INVESTOR CONFIDENCE PROJECT

ENERGY PERFORMANCE PROTOCOL

LARGE MULTIFAMILY

VERSION 1.0 - MARCH 2014

EDF ENVIRONMENTAL DEFENSE FUND™
Finding the ways that work

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1.0 INVESTOR CONFIDENCE PROJECT

The Environmental Defense Fund (EDF) developed the Investor Confidence Project (ICP) 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 forms the basis for a series of sector-specific Energy Performance Protocols (EPP) that define best practice engineering protocols. The protocols strike a balance between cost-effective project engineering measures and requirements that provide for more stable, predictable and reliable savings outcomes designed to enable greater private investment through a more efficient transparent marketplace.

Adoption of the EPP protocols as a standard approach by market actors 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 developed in accordance with the EPP protocols 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 will make the creation of an actuarial data-set possible. Such a data set will provide sufficient detail for insights into project performance risk and an ability to manage that risk based on the multitude of factors throughout the project workflow.

1.1 ENERGY EFFICIENCY PERFORMANCE PROTOCOL – LARGE MULTIFAMILY

This protocol focuses on large multifamily buildings (multifamily is typically defined as residential structures with five or more units, a typical threshold used within the housing industry for multifamily rental properties). The protocol is intended for:

- **Large Multifamily 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 Energy Performance Protocol - Large Multifamily (EPP-LMF) will not be appropriate for every multifamily building. The protocol elaborated here leans 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, or 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. Other methods may prove to be too burdensome relative to the benefit they provide. 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. The ICP invites any and all stakeholders to participate the development our protocols by applying them to retrofit projects and sharing their results. Depending on market feedback, the ICP may develop additional 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, Maintnance, and Monitoring**
5. **Measurement and Verification (M&V)**

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

- **Required Elements**
- **Required Procedures**
- **Required 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.

Obtaining comprehensive utility billing information for a multifamily building can present challenges, since many owners of multifamily buildings cannot legally access utility bills for their own properties due to tenant privacy laws. Acquisition of baseline utility data for multifamily properties typically falls into four categories, with associated ramifications that need to be considered and addressed:

Category	Baseline Situation	Baseline Development
Category 1	Owner occupied building with gross leases; building owner can access all building data and receives savings directly.	Baseline can be developed without issue, and would follow the whole-building protocol methods described here.
Category 2	Tenants pay utility bills; due to privacy laws, project/building owner cannot access the tenant data.	Methods to acquire tenant data should be pursued. If proposed ECMs only affect non-tenant utilities, a retrofit-specific baseline can be developed (see Optional section).
Category 3	Tenants pay utility bills; some portion of tenant data can be acquired, through individual agreements / solicitation directly with the tenants.	Create a representative baseline using a statistically valid sample of tenant data.
Category 4	Tenants pay utility bills; but aggregate data can be obtained anonymously from the utility or in aggregate.	Baseline can be developed without issue, and would follow the whole-building protocol methods described here.

As demonstrated in the above table, tenant privacy laws represent a challenge to baseline development that needs to be considered. Methods to acquire tenant data, or a statistically valid representation of tenant data, are beyond the scope of this protocol. A growing number of utilities are now providing aggregated tenant consumption data to building owners on a monthly or yearly basis, a relatively new approach that can overcome this barrier to data access. However, if this approach is not available, other approaches to collect or access these data will need to be pursued, so that a valid baseline can be developed to support the energy efficiency project development efforts.

For cases in which tenants pay their own utility bills, savings will be distributed between the owner-paid utilities and the tenant-paid utilities. Subsequently, separate baselines should be developed for both the owner-paid and tenant-paid utilities.

2.1 REQUIRED 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 are 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 usage greater than 10%, i.e. "major renovation." Energy usage data from any period involving a major renovation should not be used to develop the baseline.
- **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.
- **Occupancy Data**: For the defined baseline period, acquire vacancy rates, occupancy types (elderly, family, disabled, etc), number of occupants, space uses and operating schedules, following the ASTM E2797-11 Building Energy Performance Assessment (BEPA) Standard methodology.
- **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.
- **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 (physical attributes, equipment inventories), 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.
- **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.
  Note: use of the leasable or rentable floor area is not acceptable. The gross floor area needs to be calculated following Section 3.2.15 of the BEPA Standard.
- **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 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 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 in the Required 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 REQUIRED 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, equipment inventories, 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:

- **Retrofit Isolation Baseline**: For projects involving measures that only apply to owner-paid utilities, develop a retrofit specific baseline that excludes tenant-paid utilities. Develop the baseline energy use characteristics of the equipment or end use broken down into load and hours-of-use components, and whether these components may be considered constant or variable (refer to the BPA’s Verification by Equipment or End-Use Metering Protocol). The impact of the ECM is used to determine the expected post-installation energy-use characteristics.

- 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 such as restaurants.

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 REQUIRED 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 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.

3.3 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 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.

Multifamily projects may comprise a situation involving split incentives, which can potentially inhibit a building owner's incentive to invest in the energy efficiency project. A split incentive (or misaligned incentive) involves a transaction where the benefits do not accrue to the person who pays for the transaction. This occurs in situations involving tenant-paid utility bills - the building owner pays for the retrofits, but does not recover savings from reduced energy costs that accrue to the tenant. This situation warrants consideration and methods such as Green Leasing or other savings recovery methods to incentivize the building owner investment in the energy efficiency project. While critical to the financing component of project development, these considerations are beyond the scope of this protocol.

However, for these projects in which the tenants pay their own utility bills, savings estimates should be developed separately for those that accrue to the building owner, and those that accrue to the tenants, so that appropriate savings recovery efforts can be developed and potentially employed to incentivize the project. Additionally, investment costs should similarly be developed separately for those measures applicable to owner-paid utilities and tenant-paid utilities, such that methods can potentially be developed to pass on these capital expenses directly to the building tenants.

4.1 REQUIRED 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.
- **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 Required Procedures below.

- **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 REQUIRED 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.
   - Refer to the *NYSERDA Multifamily Performance Program Existing Buildings Component Simulation Guidelines* for guidance regarding specific simulation methodology, energy simulation and model calibration practices, and modeling assumptions within reasonable ranges.
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 or bulk fuel

energy types.

   b. Calibrated model must show a reasonable match (suggest 10-15%) to baseline monitored data for major energy end-uses when monitored 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).

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. Detailed ECM descriptions must be developed that can be used to develop accurate scopes of work and informed cost estimates.

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.

   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 such as estimated or sub-metered end-use energy usage.

8. Develop pricing for ECMs and finalize model-based analysis and recommendations based upon pricing from bids received or estimated pricing.

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

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 needs 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 REQUIRED 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.

- Detailed descriptions of ECMs used to develop accurate scopes of work and informed cost estimates.
- 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 REQUIRED ELEMENTS

- **Operational Performance Verification Authority**: Appointment of a qualified Operational Performance Verification Authority as manager of the performance verification process is required.
- **Operational Performance Verification Plan**: Development of an Operational Performance Verification plan (pre-construction) that describes the verification activities, target energy budgets and key performance indicators.
- **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.
- **Training**: Training of building operators in operation of the new systems/equipment, including their energy performance targets and key performance indicators.
- **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 REQUIRED 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. Develop an Operational Performance Verification plan (pre-construction) that describes the verification activities, target energy budgets and key performance indicators.
3. Consult with the energy audit team, monitor designs, submittals and project changes, and visual inspection of the implemented changes.
4. Perform operational performance verification activities, and document operational performance

verification results as part of the building's permanent documentation.

5. Train operators in the correct operation of all new systems and equipment, including meeting energy performance targets.
6. Develop a Systems Manual, documenting the modified systems and equipment, troubleshooting procedures, and the process and responsibilities for addressing issues.
7. 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 REQUIRED DOCUMENTATION

- Qualifications of the Operational Performance Verification Authority.
- A concise Operational Performance Verification plan (pre-construction) including verification activities, 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.
- 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.
- 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 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 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.
- **Outreach:** Notifying building tenants of the improvements performed in the building as part of the project, and descriptions of any behavior modifications or best practices recommended as part of the energy efficiency efforts.

6.2 REQUIRED PROCEDURES

1. Select ongoing management regime, either BAS report review by staff, software-based monitoring and fault detection, whole-building monitoring , periodic recommissioning, or a combination of these approaches.
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. Refer to the BPI's Technical Standards for the Multifamily Energy Efficient Building Operator.
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).
8. Notify building tenants of the improvements performed in the building as part of the project, and descriptions of any behavior modifications or best practices recommended as part of the energy efficiency efforts.

6.3 REQUIRED DOCUMENTATION

- Points list of key variables to be trended in the BAS.
- 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 (vacancy rates), 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:

$$EnergyUsage_{New} = EnergyUsage_{Baseline} +/- Adjustments$$

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 Operational Performance Verification activities, 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 REQUIRED 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.
- 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 routing 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).

- 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.
- Model statistics such as number of points, number of operating periods, CV(RMSE), and uncertainty.

7.2 REQUIRED PROCEDURES

Comply with applicable sections of IPMVP Option C and ASHRAE Guideline 14-2002.

- 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.
- Uncertainty: while uncertainty does not necessarily need to be quantified, quality assurance activities should be employed to minimize uncertainty and risk throughout the energy efficiency project development process.

7.3 REQUIRED 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 Multifamily**:

- 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