PROJECT DEVELOPMENT SPECIFICATION

Version 2.0 – December 2017

Green Business Certification Inc. (GBCI)
Washington, DC

Table of Contents

THE INVESTOR CONFIDENCE PROJECT

The Investor Confidence Project (ICP) is a global initiative that focuses on increasing energy efficiency deal flow by ensuring that projects are engineered robustly, financial returns are predictable, and project underwriting can be streamlined. The ICP system is comprised of the ICP Protocols and the Investor Ready Energy Efficiency™ Certification which offer a standardized roadmap for project developers, a market tested methodology for program administrators and a certification system for investors and building owners to accurately and efficiently assess project risk.

ICP is administered by Green Business Certification Inc. (GBCI) and was conceived, incubated and developed by the Environmental Defense Fund (www.edf.org).

For more information, please visit:

ICP North America (www.eeperformance.org) or ICP Europe (europe.eeperformance.org)

INVESTOR READY ENERGY EFFICIENCY™

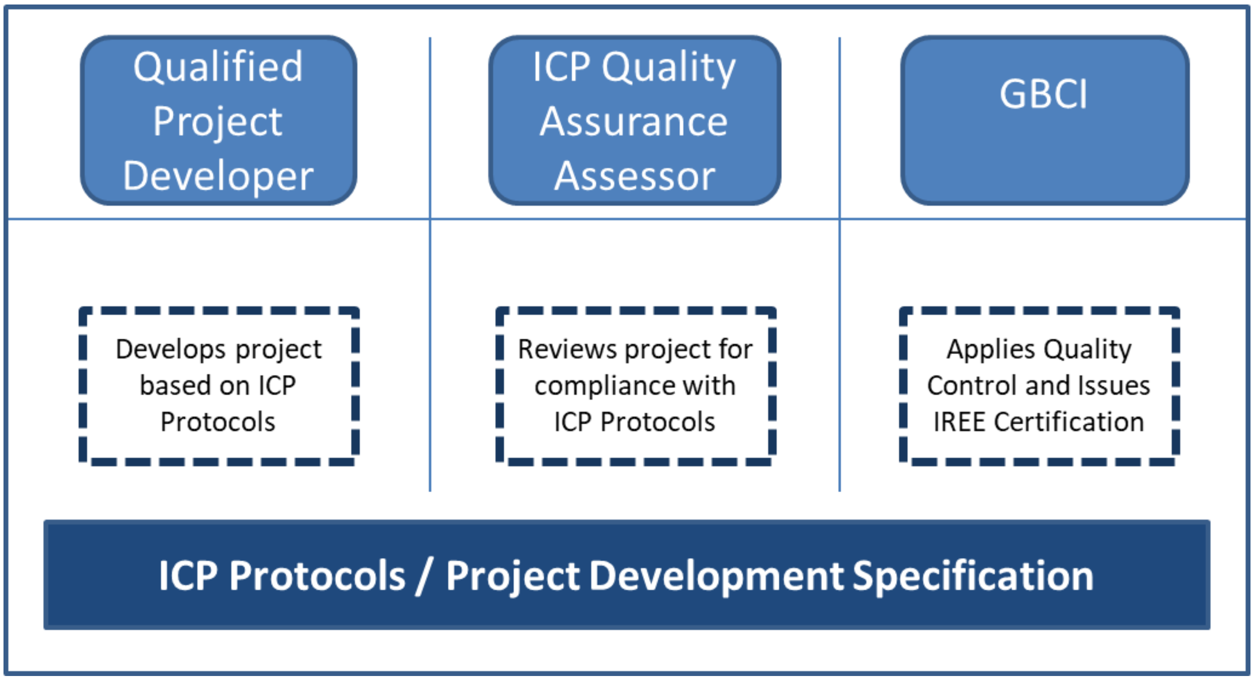
Investor Ready Energy Efficiency™ (IREE) is a certification awarded to energy efficiency retrofit projects that conform to the requirements of the ICP Protocols. The ICP Protocols standardize the technical requirements associated with project development by offering a roadmap consisting of required procedures and documentation. The ICP Protocol suite includes protocols to accommodate all sizes and scopes of commercial and multifamily projects in the United States and Europe. All of the ICP Protocols are open source and available on the ICP websites. An overview of the requirements in the ICP Protocols and its structure can be found in the Project Development Process Table located in Appendix A.

The firms developing a retrofit project (project development team) are responsible for developing IREE compliant projects based on sound engineering principles and best practices as defined by the ICP Protocols. IREE certified projects must be developed by qualified project developers - these requirements can be found in the ICP Protocols. All projects seeking IREE Certification must be registered with GBCI. It is recommended that projects be registered as early as possible.

Once a project has been fully developed and documented according to the ICP Protocols, it may be submitted to an ICP Quality Assurance (QA) Assessor for technical review. ICP QA Assessors will review eligible projects to determine if they meet all of the procedural and documentation requirements specified in the ICP Protocols. ICP QA Assessors work with the project development team to identify and resolve any issues which would result in an unsatisfactory review. Additionally, ICP encourages project developers to collaborate with the selected ICP QA Assessor early and throughout the project development phase to ensure efficient development of the project.

An important requirement of the IREE process is that the ICP QA Assessors must be an independent-party to the project developer and transaction in order to ensure objectivity and confidence that projects truly meet ICP requirements. All ICP QA Assessors are contractually obligated by GBCI to provide services that meet a high level of quality and to operate in a professional manner. They have also been verified by GBCI to possess required industry credentials and a requisite level of professional experience. ICP related technical review may be performed either by independent ICP QA Assessors or in a centralized model through ICP program partners, contracted by GBCI as a QA Assessor.

The last step in the IREE process is certification by GBCI. Projects that have been registered with GBCI and deemed compliant through a technical review by an ICP QA Assessor are eligible for certification. GBCI will issue brand fulfilment and official IREE Certification for eligible projects. GBCI maintains a quality control process to ensure the continued quality of IREE projects and may further review submitted projects.



THE ICP PROJECT DEVELOPMENT SPECIFICATION

This Project Development Specification (PDS) is intended to be a comprehensive reference for the procedures and documentation requirements specified in the ICP Protocols. The PDS provides a reference for any questions or clarifications associated with the ICP Protocols throughout the project development and IREE Certification process. This document provides essential information about the protocol requirements, best practices, quality management tasks, and references to ensure that all stakeholders are operating from a common set of requirements and practices. It also provides additional commercially available, non-proprietary resources including standards, guidelines, tools, and other materials that can be used or referenced as part of the project development process. In order to enhance their usability, the ICP Protocols have been cross-referenced with the PDS and link directly to the appropriate section of this document.

Throughout the project development and IREE Certification process, the PDS should be consulted regarding any questions or clarifications associated with the ICP Protocol requirements by all participants including the project developer team, QA Assessors, building owners, program administrators, and investors. If the PDS does not provide sufficient clarity, project developers and other users are urged to work with the selected ICP QA Assessors and/or an ICP representative.

ICP QA Assessors should review and execute the QA tasks listed in each section to guide the technical review process. In general, it is not feasible or necessary for the QA Assessor to recreate the entire project development process and instead the QA effort should involve application of available resources to review and address the areas of a project that represent the greatest level of potential uncertainty and risk. The QA Assessor should take a collaborative approach, working with the project development team to resolve issues in order to develop a financially sound investment built on strong engineering and conservative assumptions.

PROJECT DEVELOPMENT SPECIFICATION ORGANIZATION

The PDS is aligned with the ICP Protocols and is organized based on a common definition for the project lifecycle phases typically found in a well-executed project. ICP's project phase definition is based on existing industry standard definitions and is comprised of:

1. **Baselining**
2. **Savings Calculations**
3. **Design, Construction, and Verification**
4. **Operations, Maintenance, and Monitoring**
5. **Measurement and Verification**

Within each ICP Protocol, sets of required procedures and documentation have been identified and are listed within the appropriate lifecycle stage.

It is important to understand that the development of preceding components of a project will affect subsequent project components and results. For example, the baseline and energy end-use consumption estimates are used in the calibration of a dynamic building simulation and in M&V efforts so any inaccuracies in the baseline may result in an over-prediction of energy savings estimates and/or an inaccurate assessment of verified energy savings.

Related to the project lifecycle is ICP's definition of two project periods relative to IREE Certification. Since IREE Certification occurs after completion of project design and engineering, but prior to construction, the identification of these periods helps to clarify how IREE Certification integrates with various activities that occur before and after IREE Certification. The periods consist of:

- **Certification Period** (pre-IREE Certification). The Certification Period includes all procedures and documentation elements associated with project development that occur prior to IREE Certification. This includes all activities associated with baseline development and savings calculations as well as the development of plans (such as the Operational Performance Verification

(OPV), Operations, Maintenance and Monitoring (OM&M), and Measurement and Verification (M&V) plans) that describe the tasks and documentation that will be performed during the Performance Period.

- **Performance Period** (post-IREE Certification). The Performance Period refers to the construction and post-construction (post-retrofit) periods that occur after IREE Certification is achieved. The ICP Protocols require certain procedures and documentation elements that occur during the Performance Period which are specified in various plans that are developed during the Certification Period. These plans, and the requirements identified in them, should be explicitly required by the investor or building owner to be included in the project developer's scope of work and contract. If necessary, the services of the QA Assessor or other third parties may be retained during the Performance Period to oversee their implementation.

PLANNING FOR THE DEVELOPMENT OF AN IREE PROJECT

Industry best practices for project development urge the development team to determine a comprehensive project development approach as early as possible. This is especially true for IREE projects where certain methodologies will dictate which ICP Protocol to use and a strategy for meeting its requirements.

One important consideration is determining whether to use dynamic calibrated building simulation or other tools (such as spreadsheet calculations) to estimate energy savings for the project. In general, the development of a simulation model requires a greater level of effort, as well as specific skills pertaining to simulation model development. However, building simulation offers a comprehensive assessment of a building's operation and of the interactive effects that will occur when considering multiple measures for a project. These considerations and the particulars of the project should be considered by the project team to determine whether the scope of a project warrants the use of a dynamic building simulation.

Another consideration which must be planned for early in project development is the selection of the appropriate Measurement and Verification (M&V) approach(es). The ICP Protocols require a specific International Performance Measurement and Verification Protocol (IPMVP) Option be utilized depending on the selected protocol. For more comprehensive projects and whole building retrofits, the IPMVP Option C, *Whole Facility* approach is recommended which analyzes pre- and post-retrofit utility bills to verify performance and represents a comprehensive method for savings verification. However, for more targeted projects that involve a smaller project scope, IPMVP Options A and/or B approaches, which deal with key or all parameter measurement of a *Retrofit Isolation*, may be more appropriate as they require fewer resources and can isolate the performance of individual measures for appropriate projects. As the IPMVP approach will ultimately dictate the effectiveness of the M&V efforts, as well as the selection of the appropriate ICP Protocol, it is crucial that the project developer carefully evaluates which IPMVP option best suits a given project. For more information on selecting an IPMVP approach, please refer to the IPMVP Core Concepts or Section 5.0 of the PDS.

As soon as project development approaches have been determined, it is recommended that the project developer select the appropriate ICP Protocol.

The ICP Protocols consist of a suite of protocols that are designed to accommodate projects based on region of origin, project scope, and building type. For each region (North America and Europe) there are currently six protocols divided between Commercial/Tertiary and Multifamily/Apartment Block building types. For each building type there is a Large, Standard, and Targeted protocol that are associated with differing project scopes. Correct selection of the appropriate protocol must involve assessment of the specifics of the project including not only the project scope/scale, but the previously discussed project development approaches as well as the level of investment and project risk factors. The protocols consist of:

The **Large Commercial/Tertiary or Multifamily/Apartment Block protocols** are intended for:

- **Large Buildings**, where the cost of improvements and magnitude of energy cost 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
- **Calculation Methods** - projects that plan to use dynamic calibrated building simulations to estimate energy savings; and
- **Measurement and Verification** - projects that will apply an IPMVP Option C, Whole Facility approach.

It should be noted that currently ICP does not allow the use of an IPMVP Option D, *Calibrated Simulation* approach for M&V. Instead, it requires the use of IPMVP Option C to be combined with calibrated simulation as the calculation method for projects using the Large Protocol, rather than by measuring energy use at the utility meter level alone. This is described further in Section 5.0 of this document.

The **Standard Commercial/Tertiary or Multifamily/Apartment Block protocols** are intended for:

- **Standard Projects** - multiple measure projects where engineering requirements must be scaled to fit performance risk
- **Calculation Methods** - projects that plan to use non-dynamic building simulation methods to estimate energy savings; and
- **Measurement and Verification** - projects that will apply an IPMVP Option A and/or B, Retrofit Isolation approach.

The **Targeted Commercial/Tertiary or Multifamily/Apartment Block protocols** are intended for:

- **Non-interactivity -** single measure projects or multi-measure projects with no interactivity (apart from lighting/HVAC ECMs)
- **Targeted Scope** - the scope of the measures is typically not that complex, and engineering requirements are scaled to fit performance risk
- **Calculation Methods** - projects that plan to use non-building simulation methods to estimate energy savings; and
- **Measurement and Verification** - projects that will usually apply an IPMVP Option A and/or B, Retrofit Isolation method; in some cases, IPMVP Option C may be more appropriate.

Each project will have its own set of characteristics, as well as limitations on resources and time, and it is recommended that the project development team work with an ICP Quality Assurance Assessor and investors to determine the most suitable protocol to apply to any given project. The diagram below provides simplified guidance on the protocol selection process.

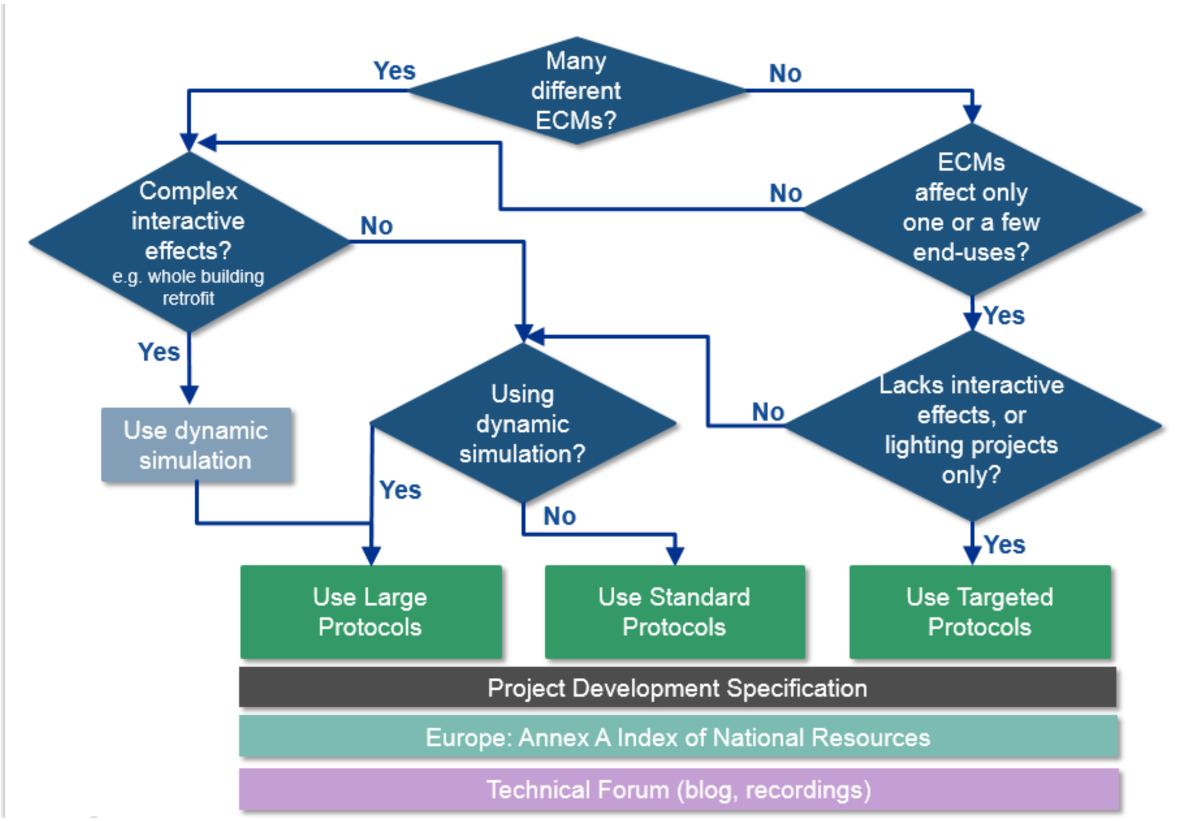


Figure 1 Protocol selection decision flowchart

1.0 BASELINING

1.1 OVERVIEW

A TECHNICALLY SOUND ENERGY CONSUMPTION BASELINE PROVIDES A CRITICAL STARTING POINT FOR THE ACCURATE PROJECTION OF POTENTIAL ENERGY SAVINGS AND IS ALSO CRITICAL FOR MEASUREMENT AND VERIFICATION UPON COMPLETION OF A RETROFIT AND/OR RETRO-COMMISSIONING EFFORT.

The building baseline must establish how much energy a building can be expected to use over a representative 12-month period at a minimum. The exception to this is the case of the Targeted protocols where only a Retrofit Isolation Baseline associated with the proposed ECMs is required (see section 1.5).

The baseline needs to cover all energy sources and account for:

- Total electricity purchased
- Purchased or delivered steam, hot water, or chilled water
- Natural gas
- Fuel oil
- Coal
- Propane
- Biomass
- Any other resources consumed as fuel and any electricity generated on site from alternative energy systems
- Any renewable energy generated and used on site

It must also factor in the impact of independent variables on the building's energy consumption such as weather, occupancy, and operating hours.

There are currently a number of baselining and benchmarking tools and software applications that are commercially available to assist with baseline development. While not required, these tools can dramatically reduce costs compared with more ad hoc analysis methods. These energy management software tools store, analyze, and display energy consumption or building systems data, and can be used to automate the processes involved in the baselining component of energy efficiency (EE) project development. Many of these tools can also be used to automate the tasks involved with an IPMVP Option C approach to measurement and verification (M&V). The resources subsection describes and compares applications of energy management tools in greater detail.

The table below indicates which elements described in this document apply to each protocol.

Procedure	Section	Protocol		
		Large	Standard	Targeted
Collect energy source data, independent data, and utility rate schedules	1.2	✓	✓	✓
Calendared the independent variable data	1.3	✓	✓	
Develop the baseline regression model	1.4	✓	✓	
Develop the retrofit isolation baseline	1.5		if used	✓
Establish monthly peak demand and pricing/Chart average daily demand	1.6	if necessary	if necessary	if necessary

1.2 Energy Source Data, Independent Data, and Utility Rate Schedules (All Protocols)

1.2.1 Historical energy use (Large and Standard Protocols)

Historical energy consumption and cost data must be collected for electricity, on-site fuel for heating and cooling, district steam, and hot or chilled water. It is recommended that data are collected for a three year period (or a minimum one year period) over a representative period for the following information (US: see Section 10.3 of the ASTM E2797 Building Energy Performance Assessment (BEPA Standard):

- Electricity consumption
  - Utility name
  - Electricity consumption (total annual kWh)
  - Peak electricity demand (maximum kW demand for each month of a 12-month period) (see section 1.6)
  - On-site electricity generation (total annual kWh) and method
- On-site fuel for heating or cooling
  - Fuel type(s), including renewable energy
  - Utility or provider name

    - Fuel use (total annual)
- District steam, hot water, or chilled water
    - Type
    - District steam provider
    - Use (total annual)
- Cost data in local currency
    - Total annual purchased electricity cost
    - Total purchased electricity cost per kWh
    - Total annual on-site fuel use cost
    - Total annual on-site cost per unit of fuel used
    - Total annual cost per unit of district steam, hot water, or chilled water

Building energy consumption metrics should be developed using the baseline historical utility data. This should include kWh/yr and kWh/(ft^2-yr) (kWh/(m^2-yr)), as well as (US) kBtu/yr and kBtu/ft^2-yr. Heating values of fuels reported on utility bills are typically adjusted for delivered heat content, elevation, and temperature. If fuel content values are not available from the local utility, they should be estimated and documented using recognized calculation methods. If the building is located at higher elevations, gas heating values should be adjusted for elevation according to best practices and in consultation with the gas supplier (US: see section 11.3.2 of the ASTM BEPA standard).

Quality Assurance Methods (Certification Period)

- ❖ Perform a review of collected data to ensure that a minimum of 12 months of contiguous data have been collected, using up to three years' worth of data. Ensure that all energy consumption data types have been accounted for. Ensure appropriate calorific values for fuels have been used.
- ❖ Ensure that the collected data does not include any periods involving major renovations (any renovation that affects more than 10% of the total floor area or more than 10% of the building's total energy consumption).

Resources

ASHRAE Standard 105 - Provides a common basis for reporting building energy-use in terms of delivered energy forms and expressions of energy performance.

ASTM E2797 Building Energy Performance Assessment (BEPA) Standard - Provides a methodology for the collection, compilation, analysis, and reporting of building energy performance information associated with a commercial building.

1.2.2 ENERGY END-USE CONSUMPTION (LARGE AND STANDARD PROTOCOLS)

Estimating or measuring energy end-use consumption is an important component of baseline development. The results of this effort can be used to calibrate the dynamic building simulation (for Large Protocols) as well as to calibrate energy savings estimates. There are three acceptable approaches as specified in the ICP protocols:

1. Sub-metering represents an accurate method to measure energy end-use consumption. For weather dependent end-uses, or end-uses that vary based on other independent variables, the metering period should cover a period that will capture both minimum and maximum loads. Regression analysis can then be used to estimate annual energy consumption for each end-use. Similar to the methodology described in the total building energy baseline development effort, this regression analysis requires the development of an energy use equation which relates the dependent variable to independent variables known to impact the end-use energy consumption.
2. A bottom up (calculated) approach to estimated energy end-use consumption may also be employed. This involves using the information collected during the energy audit to calculate energy consumption associated with each end-use. This includes lighting inventories, mechanical schedules, plug load inventories, domestic hot water inventories, etc., combined with associated operating schedules. For example, the total demand (kW) associated with the lighting fixtures can be multiplied by the annual full load hours (AFLHs) of the lighting fixtures to develop the lighting energy end-use consumption.
3. A third and simpler approach to energy end-use consumption estimation involves the use of national sources of data representing typical building energy characteristics. The ASHRAE Sample End-Use Breakdown workbook can be used to assist with this approach. In Canada, the Natural Resources Canada's National Energy Use Database (NEUD) can be utilized. In Europe, where no national resources exist, European-wide resources should be used, such as the *EU Building Stock Observatory (see https://ec.europa.eu/energy/en/eubuildings)*. Based on building type, age and country, the appropriate estimated end-use consumption percentages can be applied to the total historical energy consumption of the building. While not as accurate as the aforementioned methods, this method can provide a cost-effective alternative when more detailed methods are cost or resource prohibitive.

Once developed, the energy end-use consumption estimates can be used to calibrate the energy end-use consumption predicted by a dynamic building simulation or spreadsheet calculation for the base year, allowing the individual developing the baseline to work within realistic expectations of energy consumption. Similarly, energy savings estimates associated with a specific end-use can be compared to the total energy consumption of that end-use to develop reasonable and realistic estimates of energy savings.

Quality Assurance Methods (Certification Period)

- Review energy end-use consumption estimation methods and results for reasonableness.
  - Sub-metering estimates: ensure that adequate monitoring periods capture minimum and maximum energy consumption and are regressed based on appropriate independent variables adhering to the methodologies described in the baseline development section.

Quality Assurance Methods (Certification Period)

- Check that the weather data were collected from a weather station in close proximity to the building, and that an alternative weather station is not more representative of the weather in the building's area.
- Check that actual weather data corresponding to the period covered by the historical utility billing information are used for dynamic building simulation calibration purposes or data analysis.

Resources

Degree Days.net *(BizEE)* - Degree day data resource aimed at energy efficiency professionals.

DOE2.com - Weather data repository containing TMY weather files.

Elements *(RMI, Big Ladder Software)* - A format neutral weather application that provides inputs for dynamic building simulations. This tool allows the user to read/write/convert between all major weather file formats, create custom files from measured data, display statistical data, and visualize or inspect data graphically.

Canadian Weather Energy and Engineering Datasets - Historical weather data for Canada

National Climatic Data Center *(NOAA)* - Resource for historical climate and weather data.

1.2.4 Occupancy Data (Large and Standard Protocols)

For projects using the ICP Large and Standard Protocols, collect monthly occupancy (or vacancy) rates corresponding to the baseline period for three years (or a minimum one-year period). The data should not include any periods of major renovation (changes to the building affecting more than 10% of the buildings gross square footage or 10% of the building's energy use). Indicate occupancy types, space types, and occupancy schedules for all spaces within the building where these are relevant to the baseline.

Significant changes in occupancy, occupancy schedules, or space types that affect the overall building energy consumption may warrant non-routine adjustments to the baseline. If post-retrofit occupancy and space use differ from baseline conditions, adjustments should be made to account for the corresponding changes in building heating or cooling loads due to these variations, as well as how these changes in occupancy or space use impact the energy consumption of the heating or cooling equipment serving these spaces.

For projects following the Targeted protocol, the above approach should be taken where occupancy significantly affects the retrofit isolation baseline energy consumption for the specific systems involved with the ECMs.

Quality Assurance Methods

- During the Certification Period, ensure that occupancy data, occupancy types, space types, and occupancy schedules were collected and documented.
- During the Performance Period, note any significant deviations from "normal" occupancy,

occupancy schedules, or space types.

Resources

EN 16247-2 Energy Audits – Part 2: Buildings (section 5.3.2) – Provides guidance on information required relating to occupancy as part of an energy audit.

1.2.5 Building Asset / Operational / Performance Data (All Protocols)

Collection of accurate building asset, operational and performance data is critical to the decision-making process. These data provide the foundation for all important investment decisions, including building performance tracking, assessment of energy efficiency opportunities, ECM investment implementation and performance tracking.

Information regarding the building's operation and system performance should be collected by conducting an energy assessment of the building(s) or system(s) that are to have ECMs installed. For projects using the Targeted protocol, where numerous sites may be involved, a sampling approach to auditing may be adopted provided an explanation is given for the selection of sites to be audited in the context of all the sites in the project and an estimate is made of any associated uncertainty.

Information to be collected can include: site observations and equipment nameplate data; building as-built drawings; interviews with facility personnel, maintenance personnel, manufacturer's representatives, service providers and occupants; commissioning and recommissioning reports; sequences of operation; test, adjustment and balance (TAB) reports; spot measurements or short-term monitored data; or previous energy audits. A checklist of key building information that should be collected at a minimum is provided below (in the US, refer to BEPA standard Appendix X8):

1. Building information
    a. General building information, such as building location, type, age
    b. Energy performance certificate, if available
    c. Air conditioning inspection reports, if available
    d. As built plans
    e. Building floor area, including a description of how this has been calculated – the calculation should include all conditioned parts of the building
    f. Details of car parking - including whether or not it is enclosed and mechanically ventilated, and associated floor areas
    g. Description of tenant type(s), area in ft^2 (m^2) of building occupied, and details of their lease agreement
    h. Energy related data (see section 1.2.1) – including details of the building's energy supply and metering arrangements, as well as details of any sub-meters (drawings, schedules)
    i. Variables affecting energy consumption e.g. weather data, occupancy patterns
    j. Information on changes made to the building in the last three years that may affect energy

consumption related to the energy baseline or ECMs, such as physical changes to the building or its systems, or changes related to occupancy

2. Systems and equipment information, where relevant to the ECMs
    a. Overview of systems description e.g. from Operation and Maintenance manuals
    b. Building services schematics – mechanical and electrical
    c. Details of the energy consuming systems, plant and equipment for relevant areas of the building, including type, number, capacity, hours of operation, location, areas served, and controls, including:
        i. Heating and hot water, including heat recovery
        ii. Mechanical ventilation
        iii. Air conditioning
        iv. Lighting – internal and external
        v. Motors and drives
        vi. Low and zero carbon technologies e.g. solar photovoltaics, combined heat and power etc.
        vii. Elevators and escalators
        viii. Information Technology and small power equipment
        ix. Specialist equipment e.g. commercial refrigeration, compressed air
3. Controls and Building Management System
    a. Information on how the building is controlled including key data such as set points and time clock settings
4. Building envelope details where relevant to the proposed ECMs

It is important to collect this information in a consistent and standardized way. Therefore, the data collection process should utilize standardized forms and methods, or tablet-based applications designed for energy audit data collection. The collection of information must be thorough, as well as specific to the building and system types. Equipment schedules, tables, and building and system descriptions must be developed in order to compile this information in a way that can be easily and clearly referenced in associated project development tasks. The underlying concept is that energy auditors with different levels of skill or experience should be able to follow a specific process and utilize standardized tools such that each one would gather the same information independently in a comprehensive and accurate manner.

While collection of complete and accurate building data is important, of equal importance is the proper and thorough documentation of these data and their sources. These resources will then be easily referenced, shared, and used in all subsequent project development efforts, including: energy conservation measure (ECM) descriptions; dynamic building simulation development; ECM savings calculations; cost estimation; design and construction; operational performance verification; operations, maintenance and monitoring (OM&M); and M&V efforts. Without these sources of data collection, other project development tasks may be hindered.

The energy audit report must include building asset, performance, and operational data collected and used for the project development. The report must also note the sources of the information and a description of how the information was collected. Standardizing the way these data are reported is also critical.

At a minimum, the report should include:

- Summary, including technical and non-technical overview
- Background to the building, its systems and its operation (see earlier in this section)
- Any key observations made during the audit
- Historical energy consumption analysis (see section 1.2.1) and including details of energy costs (see section 1.6)
- Energy efficiency opportunities identified and description of proposed ECMs – including anticipated savings and cost (see section 2)

The format of the report should also satisfy the project's requirements including client's and other stakeholder's expectations.

The ICP Building Button project is a specification for a standard XML dataset based on the U.S. Department of Energy's (DOE's) Building Energy Data Exchange Specification (BEDES). It is an ongoing, effort that defines a common format for the reporting, exchange, and aggregation of building data. The ICP Building Button accommodates diverse data from disparate sources and allows it to be easily exchanged between project developers and a wide range of investors and other stakeholders. The standardization of data exchange through the ICP Building Button will lead to the wide-spread availability of reliable actuarial data on energy efficiency project performance throughout the industry.

Additional information on energy surveys and data collection methods can be found in the *ASHRAE Procedures for Commercial Building Energy Audits* and the *ASHRAE Handbook - HVAC Applications*, Chapter 36, "Energy Use and Management," and Chapter 41, "Building Energy Monitoring."

Quality Assurance Methods (Certification Period)

- Review data collection methods and tools (interview questions, data collection forms, tablet applications) to ensure that they are comprehensive and consistent with required standards.
- Review collected data and perform spot check comparisons of resources to collected data (e.g. compare building drawings to equipment inventories) to ensure that data was collected accurately. Ensure that the sources of this data are documented.
- Review operational and performance data analysis results (spot measurements, short-term monitoring, and functional performance tests). Ensure that conclusions regarding system performance correspond to and are consistent with analysis results.
- Review report (or report sections) to ensure that building asset, operational, and performance

data have been properly represented and the sources of these data are well documented.

Resources

ASHRAE Handbook - HVAC Applications - *Chapter 36*, "Energy Use and Management," and *Chapter 41*, "Building Energy Monitoring."

ASHRAE Procedures for Commercial Building Energy Audits *(Second Edition 2011)* - Defines best practices for energy surveys and analysis. This is useful for both purchasers and providers of energy audit services.

ASHRAE Standard 100 - Energy survey requirements, operation and maintenance requirements, and building and equipment modification requirements.

ASTM E2797 Building Energy Performance Assessment *(BEPA) Standard* - Provides a methodology for the collection, compilation, analysis, and reporting of building energy performance information associated with commercial buildings.

Building Energy Data Exchange Specification *(LBNL/DOE)* - Designed to facilitate the utilization and sharing of empirical building energy performance data among software tools and data collection and analysis activities.

EN 16247-2 Energy Audits – Part 2: Buildings *(section 5.3.2 and Annex D)* – Provides guidance on information required as part of an energy audit; *(section 5.6)* – Provides guidance on standard reporting.

1.3 Calendarization of the Independent Variable Data (All Protocols)

Data that do not correspond to calendar month periods (such as for two partial months) should be converted to calendar months. Determine average daily consumption during each partial month, and multiply the daily average consumption by the total number of days in the calendar month. For raw fuel delivered to the facility (e.g. fuel oil, propane), estimate monthly energy consumption based on actual consumption between fuel deliveries, or by pro-rating actual consumption between deliveries by an appropriate metric such as heating degree days.

Quality Assurance Methods

- Review calculations carried out to calendarize data.

Resources

ISO 16346:2013 Energy Performance of Buildings – Assessment of Overall Energy Performance *(section 8.2.2)* - Provides guidance partial year/month data "calendarization".

1.4 Baseline Regression Model (Large and Standard Protocols)

Normalization is used to analyze, predict and compare energy performance under equivalent conditions. Regression-based modeling is a specific type of normalization, and involves the development of an energy use equation, which relates the dependent variable (total site energy consumption, including electricity and on-site fuel or district energy) to independent variables known to significantly impact the building's energy consumption. Independent variables typically include weather (heating and cooling degree days), and may include other variables such as operating hours, occupancy or vacancy rates, and number of occupants.

The energy use equation should be determined using a regression analysis – the process of identifying the straight line of 'best fit' between the building's energy consumption (usually on a monthly basis) and one or more independent variables. An example of this is shown below:

Energy consumption (kWh) = $m_1X_1 + m_2X_2 + C$

Where

C = energy baseload in kWh (determined from regression analysis)

$m_{1,2,etc}$ = energy consumption in kWh per unit e.g. energy consumption per degree days kWh/^{o}F (kWh/°C) (determined from regression analysis)

$X_{1,2,etc}$ = number of units e.g. number of degree days in ^{o}F (°C)

Further variables can also be included – this is known as multiple-linear regression. More complex regression techniques may also be employed where required, in which case the reasoning and calculation details must be provided.

For projects following the Standard protocols, where it is deemed that the independent variables do not have a significant effect on the baseline, then normalization and development of the energy consumption equation is not required. However, clear justification for this approach should be provided, including an estimate of the impact on energy savings.

The regression-based energy model and the energy consumption equation should result in adjusted R^2 values of at least 0.75 and a Coefficient of Variation [Root Mean Square Error] or CV[RMSE] less than 0.2. Every attempt should be made to develop a model that falls within these accepted parameters. If these criteria cannot be met due to bad or inconsistent data or other extenuating circumstances the reasons for this discrepancy must be noted. In these cases, it is recommended that the uncertainty that these discrepancies may have on the project's outcome be quantified.

Linear Regression Example

An energy efficiency project is anticipated to impact on the heating demand of a building, and therefore the building's gas consumption needs to be normalized against weather data. In this case, the monthly gas consumption, which has been taken from the utility bills, would be plotted against heating degree day data using the form of linear regression described above – this is shown in the example below, which has been created using standard functions in Excel (using the 'least squares' method). The correlation of the gas consumption data with the degree data is checked by establishing the R^2 value – here, it is 0.8, indicating an acceptable correlation. Using the form of the energy consumption equation described above, the value of 'm', or the gradient of the line, is 2,579 kWh/°C HDD, and the y-intercept value is 181 MWh which represents the base gas demand for uses such as domestic hot water and catering. These figures can be applied together to average historical weather data (for example, 20-year average heating degree day data) to create a normalized energy consumption for each month.

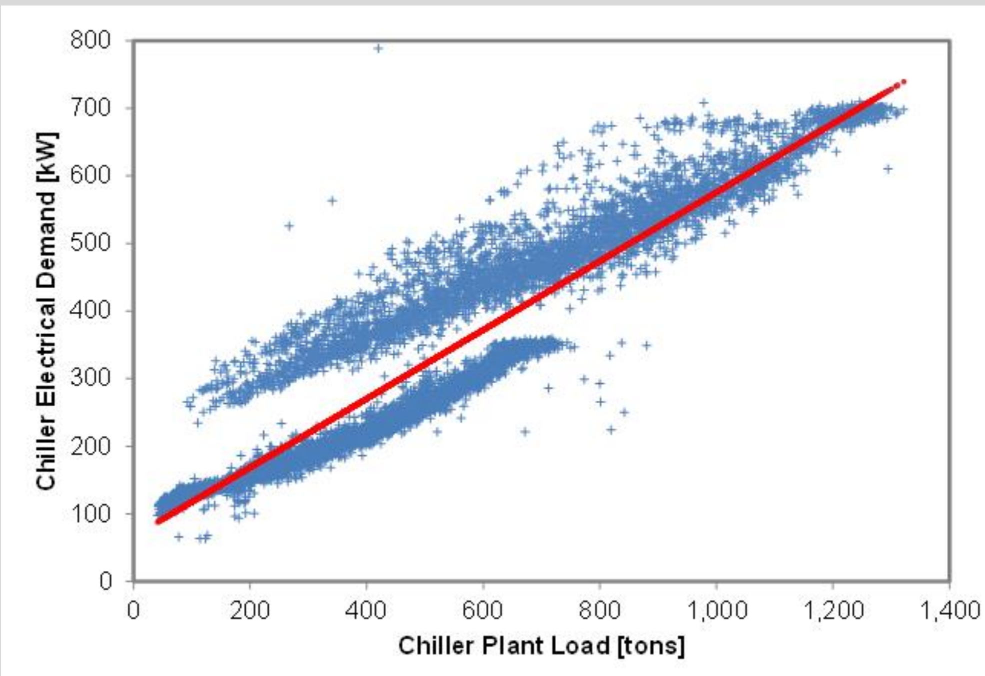


Figure 2 Example linear regression graph for gas consumption against heating degree day data

While not required by ICP, it is considered a best practice to quantify uncertainty for the developed baseline in the form of a lower and upper bound. This can be accomplished by comparing the building's energy consumption predicted by the developed energy consumption equation to the actual utility bills for the baseline period using the difference in energy consumption to calculate the error associated with the baseline. This derived calculation, combined with the standard deviation and the required confidence/precision levels, can subsequently be used to create a range around the baseline (minimum and maximum).

The process of data collection, compilation, analysis, and reporting should be consistent, transparent, and practical. While in-house tools for performing these tasks represent a reasonable approach, there are also a myriad of available proprietary tools that automate many of these tasks that should be considered to enhance the project development process. These tools can download data automatically from the energy provider, perform regressions, provide visualization of the data, and typically include reporting and exporting features. Many of these applications also provide benchmarking capabilities or can be used to perform IPMVP Option C M&V analysis or can bound energy savings estimates.

The baseline utility data collection process should note any renovation affecting greater than 10% of building floor area, or a change that affects estimated total building energy consumption by greater than 10%, i.e. "major renovation." Where this is the case, information regarding renovations or changes to the building or its operation should be collected during the energy audit, along with the technical information relating to these changes – for example, changes to the insulation or glazing in the building and the corresponding changes to their U values. Energy consumption data from any period involving a major renovation should not be used to develop the baseline.

The report describing the baseline and its development (in the US, see BEPA standard Appendix X6 for an outline of this report format) should include the following as a minimum:

- Data for 12 months of energy consumption by fuel type
- Details of all calculations carried out (e.g. calendarization and normalization) including any assumptions made or supporting data used (e.g. degree day data)
- If developed, the range of building energy consumption compared with the normalized baseline with lower and upper bounds

Quality Assurance Methods (Certification Period)

- ❖ Review the regression-based energy model and the energy use equation form. Ensure that all independent variables that significantly affect energy consumption have been accounted for and are represented in the energy use equation. Check that adjusted R^2 values are at least 0.75 and that CV[RMSE] is less than 0.2. If the model does not fall within these parameters, check that the reasons for these discrepancies have been documented and are justifiable, and that the resulting uncertainty has been accounted for.
- ❖ Review the report (or report sections) illustrating baseline development and energy consumption results to ensure that all information and methodologies have been presented, that the results presented correspond with analysis results, and that all sources of information have been documented.

Resources

EN 16212:2012 Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods (section 5.2.3.1) – Provides guidance on carrying out normalization of climate dependent energy consumption.

Inventory of Commercial EMIS for M&V Applications (PECI) - Report that provides descriptions and comparisons of EMIS tools useful for baseline development.

Inverse Modeling Toolkit (ASHRAE) - Guidelines for calculating linear, change-point linear, and multiple-linear inverse building energy models. This toolkit describes the numerical algorithms used to find general least squares regressions, variable-base degree day change-points, and combination change-point multivariable regression models. It also describes the equations used to estimate the uncertainty of predicting energy use for the purpose of measuring savings.

ISO 50006:2014 Energy Management Systems – Measuring Energy Performance Using Energy Baselines and Energy Performance Indicators (Annex D) - Provides an overview of Normalization and regression modeling.

1.5 RETROFIT ISOLATION BASELINE (STANDARD AND TARGETED PROTOCOLS)

A retrofit isolation baseline presents a baseline specific to the proposed ECMs. The development of the retrofit isolation baseline(s) should follow a similar procedure to that described in the previous baseline development section (section 1.4). It should be informed by, and be consistent with, all collected field data that describes operation of the facility and systems.

Development of the retrofit isolation baseline should include a clear definition of the measurement boundary. The boundary can be defined around a specific piece of equipment, a combination of equipment comprising a building subsystem, or a specific end-use. The measurement boundary should also account for whether the equipment or end-use is a constant or variable load, or a constant or variable schedule.

For the proposed ECMs, the load and hours-of-use components, and whether these components are constant or variable, should be documented. The measured and estimated parameters should be defined based on the characteristics of the proposed ECMs. When these have been identified, the measurement period should be selected so that it is appropriate for the measured parameters identified and the associated operating conditions relating to the ECM.

The developed baseline(s) should be informed by all available information, including equipment inventories and operating performance, and should be compared to simple estimation efforts or previous energy savings estimates to ensure reasonability. These baselines should be used to bound savings estimates and subsequently to verify achieved energy savings.

Quality Assurance Methods (Certification Period)

- ❖ Ensure that retrofit isolation baseline(s) are developed following a similar approach to that outlined in section 1.4 of this specification. The baseline should be informed by, and be consistent with, available data and should correspond to end-use energy consumption calculations.
- ❖ Ensure that baselines document load and hours-of-use components and whether these components are constant or variable.
- ❖ Ensure that a suitable measurement boundary has been clearly identified as well as measured and estimated parameters and the measurement period.

- Ensure that developed baseline(s) are used to bound savings estimates and are used for IPMVP Option A or B M&V efforts (if applicable).

Resources

International Performance Measurement and Verification Protocols (EVO), Core Concepts - Section 45.1 provides guidance on identifying the measurement boundary.

Verification by Equipment or End-Use Metering Protocol *(BPA)* - Presents methods for isolating equipment or end-uses, methods for monitoring / metering, and M&V practices specific to retrofit isolation. Intended for measures that change load or operating hours, or both.

1.6 Monthly Peak Demand and Pricing and Charting Average Daily Demand (All Protocols)

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 or time-of-use pricing are in effect load profiles must be provided to show the pattern of daily demand in order to accurately predict savings. 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 consumption.

Analysis of whole-building monthly energy consumption and demand data also facilitates M&V efforts and the analysis of interval data and the development of load profiles can provide additional insight into building operation, load disaggregation, end-use benchmarking, and potential energy saving opportunities. The increased availability of energy consumption data at resolutions of one hour or less (due largely to recent increases in smart or time-of-use metering) provides greater resources to perform this level of analysis on energy efficiency projects.

Describe how the facility purchases energy, including the pricing that applies to peak and off-peak energy, for all energy types, and present at least one bill for electricity and also at least one bill for each fuel type. The price schedule should be obtained from the energy supplier. This price schedule should include all elements that are affected by metered amounts, such as consumption charges, demand charges, transformer credits, power factor, minimum demand charges, fuel price adjustments, early payment discounts and taxes. Average or blended prices should never be used to calculate cost savings, other than for early stage feasibility assessments.

The price schedule used for the purposes of M&V will need to be determined - whether energy-cost savings are verified using the price schedule which corresponds to the baseline or reporting period. Typically, the price schedule associated with the reporting period is used to calculate verified costs savings so that they are a function of demand changes rather than a mix of demand and price/tariff changes.

If interval data are available, it can be used to develop load shapes. Interval data may also be referred to as "interval meter data," "demand interval data," "kW interval data," or "electricity interval data." Common forms of interval data include 15-minute data and half-hourly data.

At a minimum, monthly load profiles showing peak demand should be developed using monthly data. Where these data are 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.

Where demand charges or time-of-use pricing is in effect, load profiles should be developed using available interval data for typical weekday and weekend days in the spring, summer, autumn and winter. Time should be charted on the x-axis and appropriate energy units (such as kWh or MBtu) on the y-axis.

The developed load profiles can indicate excessive energy consumption during normally unoccupied periods (such as evenings or weekend days). The load profiles can also show peak periods of demand, which represent potential opportunities for demand reduction or demand limiting efforts. Load profiles can also be used to assist with dynamic building simulation calibration efforts.

Quality Assurance Methods (Certification Period)

- Ensure that all price schedules have been provided, and that the price schedule to be used for the purpose of calculating verified cost savings has been identified.
- Review developed load shapes (if interval data is available) and how they were used to inform identification of ECMs or energy-modeling calibration efforts.

Resources

Energy Charting and Metrics Tool *(Bill Koran; multiple funders)* - ECAM is an add-on for Microsoft Excel® which facilitates the analysis of data from the building (energy and other data). Key features of ECAM include: creation of charts to help re-tuning, creation of schedules and day-type information using time series data; filtering data from months, years, days, day-type, day of week, day of month, occupancy, temperature binned weather data, pre/post comparisons after retrofits or retro-commissioning; normalizing data and creating metrics based on consumption or equipment; creation of various load profiles or scatter charts for data selected by the user; and new M&V for meter data.

2.0 SAVINGS CALCULATIONS

2.1 OVERVIEW

Savings calculations can be performed using detailed dynamic building simulation, spreadsheet calculations, or other methods, depending on the requirements of the project and protocol. Regardless of the method employed, the procedure should be transparent and well documented. For Large and Standard projects, calculation methods must be based on sound engineering methods and be consistent with the IPMVP approach (refer to IPMVP Core Concepts, 2016, section 5) and (in the United States and Canada) ASHRAE principles and methodology. Assumptions must be based on observations, field measurements, monitored data, or documented resources. In all cases, these assumptions should be conservative, transparent, and documented.

Interactive effects are secondary energy effects occurring as a result of ECMs, usually associated with heating and cooling, and must be considered for all types of projects.

ECM descriptions should be thorough and document existing conditions, the proposed retrofit, and potential interactive effects. The descriptions should provide enough detail so that they can be used to develop accurate scopes of work and informed cost estimates.

For Large and Standard projects, the results of the savings calculations must be calibrated to estimated or known end-use energy consumption.

The table below indicates which elements described in this document apply to each protocol.

Element	Section	Protocol		
		Large	Standard	Targeted
ECM Descriptions	2.2	✓	✓	✓
Dynamic Building simulation (Model Data, Calibration, Process Description)	2.3	✓	Alternative	
ECM Modeling	2.4	✓	Alternative	
ECM Calculations (Measure Calculation Tools, Calculation Data, Measure Calibration, Calculation Process Description)	2.5		✓	✓
Interactive Effects	2.5.1		✓	✓

Element	Section	Protocol		
		Large	Standard	Targeted
	2.5.2			(Lighting ECMs only)
Investment Criteria	2.6	✓	✓	✓
Cost Estimates	2.7	✓	✓	✓
Reporting	2.8	✓	✓	✓

2.2 ECM Descriptions (All Protocols)

The results of the energy audit or assessment of specific systems will allow for the development of a list of ECMs that can include low-cost and no-cost measures, operations and maintenance (O&M) improvements, and capital cost items. Estimates of annual energy savings and implementation costs are key components of the financial evaluation of an EE project (see section 2.6) and therefore detailed descriptions of the measures must be developed so that these estimates can be accurately developed.

As a minimum, documentation for each recommended measure should include the following information:

- The present condition of the system or equipment
- Recommended action or improvement

A best practice approach would also include:

- Risk of equipment failure
- Schedule for implementation
- Summary of specific maintenance requirements or considerations associated with the ECMs, particularly any impacts on maintenance costs
- Interaction with other end uses and ECMs (see section 2.5)
- Potential issues which may prevent successful completion
- Organizations and individuals involved in implementing this action or improvement, and their responsibilities
- Staff effort required

Quality Assurance Methods (Certification Period)

- Review the ECM descriptions to ensure that they contain sufficient information as described above.

2.3 Dynamic Building Simulation (Large Protocol)

Dynamic building simulation is best suited to projects with a large number of potentially interactive ECMs being considered and where there is a higher level of performance risk associated with the project. Development of an accurate dynamic building simulation, calibrated to historical utility bills, is critical for the accurate estimation of energy savings associated with the ECMs. The dynamic building simulation used should be developed using public domain or commercially available software that meets the current nationally or internationally recognized specifications for 8760-hour annual simulation of building energy consumption. Internationally recognized specifications include *ISO 13790:2008 Energy performance of buildings – Calculation of energy use for space heating and cooling* and (in the United States) *ASHRAE Standard 140-2011 Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs.*

The modeling process starts with complete descriptions of the facility, building envelope, mechanical systems, service water heating, and electrical systems, and also includes climate data and utility rate information. The following are specific components that need to be entered into the dynamic building simulation:

- Building location and orientation
- Descriptions of all building envelope assemblies, including exterior walls, windows, doors, roofs, underground walls and floors as well as component dimensions and orientations
- Space use classifications that best match the uses within the building or individual spaces as well as space sizes (volume). These classifications determine default occupant density, plug loads, service water heating, minimum outdoor ventilation air, operating schedule, and lighting assumptions when this information is unknown
- Internal loads associated with each space, including occupant density, plug loads, process loads, infiltration, thermal mass, refrigeration equipment, cooking equipment, miscellaneous equipment, elevators and escalators, and lighting, as well as associated schedules and controls
- Zones representing areas of the building served by a single thermostat. Zones may be combined to simplify the dynamic building simulation, assuming these zones are served by the same HVAC system or system type, have similar conditioning requirements, similar minimum airflows, and similar loads
- Information on all HVAC systems and equipment, including which systems serve which zones. All information regarding the system type, efficiency, performance curves and operation needs to be inputted into the model. This includes setpoints, control strategies, ventilation, and schedules
- Domestic hot water systems and associated schedules or controls
- Exterior lighting and associated schedules or controls

- Swimming pools and other miscellaneous fuel or electricity using equipment
- Climate data - see section 1.2.3
- Utility rate information – see section 1.6

When developing a dynamic building simulation, it is often necessary to make assumptions about how the building is being operated, or about the loads or schedules pertaining to the building. Reliance on assumptions should be minimized but may be necessary due to lack of resources or available information. Assumptions may include thermostat settings, number of occupants, plug loads, process loads, hot water loads, as well as schedules of operation for HVAC systems, lighting systems and other systems. Assumptions should always be conservative and clearly documented.

While every reasonable attempt should be made to determine these inputs through the energy auditing activities, other resources can be used to generate reasonable assumptions to use in place of unknown data such as nationally recognized sources of design data. One such resource includes the Commercial Energy Services Network (COMNET), which provides guidance regarding defaults for these items.

Calibration of the dynamic building simulation to the baseline utility bill analysis represents a critical step toward ensuring accurate estimates of the building's energy performance and energy savings for proposed ECMs. Under a best practice approach, the calibration process requires development of a custom weather file conforming to the selected baseline period (not the use of averaged weather data). When creating a custom weather file, the weather data parameters that the building simulation program requires must be determined. This weather data may in some cases need to be collected from different weather stations.

IPMVP *Core Concepts* (section 6.6.3) sets out the steps associated with calibrating the simulation:

1. Collect and document detailed operating data e.g. occupancy, weather, equipment ratings and operating hours. It may be necessary to carry out short or medium-term monitoring for inputs which may vary in practice and which have a significant impact on results (e.g. lighting loads, equipment efficiency, etc.).
2. Collect real weather data covering the baseline period. However, in some cases, obtaining and preparing actual weather data for use with a simulation may be time-consuming and expensive. If this is found to be the case, then it may be acceptable to adjust an average weather file using valid statistical methods – in this instance, justification should be provided on why this approach is necessary.
3. Run the simulation and verify that it predicts operating parameters such as temperature and humidity.
4. Compare the simulated energy results with the metered energy data from the calibration period, on a monthly, daily, or even hourly basis. Monitored data of systems, subsystems or end uses can also inform the modeling and calibration process. Daily load profiles can also be used to assist in this process if available.
5. Determine the calibration accuracy. The calibrated model results should give a Mean Bias Error (MBE) of ±5% and CV(RMSE) of 15% relative to monthly calibration data. The accuracy of the

estimate can further be assessed using standard error of the estimate and the associated value of the t-statistic. IPMVP's Statistics and Uncertainty Application Guide for IPMVP provides guidance on how these measures are calculated.

6. Optimize the model by adjusting any unknown input data to bring predicted results within the required tolerance set out above. Adjustments to unknown or assumed inputs should be conservative and within reasonable defined parameters. Collect more actual operating data from the facility to meet the calibration specification if necessary. The calibration process should not include the adjustment of any known model inputs.

All modeling inputs and assumptions should be well documented in the form of a report that describes the modeling process. The report should include key modeling inputs and outputs as well as full disclosure of any modeling warnings or errors.

Quality Assurance Methods (Certification Period)

- Review modeling inputs to ensure that they correspond to field data collected during the audit. If spot checking items, which is common, review inputs that have the greatest potential impact on building energy performance or ones that are directly related to the proposed ECMs. Check that assumptions used for unknown variables are conservative.
- Check that the proper energy cost rate schedule(s) have been used in the dynamic building simulation.
- Review model errors or warnings and make corrections/amendments to the model where necessary.
- Review output reports and compare metrics to typical comparable metrics (such as Energy Consumption Intensity, ventilation rates, load densities, etc.).
- Review calibration methods to ensure that adjustments to the model are reasonable. Calibration efforts should utilize a local weather file for the time period corresponding to the baseline. Calibration results should result in a MBE of ±5% and a CV(RMSE) of 15% relative to monthly calibration data.

Resources

ASHRAE Guideline 14-2014 - Highly technical document strongly focused on calculating energy and demand savings using measurements and measurement uncertainty analysis, applicable to Options B, C and D M&V approaches. Section 6.3.3 contains details specific to dynamic building simulation development and calibration efforts.

ASHRAE Hourly Simulation Checklist - Checklist useful for verifying that all appropriate energy modeling inputs have been satisfied.

ASHRAE RP-1051 - ASHRAE Research Project that describes an analytical calibration process that includes four distinct processes: sensitivity analysis, parameter identification analysis, optimization and uncertainty analysis.

ASHRAE Standard 140-2017 Standard Method of Test for the Evaluation of Building Energy Analysis

Computer Programs - Specifies test procedures for evaluating the technical capabilities and ranges of applicability of computer programs that calculate the thermal performance of buildings and their HVAC systems.

ASHRAE Standard 209 *"Energy Simulation Aided Design for Buildings Except Low-Rise Residential Buildings"* - ASHRAE-sponsored effort describing a modeling standard. The scope will apply to new buildings, major renovations and additions, and will define nominal requirements for using modeling to support integrated design efforts.

BEM Library *(IBPSA)* - The concept behind the DOE-funded Building Energy Modeling (BEM) Library project is to develop a freely-shared, information repository for building energy modeling. The BEM Library consists of best practice methods and key resources linked to frameworks used for delivering services. The frameworks draw from the same set of best practices, methods and resources promoting consistency across the many uses for building performance simulation.

BEMBook Wiki *(IBPSA-USA)* - A guide to the BEM Body of Knowledge, which describes what portion of the Body of Knowledge is generally accepted, organizes that portion, and provides topical access to the information.

Building Component Library *(NREL)* - U.S. Department of Energy's comprehensive online searchable library of energy-modeling building blocks and descriptive metadata.

COMNET *(IMT/NBI)* - A quality assurance initiative to standardize dynamic building simulation development by creating consistent baselines relative to various energy codes and standards. COMNET extends and supports existing systems for assessing and rating the energy efficiency of new commercial and multifamily buildings in the United States. The core component of COMNET comprises a set of guidelines and procedures that governs this standardization.

Contrasting the Capabilities of Building Energy Performance Simulation Programs (Crawley et al) - Paper that provides comparisons of twenty major building energy simulation programs.

Elements *(RMI, Big Ladder Software)* - This tool provides a format neutral weather application to provide input for building energy modeling. The tools allow the user to read/write/convert between all major weather file formats, create custom files from measured data, display statistical data, and visualize or inspect data graphically.

EN 15265:2007 Energy Performance of Buildings *– Calculation of energy needs for space heating and cooling using dynamic methods – General criteria and validation procedures* – Sets out validation criteria for dynamic building simulations.

EN ISO 13790:2008 Energy Performance of Buildings *– Calculation of energy use for space heating and cooling* – Sets out the calculation procedures for detailed dynamic simulation methods for energy consumption associated with space heating and cooling.

Energy-Modeling Input Translator *(RMI)* - EMIT comprises a compilation of spreadsheet-based calculators developed in response to the need for tools that help building professionals translate design data and code requirements into typical energy model inputs.

International Performance Measurement and Verification Protocol: Core Concepts *(EVO)* – Section 6.6.3 sets out how to use a computer simulation to predict building energy consumption.

Model Manager (RMI) - An Excel-based tool that accesses eQUEST batch processing capabilities as well as results extraction functions.

Modelica - A non-proprietary, object-oriented, equation-based language to conveniently model complex physical systems containing mechanical, electrical, electronic, hydraulic, thermal, control, electric power or process-oriented subcomponents. Utilizes open programming standards that allows reusing technologies (model libraries, numerical solvers, tools for code generation) that are shared across industries and can be used to consistently model advanced building controls.

Multifamily Performance Program: Existing Buildings Standard Path Simulation Guidelines - Methodologies for energy simulation and model calibration specific to existing multifamily buildings.

2.4 ECM Savings Calculations – Dynamic Building Simulations (Large Protocol)

The calibrated baseline model, developed using dynamic building simulation software, should be updated to include the proposed ECMs and to estimate the resulting energy savings. In order to account for interactive effects, the measures can be modelled iteratively, effectively creating a “rolling” baseline that includes all previously modelled ECMs in subsequent runs with the final run representing the package of all proposed measures. Measures that affect the building’s loads (envelope improvements or lighting retrofits) should be modelled first, followed by those that impact schedules. Subsequent ECMs should include those that affect HVAC subsystems, followed by those that affect the central plant. This approach is best applied when all of the ECMs are being considered, such that the final run represents a bundle of all proposed ECMs and their potential interactive effects.

If ECMs are not modelled to include previous measures, and are modelled in isolation, it is important to keep in mind that these model runs do not capture the interactive effects between measures and savings will not therefore be additive (the sum of the parts will be greater than the whole). Instead, final packaged runs representing multiple ECM bundles will need to be performed so that the interactive effects can be quantified for each package of measures being considered.

The manner in which measures are modelled should be documented, including the key parameters or programming that was performed to model the measures as well as the assumptions used and their sources. As with all ECM energy savings calculations, assumptions should be conservative. The resulting energy savings estimates should be compared to baseline and end-use energy consumption, previous project results, or simple estimation methods to ensure that energy savings are realistic and in line with other sources.

Quality Assurance Methods (Certification Period)

- Check ECM modeling parameters and programming logic as well as assumptions used to ensure that they are conservative and documented.
- Ensure that savings estimates are reasonable, as compared to baseline and end-use energy consumption, previous project results, or simple estimation methods.

❖ Check that interactive effects have been accounted for in the form of iterative modeling or the modeling of packages (bundles) of ECMs.

Resources

See Section 2.3, *Dynamic Building Simulation*, for associated resources.

2.5 ECM Savings Calculations – Non-Dynamic Building Simulation (Standard and Targeted Protocols)

Calculation methods other than dynamic building simulation, such as regression analysis, are a practical and effective method for estimating energy savings associated with proposed ECMs. Any calculation methods used should be based on sound engineering principles and methodologies. Inputs should be derived from weather data, system design information, manufacturer specifications, and operational data from on-site monitoring. For each ECM, the calculation methodology, formulas, inputs, assumptions and their sources need to be clearly documented.

References such as the IPMVP Core Concepts Guide and the U.S. Department of Energy's Uniform Methods Project (UMP) provide detailed guidelines for calculation methods and best practices. Vetted resources for calculation tools, particularly those that are nationally recognized, can be used or referred to as models for calculation methods.

When developing spreadsheet-based savings calculations, assumptions and values should never be "embedded" in formulas. Formulas should use cell references for constants, assumptions and other inputs. These inputs should be clearly defined, calculations explained, and associated units noted elsewhere in the spreadsheet. This clear, consistent, "open book" approach is critical to the quality assurance process.

Each ECM calculation should contain sufficient description such that (with the necessary input information) a reviewer can reconstruct the calculations. This description should include documentation of the formulas used as well as any assumptions and their sources.

Inputs for the savings calculations are derived from the outputs of the energy audit. Each of these inputs is critical to the accurate estimation of energy savings and should always be conservative, especially if not well defined or unknown. Operational and performance data also provide key inputs to inform and bound the savings calculations. This data can be obtained from functional performance tests or short-term monitored data, supplemented by driving variables (such as occupancy or weather), and can help identify opportunities or deficiencies in operation or performance.

Interactions are also an important part of the energy savings calculation process. Savings calculations should always take into account the potential effects of other proposed ECMs. For example, a measure that involves replacement of a piece of equipment with a higher efficiency unit may need to account for a reduced operating schedule associated with another ECM. As with more complex building simulation, it is best to calculate savings for ECMs affecting schedules or building loads first, then zone-level equipment, and finally plant-level equipment. This method allows for effectively "carrying through" the characteristics of the earlier measures through to the later measures.

If independent-party proprietary calculation tools are used, sufficient documentation must be included to validate that assessment of energy savings estimates are unbiased. This documentation should include sources such as calculation methodology, white papers, and independent testing results of the application. Caution should be applied when using any tools provided by any retailer or manufacturer to estimate the energy savings associated with their product.

Estimated energy savings should always be compared to estimated or measured energy end-use consumption to ensure that the estimated energy savings are reasonable. Estimated energy savings should also be compared to simple estimation efforts or previous energy savings estimates. This ensures figures are credible and provides a first level of quality assurance.

Quality Assurance Methods (Certification Period)

- Ensure that the appropriate calculation methodology has been applied. Check that no constants or assumptions have been embedded as numbers within cell formulas. When dealing with spreadsheet calculations, typically the best way to check the calculations is to begin with the savings estimate result and work back through the formulas and methodologies to look for any errors.
- Check that all assumptions and inputs are reasonable and documented, and that they match the results of the field investigation or data analysis. If assumptions are used, check that they are conservative.
- Check that the appropriate weather file has been used as well as the appropriate operating schedule for the equipment being affected by the measure. Constants used in calculations should also be appropriate for the region or elevation (density of air, energy content of fuel, etc.).
- Check that the results have been compared to energy end-use consumption or simple calculation methods and appear reasonable.
- If independent-party proprietary, calculation tools must be used for any ECM, ensure that the application is well documented and provides unbiased results.

Resources

EN 16212 Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods – Section 6.2 provides general guidance on calculating energy savings using a bottom-up approach

Guidelines for Verifying Savings from Commissioning Existing Buildings *(CCC)* - Provides standardized methods that may be used to calculate and verify energy savings. Chapter 4 contains a description of methods to use to develop engineering calculations coupled with field verification.

Uniform Methods Project *(National Renewable Energy Laboratory)* – Resource which provides detailed guidelines for calculation methods and best practices.

US Department of Energy (DOE) Federal Energy Management Program (FEMP) - Calculators and tools that can be used or referred to as models for calculation methods.

2.5.1 Interactive Effects (Standard Protocols)

For Standard projects, calculations should take into account measure interactions with building heating and cooling loads (e.g. lighting retrofit) as well as interactions between measures. Interactive effects may be ignored where the estimated adjustment required for each measure can be shown to be less than 5% of the predicted saving for the measure. This should be clearly documented and include a description of each interactive effect and how the estimated impact has been made.

For example, consider a lighting retrofit project where the reduced heat gains from the lighting system may affect the energy savings by increasing the heating demand but also decreasing the cooling demand. If the overall interactive effect is expected to have a significant impact on the savings, conventional heating and cooling calculations would be used to determine the appropriate fraction(s) for each season. However, if the measurement boundary can be expanded to encompass interactive effects during the baseline period, there is no need to estimate them.

Quality Assurance Methods (Certification Period)

- Ensure that measure interactions have been taken into account in the appropriate manner.

Resources

International Performance Measurement and Verification Protocols (EVO), Volume I, 2012 - Section 4 describes interactive effects and how they may be addressed under an IPMVP compliant approach.

2.5.2 Interactive Effects (Targeted Protocols)

For the Targeted protocols, there should be no interactive effects between measures. The exception to this applies to lighting retrofit projects where there may be interactions between the lighting-related measures and the heating and cooling loads – that is, a significant improvement in lighting efficiency in a building will reduce heat gains and therefore potentially reduce cooling loads and/or increase heating loads.

Where this type of project is planned, one of the following approaches should be adopted:

a. The impact on heating and cooling loads must be estimated for each season of the year using conventional heating and cooling calculations. The result should be presented as a proportion of the lighting energy savings and the total energy savings should be adjusted accordingly; or
b. The impact on heating and cooling loads must be estimated using the simplified methodology outlined below. The result should be presented as a proportion of the lighting energy savings, and the total energy savings should be adjusted accordingly; or
c. The measurement boundary should be expanded to include the interactive effects.

Where Option 'a' above is chosen, the following should be taken into account:

- Lamp or lighting fixture efficiency improvement
- Annual full load hours of operation
- HVAC system type
- HVAC system efficiencies
- Climate

Option 'b' should be carried out as follows:

1. Estimate the reduction in lighting load in kW and the change in annual full load operating hours, then multiply together to provide a total energy change in kWh.
2. Estimate number of hours in the year when the building is in heating or cooling mode, if applicable. This should be based on sub-metered data for the operation of the boilers and chillers, if available. Present as percentages of the year.
3. Apply percentages to the total energy change to provide the increase in heat demand and reduction in cooling demand in kWh, unless the energy change is less than 5% of the predicted lighting energy savings where the interactive effect may be ignored.
4. Apply plant efficiencies (i.e. boiler efficiency or chiller COP) to calculate primary energy consumption change. Plant efficiencies should be documented, and their sources clearly identified.

Quality Assurance Methods (Certification Period)

- ❖ Ensure that all potential interactive effects resulting from proposed ECMs are considered.
- ❖ Where lighting projects are proposed, ensure either the impact on heating and cooling is documented or that the measurement boundary is shown to include interactive effects.
- ❖ Review estimated heating and cooling loads to ensure that they are accurate and reasonable.

Resources

International Performance Measurement and Verification Protocols (EVO), Core Concepts - Section 5 describes interactive effects and how they may be addressed under an IPMVP compliant approach.

2.6 INVESTMENT CRITERIA (ALL PROTOCOLS)

Different owners, investors, and programs will each have their own financial metrics, criteria, and requirements in order to help ensure that their investment goals are met. ICP's goal is to create confidence in project energy performance but does not take a position on which financial metrics or criteria should be used to evaluate a potential investment. ICP also does not require or promote any specific financial "hurdle rate" such as a specific payback or SIR rate.

Determining which financial metrics are important to the investors when assessing the financial performance of a proposed project should be the first step in the investment criteria process. In these discussions, the project team should also attempt to discover any specific metric requirements (such as payback less than 5 years or an SIR greater than 1) as well as figures that are required for calculations such as discount rates. Once these preferences are uncovered, it is then the responsibility of the project development team to provide the necessary data and calculations necessary that will allow the investors to evaluate the project's potential according to their preferences. The metrics used should be properly defined and calculated using accurate implementation costs, estimated savings, available incentives, effective useful life, escalation rates, interest rates, discount rates, cost of capital, lease terms, and other appropriate financial inputs.

The following are common metrics used to assess the financial performance of a proposed energy efficiency project. In general, use of the simple payback method as the sole criterion for evaluation of a capital investment is discouraged as by itself it does not provide an accurate view of a project's economic potential. Instead, projects should consider using additional methods such as net present value, internal rate of return, or savings to investment ratio, to incorporate the time value of money and more complex cash flows.

Internal Rate of Return (IRR) - the interest rate at which the net present value of all the cash flows (both positive and negative) from a project or investment equal zero. Internal rate of return is used to evaluate the attractiveness of a project or investment. If the IRR of a new project exceeds a company's required rate of return, that project is desirable. If IRR falls below the required rate of return, the project should be rejected.

Net Present Value (NPV) - the delta between the sums of discounted cash inflows and cash outflows discounted based on a given interest rate. It is a useful metric, since NPV compares the value of an investment today to the present value of future cash inflows it accounts for the cost of money as well as inflation. A positive calculation indicates that investing in a project is more profitable than "doing nothing" And the project's NPV can be compared to other project's NPVs to prioritize capital spending. This metric is an absolute measure rather than a relative measure and is best used when comparing the profitability between projects of a similar scale to give a more straightforward comparison.

Savings to Investment Ratio (SIR) - the ratio of the present value of an energy saving stream with respect to the present value of the cost of making the energy efficiency improvements. Divide the total savings over the project's useful life by the cost of the project. The SIR is a measure of how many times an investment is recouped over the life of a project. A number above 1 indicates the project is saving money over the life of the project, while a number below 1 indicates the investment will not be recouped. The major limitation with this metric is that this is a relative measure rather than an absolute measure of the size of the savings from the project.

Simple Payback (SPB) - the investment of a project divided by the annual savings (first year). The simple payback is a measure of how much time in years it takes to recoup an investment based on the first year's annual savings. This metric should only be used in conjunction with other metrics.

Quality Assurance Methods (Certification Period)

- Ensure that the financial metrics, as they are defined in this specification, are being applied properly to the project. The metrics used should be calculated using accurate implementation costs, estimated savings, available incentives, effective useful life, escalation rates, interest rates, discount rates, cost of capital, lease terms, and other appropriate financial inputs.

Resources

Building Life Cycle Costs (NIST) - Program to provide computational support for the analysis of capital investments in buildings.

International Energy Efficiency Financing Protocol, 2009 (EVO) - The global "blueprint" for educating and training on the special intricacies, benefits and risks associated with financing EE projects. It is intended to serve as a growing set of best practices, resource materials, case studies, standardized tools and guidelines to support economic and financial evaluation of EE projects.

Life Cycle Costing Handbook 135 (NIST) - Guide to understanding the LCC methodology and criteria established by FEMP for the economic evaluation of energy and water conservation projects.

LCCAid (RMI) - An Excel-based tool designed to make LCCA easier for architects, engineers and other building design and construction professionals who do not have extensive financial backgrounds.

RETScreen Financial Analysis Workbook - Workbook used to analyze financial performance and viability of an EE project.

2.7 ECM Pricing (All Protocols)

Accurate cost estimation for the proposed ECMs are the basis for developing sound financial metrics to evaluate a proposed EE project (see section 2.6).

At the feasibility stage, initial quotes may be obtained from the contractor. 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.

However, ultimately the final investment package should have pricing based upon bids that represent the actual price for which a contractor has committed to make the improvements. Cost estimates during the calculation phase should include as applicable:

- 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 including civil (structural and site

work, demolition, rigging), mechanical, plumbing, electrical, architectural (including finishes), environmental (hazardous material mitigation), and any provision of temporary services (if applicable). Underlying lists or spreadsheets that include cost information must be submitted.

- All lines by trade must include labor and materials. "Labor" can be specified by budgetary allowance rather than by hours and hourly rates.
- Estimated Operation and maintenance costs throughout the life of the project.
- Line items for professional fees, engineering, commissioning, construction management, architectural, 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.

Quality Assurance Methods

- ❖ Check that a construction feasibility review was performed and is included.
- ❖ Check that all specified cost estimate components are included and accurately reflect the scope of work involved with the proposed ECMs.
- ❖ Ensure that cost estimates are conservative and reasonable.
- ❖ Ensure that cost estimates have been bifurcated if necessary (total cost and incremental cost).

Resources

ISO 15686-5:2008 Buildings & Constructed Assets – Service life planning – Part 5: Lifecycle Costing – Guide to the LCC methodology and criteria for the economic evaluation of energy projects.

LCCAid (RMI) - An Excel-based tool designed to make LCCA easier for architects, engineers and other building design and construction professionals who do not have extensive financial backgrounds. This analysis tool is intended to comply with all government standards for LCCA, including NIST Handbook 135 and its 2009 supplement; Current Facility Requirements (CFR) Title 10 Part 436; and Office of Management and Budget (OMB) Circular No. 11-A Part 7.

Life Cycle Costing Handbook 135 (NIST) - Guide to understanding the LCC methodology and criteria established by FEMP for the economic evaluation of energy and water conservation projects.

2.8 Reporting (All Protocols)

An industry-accepted format should be used for reporting project analysis results and the compilation of methods used, as well as underlying data used for individual ECM calculations and for the package of recommended measures. Annual energy savings by fuel type shall be documented including the energy units, a percentage of the total consumption of each fuel type, and the associated cost savings using the correct marginal rate for that energy type.

The report should be written in such a way as to be relevant to both technical and executive personnel. Typically, the report should cover the following key areas:

1. Executive summary
    - Overview of building energy consumption and performance
    - Ranked ECMs including ECM summary table
    - Recommended opportunities and overall timeframe for implementation
2. Introduction:
    - Background, description/scope of the building audit carried out and methodology
    - Contact details of parties involved (investor, auditor, etc.)
    - Investor objectives
3. Building energy use
    - Summary of building energy consumption and details of associated costs - see section 1
    - A simple analysis of building energy performance and/or energy performance indicators
4. Building information
    - Description of the building
    - Description of the existing building and its systems i.e. building asset and operational information - see section 1.2.5
5. Energy conservation measures
    - Description of the ECMs under consideration – see section 2.2
    - ECM pricing – see section 2.7
    - Financial analysis – see section 2.6
    - Details of all assumptions made
    - ECM summary table of measures, including capital cost, energy and cost savings. Measures should be ranked according to attractiveness based on the financial metrics used
    - Recommendations and suggested implementation program

6. Building and ECM dynamic building simulation details (Large Protocol)
    - See section 2.3 and 2.4
    - Details of the software used
    - Description of the calculation process, with necessary inputs and all assumptions made
    - Model outputs
    - Model accuracy/calibration details
7. Non-dynamic building simulation savings calculations (Standard and Targeted Protocols)
    - See section 2.5
    - Details of the calculation tool used
    - Description of the calculation process, with necessary inputs, and all assumptions made
    - Calculation outputs
    - Calculation accuracy details
    - Description of any measure interactions and how these have been addressed – see section 2.5.1
8. Conclusions and recommendations
    - Any recommendations for implementation
    - Any recommendations for monitoring and verification to assist in developing the M&V plan
9. Appendix
    - Details of any supporting information, such as manufacturer's information
    - Any measured data or monitoring results

Quality Assurance Methods (Certification Period)

- Ensure that the report is clear and that it covers all the required elements; identify any gaps.
- Ensure that the investor's objectives are clearly set out and that the ECMs identified meet these objectives.

Resources

EN 16247-2 Energy Audits – Part 2: Buildings - Section 5.6 and Annex J set out the content required for energy audit reports, including an example table of contents for a comprehensive building energy audit.

ISO 50002:2014 Energy Audits – Requirements with guidance for use – Section 5.8.2 sets out the topics that an energy audit report should cover.

3.0 DESIGN, CONSTRUCTION AND VERIFICATION

3.1 OVERVIEW

This part of the process focuses on the engineering, implementation and operational performance verification phase of the project. The key objectives are to ensure that the project is designed and implemented as intended by providing oversight to the design as well as general oversight during construction. The submission of designs, equipment, performance specifications and installation plans should all be carefully reviewed to ensure that they are tailored for the proposed project and that they meet the stakeholder's requirements.

The term "Operational Performance Verification" (OPV) is used specifically for retrofit or energy efficiency upgrade projects to distinguish the activity from "comprehensive" commissioning. OPV focuses on the commissioning activities specific to the EE upgrades and ECMs, rather than involving the commissioning of all building systems and components.

An important part of the OPV process is ensuring that roles, responsibilities, expectations, timelines, communication and site access requirements have been established. Furthermore, during the OPV effort (during construction and post-retrofit) it should be confirmed that arrangements have been made regarding inspections, operational performance verification activities, testing, balancing, training, acceptance criteria, operations, maintenance and monitoring requirements, and that M&V guidelines are being met.

A qualified OPV Specialist should be appointed to manage the process, either as part of an in-house role or using an independent-party. Although there are advantages to appointing an in-house representative, the use of an independent-party is recommended to avoid conflicts of interest and to take advantage of specialized skills. See section 3.2 for further detail.

The QA review of the OPV effort should provide unbiased recommendations for fast and fair resolution of any project related issues that might arise during design and/or construction. The QA Assessor should work closely with the OPV Specialist, stakeholders and project development/construction teams to ensure that the project is implemented properly.

The table below indicates which elements described in this document apply to each protocol.

Element	Section	Protocol		
		Large	Standard	Targeted
Operational Performance Verification Plan	3.2	✓	✓	Simplified plan
Operational Performance Verification Report	3.2	✓	✓	
Training	3.3	✓	✓	✓
Systems Manual	3.4	✓	✓	✓

3.2 Operational Performance Verification (All Protocols)

For all projects, the OPV effort begins during the ICP certification phase with the development of an OPV plan. For projects using the Targeted Protocols, this can be in the form of a "simple OPV plan" which is intended to address less complex projects. The plan should be developed pre-construction, and should describe the verification activities, target energy budgets and key performance indicators associated with the project and the individual ECMs. Performance indicators should be determined in order to identify underperformance (although these are not required under the Targeted Protocols).

The plan should also describe the data logging, control system trending (the analysis of historical data to predict future performance often in conjunction with the EMS/BMS), functional performance tests, spot measurements, and/or observations that will be used to establish both baseline operation as well as post-construction operation to demonstrate observed and predicted future performance.

The OPV process itself, led by the OPV Specialist, should include consultation with the energy audit team. For projects using the Large and Standard Protocols, this may include the monitoring of designs, submittals or project changes, and inspections of the implemented measures. It also includes the responsibility for and means of reporting deviations from design and projected energy savings to the project owner in an issue log. If the collected post-installation data, testing results, or other observations indicate current of future underperformance, the OPV Specialist will need to:

- Help the customer/project development team fully install the ECM properly and then re-verify its performance; or
- Work with the project development team to revise the ECM savings estimates using the actual post-installation data and associated inputs.

Successful OPV is achieved by applying traditional commissioning methods to the ECMs and affected systems involved in the project and supplementing these methods with more data-driven activities, such as data logging, trending, and functional performance testing, as appropriate.

The level of effort required to verify proposed ECMs will vary. Measures that are well-known, have relatively low expected savings, or whose savings are considerably certain may only warrant installation verification through visual inspection to ensure that the measures have been implemented properly. This would apply, for example, to wall insulation and windows. Measures with greater savings at risk or greater uncertainty will require a greater depth of OPV. This would include sample spot measurements (e.g. lighting fixtures and constant speed pumps), short term performance testing (e.g. fans fitted with variable frequency drives), and the collection and analysis of post-installation performance data (e.g. more complex projects with multiple ECMs).

The M&V method being employed may also affect the OPV approach taken. That is to say, if an Option B M&V approach is being employed where all key parameters associated with the ECM are to be measured, then a more simplified visual inspection may suffice for OPV. However, if an Option A or Option C approach is being employed, then a more thorough OPV approach should be utilized to verify ECM functionality.

Typical OPV approaches include:

- *Visual inspection* - verify the physical installation of the ECM; applied when ECM operation is well understood and uncertainty or anticipated relative savings are low.
- *Spot measurements* - measure key energy consumption parameters for ECMs or a sample of ECMs; applied when ECM performance may vary from published data based on installation details or load, or anticipated relative savings are low.
- *Functional performance testing* - test functionality and proper control; applied when ECM performance may vary depending on load, controls, or interoperability of other systems or components, and savings or uncertainty are high.
- *Trending and data logging* – setup EMS/BMS trending or install data logging equipment and analyze data, and/or review control logic; applied when ECM performance may vary depending on controls or loads, and savings or uncertainty are high.

In addition to describing the OPV effort, the OPV plan developed during the Certification Period needs to address the following:

- Provisions for the development and implementation of a training plan for operators to be conducted at the conclusion of the OPV effort. This training should focus on the correct operation of all new systems and equipment including how to meet energy performance targets.
- Provisions to develop a Systems Manual (or update an existing one) at the conclusion of the OPV effort to document the modified/installed systems and equipment as well as the process and responsibilities for addressing any future operational issues.

- Description of a simple OPV report to be developed at the conclusion of the OPV effort that will detail activities completed as part of the OPV process and include any significant findings identified from those activities.

Quality Assurance Methods

- ❖ Review the OPV plan during the Certification Period to ensure that it adequately describes all OPV activities, target energy budgets and key performance indicators associated with the project and the individual ECMs.
- ❖ The OPV plan should also contain provisions to perform training of the building operators, provisions to update or create a Systems Manual, and a description of the OPV report to be developed during the Performance Period.
- ❖ Review the OPV report during the Performance Period, including the results of any analysis and tests carried out and the issues log. /ensure that appropriate actions are being taken to resolve any identified issues or revise savings estimates if necessary.

Resources

ASHRAE Standard 202-2013 - Describes how to plan, conduct, and document this vital part of a successful project. Informative appendices provide sample documentation, including checklists, systems manual, reports, training plan, and more.

ICP Operational Performance Verification Plan template - A template that can be used to develop an ICP-compliant OPV plan.

International Performance Measurement and Verification Protocols (EVO), Core Concepts - Section 5.5 contains information regarding the operational performance verification general process.

Verification by Equipment or End-Use Metering Protocol (BPA) - Presents methods for isolating equipment or end-uses, and monitoring / metering methods and M&V practices specific to retrofit isolation. Provides descriptions of the operational performance verification general process.

3.3 Training (All Protocols)

Training of the facility staff and building operators may be one of the most important factors for ensuring the operational performance of installed ECMs and ensuring the persistence of energy savings. Without the proper understanding of the new systems, the skills to operate the systems correctly, and the knowledge of how to resolve or report issues, it will be impossible for staff to ensure that an energy efficiency project can succeed and perform optimally over time.

During construction and the Performance Period the building's operations staff should be involved with all OPV activities, from planning through implementation. Assisting with the OPV process provides critical on-the-job training and ensures familiarity with the new systems and installed ECMs.

During the Certification Period, the OPV plan should contain provisions for the training of the building's operations staff. A well-developed training plan should then be created during the Performance Period and supported by comprehensive and useful building documentation. As a best practice approach, and where appropriate, recording of the training sessions should be performed so that it is available for future staff. The training sessions should cover the operational changes associated with the energy efficiency project and the implemented ECMs. The session should be developed/contributed to and performed by the consultants, vendors, and/or contractors as appropriate.

The training associated with the OPV activities should be combined with the training performed as part of the OM&M efforts (see section 4.4). The combined training effort will provide a thorough understanding of the proper operation of the systems and how to diagnose and respond to issues that may arise over time. Key points to be covered by the OPV and OM&M training may include:

- Thorough descriptions of the ECMs implemented and descriptions of improved performance generated by these ECMs
- Review of the OPV plan
- Objectives for the investor and building users with respect to the ECMs
- Energy performance targets
- Key performance indicators
- Operating schedules and owner's or tenant's operating requirements
- Procedures for ongoing data analysis to identify and resolve any deficiencies in performance including the use of diagnostic methods and instruments for maintenance associated with the ECMs. This should include procedures for collecting, analyzing and storing data
- OM&M requirements needed to ensure persistence of performance and savings (service, corrective maintenance and preventative maintenance tasks, and associated schedule of these tasks)
- Staff roles and responsibilities associated with monitoring performance and specified methods for responding to or reporting issues
- Relevant health and safety issues and concerns
- Any requirements associated with maintaining equipment warranties

The level of training can vary based on the project scope. The training effort might be simplified (in some cases significantly) for some projects, especially those using the Targeted protocols for example.

Quality Assurance Methods (Performance Period)

- ❖ Review the training plan to ensure that key items listed above have been addressed.
- ❖ Interview building operators to ensure that training efforts met their needs, that they understand the installed ECMs including their operation and how to diagnose any issues. Ensure that the operators understand any new roles and responsibilities as well as the details of the associated response network.

Resources

ASHRAE Standard 202-2013, *The Commissioning Process* - Describes the Commissioning Process capable of verifying that a facility and its systems meet the Owner's Project Requirements. The procedures, methods, and documentation requirements in this guideline describe each phase of the project delivery and the associated Commissioning Processes from pre-design through occupancy and operation

EN 15331:2011 Criteria for Design, Management and Control of Maintenance Services for Buildings – Describes the criteria and general methods that can be used in the planning, management and control of maintenance in buildings

3.4 Systems Manual (All Protocols)

A Systems Manual contains all relevant information and documentation regarding building design and construction, commissioning, operational requirements, maintenance procedures, associated training plans, and testing. The document is intended to support building operations and maintenance staff and to enable them to optimize the performance of facility systems over their useful lives. It includes technical instructions to ensure systems and equipment reach their optimum performance according to their technical specifications. The manual also should include the necessary information to ensure that systems can be properly preserved and can function in their optimum state.

Provisions for updating (or creating) the Systems Manual should be included in the OPV plan developed during the Certification Period. Then, the Systems Manual updated (or developed) during the Performance Period should document the modified systems and equipment involved with the energy efficiency project and should be comprehensive yet concise so that it is usable by the facility personnel. It should also include the following information as appropriate (defined in more detail in *EN 13460:2009 Maintenance – Documents for maintenance,* and in the US, in the ASHRAE Guideline 1.4-2014, *Procedures for Preparing Facility Systems Manuals*):

- *Facility design and construction*: owner's project requirements (OPR); current facility requirements (CFR); basis of design (BOD); and construction / project record documents
- *Facility, systems and assemblies information*: specifications; approved submittals; coordination drawings e.g. system schematics, circuit diagrams, plant room drawings; assets register; manufacturer's operation and maintenance data; warranties; as well as contractor/supplier listing (including components lists and spare parts lists) and contact information
- *Facility operations*: operating plan; organizational structure, including roles and responsibilities; building and equipment operating schedules; set points and ranges; sequences of operation; limitations and emergency procedures/actions; maintenance procedures, checklists and records; maintenance schedules; record of maintenance costs; instrument/meter calibration procedures and logs; ongoing commissioning procedures; cleaning plans and procedures; utility measurement and reporting
- *Training:* plans and materials; training records; training for ongoing system manual updating
- *Commissioning process report*: commissioning (or OPV) plan; design and submittal review reports; testing reports, permits and inspections, and certificates; commissioning (or OPV)

progress reports; issues and resolution logs; item resolution and open items

The development of the manual should be coordinated with operations and maintenance personnel so that it best serves their needs. In addition to containing facility operating procedures associated with the equipment, the manual should also provide details regarding ongoing optimization of the systems and a clear process and responsibility matrix for addressing issues.

Note that for Targeted projects, if an existing Systems Manual exists it should be updated; if one does not exist, then development of a new Systems Manual is not required.

Quality Assurance Methods (Performance Period)

- Compare the contents of the Systems Manual to the content requirements described above.
- Through interviews with operations and maintenance personnel, ensure that the Systems Manual has been developed so that it meets the needs of the facility staff responsible for the energy-efficient operation of the new systems and equipment.
- Ensure that the Systems Manual contains details regarding ongoing optimization of the systems and a clear process and responsibility matrix for addressing issues.

Resources

ASHRAE Standard 202-2013, *The Commissioning Process* - Section 6.2.6 and Annex O, contain information about Systems Manuals and contents.

ASHRAE Guideline 1.4-2014, *Procedures for Preparing Facility Systems Manuals* - Detailed guideline specifying development of a Systems Manual, content materials, and instructions for updating the manual, for new and existing buildings.

EN 13460:2009 Maintenance – Documents for Maintenance - Section 5 and Annex A, contain information about Systems Manuals and contents.

4.0 OPERATIONS, MAINTENANCE AND MONITORING

4.1 Overview

OM&M and building performance tracking is a process of continuous improvement and involves the tracking, analyzing, diagnosing and resolution of issues involving all building energy-consuming systems. While the focus from an energy efficiency project perspective is on building system energy performance, it is important to consider and efficiently maintain the building occupants' needs including comfortable temperatures and humidity levels, ventilation requirements, and lighting requirements.

The Operations, Maintenance & Monitoring (OM&M) process must ensure that an appropriate and reasonable practice has been selected and developed to monitor energy system performance, and that corrective action plans have been developed to ensure "in specification" energy performance. The OM&M practice can vary in scope, and may involve ongoing commissioning, monitoring-based commissioning, performance-based monitoring (fault detection and diagnostics), periodic recommissioning, building re-tuning, or periodic inspections.

The table below indicates which elements described in this document apply to each protocol.

Element	Section	Protocol		
		Large	Standard	Targeted
OM&M Plan	4.2	✓	✓	✓
Operator's Manual	4.3	✓	✓	✓
Training on OM&M Procedures	4.4	✓	✓	✓
Tenant Outreach	4.5	✓	✓	✓

4.2 Operations, Maintenance & Monitoring Procedures (All Protocols)

Good OM&M processes involve a proactive strategy for achieving occupant comfort while optimizing energy performance. A common problem that often arises in commercial or tertiary buildings is due to the fact that building operators' first responsibility is to provide occupant comfort, essentially responding to and resolving "hot and cold" complaints. This directive is often counterproductive to a building's energy efficiency performance. Development of specific OM&M procedures can provide clear direction to the facility's operations and maintenance staff enabling them to satisfy both occupant requirements and efficient energy use, empowering them and providing specific methods for identifying, analyzing, and resolving issues over time.

An OM&M plan needs to be developed during the Certification Period. This can be a simplified plan for projects using the Targeted protocol. The plan needs to address the overall OM&M process which should involve the following key components:

1. *Data collection and performance tracking* - HVAC, lighting and other energy-consuming equipment performance data are tracked along with energy consumption data. Various tools are available to support this process, and typically multiple tools are employed as part of the overall management strategy.
2. *Detection of performance issues* - use of automated tools to perform real-time analysis and identification of issues (fault detection and diagnostics), or the use of tools to present information in a way that facilitates identification of problems manually.
3. *Diagnosing issues and identifying solutions* - while automated tools can help facilitate issue diagnostics and the development of solutions, the skill, knowledge and training of building operators supplemented by the assistance of service contractors or consultants are critical components in diagnosing issues successfully and identifying appropriate solutions.
4. *Resolve issues and verify results* - issues should be resolved in a manner that addresses occupant comfort while also considering energy performance.
5. *Equipment maintenance* - incorporation of any new systems or equipment into the building's routine maintenance and preventative maintenance plans.

A strong OM&M management framework, as defined in the OM&M plan, needs to clearly specify how automated or manual tools and processes are to be used to extract, interpret and act on the monitored performance data. The framework should also provide sufficient guidance on how to analyze results in order to identify and resolve issues. This management framework should indicate dedicated resources to the OM&M effort by establishing roles and responsibilities and assigning them to the appropriate team member. The framework must set quantifiable performance goals and define the performance tracking methods and metrics (the performance indicators).

Identifying energy performance indicators in the OM&M plan will depend on the proposed ECMs, the factors affecting the associated energy consumption characteristics, and the factors affecting this. The energy performance indicators can be applied at an equipment, system, or whole building level. Energy performance indicators are usually directly measured (e.g. kWh), calculated using a ratio of measured values (e.g. efficiency) or using a modelled relationship between energy consumption and relevant variables (e.g. linear regression modeling to determine kWh/degree day). For example, a performance indicator for a lighting system could be energy consumption kWh/occupant-hour and peak power draw in kW.

Automated energy management systems (EMS) can be incorporated into the OM&M management regime and can provide a method for tracking, analyzing, and assessing energy performance against savings projections and benchmarks. These tools can be used at the project development and implementation stages to support the baselining and M&V activities.

Data collection systems are used to collect energy data and transmit these data to the EMS. These data are typically collected in intervals of between one minute and one hour and can track either whole-building energy consumption or the energy consumption or performance of specific systems or end-uses. The EMS aggregates these data, identifies errors, analyzes the data, and provides graphical representations of the data or reports used to assess the energy performance of the building in real time.

While EMS tools provide the ability to identify underperformance or problems, they often cannot diagnose the cause of these problems. Trending and analysis through the use of automated fault detection and diagnostic (FDD) tools provides system tracking methods that can pinpoint problems with system operation and performance in real time providing more accurate diagnosis. Use of the EMS to track key performance metrics can however, present a cost-effective method for tracking and identifying building performance improvements. Trended metrics can be plotted and reviewed on a regular basis to identify abnormal changes in values that might indicate problems. Long term patterns, averages, and minimum or maximum values can also be used to identify issues and track energy efficiency and system performance. Performance metrics typically include zone temperatures, equipment efficiencies, system efficiencies, and ventilation rates.

While use of the EMS to track performance metrics provides a useful method to track system performance, FDD tools provide functionality beyond these tracking methods. FDD tools utilize system-level performance data to automatically detect and in some cases quantify issues and report problems in real time.

FDD tools utilize existing EMS points and in some cases additional dedicated sensors external to the EMS, to analyze the data using fault detection algorithms. These algorithms are typically proprietary, but some tools allow for customization or programming of additional fault detection routines. FDD tools vary in their features, diagnostic levels and associated costs can vary significantly.

Another acceptable approach to OM&M is based on periodic retro-commissioning or recommissioning (RCx). RCx is a cost-effective means to improve the performance of existing buildings with the goals of reducing overall energy consumption, peak demand consumption, improving system performance, improving occupant comfort, and reducing maintenance issues and costs. RCx involves a review of the building's systems and their operation that identifies problems due to system operation deficiencies or design flaws that occurred during the original construction. RCx also identifies problems that may have developed during the building's existence. Typical measures identified during the RCx process focus on improving control of existing equipment or correcting hardware and sensor malfunctions.

Quality Assurance Methods

- Ensure that an OM&M plan has been developed during the Certification Period. It must identify an appropriate ongoing management regime given the scope of the project, complexity of systems, and the skill level of the facility staff. Review the plan for fault detection and remediation procedures as well as the specification of the required, content of periodic performance reports.
- Ensure that key performance indicators have been selected are SMART (specific, measurable, achievable, realistic and trackable) and will provide adequate representation of system operation and energy performance. If appropriate, review the monitoring points, interval and duration, and functionality of the automated tools used for issue detection and analysis.
- Ensure that the management regime and hierarchy are well defined with clear roles and

responsibilities including plans of action for response and issue resolution. Review reporting processes and ensure that accountability is factored into the management regime.

Resources

Building Performance Tracking Handbook (CCC) - Outlines the steps needed to continually manage building performance, describes the complex array of building performance tracking tools available, and provides guidance on selecting the most appropriate tracking strategy.

ICP OM&M Plan template - A template that can be used to develop an ICP-compliant OM&M plan.

ISO 50001 Energy Management Systems – Requirements with guidance for use – Sets out a management approach for organizations to improve energy performance, including energy efficiency, use and consumption, based on the Plan – Do – Check – Act continuous improvement framework.

ISO 50006:2014 Energy Management Systems – Measuring Energy Performance Using Energy Baselines and Energy Performance Indicators – Section 4.3 and Annex C provide detailed guidance on identifying energy performance indicators, with examples.

O&M Best Practices Guide to Achieving Operational Efficiency (PNNL) - Guide with information regarding O&M management, technologies, energy efficiency, and cost-reduction strategies.

4.3 Operator's Manual (All Protocols)

Provisions for the development or updating of an Operator's Manual must be included in the OM&M plan developed during the Certification Period. 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. If this is the case, the Requirements described in Section 3.4 of this Specification should be adhered to for development of the manual. Otherwise, these two manuals can be developed as two separate documents.

The Operations and Maintenance sections of the Systems Manual, or the separate Operator's Manual, should contain the following information as appropriate: photographs; reduced-size as-built drawings and schematics; list of major equipment; invoices for major equipment purchases and repairs; balance reports; equipment locations; control system logic; O&M instructions; training materials; warranty information; preventative maintenance requirements.

Note that for Targeted projects, any existing Operators Manual should be updated; if one does not exist, then a new manual is not required.

Quality Assurance Methods (Performance Period)

- Review the Operator's Manual, or O&M sections of the Systems Manual, to ensure that it meets the needs of the facility staff responsible for the energy-efficient operation of the new systems and equipment.

4.4 Training on OM&M Procedures (All Protocols)

The OM&M specific training practices described here should be combined with the OPV training efforts and best practices described in Section 3.3.

Proper operation, maintenance practices, and monitoring are tasks critical to the ongoing energy-efficient performance of the building's systems and ensuring that energy savings will persist over time. For example, the overriding of system setpoints or controls and diminishing performance of equipment due to improper maintenance are common issues that degrade energy performance and therefore jeopardize the financial performance of an energy efficiency project. The proper training of the building operators represents perhaps the single most critical component of the OM&M process in order to avoid these types of issues.

Provisions to develop a training plan must be included in the OM&M plan developed during the Certification Period. In conjunction with the training associated with the OPV efforts, a well-developed training plan should be created specific to the OM&M tasks and combined with the OPV training. OM&M training should include comprehensive relevant building and systems documentation. Any training sessions should be video recorded for the future training of operators. The training should, at a minimum, cover the following OM&M components (for the Targeted protocols, some components may not be relevant or necessary such as automated management):

- *Management structure* - Development and structure of the management, responsibility and reporting process and its components, including operations, maintenance, engineering, training, and administration.
- *Performance metrics* - Development of analysis methods to evaluate maintenance, operational and energy performance of the building's systems. This should also include review of the M&V plan.
- *ECM maintenance* - Responsibility for the operation, maintenance, repair and replacement of each ECM.
- *Reporting* - Reporting requirements for O&M activities and their frequency, including submission of ECM-specific O&M checklists.
- *Manuals* - Review of the Operator's/Systems Manual(s).
- *Automated management* - Integration of the ECMs into a computerized maintenance management system if applicable.
- *Issue identification and resolution* - Discussion of potential issues that can adversely affect operation or savings persistence and a review of the process to address or report identified issues.

A properly designed OM&M program, and associated training, must include predictive maintenance best practices. Predictive maintenance attempts to detect the onset of a degradation mechanism with the goal of correcting that degradation prior to significant deterioration in the component or equipment. Training as it is applied to predictive maintenance is particularly important, as it is continuously becoming more sophisticated and technology-driven.

Predictive maintenance can incorporate many different approaches, and all of the following should be considered for inclusion in the OM&M management structure, with associated training: vibration monitoring/analysis, lubricant and fuel analysis, wear particle analysis, bearing and temperature analysis, performance monitoring, ultrasonic noise detection, ultrasonic flow, infrared thermography, non-destructive testing (thickness), visual inspection, insulation resistance, motor current signature analysis, motor circuit analysis, polarization index, and electrical monitoring.

The OM&M activities will include a method to monitor and assess the ongoing performance of the installed ECMs. As part of the training curriculum, the building operators must be trained on how to utilize and interpret systems in place to monitor the ECMs and associated building systems, and how to respond to issues identified as a part of this process. The building operators represent the "first line of defense" against performance degradation and it is crucial to train them on the proper use of the selected monitoring approaches and tools.

Where available, nationally recognized competency-based training and certification programs should be used to formally educate building operators on the proper operation and maintenance of building systems.

Quality Assurance Methods (Performance Period)

- Review training plan to ensure that key items previously described in this section and section 3.3 have been addressed.
- Interview building operators to ensure that training efforts met their needs, that they understand the ECMs installed and how to operate, maintain and monitor their operation, and that roles and responsibilities and the associated response network are defined and understood.

Resources

ASHRAE Handbook - HVAC Applications, Chapter 39 - Description of proper maintenance best practices.

ASHRAE/ACCA Standard 180 - Standard Practice for Inspection and Maintenance of Commercial HVAC Systems - Establishes minimum HVAC inspection and maintenance requirements that preserve a system's ability to achieve acceptable thermal comfort, energy performance, and indoor air quality.

Building Operator's Certification (BOC) - Nationally recognized, competency-based training and certification program that offers facilities personnel the improved job skills and knowledge to transform workplaces to be more comfortable, energy-efficient and environmentally friendly.

EN 15331:2011 Criteria for Design, Management and Control of Maintenance Services for Buildings – Describes the criteria and general methods that can be used in the planning, management and control of maintenance in buildings.

Operations and Maintenance Best Practices (FEMP) - Provides information regarding O&M management, technologies, energy and water efficiency, and cost-reduction approaches.

4.5 TENANT OUTREACH (ALL PROTOCOLS)

Tenant behavior can be critical to the success or failure of an energy efficiency project. Ensuring tenants understand the impact of their behavior on building energy consumption, especially in association with any new ECMs, is integral to this success. Fostering increased energy awareness during the Performance Period may be accomplished through poster campaigns, flyer distribution, training sessions for building occupants, tenant incentive programs or even gamification. Consideration should also be given to involving tenants in the design of certain ECMs if this is deemed appropriate.

Quality Assurance Methods (Performance Period)

- Ensure tenants have been notified of improvements made in the building and any anticipated relevant behavior modifications have been communicated to them.

5.0 MEASUREMENT AND VERIFICATION

5.1 Overview

All Measurement & Verification (M&V) efforts involve reliably quantifying the calculated realized savings resulting from energy efficiency projects (or individual ECMs) by comparing the established pre-installation baseline with actual post-installation energy usage, normalized to reflect the same sets of conditions.

The M&V requirements specified in the ICP protocols are founded upon EVO's International Performance Measurement and Verification Protocol (IPMVP) and support the use of Option A (*Retrofit Isolation: Key Parameter Measurement*), Option B (*Retrofit Isolation: All Parameter Measurement*), and Option C (*Whole Facility*) based on the individual project and the selected ICP Protocol. Currently, ICP does not allow the use of an IPMVP Option D, *Calibrated Simulation* approach as it is primarily intended for new construction projects, where there are no baseline data available, while the ICP is designed to address the retrofit of existing buildings that typically have utility data which can be used to develop a baseline. For existing buildings that do not have baseline utility data (e.g. the building was not metered or is being repurposed so existing utility data are not relevant), methods for estimating baseline energy use should be employed, or an Option A and/or B approach to M&V could be used.

For most M&V efforts, non-routine adjustments need to be made to the baseline to reflect unanticipated changes in the building's energy use after the retrofits have been completed. This would include adjustments such as increased occupancy, new internal loads, additional floor area, and others. These items affect heating and cooling load as well as other building energy uses and should be calculated and subtracted from or added to the baseline in order to accurately compare pre-retrofit and post-retrofit energy when using an Option C approach.

Calculation of the effects of these adjustments on the building's energy use can be challenging. This is especially true for adjustments that affect the loads in the building and have potentially complex interactive effects with the building's HVAC systems. The calibrated dynamic building simulation can subsequently be used to estimate these effects on energy use in a more comprehensive and accurate manner than spreadsheet calculations or other methods.

Table 1 Overview of M&V Options[1]

IPMVP Option	How Savings Are Calculated	Typical Applications
A. Retrofit Isolation: Key Parameter Measurement Savings are determined by field measurement of the key performance parameter(s) which define the energy use of the ECM's affected system(s) and/or the success of the project. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter and the length of the reporting period. Parameters not selected for field measurement are estimated. Estimates can be based on historical data, manufacturer's specifications, or engineering judgment. Documentation of the source or justification of the estimated parameter is required. The plausible savings error arising from estimation rather than measurement should be evaluated.	Engineering calculation of baseline and reporting-period energy from: - short-term or continuous measurements of key operating parameter(s); and - estimated values. Routine and non-routine adjustments as required.	A lighting retrofit where power draw is the key performance parameter that is measured periodically. Estimate operating hours of the lights based on facility schedules and occupant behavior.

[1] Courtesy of *IPMVP, Core Concepts*

IPMVP Option	How Savings Are Calculated	Typical Applications
B. Retrofit Isolation: All Parameter Measurement Savings are determined by field measurement of the energy consumption of the ECM-affected system. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the savings and the length of the reporting period.	Short-term or continuous measurements of baseline and reporting-period energy, and/or engineering computations using measurements of proxies of energy consumption. Routine and non-routine adjustments as required.	Application of a variable speed drive and controls to a motor to adjust pump flow. Measure electric power with a kW meter installed on the electrical supply to the motor, which reads the power every minute. In the baseline period this meter is in place for a week to verify constant loading. The meter is in place throughout the reporting period to track variations in power consumption.
C. Whole Facility Savings are determined by measuring energy consumption at the whole facility or sub-facility level. Continuous measurements of the entire facility's energy consumption are taken throughout the reporting period.	Analysis of whole facility baseline and reporting-period (utility) meter data. Routine adjustments as required using techniques such as simple comparison or regression analysis. Non-routine adjustments as required.	Multifaceted energy management program affecting many systems in a facility. Measure energy consumption with the gas and electric utility meters for a twelve-month baseline period and throughout the reporting period.

The QA Assessor will review the M&V Plan during the Certification Period, verification inspections, baseline development, application of adjustments (routine and non-routine), monitoring equipment, collected data, and calculations performed to quantify verified savings during the Performance Period. Review of M&V reports and baseline adjustments will also be necessary throughout the duration of the Performance Period.

The table below indicates which elements described in this document apply to each protocol.

Element	Section	Protocol		
		Large	Standard	Targeted
M&V Plan and Implementation	5.2	✓	✓	✓
Energy Data	5.3	✓	✓	✓
Regression-Based Model: IPMVP Option C	5.4	✓	May be optionally applied	
Estimated Parameters: IPMVP Option A	5.5		✓	✓
Revised Calculations: IPMVP Options A and B	5.6		✓	✓
Portfolio Approach	5.7			May be optionally applied

5.2 M&V Plan and Implementation (All Protocols)

The M&V process can be categorized by the following fundamental activities:

1. Document baseline energy usage
2. Plan and coordinate M&V activities (M&V Plan)
3. Verify operations
4. Gather data
5. Verify savings
6. Report results

The first step in the M&V process, the development and documentation of the baseline, is covered in section 1 of this specification. The level of uncertainty should be quantified as part of this process. This can be performed by using the energy use equation and actual weather data (not averaged weather data) to determine the monthly baseline energy consumption, and then comparing the results to the actual historical energy consumption associated with the baseline period. The difference in the calculated baseline (or error) can then be combined with the standard deviation and the confidence/precision levels to develop the uncertainty in the energy use equation.

The second step in the process involves planning and coordinating the M&V activities which are specified by the M&V Plan. The M&V Plan should be developed shortly after the energy efficiency project has been defined. Early development of the plan will ensure that all data needed for the savings calculations during the baseline period will be collected and available. This is particularly important in an Option A or B approach, in which pre-retrofit data are needed to establish the baseline operation of systems affected by the proposed ECMs. Early development of the M&V Plan will also allow for coordination with Operational Performance Verification activities.

The M&V Plan should adhere to the selected IPMVP option, which defines the M&V requirements (Section 7.1 of the IPMVP Core Concepts). The M&V Plan should address the following topics:

- Descriptions of the ECMs and operational performance verification procedures
- Definition of the measurement boundary and discussion of potential interactive effects
- Documentation of the baseline period, energy use, and conditions. Include descriptions of independent variable data coinciding with the energy data and static factors coinciding with the energy data (the routine and non-routine adjustments)
- Definition of the reporting period (typically the length of time required to recover the investment costs associated with the energy efficiency project)
- Descriptions of the basis for adjustments (routine and non-routine)
- Description of the analysis procedures, including algorithms and assumptions to be used for savings verification
- Definition of energy prices used to value the energy savings, and future adjustments to energy prices
- Description of the proposed metering plan and meter specifications, including methods for handling the data, and responsibilities for reporting and recording the data
- Qualitative descriptions of expected accuracy (and qualitative descriptions if feasible)
- Definition of the budget and resources required for the M&V process (both initial and ongoing)
- Description of the M&V reporting format and schedule
- Description of quality assurance procedures applicable to the M&V process

The third step in the M&V process involves operational performance verification, which provides a means for realizing savings potential and is covered in section 4 of this specification. The fourth step involves data collection, which must be performed both before and after the planned retrofit and is covered in the following subsection (5.3).

The fifth step involves determination of verified energy savings. Savings should be determined according to the appropriate IPMVP option. In all cases, the determination of verified savings should involve consideration of the measurement boundaries, interactive effects, selection of appropriate measurement periods, and basis for adjustments.

5.2.1 VERIFIED ENERGY SAVINGS - OPTION C

For Option C approaches, the measurement boundary will include the entire building. The measurement periods should adhere to the guidance set out in IPMVP Core Concepts (2016) section 6.5.1 and must include at a minimum a representative 12-month period for both pre- and post-retrofit utility data.

Adjustments to the baseline must be well defined and applied conservatively. The “adjustments” term is commonly used to restate the baseline energy consumption in terms of the reporting-period conditions. The verified savings equation expressed in the IPMVP is defined as:

Savings = (*Baseline Energy* +/- *Routine Adjustments* to reporting-period conditions +/- *Non-Routine Adjustments* to reporting-period conditions) - *Reporting-Period Energy*

Routine adjustments (most commonly weather) which are expected to change routinely can be accounted for through regressions or other techniques to adjust both the baseline and reporting periods to the same set of conditions. This allows for accurate comparison between the two measurement periods.

Non-routine adjustments include factors which affect energy consumption that were not expected to change such as facility size, operation of installed equipment, conditioning of previously unconditioned spaces, number of occupants, load changes, and other unexpected situations. The first step is to identify these changes in the reporting period and to specifically pinpoint those adjustments that present a reasonable effect on energy consumption. This can be accomplished through interviews with the building owner and facility personnel, periodic site visits, observation of unexpected energy consumption patterns, or other methods.

Accurate and conservative calculation of the effects that these non-routine adjustments have on energy consumption is critical. Sometimes these effects can be estimated within the dynamic building simulation software that was used to calculate the energy savings for the project. In other cases, side calculation methods need to be employed, in which case applying the appropriate level of rigor and sound engineering principles is key. This includes accurately determining any assumptions used in these calculations.

In all cases, the application of adjustments needs to be handled with care. Only adjustments that are expected to have a relatively significant impact on energy consumption should be considered. And assumptions used within the adjustments need to be conservative and based on actual measurements, field observations, or well vetted and documented sources.

5.2.2 VERIFIED ENERGY SAVINGS - OPTIONS A AND B

For Option A or B approaches, the measurement boundary must be considered and defined. The measurement boundary should be drawn around the equipment or systems affected by the ECMs and all significant energy requirements of the equipment within the boundary should be determined. Determination of the energy performance of the equipment can be accomplished by direct measurement of the energy flow, or through direct measurement of proxies of energy consumption that provide an indication of energy consumption.

All energy effects of the ECMs should be considered and measured if possible. In particular, interactive effects of the measures beyond the measurement boundary should be evaluated to determine if their effects warrant quantification, or if these effects can be reasonably ignored (refer to sections 2.5.1 and 2.5.2). The M&V Plan should still include a discussion of each effect and its likely magnitude.

Both the baseline period and the post-retrofit (reporting) period need to be determined early on in the project development so that appropriate and adequate baseline data can be captured. The measurement periods need to collect data that reflect equipment operation through its full operating cycle (maximum energy consumption to minimum). The data should represent all operating conditions, and the baseline period should ideally coincide with the period immediately before commitment to undertake the retrofit.

Quality Assurance Methods

Certification Period:

- Review of the M&V Plan for adherence to the IPMVP during the Certification Period.

Performance Period:

- Ensure that operational performance verification (as described in Section 3) was performed and documented.
- Review the developed baseline according to the QA methods described in Section 1.
- Ensure that appropriate measurement boundaries are defined and that appropriate interactive effects are being considered and/or quantified.
- Ensure that appropriate measurement periods have been selected to reflect equipment operation through its full operating cycle (for both the baseline and reporting periods). The baseline period should coincide with the period immediately before commitment to undertake the retrofit.
- Ensure that all appropriate adjustments were considered that would affect energy performance of the building or measures and review proper application of adjustments (routine and non-routine) to ensure they have been conservatively applied.

Resources

Federal Energy Management Program M&V Guidelines *(Nexant)* - Guidelines and methods for measuring and verifying energy, water, and cost savings associated with federal energy savings performance contracts.

ICP Option C M&V Plan *template* - M&V plan template that can be used to develop an IPMVP-adherent M&V plan following Option C.

International Performance Measurement and Verification Protocols Core Concepts *(EVO),* - Defines basic terminology used in the M&V field. It defines general procedures to achieve reliable and cost-effective determination of savings.

ISO 50015 Energy Management Systems, Measurement and Verification of Energy Performance of Organizations, General Principles and Guidance – Provides an overview of the general principles and guidelines for the process of M&V of energy performance of an organization or its components

5.3 Energy Data (All Protocols)

Data collection can be performed through the use of metering equipment, remote data logging equipment, trending through the EMS, or other methods. It is important to ensure that all equipment used for data collection is calibrated and that the calibration is documented. Sensor placement should also be considered carefully for measurements such as temperature or airflow.

Issues such as reducing computer processing speeds, consuming excess communication bandwidth, storage limitations, or security and access issues should be considered and resolved before any data collection plan is implemented. This includes data collection requirements which can vary widely. There will almost always be issues arising from erroneous or missing data which should be managed through interpolation of the data, changing the baseline or reporting periods, omission, adjustment through recalibration, or adjustment to a nominal value. The applied methods for error remediation should be well documented as part of the M&V plan. Documentation should also establish a maximum acceptable rate of data loss as part of the overall acceptable level of accuracy and also specify how it will be measured.

Commercially available tools are available that can be used to automatically manage data errors as well as to perform interpolation or time and interval correction.

Quality Assurance Methods (Performance Period)

- Review of monitoring equipment (calibration, proper installation) and collected data.
- Ensure that erroneous or missing data have been identified and managed through interpolation, changing the baseline or reporting periods, omission, adjustment through recalibration, or adjustment to a nominal value. All methods for addressing or managing insufficient data must be documented.

Resources

ASHRAE Guideline 14-2014 - Highly technical document strongly focused on calculating energy and demand savings using measurements and measurement uncertainty analysis, applicable to Option B approaches. Details regarding data collection and instrumentation can be found in Section 7 of the Guideline.

ASTM E2797 Building Energy Performance Assessment (BEPA) standard - Prescriptively addresses the baseline data collection and analysis process for Option C approaches.

International Performance Measurement and Verification Protocols (EVO), Statistics and Uncertainty for IPMVP - Section 4 contains information regarding sensors, calibration techniques, lab standards for measurements, and test methods.

ISO 50015 Energy Management Systems, Measurement and Verification of Energy Performance of Organizations, General Principles and Guidance – Section 5.9 describes data collection and associated considerations. Section 7 provides an overview of assessing uncertainty in M&V results, with examples of measurement uncertainty given in Annex B.

Measurement and Verification Operational Guides *(Nexant)* - A collection of M&V operational guides to translate M&V theory into successful M&V projects. Materials include project planning templates, application-specific guidebooks and guides for new and experienced M&V practitioners.

Universal Translator v3 (PG&E) - The UT3 is software designed for the management and analysis of data from loggers and trend data from building management systems. The software features import routines, time and interval correction, calibration error correction, data filters, charting tools, and export capabilities. It features analysis modules to analyze economizers, lighting loads, plug loads, psychometrics, setpoints, statistics, control loop diagnostics, fans, AHUs, terminal units, and fan coils. IT also provides an M&V analysis module (regression modeling).

5.4 Regression-Based Model: IPMVP Option C (Large Protocol)

IPMVP Option C will always be required under the Large protocols. Under the Standard protocols, IPMVP Option A or B will usually be most appropriate, but in some cases, Option C may be considered more appropriate. There are a number of factors that will dictate this including e nature of the ECMs and the availability of data.

Under IPMVP Option C, a regression-based energy model is likely to be required. This involves the development of an energy use equation which relates the dependent variables (total site energy consumption, including electricity and on-site fuel or district energy) to independent variables known to significantly impact the building’s energy consumption. Independent variables typically include weather (heating and cooling degree days) and may include other variables such as operating hours, occupancy or vacancy rates, number of occupants, or other variables. Regression analysis is described in more detail in section 1.4.

The energy use equation can be determined using a least squares regression. Where there is more than one dependent variable, multiple-linear regression can be used. This approach enables the comparison and analysis of the building’s energy consumption as a function of the independent variable(s) that vary monthly.

More complex regression techniques may also be required. The IPMVP provides descriptions of various techniques that may be employed to develop these more complex regression-based energy models including an overview of non-linear regression techniques. General guidance regarding choosing an appropriate model can also be found in Section 4.2.2 of the FEMP M&V Guidelines.

There are many commercially available software tools that can be used to automate an IPMVP Option C approach to M&V. Keep in mind that while many applications or tools can help automate the Option C M&V process, they all still require a minimum level of engineering expertise. A solid understanding of IPMVP principles, analysis techniques, and application of routine and non-routine adjustments are essential skills that the M&V agent should have when performing M&V activities and analysis regardless of their use of automated software tools.

Quality Assurance Methods (Performance Period)

- Inspect the energy use equation (model) to ensure that the appropriate independent variable(s) that affect energy consumption have been considered and incorporated into the equation. Any selected variables must be truly independent.
- Ensure that statistical results meet appropriate standards. Suggested standards include:
  - Coefficient of determination (R squared) > 0.75 [lower R squared values may indicate independent variables missing, or the need for more data]
  - Coefficient of variation of root mean square error CV(RMSE) < 15% [indicates overall uncertainty in the model]
  - Mean bias error (MBE) +/- 7% [indicates whether model over or under predicts values]
  - t-statistic (t-stat) > 2.0 [value greater than 2.0 indicates that independent variables are significant]

Resources

ASHRAE Guideline 14-2014 - Highly technical document strongly focused on calculating energy and demand savings using measurements and measurement uncertainty analysis, applicable to Option B approaches.

EN 16212:2012 Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods (section 5.2.3.1) – Provides guidance on carrying out normalization of climate dependent energy consumption.

Federal Energy Management Program M&V Guidelines (Nexant) - Guidelines and methods for measuring and verifying energy, water, and cost savings associated with federal energy savings performance contracts.

Inventory of Commercial EMIS for M&V Applications (PECI) - Report that provides descriptions and comparisons of EMIS tools (IPMVP Option C approach).

Inverse Modeling Toolkit (ASHRAE) - Toolkit for calculating linear, change-point linear, and multiple-linear inverse building energy models. Describes the numerical algorithms used to find general least squares regression, variable-base degree- day change-point, and combination change-point multivariable regression models, as well as the equations used to estimate the uncertainty of predicting energy use for the purpose of measuring savings.

ISO 50006:2014 Energy Management Systems, Measuring Energy Performance Using Energy Baselines and Energy Performance Indicators methodology *(Annex D)* - Provides an overview of normalization and regression modeling.

5.5 ESTIMATED PARAMETERS: IPMVP OPTION A (STANDARD AND TARGETED PROTOCOLS)

For certain projects and ICP protocols, Option A may be applied to a single measure or at the system level for M&V assessment. The approach is intended for retrofits where key performance factors such as end-use capacity, demand, power, or operational factors such as lighting or pumping power can be spot-measured or short-term-measured during the baseline and post-retrofit periods. Under Option A, any factor not measured must be estimated based on assumptions, analysis of historical data, or manufacturer's data, and is referred to as stipulated.

While Option A can provide a more economical approach to M&V than Option B, it should only be applied to "simpler" measures. This would include measures in which at least one of the parameters is expected to be fairly constant or consistent and can therefore be estimated/stipulated.

When considering an Option A approach and what variables to estimate, thought should be given to the amount of variation in baseline energy consumption or the energy impact that variables have on the ECMs before establishing which variables to estimate. Estimates should be based on reliable and documentable sources that possess a high degree of confidence. These estimates should never be based on "rules-of-thumb," proprietary sources ("black box"), or "engineering estimates." All stakeholders should agree on the legitimacy of using estimates for these variables.

Key parameters that are not consistent must be measured as opposed to estimated. These typically include parameters such as capacity, efficiency, or operation - essentially, any parameters that represent a significant portion of the savings uncertainty. Savings themselves can never be stipulated under IPMVP; only specific parameters associated with an ECM. The amount that the key parameter is expected to vary will determine the frequency of measurement (i.e. continuously and/or the frequency of periodic measurements).

Resources

International Performance Measurement and Verification Protocols (EVO), Core Concepts - Section 6.2 sets out the considerations to be taken into account when determining the measurement boundary and frequency of measurement.

Quality Assurance Methods (Certification Period)

- Ensure that Option A is appropriate for the measures it is being applied to (simpler measures or measures with parameters that are fairly constant or consistent).
- Ensure that estimated parameters do not include variables that are typically not consistent.
- Check source and reasonableness of estimated parameters.

5.6 Revised Calculations: IPMVP Options A and B (Standard and Targeted Protocols)

Following the installation of the ECMs, application of an Option A or B approach will require revisions to the original savings calculations to determine verified energy savings for the associated ECMs. Spot or short-term measurements and observations of post-retrofit operation should provide the inputs to the assumptions originally used in the savings calculations so that accurate (verified) savings associated with the actual operation of the measures can be calculated. The measurement plan and process to apply the results to the verified savings calculations should be documented in the M&V Plan and adhered to for these efforts.

As with the original savings calculations, all inputs and assumptions should be transparent and well documented through data analysis, pictures, EMS screenshots, or other resources used to inform the verified savings calculations.

Quality Assurance Methods (Performance Period)

- Review of the calculations performed to quantify verified savings.
- Check all revised assumptions, to ensure that they reflect observations and data analysis conclusions, and that they have been well documented.

5.7 Portfolio Approach to M&V

In many cases, multiple projects or portfolios of projects using the Targeted Protocol will typically perform M&V activities using an independent-party aggregator. In these situations, a portfolio-based approach to M&V can be employed where savings are tracked using a simplified Option C weather normalized approach. In these cases, the impact of any standard error is reduced by the large amount of data points generated by the number of included assets. This approach will not be accurate on a per building level but will reduce variance across the portfolio.

The aggregator can track performance in terms of both average realization rates and the level of standard deviation across the entire portfolio. The aggregator can then analyze these data to identify outlier projects (bottom 10% of performers) as well as looking at outliers in terms of contractors, technologies, building types, etc. Projects where performance levels are lacking can then be investigated further by applying the per building M&V methods described above.

This approach addresses the reality that there is limited budget for M&V on small projects, while maintaining quality and rigor.

6.0 OTHER PROJECT DEVELOPMENT TOPICS

6.1 INDEPENDENT-PARTY INVOLVEMENT

Energy efficiency projects can be inherently complex, with numerous components and activities that need to be developed and performed including baselining, savings calculation estimates, operational performance verification, and M&V, among others. A well-developed project needs to ensure that each component is developed by experienced professionals using well-established tools and practices.

Selecting an experienced and reputable energy efficiency project development team is critically important to the success of any project. Of equal importance, is the involvement of an independent owner's representative, to provide oversight to the development of the project and to represent the owner's best interests.

6.1.1 PROVISION OF INDEPENDENT-PARTY OPV AND M&V SERVICES

Operational performance verification and measurement and verification specialists are independent providers whose services can provide an opportunity to obtain an unbiased and specialized evaluation of system and energy performance to ensure projects perform as successfully as possible.

Performance of OPV and M&V tasks by the project development team has many advantages, including the project team's familiarity with the building and ECMs. However, conflicts of interest may arise during both of these activities, since the project development team may have a financial or reputational stake in the project's success. For these reasons, although this is not an ICP requirement, it is recommended that the activities be provided or managed by independent providers and hired directly by the building owner or investor.

6.1.2 INDEPENDENT-PARTY QUALITY ASSURANCE ASSESSOR

Engagement of an independent Quality Assurance Assessor is required in order to perform a review for compliance with the ICP Protocols prior to GBCI issuing IREE Certification. It is recommended that in all cases the QA Assessor is hired at the very beginning of the process. This will allow them to verify that the appropriate protocol has been selected, review documentation in parallel with the project development process, and provide any necessary guidance to the project development team. Their input at these early stages can help streamline IREE Certification and avoid issues that may not otherwise become evident until late in the project, when addressing them may be difficult or impossible.

6.2 UNCERTAINTY AND RISK

Investors of all types (including building owners) must accurately predict both accurate future cash flows resulting from estimated energy savings as well as the total capital expenditure and operational costs associated with energy efficiency upgrades in order to make informed decisions. Most energy efficiency project proposals only provide a few extremely aggregated figures such as project cost and total return to potential investors, even though these calculations are comprised of dozens of other derived calculations. Rarely are investors provided with any kind of identification of risk factors or probability analysis that would enable to more accurately determine a risk adjusted expected value for the project. The result is that investors tend to inflate the required rate of return, or worse yet, choose not to invest in projects at all. This practice undermines the viability or projects at a project level while decreasing the industry's overall deal flow and impact.

Uncertainty can occur from an extremely wide variety of sources, including:

- Instrumentation equipment errors
- Modeling errors
- Statistical sampling
- Interactive effects
- Inaccuracy of assumptions (estimations)

Each of these sources of error can be minimized however, it must also be recognized that reducing uncertainty in savings estimates generates increased cost, and at some point will only provide diminished returns.

For most uncertainty analysis methods, the inputs (assumptions) need to be specified as ranges and their distribution type specified (such as normal, lognormal, uniform, log-uniform, etc.). A statistical sampling method is then applied to develop sets of parameter values for the assumptions to represent all possible combinations. The calculations are then performed with these sample sets and a probability distribution function can be developed and reported to indicate the predicted uncertainty.

Specification of the accuracy of an estimate requires both the definition of the absolute or relative bounds and also the level of confidence that the actual values fall within these defined bounds. In general, a 90/10 standard is typically accepted for energy efficiency projects, meaning that the level of accuracy reflects a 10% relative precision at a 90% confidence level.

For projects utilizing spreadsheet calculation methods, automated calculation tools can be employed such as the Monte Carlo simulation method or the Latin Hypercube sampling method, or a combination of the two. During a Monte Carlo simulation, values are sampled at random from the input probability distributions. Each set of samples is called an iteration and the resulting outcome from that sample is recorded. Monte Carlo simulation performs this iteration hundreds or thousands of times and results in a probability distribution of possible outcomes. There are many Monte Carlo based simulation functions that are available as add-ins to Microsoft Excel that automate Monte Carlo simulation.

The Latin Hypercube is another simulation method but uses stratified sampling. This method is commonly used to reduce the number or runs necessary for a Monte Carlo simulation to achieve a reasonably accurate random distribution. It can be incorporated into an existing Monte Carlo model fairly easily, and work with variables following any analytical probability distribution.

For projects utilizing an energy model, a similar approach can be applied using sampled values from input probability distributions (based on the methods described above) to perform multiple iterations of the energy model calculations. Typically, this is done manually by the energy modeler, but in the near future OpenStudio, an open-source software application that is integrated with EnergyPlus and

Radiance, will feature an automated uncertainty analysis tool. This tool leverages modeling data developed by Sandia National Laboratories and also allow for a comprehensive assessment of critical input parameters and their interaction. OpenStudio is expected to provide a more automated and comprehensive approach to assessing uncertainty for energy models.

While it is important for a financial investor to be aware of potential uncertainty involved in an EE project, in many cases the resources required to more fully quantify the uncertainty associated with a proposed project may not be available or justified. A cost-effective alternative to attempting to more fully quantifying uncertainty is simply to reduce risk.

A key area to apply this strategy to is in energy savings calculations. By reducing the number of assumptions used in the savings calculation and cost estimation efforts or by utilizing conservative assumptions for inputs that can't be eliminated, a significant amount of associated risk can be mitigated easily.

But perhaps the most straightforward means to reduce risk is simply to follow the ICP Protocols and to ensure that all the plans that are created during the process are actually executed later during the Performance Period. This includes activities intended to ensure the persistence of savings that are specified in the Construction, Design and Verification phase and the Operations, Maintenance, and Monitoring phase. In particular, risk can be mitigated by ensuring that the following tasks are performed thoroughly:

- Operational Performance Verification
- Identification of key operational requirements of installed and modified systems
- Monitoring of systems operations and key performance indicators
- Identification of processes to address and resolve any detected performance inconsistencies including staff responsibilities
- Thorough training of staff on all new systems operations, monitoring, and issue related processes
- M&V activities carried out according to M&V plans along with analysis of the results

Lastly, an often neglected but powerful practice is including a comprehensive quality assurance process across the entire project lifecycle. Because of this, ICP mandates the use of independent Quality Assurance Assessors to perform an IREE verification for projects seeking IREE Certification. ICP highly recommends that a qualified and independent party be retained to perform quality assurance tasks throughout the lifecycle of the project including during the Performance Period after IREE Certification.

Resources

ASHRAE Guideline 14-2014 - Technical document focused on calculating energy and demand savings using measurements and measurement uncertainty analysis. Annex B of the Guideline details the determination of savings uncertainty for energy efficiency projects.

Federal Energy Management Program M&V Guidelines *(Nexant)* - Table 3-1 contains an Energy Savings Performance Contract Risk, Responsibility, and Performance Matrix in the US.

International Performance Measurement and Verification Protocols (EVO), Volume I, 2012 - Appendix B contains methods for quantifying and evaluating uncertainty, as well as methods for reducing uncertainty. Appendix C provides references for applying standard-error-analysis methods for typical savings calculations.

7.0 DOCUMENTATION PACKAGE

This section presents a list of the documentation required of an ICP compliant project. All documents specified by the ICP Protocols must be available for review and should be stored in a central project repository and it is recommended that role-based security be applied to grant authorized access to specific user groups and users including the Quality Assurance Assessor, investors, owners, and other project participants. The repository should leverage a sensible and well-defined folder structure preferably aligned with the ICP project phases. Sub folders should be used to organize documents and named to accurately describe what documents and information they contain Project documents should be labelled to clearly describe their purpose, the information they contain, and how they pertain to the ICP documentation requirements.

ICP provides a sample folder structure for developers and others to use as a basis for providing a well-organized documentation package that is compliant with the ICP Protocols and the requirements of IREE Certification that can be accessed by contacting GBCI. Projects seeking IREE Certification will utilize GBCI's online platform to conveniently upload all required documentation for review and record keeping.

In order to facilitate the project development process, ICP provides ready-made templates for certain documentation requirements as specified in the ICP Protocols that are available on the ICP United States and Europe websites. The templates include:

- **Operation Performance Verification template** – this template provides a framework that allows developers to easily create an ICP compliant Operational Performance Verification (OPV) plan. The OPV plan allows developers to quickly describe the requisite targeted commissioning process for projects tailored fit owner and project specific requirements.
- **Operations, Maintenance and Monitoring Plan template** – this template provides a framework that allows developers to easily for create an ICP complaint OM&M plan. The OM&M plan allows developer to quickly describe the OM&M process for projects to fit owner and project specific requirements.
- **M&V Plan template** (for Measurement and Verification, IPMVP Option C -Whole Facility) – this M&V plan template provides a framework for creating an ICP compliant M&V plan that adheres to the IPMVP Option C, Whole Facility approach. The M&V plan can be used to easily describe the M&V process as required by the ICP Protocols. Various sections will require the user to customize the language to fit project-specific details.

Table 2 (below) Key:

L = Large Commercial/Tertiary and Large Multifamily/Apartment Block

S - Standard Commercial/Tertiary and Standard Multifamily/Apartment Block

T = Targeted Commercial/Tertiary and Targeted Multifamily/Apartment Block

Table 2 Documentation Package

The following table is an overview that depicts which documentation elements are required for which ICP Protocols

Protocol Section	Protocol	Documentation Required	Comments
Baselining	All (T where relevant to the baseline)	Weather data	Can be the actual weather file or data, or a reference to the source of the data used (e.g. weather station)
Baselining	All (T where relevant to the baseline)	Baseline utility data	Raw utility data
Baselining	All	Description of baseline period	Minimum 12-month period; include start/end dates
Baselining	All	Utility rate structures	
Baselining	All (T where relevant to the baseline)	Energy end-use consumption	Estimates or metered data
Baselining	All	Building asset / operational / performance data	Building drawings, equipment inventories, system and material specifications, field survey results and/or CAD take-offs, observations, short-term monitored data, spot measurements, and functional performance test results as appropriate
Baselining	All (T where relevant to the baseline)	Assessment of interactive effects	Projects with multiple ECMs; for Targeted projects, those that involve a lighting retrofit
Baselining-optional	All	Interval meter data	If interval data are used
Baselining-optional	All	Sub-metering data	If sub-metered data are collected and used
Baselining-optional	All	On-site weather data	If on-site weather data are used
Baselining-optional	All	Calibration certificates	For meters
Baselining-optional	All	Owner's rental information	
Baselining-Demand	All (T where relevant to the baseline)	Copies of utility bills	At least one for electricity and each fuel

Protocol Section	Protocol	Documentation Required	Comments
Baselining-Demand	All (T where relevant to the baseline)	Monthly consumption load profiles	If load profiles are developed
Baselining-Demand	All (T where relevant to the baseline)	Monthly peak demand	If demand charges exist, and ECMs affect demand
Baselining-Demand	All (T where relevant to the baseline)	Interval meter data	If interval demand data exist
Savings Calculations	L	Modeler qualifications	
Savings Calculations	S and T	Savings calculator qualifications	
Savings Calculations	L	Model calibration	Demonstrate that the calibration criteria are met
Savings Calculations	L	Model input/output files	Including information about modeling software used and version number
Savings Calculations	All	Descriptions of ECMs	Including information about any interactive effects
Savings Calculations	S and T	Calculations	Workbooks, spreadsheets and other calculation tools
Savings Calculations	All (T where relevant to the ECMs)	Weather file	Used for simulation or savings calculations
Savings Calculations	All	Calculation results	
Savings Calculations	All	Cost estimate details	For each ECM
Savings Calculations	All	Bids by trade	If applicable
Design, Construction &	All	OPV authority	

Protocol Section	Protocol	Documentation Required	Comments
Verification		qualifications	
Design, Construction & Verification	L and S	OPV Plan	Template available on US and Europe ICP websites
Design, Construction & Verification	All	OPV statement of project conformity	Project conforms with audit intent and scope
Design, Construction & Verification	All	OPV report	
Design, Construction & Verification	All	Training materials	And record of training if available
Design, Construction & Verification	All	System manual(s)	For all new and modified systems and equipment; only applicable to Targeted if a Systems Manual already existed
OM&M	All	Points list/trending plan	Key variables trended in EMS, if applicable
OM&M	All	Plan for fault detection and remediation	Template available on US and Europe ICP websites
OM&M	All	Organizational chart	Persons involved with OM&M, and responsibilities for monitoring and response
OM&M	All	Operator's Manual	For all new and modified systems and equipment; only applicable to Targeted if a Systems Manual already existed
OM&M	All	Maintenance plans / service response logs	Including warranties for new equipment
OM&M	All	Training curriculum	And record of training if available
M&V	All	M&V Plan	Template available on US and Europe ICP websites for Option C approach

Protocol Section	Protocol	Documentation Required	Comments
M&V	All	Routine adjustments	
M&V	All	Non-routine adjustments	
M&V	L	Reporting-period utility data	Used in the Option C analysis
M&V	L	Reporting-period independent variable data	Used in the Option C analysis
M&V	L	Reporting-period dependent variable data	Used in the Option C analysis
M&V	L	Regression-based energy model	Used in the Option C analysis
M&V	S and T	Data collected	Used in the Options A/B analysis
M&V	S and T	Verified savings calculations	Used in the Options A/B analysis, including assumptions

APPENDIX A – ICP PROJECT DEVELOPMENT PROCESS OVERVIEW

STAGE	Develop Baseline	Audit / ECM List	Savings Calculations / Investment Package	Design, Construction & Verification	Operations, Maintenance & Monitoring	Measurement & Verification (Post-Implementation)
PROJECT TASKS	Collect utility data	Collect building asset data	Develop / calibrate energy model	Develop OPV plan	Develop OM&M plan	Option A/B: Collect post-retrofit energy / performance data
	Develop energy end-use consumption	Collect building operational / performance data	Perform model / spreadsheet calculations	Perform OPV tasks	Set up FDD, develop RCx plan, or other monitoring method	Option A/B: Performance data analysis
	Collect utility rate info	Develop ECM descriptions	Develop costs / constructability	Develop / updated systems manual	Develop / update operator's manual	Option A/B: Verified savings calculations
	Load shape development		Develop / inform investment criteria	Perform building operators training	Perform building operators training	Option C: Post-utility data
	Develop energy use equation and establish accuracy		Develop ECM bundles & packages	Develop M&V plan (before construction)		Option C: Identify / quantify non-routine adjustments
	Identify adjustments		Develop audit report	Option A/B: Collect pre-retrofit energy / performance data (before construction)		Option C: Regression based analysis
	Collect weather / occupancy data		Account for any interactive effects in savings			All Options: M&V report
	Estimate any interactive effects in establishing baseline					
QUALITY ASSURANCE TASKS	Review and approve utility data and rates, weather data, and energy baseline	Review and approve asset / operational / performance data, including: audit forms and field observations, control sequences, drawings, equipment schedules, performance data analysis, and pictures	Review and approve audit report including baseline, building/systems and ECM descriptions, savings calculations, performance and cost analysis	Review and approve credentials of individual responsible for OPV	Review and approve OM&M plan, setting out procedures	Review and approve credentials of individual responsible for M&V
	Review and approve energy use equation		Review and approve credentials of individual responsible for energy model/savings calculations	Review and approve OPV plan	Review and approve FDD, RCx plan, or other monitoring method	Review and approve M&V report(s)
	Review and approve energy end-use consumption		Review and approve energy model inputs and outputs, and weather files; check calibration	Review and approve equipment specifications and cut sheets	Review and approve issues and opportunities identified during OPV phase and on an ongoing basis	Option C: Review and approve performance-period utility data (12 months), regression based model, and adjustment calculations
	Review and approve load profiles and interval data		Review and approve savings spreadsheet calculations, including supporting data	Review and approve OPV report	Review and approve maintenance plans associated with new equipment	Option A/B: Review and approve monitored data files, data analysis results, and revisions to savings calculations
			Review and approve supporting costs / constructability information	Review and approve M&V plan	Review and approve operator's manual	Review and approve adjustments and proper application
			Review and approve ECM bundles / investment package	Review and approve systems manual	Review and approve training (interview building operators)	
				Review and approve training (interview building operators)	Review and approve service response logs and warranties for new equipment	
				Option A/B: Ensure pre-retrofit energy / performance data collected		

Key / Legend					
All protocols	Large Protocols Only	Large and Standard Protocols Only	For Targered not requred unless relevant to ECMs	Standard and Targeted protocols only	Performance period (stripe overlay)