



# Better Buildings

U.S. DEPARTMENT OF ENERGY

## Energy Savings Performance Contracting Measurement and Verification

# Merging Fact into Fiction

M&V trends in federal ESPC, 20 years later

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- **Too much reliance on Option A**
  - 67% of ECMs in FEMP IDIQ ('98-'13)
  - Even on complex measures (controls, chillers, etc.)
- **Vague measurement commitments**
  - Lots of “monitoring” and “trending” without real measurements
  - “The first thing I ask myself when I review these plans is ‘how could the ESCO fail?’ If there’s no answer, there’s a problem.” (John Shonder, Oak Ridge N. L.)
- **Other dubious practices**
  - E.g., simulation w/out calibration ... and called Option A???

- **Some agencies (inc. VA and some GSA regions) ceased all ESPC for long periods**
  - “We just don’t believe in them.”
- **Some instituted tight controls, stifling quantity and quality**
  - 3<sup>rd</sup>-party audits as basis for projects
  - Selection by preliminary assessment (from multiple ESCOs) – and no changes allowed
  - Only large infrastructure projects – no lighting, motors, etc.

- **Is IPMVP the problem?**
  - No, but maybe it's "necessary but insufficient"
  - Just a menu – it doesn't tell you what you'll like or how it should be prepared
- **Trend: IPMVP, but with direction**
  - Which option is appropriate for which ECMs?
  - How long should measurements be taken?

- **Guidance from M&V working group of Federal ESPC Steering Committee (FESC)**
  - Two-page document with seven principles
- **GSA’s “National Deep Energy Retrofit” pilot program (and other GSA projects)**
  - Two of eight NDER projects used Option C, as well as another GSA ESPC (cf. 7% for FEMP IDIQ contract, ‘98-’13)
- **FEMP M&V Guidelines v. 4.0 (Fall, ‘15?)**
  - Consistent with IPMVP, but clear direction on appropriate use of options

- **Premises**
  - Low confidence in fed. ESPC M&V
  - More M&V guidance and review warranted
  - Improvements should balance rigor with cost
- **Key provisions**
  - Option A okay in limited circumstances but measurements should continue if ECM's performance likely to vary over time
  - Option C preferred when majority of energy use addressed or ECMs highly interactive
    - But switch to another option after few years okay
  - Option B best w/ less usage and when ECM can be isolated

- **GSA HQ attempt to re-engage w/ ESPC**
  - Past (late-'90s/early-'00s): ESPC disappointments
    - Low savings, O&M problems, etc.
  - But agency told not to expect conventional funds
- **Key features of pilot**
  - Project mgmt. by central office
  - Strong push for deep savings
  - Clear signal that M&V had to be legitimate
- **Results**
  - Avg. 38% savings (cf. 19% in recent gov't. sample)
  - Option C in 2/8, but for short-term (2-3 yrs.)
    - Almost no Option A (cf. 67% across FEMP IDIQ)



- **Effort to streamline**
  - 40% shorter than v. 3.0: succinct
  - Elimination of sections covered elsewhere
    - E.g., gov't. witnessing guidance
- **Guidance enhancements/changes**
  - **Strengthening of Option A**
    - Default is annual measurement *throughout* term
  - **Plan outlines for 21 diff. ECMs**
    - From lighting to renewables to TES
- ***Big* opportunity to influence field practice**
  - **But must be promoted well ... and enforced**

- **M&V on federal ESPC has been weakness**
  - And turned off some federal customers
- **Some agencies giving ESPC a new look**
  - Partly b/c they can't get energy project appropriations
- **And M&V thinking is turning corner**
  - Key theme: IPMVP options, but w/ more direction
  - Key breakthrough: new FEMP Guidelines (v. 4.0)
- **This should lead to increased savings realization and persistence ...**
  - ... and help credibility of ESPC

# **Measurement and Monitoring of Building Equipment Performance**

**Better Buildings Summit, May 2015  
Washington, D.C.  
Dave Birr, President  
Synchronous Energy Solutions, Inc.**

# Measurement and Monitoring of Equipment Performance

- **Automatic Alarms for Performance Feedback**
- **Monitoring Based Commissioning**
- **Equipment Root Cause Failure Analysis**
- **Commissioning the Design of Control Systems**
- **Systems Approach to Building Performance**
- **Strategy for High Performance Buildings**

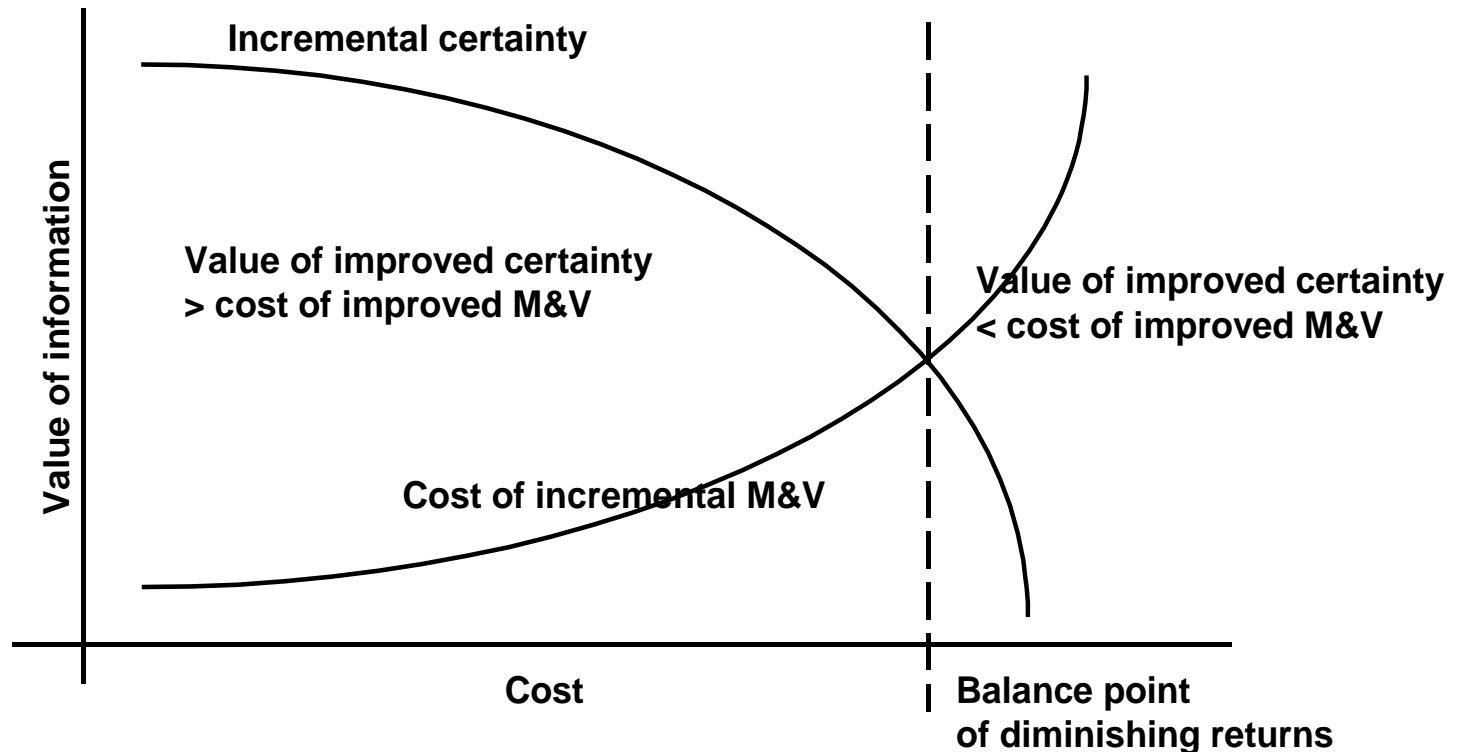
# Baseline Operating Conditions

- Measurements where use rates may change over time (VFD controlled loads, multi-level switching, temperature setbacks)
- Operating hours – Data loggers and field observations to correct building operator reports
- Adequate, accurate documentation and measurement of current equipment operating conditions, sizes, loads and schedules
- Existing lighting levels, ventilation rates, temperature set points and any proposed changes to building comfort service levels
- Seasonality matters for accurate heating and cooling efficiency measurement. Plan your audit schedule

# Why Individual End-Use Equipment is Measured

- Isolates affected end-use from total building meter for more accurate savings calculations
- Quantifies parameters for engineering calculations and simulation models (e.g., temperatures, run times, control settings)
- Provides equipment operation diagnostic data
- Corrects catalog data estimates, which can vary by application, design, quality of installation and control

# How Much M&V is Enough?



# Key Findings In Savings Uncertainty Analysis

- Properly defining measurement baselines is critical and should be discussed before signing the audit contract so correct data is collected
- Dedicated and independent ESCO M&V team should collect accurate data for key performance parameters :
  - ◆ quantify existing operations accurately
  - ◆ trend log data for HVAC system operation
  - ◆ efficiency tests for chiller and boiler systems
  - ◆ data loggers for estimating operating hours



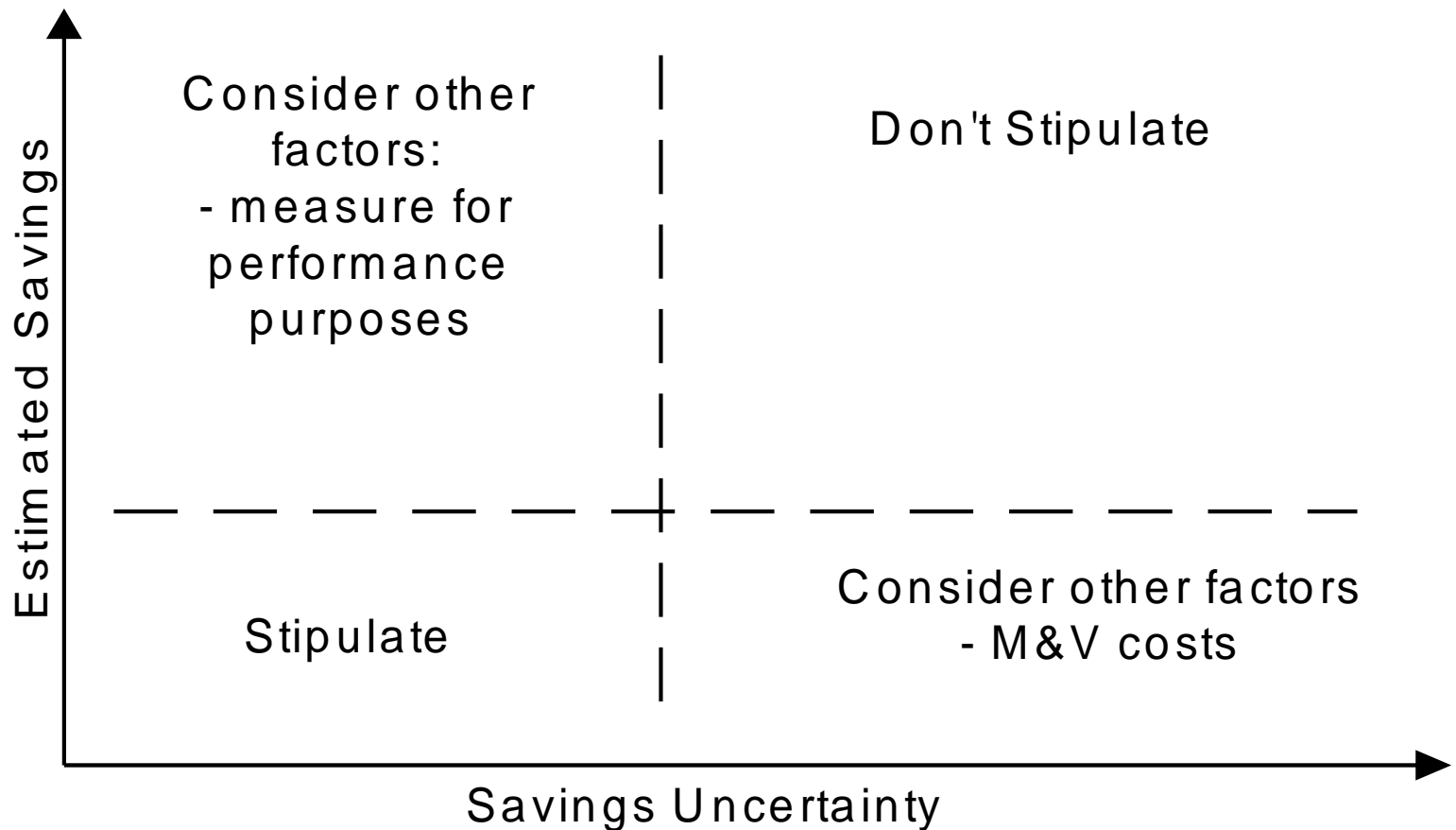
# Project Performance Factors

- High quality well planned audit
- Equipment selection fits functional requirements
- Project construction and commissioning
- Effective operations and maintenance

**M&V can not eliminate  
all project performance risks**

# Is Stipulation Appropriate

- Stipulating savings vs. stipulating specific parameters
- Reality: M&V costs money. If money was not an issue, no need to consider stipulation



# Using Engineering Savings Estimates

## Appropriate:

- Project savings are small
- High quality engineering data is available
- Cost of measurement is very high
- Sophisticated customer understands risks
- ECM has high probability of performing properly

## Inappropriate:

- Project savings are large
- Project performance variables have high uncertainty
- Estimates shift excessive performance risk to customer
- Savings are highly dependent on proper functioning of controls
- Customer needs to verify a specific reduction in a budgeted cost

# Project M&V Maintaining Data Quality

- More accuracy is required for diagnostics on equipment performance than for day-to-day equipment control
- Sensors fail, are inaccurate and lack calibration
  - Specify how devices will be calibrated and the frequency of calibration
- High quality sensors have lower lifecycle costs

# Using Data for Calculating Savings

- Turn data into useful information
- Specify how measurements or calculated data will be used in building modeling to account for interactive effects
- Define spreadsheet calculations in adequate detail
- Specify time intervals for measurements and calculations
  - Trend log and metered data allows building operators to spot operational problems and correct maintenance issues
- Specify standard format for written reports

# Evolution of Measurement and Verification Methods

- **Score Keeping, Utility Bills and Guarantees ( Old Way)**
- **Equipment Savings Performance and Building System Optimization (New Way)**
- **Convergence of Monitoring Based Commissioning and M&V**
- **Falling cost to acquire and analyze data makes detailed equipment monitoring cost effective**
- **Quantifying operation and maintenance savings becomes a significant focus for many projects**
- **Quantifying environmental benefits becomes important because emissions reductions can be monetized**

# Why Monitoring Based Commissioning

- To optimize the operation of existing systems
- To improve building comfort within the capabilities of the installed system
- To maximize energy savings over time
- To insure proper air ventilation and distribution
- To reduce operational and maintenance costs
- Train building operators on optimizing system performance

## ***Monitoring Based Commissioning:***

- **Provides feedback to building operators on how specific equipment is functioning**
- **It allows them to formalize operational procedures that optimize control**
- **Helps document the energy savings and proper equipment operation over time**
- **Provides on-going alarm monitoring and diagnostics on system operation**



# Monitoring Based Commissioning *(continued)*

- Extends equipment life
- Reveals additional cost savings
- Strengthens operational understanding
- Can justify funding to improve equipment
- Performance based business model
- Provides credible building performance data
- Reduces functional equipment failure risk

**Only dynamic monitoring provides long-term performance visibility.**

# Monitoring Benefits

- **Continuous and effective monitoring is the key to creating persistent quality performance and savings**
- **Building operators and ESCOs need timely and focused performance data which allows them to rapidly identify and correct system performance problems**
- **Monitoring provides incentives for optimizing operations and maintenance, and documenting system performance. Everyone is more careful when they know results are monitored and there is accountability for equipment performance over time**

# New Monitoring and Control Technologies

- Low cost monitoring equipment
- Wireless Controls
- Energy Information Systems/Dashboards
- More sophisticated trend logging capability
- Cloud based monitoring and analytics

# DDC Systems Commissioning

- **Most DDC systems do not operate as designed because of:**
  - ◆ **Poor design**
  - ◆ **Insufficient commissioning start up documentation**
  - ◆ **Little or no long-term tuning**
  - ◆ **Low quality sensors**
  - ◆ **Poor program writing or loading**
  - ◆ **No optimization for efficiency by trending to diagnose and tune**
  - ◆ **Poor sensor location**
  - ◆ **Low quality installation due to low bid**

# DDC Project Performance Factors

- Does the integration logic of the software layer of the control system sequence of operations work?
- Does your operational control spec include ventilation, comfort, hardware, points, control strategies and acceptance testing?
- Does the system provide effective and reliable control?

**Catch and correct errors before they get built into the project**

# DDC Implementation Challenges

- ◆ Fees for system design are dropping
- ◆ Controls manufacturers do not provide enough training and documentation
- ◆ Equipment level protocols are not standard
- ◆ Using gateways for integrating legacy systems is complicated
- ◆ Sequence of operations and points lists are under specified or altered during implementation
- ◆ Control technicians do not get efficiency

# Strategy for High Performance Buildings

## ■ Focus on Performance Goals

- ◆ focus data collection on high value results
  - ◆ management buy in to high performance
  - ◆ well trained staff with comprehensive systems understanding of performance
  - ◆ view building operation as a learning cycle
  - ◆ increase the speed and frequency of relevant feedback with adequate trending requirements and data storage
  - ◆ monitoring based commissioning
- Optimize over time!**

# High Performance Systems

- What do you need for high performance?
  - ◆ Reliable monitored data
  - ◆ Easy to understand relevant graphic data
  - ◆ Trained building operators
  - ◆ Prompt issue identification and resolution
  - ◆ Expert support for building operators
  - ◆ Monitoring based commissioning to catch mechanical failures which the control system might compensate for with suboptimal control changes

**CLOSE THE FEEDBACK LOOP**



# Information Monitoring and Diagnostic System

- Data acquisition system (measure/record)
- High quality sensors ( operating parameters)
- Data visualization tools (analyze)
- Capture synergy between monitoring based commissioning and maintenance
- Frequent trend data with adequate storage
- Automated diagnostic software allows you to find and fix problems quickly (optimize)

# Support for Building Operations and Maintenance

- **More extensive use of Monitoring Based Commissioning in conjunction with Measurement and Verification**
- **More comprehensive condition based maintenance services**
- **Computerized Maintenance Management Software and Services**

# Quality Training Reduces Problems

- 30-50% of maintenance failures are due to a lack of maintenance knowledge by staff
- 20-30% of failures come from staff not following best maintenance practices
- Over 90% of maintenance staffs lack fundamental knowledge of how to optimize or tune building operation over time
- Due to the aging of the baby boomer generation it is estimated that there will be a loss of 40-70% of existing maintenance personnel