



## 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 Efficiency: Equipment Replacement Incentive Initiative 2011 – 2014 are installed and resulting in Energy Savings and Demand Savings.

This protocol will assist the LDC and their Project Evaluators as well as 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 conservation measure.

### 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) Volume 1 – Concepts and Options for Determining Energy and Water Savings as in effect from time to time. See [www.evo-world.org](http://www.evo-world.org)

Four generic 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 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** the primary considerations are:

1. Is the 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 load.

Where operating hours are constant, stipulated values can be applied, subject to validation. Where operating hours are variable, short term or continuous measurement may be required.



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) are 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 conservation Measures (ECMs)**, where three 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 will 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. (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 Efficiency: *Equipment Replacement Incentive Initiative 2011 - 2014*:

- 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 Savings. However the determination of Energy Savings will be of secondary importance for measures that attract a Demand Savings incentive.
- 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 by Eligible Measure

The following table 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 maximum reduction in electricity demand between the Base Case and the Energy Efficient Case occurring in the same hour between 11 am to 5 pm on business days, May through October. For Measures that are weather dependent, Demand Savings shall be considered as occurring at peak design load conditions.

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

Generally,

**'Basic'** M&V will be used for Large Project that include Custom Measures with estimated Participant Incentives greater than \$10,000 and equal to or lesser than \$25,000.

**'Enhanced'** M&V will be used for Large Custom Projects. Large Custom Project means a Project with Custom Measures that has an estimated Participant Incentive greater than \$25,000.

The table below identifies the Project M&V Procedure to be used dependent on the Custom Measure Type and whether Basic or Enhanced M&V is required.

Custom Measure Type	M&V Procedure	
	<i>'Basic'</i>	<i>'Enhanced'</i>
Lighting Retrofit	LR-B	LR-E
Equipment Replacement	ER-E	ER-E
HVAC Re-Design	HVAC-E	HVAC-E
Variable Speed Drives (VSDs)	VSD-B	VSD-E
Building Envelope	BE-B	BE-E
Building Automation Systems (BAS)	BAS-B	BAS-E
Lighting Controls	LC-B	LC-E
Sub Metering	SM-E	SM-E
Deep Lake Water Cooling	DLWC-E	DLWC-E
Ground Source Heat Pumps	GSHP-E	GSHP-E
Other Custom Measures	OCM-E	OCM-E
Power Conditioning Devices	PCD-E	PCD-E
Elevator Retrofit	ELR-E	ELR-E
Elevator Controls	ELC-E	ELC-E



The following sections identify Project M&V Procedures by Custom Measure type in accordance with the table above.

### 1. Lighting Retrofit

- These Projects are likely to claim a Demand Savings incentive (\$/kW) as load is constant when operating
- Stipulation of operating hours for determination of Energy Savings is acceptable, subject to validity checks.
- The same procedure identified below applies to both Demand Savings and Energy Savings incentive Measures.
- Where there are different lamp types being employed in a given fixture, the default baseline condition will generally be the lowest wattage value.

#### **LR-B: 'Basic' M&V:**

- Baseline wattage established from industry references to the various lamp/ballast types installed.
- Post-retrofit wattage is to be established from manufacturer's data sheets (to be provided with application) and/or industry references.

#### **LR-E: 'Enhanced' M&V:**

- Provide same information as LR-B above, as well as the following information:
  - Spot measurement Root Mean Square (RMS) wattage readings for a minimum of 6 randomly selected lighting fixtures of each type of lamp/ballast combination for both baseline and post-retrofit conditions.
  - Post retrofit measurements must allow for a minimum 100 hours of burn-in
  - (Note: Applicants must be prepared to demonstrate wattage readings during site inspections by the Project Evaluator).

NOTE: Both LR-B and LR-E require the Participant to provide detailed site surveys that include:

- Inventory of lamp/ballast fixture type by area
- Usage area designation and operating periods (e.g. common space 7x24; tenant space – lease hours).
- Counts of operating and non-operating fixtures and lamps

### 2. Equipment Replacement: Chillers, Motors, Refrigeration

- These Projects may claim either a Demand Savings incentive (\$/kW) or an Energy Savings incentive (\$/kWh).
- Whether load is constant or variable refer to manufacturers' data, 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, baseline and proposed post-retrofit, showing quantities, thermal and electrical ratings.



**ER – B: ‘Basic’ M&V**

Chillers and Refrigeration:

- Demand Savings determination:
  - o 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), the baseline equipment will be assumed to operate at 80% of the nameplate capacity of the retrofit equipment.
- Energy Savings determination:
  - o Use stipulated values 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.

**ER – E: ‘Enhanced’ M&V:**

Chillers and Refrigeration:

- Demand Savings determination:
  - o Baseline and post retrofit performance is to be measured at current peak design load. This is to reflect design load for the facility, not 100% capacity of the equipment. Measurements are to be made at three different times and averaged. Measurements may be normalized to design temperature conditions. If equipment capacity is to be changed, apply the baseline tonnage for both measurements. If Amperage measurements are used they must be referenced to manufacturers’ performance data sheets showing amps vs. tonnage load.
  - o In the absence of measured performance data the default assumption will be 60% of retrofit equipment nameplate rated load.
- Energy Savings determination:
  - o Baseline and post retrofit performance is to be measured at representative distributed load levels spanning total design loads, multiplied by stipulated operating hours at each point.

Motors:

- Demand Savings determination:
  - spot or short term measurements of kW input and power factor.
- Energy Savings determination:
  - o Energy Savings = Demand Savings x stipulated operating hours



- if variable load, measure kW input and power factor at representative load levels, and stipulate operating hours at each level.
- Measurements shall be made on not less than 20% of a sample population and load of comparable equipment.

### 3. HVAC Redesigns (all require 'Enhanced' M&V)

#### **HVAC – E: 'Enhanced' M&V**

- These Projects may claim either a Demand Savings incentive (\$/kW) or an Energy Savings incentive (\$/kWh)
- Review of baseline conditions, including short-term measurement, reference to engineering estimates.
- Engineering review and validation of proposed changes, subject to spot or short-term measurement for post-retrofit conditions.
- Provide proposed M&V plan, consistent with IPMVP protocols.
- Component measures within the HVAC Re-design are to be considered separately and in isolation, to the extent practical.

### 4. Variable Speed Drives (VSDs)

- These Projects are likely to claim an Energy Savings incentive (\$/kWh)
- Load is likely constant for baseline, variable (by definition) post retrofit.
- Refer to manufacturers' data, industry references, for kW ratings at various load points.

#### **VSD – B: 'Basic' M&V**

- 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.

#### **VSD – E 'Enhanced' M&V**

- Spot or short-term measurements to establish operating load profile for baseline and post-retrofit conditions.
- Participant should ensure comparable operating conditions for both baseline and post-retrofit measurements.
- Measurements shall be made on not less than 10% of a sample population and load of comparable equipment and operating profiles.

### 5. Building Envelope

- These Projects may claim either a Demand Savings incentive (\$/kW) or an Energy Savings incentive (\$/kWh)
- Involves consideration of cooling efficiency in assessing summer savings.
- Refer to manufacturers' data, industry references, for thermal or leakage properties.

#### **BE – B: 'Basic' M&V**

- Stipulated values for cooling 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.



**BE- E: 'Enhanced' M&V**

- Refer to ER- E for determination of cooling kW/ton
- Use hour-by-hour annual whole building energy simulation model for Energy Savings, calibrated against whole building metered data for electricity used in the building. (Peak month only for kW). Simulations should demonstrate solar effects and coincident loading for all orientations.
- Detailed models as provided by manufacturers or by the Applicant that account for glazing types and orientation are acceptable in the absence of simulation models for the specific facility.
- Blower door tests are required to demonstrate infiltration reduction

**6. Building Automation System (BAS)**

- These Projects are likely to claim an Energy Savings incentive (\$/kWh)
- Recognized as inherently uncertain.
- May be a new BAS installation or an enhancement of an existing system.

**BAS – B: 'Basic'**

- 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.
- Discount savings that have supporting baseline data by 25%
- Discount savings that have no supporting baseline data by 50%

**BAS – E: 'Enhanced'**

- Spot or short-term measurements, during the summer season, to substantiate operating profile and set points (baseline and post-retrofit) in a sample of loads.
- Discount savings that can be spot tested by 25%
- Discount savings that cannot be spot tested by 50%

**7. Lighting Controls**

- These Projects are likely to claim an Energy Savings incentive (\$/kWh)
- Recognized as inherently uncertain.
- May be a new installation or an enhancement of an existing system.

**LC – B: 'Basic' M&V**

- 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.
- Discount savings that have supporting baseline data by 25%
- Discount savings that have no supporting baseline data by 50%

**LC – E: 'Enhanced' M&V**

- Spot or short-term measurements, during the summer season, to substantiate operating profile and set points (baseline and post-retrofit) in a sample of loads representing not less than 10% of similar circuits.





- Discount savings that can be spot tested by 25%
- Discount savings that cannot be spot tested by 50%

### 8. Tenant Sub-Metering

- These Projects are likely to claim an Energy Savings incentive (\$/kWh)
- Recognized as inherently uncertain.
- Note that there is only one M&V procedure ('Enhanced') that applies to all projects regardless of size. This differs from other Measures in that an initial incentive payment is determined following implementation, with opportunity for additional incentives based on subsequent results achieved.

Savings will be determined according to metered tenant load that is subsequently cost allocated as a result of sub-meter installation. Unoccupied floor space shall not be considered.

#### **SM – E: 'Enhanced' M&V:**

Provide detailed description of:

- Loads that are proposed to be sub metered
- Details of the tenant billing procedure.
- Description of planned tenant education and engagement activities to support the reduction of discretionary tenant energy usage.
- Preliminary estimate of metered tenant load, including assumptions.
- Actual metered tenant load shall be determined from measurements of at least one month duration following implementation. The initial incentive payment will be based on 5% of this value.

Following an implementation period of not less than 6 months, provide:

- Description of tenant engagement experience and supporting metering of tenant usage over the period.
- A calculation of savings, based on the minimum 6 month engagement period, properly reconciling for vacant space and material changes to energy consuming equipment.
- The incremental payment will be made based on the difference between the post 6-month calculations of savings less the initial 5% payment. There will be no claw back of the initial 5% payment. Discount of incremental savings will be from 0-50% depending on the duration of measurement and quality of data and presentation.

### 9. Deep Lake Water Cooling (all require 'Enhanced' M&V)

- These Projects are likely to claim a Demand Savings incentive (\$/kW)

#### DLWC – E: 'Enhanced' M&V

- Rigorous review of existing chiller operations, including peripherals (cooling tower, condenser pumps): kW/ton, peak loading, equivalent run-hours. Reference to industry norms, manufacturer's data, and sub-metering data where available. Utilize billing data and interval data for validation where possible.
- Savings will be discounted by a stipulated value to account for energy requirements in the delivery of DLWC.
- The Participant has the option to use actual measured tons and ton-hours post retrofit to confirm final savings.





## 10. Ground Source Heat Pumps (all require 'Enhanced' M&V)

### GSHP – E: 'Enhanced' M&V

- Provide details of existing cooling plant operations, and (if applicable) existing electric heat operations. – system type, capacities.
- Provide load calculations as applicable to support the selection of ground source heat equipment.
- Provide equipment details regarding the new ground source heat pump equipment and expected operation, specifically including the installed tons of cooling capacity.

## 11. Other Custom Measures (all require 'Enhanced' M&V)

### *Other Custom Measures – E: 'Enhanced' M&V:*

M&V for Other Custom Measures must adhere to the principles described in the IPMVP Volume 1, 2002 or later. M&V should also be consistent with the principles described here as applying to the Equipment Replacement Incentive Initiative 2011 – 2014 and consistent with Measure specific M&V procedures as described here, to the extent applicable.

## 12. Power Conditioning Devices (all require 'Enhanced M&V')

### *PCD – E: 'Enhanced M&V:*

This procedure addresses the application of power conditioning devices that are connected either directly at end-use equipment or at a distribution panel or service entrance serving multiple end use loads and/or circuits.

Power conditioning devices are employed to provide operational benefits and cost savings through techniques such as voltage regulation, power factor correction, reduction of harmonic content, and elimination of electrical transients.

While tangible operational benefits can result from employing such devices, it must be noted that the Equipment Replacement Incentive Initiative 2011 – 2014 only provides incentives for quantifiable energy reductions and/or peak demand reductions measured as real power (kW) or energy (kWh). To confirm, savings in reactive power (kVar) or apparent power (kVA) are not eligible for incentives.

Savings attributable to the application of power conditioning equipment are considered to be specific to the end use equipment and its operating characteristics, and the local electrical environment.

An ideal M&V approach is to assess the energy usage of given end-use equipment, both with and without the application of the power conditioning device, under identical operating conditions.



In practice, comparing under identical operating conditions may not be practical due to normal variations in equipment loading and electrical supply conditions.

Recognizing this inherent variability, the M&V procedure for Power Conditioning Devices is designed to minimize the effects of variability by employing successive measurements with the power conditioning device activated and not activated ( i.e. 'On-Off') over a period of time.

Specific procedures are as follows:

- Measurements of real power (kW) shall be taken with a three-phase power analyzer capable of recording at a minimum of 128 samples per cycle, and calibrated to within +/- 1% of reading accuracy.
- Measurements shall be taken on the load that is subject to the application of the power condition device under typical operating conditions, with a minimum of expected variability.
- Measurements shall be recorded for successive 15 minute intervals of the power conditioning device being activated and not activated. These recordings shall occur over a period of a minimum of 4 hours duration, over which time there shall be a minimum of 8 fifteen minute periods of the power conditioning device being both activated and not activated.
- Energy (kWh) Savings for the measurement period shall be assessed as the difference between the cumulative recorded energy in each of the 'on' and 'off' intervals. Annual energy savings shall be considered as the % energy savings during the measurement period multiplied by the annual consumption of the measured circuit/application. Annual consumption can be estimated by extrapolating from recorded energy usage of minimum 1 week duration.
- Demand (kW) Savings, if they are to be considered, shall be assessed as the difference in average demand in each of the 'on' and 'off' recorded intervals. Average demand is to be calculated as total cumulative energy in kWh divided by total hours for intervals in which the power conditioning device is activated, and not activated, respectively. Note that for demand savings to be considered the measurements shall be taken on business days during the hours of 11 a.m. to 5 p.m. June through September and the application must be considered to be operating routinely during such times.
- Where multiple Power Conditioning Devices are employed the sample size for measurement shall be 20% of the equipment operating under like conditions.

Savings shall not be extrapolated to alternate operating conditions without measurement under such conditions.

### 13. Elevator - Retrofit (Motors & VSD)

- These Projects may claim either a Demand Savings incentive (\$/kW) or an Energy Savings incentive (\$/kWh)
- Demand Savings:
  - Use stipulated values for efficiency and power factor, at 80% load, using manufacturer ratings.
- Energy Savings = Demand savings x stipulated operating hours
- Load is likely constant for baseline, variable (by definition) post retrofit.
- If variable load, stipulate efficiency and power factor at representative load levels, and stipulate operating hours at each level.

Refer to manufacturers' data, industry references, for kW ratings at various load points



**ELR – E: ‘Enhanced’:**

Elevator modifications (where only variable speed drives are added or elevator motors are replaced), are classified as Elevator Retrofit (ELR), and should follow VSD or ER methods, respectively.

In addition to the requirements of VSD or ER methods:

- For Basic methods the Demand Savings shall be computed to reasonably reflect the likely elevator operating profile on business days during the hours of 11 a.m. to 5 p.m. June through September.
- For Enhanced methods, continuously record the electricity use of all affected equipment for duration sufficient to establish an operating profile, minimum of 24 hours, for both baseline and retrofit conditions. Provide evidence that building occupancy was similar for the two test periods, and how they might be different for normal summer occupancy. Recordings shall show power draw averaged over one hour intervals. These recordings shall be used:
  - for kW calculations, to determine the measured electrical demand that occurs during typical summer peak periods on the associated utility meter; and
  - for kWh calculations, to support the stipulation of annual motor operating hours for each representative load level, with due consideration of operating profile during off peak periods.

**14. Elevator - Controls**

- These Projects may claim either a Demand Savings incentive (\$/kW) or an Energy Savings incentive (\$/kWh)
- Demand Savings determination:
  - Use stipulated values for efficiency and power factor, at 80% load, using manufacturer ratings.
- Energy Savings determination:
  - Energy Savings = Demand Savings x stipulated operating hours

All other types of elevator modifications, including elevator replacement, are classed as Elevator Controls (ELC), and recognized as inherently uncertain. Due to the variability in elevator usage and the lack of established information on which to base assumed usage profiles, no Basic method is available.

**ELC – E: ‘Enhanced’ (for all sizes of elevator control projects)**

- Describe the normal weekly elevator usage profile, and the baseline and post-retrofit control logic.
- Continuously record the electrical load of all affected equipment for one week that is representative of normal operation, under both baseline and retrofit conditions. Where multiple, identical elevators exist measurements shall be made on not less than 10% of the sample population. Electrical recordings shall show power draw averaged over one hour intervals. These recordings shall be used:
  - to determine the kW impact of the retrofit during peak daytime hours.; and
  - to determine the weekly change in total kWh, which must then be adjusted for any changes in relevant occupancy conditions, and projected to annual kWh savings.



- For the period of the electrical logs, provide information to demonstrate that occupancy was normal or at least the same during the two periods. Also provide logs to show that the baseline and control logic remained in place throughout the respective period