**U.s. Energy Department**

**Federal Energy Management Program**

**ESPC ENABLE Measurement and Verification Protocol**

January 2018, version 4.1

***PLEASE READ THIS PROTOCOL BEFORE COMPLETING THE MEASUREMENT AND VERIFICATION PLAN TEMPLATE***

Introduction: This document provides an overview of the Measurement and Verification (M&V) Protocol utilized within ENABLE energy savings performance contract projects. This document is intended to serve the following purposes:

* Outline the M&V Protocol to be utilized within ENABLE projects and provide supporting instruction that is in alignment with the requirements set forth in the most recent FEMP Guidelines[[1]](#footnote-1) (FEMP M&V guidance for all federal ESPC projects)
* Provide supporting information for the completion of the M&V Plan Template

Detailed information and background pertaining to the M&V methods covered in this document can be found in FEMP’s M&V Guidelines; however, this protocol document should provide the user with an understanding of M&V requirements specific to the scope of energy conservation measures within the ENABLE program. The M&V Plan Template; a component of the ESCO’s Final Proposal submission to the Agency, generally follows the format of this protocol and contains summarized portions of the protocol text.

Contents

1. [**SUMMARY OF ENABLE M&V APPROACH** 4](#_Toc381783655)

[1.1 M&V Overview 4](#_Toc381783656)

[1.2 M&V Plan Template Summary 4](#_Toc381783657)

[2. **Whole Project Data / Global Assumptions** 4](#_Toc381783658)

[2.1 Energy, Water, and Operations and Maintenance (O&M) Rate Data 4](#_Toc381783659)

[2.2 Schedule and Reporting for Verification Activities 6](#_Toc381783660)

[3. **ECM 1 — Lighting ImpROVEMENTS M&V Approach AND SAVINGS CALCULATION METHODS** 7](#_Toc381783661)

[3.1 M&V Approach and Savings Calculation Summary 7](#_Toc381783663)

[3.2 Baseline and Savings Calculation Methodology 7](#_Toc381783664)

[3.3 Proposed Annual Savings for ECM 9](#_Toc381783667)

[3.4 Post-Installation and Performance Period Activities 9](#_Toc381783668)

[4. **ECM 2 — Water Conservation M&V APPROACH AND SAVINGS CALCULATION METHODS** 9](#_Toc381783669)

[4.1 M&V Approach and Savings Calculation Summary 9](#_Toc381783670)

[4.2 Baseline and Savings Calculation Methodology 10](#_Toc381783671)

[4.3 Proposed Annual Savings 11](#_Toc381783675)

[4.4 Post-Installation Activities 12](#_Toc381783676)

[5. **ECM 3 — HVAC Controls M&V Approach AND SAVINGS CALCULATION METHODS** 12](#_Toc381783677)

[5.1 M&V Approach and Savings Calculation Summary 12](#_Toc381783678)

[5.2 Baseline and Savings Calculation Methodology 12](#_Toc381783679)

[5.3 Proposed Annual Savings 14](#_Toc381783681)

[5.4 Post-Installation M&V Activities 14](#_Toc381783682)

[6. **ECM 4 — HVAC Equipment M&V Approach AND SAVINGS CALCULATION METHODS** 14](#_Toc381783683)

[6.1 M&V Approach and Savings Calculation Summary 14](#_Toc381783684)

[6.2 Baseline and Savings Calculation Methodology 15](#_Toc381783685)

[6.3 Proposed Annual Savings 16](#_Toc381783687)

[6.4 Post-Installation M&V Activities 17](#_Toc381783688)

[7. **ECM 5 — Solar PV M&V Approach AND SAVINGS CALCULATION METHODS** 17](#_Toc381783689)

[7.1 M&V Approach and Savings Calculation Summary 17](#_Toc381783690)

[7.2 Baseline and Savings Calculation Methodology 17](#_Toc381783691)

[7.3 Proposed Annual Savings 18](#_Toc381783693)

[7.4 Post-Installation M&V Activities 18](#_Toc381783694)

[8. **Post Installation and Annual M&V** 18](#_Toc381783695)

[8.1 Post Installation M&V 18](#_Toc381783696)

[8.2 Annual M&V Activity and Reporting 20](#_Toc381783697)

[9. **M&V Sampling** 21](#_Toc381783698)

[9.1 Overview of Point Estimation – Confidence and Precision 22](#_Toc381783699)

[9.2 Sample Size 22](#_Toc381783700)

[**Appendix A - Post Installation M&V and Cx Report Outline** 25](#_Toc381783701)

[**Appendix B - Annual M&V Checklist Template Example** 28](#_Toc381783702)

[**Appendix C - Annual M&V Report Outline** 29](#_Toc381783703)

## Summary of ENABLE M&V Approach

## M&V Overview

This document contains M&V protocol for the five ENABLE program energy conservation measures (ECM’s) utilizing the following M&V Options:

* Lighting Improvements – Option A
* Water and Sewer Conservation Systems – Option A
* HVAC Controls – Option A
* HVAC Equipment Replacement – Option A
* Solar Photovoltaic (PV) Systems – Option B

The ESCO will perform measurement and verification (M&V) activities for each of the ECM categories selected for implementation in order to estimate the actual cost savings achieved in the project. The M&V protocols for each of the ECMs within the ENABLE program are described in greater detail in Sections 3 through 7 of this document.

## M&V Plan Template Summary

DOE FEMP has developed a comprehensive M&V Plan Template for completion and submission by the ESCO as part of their final proposal to the federal agency. The M&V plan provides the agency with an overview of the M&V approach including:

* Energy and Water Rate Data to be used in baseline calculations
* Energy and Water Rate escalation rates for use in projected annual savings
* Development of energy baseline by ECM (including sample measurements and collection of lighting wattage/burn hours, water flow rates/usage profiles, building control strategies/usage)
* Savings calculation methodology (description of ENABLE IGA Tool calculations)
* Proposed Savings by ECM
* Post Installation Activity (sample measurements of retrofit equipment to verify savings projections)
* Performance Period Activity (Annual site audit requirement to verify expected savings)

The M&V Plan Template along with other ENABLE process documentation can be found on the DOE FEMP ENABLE website.[[2]](#footnote-2)

# Whole Project Data / Global Assumptions

## Energy, Water, and Operations and Maintenance (O&M) Rate Data

The energy rates will be escalated to account both for inflation and for changes to the price of energy using The Energy Escalation Rate Calculator (EERC)[[3]](#footnote-3) provided by the Federal Energy Management Program. The EERC computes an average annual escalation rate for fuel prices from the annual energy price forecasts of the DOE Energy Information Administration.

The EERC tool interface is shown in the image on the left. The steps below will provide instruction for use of the tool.

***1. Percentage of Energy Cost Savings:*** For purposes of population, individual fuel type escalation rates within the M&V plan set individual fuel type to 100%. The EERC tool can also generate a blended annual energy escalation rate by identifying the percentage of energy cost savings in the project by fuel type. A blended rate may be used in completing the financial TO schedules

***2. Fuel Rate Information:*** For “Location” select project state from list. Set “Sector” to “Commercial”

***3. Performance Period:*** Select estimated year of project performance period start. Select duration (yrs.) of performance period. If less than 10, select “10”.

***4.*** ***Carbon Pricing Policy:*** Set to “No carbon price”

***5. Annual Energy Escalation Rate:*** Use default inflation rate loaded within the tool. Utilize “Nominal” rate for energy escalation rate value.

## Schedule and Reporting for Verification Activities

The agency should be provided the opportunity to witness the baseline and post installation M&V data collection. The ESCO will provide the Contracting Officer with the M&V task list and schedule at least 14 days in advance of the M&V data collection activity, in order to allow for scheduling of appropriate personnel. The Agency will be required to provide the access to various buildings and mechanical rooms in order to facilitate data collection. In the event that M&V data collection is to occur across the installation timeline as equipment is installed, the Agency may elect to witness re-measurement of a sample of previously obtained M&V data points. It is suggested that this M&V sampling be performed in conjunction with the final commissioning and inspection activity

The schedule of M&V submissions is summarized in Table 2.2.

Table 2‑3: Schedule of Verification Reporting Activities

|  |  |  |
| --- | --- | --- |
| **Item** | **Time of submission** | **Owner’s review and acceptance period** |
| Post-Installation M&V and Cx Report | By completion of 30 day equipment acceptance test period | 30 days |
| Annual Report | 30 days after annual performance period or receipt of M&V checklist from Agency (where Agency assumes M&V audit role) | 30 days |

The Post-Installation M&V and Cx Report will be submitted by the end of the 30-day acceptance test period. The Agency representative will then have 30 days to review and approve the Post-Installation M&V and Cx Report. The Post-Installation M&V and Cx Report will document any deviations from the specified equipment. The Post-Installation M&V and Cx Report will follow the format and content defined for ESPC ENABLE projects as outlined in Appendix A of this document. The specific items that will be reported are described in the M&V plan for each ECM. Assuming that all ECMs are operational as of the end of the 30-day acceptance test period, the Agency may at their discretion issue the ESCO a written notification of project acceptance, prior to final approval of the Post Installation M&V and Cx report.

The Annual Report will be due within 30 days of the end of the annual performance period or receipt of the annual M&V checklist from the Agency (where Agency assumes annual M&V audit role). The Agency representative will have 30 days to review and approve the Annual Report. The Annual Report will follow the format and content defined for ESPC ENABLE projects as outlined in Appendix B of this document. The specific items that will be reported are described in the M&V plan for each ECM.

# 3. ECM 1 — Lighting ImpROVEMENTS M&V Approach AND SAVINGS CALCULATION METHODS



## M&V Approach and Savings Calculation Summary

The M&V approach for the lighting efficiency retrofits will follow FEMP M&V Option A.

The baseline energy consumption is to be documented through accurate accounting of all existing lighting equipment during an IGA performed at the project site. Fixture powers are to be measured on a sample of the most common fixture types. For less common fixture types, fixture power can be based on a table of standard fixture powers or manufacturer’s data.

Option A will be used to quantify the energy consumption savings associated with the lighting upgrade. Option A has been selected for this retrofit due to the confidence with which the fixture demand and operating hours can be established. Equipment numbers and locations are assumed not to vary, and operating hours are not projected to change after the project is implemented.

The M&V Plan for an ENABLE ESPC lighting retrofit will assume:

1. Operating hours will be established before the retrofit. The hours for the lighting fixtures will be the same before and after the equipment retrofit for the purpose of energy savings calculations, with the exception of adjustments for implementation of lighting controls measures. Where lighting controls are implemented, operating hours will be reduced as defined in the FEMP ENABLE IGA Tool.
2. Fixture power before and after the retrofit will be measured.
3. Interactive effects on heating and cooling equipment from the lighting retrofit will be considered by the FEMP ENABLE IGA Tool.
4. Lighting levels as a result of the lighting equipment retrofit will not be reduced below lighting luminance levels as recommended by the Illuminating Engineering Society of North America (IESNA). Lighting levels before and after the retrofit will be measured.

Projected energy savings are determined through the use of the FEMP ENABLE IGA Tool. The tool projects energy savings by multiplying the difference between baseline lighting load and post installation lighting load by the established operating hours, and then multiplying the product by the approved energy costs. In addition, the tool incorporates interactive effects on HVAC systems and allows for the capture of reductions in usage from lighting controls.

## Baseline and Savings Calculation Methodology

**3.2.1 ENERGY BASELINE DEVELOPMENT**

The variables affecting savings from the lighting project are fixture powers, hours of operation, light levels, and diversity factor (% coincident operation when the building peak demand is set). Occupancy operating hours and diversity factors are to be determined through interviews with building manager and occupants, through observations during field surveys and/or through the use of data loggers.

Note: It is generally the intention of the ESPC ENABLE program to allow the IGA process to be conducted in a single visit to the agency site. During the project kick-off meeting (pre-IGA visit) it is recommended that the ESCO and the Agency review the approach to be utilized in collection of operating hours data to ensure that the Agency understands the general cost implications of the agreed upon approach (i.e. second visit to retrieve data loggers, if utilized)

Key system performance factors to be documented during the baseline survey period include:

* operating hours
* fixture power consumption.
* diversity factors
* lighting levels

During the IGA a comprehensive lighting audit is to be completed. A room-by-room inventory of fixture counts, types, and circuits is to be made.

### 

### Fixture Power

During the lighting survey, fixture types (lamp/ballast combinations) present in the facility under the intended project scope are to be identified. Samples of the most common fixture types are to be measured to determine the fixture power under actual operating conditions. Measured lighting fixtures should operate at least one hour prior to measurement in order to achieve typical operating temperature. The measured fixture types are to represent more than 75% of the baseline-connected load within the project scope. For the remaining fixture types that are not measured, fixture powers may be taken from a table of standard fixture powers (or from manufacturers’ specifications)

When the fixtures are replaced, power measurements will again be taken on a sample of fixtures that represent more than 75% of the new connected load. For the remaining fixture types that are not measured, fixture powers may be taken from a table of standard fixture powers (or from manufacturer specifications).

In all cases, the number of power measurements taken is to be sufficient to achieve a 20 precision at 80% confidence assuming a coefficient of variation (Cv) of 0.5. See Section 7 for details on M&V sampling methodology.

### Usage Group Operating Hours

Typical lighting hours for facility spaces may be obtained either through interviews of Agency staff and/or collected through the use of data loggers. The facility space hours are to be categorized into “usage groups” and input into the FEMP IGA lighting tool. Each of the room-by-room equipment entries within the ENABLE IGA tool are assigned an appropriate usage group representative of the number of hours that piece of equipment is expected to operate. In instances were lighting controls are deployed; the IGA tool adjusts the post-retrofit operating hours by a factor appropriate for the control technology. The established post-retrofit operating hours will be held constant as annual operating hours during the performance period.

RESULTS

Summary results of the collected fixture powers and usage group operating hours are to be presented as an appendix to the M&V Plan.

**3.2.2 Energy Savings Calculations and Methodology**

After completion of the field survey, the audit data (including room level details of existing fixtures, field measurements and operating hours data) are to be input into the ENABLE IGA Tool. The formulas within the IGA tool calculate the baseline electrical consumption by summing the product of the power level of each fixture entered into the tool in the “pre-retrofit” section by the fixtures annual operating hours assumption (“usage group”). Post retrofit energy consumption for the various lighting systems will be calculated in a manner similar to that of the baseline condition. Total post retrofit electrical consumption is calculated by summing the product of the power level of each fixture by the assumed operating hours of that fixture, making adjustments to operating hours for the use of lighting controls where applicable. The IGA tool calculates total energy savings by comparing pre and post electrical consumption as well as accounting for savings from demand reduction (where applicable) and interactive effects with HVAC equipment energy usage.

Cost savings will be generated based on the energy savings calculated from FEMP tool simulations and the energy rates outlined in Section 2.1.

## Proposed Annual Savings for ECM

A detail of baseline usage, post retrofit usage and proposed annual energy and cost savings for this ECM is to be presented with the appendix of the M&V Plan. The IGA Tool generates a summary table of this information on the worksheet entitled “Project Summary Table”.

## Post-Installation and Performance Period Activities

Details of post installation and performance period activities for each ECM type are provided in Section 8 of this document.

# ECM 2 — Water Conservation M&V APPROACH AND SAVINGS CALCULATION METHODS

## M&V Approach and Savings Calculation Summary

The M&V approach for the water conservation upgrades will follow FEMP M&V Option A.

The baseline water consumption is to be documented through accurate accounting of all existing water fixtures during an IGA performed at the project site. Verified water and energy savings will be based on measured flow rates of the existing baseline and post-installation fixtures. The fixture use characteristics and schedules are described in this section.

Option A will be used to quantify the water and energy consumption savings associated with the water measure upgrades. Option A has been selected for this retrofit due to the confidence with which the fixture flow rates and usage can been established. Equipment numbers and locations will not vary, and usage is not projected to change after the project is implemented.

The M&V Plan for ENABLE water conservation retrofits will assume:

* The usage profile for the water fixtures will be the same before and after the equipment retrofit for the purpose of water and energy savings calculations.
* Fixture consumption before and after the retrofit will be measured.
* Ancillary energy savings due to reductions in the heating of domestic hot water will be considered.

Projected energy savings will be determined through the use of the ENABLE IGA Tool. The tool calculates water savings by multiplying the difference between fixture baseline and post installation flow rates by the established usage schedule, and then multiplying the product by the approved water and sewer costs. The tool calculates energy savings by multiplying appropriate portions of the flow rate reductions mentioned by an established hot water usage schedule and then by the approved energy costs.

## Baseline and Savings Calculation Methodology

**4.2.1 Energy Baseline Development**

The variables that affect the water and energy baseline are the water usage profiles of the fixtures, which are related to the occupancy patterns of the areas affected. Occupancy patterns and usage were defined within ENABLE IGA tool and based upon U.S. Green Building Council guidance on non-residential water fixture use profiles.

Key system performance factors to be documented during the baseline survey period include:

* fixture types
* fixture water consumption
* usage profiles

During the IGA a comprehensive sanitary plumbing system audit is to be completed. A room-by-room audit and inventory of fixture counts and types is to be made.

### Fixture Consumption

During the sanitary plumbing system survey, fixture types present in the facility are to be identified and baseline water flow measured for a sample of each fixture type proposed for retrofit. Use of devices such as a “Flushometer” for measurement of toilet volumes per flush and calibrated flow bags for measurement of flow rates in showers and faucets would be considered typical measurement approaches for these device types. In all cases, the number of flow measurements taken per fixture type shall be sufficient to achieve a 20% precision at 80% confidence assuming a coefficient of variation (Cv) of 0.5. See section 7 for details on M&V sampling methodology.

### Usage Profiles

Water usage profiles are defined within the ENABLE IGA Tool and are based upon U.S. Green Building Council guidelines. Occupancy data on the number of full time employees and transient staff and visitors is to be collected through interviews with facility managers and other site personnel. Occupancy data is utilized by the IGA tool in combination with the usage profile for the calculation of the baseline usage and resulting water and energy savings. The occupancy and usage profiles will be held constant during the performance period.

### Results

Summary results of the collected fixture water consumption or flow rates are to be presented as an appendix to the M&V Plan

**4.2.2 Water and Ancillary Energy Savings Calculations and Methodology**

After completion of the field survey, the audit data (including room level details of existing fixtures and field measurements) are to be input into the ENABLE IGA Tool. The formulas within the FEMP tool calculate the baseline water consumption by summing the product of the fixture consumption or flow rate for each fixture type defined by the fixtures daily assumed usage per person (U.S. Green Building Council values) and by the number of operating days per year. Post retrofit energy consumption for the various water fixtures will be calculated in a manner similar to that of the baseline condition utilizing the reduced consumption or flow rate assumption for the retrofit equipment. The IGA tool calculates total water and savings by comparing pre and post water consumption. In addition, the tool accounts for savings from related to reductions in domestic hot water usage. In instances of water conservation approaches outside of domestic sanitary fixtures (i.e. programmable irrigation systems, washing machines, dishwashers, ice machines, dish spray nozzles, etc.) the IGA tool allows for input of these measure as “miscellaneous” items, however savings calculations for these items must be generated outside of the IGA tool by the ESCO and the annual baseline and post-retrofit water consumption values are to be entered into the IGA tool. For miscellaneous items, the Agency should be provided the calculation methodology utilized to produce the annual water savings values as an appendix to the final proposal.

Cost savings will be generated based on the energy savings calculated from ENABLE IGA tool simulations and the energy rates outlined in Section 2.1.

## Proposed Annual Savings

A detail of baseline usage, post retrofit usage and proposed annual energy and cost savings for this ECM is to be presented with the appendix of the M&V Plan. The ENABLE IGA Tool generates a summary table of this information on the worksheet entitled “Project Summary Table”.

## Post-Installation Activities

Details of post installation and performance period activities for each ECM type are provided in Section 8 of this document.

# ECM 3 — HVAC Controls M&V Approach AND SAVINGS CALCULATION METHODS

## M&V Approach and Savings Calculation Summary

The M&V Approach for HVAC Controls upgrades will follow FEMP M&V Option A. The option A approach will be used to quantify the energy consumption savings associated with the HVAC controls upgrade and annual verify that the measure continues to operate and perform as specified in the Final Proposal.

The M&V approach for this retrofit assumes:

* Building occupancy hours and number of occupants will be established before the retrofit. Pre and post retrofit operating hours are the same for the purpose of energy savings calculations.
* Existing space temperatures, set points and schedules will be documented before the retrofit. Post retrofit temperatures, set points and schedules are held constant during the performance period for the purpose of energy savings calculations.
* An annual verification of the measure will be performed to document that temperatures, set points and schedules are as specified in the Final Proposal.

The baseline and post-installation energy use for this ECM is to be developed using the FEMP ENABLE IGA Tool. The HVAC Controls portion of the IGA tool utilizes EnergyPlus, an hourly building simulation modeling software to generate baseline and post-retrofit models of the facility’s energy use. The tool extracts the change in energy use between the two models and calculates cost savings based on the input costs for energy sources utilized at the facility.

## Baseline and Savings Calculation Methodology

* + 1. **ENERGY BASELINE DEVELOPMENT**

The baseline energy consumption it to be established through collection of a series of baseline data parameters including:

Building Structure

* Number of floors
* Exterior footprint (Length, Width for calculation of square footage)
* Roof type/style
* Wall type
* Plenums (Yes/No)
* Fenestration
  + Glazing % (window to wall % for each side of the building)
  + Window type (for each side of the building)

Building Activity

* Number of occupants
* Electric Plug Intensity\* (W-sq.-ft.)
* Lighting Intensity\* (W/sq-ft)
* Exterior Lighting\* (W)

HVAC Equipment

* HVAC System Type
* Heating Type (electric/natural gas)
* Reheat Type (electric/natural gas)
* Fan Static Pressure\* (inches of water)
* Total Fan Efficiency\* (%)
* Cooling COP\*
* Heating Efficiency\* (%)
* Outside Air Ventilation per person\* (cfm/person)
* Outside Air Ventilation per area\* (cfm/sq-ft)
* Flow per exterior surface area\* (infiltration – cfm/sq-ft)

Control Strategy

* Cooling and Heating Setback Temperature
* Cooling and Heating Setpoint Temperature
* Weekday/Weekend Occupancy Start Time/End Time

\* - Indicates that “typical” values are available as defaults within the ENABLE IGA tool in the event actual values are unknown or cannot be determined during the site audit. More details on the data parameters can be found within the IGA tool on the worksheet entitled “HVAC-Controls – Definitions”.

The data collected is to be used within the ENABLE IGA Tool to generate baseline energy consumption for the HVAC system. The IGA tool analyzes the baseline inputs through a building simulation engine to generate a baseline energy model.

**5.2.2 ENERGY SAVINGS CALCULATIONS AND METHODOLOGY**

The FEMP ENABLE IGA Tool utilizes EnergyPlus, an hourly building simulation model to generate and baseline and post-retrofit models of the facilities energy use. The tool extracts the change in energy use between the two models and calculates savings based on the input costs for energy sources utilized at the facility.

EnergyPlus essentially utilizes standard heat transfer equations to determine heating and cooling loads based on the heat loss or gain through the building envelope, the amount of outdoor air brought into the building, and any source of internal heat gain such as lighting or occupants.

Post installation heating and cooling energy use are calculated using the same model and equations that were used in the baseline calculations, but the post-installation model inputs were changed parametrically to reflect the control strategies that will be put in place under this ECM.

Cost savings will be generated based on the energy savings calculated from the ENABLE IGA tool simulations and the energy rates outlined in Section 2.2.

## Proposed Annual Savings

A detail of baseline usage, post retrofit usage and proposed annual energy and cost savings for this ECM is to be presented with the appendix of the M&V Plan. The ENABLE IGA Tool generates a summary table of this information on the worksheet entitled “Project Summary Table”.

## Post-Installation M&V Activities

Details of post installation and performance period activities for each ECM type are provided in Section 8 of this document.

# ECM 4 — HVAC Equipment M&V Approach AND SAVINGS CALCULATION METHODS

## M&V Approach and Savings Calculation Summary

The M&V Approach for HVAC Controls upgrades will follow FEMP M&V Option A. The option A approach will be used to quantify the energy consumption savings associated with the HVAC equipment upgrade and annual verify that the measure continues to operate and perform as specified in the Final Proposal.

The M&V approach for this retrofit assumes:

* Building occupancy hours and number of occupants will be established before the retrofit. Pre and post retrofit operating hours are the same for the purpose of energy savings calculations.
* Existing space temperatures, set points and schedules will be documented before the retrofit. Post retrofit temperatures, set points and schedules are held constant during the performance period for the purpose of energy savings calculations.
* An annual verification of the measure will be performed to document that temperatures, set points and schedules are as specified in the Final Proposal.

The baseline and post-installation energy use for this ECM is to be developed using the FEMP ENABLE IGA Tool. The HVAC Equipment and Controls portion of the IGA tool utilizes EnergyPlus, an hourly building simulation modeling software to generate baseline and post-retrofit models of the facility’s energy use. The tool extracts the change in energy use between the two models and calculates cost savings based on the input costs for energy sources utilized at the facility.

## Baseline and Savings Calculation Methodology

* + 1. **ENERGY BASELINE DEVELOPMENT**

The baseline energy consumption it to be established through collection of a series of baseline data parameters including:

Building Structure

* Number of floors
* Exterior footprint (Length, Width for calculation of square footage)
* Roof type/style
* Wall type
* Plenums (Yes/No)
* Fenestration
  + Glazing % (window to wall % for each side of the building)
  + Window type (for each side of the building)

Building Activity

* Number of occupants
* Electric Plug Intensity\* (W-sq.-ft.)
* Lighting Intensity\* (W/sq-ft)
* Exterior Lighting\* (W)

HVAC Equipment

* HVAC System Type
* Heating Type (electric/natural gas)
* Reheat Type (electric/natural gas)
* Fan Static Pressure\* (inches of water)
* Total Fan Efficiency\* (%)
* Cooling COP\*
* Heating Efficiency\* (%)
* Outside Air Ventilation per person\* (cfm/person)
* Outside Air Ventilation per area\* (cfm/sq-ft)
* Flow per exterior surface area\* (infiltration – cfm/sq-ft)

Control Strategy

* Cooling and Heating Setback Temperature
* Cooling and Heating Setpoint Temperature
* Weekday/Weekend Occupancy Start Time/End Time

\* - Indicates that “typical” values are available as defaults within the ENABLE IGA tool in the event actual values are unknown or cannot be determined during the site audit. More details on the data parameters can be found within the IGA tool on the worksheet entitled “HVAC-Controls – Definitions”.

The data collected is to be used within the ENABLE IGA Tool to generate baseline energy consumption for the HVAC system. The IGA tool analyzes the baseline inputs through a building simulation engine to generate a baseline energy model.

**6.2.2 ENERGY SAVINGS CALCULATIONS AND METHODOLOGY**

The FEMP ENABLE IGA Tool utilizes EnergyPlus, an hourly building simulation model to generate and baseline and post-retrofit models of the facilities energy use. The tool extracts the change in energy use between the two models and calculates savings based on the input costs for energy sources utilized at the facility.

EnergyPlus essentially utilizes standard heat transfer equations to determine heating and cooling loads based on the heat loss or gain through the building envelope, the amount of outdoor air brought into the building, and any source of internal heat gain such as lighting or occupants.

Post installation heating and cooling energy use are calculated using the same model and equations that were used in the baseline calculations, but the post-installation model inputs were changed parametrically to reflect the new HVAC equipment and any changes to control strategies that will be put in place under this ECM.

Cost savings will be generated based on the energy savings calculated from the ENABLE IGA tool simulations and the energy rates outlined in Section 2.2.

## Proposed Annual Savings

A detail of baseline usage, post retrofit usage and proposed annual energy and cost savings for this ECM is to be presented with the appendix of the M&V Plan. The ENABLE IGA Tool generates a summary table of this information on the worksheet entitled “Project Summary Table”.

## Post-Installation M&V Activities

Details of post installation and performance period activities for each ECM type are provided in Section 8 of this document.

# ECM 5 — Solar PV M&V Approach AND SAVINGS CALCULATION METHODS

## M&V Approach and Savings Calculation Summary

The M&V Approach for Solar PV installations will follow FEMP M&V Option B. The option B approach will be used to quantify the energy consumption savings associated with the Solar PV installation and annually verify that the measure continues to operate and perform as specified in the Final Proposal.

The M&V approach for this retrofit assumes:

* The annual solar radiation as utilized in the calculation of the annual electrical generation of the PV array will be assumed to represent a typical meteorological year (TMY) and will be held constant during the performance period for the purpose of energy generation calculations
* PV Module Performance and inverter efficiencies are based on manufacturer’s data.
* An annual verification of the measure will be performed to document that PV system remains installed and performing as specified in the Final Proposal.
* An annual collection of the generated electrical output from the PV system will be performed and recorded as verified savings.
* The energy generation potential for this ECM is to be developed using the FEMP ENABLE IGA Tool. The solar PV component of the IGA tool utilizes the National Renewable Energy Laboratory’s (NREL) PVWatts tool to calculate the expected electrical output for the PV array on an annual basis. The “Net Energy Use”[[4]](#footnote-4) approach will be used, meaning the cumulative energy generated on an annual basis is the amount saved.

## Baseline and Savings Calculation Methodology

* + 1. **ENERGY BASELINE DEVELOPMENT**

The electricity generated by the solar PV system is to be treated as an offset of electricity currently provided to the site by another source, therefore a baseline is not utilized for this measure.

**7.2.2 ENERGY SAVINGS CALCULATIONS AND METHODOLOGY**

Energy savings (generation) is to be developed through use of the FEMP ENABLE IGA Tool, which is linked with NREL’s PVWatts tool to calculate the annual electrical generation from the PV system. NREL's PVWattscalculator determines the energy production and cost savings of grid-connected photovoltaic (PV) energy systems by creating hour-by-hour performance simulations that provide estimated monthly and annual energy production in kilowatts and energy value. Users select a geographic location of the PV installation and establish system parameters for size, electric cost, array type, tilt angle, and azimuth angle. Using typical meteorological year weather data for the selected location, the PVWatts calculator determines the solar radiation incident of the PV array and the PV cell temperature for each hour of the year. The DC energy for each hour is calculated from the PV system DC rating and the incident solar radiation and then corrected for the PV cell temperature. The AC energy for each hour is calculated by multiplying the DC energy by the overall DC-to-AC derate factor and adjusting for inverter efficiency as a function of load. Hourly values of AC energy are then summed to calculate monthly and annual AC energy production.

Cost savings will be based on the energy amount of annual electricity generation as calculated by the ENABLE IGA tool multiplied by the electrical rates outlined in Section 2.2.

## Proposed Annual Savings

A detail of baseline usage, post retrofit usage and proposed annual energy and cost savings for this ECM is to be presented with the appendix of the M&V Plan. The ENABLE IGA Tool generates a summary table of this information on the worksheet entitled “Project Summary Table”.

## Post-Installation M&V Activities

Details of post installation and performance period activities for each ECM type are provided in Section 8 of this document.

# Post Installation and Annual M&V

## Post Installation M&V

Upon installation completion, an as-built inventory of post-installation equipment is to be supplied in the Post Installation M&V and Cx report. Savings predictions are to be corrected based on as-built data and also reported in the Post-Installation M&V and Cx Report, which is to be presented in the format as outlined in **Appendix A**.

Lighting

Immediately following installation, fixture power will be measured in a manner identical to that for the baseline fixtures. Sample sizes for measurements and procedures are further described in section 9 (i.e. measurement of fixtures that represent 75% of the connected load within the project scope). Measurement of standard deviations should be calculated in the field to ensure that proper sampling requirements have been satisfied and whether addition samples are required. Any fixture types exceeding a Cv of 0.20 will require that three additional measurements be taken and the fixtures will be inspected to verify that the correct fixtures have been installed. These measurements will be used to calculate actual expected energy savings, and will be detailed in the Post-Installation M&V and Cx Report.

Where lighting controls have been installed, devices are to be verified for proper on and off and/or dimming activation. Occupancy sensors are also to be verified for compliance with intended timing settings.

Water

Immediately following installation, fixture flow will be measured in a manner identical to that for the baseline fixtures. Sample sizes for measurements and procedures are described in Section 9. Measurement standard deviations will be calculated in the field. Any fixture types exceeding a Cv of 0.20 will have three additional measurements taken and the fixtures will be inspected to verify that the correct fixtures have been installed. These measurements will be used to calculate actual expected energy savings, and will be detailed in the Post-Installation M&V and Cx Report.

HVAC Controls

All setpoints and control strategies for each control device/system installed are to be reviewed in detail. Where applicable data points, such as outside air temperature, return air temperature, mixed air temperature, supply air temperature, zone temperature, equipment status, and CO2 levels, are to be reviewed for reasonableness. If the control systems do not meet intended performance specifications or the system fails to perform as specified in the Final Proposal, necessary adjustments will be made to the system or the savings calculations will be modified. This will be reported in the Post-Installation M&V and Cx Report.

HVAC Equipment

All equipment performance parameters of the installed system(s) are to be verified against values originally utilized within IGA tool for generation of energy and cost savings. All setpoints and control strategies for each control device/system installed are to be reviewed in detail. Where applicable data points, such as outside air temperature, return air temperature, mixed air temperature, supply air temperature, zone temperature, equipment status, ventilation rate, and CO2 levels, are to be measured and reviewed for reasonableness with values utilized within the IGA tool. If the equipment and control systems do not meet intended performance specifications or the system fails to perform as specified in the Final Proposal, necessary adjustments will be made to the system or the savings calculations will be modified. This will be reported in the Post-Installation M&V and Cx Report.

Solar PV

After installation and functional testing of the PV system, a measurement of instantaneous system power output it to be made and compared against the expected system power output for the given operating conditions at the time of measurement. The PV system should have a instantaneous power output of +/- 5% of the expected power output as dictated by the design parameters and measured field conditions. The ENABLE IGA tool provides a calculator for completing this component of M&V. Verifying instantaneous output power for a PV system requires three readings: inverter output power (W), cell temperature of a module in the array (oC), and irradiance in the plane of the array (W/m2). These measurements should be taken under the same ambient conditions, ideally at the same time. In addition, system derate factors and the module’s temperature coefficient of maximum power (%/oC) are required. A system derate factor calculator is provided within the ENABLE IGA tool as part of the instantaneous output calculator. The module’s temperature coefficient of maximum power should be obtained from the module manufactures specification sheet for the product installed. The results of the instantaneous system output measurement will be reported in the Post-Installation M&V and Cx Report.

## Annual M&V Activity and Reporting

Annual M&V Audit

Once per year the ESCO will perform a site visit, or the agency/site technical staff will perform a simple audit, during which the ECMs will be inspected to verify proper operation, ensure that that they have been maintained and that they continue to have the potential to generate the expected savings.

***Solar PV installations:*** The new photovoltaic generation is to be metered and totaled on an annual basis to determine the amount of verified energy savings. It is recommended that the metered data be stored in no less than hourly increments. In projects where the agency is to assume the annual M&V audit responsibilities, it is recommended that the ESCO and Agency consider the inclusion of an annual service agreement for the PV system through the installing contractor or a local PV resource. A typical scope of services should include cleaning of the array, inspection of all connections, roof penetrations, racking system, grounding, and lighting arrestors, inspection and securing of cabling and cleaning of the inverter. Timing of the annual service inspection of the PV system should ideally coincide with the agency’s annual M&V audit.

Annual M&V Checklist

The ESCO is to generate an annual M&V checklist for use during the annual M&V audit. Where the agency is performing the annual M&V audit of the site, the ESCO is to provide the agency with the annual M&V checklist at least 30 days prior to the end of that year’s performance period. The agency is to utilize the checklist for performance of the annual M&V activity and return the completed checklist to the ESCO for incorporation into the Annual M&V Report.

***Guidance on Checklist Development:*** An example of an M&V Checklist template can be found in Attachment 2. An editable version of the checklist can be found in the IGA tool in the worksheet entitle “Annual M&V - Checklist”. The checklist should be developed to consist of a sampling of each type of retrofit equipment across the project (i.e. each retrofit code as utilized within the IGA tool). The sampling approach should be based on the following table:

**Table 2:** ECM Sampling Requirements for Annual M&V Checklist

|  |  |  |
| --- | --- | --- |
| **ECM** | **Percentage of installations to be Sampled** | **Maximum sample** |
| Lighting | Select IGA line items (room locations) that represent ~10% of the connected load for the project scope, rotate line item selection annually.  Controls: 10% of all lighting controls (room locations), rotate line item selection annually | For a minimum of 3 fixtures at each room/area location identified, open units to verify lamp counts and lamp and ballast types.  Controls: All units listed |
| Water | 10% of IGA line items | All units listed |
| HVAC Controls | 100% | All units listed |
| HVAC Equipment | 100% | All units listed |
| Solar PV | 100% | All installations listed |

Annual M&V Report

The annual M&V report will detail the results of annual inspections, noting any significant problems. An estimate of energy and cost savings for the year will be provided. The Agency/site is responsible for the consistency of operating hours or usage and equipment replacement with identical or comparable equipment. Changes in equipment type, operating hours or usage will not result in adjustments to the reported (guaranteed) savings. The annual M&V report will be submitted in a format as outlined in **Appendix B**.

# M&V Sampling

The following section summarizes key topics in the area of M&V sampling requirements for ENABLE projects. The sampling approach is derived from FEMP’s *“M&V Guidelines: Measure and Verification for Federal Energy Projects, v3.0, Appendix B”,* which contains further detailed information on sampling methodology and mathematical methods.

## Overview of Point Estimation – Confidence and Precision

When we use sampling to estimate an average value of an entire population, we are performing an activity know as *point estimation.* A value or ‘point’ that is estimated based on a sample is not the actual average value but rather, is a value that is “reasonably close” to the actual average value. The question, then, for the M&V practitioner is: “What do we mean when we say ‘reasonably close’?” The question is answered using the following statistical terms.

* Confidence: Confidence is fundamentally the same as probability, except that confidence refers to data already obtained, while probability refers to a future value. A confidence of 80% is utilized within ESPC ENABLE projects. So, using our 80% example, when we refer to a confidence level, we are saying, “We are 80% *confident* that the measured value is within the stated *confidence interval*.”
* Confidence Interval (or Precision): Because the value estimated by sampling cannot be expected to be the actual value, it is useful to state an interval in which we have confidence the true value lies. Confidence interval is also often referred to as *precision*. An M&V practitioner may state that they know the value has a *precision* of 20%, which would mean that the “The estimated is within 20% of the true value.” Confidence and precision, then, are the values referred to when a 80/20 criteria is specified.

## Sample Size

The Table 3 illustrates the sample size requirements for a given population size for a given coefficient of variation (Cv) assumption. Coefficient of variation is a statistical term representing the normalized measure of dispersion of a probability distribution as illustrated in Figure 1 below. For ENABLE projects involving measurements of lighting wattage and water fixture consumption/flow rate a Cv value of 0.5 is utilized for pre-retrofit conditions, while post retro-fit conditions will utilize a Cv value of 0.2. Figure 1 illustrates the differences between two populations with the same mean value but very different distributions.

Lighting

The ESCO is to utilize Table 3 to determine the sampling requirements for each unique pre or post retrofit code as utilized within the IGA tool that represent 75% of the connected load within the project scope

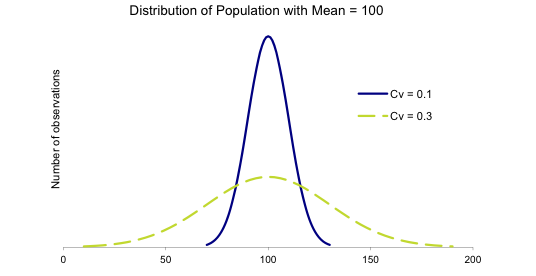
Water

The ESCO is to utilize Table 3 to determine the sampling requirements for each unique pre or post retrofit code for domestic sanitary fixtures as utilized within the IGA tool.

**Table 3: M&V Sample size requirements**

|  |  |  |
| --- | --- | --- |
| **Sample Size Requirements  Based on Population Size** | | |
| **Precision** | 20% | |
| **Confidence** | 80% | |
| **Z-Statistic** | 1.282 | |
| **Assumed Cv** | **0.5** | **0.2** |
| **M&V stage** | **pre-retrofit** | **post-retrofit** |
| **Population Size** | **Sample Size** | |
| 4 | **3** | **2** |
| 8 | **5** | **2** |
| 12 | **6** | **2** |
| 16 | **7** | **2** |
| 20 | **7** | **2** |
| 25 | **8** | **2** |
| 30 | **8** | **2** |
| 35 | **8** | **2** |
| 40 | **9** | **2** |
| 45 | **9** | **2** |
| 50 | **9** | **2** |
| 60 | **9** | **2** |
| 70 | **9** | **2** |
| 90 | **10** | **2** |
| 100 | **10** | **2** |
| 125 | **10** | **2** |
| 200 | **10** | **2** |
| 300 | **10** | **2** |
| 400 | **11** | **2** |
| 500 | **11** | **2** |
| Infinite | **11** | **2** |

**Figure 1:** Plot of Two Populations with same mean, but different distributions



**9.2.1 COLLECTION AND ANALYSIS OF SAMPLE DATA**

Sampling data is to be added to the ENABLE IGA tool for each pre or post retrofit code listed in the lighting or water equipment master lists. After sampling has been completed, the values collected can be analyzed for compliance with the sampling requirements by utilizing the M&V Sampling Tool worksheet contained within the IGA tool. The sampling tool will assist in calculating the mean, standard deviation and Cv of the collected data for each group. If the actual Cv is equal to or less than the Cv originally assumed to calculate the sample size, then the confidence interval will have been met. (Worksheet will indicate acceptable results with “green” cell formatting). The sampling tool will also calculate the maximum error and confidence interval (precision) at the selected confidence level. The confidence interval is then either accepted (“green” cell formatting) or, if it is too large (“red” cell formatting), additional sampling (and possible sampling redesign) may be required.

**9.2.2 EXTRAPOLATE THE RESULT FROM THE SAMPLE OVER THE ENTIRE POPULATION**

Once the sampling data is verified as complying with the 80/20 criteria, then the mean values as calculated in the FEMP IGA Tool Equipment Master Lists are suitable for use in calculation of the pre-retrofit baseline and post-retrofit energy and water consumption values.

# Appendix A - Post Installation M&V and Cx Report Outline

**POST-INSTALLATION M&V AND Cx REPORT OUTLINE**

**1. EXECUTIVE SUMMARY**

* 1. **Project Overview**

Provide an overview of project background, including:

A. Contract #, Project Name/Site(s) within project scope

B. Provide an overview what was done and how savings are generated.

C. Note any changes in project scope between the final proposal (including any relevant contract modifications) and as-built conditions.

**1.2 Proposed & Expected Year 1 Energy & Cost Savings**

A. Summarize information in Table 1 and 2

B.Compare expected savings for first performance year to first year guaranteed cost savings. State whether guarantee is expected to be fulfilled for first year, if not provide detailed explanation

**Table 1 - Proposed Annual Savings Overview**

[Include all applicable fuels/commodities for project, e.g., electric energy, electric demand, natural gas, fuel oil, coal, water, etc. Add or remove columns as needed]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ECM** | **Total energy savings (MBtu/yr)** | **Electric energy savings (kWh/yr)** | **Electric demand savings (kW/yr)\*** | **Natural gas savings (MBtu/yr)\*\*** | **Water savings (gal/yr)** | **Total energy and water cost savings, Year 1 ($/yr)** | **O&M cost savings, Year 1 ($/yr)** | **Total cost savings, Year 1 ($/yr)** |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Total savings |  |  |  |  |  |  |  |  |
| First Year Guaranteed Savings: $ | | | | | | | | |
| **Notes**  **MBtu=106 Btu.**  \*Annual electric demand savings (kW/yr) is the sum of the monthly demand savings.  \*\*If energy is reported in units other than MBtu, provide a conversion factor to MBtu for link to cost schedules (e.g., 0.003413 MBtu/kWh). | | | | | | | | |

**Table 2 - Expected Savings Overview for 1st Performance Year**

[Include all applicable fuels/commodities for project, e.g., electric energy, electric demand, natural gas, fuel oil, coal, water, etc. Add or remove columns as needed]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ECM** | **Total energy savings (MBtu/yr)** | **Electric energy savings (kWh/yr)** | **Electric demand savings (kW/yr)\*** | **Natural gas savings (MBtu/yr)\*\*** | **Water savings (gal/yr)** | **Total energy and water cost savings, Year 1 ($/yr)** | **O&M cost savings, Year 1 ($/yr)** | **Total cost savings, Year 1 ($/yr)** |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Total savings |  |  |  |  |  |  |  |  |
| **Notes**  **MBtu=106 Btu.**  \*Annual electric demand savings (kW/yr) is the sum of the monthly demand savings.  \*\*If energy is reported in units other than MBtu, provide a conversion factor to MBtu for link to cost schedules (e.g., 0.003413 MBtu/kWh). | | | | | | | | |

Note: The proposed savings for each ECM are included in TO-4 of the contract.

Expected savings are prediction for first year based on post-installation M&V activities. Verified savings for first year of post-acceptance performance period will be documented in annual report.

**1.4 Savings Adjustments**

A. Provide summary of any energy and/or cost savings adjustments required between final proposal (including any relevant contract modifications) and as-built conditions.

B. Describe the impact in changes between the final proposal (including any relevant contract modifications) and as-built conditions based on post-installation M&V results.

**1.5 Status of Rebates** [Include if applicable]

Provide a summary of the source and status of any third-party rebates or incentives provided on this project.

**2. ECM-SPECIFIC M&V AND COMMISSIONING ACTIVITIES** [Develop section for each ECM.]

**2.1 [ECM #1 Title]**

**2.1.1 Post-Installation M&V Activities Conducted**

Detail measurements, monitoring, and inspections conducted in accordance with M&V plan (include all that apply for each one):

A. Details to confirm adherence to sampling plan. Include all post-installation measured values. (Use appendix and electronic format as necessary, including M&V Sampling Tool worksheets from IGA Tool).

B. Describe how performance criteria have been met.

E. Detail any performance deficiencies that need to be addressed by ESCO or agency.

F. Note impact of performance deficiencies or enhancements on generation of savings.

G. Details of any baseline or savings adjustments made

**2.2.2 Commissioning Activities Conducted**

Provide an overview of commissioning scope, general description of testing & verification methods and summary of findings and conclusions. For each system report on:

1. Functional performance. Completed functional performance test documentation to be provided as an appendix
2. Outstanding, non-compliant or unresolved issues. A detailed list of all issues, including reference to the specific test, inspection, etc. where the deficiency is documented should be provided as an appendix.

C. Operator Training

# Appendix B - Annual M&V Checklist Template Example

Excel base versions of checklists for each ECM type can be found in the ENABLE IGA tool. The following is a checklist template for lighting measures.



# Appendix C - Annual M&V Report Outline

**ANNUAL MEASUREMENT AND VERIFICATION REPORT OUTLINE**

**Contract #/Task Order #/Task #:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (*include as appropriate*):

**Post-Acceptance Performance Period Dates Covered:** \_\_\_\_\_\_\_\_\_\_\_to\_\_\_\_\_\_\_\_\_\_\_\_\_

**Contract year #:** \_\_\_\_\_ of \_\_\_\_\_\_\_ (*enter current reporting year and total years of*

**1 EXECUTIVE SUMMARY**

* 1. **Project Overview**

Provide an overview of project background, including:

1. Contract #, Project Name/Site(s) within project scope
2. Project Acceptance Date

C. Provide an overview what was done and how savings are generated (Brief ECM descriptions).

**1.2 Summary of proposed and verified energy and cost savings.** Compare verified savings for Performance Year # to Guaranteed Cost Savings for Year #. State whether guarantee is fulfilled for year. If not, provide detailed explanation.

A. Summarize Tables 1, 2.

**Table 1 - Proposed Annual Savings Overview**

[Include all applicable fuels/commodities for project, e.g., electric energy, electric demand, natural gas, fuel oil, coal, water, etc.]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ECM** | **Total energy savings (MBtu/yr)** | **Electric energy savings (kWh/yr)** | **Electric demand savings (kW/yr)\*** | **Natural gas savings (MBtu/yr)\*\*** | **Water savings (gallons/yr)** | **Total energy and water cost savings, Year # ($/yr)** | **O&M cost savings, Year # ($/yr)** | **Total cost savings, Year # ($/yr)** |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Total Savings |  |  |  |  |  |  |  |  |
| **Notes**  **MBtu=106 Btu.**  \*Annual electric demand savings (kW/yr) is the sum of the monthly demand savings.  \*\*If energy is reported in units other than MBtu, provide a conversion factor to MBtu for link to cost schedules (e.g., 0.003413 MBtu/kWh). | | | | | | | | |

**Table 2 - Verified Savings for Performance Year #**

[Include all applicable fuels/commodities for project, e.g., electric energy, electric demand, natural gas, fuel oil, coal, water, etc.]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ECM** | **Total energy savings (MBtu/yr)** | **Electric energy savings (kWh/yr)** | **Electric demand savings (kW/yr)\*** | **Natural gas savings (MBtu/yr)\*\*** | **Water savings (gallons/yr)** | **Total energy and water cost savings, Year # ($/yr)** | **O&M cost savings, Year # ($/yr)** | **Total cost savings, Year # ($/yr)** |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| Total Savings |  |  |  |  |  |  |  |  |
| Notes  MBtu = 106 Btu.  \*Annual electric demand savings (kW/yr) is the sum of the monthly demand savings.  \*\*If energy is reported in units other than MBtu, provide a conversion factor to MBtu for link to cost schedules (e.g., 0.003413 MBtu/kWh). | | | | | | | | |

**Table 3. Verified Savings for Post-Acceptance Performance Period to Date**

[Include all applicable fuels/commodities for project, e.g., electric energy, electric demand, natural gas, fuel oil, coal, water, etc.]

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year #** | **Total energy savings (MBtu/yr)** | **Electric energy savings (kWh/yr)** | **Electric demand savings (kW/yr)\*** | **Natural gas savings (MBtu/yr)\*\*** | **Water savings (gallons/yr)** | **Total energy and water cost savings, Year # ($/yr)** | **O&M cost savings, Year # ($/yr)** | **Total cost savings, Year # ($/yr)** | **Guaranteed cost savings for year** |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Total savings |  |  |  |  |  |  |  |  |  |
| **Notes**  MBtu = 106 Btu.  \*Annual electric demand savings (kW/yr) is the sum of the monthly demand savings.  \*\*If energy is reported in units other than MBtu, provide a conversion factor to MBtu for link to cost schedules (e.g., 0.003413 MBtu/kWh). | | | | | | | | | |

[Table 4 is to summarize the variance to guaranteed savings as verified per the M&V plan and Risk and Responsibility Matrix as well as an estimated net variance to the guarantee when including impacts to cost savings due to government actions that are outside the ESCO’s responsibility. Government impacts to savings may include, but are not limited to operational hours changes, heating/cooling set point changes and/or physical changes or removal of equipment.]

**Table 4. Summary of Cost Savings Impact Due to Performance and O&M Issues**

|  |  |  |  |
| --- | --- | --- | --- |
| I. Per M&V Plan and RRPM Matrix | **Energy (MMBtu)** | **($)** | Responsibility |
| a. Proposed Cost Savings [from Table E-1] |  |  | ESCO |
| b. Verified Cost Savings [from Table E-2] |  |  | ESCO |
| c. Guaranteed Cost Savings [from Table E-2] | N/A |  | ESCO |
| d. Variance to Guarantee (b. - c.) | N/A |  | ESCO |
|  | | | |
| II. Estimated Government Impact to Savings | **Energy (MMBtu)** | ($) | Responsibility |
| e. Government Impact on ECMs (Estimated change to energy/cost savings, express losses as negative, increases as positive) |  |  | Government |
| f. Net Energy/Cost Savings to Government (b. + e.) |  |  |  |
| g. Net Variance (f. - c.) | N/A |  |  |

**1.4 Performance and O&M Issues**

A. Note impact of operating deficiencies or enhancements on generation of savings.

B. Note impact of maintenance deficiencies on generation of savings.

C. Detail any deficiencies to be addressed by contractor or agency

**Table 5: Detail of Cost Savings Impact due to Performance and O&M Issues**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ECM # | Impact to Energy Savings (MMBtu) | Impact to Cost Savings ($) | ECM Location | Cause of Savings Impact | Responsibility  (ESCO/Government) |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

**2 ECM Specific Activities** [*Develop section for each ECM.*]

**2.1 [ECM #1 Title]**

**2.1.1 M&V Activities Conducted This Period**

Detail inspections conducted this reporting period in accordance with M&V plan (include all that apply for each one):

A. Dates of inspections, names of personnel, and documentation of Government witnessing (if applicable)

B. Describe how performance criteria have been met. (Include M&V Checklist as Appendix)

C. Additional detail of operating or maintenance deficiencies as outlined in section 1.4 (if needed).

1. FEMP M&V Guidelines and information are available at <https://www.energy.gov/femp/measurement-and-verification-federal-energy-savings-performance-contracts>. [↑](#footnote-ref-1)
2. 08 ESPC ENABLE M&V Plan Template available at: <http://energy.gov/sites/prod/files/2014/03/f10/enable_mvtemplate.docx> [↑](#footnote-ref-2)
3. EERC tool available at: <http://www1.eere.energy.gov/femp/information/download_blcc.html#eerc> [↑](#footnote-ref-3)
4. Based on Renewable Energy Project guidance found in FEMP M&V Guideline V 3.0, section 11.8 available at:  [http://www1.eere.energy.gov/femp/pdfs/mv\_guidelines.pdf](C:\\Users\\pvoss\\Downloads\\ http:\\www1.eere.energy.gov\\femp\\pdfs\\mv_guidelines.pdf) [↑](#footnote-ref-4)