



INVESTOR CONFIDENCE PROJECT

LARGE APARTMENT BLOCK PROTOCOL

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1.0 INVESTOR CONFIDENCE PROJECT

The Investor Confidence Project (ICP) Europe, is an Energy Efficiency (EE) initiative addressing investment market barriers, which have been repeatedly identified as the main impediments to mass scaling of EE investments in Europe, by the International Energy Agency, the Buildings Performance Institute Europe, the Energy Efficiency Financial Institutions Group, as well as other relevant EE stakeholders in Europe.

The initiative builds on the successful experience of its United States counterpart, which has been pointed out as a best-practice approach by the Energy Efficiency Financial Institutions Group and the International Energy Agency.

The project is supported by the Horizon 2020 European Research and Innovation Programme and by the Stiftung Family Foundation and aims to establish itself as an EU-wide, open access system, to provide more stable, predictable, and reliable savings outcomes and to enable greater private investment through a more efficient transparent marketplace.

At the core of the system are ICP Europe protocols which provide comprehensive and robust guidance for project development at a European level, allowing market entities to dramatically streamline project underwriting processes related to project performance.

This is the Large Apartment Block protocol, one of the six that comprise the ICP Europe system, along with the Project Development Specification document which compiles all relevant and supporting information and best-practices for system application, which will also be supported by a suite of tools, resources and software products facilitating system application. References to relevant sections in the Project Development Specification are provided throughout this document, indicated as [PD Sec X.X].

The 2010 Energy Performance of Buildings Directive and the 2012 Energy Efficiency Directive are the EU's main legislation related to reducing the energy consumption of buildings (see section 4.2.5 of the Project Development Specification). All methodologies and procedures across all ICP protocols have taken into consideration the requirements of these key laws.

1.1 LARGE APARTMENT BLOCK PROTOCOL

This protocol focuses on large apartment blocks. The protocol is intended for:

- **Large Apartment Blocks**, 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

Even with these qualifications, the Large Apartment Block Protocol will not be appropriate for every large apartment block. The protocol elaborated here leans heavily toward a whole building metered pre- and post- retrofit data-driven (IPMVP Option C: *Whole Facility*) 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 characterised 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 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

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and measurement. 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. A glossary of key terms used in this protocol is also provided.

This document will evolve over time. Some methods may move from an “additional” or “recommended” category to a standard requirement. 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.

Throughout this document, reference is made to European and international standards, guidance and resources which are relevant to the requirements of the protocol. Where a relevant national standard, guidance or resource is available, this may be used as an optional alternative resource to the European or international standard. Relevant national standards are shown in Annex A. Resource references are shown in *italics*, followed by a specific reference number in square brackets (e.g. “[2a]”) which can be used to locate it in Annex A.

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

1.2 PROTOCOL FRAMEWORK

The ICP protocol 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**

The following table provides an overview of the requirements at each stage of the ICP process. In order to fully comply with ICP requirements, the table should not be used in isolation to develop compliant projects, but in conjunction with the entire protocol and relevant supporting sections of the Project Development Specification.

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Table 1 Protocol Summary: Large Projects

Phase	Objective	Task	Description
Baselining	Establish current energy consumption, which will form the basis for savings calculations	Collect energy source information	Collect energy source data and rates for all energy sources to inform baseline and savings calculations. Develop load shapes if demand charges or time-of-use pricing are in effect to establish the impact on potential monetary savings.
		Estimate energy end-use consumption	Develop an energy end-use consumption breakdown to create boundaries and reality checks, using sub-metering, calculations or nationally recognised benchmarks.
		Develop energy consumption equation	Identify independent variables that affect energy consumption (e.g. weather, occupancy) and calendarise data to match baseline period. Establish any interactive effects that may affect the energy savings. Develop baseline regression model using independent variable data, and establish accuracy in order to validate the robustness of the data.
		Carry out energy audit to identify ECMs	Collect building asset, operational and performance data , to be used to inform the energy model. Create a list of routine adjustments (expected changes in energy use) and non-routine adjustments (unexpected changes e.g. change in type of space use) which will be used to adjust the baseline during the Measurement & Verification (M&V) process. Develop Energy Conservation Measures (ECM) descriptions .
Savings calculations	Produce valuation of proposed projects	Carry out dynamic energy modelling on whole building retrofit	Prepare model inputs based on on-site observations and measured data. Develop energy model using accredited software, carried out by suitably qualified individual. Calibrate energy model to match actual monthly data, and adjust model if necessary using actual building data. Document inputs, assumptions and results.
		Develop investment package	Establish the investor's required investment criteria , and prepare an initial set of ECMs. Prepare comprehensive preliminary cost estimate to rank ECMs (the final investment package should be based on contracted bids), and establish the financial performance of each measure individually and then as a package . Prepare final report summarising ECMs, constructability, projected savings and all supporting data.
Design, Construction & Verification	Ensure ECMs are implemented correctly and that savings can be realised	Perform Operational Performance Verification (OPV) activities	Appoint qualified OPV specialist . The specialist will develop the OPV plan (pre-construction), which describes verification activities, target energy budgets and key performance indicators , and then perform OPV tasks (monitor designs, submittals and project changes, and carry out visual inspections and functional performance tests of the ECMs). Document results in the form of an OPV report , with a statement of conformity.
		Provide guidance on ECMs	Develop Systems Manual on modified systems and equipment. Train building operators in how to operate new systems and equipment, and on energy performance targets.
Operations, Maintenance & Monitoring	Ensure in-specification performance	Develop Operations Maintenance & Monitoring (OM&M) procedures	Select ongoing management regime , including plan for fault detection and remediation. Set up fault detection and diagnostics, develop retro- or re-commissioning plan, or other monitoring method . Collate periodic performance reports to compare actual performance with predicted performance.
		Provide guidance on operation of ECMs	Develop Operator's Manual , which can be part of Systems Manual – this should include assignment of responsibilities for performance issues/corrective actions, maintenance plans and service response log, warranties for new equipment, and any KPIs or targets. Train building operators in supporting OM&M programme and conduct tenant outreach if appropriate.
Measurement & Verification	Validate savings and effectiveness of the ECMs, post-installation	Comply with IPMVP Option C	Appoint suitably qualified third-party M&V professional and develop M&V plan pre-construction. Gather pre- and post-retrofit data , and verify savings for whole building, based on regression-based on energy model, and taking into account routine and non-routine adjustments. Document analysis and results in the form of an M&V report .

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, as well as any renewable energy that is generated and used on site. 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 residential building can present challenges, since many owners of residential buildings cannot legally access utility bills for their own properties due to tenant privacy laws. Acquisition of baseline utility data for residential 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 building owner paying for the property’s utility costs, taxes, insurance and maintenance; 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 ELEMENTS

- **Historical Energy Usage:** Collect 36 months (or a minimum of 12 months of energy usage data when heating and cooling degree days are available for that period and the building's location) 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. This should be used as the basis for an analysis that is compliant with IPMVP Option C. For non-metered fuel types either install sub-metering, or utilise billing or other usage data to estimate energy use. The baseline period should be of sufficient duration to capture variations in relevant variables, such as weather and building occupancy. 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." Cost data for electricity and each fuel consumed (including low and zero carbon energy sources) should also be collected, including unit and total annual costs. For electricity, peak demand (in kW) should be recorded, as well as the peak output from any on-site generation and the associated fuel source e.g. gas, solar, wind etc. [PD Sec 4.2.1]
- **Energy End-use:** Use energy end-use breakdowns to create boundaries and reality checks associated with energy savings estimates and total energy consumption of the baseline case. Sub-metering can be used to assess the energy consumption associated with each end-use and the anticipated ECMs, or calculations performed to estimate energy end-use. In place of sub-metering or calculations, national resources should be used to estimate energy end-use, based on building characteristics and region, applied to the total historical energy consumption of the building – refer to Annex A. In the absence of a national source of data, European resources such as the *Buildings Performance Institute Europe's Data Hub for the Energy Performance of Buildings [2f]* (see <http://www.buildingsdata.eu/>) should be used. [PM Sec 4.2.2]
- **Weather Data:** For the defined baseline period, acquire weather data (at least degree-days for heating and cooling) from the closest weather station, or on-site measurement, at the time interval coinciding with the interval of the energy usage. [PD Sec 4.2.3]
- **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 requirements set out in *EN 16247-2 Energy Audits – Part 2: Buildings (section 5.3.2) [2b]*. This should include details of the nature of the lease, showing occupancy and lease dates, and types of space use by tenants. [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.
- **Baseline Operational/Performance Data:** System performance data used to inform the energy model (e.g. equipment efficiencies and capacities). This data needs 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. [PD Sec 4.2.5]
- **Building Asset Data:** Accurate total floor area (for conditioned and unconditioned spaces) following the guidance provided by *EN ISO 13790:2008 Energy performance of buildings – Calculation of energy use for space heating and cooling (section 3.2.6) [2a]*, and system and material specifications/inventories based on building drawings (for example, details of HVAC equipment), following the requirements set out in *EN 16247-2 Energy Audits – Part 2: Buildings (section 5.3.2 and Annex D) [2c]* 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. [PD Sec 4.2.5]
- **Accuracy:** Achieve an appropriate goodness of fit of energy data variability to independent

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variables, following the IPMVP methodology (see IPMVP Volume I 2012, Appendix B) . Adjusted R2 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 data, operational/performance data, and building asset data. Identify which independent variables are considered the most important, based on the building type and space uses.
2. Calendarise the independent variable data to same time interval that aligns with the defined baseline period.
3. Normalise baseline data against the variables identified above to develop the baseline, using the methodology described in *ISO 50006:2014 Energy Management Systems – Measuring Energy Performance Using Energy Baselines and Energy Performance Indicators (Annex D) [2e]*.
4. Perform model sufficiency test to the accuracy in the Required Elements (section 2.1).
5. Create a list of project-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. Local currency should be used.
 - 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 integer years/months periods applied. Dates of meter reading periods will vary from one energy source to another. Refer to *BS ISO 16346:2013 Energy Performance of Buildings – Assessment of Overall Energy Performance (section 8.2.2) [2d]* for guidance on partial year/month billing data “calendarisation.”
- 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

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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.
- Building owner's rental information (showing occupancy and lease dates for each tenancy) 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.

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 monetary 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. Where there are charges for a minimum proportion of annual peak demand throughout the year, these 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. Where monthly data is not available, explain why, and describe any potential impacts this may have on the baseline and savings calculations, and how these issues will be addressed.
2. Where demand charges or time-of-use pricing is in effect, chart average daily demand in 15-minute intervals (maximum available frequency if 15-minute is not available) with time on the x axis and kW on the y axis for typical weekday and weekend days in the spring, autumn, 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 tariff structure, and any fixed charges. If tenants pay their bills direct, provide a breakdown by owner-paid and tenant-paid utilities. 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.

Residential 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 incentivise 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 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 to the tenants, so that appropriate savings recovery efforts can be developed and potentially employed to incentivise 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 ELEMENTS

- **Software:** Application of public domain or commercially available software that meets *EN ISO 13790:2008 Energy performance of buildings – Calculation of energy use for space heating and cooling*, is validated according to the criteria in *EN 15265:2007 Energy performance of buildings – Calculation of energy needs for space heating and cooling using dynamic methods – General criteria and validation procedures [4a]*, and complies with current national standards 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 *Nationally recognised software modelling certification [4b]*, **or**
 - b Professional engineering accreditation, **or**
 - c Five years of energy modelling experience and demonstration of past energy modelling projects, documented in the form of a CV outlining relevant project experience
- **Energy Conservation Measure Descriptions:** Descriptions of the existing conditions, proposed retrofit, and potential interactive effects for each measure under consideration.
- **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 set out below. [PD Sec 6.2.2]
- **Modelling Process Description:** Sufficient description of the modelling processes such that

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(with the necessary input files) a reviewer can reconstruct the simulation. This description should include adjustments made for calibration. Modellers 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. Modeller 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. At present, the industry standard for report presentation of ECM, building, and energy use data is *EN 16247-2 Energy audits – Part 2: Buildings (section 5.6) [4c]*. The report shall include data on 12 months energy use by fuel type for 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 consumption of each fuel, and as cost savings using the correct marginal rate for that energy type. [PD Sec 6.2.8]

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, cleaning schedules and practices.
2. **Inform and Tune.** Investigate discrepancies between actual billing and modelled 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. Follow *IPMVP Volume 1: 2012 (section 4.9.2)* on modelling accuracy. 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 monitored data for major energy end-uses when monitored data are used. Modeller must explain large variations.
 - c. Ensure 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 European or national guides/resources on energy end use benchmarks (see section 2.1). 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

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and equipment.

Analysis of Energy Conservation Measures (ECMs)

1. Ascertain and record the return on investment criteria of the investors, which could include both landlord and tenant, 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 6.2.7]
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 modelling, and contractor recommendations. Detailed ECM descriptions must be developed that can be used to develop accurate scopes of work and informed cost estimates. [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 the monetary value of the savings. Provide this for both building owner and tenants if the savings are to be shared. 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. Utilise the European Central Bank’s Harmonised Index of Consumer Prices (<https://www.ecb.europa.eu/stats/prices/hicp/html/index.en.html>) or source of national data forecasts [4e] for inflation values if applied in the analysis. Where relevant, details of any demand-side management tariffs/payments should be provided.
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 and data from comparable projects.
8. Develop pricing for ECMs including operation and maintenance costs, and finalise 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.

Pricing / Cost Estimation [PD Sec 6.2.6]

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.

At the feasibility stage, initial quotes may be obtained from the contractor, provided a minimum of three are used. It is recommended that the project use any contractors familiar to the building owner. Alternatively, cost estimates may be based upon the engineer’s experience with previous projects.

Either of these approaches can be used to rank improvements and determine which measures will be included in a final bid package. Cost estimates at the modelling phase must include:

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- A construction feasibility review indicating which measures will be included, description of construction methods, allowable working hours, impacts on the facility, access points for bringing in any large equipment, major removals (demolition), permits required, and possible 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 which include cost information must be submitted.
- All lines by trade must include labour and materials. "Labour" can be specified by budgetary allowance rather than by hours and hourly rates.
- Operation and maintenance costs throughout the life of the project.
- Line items for professional fees, engineering, commissioning, construction management, permitting, measurement & verification, contractor overhead and profit (O&P), and contingency. These are typically estimated as percentages of the total implementation costs.
- Cost estimates may need to be split into total cost and incremental cost, depending on the audience and the investment contemplated. The incremental cost is the additional cost of installing the energy efficient system or piece of equipment compared to the baseline cost, or non-energy-related investment. 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. Refer to *ISO 15686-5:2008 Buildings & constructed assets – Service life planning - Part 5: Life cycle costing [4f]*.
- 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 (i.e. using the lower end of lifespan ranges provided) and based on accepted values – refer to *EN 15459:2007 Energy performance of buildings – Economic evaluation procedure for energy systems in buildings (Annex A) [4g]* for lifespan data.

Quality Control Process

1. Compare model outcomes to comparable projects. Assess whether outcomes are consistent with data from comparable projects. If not consistent with this data, provide reasons why the project under consideration is different.
2. Compare model outcomes based on experience (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.
- Detailed descriptions of ECMs used to develop accurate scopes of work and informed cost estimates.
- Specific documentation requirements include, without limitation:

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- Simulation Model Input file (or multiple files) together with information about the modelling 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 modelled results against data from comparable projects. Savings should be expressed as a percentage of energy end-use consumption.

5.0 DESIGN, CONSTRUCTION AND VERIFICATION

The design and construction team must commit to realising the intent of the energy audit recommendations – that is, the ECMs - 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 Specialist:** Appointment of a qualified Operational Performance Verification Specialist 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. [PD Sec 7.2.1]
- **Design and Construction:** The Specialist must ensure 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, project changes, and inspections of the implemented changes. The Specialist 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. [PD Sec 7.2.1]

5.2 PROCEDURES

1. Appoint a qualified Operational Performance Verification Specialist (the ‘Specialist’) 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. The Specialist should 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. [PD Sec 7.2.3]

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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 DOCUMENTATION

- Qualifications of the Specialist.
- 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 and 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.
- A concise Operational Performance Verification Report, which is a record of operational performance verification results. The report should include photographs, screen captures of the Building Automation System (BAS), copies of invoices, testing and data analysis results as appropriate.
- Statements by the Specialist 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.
- Training materials and record of training.
- Full documentation of all new and modified systems and equipment in the form of Systems Manuals, to be prepared following the guidance set out in *EN 13460:2009 Maintenance – Documents for maintenance [5a]*.
- 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 implementing 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 Operator’s manual (see section 6.3). Key performance indicators must be measurable.
- **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. Development of a concise, targeted Operator’s Manual discussing the new ECMs or systems, including 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 behaviour modifications or best practices recommended as part of the energy efficiency efforts.

6.2 PROCEDURES

1. Select ongoing management regime, either Building Management System (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 the performance 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. Collate periodic performance reports covering all monitored points including all observed deviations from projected operation, analysis of cause, and corrective actions taken or recommended.
7. Development of a concise Operator’s Manual targeting the new systems and their operation, including assignment of responsibilities for communication of performance issues and implementation of corrective action. This should include details of how the systems should be used and operated, as well as KPIs, benchmarks and any additional goals or success criteria. In many cases, the Operator’s Manual and Systems Manual can be combined into one document to be used by the operations and maintenance personnel. [PD Sec 8.2.2]

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8. Train operators in proper maintenance best-practices for all new systems and equipment - refer to *EN 15331:2011 Criteria for design, management and control of maintenance services for buildings [6a]* for guidance). [PD Sec 8.2.3]
9. Notify building tenants of the improvements performed in the building as part of the project, and descriptions of any behaviour modifications or best practices recommended as part of the energy efficiency efforts.

6.3 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.
- Organisational 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.
- Operator's Manual describing the new systems and their proper operational performance, as well as an organisational chart establishing contact information for all personnel involved in ongoing system operation 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 authorised 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 method outlined IPMVP Option C, supported by the data collection methodology described in *EN 16247-2 Energy Audits – Part 2: Buildings [2c]*, should be followed. Prior to investment decision-making (e.g. as part of contract development and investment due diligence) an M&V Plan for an energy efficiency improvement 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 normalised to reflect the same set of conditions. For purposes of this protocol, the pre-retrofit energy usage baseline that was developed in the Baseline section of this protocol is the starting point for measurement and verification. The standard method is to utilise 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:

$$\text{EnergyUsage}_{\text{New}} = \text{EnergyUsage}_{\text{Baseline}} \pm \text{Adjustments}$$

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.

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Alternative M&V Method

In certain cases, full annual utility data may not exist, making it impossible to perform M&V under IPMVP 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, this 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 Commissioning 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 Certified Measurement & Verification Professional (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 (see Chapter 5). This is the foundation of the M&V activities, and should be developed as early as possible in the project. [PD Sec 9.2.1 provides a list of what this should include.]
- Definition of the baseline period.
- All baseline energy use and cost parameters (the dependent variables in an adjustment calculation).
- Definition of the baseline values of routine adjustment parameters (the independent variables, such as external temperature).
- 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 be made available 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, or polynomial model. Refer to the guidance provided in Section 2.2 of this document on regression modelling. [PD Sec 9.2.3]

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- Model statistics such as number of points, number of operating periods, Coefficient of Variation of the Root Mean Square Error (RMSE), and uncertainty.

7.2 PROCEDURES

This involves planning and coordinating M&V activities. Comply with applicable sections of IPMVP Option C. [PD Sec 9.2.1]

1. Develop an IPMVP-adherent M&V plan. This should be developed pre-construction.
2. Gather necessary data – before and after the planned retrofit. [PD Sec 9.2.2]
3. Verify savings for the entire facility, as set out in section 7.1 above. This involves consideration of the measurement boundaries, interactive effects, selection of appropriate measurement periods, and basis for adjustments. The following should be taken into account during the reporting period:

- Routine Adjustments:
 - See IPMVP Option C
- 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 a 'like for like' 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 minimise uncertainty and risk throughout the energy efficiency project development process.

4. Report results.

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

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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 **Large Apartment Block Protocol**:

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

Name

Title

Address

Registration / License Number

Phone Number

State

Signature

Date

9.0 GLOSSARY

Building simulation model – computer-based modelling used to assess the energy performance of a building dynamically i.e. over the course of a whole year.

Energy conservation measure (ECM) – measure implemented in order to reduce primary energy consumption. This can include energy efficiency measures, such as variable speed drives and lighting controls, and also low and zero carbon measures, such as Combined Heat and Power, and solar photovoltaic panels.

Energy end-use – energy consumed by system or equipment, classified according to type of load e.g. internal lighting, cooling, process, pumps etc.

Energy use baseline – energy consumption over a specified period providing a basis for comparison of energy performance, before and after implementation of ECMs. The baseline is usually normalised against variables affecting energy consumption.

Green leasing – a standard lease which includes additional specific obligations and targets to ensure the building is operated sustainably and efficiently.

International Performance Measurement and Verification Protocol (IPMVP) - standardised approach to energy efficiency M&V, developed by Efficiency Valuation Organization.

Measurement and verification – process used to quantify the actual savings achieved, following the implementation of ECMs, and to determine whether they meet the predicted savings targets.

Non-routine adjustments – adjustments made to the baseline to account for unexpected changes in energy use not due to installed ECMs, such as changes in occupancy, type of space use, equipment, operating hours, service levels, and utility rates.

Operators manual – document targeted at operations and maintenance personnel, and containing all the information required for the correct use and operation of ECMs or systems, such as as-built drawings, equipment location and training materials. In many cases, this is a section within the Systems Manual.

Operational performance verification – process used to ensure that the implemented ECMs have been implemented properly and will have the ability to achieve the predicted energy savings during the operational phase.

Project Development Specification - document which compiles all relevant and supporting information and best-practices for system application

Routine adjustments – adjustments made to the baseline to account for expected changes in energy use, typically include those for weather.

Submittals – these are submissions from contractors for approval (e.g. drawings or equipment details).

Systems manual - document describing the modified systems and equipment, intended to support building operations and maintenance, and to optimise the facility systems over their useful lives. It contains information and documentation regarding building design and construction,

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commissioning, operational requirements, maintenance requirements and procedures, training, and testing.

10.0 QUALITY ASSURANCE CHECKLIST

ICP Quality Assurance Checklist v1.0

Client:

Project:

Project Developer:

QA Provider:



Energy Performance Protocol
Large Apartment Blocks v1.0



BASELINING CORE REQUIREMENTS

- 12-36 months utility data
- Utility baseline period
- Energy end-use estimates
- Weather data - related baseline
- 12 mos occupancy - related baseline
- Building asset data
- Baseline operational/performance data
- Normalised / regression-based baseline
- Utility rate structure
- (if Demand Charges or Time of Use apply)*
- Annual load profile
- Average daily load profiles
- Peak usage
- TOU summary by month *(if applicable)*



SAVINGS CALCULATIONS

- Software type
- Modeller credentials
- Weather file
- Model input files
- Model output files
- Model calibration
- Model process description
- Energy Efficiency Report
- Energy Conservation Measures (ECMs)*
- Investment criteria
- ECM model variables
- ECM results, and package results
- Cost estimates
- Quality assurance statement



DESIGN, CONSTRUCTION, AND VERIFICATION

- Operational Performance Verification plan
- OPV authority credentials



MEASUREMENT AND VERIFICATION

- Measurement and Verification plan
- M&V agent credentials



OPERATIONS, MAINTENANCE, AND MONITORING

- Ongoing management regime



MEASUREMENT AND VERIFICATION

- Project Developer Credential

QA Firm:

Reviewer*:

Date:

Signature:

* Reviewer must be qualifying individual per ICP QA Application



By signing this ICP QA checklist, the ICP Quality Assurance Provider attests to having reviewed the project development documentation and certifies that the project substantially follows the ICP Energy Performance Protocols and the ICP Project Development Specification. This Quality Assurance review and signature does not constitute a guarantee of energy savings performance, nor does it signify that the reviewer is taking professional responsibility for the required documents and engineering produced by the Credentialed Project Developer.

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