

**Measurement and Verification Plan**

**Template**

**Version 1.1**

# 1.0 Introduction

This Measurement and Verification (M&V) plan describes in detail how energy savings will be quantified for NAME OF PROJECT. The M&V plan presented here adheres to the specifications set forth in the International Performance Measurement and Verification Protocol (IPMVP) Core Concepts - 2014.

M&V involves the process of using measurements to reliably quantify actual energy savings from an energy savings project within a facility, a process, a building, or a building subsystem. M&V may be used to verify that an energy efficiency project is achieving its intended savings. Energy savings represents the absence of energy use and cannot be directly measured. M&V describes how savings are determined from measurements of energy use before and after implementation of an energy or water savings project, with appropriate adjustments made for changes in conditions. Such adjustments may be routine and expected, while others are non-routine and due to factors unrelated to the project.

This M&V Plan describes how baseline energy use is documented, how it varies, and what factors are its primary drivers. The M&V plan also describes how adjustments to baseline energy use are made for unexpected events, such as added equipment or loads, or other unforeseen events that materially affect energy use and savings.

The M&V Plan is required to document and describe the approach to quantifying savings, the key measurements required and computation methods, the timing of these activities, roles and responsibilities of involved parties, and the quality assurance requirements associated with the process.

# 2.0 Project Description

[[Provide a general description of the project. This can be copied from an Energy Audit Report or similar document.]]

## 2.1 Energy Conservation Measures

[[Add a table listing the ECMs and estimated savings in energy units and dollars.]]

[[OPTIONAL: add brief descriptions of each ECM.]]

# 3.0 Measurement and Verification

## 3.1 IPMVP Option and Measurement Boundary

IPMVP Option C, *Whole Facility* will be used for savings determination. Option C was selected because multiple energy conservation measures (ECMs) are included in the project, and may have interactive effects. This approach conforms with the Investor Confidence Project (ICP) Large and Standard Energy Efficiency Protocols.

The main building utility meters will be used to determine savings: the natural gas meter and the main electricity meter. These meters account for all energy use of the facility.

## 3.2 Baseline Period Energy and Conditions

The baseline period selected involves the 12 months immediately before the decision to implement the ECMs (BASELINE PERIOD DATES). The baseline energy data for each meter are shown in Appendix A. Key conditions during this baseline period that may change in the reporting period were recorded as shown in Appendix B. These conditions, if different in the reporting period from these baseline conditions, may necessitate non-routine adjustments to the baseline energy use.

## 3.3 Reporting Period

Annual reporting of cost avoidance will be performed.

## 3.4 Basis for Adjustment

Savings are to be reported as “cost avoidance,” under reporting period conditions. Baseline period energy will be adjusted to reporting period conditions, using the following IPMVP equation:

**Equation 1**

Avoided Energy Use (or Savings) = Baseline Energy (+/- Routine Adjustments to reporting-period conditions +/- Non-Routine Adjustments to reporting-period conditions) - Report Period Energy

## 3.5 Analysis Procedures

The energy and demand relationships with heating degree days were examined for the heating season, and cooling degree days for the cooling season, on all utility accounts using regression analysis. For gas and electrical consumption, the base temperatures selected for counting heating and cooling degree days were the outdoor temperatures which yielded the best R-squared in the regression analysis.

Appendix A shows the baseline analysis of the utility meters.

**Table 1 Regression Analysis Summary**

Routine Adjustments will be carried out based on the OpenEEmeter platform and associated open methods which can be found at: <https://www.openee.io/open-source/how-it-works>.

**3.6 Energy Prices**

Reporting of cost avoidance will use the then current rate from each utility account. Prices will be modified each time the utility price schedules change.

## 3.7 Meter Specifications

Utility company meters used for billing are the only meters used.

## 3.8 Responsibilities

**Table 3 M&V Roles and Responsibilities**

|  |  |  |
| --- | --- | --- |
| **Role** | **Responsibility** | **Contact** |
| Facility management | Collect utility bills and send to M&V agent.  Identify any static factors that have changed since the baseline period, and report these to the M&V agent. |  |
| M&V agent | Perform interviews and site visits as appropriate to assess routine / non-routine adjustments.  Calculate the effects of any applicable non-routine adjustments. |  |
| Investor | Approve application of all routine and non-routine adjustments. |  |
| Quality assurance provider | Review M&V activities and analysis, and work with M&V agent to ensure results are reliable.  Provide input to Investor regarding M&V-related issues to be resolved, and their resolution. |  |

# 4.0 Handling of Non-Routine Adjustments

### Non-Routine Adjustments

The Investor Confidence Project’s (ICP) Large Commercial and Large Multifamily protocols both specify the International Performance Measurement and Verification Protocol’s (IPMVP) Option C, Whole Facility approach. This approach makes sense for larger projects involving multiple measures, usually with interactivity, in which the predicted energy savings are greater than 10% of the building’s total energy use. It also makes sense from the fundamental perspective that building owners and financiers can use utility bills to determine whether energy savings have been realized.

The basic formula used to quantify verified energy savings using and Option C approach is:

*Savings = (Baseline Period Use - Reporting Period Use) +/- Adjustments*

The “adjustments” term is commonly used to restate the baseline energy use in terms of the reporting period conditions. Routine adjustments (most commonly weather) that 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 periods, providing an “apples to apples” comparison.  
  
***Non-routine adjustments*** are factors that were not expected to change, but that will affect the building’s energy use, not as a result of the energy conservation measures installed as part of the retrofit.

## 4.1 Non-Routine Application Process

The Option C M&V effort will require the identification of any non-routine adjustments that need to be quantified. The first step is to ensure that the building’s conditions and operations are well documented during the baselining efforts. These characteristics should be included in the IPMVP plan, so that the M&V resource can “keep an eye” out for possible changes in building operation or loads during the reporting period.

The next step is to identify any changes in the reporting period from the baseline period. This can be accomplished through interviews with the building owner and facility personnel, periodic site visits, observation of unexpected energy use patterns, or other methods. It is important to bear in mind that not all changes in the building need to be (or can reasonably be) accounted for in the M&V effort. Identifying changes that warrant adjustment is a critical part of the process.

The third step in the process is to establish a method to accurately calculate (quantify) how the identified changes will affect the facility’s energy use. 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 must be employed. Applying the appropriate level of rigor and sound engineering principles is key

## 4.2 Typical Non-Routine Adjustments

Non-routine adjustments that are typically encountered may include:

* A change in the facility size (added SF)
* A change in operating hours or equipment operation (or overrides in operation)
* A change in space type/use
* Added loads (new IT center, additional plug loads)
* A change in zone temperature set points
* A change in production volume

## 4.3 Defining Eligible Non-Routine Adjustments

Define all categories of eligible non-routine adjustments. Be as specific as possible in terms of adjustment type, quantitative trigger, and the action that will be taken.

*The table represent examples of eligible categories, adjustments, triggers, and actions. However this list is not exhaustive or applicable to all projects.*

|  |  |  |  |
| --- | --- | --- | --- |
| **Category** | **Adjustment** | **Trigger** | **Action** |
| ***Building Changes - Structural*** | | | |
|  | Increased Sq. Ft | 10% or greater increase. | Submeter new addition. And adjust baseline down based on the increase consumption |
| ***Operational Changes*** | | | |
|  | Change in Operating Hours - non load dependent | Lighting overridden during normally unoccupied hours | kW x additional hours of operation |
|  | Change in Operating Hours - load dependent | RTUs overridden during normally unoccupied hours | kW x additional hours of operation; kW calculated based on loads (weather, etc) using temp bin analysis or similar method. |
|  | Change in Production Volume | A third production shift added to manufacturing facility | Develop relationship between production volume and energy use. Use relationship to develop regression and calculate energy impact.  [Specific actions in model specified here.] |
|  | Change in occupancy schedule | New tenant has longer occupancy schedule in a section of the building | Determine activity type and schedule (Btu/person/hr). Use dynamic building simulation to calculate impact of additional loads on HVAC system energy use.  [Specific actions in model specified here.] |
|  | Change in zone temp set points | New tenant wants occupied cooling setpoints changed from 76F to 74F during occupied hours. | Use dynamic building simulation to determine impact of revised zone temp setpoints on HVAC system energy use.  [Specific actions in model specified here.] |
| ***Change in End Use - Loads*** | | | |
|  | Change in Use Type | Section of building occupancy changed from office space to conference room. | Determine new activity type and schedule (Btu/person/hr). Use dynamic building simulation to calculate impact of additional loads on HVAC system energy use.  Determine if new loads introduced to the space(s); then utilize dynamic building simulation to calculate impact of additional loads on HVAC system energy use  [Specific actions in model specified here.] |
|  | Addition of end use equipment | Additional IT equipment added to an office space | Determine additional kW in the space(s). Use dynamic building simulation to calculate impact of additional loads on HVAC system energy use.  [Specific actions in model specified here.] |
|  | Change in occupancy density | 100 additional inmates added to correctional complex existing population | Determine activity type and schedule (Btu/person/hr). Use dynamic building simulation to calculate impact of additional loads on HVAC system energy use.  [Specific actions in model specified here.] |

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## 4.4 Handling Non-Routine Adjustments

In general, quantifying the effects of non-routine adjustments on the building’s energy use involves use of the original calculation methods used to determine energy savings.For example, if a dynamic building simulation were originally used to calculate energy savings associated with the energy conservation measures (ECMs), this same model could be used to calculate the impact of additional occupancy.

If the original calculations used to estimate energy savings associated with the ECMs are not appropriate to quantifying the effects of the non-routine adjustments, separate calculations would need to be performed to quantify these effects. Calculation methods (regression analysis, temperature bin analysis, etc) similar to those used to estimate energy savings associated with the ECMs would need to employed to determine the impact that these non-routine adjustments will have on the building’s energy performance.

Once the non-routine adjustment effects have been quantified, these annual, monthly or hourly values are then applied to the baseline, to “adjust” the delta between the baseline energy use and reporting period energy use, to determine savings.

# 5.0 Acceptance of Proposed Non-routine Adjustments

The M&V agent proposes a non-routine baseline adjustment to the building owner or investor. This should include a reference to this document and the applicable pre-agreed to adjustments (table above).

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# Appendix B: Baseline Conditions (Static Factors)

The full set of static factors for the baseline period are not shown in this example. The actual information included the following facts: [[These are examples]]

* a lighting level survey, with a count of the number of burned out lamps in January
* and June;
* a survey of typical space temperatures and humidities during occupied and unoccupied periods in each of four seasons;
* a count of the number and size of all computers, monitors and printers, along with an estimate of the operating hours of each;
* a record of the number of day pupils and evening courses each month of the year;
* a record of the number of public rental hours of the gym, cafeteria, classrooms, auditorium and pool each month;
* a count of the number of window air conditioning units installed;
* the temperature setting of pool water, and domestic hot water serving the pool showers, the gym showers and the rest of the school;
* the volume of makeup water supplied to the pool each month, as recorded by a separate un-calibrated sub-meter;
* the kitchen hot water temperature and the number and rating of all kitchen equipment; and
* the open hours of the kitchen and the value of food sales each month.