INVESTOR CONFIDENCE PROJECT

ENERGY EFFICIENCY PROJECT FRAMEWORK

ENERGY EFFICIENCY PERFORMANCE PROTOCOL

LARGE COMMERCIAL

Protocol Contents

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INVESTOR CONFIDENCE PROJECT

The Investor Confidence Project was developed by the Environmental Defense Fund with participation from leading industry and engineering experts. It establishes an Energy Efficiency Project Framework (EEPF) that defines the key elements of a successful energy efficiency retrofit and is designed to house a series of sector-specific Energy Efficiency Performance Protocols (EEPP) that define best practice engineering protocols for energy efficiency projects, in order to provide for more stable, predictable and reliable savings outcomes and to enable greater private investment through a more efficient transparent marketplace.

Through adoption as a standard approach by market actors, these Energy Efficiency Performance Protocols will help to encourage deal flow and market efficiencies by enabling networks of project originators, such as engineering firms, facility managers, and portfolio owners, to develop potential energy efficiency projects and bring those projects to a marketplace of energy service companies, insurers, financial institutions, and utility programs without requiring repetitive and expensive additional engineering steps. The output of project development in accordance with a Protocol is a set of standard engineering documents (similar to an appraisal package), which will allow market entities to dramatically streamline project underwriting processes related to project performance.

Over time, the ICP Energy Efficiency Project Framework makes possible an actuarial data-set with sufficient detail to provide insight into project performance risk, and the ability to manage that risk based on the multitude of factors throughout the project workflow, ranging from initial audit to ongoing operations and maintenance.

LARGE COMMERCIAL ENERGY EFFICINECY PERFORMANCE PROTOCOL

This protocol focuses on large commercial buildings (EEPP-LC), which are among the most energy use-intensive structures and because they tend to exhibit relatively consistent usage patterns. The protocols are intended for:

- **Large Buildings**, where the cost of improvements and size of savings justifies greater time and effort in pre- and post- development energy analysis
- **Whole Building Retrofits**, projects that involve multiple measures with interactive effects rather than a single piece of equipment
- **High Performing Projects,** projects with sufficient depth necessary for pre- and post-retrofit meter data yields (i.e., savings can be anticipated to be of greater magnitude than noise)

Even with these qualifications, the EEPP-LC Protocols will not be appropriate for every building. The protocols elaborated here lean heavily toward a whole building metered pre- and post- retrofit data-driven (IPMVP Option C-type) approach as the most valid, reliable option. However, such an approach may not be appropriate for buildings that do not have relatively stable fundamental usage patterns – e.g., buildings that are characterized by large and frequent changes in the type of space use, unpredictable and inconsistent schedules. In such cases, alternative methods not covered here may be required.

The Energy Efficiency Performance Protocols are intended as base minimum requirements for an investment quality analysis and activities to maintain and validate that low level of energy usage, not an exhaustive treatment of all possible techniques. Each section of the document establishes these minimum requirements and offers additional methods and tools that can be used to improve the reliability of savings estimation and measurement. Until the protocols have been applied and tested, it is not possible to gauge the magnitude of the impact of these additional processes and tools on the confidence interval around savings projection. A checklist provided as part of this document is intended for inclusion in project documents. Engineers are asked to self-certify that they have fulfilled the requirements listed and to indicate what additional methods they applied.

This document will evolve over time. Some methods may move from an “additional” or “recommended” category to a standard requirement. Others may prove insignificant for accuracy of projections relative to the time and effort they require. Members of the ICP invite engineers, landlords, software developers, prospective lenders and investors, and others to participate in testing and improving these protocols by applying them to retrofit projects and sharing their results.

As results justify and resources allow, the ICP will expand to develop protocols for additional building types and use cases.

ENERGY EFFICIENCY PROJECT FRAMEWORK

The EEPP Framework is divided into five categories, which together are designed to represent the entire lifecycle of a well-conceived and well-executed energy efficiency project:

1. Baselining
    a. Core Requirements
    b. Rate Analysis, Demand, Load Profile, Interval Data
2. Savings Projections
3. Design, Construction, Commissioning
4. Ongoing Commissioning
5. Measurement and Verification (M&V)

For each category, the protocol establishes minimum requirements, including:

- Required Elements
- Required Procedures
- Required Documentation

BASELINING – CORE REQUIREMENTS

A sound energy usage baseline is the starting point for accurate projection of potential energy savings as well as for measurement after retrofits and/or retro-commissioning. A baseline should indicate how much fuel and electricity a building can be expected to use in a day given heating and cooling conditions and occupancy of the building (and potentially other influential factors).

REQUIRED ELEMENTS

- **Historical Energy Usage**: 14 months of energy usage data for all fuels across all meters in the building, from which a 12-month period will be selected as the basis for all analysis.
- **Weather Data**: National Weather Service Daily Min / Max weather data from the closest weather station for a period coinciding with the energy usage data, to be used to derive an average temperature for each day.
- **Occupancy Data**: For the same period, including vacancy rate, space uses and operating schedules, following BEPA / ASTM International WK 24707 process for Building Performance Assessment and Disclosure. Operating schedules should describe regular working days, weekends and holiday days, and overtime provisions.
- **Building Asset Data**: Accurate conditioned square footage and system and material specifications based on building drawings, a field survey or CAD take-offs, following BEPA / ASTM International WK 24707 process for Building Performance Assessment and Disclosure.
- **Accuracy**: Achieve an appropriate goodness of fit of energy data variability to independent variables, following ASHRAE Guideline 14. Adjusted R^2 value should be at least 0.75 and a CV[RMSE] should be less than 0.2.

REQUIRED PROCEDURES

1. Gather energy and independent variable data. Identify which independent variables are considered the most important, based on the building type and space uses.
2. Normalize to same time interval.
3. Develop baseline regression model using the ASHRAE Inverse Modeling Toolkit and following ASHRAE Guideline 14.
4. Perform model sufficiency test.
5. Identify any factors apart from weather and occupancy that affect the baseline more than expected savings (in percentage) and by roughly what magnitude.
6. Create a list of specific routine adjustment factors to be applied in a future measurement and verification process, noting also the types of potential non-routine adjustments that may be required.

REQUIRED DOCUMENTATION

- Weather data (containing average daily temperature data for site as described above)
- Full Energy data as a computer-readable file, including:
  - Meter reading, from date to date, in energy-unit value, energy usage charges ($), demand quantities and demand charges ($).
  - Dataset should cover all forms of purchased energy and energy produced on-site.
  - Readings for all energy sources must be consolidated to a set of 12 monthly periods common for all energy sources.
  - Actual dates should be provided in the record along with a brief description of how periods are consolidated to the 12 monthly periods applied. Dates of meter reading periods will vary from one energy source to another.
  - Landlord's rent roll (showing occupancy and lease dates) for the relevant period and description of types of space use by tenants. (Note particularly energy-intensive uses including restaurants and data centers.)
- Building drawings, field survey results and/or CAD take-offs.
- Utility rate structure as published by the utility and the commodity provider (if the two are separate) with a breakdown of distribution costs, commodity costs, demand charges, and taxes as well as any time-of-day variability in each of these elements. Statement of how the facility currently purchases energy is included in the next section.

Optional:

- Three years of energy usage, weather, occupancy and other building use data.
- Interval data used for review of daily consumption and demand profiles, compiled to daily totals.
- Sub-metering data, including heating and cooling equipment and other major pieces of equipment.
- On-site weather data coincident with the metered utility data.
- Copies of most recent calibration certificates for all utility meters, stating the standards to which they are calibrated.

BASELINING - RATE ANALYSIS, DEMAND, LOAD PROFILE, INTERVAL DATA

Depending upon the location of the building in question, the time of day at which energy is saved can have a significant impact on the dollar value of the savings achieved. Where demand charges are in effect or where rates for on-peak electric usage, load profiles must be provided to show the pattern of daily demand. An annual electrical load profile must be constructed for peak demand (KW) as recorded and billed by the utility. Rates that include Ratchet provisions must be identified. The same procedure must be followed for any other energy source that is sold with a peak demand charge separate from energy usage.

REQUIRED ELEMENTS

- **Energy Purchasing**: Description of how the facility is purchasing energy and the pricing that applies to distribution, commodity, peak and off-peak energy.
- **Load Profile**: Annual load profile showing monthly consumption and peak demand.
- **Peak Usage**: Graphic presentation of peak usage if interval data is available.
- **Time-of-Use**: Time-of-use summary by month if the site is under a time-of-use or real-time rate.

REQUIRED PROCEDURES

1. Establish monthly peak demand and pricing based upon the monthly bills.
2. Chart average daily demand in 15-minute intervals (larger intervals if 15-minute is not available) with time on the x axis and kW (or MMBTU as appropriate) on the y axis for typical weekday and weekend days in the spring, fall, winter, and summer.

REQUIRED DOCUMENTATION

- Copies of at least one bill for electricity and each fuel including the description of the rate class. Copies of commodity purchase contracts and/or utility rate sheets or relevant language therefrom describing peak and off-peak rates, demand charges, time periods, seasonality.
- 12 months of interval meter data for the relevant fuels (if interval metering exists), provided in spreadsheet format.

Optional

- Monthly consumption load profile for each energy type .
- Multi-year, year-over-year plotting of demand by energy type.

SAVINGS CALCULATION

Savings calculations for projects of the scale anticipated must be based on a calibrated building simulation model that meets the procedural requirements outlined in this section and by referenced documents. Once the simulation model is established and calibrated, iterative runs are conducted for individual measures. The total package of all measures must be run together for the final projection of package energy reductions.

REQUIRED ELEMENTS

- **Software**: Application of public domain or commercially available, software that meets the current ASHRAE Std 140 for 8760 hour annual simulation of building energy usage. (Manual calculation and custom spreadsheets are not acceptable).
- **Credentials**: Simulation development by an individual with either

  (1) ASHRAE BEMP certification, or

  (2) AEE BESA certification plus fulfillment of the ASHRAE BEMP eligibility requirements (as set forth in the ASHRAE BEMP Guidebook)
- **Model Data**: Disclosure and description of inputs/outputs from any companion tools (e.g. load calculators, field testing) used to create inputs for the simulation.
- **Model Calibration**: Model calibration such that model outputs for each energy type match monthly utility bills to within acceptable tolerances.
- **Modeling Process Description**: Sufficient description of the modeling process such that (with the necessary input files) a reviewer can reconstruct the simulation. This description should include adjustments made for calibration. Modelers must document how they handle non-ideal operation, malfunctioning systems, large multi-story interior spaces, stack effect for tall buildings, shading effects from surrounding buildings, and known microclimate effects.
- **Reporting**: Use of an industry-accepted format for reporting of results and for compilation of methods and underlying data.

REQUIRED PROCEDURES

Step 1. **Inform model input values** with on-site observations and measured data.

a) Prepare input files in a readily readable and usable form based on building documentation from plans, equipment schedules, and field confirmations, observations and tests.

b) Where inputs must assign efficiencies, rates, and other values that are not readily measurable, the basis of such assignments must be clearly stated.

c) Identify equipment part-load profiles, operating conditions and associated efficiencies.

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Deleted: at least five years of experience with energy efficiency project analysis and the software tool utilized. Acceptable certifications as a building energy modeler are from ASHRAE or AEE.

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d) Confirm operating schedules for seasonal variations, zone variations, overtime usage, cleaning schedules and practices.

Step 2. **Inform and tune.** Investigate discrepancies between actual billing and modeled results. Dig deeper into areas of greatest discrepancy. Inform changes based on actual building data.

Step 3. **Check calibration criteria** to see whether it is good enough. Repeat Step 2 if calibration criteria are not met.

Below is a table that summarizes criteria and their values. For more detail, refer to FEMP M&V Guidelines version 2.2 and ASHRAE Guideline 14-2012.

Criterion	**Equation***	**Monthly Data**	**Hourly Data**
ERRmonth	100*(M-S)/M	+/- 15%	
Mean ERRmonth	ΣERRmonth/12	+/- 5-10%	+/- 7-10%
CV[RMSEyear]	$(\Sigma[(M-S)^2/12])^{0.5}$	+/- 10%	+/- 30%

*M – measured S – simulated

Step 4. **Use findings to met project objectives and provide added value.**

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Comment [ES1]: Ellen, these are the "procedures" that were in the document prior to my pointing out that we needed a round of changes. I believe they all fit under this Step 1, Inform model input values with on-site observations and measured data, but please let me know if you disagree.

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Comment [ES2]: Ellen, I googled this, hoping to find a link, and what I keep coming up with is FEMP M&V Guidelines for Federal Energy Projects version 3.0. So my question is twofold: First, are these the right guidelines at all – do we think that guidelines for federal projects are appropriate for commercial buildings? (Or is there some other Guildelines document that I'm just failing to find that is not federal government-specific?) And second, if these are the right guidelines, should I be pointing to version 3.0 rather than 2.2?

Comment [EF3]: They excluded the chapter on calibration in v 3.0 thus you need to reference 2.2. If you google FEMP M&V 2.2. you should find the older version.

Comment [ES4]: Ellen, I inserted this whole section manually, but I assume it is in fact superseded by the calibration criteria in the next section, and therefore all of this (the table and the language describing the table) should come out. Is that correct?

Comment [EF5]: Yes, I agree. This section should be excluded since the criteria are covered in the preceeding section.

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Deleted: <#>Prepare input files in a readily readable and usable form based on building documentation from plans, equipment schedules, and field confirmations, observations and tests.¶
<#>Where inputs must assign efficiencies, rates, and other values that are not readily measurable, the basis of such assignments must be clearly stated. ¶
<#>Identify equipment part-load profiles, operating conditions and associated efficiencies. ¶
<#>Confirm operating schedules for seasonal variations, zone variations, overtime usage, cleaning schedules and practices. ¶

Model Calibration

1. Calibration Criteria: The following calibration requirements must be met:
   a) CV[RMSE] +/- 15% (monthly billing period versus simulated utility data) (FEMP 2.2 Guidelines, ASHRAE Guideline 14 2002). Utilities may include electricity, natural gas, fuel oil, central plan chilled water, central plant steam.
   b) Calibrated model must show a reasonable match to baseline monitoring data for major energy end-uses as apparent through graphical visual inspection. Modeler must explain large variations.
   c) Key metrics for the existing building model and the retrofit building model fall within expected ranges. Key metrics and ranges should match those contained in [ ]. If metrics fall outside the expected range, explanatory factors must be identified.
2. Use baseline monitored data to support the calibration of major energy end-uses, systems and equipment.

Comment [EF6]: We had talked about requiring the calibration to use actual weather data that coincides with the utility billing data period. If not used, the reason should be explained and sensitivity studies provided to justify not meeting the requirement. We also talked about requiring the use of 15-minute electrical data be used for the calibration if available from the utility. Were these intentionally excluded?

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Comment [ES7]: Ellen, I assume this is really where the "modeling rules of thumb" fit in, but I don't think this document is the right place to be spearheading brand new rules of thumb, and the workshop page where I'd thought I might find them seems to be MIA right now. Thoughts?

Comment [EF8]: You could reference the original work by Waltz (see http://www.rmi.org/Content/Files/WaltzGuide.pdf) but what's nice about the RMI table is that it gives a sets of metrics for 3 tiers of efficiency. We could post it the table on our website if you think it gives It more credibility.

Deleted: Match modeled results to actual energy use for each energy type as shown on utility and other meters on a monthly basis.

Deleted: Tune the simulation to within 10% difference between modeled and actual monthly usage for a calendar year. ¶
Modeled monthly demand should show daily and weekly load profiles that generally match to within 10% the historical monthly load profile as established from 15-minute interval data but may ignore short duration demand spikes. ¶
Demand spikes or other anomalies (e.g. – high overnight or weekend energy use) that appear during the calibration process should be investigated for possible operational issues that should be corrected. Insofar as such operating conditions are identified, confirmed and quantified, the model can be accepted with calibration tolerance greater than 10% if attributable to such operating conditions.

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Analysis of Energy Conservation Measures (ECMs)

1. Ascertain and record the return on investment criteria of the client, best expressed for simplicity as a simple payback.
2. Prepare a set of ECMs likely to achieve the investment criteria, based on the experience of the engineers involved, landlord preferences, observed condition and operation of existing systems, preliminary modeling, and contractor recommendations.
3. Establish a preliminary cost estimate (see Pricing / Cost Estimation below).
4. Evaluate savings performance and cost effectiveness of each ECM individually. For each ECM provide a table showing the model variables changed and the basis for the change.

   Note: If the simulation model is incapable of assessing a given measure any separate calculations or "work-arounds" must be described and their incorporation into model results explained in detail.
5. Provide a statement of the energy prices used to establish dollar-value of the savings. This conversion should be based on the appropriate local utility rate schedule in effect at the time or, if the facility is purchasing from an independent vendor, the commodity price and the utility distribution schedule of charges. No inflation values should be applied in the analysis. Treatment of demand must be described for each measure
6. Perform a model iteration incorporating all selected measures in order to project the interacted savings of the full package of measures. Confirm that this package meets the Owner and Investor criteria. Confirm the measures to be included in a bid package.
7. Perform a Quality Assurance review of recommended measures and overall projected savings based on experience, reasonability, and specific comparables.
8. Bid out ECMs and finalize model-based analysis and recommendations based upon pricing from bids received.

9. Prepare a final report in an industry-standard format summarizing ECM's and compiling all required supporting data. At present, the industry standard for report presentation of ECM, building, and energy use data is the ASHRAE Guide for Commercial Building Energy Audits.

Comment [EF9]: I wasn't aware that this was going to be given as the industry standard (I should review – it sounds helpful). This guide may only be available through purchase. Does that matter. Are the documentation requirements clearly defined?

Pricing / Cost Estimation

The final investment-grade package must have pricing based upon bids that represent the price for which a contractor has committed to make the improvements.

That pricing will not be available for the modeling runs. The modeler should utilize cost estimates based upon the engineer's experience with previous projects, detailed conceptual estimates, R.S. Means estimation, general contractor quotes or other sources. Estimates so developed can be used to rank order improvements and determine those for inclusion in a final bid package. Cost estimates at the modeling phase must include:

Comment [EF10]: There are two items in my notes regarding payback analysis that I don't see below. They include 1) determining EEM costs as an incremental cost to a planned/needed system/equipment replacement and 2) in the last bullet for LCCA providing some guidance when LCCA would be beneficial. I can come up with a list of this if need be.

- A construction feasibility review indicating what has to be done, that it can be done, impacts on the facility, access points for bringing in any large equipment, major removals (demolition) necessary, and environmental issues (i.e., asbestos, other hazardous materials).
- Categories and multiple line items for all necessary trades, i.e., civil (structural and site work, demolition, rigging), mechanical, plumbing, electrical, architectural (finishes), environmental (hazardous mat mitigation), provision of temporary services as necessary. Trade categories should be backed up by underlying lists or spreadsheets with major pieces of equipment.
- All lines by trade should include labor and materials. "Labor" can be by budgetary allowance rather than hours and hourly rates but should state expressly whether or not job must be union or requires prevailing wage.
- Line items for professional fees, contractor O&P, and contingency. These are percentages of the total from above.

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Lifecycle Cost Analysis (LCCA) is not required, but may be included where benefits of the proposed retrofit other than energy cost savings are of interest.

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Quality Assurance Process

1. Compare model outcomes to comparable projects. Assess that outcomes are consistent with comparables. If not consistent with comparables, provide reasons why the project under consideration is different.
2. Compare model outcomes with experience-based guidelines of reasonability, for individual measures and for the project as a whole. These guidelines should be expressed in terms of savings as a percentage of building energy use and system-level usage.

REQUIRED DOCUMENTATION

- The project report documentation must demonstrate that the calibration criteria are met.
- Documentation should include all factors that were considered to create the calibrated model.
- Specific documentation requirements include, without limitation:

- Simulation Model Input file.
- Weather file that was used for simulation.
- Scope of work upon which Bid Packages are based.
- Bid packages.
- Bids by trade with the breakouts described in pricing (above).
- A quality assurance statement indicating the findings of a review of modeled results against project comparable and guidelines of reasonability for savings as a percentage of energy use.

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DESIGN, CONSTRUCTION AND COMMISSIONING

The design and construction team must commit to realize the intent of the energy audit recommendations accepted by the Project Owner. That this commitment is met will be part of the project's commissioning (Cx).

New retro-fitted systems must be commissioned to ensure that

1. The installation conforms to what was intended and specified.
2. The equipment and systems are operating correctly, as specified, demonstrated by tests.
3. System documentation has been provided and operators have been trained.

There are various industry standards that adequately define the new-construction commissioning process that should be applied to new retrofitted systems. Acceptable references include ASHRAE Guideline 0/1, Building Commissioning Association, and the CA Commissioning Collaborative. The project must select one such acceptable industry guideline and design and perform commissioning consistent with that guideline.

REQUIRED ELEMENTS

- **Commissioning Plan**: a commissioning plan shall be specified for all new systems and/or major pieces of equipment in the project. The Cx Plan should follow the guidance of one of the referenced acceptable industry guidelines. The Cx Plan will define all of the detailed Cx procedures and tests to be performed.
- **Cx Authority**: Appointment of a qualified Cx Authority who will act as the manager of the commissioning process. The Cx Authority must be brought onto the design team at an early phase of design and have a defined, actively involved role throughout the design and construction process.
- **Design and Construction**: The Cx Authority must assure that the project as designed and constructed conforms to the intent and scope of the energy audit and can be expected to perform as conceived and projected by the energy audit. This may include consultation with the energy audit team, monitoring of submittals and project changes, inspections, re-running of energy models to assess the impact of changes, tests, etc. The Cx Authority must have the responsibility and means of reporting deviations from projected energy savings to the Project Owner.
- **Test Requirements**: System and equipment test requirements must include specific tests that relate to the energy performance of the new systems and/or equipment, conducted over a suitable range of operating (or simulated operating) conditions.
- **Instrumentation**: The Cx Authority should assure that appropriate instrumentation is incorporated into the design to support the On-Going Monitoring aspects of the project.
- **Tracking**: Mechanism for retaining all of the Cx results as part of building documentation.
- **Equipment Documentation**: Full documentation of all new systems and equipment in the form of Operating Manuals, to be prepared following ASHRAE Guideline 4 (or update). In addition, documentation must include monthly target energy budgets and other key performance indicators for the modified building as a whole and down to the level of systems and major equipment.

- **Training**: Training of building operators in operation of the new systems/equipment, including their energy performance targets and key performance indicators.

REQUIRED PROCEDURES

1. Appoint a qualified Cx Authority. The qualification shall be a person who holds industry recognized certifications (ASHRAE, BCA, AEE) in both commissioning and in energy performance/management.
2. Develop a Cx Plan .
3. Execute all procedures and tests called for by the Cx plan.
4. Document all Cx results as part of the building's permanent documentation.
5. Provide full documentation (operating manuals) including energy performance targets for new systems and equipment.
6. Train operators in the correct operation of all new systems and equipment, including meeting energy performance targets.

REQUIRED DOCUMENTATION

- Qualifications of the Cx Authority.
- Full Cx Plan including specific tests and test procedures.
- Statements by the Cx Authority that the project, first as designed and, subsequently, as built conforms with the intent, scope and projected performance of the original energy audit and model projections or, if not, in what way(s) the energy performance projections have been altered.
- Record of Cx results .
- Operating Manuals for all new systems/equipment, including monthly target energy budgets.
- Training materials and record of training.

ONGOING COMMISSIONING

Ongoing commissioning is the practice of systematic monitoring of energy system performance and instituting corrective actions to ensure "in specification" energy performance. (Often referred to as Ongoing Commissioning, Continuous Commissioning, Monitoring-based Commissioning, Performance-based Monitoring, and Building Re-Tuning).

REQUIRED ELEMENTS

- **Performance Indicators**: Establishment of key performance indicators at component and/or system level - the performance bands outside which corrective communication/response will be taken – consistent with achieving close to desired building level energy performance
- **Monitoring**: Identification of points to be monitored by the building management system
- **Operation**: Assignment of responsibilities for communication of performance issues and implementation of corrective actions.

REQUIRED PROCEDURES

1. Select ongoing management regime, either BMS report review by staff, software-based monitoring and alarming, or a combination of the two.
2. Train facility staff and service providers on new equipment, management and monitoring software and reporting regime. Training should incorporate understanding, skills, and procedures necessary to support the commissioning program.
3. Chart the data points to be monitored and their relationship to performance assurance of the new installations.
4. Install and test alarm functions for system malfunctions or substantial deviations.
5. Compare actual performance with savings projections for the same period given adjustment factors on a (minimum) monthly basis.
6. Submit quarterly performance report covering all monitored points including all observed deviations from projected operation, analysis of cause, and corrective actions taken or recommended.

REQUIRED DOCUMENTATION

- Points list for BMS.
- Plan for fault detection and remediation – may be fully automated or a combination of automation and active response by building personnel. The plan should indicate the intervals within which performance will be measured.
- Organizational chart establishing contact information for all personnel involved in ongoing commissioning process and clear internal responsibility for the monitoring and response activities. If ongoing commissioning is outsourced to a third-party provider, the chart must clarify its relationship to the property's operating staff and senior management personnel, reporting processes and responsibilities for corrective action.

- Maintenance plan and service response log, including warranties for any new equipment.
- Training curriculum.

Optional

- Upgrade monthly monitoring, fault detection, correction and system tuning to weekly, daily or real-time.
- Follow-up monitoring to assess effectiveness of actions taken.

MEASUREMENT AND VERIFICATION (M&V)

The following overarching principles should govern any M&V Plan:

- Transparency: all input data, baseline calculations, and variable derivation should be made available to all parties and any authorized reviewers.
- Reproducibility: given the same source data and a description of the adjustment methodology, any competent practitioner should be able to produce identical or nearly identical results.
- Fairness: baseline adjustments should show no meaningful statistical bias toward a positive or negative outcome (however defined, e.g. higher or lower savings).

In general, the methods outlined in ASHRAE Guideline 14 and IPMVP Option C should be followed. Prior to investment decision-making (e.g. as part of contract development and investment due diligence) an M&V Plan for an energy efficiency improvement should be designed to ensure that reliable accounting methods for energy savings are in place.

Standard M&V Method

Quantifying the savings reliably from energy conservation projects requires the comparison of baseline and post-installation energy use normalized to reflect the same set of conditions. The standard method is to utilize the original regression-driven baseline model, applying it to post-installation conditions to represent what the baseline energy use would have been in the absence of an energy conservation program in the building (IPMVP Option C).

Savings are determined by comparison to the baseline energy and post-installation energy use, adjusted to the same set of conditions. The approach requires adjustments to baseline energy use to:

1) *Routine adjustments*: Account for expected changes in energy use, called.

2) N*on-routine adjustments*: Account for unexpected changes in energy use not due to installed ECMs.

Routine adjustments typically include those for changes in weather, occupancy, type of space use, equipment, operating hours, service levels (e.g. a new tenant requires colder air), and utility rates (where the difference in cost and not usage is the desired outcome).

The equation for an adjustment takes the general form:

$$\text{EnergyUsage}_{\text{New}} = \text{EnergyUsage}_{\text{Baseline}} \text{ X Change in Conditions}$$

For example, an engineer may estimate the impact of a change in occupancy on the overall energy usage in a building. The adjustment factor to be applied may come from a whole building simulation that estimates the impact based upon the existing systems and their ability to modulate to respond to higher or lower occupancy. Alternatively it might be derived from a comparison of actual usage data for periods of lower and higher occupancy.

Alternative M&V Method

In certain cases, full annual utility data may not exist, making it impossible to perform M&V under Option C. In such cases (and only in such cases), it may be acceptable to use Option D, Whole Building Simulation.

A third commonly practiced M&V method, Retrofit Isolation, poses difficulties in accounting for the interactive effects that may occur beyond the boundary of the measured (isolated) retrofit. Such interactions may be either positive (increasing building level savings) or negative (decreasing building level savings). Consequently, Retrofit Isolation is not acceptable as a stand-alone M&V methodology under this specification. However, the method is extremely valuable for monitoring and troubleshooting equipment performance. Retrofit isolation can play a role in improving confidence around savings measurement and trouble-shooting performance if savings do not approach projections.

REQUIRED ELEMENTS

- Definition of the baseline period.
- All baseline use and cost parameters (the dependent variables in an adjustment calculation).
- Baseline values of routine adjustment parameters (the independent variables).
- Utility rates applicable to the baseline values.
- List and describe all methods for routine adjustments.
- List and describe all known or expected non-routine adjustments.
- Provide all adjustment parameters and formulae for routing and known or expected non-routing adjustments.
- Define the principles upon which any unknown non-routine adjustments will be based.
- Input data sets, assumptions and calculations to all parties in an efficiency project and any commissioned or independent reviewers.
- Whole-building energy data recorded from building energy meters, recorded as monthly kWh consumption (minimum 12 months), or short time intervals (typ. 15-minute).
- Concurrent period hourly ambient temperatures and other independent variable data identified as significant energy use driver for subject building. Building operation schedules.
- A regression-based energy model built from the collected baseline data. Model types may be averages, simple linear, multiple regression, change-point (ref. ASHRAE RP1050), polynomial, or other type model.
- Model statistics such as number of points, number of operating periods, CV(RMSE), and uncertainty.

REQUIRED PROCEDURES

Comply with applicable sections of IPMVP Option C and ASHRAE Guideline 14.

- Routine Adjustments:
  - See IPMVP Option C and/or ASHRAE Guideline 14.
- Non-Routine Adjustment Procedures:
  - To the extent possible, ongoing commissioning processes should be used to reduce/eliminate the need for non-routine adjustments. Equipment failures and other anomalies should be identified and addressed before non-routine adjustments must be applied. Nevertheless, during the post-installation period, unexpected changes may take place in buildings. For an “apples to apples” comparison with the baseline, the impact of these unexpected changes must be quantified and adjusted for.
- Constant Load:
  - Identify the source of the additional (or removed) load and use a measurement instrument to measure the amount of power consumed. Identify the duration of the increased load and quantify the total additional energy consumed.
  - Install a monitoring device to continuously monitor the additional power. Quantify the additional energy used during the reporting period.
- Variable Load:
  - Identify the source of the additional (or removed) load and use a power monitoring device to measure the amount of power consumed over time. Integrate the power readings over the monitoring period to determine the total amount of additional energy used.
  - When enough post-installation data has been collected, exclude the period of time when a non-routine adjustment must be made. Develop an energy model based on the post-installation period energy and independent variable data. For the duration of the non-routine event, subtract the energy use predicted by the post-installation model from the measured energy use.
  - Add the resulting energy use (positive or negative) of the non-routine adjustment to the adjusted baseline energy model, and quantify the resulting overall savings.

REQUIRED DOCUMENTATION

- Data collected and used in analysis.
- Description of model type and how it was developed.
    - Option C regression model or Option D simulation model.
    - Description of routine adjustments of baseline energy use
- Non-routine adjustments
    - Description of cause or source of unexpected changes.
    - Impact
        - Temporary or permanent.
        - Constant of variable impact.
        - Amount of energy affected.
    - Measurements made to quantify non-routine adjustment.
    - Description of baseline adjustment procedure.

Optional

- Retrofit isolation
- Calibrated simulation

ENGINEERING CERTIFICATION

I hereby certify that the engineering design used in preparation of this application, attachments and supplements were done by me or under my direct supervision.

I further certify to the best of my knowledge that, with respect to the project described herein, the elements listed below have been performed in accordance with the protocols specified as part of the **Energy Efficiency Performance Protocol – Large Commercial**:

- ☐ BASELINING ENERGY USAGE
    - RATE ANALYSIS
    - DEMAND
    - LOAD PROFILE
    - INTERVAL DATA
- ☐ SAVINGS CALCULATION
    - SIMULATION MODELING TO REQUIREMENTS
- ☐ DESIGN, CONSTRUCTION AND COMMISSIONING
- ☐ ON-GOING COMMISSIONING
- ☐ MEASUREMENT AND VERIFICATION
    - M&V METHODOLOGY
    - BASELINE ADJUSTMENT FACTORS IDENTIFIED
    - CONTRACT PROVISIONS FOR M&V

EEPP-LC CERTIFICATION

Name	Firm
Address	Registration / License Number
Phone Number	State
Signature	Date