# Project Measurement and Verification Procedures

## 1) Introduction

The objective of Measurement and Verification (M&V) activities at the Project level is to confirm that the Measures that are supported by the Retrofit Program are installed and resulting in Energy Savings and Demand Savings.

This protocol will assist Participants in selecting approaches and methods for estimating Energy Savings and Demand Savings of Projects with Custom Measures. Results can also be used to support:

- Good energy management practices by program participants
- The determination of cost-effectiveness of projects

The challenge is to balance M&V costs, savings certainty, and the value of the energy efficiency measure. This Project Measurement and Verification Procedures document is applicable to Large Custom Project with Custom Measures that has an estimated Participant Incentive greater than $80,000.

## 2) Methods

Project Measurement and Verification (M&V) Procedures shall be consistent with IPMVP Protocols. IPMVP Protocols means the International Performance Measurement & Verification Protocol (IPMVP) – Core Concepts March 2022 EVO 10000 – 1:2022, or later as in effect from time to time. All Non-Routine Events (NREs) & Non-Routine Adjustments (NRAs) should be performed in accordance with the IPMVP Application Guide on Non-Routine Events & Adjustments October 2020 EVO 10400 – 1:2020

The IPMVP Protocol is applicable to Large Custom Project with Custom Measures that has an estimated Participant Incentive greater than $80,000.

IPMVP Protocols can be downloaded using the link provided here - www.evo-world.org

Four M&V options can be employed:

A) Engineering calculations (using both stipulated values and measurements)

B) Metering and monitoring (spot, short term, or continuous measurements)

C) Utility bill analysis

D) Computer simulation models.

Considerations in selecting the appropriate M&V option include:

- Complexity of the Measure
- Potential for changes in key factors that affect the baseline and post retrofit conditions
- The Measure’s savings value
- The Measure’s cost and associated Participant Incentive

**Option A** and **B** are applied at the *Measure* or *system* level.

**Option C** is applied at the *whole building* level.

**Option D** is applied at either the whole building or Measure level.

When M&V is applied at the ***Measure*** *level* the primary considerations are:

1) Is the demand or load constant (e.g. lighting fixture) or variable (e.g. VSD applied to a fan)

2) Are the operating hours constant (e.g. garage lighting) or variable (e.g. cooling hours)

Spot measurements can suffice for constant loads, whereas short term or continuous measurements may be required for variable loads.

Where operating hours are constant, stipulated values can be applied, subject to validation by the technical reviewer. Where operating hours are variable, short term or continuous measurement may be required. Short term measurement duration could be from a day to weeks depending on the expected variation in the key parameters.

Differentiate M&V first by the type of project:

1) **Custom projects - equipment retrofit only**, where efficiency gains are achieved by the retrofit or replacement of equipment, without changes in operations.

2) **Custom projects - operational change only**, where energy consumption (and possibly demand) is reduced by changing the operating periods, settings or methods, without modifications to the equipment.

3) **Custom projects - equipment retrofit and operational change**, where the combination of equipment and operational changes may impact load and energy separately or energy directly.

4) **Custom projects - multiple energy efficiency measures (ECMs)**, where two or more ECMs are implemented at a single site or facility. Multiple ECM's may enable the use of whole facility metering to determine savings.

M&V efforts should vary according to:

- Savings size (projected savings and potential incentive)
- Savings uncertainty (doubt about likely result of the measure's activity)
- For 'small' and 'certain' projects, 'least M&V effort' will involve acceptance of stipulated kW or kWh values, subject to reasonableness and validity checks, relative to industry norms.
- For 'large' and 'uncertain' projects, the 'highest M&V effort' will involve more rigorous scrutiny of baseline conditions specific to the facility, involving spot or short-term measurements on all, or a representative sample, of loads or operating hours as applicable.
- Extended post retrofit monitoring is not generally contemplated; nevertheless, the duration of post retrofit monitoring should be adequate to characterize the load pattern. (Extended monitoring may be done for other purposes, but will not be a condition of incentive payment, except if it is a specific condition of the accepted Project M&V Plan for a particular project.)
- Where available, existing data, as obtained through sub-metering, BAS logs, etc., will be utilized to the fullest extent, and will be considered as greatly enhancing the quality of the M&V.
- Enhanced M&V efforts undertaken by the Participant, including the use of existing monitoring data can be used to support savings claims (subject to acceptability of the data quality).
- Measures with a high degree of savings uncertainty will be conservatively discounted with an option (and onus) for Participants to prove greater savings through extended pre and/or post–retrofit monitoring.

As it relates to projects being evaluated under the Retrofit Program:

- M&V will be applied at the Measure and system level.
- In general, Options A and B will normally be employed – i.e. using a combination of stipulated values (referenced to industry standards or agreed site operating conditions), spot and short-term measurements.
- M&V will ensure diligence in establishing the baseline conditions and in defining the requirements for confirmation of post-retrofit savings.
- All measures will be required to report Energy and Demand Savings.
- Project M&V Procedures are subject to continuous improvement, consistent with the principles described here, as program experience and empirical data are gained.

## 3) Project M&V Procedures

The following section lists the Project M&V Procedures to be applied according to:

- Type of Custom Measure
- Estimated Participant Incentive for the Custom Measures

**Demand Savings** (kW) are the average load reduction in electricity demand between the Base Case and the Energy Efficient Case occurring between 3 pm to 9 pm on business days, June 1 through September 30 as shown below. Refer to the 'EM&V Protocols and Requirements' for more details on the Standard Definition of peak for calculating demand Savings at https://www.ieso.ca/en/Sector-Participants/Energy-Efficiency/Evaluation-Measurement-and-Verification.

**Energy Savings** (kWh) are those electricity savings achieved over the course of the first year after the completion of a Project.

Generally,

**Engineering Calculations** will be used for Large Projects. A Large Project is a Project with estimated Participant Incentives greater than $10,000 and equal to or lesser than $80,000. Participants are required to submit engineering calculations using either IESO's Engineered Worksheets listed below; or Applicant or Applicant Representative's customized measure specific engineering calculations showing detailed energy and demand savings calculations and methodologies based on industry accepted & sound engineering principles and practices. The IESO reserves the right to request that the calculation be verified and signed off by a professional engineer as part of the submission. The Applicant or Applicant Representative is required to complete and submit both the Retrofit Program Custom Projects Worksheet and applicable Engineered Worksheet(s) to the IESO Retrofit Program online application submission portal.

IESO's Retrofit Program Engineered Worksheets provide a consistent methodology to determine energy and demand savings for common energy efficiency measures (EEMs). The following Engineered Worksheets are available online at https://saveonenergy.ca//en/For-Business-and-Industry/Programs-and-incentives/Retrofit-Program Refer to Appendix A for more details on Engineering Calculation Procedures.

- Retrofit Program Engineered Worksheet - Horticultural Lighting
- Retrofit Program Engineered Worksheet - Compressed Air
- Retrofit Program Engineered Worksheet - Unitary AC
- Retrofit Program Engineered Worksheet - VSD Compressed Air
- Retrofit Program Engineered Worksheet - VSD Fan
- Retrofit Program Engineered Worksheet - VSD Pump
- Retrofit Program Custom Projects Worksheet

**Measurement & Verification (M&V)** is required for Large Custom Projects. A Large Custom Project is a Project with Custom Measures that has an estimated Participant Incentive greater than $80,000. IPMVP Option B, C or D should be used for Large Custom Projects. Participants are required to submit an M&V Plan in complete adherence to the IPMVP Protocol Core Concepts March 2022 EVO 10000 – 1:2022 or the later version if in existence. An M&V Plan shall be developed for each Large Custom Project by a qualified professional such as a Certified M&V Professional (CMVP), Performance M&V Analyst (PMVA), or Performance M&V Expert (PMVE). A generic Large Custom Project M&V Plan template can be found in Appendix C. This M&V template can be used by the Applicant or Applicant Representative as the basis for submitting an M&V Plan and Saving Report. This template lays out the minimum information requirements to be submitted by the participant to enable the review of the application. The template is provided to help maintain consistency in documenting the information with regards to Large Custom Projects. The Applicant or Applicant Representative is required to complete and submit both the Retrofit Program Custom Projects Worksheet and the M&V Plan to the IESO Retrofit Program through the online application submission portal.

The table below identifies the Large Custom Project M&V Procedures to be used dependent on the custom measure type.

Table 1: Selection of Large Custom Project M&V Procedures

| | **Custom Measure Type** | **M&V Procedures** |
|---|---|---|
| 1 | Specialty Lighting Retrofit | SLR |
| 2 | Equipment Replacement – Chillers | ER-C |
| 3 | Equipment Replacement – Refrigeration | ER-R |
| 4 | Equipment Replacement – Motors | ER-M |
| 5 | Equipment Replacement – Air Compressors | ER-AC |
| 6 | Equipment Replacement – Aeration Blowers | ER-AB |
| 7 | HVAC Redesign | HVACR |
| 8 | Variable Speed Drives | VSD |
| 9 | Building Envelope | BE |
| 10 | Building Automation Systems | BAS |
| 11 | Lighting Controls | LC |
| 12 | Other Custom Measures | OCM |

**Definitions**

Refer to the Retrofit Program Requirements for program specific definitions.

# APPENDIX A: Engineering Calculation Procedures

**Equipment Replacement**

- Whether load is constant or variable, refer to manufacturers' data and industry references for kW ratings at various load points.
- Assumptions for operating profile, both load and operating hours, to be reviewed by Project Evaluator for reasonableness.
- Participant to provide detailed inventory of all equipment, both baseline and proposed post-retrofit, showing quantities, thermal and electrical ratings.

**Chillers**

- Use stipulated values, at 80% of nameplate capacity of operating equipment, of baseline and post-retrofit kW. Baseline kW shall assume OEM rated or shop tested efficiency. In cases where the retrofit nameplate capacity is different from the baseline nameplate capacity (i.e. "right-sizing" of equipment), declare the set of conditions to which baseline energy will be adjusted as per Core Concepts of IPMVP Protocol.
- Energy Savings determination - Use manufacturer ratings for baseline and post-retrofit kW at representative distributed load levels spanning total capacity, multiplied by stipulated operating hours at each point.
- Exclude chiller auxiliary equipment (pumps and cooling tower) unless this equipment is proposed to be changed as well.

**Refrigeration**

- Use stipulated values, at 80% of nameplate capacity of operating equipment, of baseline and post-retrofit kW, Baseline kW shall assume OEM rated of shop tested efficiency. In cases where the retrofit nameplate capacity is different from the baseline nameplate capacity (i.e. "right-sizing" of equipment), declare the set of conditions to which baseline energy will be adjusted as per Core Concepts of IPMVP Protocol.
- Energy Savings determination - Use manufacture ratings for baseline and post-retrofit kW at representative distributed load levels spanning total capacity, multiplied by stipulated operating hours at each point.
- Exclude chiller auxiliary equipment (pumps and cooling tower) unless this equipment is changed as well.

**Motors**

- Energy Savings determination - Use stipulated values for efficiency and power factor, at 80% load, using manufacturer ratings. Energy Savings = Demand Savings x stipulated operating hours.
- If variable load, stipulate efficiency and power factor at representative load levels, and stipulate hours at each level.

**Air Compressors**

- Energy Savings determination - Use CAGI data sheets for baseline and post-retrofit kW at representative distributed load levels spanning total capacity, multiplied by stipulated operating hours at each point. Airflow in ACFM can be stipulated, as obtained from CAGI data sheets
- In the absence of an appropriate CAGI data sheet, Baseline performance is to be measured. Measured parameters include power (kW) or voltage, amperes and power factor.
- Continuous interval measurement should be conducted to reflect typical operating cycles – e.g. Monday to Friday, a full working week.
- Retrofit case flow and power consumption is to be measured by the same method as the Baseline measurement.

**Variable Speed Drives**

- Load is likely constant for baseline, variable (by definition) post-retrofit.
- Refer to manufacturers' data and/or industry references for kW ratings at various load points.
- Stipulate baseline motor efficiency and power factor if baseline is constant; stipulate efficiency and power factor at representative load levels if baseline is variable; stipulate operating hours at each level.
- Assumptions of operating profile both load and operating hours, will be reviewed for reasonableness.

**Building Envelope**

- Involves consideration of cooling efficiency in assessing summer savings.
- Refer to manufacturers' data, industry references, for thermal or leakage properties.
- Stipulated values for cooling in kW/ton
- Stipulated values, derived from detailed simulation modeling provided by the manufacturer of the installed product for typical buildings. The model shall account for actual glazing types, and actual building envelope features, shading, orientation and normal local weather. The model shall be adjusted to the specific site conditions.

**Building Automation System**

- Recognized as inherently uncertain.
- May be a new BAS installation or an enhancement of an existing system.
- Provide detailed description of baseline and post-retrofit operating conditions, with anticipated savings.
- Provide operating logs or other monitoring data to support claimed operating conditions.
- No discount to savings that have supporting baseline data
- Discount savings that have no supporting baseline data by 25%

**Lighting Controls**

- Recognized as inherently uncertain.
- May be a new installation or an enhancement of an existing system.
- Provide detailed description of baseline and post-retrofit operating conditions, with anticipated savings.
- Provide operating logs or other monitoring data to support claimed operating conditions.
- No discount to savings that have supporting baseline data
- Discount savings that have no supporting baseline data by 25%

# APPENDIX B: Large Custom Project M&V Procedures

**Measure #1 – Specialty Lighting Retrofit SLR**

| Required Parameters | M&V Procedures |
|---|---|
| **Existing System Description** | Provide Inventory of existing lamps, fixtures, and ballasts affected including fixture, lamp and ballast types, operating log (e.g. common space 24/7; tenant space lease hours), usage area designation, counts of operating and non-operating fixtures and lamps*<br>**Reporting of non-operating fixtures is required and should be limited to 10% of the total number of fixtures. If there is more than 10% of non-operating fixture, these should be excluded from the project.* |
| **Proposed System Description** | Inventory of Retrofit lamps, fixtures, and ballasts affected including fixture, lamp and ballast types, operating log (e.g. common space 24/7; tenant space lease hours), usage area designation, counts of operating and non-operating fixtures and lamps |
| **Measurement Boundaries** | For power measurements, include only those equipment (i.e. fixtures, lamps) types selected as per Sampling protocol within measurement boundaries.<br>Measurement boundary should include all the fixtures being replaced as per Project Scope |
| **Measurement Conditions** | Post Retrofit measurements should allow for a minimum 100 hours of burn–in<br>A statistically significant sample of fixtures as per Sampling protocol should be measured |
| **Sampling** | Representative sampling to be followed for the selection of samples. Sampling is to be distributed across the facility. The measurement data should be collected for each fixture usage group. Measurement data should be obtained for a sample of loads (Sampling size determination is typically 90% Confidence and ±10% Precision for each homogeneous population) for both Baseline and Retrofit for each type of fixtures. Selecting the appropriate sampling criteria requires balancing accuracy requirement with M&V costs within the budget. It may be appropriate to establish a maximum sample size in the M&V Plan. If this maximum is actually reached after the re-computations, the saving report should note the actual precision achieved by the sampling. |
| **Baseline Period and Reporting Period Duration** | Installation report is required to substantiate burn-in hours (100 hours). Operating hours logging is required for Large Custom Projects to validate operating hours. Retrofit measurements for Lighting Measure wattages should allow for a minimum of 100 hours of burn-in hours. |
| **Metering Requirements** | In cases where measurements are not commercially reasonable, fixture wattages should be stipulated using Standard Lighting Tables or manufacturer's data sheets available<br>Spot metering should be conducted for Retrofit fixtures using the same methods and procedures used for the Baseline fixtures.<br>Metering to be conducted for both RMS wattage and/or operating hours (manual or metered)<br>For lighting retrofit projects with financial incentive amount greater than or equal to $80,000, IPMVP M&V Option B should be used.<br><u>Metering Instructions for both Baseline and Retrofit:</u><br>*(1) Metering of Fixture Wattages:* Requires the use of RMS meter, continuous monitoring on a sample population within each usage group, the readings should be averaged and calibrated Meters should be used.<br>*(2) Logging Operating Hours:* Continuous monitoring (manual or metering) on a sample population within each usage group should be conducted for a minimum of one week or span across full operating cycle. When seasonal variations or scheduled activity affect equipment operation, metering should be conducted during each variation period. (e.g. summer operating schedules in classrooms). Metering period should not include vacations or holidays. |
| **Demand Savings Calculation** | Refer to EM&V's protocol for demand saving definition<br>$kW_{Savings} = kW_{Baseline} - kW_{Retrofit}$ |

| Required Parameters | M&V Procedures |
|---|---|
| **Energy Savings Calculation** | If Baseline and Retrofit Operating hours are the same:<br>$kWh_{Savings} = (kW_{Baseline} – kW_{Retrofit}) \times Op\ Hrs$<br>If Baseline and Retrofit Operating hours vary:<br>$kWh_{Savings} = (kW \times Op\ Hrs)_{Baseline} – (kW \times Op\ Hrs)_{Retrofit}$<br>Operating hours should be logged for at least one week to establish an operating schedule for each usage group. Operating hours can be assumed to be constant during each season. |
| **Baseline Adjustments** | Baseline Adjustments are required in the case that quantity, lighting level and operating hours are reduced significantly (typically more than 30%) |

**Measure #2 - Equipment Replacement - Chillers ER-C**

| Required Parameters | M&V Procedures |
|---|---|
| **Existing System Description** | Baseline information of existing equipment including chiller nameplate data, load served, efficiency ratings, operating schedule and equipment location |
| **Proposed System Description** | Baseline information of proposed equipment including chiller nameplate data, load served, efficiency ratings, operating schedule and equipment location |
| **Measurement Boundaries** | Measurements to be taken at Measure level and should include equipment that will be retrofitted |
| **Measurement Conditions** | Baseline metering is normally performed during a period where a range of cooling loads exists (e.g. summer). Baseline and Retrofit performance are to be measured at representative distributed load levels spanning total design loads, multiplied by stipulated operating hours at each point. |
| **Sampling** | Samples should span across different load levels with minimum of 20% sample across the different load levels. |
| **Baseline Period and Reporting Period Duration** | Continuous interval measurements are to be made to reflect the full cycle of operation of Baseline and Retrofit chiller for a minimum of 1 week. |
| **Metering Requirements** | Multiple measurements are made while the cooling systems are operating at different loads so that the complete range of chiller performance can be evaluated<br>Metering to be conducted for both continuous interval metering of chiller kW using true RMS meter and cooling load using a BTU meter or monitoring of supply and return chilled water temperature and chilled water flow rate. |
| **Demand Savings Calculation** | Refer to EM&V Protocols for demand saving definition<br>$kW_{Savings} = (kW_{Baseline} - kW_{Retrofit})$ |
| **Energy Savings Calculation** | $kWh_{Savings} = (kWh_{Baseline} - kWh_{Retrofit}) \pm Routine\ Adjustment \pm Non\ Routine\ Adjustment$<br>$kWh_{Baseline}$ is the Baseline energy consumption totaling the sum of the energy consumption for each hour of the year (kWh)<br>$kWh_{Retrofit}$ is the Retrofit energy consumption totaling the sum of the energy consumption for each hour of the year (kWh) |
| **Baseline Adjustments** | Baseline Adjustment is required when Retrofit cooling load is significantly different from the measured Baseline cooling load. The Baseline should be adjusted to the Reporting Period conditions using CDD, HDD or rate of production. |

**Measure #3 - Equipment Replacement - Refrigeration ER-R**

| Required Parameters | M&V Procedures |
|---|---|
| **Existing System Description** | Baseline information of existing equipment required refrigeration unit nameplate data, load served, efficiency ratings, operating schedule and equipment locations |
| **Proposed System Description** | Baseline information of proposed equipment required refrigeration unit nameplate data, load served, efficiency ratings, operating schedule and equipment locations |
| **Measurement Boundaries** | Measurements to be taken at *Measure* level and boundaries should include equipment that will be retrofitted |
| **Measurement Conditions** | Baseline and Retrofit performance are to be measured at representative distributed load levels spanning total design loads, multiplied by stipulated operating hours at each point. |
| **Sampling** | Sampling should be carried out as per IPMVP protocol |
| **Baseline Period and Reporting Period Duration** | Continuous interval measurements are to be made to reflect the full cycle of operation of existing and retrofit units for a minimum of 1 week. |
| **Metering Requirements** | Metering to be conducted for both continuous interval metering of Refrigeration kW and metering of Cooling Load |
| **Demand Savings Calculation** | Refer to EM&V's protocol for demand saving definition<br>$kW_{Savings} = (kW_{Baseline} - kW_{Retrofit})$ |
| **Energy Savings Calculation** | $kWh_{Savings} = (kWh_{Baseline} - kWh_{Retrofit}) \pm Routine\ Adjustment \pm Non\ Routine\ Adjustment$<br>$kWh_{Baseline}$ is the Baseline energy consumption totaling the sum of the energy consumption for each hour of the year (kWh)<br>$kWh_{Retrofit}$ is the Retrofit energy consumption totaling the sum of the energy consumption for each hour of the year (kWh) |
| **Methodology Applied for Variable Load** | Continuous interval kW measurement required at various load levels |

**Measure #4 - Equipment Replacement - Motors ER-M**

| Required Parameters | M&V Procedures |
|---|---|
| **Existing System Description** | Provide Inventory of existing motors affected including nameplate data, motor horsepower, quantity, load profile, operating schedule and motor application |
| **Proposed System Description** | Provide Inventory of proposed motors affected including nameplate data, motor horsepower, quantity, load profile, operating schedule and motor application |
| **Measurement Boundaries** | Measurement boundaries should include all motors that will be replaced and including all dependent and independent variables |
| **Measurement Conditions** | A statistically significant sample of motors should be measured |
| **Sampling** | In the case of multiple motor replacements, sampling is to be done on the type of load they serve by usage groups.<br>For projects in which a large number of equal-sized motors and same operating hours, metering can be conducted on a sample of motors and the results can be extrapolated to the population<br>Measurements should be made on the lesser of 30 motors or 10% of the population. This should be applied to each usage group of comparable load application |
| **Baseline Period and Reporting Period Duration** | Metering observation should be made for both Baseline and Retrofit in 15-minute intervals for variable or constant load respectively and should span a full operating cycle from maximum to minimum energy. |
| **Metering Requirements** | In cases where measurements are not practically possible, kW should be stipulated using manufacturer's datasheets or nameplates.<br>Where metering is required, spot metering should be conducted for Retrofit motors using the same methods and Procedures used for the Baseline motors.<br>Metering is required for both spot/short term power measurements and operating hours<br>Metering Instructions:<br>*(1) Power Consumption Measurements (kW)* - For constant load motors, spot or short-term measurements on a sample population within each usage group should be conducted to obtain three-phase amps, volts, Power Factor, kW, and RPM. Multiple spot measurements at each load level are required for variable load application.<br>*(2) Logging Operating Hours* - Continuous monitoring on a sample population within each usage group should be conducted for a minimum of one week or span across full operating cycle. When seasonal variations or scheduled activity affect equipment operation, metering should be conducted during each variation period. Metering period should not include vacations or holidays. |
| **Demand Savings Calculation** | Refer to EM&V's protocol for demand saving definition<br>$kW_{Savings} = kW_{Baseline} - kW_{Retrofit}$<br>$kW_{Baseline}$ and $kW_{Retrofit}$ to be collected in 15-minute intervals for variable or constant load. A continuous interval measurement of $kW_{Baseline}$ and $kW_{Retrofit}$ is required. |
| **Energy Savings Calculation** | For same operating hours: $kWh_{Savings} = (kW_{Baseline} - kW_{Retrofit}) \times Op\ Hrs$<br>For different operating hours: $kWh_{Savings} = (kW \times Op\ Hrs)_{Baseline} - (kW \times Op\ Hrs)_{Retrofit}$<br>Operation hours should be logged for one operating cycle to establish an operating schedule for each usage group. The data can be then extrapolated for whole year with adjustment for seasonal variation. For motors with seasonal load patterns, the average operating hours should be weighted according to relative length of each seasonal period |

**Measure #5 - Equipment Replacement - Air Compressors ER-AC**

| Required Parameters | M&V Procedures |
|---|---|
| **Existing System Description** | Baseline information of existing equipment including compressor nameplate data, CFM at full load, Voltage, Amps (FLA), Amps (LRA), pressure, age, operating schedule and conditions, equipment location, type (reciprocating, rotary screw, etc.), operation type (modulating, load/unload, etc.), annual operating hours. |
| **Proposed System Description** | Baseline information of proposed equipment including compressor nameplate data, CFM at full load, Voltage, Amps (FLA), Amps (LRA), pressure, age, operating schedule and conditions, equipment location, type (reciprocating, rotary screw, etc.), operation type (modulating, load/unload,etc.), annual operating hours. |
| **Measurement Boundaries** | Measurements to be taken at *Measure* level. Measurement boundaries should include equipment and other accessories that will be Retrofitted. |
| **Measurement Conditions** | Baseline and Retrofit performance are to be measured in 15-minute continuous interval measurements to represent the full operating cycle. |
| **Sampling** | Samples should span across different load levels. Minimum of 20% sample across the different load levels |
| **Baseline Period and Reporting Period Duration** | Continuous interval Measurement should be conducted to reflect the typical operating cycle – e.g. Monday to Friday, a full working week. |
| **Metering Requirements** | Measured parameters include power (kW) or voltage, amps, power factor and airflow load (CFM), and/or pressure. For Retrofit, Power (kW) and design load (CFM) are to be measured and compared with Baseline measurement. If the process flow is significantly different, Baseline adjustment should be made to reflect the Retrofit conditions. . |
| **Demand Savings Calculation** | Refer to EM&V's protocol for demand saving definition.<br>$kW_{Savings} = kW_{Baseline} - kW_{Retrofit}$<br>Baseline performance is to be measured and/or simulated by using stipulated values (nameplate data, manufacturer specifications, etc.). Measured parameters include power (kW) or voltage, amps, power factor and airflow load (CFM), and/or pressure.<br>Measurement should be conducted to reflect the typical operating cycle – e.g. Monday to Friday, a full working week.<br>Retrofit case performance is to be measured by the same method as the Baseline measurement. Power (kW) and design load (CFM) are to be measured and compared with Baseline measurement. |
| **Energy Savings Calculation** | Energy Consumption (kWh) may be calculated by multiplying average demand (kW) by operating hours.<br>$kWh_{Savings} = (kWh_{Baseline} – kWh_{Retrofit}) \pm Routine\ Adjustment \pm Non\text{-}Routine\ Adjustment$<br>Operating hours are required to be logged (manual or monitor). Operating logs and other documents may be used to support the operating hours. |
| **Baseline Adjustments** | In the case where the design load (CFM) is significantly different between Base and Energy Efficient Case, the measurement may be normalized. The normalization may be taken in the Retrofit stage as the Savings may be subject to change based on the Energy Efficient case measurement. Regression analysis (kW vs. CFM) is required for normalization.<br><u>Baseline Adjustment Calculation</u><br>*Baseline Efficiency [kW/CFM] = Baseline Peak Demand [kW] ÷ Baseline Average Airflow Load [CFM]*<br>*Adjusted Baseline Demand [kW] = Baseline Efficiency [kW/CFM] x Retrofit Case Average Airflow [CFM]*<br><u>Savings Calculation after Adjustment</u><br>*Demand Savings [kW] = Adjusted Baseline Demand [kW] – Retrofit case Demand [kW]*<br>*Annual Savings [kWh] = Adjusted Baseline Consumption [kWh] – Retrofit case Consumption [kWh]* |

**Measure #6 - Equipment Replacement - Aeration Blowers ER-AB**

| Required Parameters | M&V Procedures |
|---|---|
| **Existing System Description** | Baseline information of existing equipment including manufacturer/Model Number, HP, load, voltage, amps, constant speed/variable speed, and annual operating hours |
| **Proposed System Description** | Baseline information of proposed equipment including manufacturer/Model Number, HP, load, voltage, amps, constant speed/variable speed, and annual operating hours |
| **Measurement Boundaries** | Measurements should be taken at Measure e.g. blowers, level and boundaries should include equipment that will be replaced. |
| **Measurement Conditions** | A minimum of 1-week monitoring period representative of the typical blowers' operating schedule or a typical full cycle of operation. |
| **Sampling** | Samples should span across different load levels. A minimum of 20% sample across the different load levels. |
| **Baseline Period and Reporting Period Duration** | Utility bill comparison analysis is recommended for when blowers represent 50% or more of the total facility electrical Energy Consumption. Establish a regression model compiling utility meter data and historical wastewater flow volume as independent variable for the Baseline Period. |
| **Metering Requirement** | Measured parameters include power (kW) or voltage, amps, power factor and airflow (CFM), and/or pressure at 15-minutes interval for a minimum of one week. If the process flow is significantly different, Baseline adjustment should be taken to adjust the Savings. |
| **Demand Savings Calculation** | The following equations will be used to calculate Demand Savings. It is required that 15-minute interval data covers the peak demand period for both pre- and post- installation. Refer to EM&V's protocol for demand saving definition. Refer to EM&V's protocol for peak demand and demand saving definition.<br>$$[\boldsymbol{kW}_{\boldsymbol{savings}}] = \boldsymbol{kW}_{\boldsymbol{Adj\_Baseline}} - \boldsymbol{kW}_{\boldsymbol{Retrofit}}$$ |
| **Energy Savings Calculation** | Energy Savings is calculated comparing utility metered data in post-retrofit with the adjusted Baseline energy consumption. The following equations will be used to calculate Energy Savings:<br>$$[\boldsymbol{kWh}_{\boldsymbol{savings}}] = \boldsymbol{kWh}_{\boldsymbol{Adj\_Baseline}} - \boldsymbol{kWh}_{\boldsymbol{Retrofit}}$$<br>$kWh_{Adj\_Baseline}$= Total annual Energy Consumption Baseline model as determined by the regression analysis for pre-Retrofit billing data and correlated to the Retrofit wastewater flow volume.<br>$kWh_{Retrofit}$= Total annual Energy Consumption as reported in utility billing data after the Retrofit installation |
| **Baseline Adjustments** | Perform non-routine Baseline Adjustment when Retrofit wastewater effluent is significantly different from those recorded in the Baseline Period. A regression model should be established to calculate the adjusted Baseline with the Retrofit wastewater effluent in the Reporting Period. A minimum of R-squared ($R^2$) statistic of greater than 75% should be used. R-squared is a statistical measure of how close the data are to the fitted regression line. |

**Measure #7 – HVAC Redesign HVACR**

| Required Parameters | M&V Procedures |
|---|---|
| **Existing System Description** | Inventory of Baseline equipment affected. Baseline information of all components in HVAC system to be studied including but not limited to HVAC equipment (refrigeration units, AC units, fans, etc.), Location – weather bin data, HDD, CDD, Cooling/heating load and Operating schedule |
| **Proposed System Description** | Inventory of Baseline equipment affected. Proposed System information of all components in HVAC system to be studied including but not limited to HVAC equipment (refrigeration units, AC units, fans, etc.), Location – weather bin data, HDD, CDD, Cooling/heating load and Operating schedule |
| **Measurement Boundaries** | Measurement boundaries should include all components within the HVAC system and any other auxiliary components that are affected by the proposed re-design.<br>Measurements to be taken at system level<br>Component Measure within the HVAC Re-design is to be considered separately and in isolation, to the extent practical |
| **Measurement Conditions** | Measurement conditions should be comparable between Baseline and Retrofit case (e.g. operating profile, time and duration of measurement, measured parameters, equipment, etc.) |
| **Sampling** | For project that involves other Measure combined with replacement of HVAC units sampling can be excluded for HVAC units |
| **Baseline Period and Reporting Period Duration** | Reporting duration should cover full operating profile of the system and the result is to be compared with engineering references (manufacturer specifications of equipment, reasonable and practical operating hours |
| **Metering Requirements** | Metering to be conducted will require short and/or long-term continuous interval measurements<br>Continuous interval measurements are to be made to reflect full cycle of operation of all components of the existing and re-designed HVAC system performance<br>The measurement method/approach for both Baseline and Retrofit should be comparable (e.g. time, method, etc.). |
| **Demand Savings Calculation** | Refer to EM&V's protocol for peak demand and demand saving definition<br>$kW_{Savings} = kW_{Baseline} - kW_{Retrofit}$<br>Continuous interval measurements to be used to establish Baseline.<br>Demand Savings is to be determined by measured peak Demand for Baseline and Retrofit case.<br>Output load such as cooling/heating load should also be considered according to the type of proposed redesign |
| **Energy Savings Calculation** | Energy Savings, kWh can be calculated by Baseline kW multiplied by operating hours.<br>The operating hours may be estimated by extrapolating from measurement period.<br>$kWh_{Savings} = (kWh_{Baseline} – kWh_{Retrofit}) \pm Routine\ Adjustment \pm Non\ Routine\ Adjustment$ |
| **Baseline Adjustments** | Baseline Adjustments should be made based on Operating Profile, cooling and heating load, weather data (location, HDD, CDD) |
| **Methodology Applied for Variable Load** | For various load, continuous interval measurement should be performed for kW at various load and/or use engineering reference.<br>Output such as airflow rate, cooling and heating load are also to be measured and studied to establish kW at each representative load. |

**Measure #8 – Variable Speed Drives VSD**

| Required Parameters | M&V Procedures |
|---|---|
| **Existing System Description** | Inventory of Baseline equipment affected. Baseline information of existing equipment including Nameplate data, Motor horsepower, Quantity, Load served, Operating schedule, Motor application, Location, Spot-metering data for a Baseline sample that is representative of each usage group |
| **Proposed System Description** | Inventory of Baseline equipment affected. Proposed system information of existing equipment including Nameplate data, Motor horsepower, Quantity, Load served, Operating schedule, Motor application, Location, Spot-metering data for a Baseline sample that is representative of each usage group |
| **Measurement Boundaries** | Measurement boundary should include all existing equipment that will be Retrofitted with VSD(s). The measurement boundary should capture all existing equipment and not only those that are selected to be representative samples during measurements. |
| **Measurement Conditions** | Measurements should be conducted to include all operating parameters and to reflect the various operating points |
| **Sampling** | Baseline equipment should be grouped into usage groups according to those with identical operating characteristics and/or expected operating hours.<br>The lesser of 30 or 10% of the existing equipment from each usage group should be subject to metering where measurements are required<br>For projects in which a large number of equal-sized motors with the same application and operating schedule will be replace, metering may be conducted on a sample of motors and the results extrapolated to the applicable population. |
| **Baseline Period and Reporting Period Duration** | Reporting duration should span through a full operating cycle in both Baseline and Reporting periods. A typical operating cycle should reflect the highest and lowest consumption and various operating points. |
| **Metering Requirements** | Metering to be conducted for both motor power draw to be defined using continuous-metering at each motor load level. Operating hours to be logged for each load levels.<br>Metering Instructions:<br>For both Baseline and Retrofit:<br>*(1) Power Consumption Measurements (kW)*<br>• For constant load motors, spot or short-term measurements on a sample population within each usage group should be conducted to obtain three-phase amps, volts, Power Factor, kVA, kW, and RPM.<br>• Multiple spot measurements at each load level are required for variable load application.<br>*(2) Logging Operating Hours*<br>• Continuous monitoring on a sample population within each usage group should be conducted for a minimum of two weeks or span of full operating cycle.<br>• When seasonal variations or scheduled activity affect equipment operation, metering should be conducted during each variation period. (e.g. HVAC system motors should be measured during summer peak months).<br>• Metering period should not include vacations or holidays. |
| **Demand Savings Calculation** | Refer to EM&V's protocol for demand saving definition<br>• Baseline Demand is assumed to stay constant into Retrofit stage, as Baseline and Retrofit equipment are not changed<br>• In the case where there are multiple usage groups, Demand is the sum of $kW_{usage\ group}$:<br>$kW_{usage\ group} = (kW/Motor)\ x\ (Motor\ Quantity\ in\ Usage\ Group)$<br>This equation applied to both Baseline and Retrofit calculations. Motor quantities and number of usage groups should remain constant. If these values change, refer to Baseline Adjustment.<br>$kW_{Baseline} = kW_{Baseline\ usage\ group}\ x\ (\#\ of\ usage\ groups)_{Baseline}$ |

| Required Parameters | M&V Procedures |
|---|---|
| | $kW_{Retrofit} = kW_{Retrofit\ usage\ group}$ x (# of usage groups)$_{Retrofit}$<br>$kW_{Savings} = kW_{Baseline} - kW_{Retrofit}$<br>Measurements of $kW_{Baseline}$ and $kW_{Retrofit}$ to be collected in 15-min interval RMS metering wattage measurements. |
| **Energy Savings Calculation** | If Baseline and Retrofit Operating hours are the same:<br>(1) $kWh_{Savings} = (kW_{Baseline} - kW_{Retrofit})$ x Stipulated Op Hrs<br>If Baseline and Retrofit Operating hours vary:<br>(2) $kWh_{Savings} = (kW \times Op\ Hrs)_{Baseline} - (kW \times Op\ Hrs)_{Retrofit}$<br>Baseline and Retrofit hours of operation should be logged to establish an operating schedule for each usage group.<br>$Stipulated\ Op\ Hrs = \frac{Motor\ ON\ during\ Metering\ Period\ (hrs)}{Length\ of\ Metering\ Period\ (hrs)} \times 8760\ \frac{hrs}{year}$ |
| **Baseline adjustments** | Baseline Adjustments are required in the case that there are non-operating motors in the Post-stage that were normally operating or are intended for operation (e.g. typically operating motors that are intended for repair) |
| **Methodology Applied for Variable Load** | For variable load motors, continuous metering is required for each motor grouping while the motors' applicable systems are modulated over their normal operating range.<br>An average kW Demand is used for calculating Energy use.<br>Baseline operating hours can be logged for an interval then extrapolated over a year.<br>In post-VSD installation stage, operating hours should be measured. |

**Measure #9 – Building Envelope BE**

| Required Parameters | M&V Procedures |
|---|---|
| **Existing System Description** | Use of energy modeling software such as RETScreen, eQuest, EE4 or approved equivalent are required.<br>Simulation modeling shall account for actual glazing types, actual building envelops features, shading, building orientation, local weather data<br>Ontario Building code (OBC) should be used as reference in absence of Baseline parameters.<br>Specify manufacturers' data, industry references, for thermal or leakage properties. |
| **Proposed System Description** | Use of energy modeling software such as RETScreen, eQuest, EE4 or approved equivalent are required.<br>Simulation modeling shall account for actual glazing types, actual building envelops features, shading, building orientation, local weather data<br>Ontario Building code (OBC) should be used as reference in absence of Baseline parameters.<br>Specify manufacturers' data, industry references, for thermal or leakage properties.<br>Blower door test is required to demonstrate infiltration reduction<br>Simulations should demonstrate solar effects and coincident loading for all orientations |
| **Measurement Boundaries** | Measurement boundary should cover all the area impacted by proposed measure |
| **Measurement Conditions** | Measurements should be under normal operating conditions. |
| **Sampling** | Not Applicable |
| **Baseline Period and Reporting Period** | Baseline period should be not less than the most recent 12 months prior to the Retrofit installation period. A minimum of 6 months is required for the monitoring period covering the peak demand period over a block of hours as defined in IESO's EM&V protocol. |
| **Demand Savings Calculation** | To be based on hour-by-hour annual whole building model.<br>Refer to EM&V's protocol for demand saving definition |
| **Energy Savings Calculation** | Hour-by-hour annual whole building energy simulation model calibrated against whole building metered data for electricity used in the building. |
| **Baseline Adjustments** | Baseline Adjustment should be made based on cooling and heating load and operating hours |
| **Methodology Applied for Variable Load** | Variable load exists in BAS projects if they are implemented to enhance cooling/heating fans |

**Measure #10: Building Automation System BAS**

| Required Parameters | M&V Procedures |
|---|---|
| **Existing System Description** | Inventory of Baseline equipment affected by the BAS, such as: motors, fans, pumps and controls. Baseline information required for each component including manufacturer, model number, quantity, rated capacity, energy-use factors (such as rated voltage, amps, Btu/hr), nominal efficiency, load served, location, any key parameters such as weather data (HDD, CDD) and operating hours, metering data or whole facility utility bills for a minimum of 12-months |
| **Proposed System Description** | Retrofit information required for the BAS and its components. Metering data or whole facility utility bills post-BAS installation for a minimum of 12-months. Any key parameters such as weather data (HDD, CDD) and operating hours |
| **Measurement Boundaries** | Measurement boundary should include all the components that are impacted by the new BAS – such as lighting system, cooling and heating equipment, fans, etc. |
| **Measurement Conditions** | For all BAS projects, measurement conditions should be comparable between Baseline and Retrofit cases. Operating profile, time and duration of measurement and other measured parameters should be obtained and approached in similar methods. |
| **Sampling** | As BAS projects are considered as inherently uncertain, all components should be measured and analyzed |
| **Baseline Period and Reporting Period Duration** | Reporting duration should reflect full operating profile of all components that are covered under the new BAS. A typical operating profile should reflect the maximum and minimum consumption for the ECM. |
| **Metering Requirements** | All energy-use factors for each component of the existing system should be metered.<br>More complex systems where predicted Savings are greater than 10% of the site's Energy, Utility bill analysis is to be used and metering data is to be obtained from Utility bills using single point meter or a combination of multiple point meters. Measurements can be obtained from Tracking system in Post-stage as well<br>Metering Instructions:<br>For both Baseline and Retrofit:<br>*(1) Energy-use Factors' Measurements*<br>Continuous monitoring of input Energy (e.g. kWh, Btu) or Demand (e.g. kW, Btu/hr) for each component affected by the BAS Upgrade. When seasonal variations or scheduled activity affect equipment operation, metering should be conducted during each variation period<br>Metering period should not include vacations or holidays<br>*(2) Other Key Variables, if applicable:*<br>Cooling loads (Tons), Heating loads (MMBtu) |
| **Demand Savings Calculation** | Demand Savings may be available if, for example, the new BAS implements variable speed controls for ventilation fans however, there is high risk of uncertainty. If there is any replacement or modification of existing equipment, it can be applied separately as a different measure.<br>Refer to EM&V's protocol for demand saving definition |
| **Energy Savings Calculation** | Energy Savings can be calculated based on using continuous interval measurements.<br>$kWh_{Savings} = (kW_{Baseline} - kW_{Retrofit})_{metered} \times Logged\ Op\ Hrs$ |
| **Baseline Adjustments** | Baseline Adjustment should be made based on cooling and heating load and operating hours |
| **Methodology Applied for Variable Load** | Variable load exists in BAS projects if they are implemented to enhance cooling/heating fans (variable speed/air flow).<br>For various load, continuous interval measurement or kW at various load from engineering reference and/or manufacturer data should be used.<br>Recorded/measured operating profile to be used as basis to find kW at each representative load. |

**Measure #11 - Lighting Controls LC**

| Required Parameters | M&V Procedures |
|---|---|
| **Existing System Description** | Inventory of lamp/ballast fixture type affected. Baseline information required for each type including fixture, lamp and ballast types, room conditions, usage area designation, operating periods (e.g. common space 24/7; tenant space lease hours), room location and counts of operating and non-operating fixtures and lamps. Spot-metering data for a Baseline sample that is representative of each usage group |
| **Proposed System Description** | Retrofit information required for each lighting type relevant to Project. Operating periods as per post-retrofit lighting controls' settings. Metering data for duration that reflects full operating profile. |
| **Measurement Boundaries** | Measurement boundary should include all the lamps that are retrofitted and controlled by the new lighting controls system |
| **Measurement Conditions** | Readings for retrofitted fixtures should be taken at least 100 hours of burn-in time following their installation. |
| **Sampling** | Baseline fixtures should be grouped into usage groups according to those with similar occupancy areas and/or expected operating hour schedules. At least 6 sample fixtures from each usage group should be subject to metering where measurements are required. |
| **Baseline Period and Reporting Period Duration** | Baseline and Reporting Period duration should span through a full operating cycle. |
| **Metering Requirements** | Refer to EM&V's protocol for demand saving definition. Metering to be conducted for both Fixture wattages to be measured using spot or short-term representative sample of Baseline and post-installation fixtures (if lamps or ballasts are changed) and Operating hours<br>Metering Instructions:<br>For both Baseline and Retrofit:<br>*(1) Metering of Fixture Wattages:*<br>• Requires the use of RMS meter<br>• Continuous monitoring on a sample population within each usage group should be conducted. The readings will be averaged.<br>• Meters used for this task will need to be calibrated<br>*(2) Logging Operating Hours*<br>• Continuous monitoring on a sample population within each usage group should be conducted for a minimum of one weeks or span of full operating cycle.<br>• When seasonal variations or scheduled activity affect equipment operation, metering should be conducted during each variation period. (E.g. summer operating schedules in classrooms).<br>• Metering period should not include vacations or holidays. |
| **Demand Savings Calculations** | Refer to EM&V's protocol for demand saving definition: $kW_{Savings} = kW_{Baseline} - kW_{Retrofit}$ |
| **Energy Savings Calculation** | If Baseline and Retrofit Operating hours are the same:<br>$(1)\ kWh_{Savings} = (kW_{Baseline} - kW_{Retrofit}) \times Stipulated\ Op\ Hrs$<br>If Baseline and Retrofit Operating hours vary:<br>$(2)\ kWh_{Savings} = (kW \times Op\ Hrs)_{Baseline} - (kW \times Op\ Hrs)_{Retrofit}$<br>Baseline and Retrofit hours of operation should be logged to establish an operating schedule for each usage group.<br>$Stipulated\ Op\ Hrs = \frac{Fixtures\ ON\ during\ Metering\ Period\ (hrs)}{Length\ of\ Metering\ Period\ (hrs)} \times 8760\ \frac{hrs}{year}$ |
| **Baseline Adjustments** | Baseline Adjustments are required in the case that there are non-operating fixtures in the Retrofit stage that were normally operating or are intended for operation (e.g. typically operating fixtures that are intended for repair). A de-lamped fixture is not considered a non-operating fixture |

| Required Parameters | M&V Procedures |
|---|---|
| | Lighting levels are to be assessed before applying Baseline adjustments |

**Measure #12: Other Custom Measures OCM**

M&V for Other Custom Measures must adhere to the principles described in the IPMVP Core Concepts March 2022 or later. M&V should be consistent with the principles described herein, to the extent applicable. Generic Large Custom Project M&V Plan template can be found in Appendix C.

# APPENDIX C: Large Custom Project M&V Plan Template

| **1.0 General** |
|---|
| 1.1 Application Identifier |
| Building Name:<br>Building Address:<br>Building Type:<br>Application #: |
| 1.2 Facility and Project Overview |
| Provide an overall description of the facility including approximately square footage, number of floors, type of facility (e.g. office, warehouse, etc.) and occupancy schedule, and the proposed project along with a list of all the energy efficiency measures that are included as part of the project. This section should also include references to any relevant energy audit reports of other analyses used to develop the project.<br><br>*Note: This will help the reviewer to evaluate the appropriateness of the M&V plan, given the size and complexity of the facility.* |
| 1.3 Timelines and Dates |
| Details of project timelines and milestones and document dates such as:<br>Estimated Start Date:<br>Estimated Completion Date:<br>Estimated In-Service Date:<br><br>Note: Actual Start Date, Actual Completion Date and Actual In-Service Date should be reported in the final M&V Savings Report |
| **2.0 Intent of Energy Efficiency Measures** |
| At a minimum, this section should include:<br>- A detailed description of the measure.<br>- How the measure saves energy, demand, or other resources (e.g., improves efficiency, reduces operating hours, etc.).<br>- The measure's effect on operational factors such as temperature set points, hours of operation, etc., and if the measure will correct any operational deficiencies.<br>- An inventory of impacted equipment.<br>- Expected savings estimated in energy units and the source of the estimate. |
| **3.0 Selected IPMVP Option and Measurement Boundary** |

## 1.0 General

Specify which IPMVP option will be used to determine savings. Clearly identify the measurement boundary of the savings determination. The boundary may be as narrow as the flow of energy through a pipe or wire, or as broad as the total energy use of one or many facilities. Describe the nature of any interactive effects beyond the measurement boundary together with their possible effects on project savings. Quantified interactive effects should also be included in this section with appropriate justification.

Identify (IPMVP) – Core Concepts March 2022 EVO 10000 – 1:2022, M&V Option that will be used for determining the energy and demand savings including brief justification* for the selection of this M&V Option. (Check one box only)

☐ Option B Retrofit Isolation: All Parameter Measurement

☐ Option C Whole Facility: Utility Bill Analysis

☐ Option D Calibrated Simulation:

**For example, M&V Option B Retrofit Isolation is chosen for this lighting controls retrofit project because it involves only one energy efficiency measure – lighting controls, which retrofit isolation allows the narrowing of the measurement boundary in order to reduce the effort required to monitor independent variables and static factors, when retrofits affect only a portion of the facility.*

## 4.0 Baseline: Period, energy and conditions

Document the facility's baseline conditions and energy data, within the measurement boundary. This baseline documentation should include:

a) identification of the baseline period;
b) baseline energy consumption and demand data;
c) independent variable data coinciding with the energy data (e.g., production data, ambient temperature);
d) static factors coinciding with the energy data;
    1) occupancy type, density and periods;
    2) operating conditions for each baseline operating period and season, other than the independent variables;
    3) description of any baseline conditions that fall short of required conditions;
e) details of adjustments that are necessary to the baseline energy data to reflect the energy management program's expected improvement from baseline conditions;
f) size, type and insulation of any relevant building envelope elements such as walls, roofs, doors, windows;
g) equipment inventory;
h) equipment operating practices;
i) any design, install, calibrate, and commission and any special measurement equipment that is needed under the plan;
j) Significant equipment problems or outages during the baseline period.

The baseline documentation typically requires well-documented short-term metering activities. The extent of this information is determined by the measurement boundary chosen or the scope of the savings determination. If the whole-facility M&V methods are employed, all facility equipment and conditions should be documented.

## 1.0 General

## 5.0 Operational Verification Requirements

Specify the operational verification activities that are required after the energy efficiency measure installation to confirm the installation is complete, meets specifications, and has the potential to save energy as expected. This section should include:

- What data will be collected to confirm the energy efficiency measure us properly installed and meets the EEM's intent.
- Who is responsible for conducting these verification activities.
- If these activities are to be repeated during the reporting period, when and by whom
- What will be reported regarding the verification activities conducted.

## 5.0 Reporting Period

Identify the reporting period for which the measure or a project is being evaluated. The reporting period is a selected interval for evaluating and quantifying the post-installation performance of the measure. Where the baseline period and reporting period are not of the same length, explain how the time frames are normalized so the baseline and reporting energy consumption and demand are compared evenly and reliably.

## 6.0 Basis for Adjustment

Provide details on how the baseline and/or reporting period energy consumption and demand will be adjusted to allow for valid saving calculations. The method for making routine adjustments (e.g. forecasting, backcasting, or adjusting to standard conditions), the conditions selected for the basis for adjustment, and the type of savings to be reported (i.e. avoided energy use or normalized energy savings) should be specified.

Details any non-routine adjustments required to be the baseline to adjust for deficiencies in the baseline operating conditions. Provide a description of the criteria and methods for identifying a validating non-routine events and for making relevant non-routine adjustment to account for unexpected changes in the static factors during the reporting period. State criteria for when non-routine events will be evaluated and adjustments will be required to properly determine savings. Describe methods that will be used in making any non-routine adjustments in referencing specific procedures from IPMVP's Application Guide on Non-Routine Events and Adjustments. All Non-Routine Events (NREs) & Non-Routine Adjustments (NRAs) should be performed in accordance to the IPMVP Application Guide on Non-Routine Events & Adjustments October 2020 EVO 10400 – 1:2020

## 7.0 Calculation Methodology and Analysis Procedure

Specify data analysis procedures, model descriptions, and assumptions that are used to calculate savings for the reporting period. The IPMVP savings equation(s) use should be included. For each model used, identify and define all independent variables, and other model-related terms. Report all coefficients and constants, as well as statistical metrics CVRMSE, MBE, $R^2$, t-statistics for independent variables and other model elements or terms. Report the range of independent variable over which a model is valid.

## 8.0 Meter Details

## 1.0 General

Specify the details for collecting each point that will be sued as M&V data, including spot and continuous metering of energy or key parameters. For non-utility meters, specify:

- Meter specification including type, make, model as well as the range, resolution, accuracy and precision of readings.
- Data to be collected, formats, and related responsibilities.
- Meter reading and witnessing protocol if required.
- Meter commissioning or calibration procedures.
- Details for data collection and transfer.
- Method of dealing with lost data and data transfer.

## 9.0 Monitoring and Reporting Responsibilities

State responsibilities for collecting, analysing, archiving and reporting the data. Management of M&V data should be assigned to the party that is qualified to efficiently and effectively access, manage, and proved data sets. Responsibility should include as a minimum.

- Acquisition of energy and independent variable data.
- Management of measurement equipment and systems.
- Monitoring of static factors impacting energy use with the measurement boundary.
- Operational verification and periodic inspections.
- Analysis and retention of acquired data.
- Preparation for the publication of the M&V Reports.

Identify those individuals that are responsible for conducting M&V activities and prepared the M&V report (analyses and documentation).

| | |
|---|---|
| Name: | |
| Title: | |
| Company: | |
| Email Address: | |
| Phone: | |
| Address: | |

## 10.0 Expected Accuracy

Provide the expected accuracy of the reported energy savings. Describe sources of uncertainty in the savings such as measurement, data capture, sampling, modeling and data analysis, and describe uncertainty assessment to be used in the planned savings report. The assessment should include qualitative and any feasible quantitative assessment related to the level of uncertainty in the savings. Report all sources of uncertainty in savings, information on the source of uncertainty, the expected direction, and the magnitude of impact on savings. In some cases, estimate of the uncertainty in savings may be required.

## 1.0 General

## 11.0 M&V Savings Report format

The M&V Plan should include the format and contents for reporting the M&V results during the reporting period. The M&V Savings Report should include as a minimum, the following information:

- Overview of the M&V Report
- Project background
- M&V data collection activities conducted during current reporting period
- Savings calculations and methodology
- Verified savings
- Additional information required

*Note: Refer to IPMVP Core Concepts March 2022 EVO 10000 – 1:2022 Section 13.3 M&V Reporting Requirements*

## 12.0 Quality Assurance

Specify quality-assurance procedures and processes that will be used in baseline and post-retrofit data collection, calculations, saving reports, and any interim steps in preparing reports. Quality assurance procedures should include inspections at regular frequencies to ensure that the measure and equipment continue to be operated as intended and methods of dealing with lost or missing data. Other activities may include third-party oversights or review and calculating uncertainty in savings.