INVESTOR CONFIDENCE PROJECT

ENERGY PERFORMANCE PROTOCOL

Large Commercial

Version 1.2a – October 2014

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1.0 Investor Confidence Project

The Environmental Defense Fund developed the Investor Confidence Project with participation from leading industry and engineering experts. ICP has established 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 Performance Protocols (EPP) that define best practice engineering protocols while balancing cost-effectiveness 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 Performance Protocols will help to encourage deal flow and market efficiencies by enabling networks of project originators, such as engineering firms, facility managers, contractors, energy service companies 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 Performance Protocols 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.

1.1 ENERGY EFFICIENCY PERFORMANCE PROTOCOL – Large Commercial

This protocol focuses on commercial buildings, 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 typically involve multiple measures with interactive effects
- **High Performing Projects,** projects where the projected energy savings typically cover the project investment cost

Even with these qualifications, the EPP-LC Protocol 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. 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 Performance Protocols are intended as minimum requirements for an investment quality analysis and best practices to maintain, measure and verify the energy savings, 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 sufficient performance data exist for projects following the

ICP Protocols, 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. Providers 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. A scoring system may also be introduced to weigh the importance of different components and provide an overall investment confidence score for potential energy efficiency projects. Members of the ICP invite engineers, building owners, 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.

1.2 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 Calculation**
3. **Design, Construction, and Verification**
4. **Operations, Maintenance, and Monitoring**
5. **Measurement and Verification (M&V)**

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

- **Elements**
- **Procedures**
- **Documentation**

2.0 BASELINING – CORE REQUIREMENTS

A technically sound energy usage baseline provides a critical starting point for accurate projection of potential energy savings as well as for measurement after retrofits and/or retro-commissioning. The baseline must establish how much fuel and electricity a building can be expected to use over a representative 12-month period. It should also factor in the impact of independent variables such as weather, occupancy, and operating hours on the building's energy use.

2.1 ELEMENTS

- **Historical Energy Usage**: Following the ASTM E2797-11 Building Energy Performance Assessment (BEPA) Standard methodology collect 36 months (or a minimum of 14 months of energy usage data when 36 months is unavailable) for all meters and energy accounts for end-uses to be retrofitted in the building, with a goal of accounting for 100% of energy sources to be used as the basis for IPMVP Option C compliant analysis. For non-metered fuel types either install sub-metering, or utilize billing or other usage data to estimate energy use. Note any renovation affecting greater than 10% of gross floor area, or a change that affects estimated total building energy use by greater than 10%, i.e. "major renovation." [PD Sec 4.2.1]
- **Weather Data**: For the defined baseline period, acquire weather data from the closest weather station, or on-site measurement, at the time interval coinciding with the interval of the energy usage. Typically, this will incorporate daily minimum and maximum dry bulb temperatures from the National Weather Service to be used to derive heating and cooling degree days and average daily temperatures for each day. [PD Sec 4.2.3]
- **Occupancy Data**: For the defined baseline period, acquire vacancy rates, space uses and operating schedules, following the ASTM E2797-11 Building Energy Performance Assessment (BEPA) Standard methodology. [PD Sec 4.2.4]
- **Other Independent Variable Data:** For the defined baseline period chosen and as needed for an accurate regression model, acquire other independent variables that significantly affect the energy usage, such as sales or production schedule.
- **Baseline Operational/Performance Data:** System performance data used to inform the energy model. These data need to include a comprehensive data set for all building systems, and can be collected through interviews, review of building documentation (as-built plans, controls sequences, etc.), observation, spot measurements, short-term monitoring, and functional performance tests. [PD Sec 4.2.5]
- **Building Asset Data**: Accurate gross floor area and system and material specifications based on building drawings, following the ASTM E2797-11 Building Energy Performance Assessment (BEPA) Standard methodology. This information is needed as a reference for any future adjustments to the building asset that may be made. [PD Sec 4.2.5]
- **Accuracy**: Achieve an appropriate goodness of fit of energy data variability to independent variables, following ASHRAE Guideline 14-2002. Adjusted R^2 value shall be at least 0.75 and a CV[RMSE] shall be less than 0.2, subject to extenuating circumstances; in the event that the fit is outside the range, such extenuating circumstances must be described.

2.2 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 the independent variable data to same time interval that aligns with the defined baseline period.
3. Develop baseline regression model using the ASTM E2797-11 Building Energy Performance Assessment Standard methodology or the ASHRAE Inverse Modeling Toolkit and following ASHRAE Guideline 14-2002.
4. Perform model sufficiency test to the accuracy described in Elements.
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.

2.3 Documentation

- Weather data (containing heating and cooling degree day and average daily temperature data for site as described above).
- The start and end dates of the 12 month baseline period and why that period was chosen.
- Full energy data as a computer-readable file, including:
  - Raw meter readings: from date and to date, in energy-unit value, energy usage charges ($), demand quantities and demand charges ($); energy sources must be consolidated to a set of 12 monthly periods common for all energy sources. May also include bulk-delivered fuel information, including units delivered and associated costs.
  - Dataset must cover all forms of purchased energy and energy produced on-site that are part of the baseline. Where applicable this will include aggregated tenant data or an approximation of tenant energy use, as well as descriptions of the metering and sub-metering of energy in the building, and how energy costs are paid by building occupants.
- Provide 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. Leverage ASTM E2797-11 Building Energy Performance Assessment Standard methodology for guidance on partial month billing data "calendarization.Building drawings, equipment inventories, system and material specifications, field survey results and/or CAD takeoffs, observations, short-term monitored data, spot measurements, and functional performance test results as appropriate to recommended upgrades.
- 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:

- Interval data used for review of daily consumption and demand profiles.
- 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.
- Owner's rent roll (showing occupancy and lease dates) for the relevant period and description of types of space use by tenants; if details are viewed as confidential, general descriptions of end use will suffice. Auditor shall note particularly energy-intensive uses including restaurants and data centers.

3.0 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 time-of-use pricing, 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.

3.1 Elements

- **Energy Purchasing**: Description of how the facility purchases energy and the pricing that applies to 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 are available.
- **Time-of-Use**: Time-of-use summary by month if the site is under a time-of-use or real-time rate.

3.2 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. [PD Sec 5.2.1]

3.3 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 describing peak and off-peak rates, demand charges, time periods, seasonality.

Optional:

- Monthly consumption load profile for each energy type.
- Multi-year, year-over-year plotting of monthly peak demand by energy type.
- 12 months of interval meter data for the relevant fuels (if interval metering exists), provided in spreadsheet format.

4.0 SAVINGS CALCULATION

Calculations of estimated savings for projects of the scale anticipated must be based on a calibrated building simulation 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 to account for interactive effects between measures.

4.1 Elements

- **Software**: Application of public domain or commercially available software that meets the current ASHRAE Standard 140 for 8760 hour annual simulation of building energy usage (Manual calculation and custom spreadsheets are not acceptable for this protocol).

- **Credentials**: Simulation development by an individual with either:

    a ASHRAE BEMP certification, **or**

    b AEE BESA certification plus fulfillment of the ASHRAE BEMP eligibility requirements as set forth in the ASHRAE BEMP Guidebook, **or**

    c Professional Engineering license, **or**

    d Five years of energy modeling experience and demonstration of past energy modeling projects, documented in the form of a CV outlining relevant project experience

- **Model Data**: Disclosure and description of inputs/outputs (defaults versus assumptions), including those from any companion tools (e.g. load calculators, field testing) used to create inputs for the simulation. [PD Sec 6.2.2]

- **Model Calibration**: Model calibration such that model monthly outputs for each energy type match the monthly energy baseline established above to within the tolerances specified in the Procedures below. [PD Sec 6.2.2]

- **Modeling Process Description**: Sufficient description of the modeling processes 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. Modeler shall validate all fundamental operating assumptions with building owner or manager.

- **Reporting**: Use of an industry-accepted format for reporting of results and for compilation of methods and underlying data and shall include data on 12 months energy use by fuel type of the calibrated baseline model as well as for the package of recommended measures. Additionally, annual energy savings by fuel type shall be documented in terms of energy units, a percentage of the total volume of each fuel, and as cost savings using the correct marginal rate for that energy type.

4.2 Procedures

1. **Inform model input values** with on-site observations and measured data
   - Prepare input files in a readily readable and usable form based on building documentation from plans, equipment schedules, 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.
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.
3. **Check calibration criteria** to see whether it is good enough. Repeat Step 2 if calibration criteria are not met.
4. **Use findings to meet project objectives and provide added value.**

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 plant chilled water, central plant steam, or any metered energy types.
   b. Calibrated model must show a reasonable match (suggest 10-15%) to baseline monitoring data for major energy end-uses when monitoring data are used. Modeler must explain large variations.
   c. Assure key metrics for the existing building model and the retrofit building model fall within expected ranges. Key metrics and ranges must match those contained in the BEM Library Office Benchmarks. 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.

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 period, or as an internal rate of return (IRR), net present value (NPV), cash-flow analysis or savings-to-investment ratio (SIR). [PD Sec 6.2.6]
2. Prepare a set of ECMs likely to achieve the investment criteria, based on the experience of the engineers involved, building owner preferences, observed condition and operation of existing systems, preliminary modeling, and contractor recommendations. [PD Sec 6.2.1]
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. [PD Sec 6.2.3]
    a Note: If the simulation model is incapable of assessing a given measure any separate calculations or "workarounds" 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 from energy usage to cost must 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. The marginal rate must be used as the cost of the next unit of energy used or saved. Utilize the US Energy Information Administration's (EIA) guidance on the use of inflation values if 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 interactive 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 Control review of recommended measures and overall projected savings based on experience, reasonability, and specific comparables.
8. Solicit pricing for 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 ECMs and compiling all required supporting data. At present, the industry standard for report presentation of ECM, building, and energy use data is the ASHRAE Procedures for Commercial Building Energy Audits (Second Edition 2011).

Pricing / Cost Estimation [PD Sec 6.2.5]

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.

If that pricing will not be available for the modeling runs, the modeler must 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:

- A construction feasibility review indicating what has to be done, that it can be done,allowable working hours, impacts on the facility, access points for bringing in any large equipment, major removals (demolition), permits required and environmental issues (i.e., asbestos, hazardous materials, or other issues that impact indoor air quality).
- 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 material mitigation), provision of temporary services as necessary. Underlying lists or spreadsheets with major pieces of equipment must back up trade categories.
- All lines by trade must include labor and materials. "Labor" can be specified by budgetary allowance rather than hours and hourly rates but must state expressly whether or not job must be union or requires prevailing wage.

- Line items for professional fees, engineering, commissioning, construction management, permitting, measurement & verification, contractor O&P, and contingency. These are percentages of the total from above.
- Cost estimates may need to be bifurcated into total cost and incremental cost, depending on the audience and the financing contemplated. For example, utility incentives are often based on incremental cost.
- Lifecycle Cost Analysis (LCCA) is not required, but may be included where there are benefits of the proposed retrofit other than energy cost savings. See: NIST Life-Cycle Costing Handbook 135
- Estimated equipment useful life expectancy and equipment degradation are not required (although some projects may require this when assessing the financing term), but may be included to assess the overall economic performance of proposed retrofits. These estimates should be conservative and based on accepted values (ASHRAE standards).

Quality Control 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 (including, for example, benchmarking data capturing the performance of reasonably comparable buildings) for individual measures and for the project as a whole. These guidelines must be expressed in terms of savings as a percentage of building energy use and system-level usage.

4.3 Documentation

- Qualification of the person(s) developing the energy model and performing the savings calculations.
- The project report documentation must demonstrate that the calibration criteria are met.
- Documentation must include all factors that were considered to create the calibrated model.
- Specific documentation requirements include, without limitation:
  - Simulation Model Input file (or multiple files) together with information about the modeling software that has been used (including version number).
  - Weather file that was used for simulation.
  - Basis for cost estimates, including, if applicable, scope of work upon which Bid Packages are based, and bid packages.
  - If applicable, bids by trade with the breakouts described in pricing (above).
  - Calibration results.
  - A quality control 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.

5.0 DESIGN, CONSTRUCTION AND VERIFICATION

The design and construction team must commit to realize the intent of the energy audit recommendations accepted by the Project Owner. As part of this effort, the design and construction team is required to perform operational performance verification on the measures implemented as part of the project.

Unlike a full commissioning effort, this process does not involve assessment of all of the systems and controls. Instead, it is targeted at ensuring that the implemented ECMs have the ability to achieve the predicted energy savings, and involves verification that the measures were implemented properly and have the capability to perform.

The operational performance verification process involves visual inspection of the installed systems and control sequences to ensure that they were implemented as intended, as well as targeted functional performance testing, spot measurements or short term monitoring.

5.1 Elements

- **Operational Performance Verification Authority**: Appointment of a qualified Operational Performance Verification Authority as manager of the performance verification process is required.
- **Design and Construction**: The Authority must assure that the ECMs have been implemented as designed and can be expected to perform as conceived and projected by the energy audit. This will include consultation with the energy audit team, monitoring of designs, submittals and project changes, and inspections of the implemented changes. The Authority must have the responsibility and means of reporting deviations from design and projected energy savings to the Project Owner in an issue log. [PD Sec 7.2.1]
- **Training**: Training of building operators in operation of the new systems/equipment, including their energy performance targets and key performance indicators. [PD Sec 7.2.2]
- **Operational Performance Verification Report:** Concise documentation shall be provided that details activities completed as part of the operational performance verification process and significant findings from those activities, which is continuously updated during the course of a project.

5.2 Procedures

1. Appoint a qualified Authority with at least five years of demonstrated operational performance verification experience, documented in the form of a CV outlining relevant project experience.
2. Consult with the energy audit team, monitor designs, submittals and project changes, and visual inspection of the implemented changes.
3. Perform operational performance verification activities, and document operational performance verification results as part of the building's permanent documentation.
4. Train operators in the correct operation of all new systems and equipment, including meeting energy performance targets.
5. Develop a Systems Manual, documenting the modified systems and equipment, and the process and responsibilities for addressing issues. [PD Sec 7.2.3]
6. Develop 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 where required

5.3 Documentation

- Qualifications of the Operational Performance Verification Authority.
- Statements by the Authority that the project, first as designed and, subsequently, as built conforms with the intent and scope of the energy audit and has the ability to achieve predicted energy savings.
- Record of operational performance verification results in the form of a concise report. The report should include photographs, screen captures of the BAS, copies of invoices, testing and data analysis results as appropriate.
- Training materials and record of training.
- A concise Operational Performance Verification Plan specified for all new systems and/or major pieces of equipment in the project. The Plan will define all of the procedures, tests to be performed and a performance checklist.
- System and equipment test requirements must include specific tests and documentation that relate to the energy performance of the new and modified systems and/or equipment, conducted over a suitable range of operating (or simulated operating) conditions, and time period.
- Full documentation of all new and modified systems and equipment in the form of Systems Manuals, to be prepared following ASHRAE Guideline 4 and Guideline 1.4.
- Documentation must include (monthly where possible) 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 where required.

6.0 Operations, Maintenance, and Monitoring

Operations, Maintenance, and Monitoring 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, Monitoring-based Commissioning, Performance-based Monitoring, and Building Re-Tuning).

6.1 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 defined in the Current Facility Requirements document.
- **Monitoring**: Identification of points, interval and duration to be monitored by the building management system.
- **Operation**: Assignment of responsibilities for communication of performance issues and implementation of corrective actions.
- **Training**: Training of building operators in proper maintenance best-practices for the new and modified systems/equipment.

6.2 Procedures

1. Select ongoing management regime, either BMS report review by staff, software-based monitoring and fault detection, whole-building monitoring , periodic recommissioning, or a combination of these. [PD Sec 8.2.1]
2. Train facility staff and service providers on new equipment, management and monitoring software and reporting regime. Training must incorporate understanding, skills, and procedures necessary to support the operations, maintenance, and monitoring program. [PD Sec 8.2.3]
3. Chart the data points to be monitored and their relationship to performance assurance of the new installations and modified equipment/systems.
4. Install and test fault detection 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.
7. Train operators in proper maintenance best-practices for all new systems and equipment (refer to ASHRAE Handbook-2011, Chapter 39). [PD Sec 8.2.2]

6.3 Documentation

- Points list of key variables to be trended in the BMS.
- Plan for fault detection and remediation – may be fully automated, a combination of automation and active response by commissioning and building personnel, or periodic recommissioning. The plan should indicate the intervals for measurements and the duration within which performance will be measured, or a schedule and plan for periodic recommissioning.
- 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 plans 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.

7.0 MEASUREMENT AND VERIFICATION

The following overarching principles should govern any Measurement and Verification (M&V) Plan:

- **Transparency**: all input data, baseline calculations, and variable derivations must 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 must be able to produce identical or nearly identical results.
- **Fairness**: baseline adjustments must show no meaningful statistical bias toward a positive or negative outcome.

The methods outlined in ASHRAE Guideline 14 Whole Building Performance Path and IPMVP Option C should, supported by ASTM E2797-11 Building Energy Performance Assessment (BEPA) Standard data collection methodology must 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 must 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 established baseline and post-installation energy use normalized to reflect the same set of conditions. For purposes of this protocol, the pre-retrofit energy usage baseline that was developed in the Baselining section of this protocol is the starting point for measurement and verification. 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 established baseline energy and post-installation energy use, adjusted to the same set of conditions. The approach requires adjustments to baseline energy use as follows:

1. **Routine adjustments**: Account for expected changes in energy use.
2. **Non-routine adjustments**: Account for unexpected changes in energy use not due to installed ECMs.

Routine adjustments typically include those for changes in weather. Non-routine adjustments typically include changes in 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:

$$\text{EnergyUsage}_{\text{New}} = \text{EnergyUsage}_{\text{Baseline}} \text{ +/- Adjustments}$$

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, or a spreadsheet calculation method. Alternatively it might be derived from a comparison of actual usage data for periods of lower or 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 protocol. However, the method is extremely valuable for monitoring and troubleshooting equipment performance, and may be considered for incorporation into the Operations, Maintenance and Monitoring procedures and/or the Cx plan, or to inform an Option D approach. Retrofit isolation can play a role in improving confidence around savings measurement and troubleshooting performance if savings do not approach projections.

7.1 Elements

- Appointment of a third-party measurement and verification professional with AEE CMVP certification or at least five years of demonstrated M&V experience, documented in the form of a CV outlining relevant project experience, to provide M&V services, or to provide oversight to the M&V process.
- M&V plan adhering to the IPMVP. [PD Sec 9.2.1]
- Definition of the baseline period.
- All baseline use and cost parameters (the dependent variables in an adjustment calculation).
- Definition of the 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 routine and known or expected non-routine 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 (typically 15-minute). [PD Sec 9.2.2]
- Concurrent period hourly ambient temperatures and other independent variable data identified as a 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 regressions, change-point (ref. ASHRAE RP1050), or polynomial model. [PD Sec 9.2.3]
- Model statistics such as number of points, number of operating periods, CV(RMSE), and uncertainty.

7.2 Procedures

Comply with applicable sections of IPMVP Option C and ASHRAE Guideline 14-2002. [PD Sec 9.2.1]

- Routine Adjustments:
  - See IPMVP Option C and/or ASHRAE Guideline 14-2002.
- 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 sufficient post-installation data have 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.

7.3 Documentation

- Measurement and Verification plan.
- 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 or variable impact.
        - Amount of energy affected.
    - Measurements made to quantify non-routine adjustments.
    - Description of baseline adjustment procedure.

Optional:

- Retrofit isolation
- Calibrated simulation

8.0 ENGINEERING CERTIFICATION

I hereby certify that the engineering design used in preparation of this application, attachments and supplements were performed 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 Performance Protocol – Large Commercial**:

- BASELINING ENERGY USAGE
  - RATE ANALYSIS
  - DEMAND
  - LOAD PROFILE
- SAVINGS CALCULATION
  - SIMULATION MODELING TO REQUIREMENTS
- DESIGN, CONSTRUCTION AND VERIFICATION
- OPERATIONS, MAINTENANCE, AND MONITORING
- MEASUREMENT AND VERIFICATION
  - M&V METHODOLOGY
  - BASELINE ADJUSTMENT FACTORS IDENTIFIED
  - CONTRACT PROVISIONS FOR M&V

____________________ Name	____________________ Title
____________________ Address	____________________ Registration / License Number
____________________ Phone Number	____________________ State
____________________ Signature	____________________ Date