

## Introduction

Step 8 in the MBR process is Monitoring and Verification, a strategy that involves:

- Monitoring utility consumption and costs for management control and savings verification
- Reporting on savings.

It is important to note that, while Monitoring and Verification is addressed in Step 8, this function is first considered in the Feasibility Stage (Step 6 of the MBR process). There, it is recognized that planning for the savings verification strategy needs to be carried out as an element of overall project planning at the point where specific measures are being defined, well before construction and/or the implementation of measures actually occurs.

A savings verification strategy helps to ensure that predicted savings are achieved by improving savings opportunity selection. It also helps to reduce financing costs because it can enhance the confidence of lenders that predicted savings will be achieved. Monitoring and Verification also creates a management information process that contributes to ongoing energy management as an organizational priority.

Depending on the implementation option chosen for the project, savings verification may be done using internal or external resources. If the latter, the energy performance contractor or energy services company (ESCO) will typically include this function within the bounds of the contract. Alternatively, consulting firms that offer savings verification services can be employed regardless of the implementation strategy choice.

In any case, it is essential that the municipality be cognizant of verification issues throughout the planning process, and that, at least, it have the capability of reviewing and validating the verification strategy. Because of the critical importance of planning for savings verification concurrent with project planning, this section of the MBR Guide provides planning templates for the verification strategy as well as ongoing energy performance reporting.

### **Working Definitions**

It is important to distinguish among the various related functions involved in utility monitoring and savings verification. Working definitions that are generally accepted are the following:

**Measurement**, as in Measurement & Verification, is a process of quantifying energy consumption before and after an energy conservation measure (ECM – also referred to in other MBR documents as an energy-efficiency measure or EEM – ECM is used in this section) and is implemented in order to verify and report on the level of savings actually achieved.

**Energy Monitoring, Targeting and Reporting** are management techniques that can, and should, be utilized with or without specific facility retrofits in order to keep operations efficient and to monitor utility costs. These strategies are designed to drive energy costs downwards as a continuous improvement cycle.

**Energy Monitoring** is the regular collection of information on energy use. Its purpose is to establish a basis of management control, to determine when and why energy consumption is deviating from an established pattern, and as a basis for taking management action where necessary. Monitoring is essentially aimed at preserving an established pattern.

**Targeting** is the identification of levels of energy consumption, which is desirable as an ongoing management objective.

**Reporting** “closes the loop” by putting the management information generated from monitoring into a form that enables ongoing control of energy use, the setting and achievement of reduction targets, and the verification of savings.

### **Purpose**

The central purpose of Monitoring and Verification in the context of a municipal building retrofit project is to verify the energy savings achieved, either to satisfy internal financial accounting and reporting requirements, or to meet the terms of third-party contracts for project implementation and management, including energy performance contracts.

A secondary, although in the long term no less important, purpose of the techniques associated with Monitoring and Verification is to ensure that savings are maximized and sustained through ongoing management control of the use of energy (and perhaps other utilities such as water), a technique known as energy monitoring and targeting (M&T).



### Team/Partnership

The implementation strategy employed defines the roles of the parties involved in the project. The internal project team has a critical role to play and may include one or more of the following:

- Planning the Monitoring and Verification process
- Overseeing the implementation of the plan once the project has been constructed
- Reviewing and validating the plan developed by an ESCO or other external consultant
- Reviewing and distributing verification reports.

If savings verification is to be undertaken with internal resources, appropriately skilled staff from the engineering or works departments is likely to be involved. Alternatively, external partners at this stage of the project may be an ESCO or savings verification consultants.



### Information Requirements

Identify and select adjustments to be used for the baseline performance and define how they will be carried out.

Identify measurements to determine post-installation performance and define how they will be carried out.



### Action Items

Prepare Monitoring and Verification plan.



### Templates

Monitoring and Verification Planning Checklists  
 Preliminary Feasibility Study  
 Detailed Feasibility Study  
 Monitoring and Verification Planning Template



### Next Steps

If your Project Proposal identified a multi-phased approach you should now move on to the next phase.



### FCM Support

The one-day workshop entitled *Monitoring and Verification for Municipal Governments* is available through FCM, and develops a working knowledge of the techniques involved in energy monitoring, targeting and reporting for management control and savings verification. It focuses specifically on the principles of savings verification, Monitoring and Verification option selection, and planning.

## Planning and Implementing Monitoring and Verification

### General Approach to Monitoring and Verification

In principle, Monitoring and Verification simply quantifies energy savings by comparing consumption before and after the retrofit. The “before” case is defined as the “baseline performance,” and the “after” case is referred to as the “post-installation period.”

In its simplest form,

$$\text{Savings} = (\text{Baseline energy use})_{\text{adjusted}} - (\text{Post-installation energy use})$$

The complicating factors concern:

- What adjustments to the baseline performance are required and how are they carried out
- What measurements are required to determine post-installation performance, and how are they carried out.

The International Performance Measurement & Verification Protocol (IPMVP), published by the U.S. Department of Energy defines four approaches to Monitoring and Verification (Options A, B, C and D) that determine how these factors are addressed. A critical decision in Monitoring and Verification planning is the selection of one of these options. The IPMVP Guide is available on the Resource Manual on the accompanying CD ROM, or on the Knowledge Network at: <http://kn.fcm.ca>.



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### Monitoring and Verification Options

IPMVP Monitoring and Verification Options A, B, C and D are summarized in Table 8.1. They differ from one another in terms of:

- The degree to which the retrofit can be measured separately from other facility components
- The extent to which performance variables can be measured.

**Option A** applies to a retrofit or system level assessment where performance or operational factors can be spot- or short-term measured during the baseline and post-installation periods. Factors that cannot or are not measured are “stipulated,” based on assumptions, analysis of historical performance, or manufacturers’ data. Stipulation is the easiest and least expensive method of determining savings, but is also subject to the greatest level of uncertainty.

**Option B** applies to a retrofit or system level assessment where performance or operational factors can be spot- or short-term measured at the component or system level during the baseline and post-installation periods. In this option, the performance of the retrofit can be measured separately from other measures or performance factors. No factors are stipulated, and consequently, Option B involves more end-use metering than Option A and is correspondingly more expensive but not as subject to uncertainty.

**Option C** applies to the impact of a “bundle” of retrofit measures on a facility. It relies on baseline and post-installation total building energy performance data typically obtained from the utility meter at the service entrance, and involves regression analysis against independent performance variables such as weather factors, facility usage, or production (as in water pumping stations or wastewater treatment facilities).

**Option D** uses computer simulation models of component or whole-building energy consumption to determine project energy savings. Simulation inputs are linked to baseline and post-installation conditions. Some of these inputs may be determined from performance metering before and after the retrofit. Long-term whole-building energy use data may be used to calibrate the simulation models.

### Monitoring and Verification Option Selection

The selection of an Monitoring and Verification method is based on:

- Project costs
- Expected savings
- Complexity and number of measures installed
- Anticipated changes to post-installation facility or system usage
- Tolerance for uncertainty or risk of savings being achieved
- Risk allocation between the owner and the contractor

There is a trade-off between the cost of doing Monitoring and Verification and uncertainty. In general, the lower the acceptable level of uncertainty, the higher the cost. For example, a project with anticipated annual savings of \$500,000 and an estimated uncertainty of 20 per cent has a savings risk of \$100,000. If a Monitoring and Verification program costing \$25,000 can reduce that risk to 10 per cent or \$50,000, there is a cost/benefit ratio of 2/1 for the Monitoring and Verification program that may be deemed a good investment. This kind of analysis needs to be done to evaluate the cost of reducing risk.

Figure 8.1 is a selection model for choosing the Monitoring and Verification Option that takes into account the selection criteria listed above, and should be used either to select the best option for internal implementation, or to validate the method selected by an ESCO or external consultant.

**Table 8.1: Overview of Monitoring and Verification Options**

Source: U.S. Department of Energy, *Monitoring and Verification Guidelines: Measurement and Verification for Federal Energy Projects*

Monitoring and Verification Option	Performance and Operation Factors <sup>1</sup>	Savings Calculation	Monitoring and Verification Cost <sup>2</sup>
<b>Option A – Stipulated and measured factors</b>	Based on a combination of measured and stipulated factors. Spot- or short-term measurements are taken at the component or system level. The stipulated factor is supported by historical or manufacturers' data.	Engineering calculations, component, or system models.	Estimated range is one per cent - three per cent. Depends on number of points measured.
<b>Option B – Measured factors (retrofit isolation)</b>	Based on spot- or short-term measurements taken at the component or system level when variations in factors are not expected. Based on continuous measurements taken at the component or system level when variations are expected.	Engineering calculations, components, or system models.	Estimated range is three per cent - 15 per cent. Depends on number of points and term of metering.
<b>Option C – Utility billing data analysis (whole building)</b>	Based on long-term, whole-building utility meter, facility level, or sub-meter data.	Based on regression analysis of utility billing meter data.	Estimated range is one per cent - 10 per cent. Depends on complexity of billing analysis.
<b>Option D – Calibrated computer simulation</b>	Computer simulation inputs may be based on several of the following: engineering estimates, spot-, short-, or long-term measurements of system components, and long-term, whole-building utility meter data.	Based on computer simulation model with whole-building and end-use data.	Estimated range is three per cent - 10 per cent. Depends on number and complexity of systems modelled.

<sup>1</sup> Performance factors indicate equipment or system performance characteristics such as kW/ton for a chiller or watts/fixture for lighting. Operating factors indicate equipment or system operating characteristics such as annual cooling ton-hours for chillers or operating hours for lighting.

<sup>2</sup> Monitoring and Verification costs are expressed as a percentage of measure or project energy savings.

*Notes to Table 8.1**1. Option A – partial retrofit isolation with stipulation – is best used when:*

- The magnitude of savings is relatively low for the entire project or the portion of the project to which this Monitoring and Verification Option is applied, or*
- The risk of not achieving projected savings is low, or ESCO payments are not directly tied to the actual savings.*

*2. Option B – retrofit isolation – is typically used when:*

- Energy savings from equipment replacement projects are less than 20 per cent of the total facility energy use,*
- Energy savings arising from individual measures must be determined,*
- Interactive effects of multiple measures are deemed unimportant,*
- The independent variables that affect energy use – for example, operating schedule – are neither complex nor difficult to monitor, or*
- Sub-meters already exist to measure the energy use of the systems being considered for retrofit.*

*3. Option C – whole building, billing analysis – is used when the retrofit project is complex and/or involves a number of systems:*

- Predicted energy savings are relatively large (greater than 10 per cent to 20 per cent of total facility energy use),*
- The measurement of energy savings arising from individual measures is not required,*
- Interactive effects of multiple measures are to be included in the analysis, or*
- The independent variables that affect energy use may be complex, and are difficult or expensive to monitor.*

*4. Option D – calibrated simulation – is used in situations similar to Option C, or when:*

- New construction projects are involved (i.e., there is no historical data for baseline determination),*
- Energy savings per measure are required, or*
- Option C tools cannot assess particular measures or their interactions when complex baseline adjustments are anticipated.*

**Figure 8.1: Monitoring and Verification Option Selection Model****Baseline Definition**

The definition of the baseline conditions involves not only quantifying energy consumption data, but also specifying those factors that affect energy consumption. Data and information required for a complete baseline definition include:

Energy consumption data:

- Electricity consumption information – bills and derived information (kW, kVA, PF), meter readings (especially for subsystem measurements), demand profiles
- Fuel consumption information – bills, monthly consumption profiles, fuel-by-fuel data (quantity, calorific value of fuels consumed, etc.)
- Water consumption information
- Other energy sources, e.g., purchased steam, etc.

Independent variable data:

- Weather factors – HDD or CDD
- Facility occupancy or usage data – operating hours, number of patrons, etc.
- Throughput or production – as in volume of water pumped or wastewater treated
- Space conditions – set points on heating/cooling systems
- Equipment malfunctions – records of outages.

**Baseline Adjustments**

The fundamental relationship for savings verification includes adjustments of the baseline performance. Baseline adjustments potentially represent the most contentious aspect of energy performance contracts and may be the most difficult aspect of savings verification to quantify. Simply put, adjustment places the baseline energy performance on a level playing field with post-installation performance in terms of those independent variables that affect energy consumption.

As part of their Monitoring and Verification plan ESCOs must specify how they will adjust the baseline if the post-installation operating conditions are different from those used to determine the baseline. These specifications should address the independent variables listed above, as relevant to the project.

The following are examples of baseline adjustments:

- Changes in weather or occupancy: Adjustments might include recalculating the baseline consumption rates using post-installation period weather data (HDD or CDD) or occupancy data based on a mathematical expression of how energy consumption depends on these factors.
- Changes in operating schedule or tenant improvements: The real impact of the retrofit project is independent of decreases or increases in operating hours of the facility or system and, therefore, the baseline consumption needs to be scaled up or down to correspond to such changes if any occur. Similarly, tenant improvements – new plug loads, improved lighting levels unrelated to the retrofit itself, etc. – that may increase energy consumption in the post-installation period must be separated from the post-installation period performance.
- Changes in the actual function of the facility – office space being converted to storage, for example – and their impact on energy performance separate and apart from the retrofit, need to be quantified as adjustments to baseline performance.

The extent to which baseline adjustments need to be considered depends to some extent on the Monitoring and Verification Option being employed:

- Baseline adjustments are less likely to be needed when Monitoring and Verification Option A is being used since many of the performance factors are stipulated.
- Option B or retrofit isolation involves metering of energy consumption pre- and post-installation. Non-metered factors that impact on energy performance therefore need to be applied to the measured baseline consumption.
- Option C involves regression analysis to determine a functional relationship between energy consumption and independent variables. Adjustments to the baseline performance for changes in these variables are typically carried out by using a functional relationship or performance model.
- Option D accommodates adjustment within the simulation model itself. Once calibrated using actual or typical data, no other adjustments should be required.

### Sources of Information

Two key documents that have been referenced in this section will, in their entirety, provide extensive detail addressing all of the aspects of Monitoring and Verification planning and implementation:

1. Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy. *International Performance Measurement & Verification Protocol: Concepts and Options for Determining Energy Savings*. October 2000.
2. Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy. *Monitoring and Verification Guidelines: Measurement and Verification for Federal Energy Projects*. DOE/GO-102000-0960, September 2000.





# **Federation of Canadian Municipalities Municipal Building Retrofits**



## **Section 8 Monitoring and Verification**

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### **Guide**

All templates in this guide are available in text and PDF format on the accompanying CD ROM or on the Knowledge Network at <http://kn.fcm.ca>.



**Template Section 8****Page 1** **Planning Checklists**

Monitoring and Verification planning early in the project planning process is essential as the project itself becomes defined. Baseline definitions need to be done before retrofits are implemented, and the methods and costs of savings verification need to be understood and defined especially in the energy performance contract, if that is the project implementation option being used.

The following checklists are provided as guidance for Monitoring and Verification planning through the Feasibility Study and Project Implementation stages of the MBR process.

**Checklist for Monitoring and Verification Approach (Preliminary Feasibility Study)**

- 
- Project site and measures are reasonably defined.

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  - What savings will be claimed? (Energy, interactive effects, O&M, rate change, etc.)

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  - Monitoring and Verification approach (Option A, B, C or D) is defined for each measure.

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  - Baseline equipment and conditions.

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  - Plan for defining existing equipment (inventory and performance) is described.

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  - Plan for defining space conditions (foot-candles, temps, etc.) is described.

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  - How and why any baseline adjustments will be made is discussed.

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  - Post-installation equipment and conditions.

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  - Plan for defining new equipment (inventory and performance) is described.

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  - Plan for defining space conditions (foot-candles, temps, etc.) is described.

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  - Annual verification and measurement activities are described.

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  - Who will conduct the Monitoring and Verification activities and prepare Monitoring and Verification analyzes and documentation is described.

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**Checklist for Monitoring and Verification Plan and Periodic Submittals (Detailed Feasibility Study)**

- Project site and measures are defined.
- What savings will be claimed? (Energy, interactive effects, O&M, rate change, etc.)
- How will these ancillary savings be treated?
- Monitoring and Verification method(s) defined.
- Details of how calculations will be made are defined. All equations are shown.
- Provided information shows how collected data and assumptions are used.
- Energy pricing information and assumptions are defined (fixed cost, inflated per EIA, etc.).
- Baseline equipment and conditions.
- Existing equipment (inventory and performance) is defined.
- Space conditions (foot-candles, temps, etc.) are defined.
- Assumptions and stipulations – show supporting information or measurements.
- How and why any baseline adjustments will be made is discussed.
- Post-installation equipment and conditions.
- Plan for defining new equipment (inventory and performance) is described.
- Plan for defining new space conditions (foot-candles, temps, etc.) is described.
- Assumptions and stipulations – show supporting information or measurements to be taken.
- Metering equipment is specified.
- Schedule of metering, including duration and when it will occur, is defined.
- Who will provide equipment, establish and ensure its accuracy and perform calibration procedures, is described.
- How data from metering will be validated and reported, including formats, are defined.
- How electronic, formatted data, directly from a meter or data logger, will be provided.
- Any sampling that will be used, sample sizes, documentation on how sample sizes were selected, is defined.
- Annual verification and measurement activities are defined.
- Who will conduct the Monitoring and Verification activities and prepare Monitoring and Verification analyzes and documentation is defined.
- How quality assurance will be maintained and repeatability confirmed is defined.
- Reports are defined, including what they will contain and when they will be provided.
- Electronic formats and software programs to be used for reporting are defined.
- Initial and annual Monitoring and Verification costs for each measure (totals only).

## Template Section 8

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## Monitoring and Verification Planning Template

Source: **Federal Energy Management Program (FEMP) Sample Measurement & Verification Plans**, Draft for Public Review, Prepared by Schiller Associates for Lawrence Berkeley National Laboratory, January 25, 2001

The following are section headings that are recommended for Monitoring and Verification plans for municipal energy management retrofit projects. Each section heading lists a description of the required information. Annotations are provided to illustrate by way of example the kind of information that is likely to be needed.

SECTION HEADINGS	DESCRIPTION
<b>Project-level components</b>	
<b>Project Description</b>	Project goals Building details – size, location, use, equipment, energy consumption characteristics ECMs – how they save energy, water or O & M costs Applicable EE or performance standards
<b>Project Savings and Costs</b>	Anticipated energy and cost savings for each ECM and in total Anticipated costs for Monitoring and Verification
<p><i><b>Project Description:</b> The energy-efficiency project involves six measures including a lighting retrofit, HVAC system upgrades, pool heating system retrofit, operator training and occupant awareness campaign in a municipal recreation centre. The goal of the project is to reduce energy consumption by an estimated 12 per cent. Details are provided on the estimated contribution of each measure to the estimated total savings. The Monitoring and Verification process is estimated to cost approximately 3 per cent of the projected total savings.</i></p> <p><i>The savings determination is based on main electricity account #766A234-593, including demand, the auxiliary electricity account #766B122-601 serving the pool complex, and natural gas account #KHJR3333-597.</i></p>	
<b>Responsibility Matrix</b>	Important risks and their potential impact Responsibility for managing risks
<p><i><b>Risk Management Responsibility:</b> Deregulation of the electrical utility sector is creating a risk of escalating and volatile electricity rates. The energy performance contract provides a mechanism for measuring performance in energy consumption terms and adjusting the project payback schedule to accommodate higher or lower energy unit costs.</i></p>	

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SECTION HEADINGS	DESCRIPTION
<b>Schedule</b>	Schedule for ECM installation, Monitoring and Verification activities, reporting intervals, including: <ul style="list-style-type: none"> <li>• Pre- and post-installation audits and inspections</li> <li>• Monitoring and analysis activities</li> <li>• Reporting milestones</li> <li>• Commissioning reports</li> <li>• Quarterly or annual Monitoring and Verification reports</li> </ul>
<b>Reports to be Prepared</b>	Frequency, format, content of reports
<i><b>Reports:</b> The municipality has authorized the contractor to receive energy use data directly from the electrical and gas utilities until the termination of the contract. The contractor will compute and report on energy consumption and savings on a monthly basis, with reports provided to physical plant staff, works department staff, and department management. Reporting will commence immediately after completion of installation, and continue until the termination of the contract.</i>	
<b>Measure-level components</b>	
<b>Measure Description</b>	Specific details about each ECM Savings to be claimed Vintage, condition, usage, operational and maintenance history of equipment to be replaced or modified Equipment standards
<b>Monitoring and Verification Approach</b>	IPMVP Option General description of approach Accuracy of Monitoring and Verification method Savings uncertainty and confidence level Factors most uncertain or difficult to quantify
<i><b>Monitoring and Verification Approach:</b> Option C is to be used for savings determination because the total facility energy cost, as it is affected by the bundle of measures, is the focus of the project.</i>	
<b>Assumptions</b>	Baseline and post-installation assumptions that affect energy consumption (building occupancy schedules, equipment efficiencies, equipment operating strategies, load shapes, weather data, etc.) Energy price schedules, facility staff labour rates, etc.
<b>Monitoring and Verification Activities:</b> <i>Baseline Period</i>	Who will do Monitoring and Verification activities List of activities before and after installation List of variables affecting energy consumption and how they will be quantified Equipment surveys: location, type, quantity, measured data, model numbers, etc. Critical baseline condition factors: comfort conditions, lighting intensities, temperature set points, etc.
<i>Post-installation Period</i>	List of variables affecting energy consumption, variance from baseline case, and how they will be quantified New equipment surveys Critical post-installation condition factors Activities to ensure equipment operating as intended