**U.s. Energy Department**

**Federal Energy Management Program**

**ESPC ENABLE Measurement and Verification plan Template**

February 2014, version 4.0

***PLEASE READ THIS GUIDE BEFORE USING THE MEASUREMENT AND VERIFICATION PLAN TEMPLATE***

**ESPC ENABLE Measurement and Verification Plan Guide**

Introduction: This document is a comprehensive measurement and verification (M&V) plan template for a proposed ESPC ENABLE project. This document is intended to serve the following purposes:

* Provide a foundation for an M&V plan for lighting; water; heating, ventilation, and cooling (HVAC) controls; HVAC equipment; and solar photovoltaic (PV) system retrofits utilizing a “best practice” approach, which considers risk allocation, engineering accuracy, and cost-effectiveness. This document constitutes a base that must be customized for individual applications.
* Reduce development and review times on individual projects.
* Provide M&V plans for ESPC ENABLE program ECMs that are in alignment with the requirements set forth in the FEMP ESPC ENABLE M&V Protocol and FEMP M&V guidelines, Version 3.0[[1]](#footnote-1)
* Provide and promote use of a consistent format for M&V Plans for Federal ESPC ENABLE projects

This document contains M&V plans for 5 measures using Option A at a fictitious federal office building. The ECMs include:

* Lighting improvements measure – Option A
* Water conservation measure – Option A
* Simple HVAC controls – Option A
* HVAC Equipment – Option A
* Solar PV – Option B

**Instructions:** The M&V approach outlined herein contains many specific parameters. The prescribed methodologies were developed with consideration for technical accuracy, cost effectiveness, and appropriate risk allocation. The M&V Template begins on page 3 of this document. Please remove this guide, pages 1-2, before using this template.

This draft plan is intended to be used as a starting point, and must be customized for each project. Portions of the plan contain suggested text as indicated by red font and may require modification. Please review the suggested text to ensure that it meets your agency specific requirements and project goals when using the suggested text in your M&V Plan. [Red font with brackets] **indicates** **text that must be modified to reflect ESCO, agency- or project-specific information.**

In general the sample text provided should be reviewed to ensure that it is applicable to the project. In some locations, instructional text boxes are included to provide additional guidance. Text boxes may remain in the M&V plan or be removed at the ESCO’s or agency’s discretion. You should be sure to reformat this document to fit your particular agency’s formatting requirements for procurement documents.

Measurement and Verification Plan Template

for the [Insert Project or Site Name]

(Please format this document using agency-appropriate formatting for construction and procurement documents)

Provided in fulfillment of ENABLE ESPC requirements,

Task Order Number [Insert project TO Number]

By

[ESCO Name]

[Insert Date]

Project Contact Information

|  |  |  |
| --- | --- | --- |
| Name | [ESCO Contact Name] | [Agency Contact Name] |
| Title | [Title] | [Title] |
| Organization | [ESCO Name] | [Agency Name] |
| Address 1 | [Address 1] | [Address 1] |
| Address 2 | [Address 2] | [Address 2] |
| City, State, Zip | [City, State, Zip] | [City, State, Zip] |
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# m&v Overview

## M&V Plan Summary

[ESCO Name] will perform measurement and verification (M&V) activities for each of the five ECMs in accordance with the ESPC ENABLE Program M&V Protocol v4.0[[2]](#footnote-2) in order to estimate the actual cost savings achieved in the project. The M&V plans for the five ECMs are described in Sections 3 through 7 of this document, and are summarized in Table 1-3.

**Table 1-1: M&V Plan Summary**

*(remove ECM summaries not associated with scope of project, remove this note)*

|  |  |  |
| --- | --- | --- |
| **ECM &**  **M&V option** | **Summary of M&V plan** | |
| **Lighting:**  **M&V Option:** A | Key Parameters | Lighting fixture power consumption, operating hours, lighting levels. |
| Baseline | Measure a sample of fixture wattages in accordance with the ENABLE M&V Protocol. Determine operating hours through facility interviews and investigations. Baseline shall be generated using FEMP ENABLE IGA Tool |
| Post- Installation | Measure a sample of fixture wattages in accordance with the ENABLE M&V Protocol. Operating hours remain the same as baseline, except for adjustment due to implementation of lighting controls. Lighting controls (if applicable) are to be verified for on/off and/or dimming capability and timing. |
| Performance Period | Annual visual inspection of a sample set of lighting fixtures and controls (if applicable) in selected facilities to ensure the integrity of the fixtures and controls (if applicable) and confirm that the ECM still has the potential to perform as specified. |
| **Water:**  **M&V Option:** A | Key Parameters | Fixture flow rate (gallons per minute or gallons per flush), occupant use profiles provided in FEMP ENABLE IGA Tool |
| Baseline | Measure a sample of fixture flow rates in accordance with the ENABLE M&V Protocol. Fixture use profiles are based upon U.S. Green Building Council and are defined in the FEMP ENABLE IGA Tool. Baseline shall be generated using FEMP ENABLE IGA Tool. |
| Post- Installation | Measure a sample of fixture flow rates in accordance with the ENABLE M&V Protocol. |
| Performance Period | Annual inspection of a sample set of the retrofitted fixtures in selected facilities to ensure the integrity of the fixtures and confirm that the ECM still has the potential to perform |
| **Simple HVAC Controls:**  **M&V Option:** A | Key Parameters | System efficiency, building parameters, current and proposed operating schedules |
| Baseline | Observations of schedules and set points, spot measurements of temperatures, [and/or other method] and reported operation from facility staff was used to establish baseline operation and conditions of HVAC equipment. Baseline shall be generated using FEMP ENABLE IGA Tool |
| Post- Installation | Verify that proposed equipment and strategy has been implemented and is operating as intended. Post installation savings is determined from the same baseline model modified for the approved schedules, set points, and design outdoor airflows. |
| Performance Period | Annual on‐site inspections of HVAC controls and equipment for ongoing verification that energy control strategies are in place and sustainable. |

|  |  |  |
| --- | --- | --- |
| **HVAC Equipment:**  **M&V Option:** A | Key Parameters | System efficiency, building parameters, current and proposed operating schedules |
| Baseline | Observations of schedules and set points, spot measurements of temperatures, [and/or other method] and reported operation from facility staff was used to establish baseline operation and conditions of HVAC equipment. Baseline shall be generated using FEMP ENABLE IGA Tool |
| Post- Installation | Verify that proposed equipment and has been implemented and is operating as intended. Post installation savings is determined from the same baseline model modified for the new equipment and approved schedules, set points, and design outdoor airflows. |
| Performance Period | Annual on‐site inspections of HVAC equipment and controls for ongoing verification that equipment is operational and that energy control strategies are in place and that performance is sustainable. |
| **Solar PV:**  **M&V Option:** B | Key Parameters | System name plate DC rating, array tilt, array azimuth, DC to AC conversion efficiency, hours and intensity of solar radiation, annual kwh generation |
| Baseline | Baseline electrical energy is equivalent to the portion of the facility electrical load to be offset by the PV system electrical generation. PV system generation shall be calculated using the FEMP ENABLE IGA Tool, which is linked with the NREL PVWatts tool. |
| Post- Installation | Verify that proposed PV system has been implemented and is operating as intended. Instantaneous array performance to be compared against designed system output through measurement of solar insolation, module temperature and inverter output. Post installation savings is determined from the same baseline calculation modified for the as-built condition of the PV system |
| Performance Period | Annual on‐site inspections of PV equipment for ongoing verification that system is in place, operational and that guaranteed electrical generation is sustainable. Energy generation is continuously metered by the PV system’s revenue grade meter. All metered generation is reported as verified savings. |

# Whole Project Data / Global Assumptions

## Energy and Water Rate Data

Table 2-1 lists the utility rates that are to be utilized with the FEMP IGA tool for calculation of the baseline energy costs and retrofit cost savings of the equipment within the scope of the proposed project.

Table 2‑1: Rate Schedule

|  |  |  |  |
| --- | --- | --- | --- |
| **Site: [Site Name #1]** | | | |
| **Utility Type** | **Utility Provider** | **Utility Unit Cost** | **Unit** |
| Electricity | [ABC Electric] | $0.00 | $/kWh |
| Electricity Demand | [ABC Electric] | $0.00 | $/kW |
| Natural Gas | [ABC Gas] | $0.00 | $/Therm |
| Fuel Oil #2 | [ABC Oil] | $0.00 | $/gallon |
| Propane | [ABC Propane] | $0.00 | $/gallon |
| Water | [ABC Water] | $0.00 | $/kGal |
| Sewer | [ABC Water] | $0.00 | $/kGal |

(*Duplicate tables as needed for multiple sites, eliminate utility types where not applicable*)

Energy costs used to determine the value of the energy savings are based on the rates that the facility is paying as of [Insert date utility rate baselines were established]. The energy rates will be escalated to account both for inflation and for changes to the real 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. *Table 2.2* shows the escalation rates that were determined using the EERC. Future escalation rates for the cost of water will be escalated by 3% annually. If energy prices increase at a greater rate, then the agency will realize more savings than will be claimed. The agency also needs to realize that in the unlikely event that energy prices do not increase as predicted, the energy saved will still be valued at these rates.

Table 2‑2: Projected Fuel Price Indices

|  |  |  |  |
| --- | --- | --- | --- |
| **Electricity** | **Fuel Oil** | **Natural Gas** | **Water** |
| 0.00 | 0.00 | 0.00 | 3.00 |

## Schedule and Reporting for Verification Activities

Table 2‑3: Schedule of Verification Reporting Activities

|  |  |  |
| --- | --- | --- |
| **Item** | **Time of submission** | **Agency’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 role) | 30 days |

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



## Overview of M&V Plan

The M&V plan for the lighting efficiency retrofit at the [Agency/site] will follow FEMP M&V Option A. The Option A approach will be used to quantify energy consumption savings associated with the lighting equipment upgrades and annual verify that the measure continues to operate and perform as specified in the Final Proposal.

The M&V Plan for this retrofit assumes:

1. Lighting operating hours will be established before the retrofit. Pre and post retrofit operating hours are the same the purpose of energy savings calculations, with the exception of adjustments for the implementation of lighting controls measures.
2. Fixture powers before and after the retrofit will be measured.
3. Interactive effects on heating and cooling equipment from the lighting retrofit will be considered.
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)
5. An annual verification of the measure will be performed to document that equipment as specified in the Final Proposal remains in place.

## Overview of Savings Calculations

### **Energy Baseline Development**

The baseline energy consumption was documented through accurate accounting of all existing lighting equipment within the scope of the project during the IGA, which took place during [Insert date of IGA]. A room-by-room inventory of fixture counts, types, and circuits was made. Fixture powers were measured based on a sample of the most common fixture types. For less common fixture types, fixture power will be based on manufacturer’s data. A list of the inventory of all audited lighting equipment is provided in the appendices.

### Fixture Power

During the lighting survey samples of the most common fixture types were measured to determine the fixture power under actual operating conditions. The measured fixture types represent more than 75% of the baseline-connected load. For the remaining fixture types that were not measured, fixture powers were taken from manufacturers’ specifications. The measurement parameters were based on the sample size methodology in the ENABLE M&V Protocol vP-3. The measurement results can be found in Table A1-1 in 08 Appendix A- Supporting M&V Data.

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 in accordance with the ENABLE M&V Protocol vP-3. For the remaining fixture types that are not measured, fixture powers will be taken from manufacturers’ specifications.

### Usage Group Operating Hours

Typical lighting hours for facility spaces were obtained in interviews of [Agency/site] staff, categorized in “usage groups” and input into the FEMP IGA lighting tool. Each of the room-by-room equipment entries within the 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. The Usage Group Codes utilized in the IGA tool can be found in Table A1-2 in 08 Appendix A- Supporting M&V Data.

### **Energy Savings Calculations and Methodology**

After completion of the field survey [ESCO name] compiled the audit data, field measurements and operating hours data. Utilizing the FEMP ENABLE IGA Tool, details of existing fixture types, quantities, wattages and operating hours were generated. Based on [ESCO name] retrofit strategy, proposed retrofit equipment is applied against the room-by-room equipment entries within the IGA tool. The IGA tool then calculates the energy and cost savings by comparing the baseline and post installation energy consumption at the designated energy rate with additional calculations for interactive HVAC savings and electric demand cost savings where applicable.

## Proposed Annual Savings for ECM

A table detailing the baseline usage, post retrofit usage and proposed annual energy and cost savings for this ECM can be found in Table A1-3 in 08 Appendix A- Supporting M&V Data.

## Post Installation and Performance Period Activities

Details of post installation and performance period activities are provide in Section 8 of this plan.

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

## Overview of M&V Plan

The M&V Plan for the water conservation upgrades at the [Agency/site] will follow FEMP M&V Option A. The Option A approach will be used to quantify the water and energy consumption savings associated with the water fixture upgrades and annual verify that the measure continues to operate and perform as specified in the Final Proposal.

The M&V plan for this retrofit assumes:

* 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.
* An annual verification of the measure will be performed to document that equipment as specified in the Final Proposal remains in place.

## Overview of Savings Calculations

### **Energy Baseline Development**

The baseline water consumption was documented through accurate accounting of all existing water fixtures within the scope of the project during an IGA, which tool place during [Insert date of IGA]. A room-by-room inventory of fixture counts and types was made. Fixture water flow rate was measured based on a sample of the most common fixture types. For less common fixture types, fixture water flow rate will be based on manufacturer’s data. A list of the inventory of all audited lighting equipment is provided in the appendices.

### Fixture Flow Rate

During the sanitary plumbing system survey, fixture types present in this facility were identified and baseline water flow was measured for a sample of each fixture type proposed for retrofit. The measurement parameters were based on the sample size methodology in the ENABLE M&V Protocol vP-3. The measurement results can be found in Table A2-1 in 08 Appendix A- Supporting M&V Data.

When the fixtures are replaced, flow rate measurements will again be taken on a sample of each fixture type in accordance with the ENABLE M&V Protocol vP-3.

### 

### Usage Profiles

Water usage profiles (i.e. how many times an occupant would utilize a water based fixture per day) are defined within the FEMP 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 was collected through interviews with facility managers and other site personnel of [Agency/site]. The FEMP audit tool utilizes occupancy data in combination with the usage profiles to calculate baseline usage and resulting water and energy savings. The occupancy and usage profiles will be held constant during the performance period. The usage profiles utilized by the IGA tool can be found in Table A2-2 in 08 Appendix A- Supporting M&V Data.

### **Energy and Water Savings Calculations and Methodology**

After completion of site IGA, [ESCO Name] compiled the audit and field measurements data. Utilizing the FEMP ENABLE IGA tool, details of existing fixture types, quantities and flow rates were generated. Based on [ESCO name] retrofit strategy, proposed retrofit equipment is applied against the room-by-room equipment entries within the IGA tool. The IGA tool then calculates the water, energy and cost savings by comparing the baseline and post installation energy consumption at the designated energy rate The FEMP audit tool also accounts for energy cost savings associated with the reduction in heating of domestic hot water by multiplying appropriate portions of the flow rate reductions for hot water consuming fixtures by an established hot water usage schedule and then by the approved energy costs.

## Proposed Annual Savings for ECM

A table detailing the baseline usage, post retrofit usage and proposed annual water and energy savings for this ECM can be found in Table A2-3 in 08 Appendix A- Supporting M&V Data.

## Post Installation and Performance Period Activities

Details of post installation and performance period activities are provide in Section 8 of this plan.

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

## Overview M&V Plan

The M&V Plan for the HVAC upgrades at the [Agency/site] 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 annually verify that the measure continues to operate and perform as specified in the Final Proposal.

The M&V plan 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.

## Overview of Savings Calculations

### **Energy Baseline Development**

The baseline energy consumption was established through collection of baseline data parameters including:

* Existing space temperatures, set points and schedules
* Building geometry and envelope detail
* Efficiency of existing heating and cooling equipment
* Occupancy hours, number of occupants and operating hours of equipment
* Outside air ventilation levels
* Identified operating issues and problems (from facility personnel)

The data collected is used within the FEMP ENABLE IGA Tool to generate baseline energy consumption for the HVAC equipment. A list of key input parameters for the IGA tool is found in table A3-1 in 08 Appendix A- Supporting M&V Data.

### **Energy Savings Calculations and Methodology**

After completion of the field survey [ESCO name] compiled the audit data into the FEMP IGA tool. The HVAC Controls portion of the audit tool utilizes EnergyPlus, an hourly building simulation model to generate baseline and post-retrofit models of the facilities energy use. 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. Based on [ESCO name]’s retrofit approach and agency input, a proposed control strategy is applied within the IGA tool. The IGA tool creates two models of the building’s energy use (pre and post retrofit), 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.

## Proposed Annual Savings for ECM

A table detailing the baseline usage, post retrofit usage and proposed annual energy savings for this ECM can be found in Table A3-2 in 08 Appendix A- Supporting M&V Data.

## Post Installation and Performance Period Activities

Details of post installation and performance period activities are provide in Section 8 of this plan.

# ECM 4 — HVAC EQUIPMENT M&V PLAN AND SAVINGS CALCULATION METHODS

## Overview M&V Plan

The M&V Plan for the HVAC equipment replacement at the [Agency/site] 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 annually verify that the measure continues to operate and perform as specified in the Final Proposal.

The M&V plan 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 equipment and control strategies are as specified in the Final Proposal.

## Overview of Savings Calculations

### **Energy Baseline Development**

The baseline energy consumption was established through collection of baseline data parameters including:

* Existing space temperatures, set points and schedules
* Building geometry and envelope detail
* Efficiency of existing heating and cooling equipment
* Occupancy hours, number of occupants and operating hours of equipment
* Outside air ventilation levels
* Identified operating issues and problems (from facility personnel)

The data collected is used within the FEMP ENABLE IGA Tool to generate baseline energy consumption for the HVAC equipment. A list of key input parameters for the IGA tool is found in table A4-1 in 08 Appendix A- Supporting M&V Data.

### **Energy Savings Calculations and Methodology**

After completion of the field survey [ESCO name] compiled the audit data into the FEMP IGA tool. The HVAC component of the audit tool utilizes EnergyPlus, an hourly building simulation model to generate baseline and post-retrofit models of the facilities energy use. 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. Based on [ESCO name]’s retrofit approach and agency input, a proposed equipment retrofit and modified control strategy is applied within the IGA tool. The IGA tool creates two models of the building’s energy use (pre and post retrofit), 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.

## Proposed Annual Savings for ECM

A table detailing the baseline usage, post retrofit usage and proposed annual energy savings for this ECM can be found in Table A4-2 in 08 Appendix A- Supporting M&V Data.

## Post Installation and Performance Period Activities

Details of post installation and performance period activities are provide in Section 6 of this plan.

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

## Overview M&V Plan

The M&V Plan for the Solar PV installation(s) at the [Agency/site] will follow FEMP M&V Option B. The Option B approach will be used to quantify the energy 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 plan 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 the 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.

## Overview of Savings Calculations

### **Energy Baseline Development**

Given that the solar PV system is not installed at present, the energy baseline is considered to be the maximum potential annual output of the array. The baseline energy was established through collection of various data parameters including:

* Geographic location of array
* DC system size (name plate rating)
* DC-to-AC derate Factors
* Array type (fixed, tracking, etc)
* Array tilt, azimuth

The data collected is used within the FEMP ENABLE IGA Tool to generate baseline energy generation for the PV system. A list of key input parameters for the IGA tool is found in table A5-1 in 08 Appendix A- Supporting M&V Data.

### **Energy Savings Calculations and Methodology**

After completion of the field assessment [ESCO name] compiled preliminary design data for the PV system into the FEMP IGA tool which in turn is linked to the National Renewable Energy Laboratory’s (NREL) PVWatts[[4]](#footnote-4) tool. 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.

## Proposed Annual Savings for ECM

A table detailing the baseline usage, post retrofit usage and proposed annual energy savings for this ECM can be found in Table A5-2 in 08 Appendix A- Supporting M&V Data.

## Post Installation and Performance Period Activities

Details of post installation and performance period activities are provide in Section 8 of this plan. A measurement of instantaneous array performance will be taken in accordance with the approach outlined in the ENABLE M&V Protocol v4.0 and compared against the array’s derated DC nameplate rating.

# Post installation and Annual M&V

## Post-Installation Activities

Inspection and Commissioning:

All retrofit equipment in each ECM category implemented within the project will undergo a post-installation inspection and commissioning process to ensure the systems operate as intended and meets the performance specifications provided in the Final Proposal. Commissioning will be performed in accordance with the **09\_Guidelines and Checklist for Commissioning and Government Acceptance**. Commissioning observations and conclusions and will be documented in the Post-Installation Report.

M&V

Upon installation completion, an as-built inventory of post-installation equipment will be supplied. Savings predictions will be corrected based on as-built data and will be reported in the Post-Installation Report. Immediately following installation, measurements for each ECM will be taken in a manner identical to that used for the baseline development and in accordance with the **ESPC ENABLE M&V Protocol v4.0**. These measurements will be used to calculate actual expected energy and cost savings, and will be detailed in the Post-Installation Report.

Note: An outline of the requirements for the Post Installation Report can be found within Appendix A of the **ESPC ENABLE M&V Protocol v4.0**.

## Annual Performance Period Verification Activities

Once per year [ESCO will perform a site visit, or, agency/site technical staff will perform a simple audit], during which the ECMs will be inspected to verify proper operation, ensure that they have been maintained and that they continue to have the potential to generate the expected savings. Inspections will follow an annual verification checklist that is to be developed in accordance with the **ESPC ENABLE M&V Protocol** **v4.0**. An example of the template for the annual verification checklist can be found in Appendix B of the **ESPC ENABLE M&V Protocol** **v4.0**.

The annual M&V report will detail the results of annual inspections, noting significant problems such as altered or malfunctioning equipment, etc. An estimate of energy and cost savings for the year will be provided. [Agency/site] is responsible for the consistency of occupancy, usage and equipment replacement with identical or comparable equipment. Changes in equipment type or usage will not result in adjustments to the reported (guaranteed) savings. If the equipment fails to perform as specified in the Final Proposal, the annual M&V report will propose a remedy to [Agency/site] to minimize the potential for lost savings. The annual M&V report will be submitted in a format as outlined in **ESPC ENABLE M&V Protocol** **v4.0** Appendix C.

# 08 Appendix A – Supporting M&V Data

**1. LIGHTING**

Table A1-1: Fixture Wattage Measurements – Types, Sample Size and Results

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Fixture Type/Code** | **Number of fixtures** | **% of Energy Savings** | **Table Power, W** | **Sample**  **Size** | **Average Measured Power, W** |
| F44EE | 107 | 60% | 144 | 10 | 140 |
| F42EE | 60 | 8% | 72 | 9 | 74 |
| F82ES | 84 | 7% | 128 | 9 | 120 |
| 75 Watt Inc. | 20 | 1% | 75 | 7 | 75 |
| Totals |  | 76% |  |  |  |

**Table A1-2: Usage Group Operating Hours**

|  |  |
| --- | --- |
| **Usage Group Code** | **Annual Operating Hours** |
| Conference Room | 900 |
| Open Office | 2860 |
| Private Office | 2855 |
| Hallway | 3780 |
| Storage | 600 |
| Restroom | 8760 |
| Parking Lot | 4380 |
| Exit Signs | 8760 |

Table A1-3: Baseline and Proposed Annual Savings for ECM 1- Lighting

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Total energy use (MMBtu/yr)** | **Electric energy use (kWh/yr)** | **Electric energy cost, Year 1 ($/yr)** | **Electric demand\* (kW/yr)** | **Electric demand cost, Year 1 ($/yr)** | **Natural gas use (MMBtu/yr)\*\*** | **Natural gas cost, Year 1 ($/yr)** | **Water use (gal/yr)** | **Water cost, Year 1 ($/yr)** | **Other energy use (MMBtu/yr)\*\*** | **Other energy cost, Year 1 ($/yr)** | **Other energy-related O&M costs, Year 1 ($/yr)** | **Total costs, Year 1 ($/yr)** |
| Baseline use |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Post-installation use |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Savings |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Notes \*Annual electric demand savings (kW/yr) is the sum of the monthly demand savings.  MMBtu = 106 Btu.  \*\*If energy is reported in units other than MMBtu, provide a conversion factor to MMBtu (e.g., 0.003413 MMBtu/kWh). | | | | | | | | | | | | | |

**2. WATER**

**Table A2-1: Fixture Flow Measurements – Types, Sample Size and Results**

|  |  |  |  |
| --- | --- | --- | --- |
| **Fixture Type** | **Number of fixtures** | **Sample**  **Size** | **Mean Flow, GPM, GPF** |
| Toilet | 20 | 7 | 4.05 |
| Urinal | 15 | 6 | 1.58 |
| Faucet | 30 | 8 | 2.48 |
| Shower | 5 | 5 | 3.50 |

**Table A2-2: Usage Profiles**

|  |  |  |  |
| --- | --- | --- | --- |
| **Fixture Type** | **Duration (Sec)** | **Uses / Day** | |
| **Full Time Employee** | **Transient** |
| Toilet (Female) | n/a | 3 | 0.5 |
| Toilet (Male)1 | n/a | 1 | 0.1 |
| Urinal (Male) | n/a | 2 | 0.4 |
| Lavatory Faucet | 302 | 3 | 0.5 |
| Shower | 300 | 0.1 | 0 |
| Kitchen Sink | 15 | 1 | 0 |

1 If urinals are not installed for the fixture usage group, then the Toilet (Male) usage rates are the same as the Toilet (Female).

2 Default duration for the metering type /autocontrol faucet is 15 seconds for the baseline and 12 seconds for the retrofit case

**Table A2-3- Baseline and Proposed Annual Savings for ECM 2 -Water**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Total energy use (MMBtu/yr)** | **Electric energy use (kWh/yr)** | **Electric energy cost, Year 1 ($/yr)** | **Electric demand\* (kW/yr)** | **Electric demand cost, Year 1 ($/yr)** | **Natural gas use (MMBtu/yr)\*\*** | **Natural gas cost, Year 1 ($/yr)** | **Water use (gal/yr)** | **Water cost, Year 1 ($/yr)** | **Other energy use (MMBtu/yr)\*\*** | **Other energy cost, Year 1 ($/yr)** | **Other energy-related O&M costs, Year 1 ($/yr)** | **Total costs, Year 1 ($/yr)** |
| Baseline use |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Post-installation use |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Savings |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **Notes**  \*Annual electric demand savings (kW/yr) is the sum of the monthly demand savings.  MMBtu = 106 Btu.  \*\*If energy is reported in units other than MMBtu, provide a conversion factor to MMBtu (e.g., 0.003413 MMBtu/kWh). | | | | | | | | | | | | | |

**3. SIMPLE HVAC CONTROLS**

**Table A3-1 – Simulation Model Key Parameters**

|  |  |
| --- | --- |
| **Parameter** | **Source of Data** |
| Building construction and layout | Engineering drawings and field observations |
| Number of building occupants | Field observations and interviews with facility staff |
| Lighting Power Density | [ESCO name] lighting audit |
| Ventilation Airflow Rates | Measured data and design data |
| HVAC Equipment Efficiency | Field observation of equipment age and condition |
| Infiltration Rate | FEMP IGA tool default value based on building construction parameters |
| HVAC System Operating Hours | Baseline hours collected from input from facility staff |
| HVAC System Temperature Setpoints | Measured data, design data, and information collected from existing controls |

**Table A3-2 – Baseline and Proposed Annual Savings for Simple HVAC Controls ECM 3.0**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Total energy use (MMBtu/yr)** | **Electric energy use (kWh/yr)** | **Electric energy cost, Year 1 ($/yr)** | **Electric demand\* (kW/yr)** | **Electric demand cost, Year 1 ($/yr)** | **Natural gas use (MMBtu/yr)\*\*** | **Natural gas cost, Year 1 ($/yr)** | **Other energy use (MMBtu/yr)\*\*** | **Other energy cost, Year 1 ($/yr)** | **Other energy-related O&M costs, Year 1 ($/yr)** | **Total costs, Year 1 ($/yr)** |
| Baseline use |  |  |  |  |  |  |  |  |  |  |  |
| Post-installation use |  |  |  |  |  |  |  |  |  |  |  |
| Savings |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **Notes**  \*Annual electric demand savings (kW/yr) is the sum of the monthly demand savings.  MMBtu = 106 Btu.  \*\*If energy is reported in units other than MMBtu, provide a conversion factor to MMBtu (e.g., 0.003413 MMBtu/kWh). | | | | | | | | | | | |

**4. HVAC EQUIPMENT**

**Table A4-1 – Simulation Model Key Parameters**

|  |  |
| --- | --- |
| **Parameter** | **Source of Data** |
| Building construction and layout | Engineering drawings and field observations |
| Number of building occupants | Field observations and interviews with facility staff |
| Lighting Power Density | Lighting audit or estimated based on interviews with facility staff |
| Ventilation Airflow Rates | Measured data and design data |
| HVAC Equipment Efficiency | Field observation of equipment age and condition |
| Infiltration Rate | FEMP IGA tool default value based on building construction parameters |
| HVAC System Operating Hours | Baseline hours collected from input from facility staff |
| HVAC System Temperature Setpoints | Measured data, design data, and information collected from existing controls |

**Table A4-2 – Baseline and Proposed Annual Savings for HVAC EQUIPMENT ECM 4.0**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Total energy use (MMBtu/yr)** | **Electric energy use (kWh/yr)** | **Electric energy cost, Year 1 ($/yr)** | **Electric demand\* (kW/yr)** | **Electric demand cost, Year 1 ($/yr)** | **Natural gas use (MMBtu/yr)\*\*** | **Natural gas cost, Year 1 ($/yr)** | **Other energy use (MMBtu/yr)\*\*** | **Other energy cost, Year 1 ($/yr)** | **Other energy-related O&M costs, Year 1 ($/yr)** | **Total costs, Year 1 ($/yr)** |
| Baseline use |  |  |  |  |  |  |  |  |  |  |  |
| Post-installation use |  |  |  |  |  |  |  |  |  |  |  |
| Savings |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **Notes**  \*Annual electric demand savings (kW/yr) is the sum of the monthly demand savings.  MMBtu = 106 Btu.  \*\*If energy is reported in units other than MMBtu, provide a conversion factor to MMBtu (e.g., 0.003413 MMBtu/kWh). | | | | | | | | | | | |

**5. SOLAR PV**

**Table A5-1 – Simulation Model Key Parameters**

|  |  |
| --- | --- |
| **Parameter** | **Source of Data** |
| DC System Size (kW) nameplate rating | Manufacturers Design Data |
| Array Type (Fixed, Tracking) | Design Data |
| Array Tilt (deg) | Design Data |
| Array Azimuth (deg) | Design Data |
| PV Module Nameplate Derate factor | Manufacturers Design Data or IGA tool default value |
| Inverter and Transformer Derate factor | Manufacturers Design Data or IGA tool default value |
| Module Mismatch factor | Design Data or IGA tool default value |
| Diodes and Connections Derate factor | Design Data or IGA tool default value |
| DC Wiring Derate Factor | Design Data or IGA tool default value |
| AC Wiring Derate Factor | Design Data or IGA tool default value |
| Module Soiling Derate Factor | Field Observation or IGA tool default value |
| System Availability Derate Factor | Field observation and/or design data or IGA tool default value |
| Shading Derate Factor | Field observation and/or design data or IGA tool default value |

**Table A5-2 – Baseline and Proposed Annual Savings for Solar PV ECM 5.0**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Total energy use (MMBtu/yr)** | **Electric energy use (kWh/yr)** | **Electric energy cost, Year 1 ($/yr)** | **Electric demand\* (kW/yr)** | **Electric demand cost, Year 1 ($/yr)** | **Natural gas use (MMBtu/yr)\*\*** | **Natural gas cost, Year 1 ($/yr)** | **Other energy use (MMBtu/yr)\*\*** | **Other energy cost, Year 1 ($/yr)** | **Other energy-related O&M costs, Year 1 ($/yr)** | **Total costs, Year 1 ($/yr)** |
| Baseline use |  |  |  |  |  |  |  |  |  |  |  |
| Post-installation use |  |  |  |  |  |  |  |  |  |  |  |
| Savings |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **Notes**  \*Annual electric demand savings (kW/yr) is the sum of the monthly demand savings.  MMBtu = 106 Btu.  \*\*If energy is reported in units other than MMBtu, provide a conversion factor to MMBtu (e.g., 0.003413 MMBtu/kWh). | | | | | | | | | | | |

1. FEMP M&V Guideline V 3.0 available at

   [http://www1.eere.energy.gov/femp/pdfs/mv\_guidelines.pdf]( http://www1.eere.energy.gov/femp/pdfs/mv_guidelines.pdf) [↑](#footnote-ref-1)
2. <http://energy.gov/sites/prod/files/2014/03/f10/enable_mvprotocol.docx> [↑](#footnote-ref-2)
3. <http://www1.eere.energy.gov/femp/information/download_blcc.html#eerc> [↑](#footnote-ref-3)
4. <http://rredc.nrel.gov/solar/calculators/pvwatts/version1/> [↑](#footnote-ref-4)