless of what the actual parameter does during the contract term
- Stipulated values must be based on reliable, documented and traceable sources of information
- Direct stipulation of energy savings are not allowed

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Option A:
Partially Measured Retrofit Isolation

- Engineering Calculations
  - Spot measurements of performance factors
  - Short-term metering to develop stipulated operation
    - Trend logs off EMS
    - Portable data loggers

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Option A:
Partially Measured Retrofit Isolation

- Verification of performance factors - “potential to perform”
  - Pre- and post-installation lighting kW
  - Pre- and post-installation chiller COP
- Long-term savings based on “stipulations”
  - Lighting runtime
  - Cooling load ton-hours or $kW_{thermal}$-hours

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Option A:
Partially Measured Retrofit Isolation

- Stipulated savings appropriate when:
  - Customer willing to accept some risk
  - Customer has experience with similar projects
  - ECM has high probability of success
  - Measure contributes a small percentage to overall project savings or to the overall uncertainty
  - Cost of monitoring not justify by better accuracy
  - Stipulated parameters do not significantly contribute to overall uncertainty

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Option A:
Partially Measured Retrofit Isolation

- Stipulated parameters should come from:
  - Engineering analysis
  - Actual measurements and monitoring
  - Manufacturer's data or standard tables/curves
  - Industry-accepted performance curves such as ANSI, ARI, ASHRAE
  - TMY weather data
  - Utility records or EMCS
  - Observations of building or occupant behavior
  - Facility operation and maintenance logs

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Option A:
Partially Measured Retrofit Isolation

- Stipulated parameters should NOT come from:
  - Undocumented assumptions or “rules-of-thumb”
  - Proprietary “black-box”, or other undocumented software
  - Handshake agreements with no supporting information
  - Guesses at operating parameters
  - Equations that do not make mathematical sense or are derived from questionable data
- Always exceptions to any rule but must use sound engineering judgment

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Option A - Best Applications

- Can isolate systems using ECMs
- Interactions with other equipment not significant or can be measured
- Want to avoid difficult future baseline adjustments
- Variables not complex or difficult/expensive to monitor
- Sub-metering already exists
- Can use metering equipment for other purposes
- Continued effectiveness of ECM can be assessed by routine visual inspection of stipulated parameters
- Uncertainty is acceptable

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OEMC Recommendations for Use of Option A

- Lighting
  - Use fixture wattages pre and post-retrofit from Xcel or EPRI lighting tables
  - Measurement of hours of operation using statistically significant sampling - 80% confidence/20% error (max sample size is 11) - Use results of monitoring - not assumed hours if measured are above 95%.
- Motors (fans and pumps)
  - When constant load w/ predictable hours (i.e. 24 hour/day)
  - Measure pre and post kW
- Water
  - Assume flushes/use per day (only if very conservative and water bills underestimated by 25%)
  - Measure pre and post flow on sampling basis (80%/20%)

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Option B: Retrofit Isolation

- Savings determined by field measurement of the energy use of ECM
- Separate from the whole facility energy use
- Measurement is either short-term or continuous
- No parameters may be “stipulated”

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Option B: Retrofit Isolation

- Engineering calculations
- End-use data analysis for baseline
- Long-term metering post-installation of actual energy consumption
- Requires less commissioning and post-installation inspection since performance is measured.

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Option B: Retrofit Isolation

- Measurement of pre-installation performance factors
  - Lighting kW
  - Chiller COP (kW/ton curve)
  - Motor efficiency
- Short or long-term measurement of performance factors AND load
  - Lighting runtime and spot kW or continuous kW
  - Cooling load ton-hours and kW/ton curve or continuous kW

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Option B - Best Applications

- Can isolate systems using ECMs
- Interactions with other equipment not significant or can be measured
- Want to avoid difficult future baseline adjustments
- Variables not complex or difficult/expensive to monitor
- Sub-metering already exists
- Can use metering equipment for other purposes
- Measurement of parameters is less costly than other options

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OEMC Recommendations for Use of Option B

- Chillers
  - Use short term monitoring to develop chiller efficiency (kW/ton) vs. outdoor weather (dry bulb temp or enthalpy)
  - Measure actual chiller consumption and adjust baseline for actual weather
- VSD
  - Use short term monitoring to determine baseline energy use vs. time (schedule) or use
  - Measure actual VSD power consumption and adjust baseline for actual use conditions
- Economizers or reset
  - Use short term monitoring to establish baseline conditions (i.e. no economizer or reset)
  - Measure actual cooling delivered by economizer or hours of reset

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OEMC Recommendations for Use of Option B

- Use EMS system for long term monitoring and calculation of savings
- Monthly review of results ensures not only complete data collection but functioning of EMS system
- Train operators to monitor and print reports or automatic report generation by EMS system

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Option C: Whole Facility

- Savings determined by measuring energy use at whole facility
- Measurement is either short-term or continuous throughout the post-retrofit period
- Use current year and historical utility meter or sub-meter data (12, 24 or 36 months)
- Billing analysis using simple comparison or regression analysis methods

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Option C: Whole Facility

- Assesses the impact of any ECM but not individually if more than one is used
- Determines the collective savings of all ECMs applied to area served by utility meter
- Good for use where there is high degree of interaction between measures
- Best where impacts on total utility bill are large compared to normal bill variations

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Option C: Whole Facility

- Energy savings = Baseline energy bill - post-retrofit period energy bill +/- adjustments
- Adjustment term calculated by developing a valid model of base year energy use correlated to independent variables:
  - Weather - degree days (appropriate base temp.)
  - Occupancy - weekday/weekend - summer/winter
  - Usage - special events
  - Production - lbs/tons of product, units of product

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Option C - Best Applications

- Energy performance of whole facility to be assessed
- Many different types of ECMs in one building
- ECMs cannot be easily isolated (operations, windows)
- Large enough savings
- Interaction between ECMs complex
- Major future changes to facility not expected
- Good correlations between energy use and independent variables (good R^2, CV)

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OEMC Recommendations for Use of Option C

- Boiler retrofits
  - Must establish good regression during Audit!
- Gas measures
- Water measures

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Option D: Calibrated Simulation

- Savings determined by simulation of the energy use of components or the whole facility
- Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility
- Requires considerable skill in calibrated simulation

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Option D: Calibrated Simulation

- Energy use simulation calibrated with hourly or monthly utility billing data or end-use metering
- Simulation used to predict pre and/or post retrofit energy consumption
- Can assess all ECMs implemented but multiple computer runs may be required
- Can be used to assess only one ECM but monitored data for calibration must be available

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Option D: Calibrated Simulation

- May require 2 sets of weather data
  - Weather data corresponding to same time period as calibration data
  - Long-term average weather data
- Requires multiple simulations and adjustments of independent variables to calibrate to measured data

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Option D - Best Applications

- Either base-year or post-retrofit energy data is unavailable or unreliable
- Too many ECMs to assess using Option A or B
- ECMs involve diffuse activities which cannot be easily isolated from the rest of the facility (operator training or wall and window upgrades)
- Want to assess individual ECMs but Option A or B to costly
- ECM interactions complex or difficult to measure
- Major changes in facility usage are expected
- Adequate budget and experience available

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OEMC Recommendations for Use of Option D

- Master meter applications (campus)
  - Must establish good calibration with short term metering data
  - Baseline established by simulation, post retrofit energy consumption measured

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OEMC Contract Guidelines

- Baseline will be established as part of the audit (M&V approach identified before audit complete) This ensures time for short or long term monitoring
- Baseline will be included in the Contract (Schedule E)
- Contract should contain all pre installation data used in calculations and forms for post installation data collection.
- All equations for savings calculations will be included in long form (not spreadsheets with “blind cell” calculations)
- Utility rates will be clearly identified

Assume an energy professional unrelated to the project was calculating the savings for the first time using only the contract documents and instructions on what post installation data to collect and how it is to be collected

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