Measurement and Verification Protocols

for

Large Custom CIP Projects

Version 1.0

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Prepared by Minnesota Office of Energy Security

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I. Background

Measurement and verification (M&V) refers to the practice of collecting physical evidence of the energy and cost savings from energy efficiency projects. Staff of the Minnesota Office of Energy Security (Staff) prepared these M&V protocols for large custom energy efficiency projects done as part of Minnesota electric and natural gas utility Conservation Improvement Programs (CIPs).

These protocols were developed as part of a collaborative process with Minnesota utilities and other stakeholders initiated under docket E,G999/CIP-06-1591. Many of the general principles and guidelines were adapted from the industry-standard International Performance Measurement and Verification Protocol (IPMVP), *Concepts and Options for Determining Energy and Water Savings, Volume 1*[1]. The reader is referred to this document for more information on M&V.

As formal M&V is new to CIP as of 2008, Staff consider this document a work in progress and welcome input from utilities and alternative CIP providers as to how it can be improved.

II. Why Measure and Verify?

There are several reasons to measure and verify savings from CIP projects, including:

- Demonstrate the project savings to the customer;
- Find additional savings beyond up-front estimates;
- Provide a feedback mechanism to improve future CIP projects;
- Provide measured outcomes to justify the use of ratepayer dollars; and
- Improve the accuracy of reported CIP savings.

Staff initiated the M&V protocol development process in order to standardize M&V activities among Minnesota utilities. Doing so adds credibility to CIP as an energy resource, as large custom projects make up a significant portion of total CIP savings.

III. What Projects Apply?

All individual custom CIP projects with estimated annual savings greater than 1,000,000 kilowatt-hours (kWh) of electricity or 20,000 thousand cubic feet (MCF) of natural gas qualify for formal M&V under this document. This document takes effect in April 2008[2].

A custom project is defined as any project with one or more non-prescriptive energy conservation measures (ECMs) or a project with multiple interactive prescriptive ECM such that the operation of each measure is affected by one or more of the other ECM.

[1] This document is available for download from www.evo-world.org.
[2] Custom projects initiated prior to April 2008 are excluded from the requirements in this document.

Please consult Office of Energy Security Staff if there is a question regarding whether a project qualifies for formal M&V under this document.

IV. M&V Options

There are three primary options for performing M&V, adapted from IPMVP Options A through C. The options are to be applied on a per-ECM basis.

Option No. 1: Third-party Engineering Review[3]

Option 1 is appropriate for projects where the conservation measure affects the energy use of components that cannot be sub-metered and the expected savings are small compared to the consumption of the entire facility.

Under Option No. 1, a third-party engineering firm designs and supervises an evaluation of the energy savings realized by the conservation measures undertaken. The energy savings are derived by calculations using these measurements. The evaluation will likely involve measuring variables for several components that have a known effect on facility energy use. In some cases, effects on energy use of components will be readily identified, and in other cases the correlation may involve multivariable regression analysis. The objective of Option 1 is to derive an estimate of energy saved that is accurate, repeatable, and with known precision and bias.

Requirements:

- Required measurement frequencies and durations will be determined by the engineering analysis.
- A licensed professional engineer must perform an on-site investigation and certify that the technical assumptions and engineering calculations are reasonable and accurate to the best of his/her knowledge.

Example application:

- Chiller upgrade. A model of the pre-existing chiller's energy use as a function of chiller load, supply/return temperatures, and flow rates is derived. The post-installation chiller's energy use and operating conditions are monitored. The model is used to estimate baseline energy use under post-installation operating conditions.

Option No. 2: Equipment Sub-Metering[4]

Option No. 2 is intended to be used whenever direct metering of pre- and post-retrofit equipment is feasible and there are no significant interactive effects on non-project equipment. Electricity or natural gas usage is monitored pre- and post-project over

[3] This option is similar to International Performance Measurement and Verification Protocol (IPMVP) Options A or B.
[4] This option is similar to IPMVP Option B.

appropriate timeframes to capture actual operating conditions. With the utility's confirmation that the pre- and post-project metering periods provide accurate representations of predicted operational patterns, the collected data may then be used to extrapolate to baseline and post-project annual energy use.

Sampling may be used for projects with large numbers of measure-affected equipment (for example, a lighting upgrade in a large office building). By convention, sampling designs should strive to obtain 90/10 accuracy, or 90% confidence with ±10% precision, though M&V cost considerations (see section VI) may lower the achievable accuracy.

Requirements:

- Required measurement frequencies and durations are dependent on the nature of the measure-affected equipment and will be determined by the utility.

Example applications:

- Installation of a constant-speed drive motor. Measure baseline operating hours. If hours of operation are predictable (i.e. 24 hrs/day), stipulation of post-retrofit operating hours is acceptable. If hours of operation are variable or change, measure post-retrofit motor runtime. Measure baseline and post-retrofit power draws (vary with load); spot measurements are acceptable for constant loads.
- Replace constant-speed drive motor with variable-speed drive motor. Measure baseline operating hours. Measure baseline power draw; spot measurements are acceptable for constant loads. Measure post-retrofit power and operating hours continuously over two weeks that are representative of expected operating conditions.
- Lighting retrofit project in a large office building. The CIP deemed savings database is referenced to determine pre- and post-project fixture wattages. A sampling plan is designed to measure the average lighting hours in different rooms. Data loggers are placed within light fixtures to record on/off switching over the course of one month.

Option No. 3: Facility Metering[5]

Option No. 3 is appropriate for projects in which two or more measures will be interacting, projects involving changes to occupant behavior, and where ambient weather conditions affect facility energy use. The option is most appropriate for building performance improvements, where weather-normalized monthly energy use data for at least one year before project implementation is compared to data for a similar period of time following project implementation.

It is also appropriate for commercial and industrial projects in which analysis of the main facility metering data can provide an accurate estimate of savings. This

[5] This option is similar to IPMVP Option C.

application would be most appropriate if the non-project loads are relatively constant compared to the measured-affected loads.

The IPMVP guidelines caution against using facility metering if the estimated annual savings are expected to be less than 10 percent of the baseline facility annual energy use. If this condition applies, then Option No. 1 or 2 should be used instead.

Requirements:

- For building performance improvement projects, at least one year of monthly energy use data collected pre- and post-project.
- For other commercial or industrial projects, metering frequencies and durations are dependent on the nature of the measure-affected equipment and will be determined by the utility.

Example applications:

- Building recommissioning
- Installation of energy management control system
- Behavioral modification programs
- Boiler retrofit: A regression model of weather effects on facility gas use is developed using pre-retrofit utility bills. Gas savings are estimated from comparison of utility bills before and after the retrofit, using the regression model to eliminate weather effects from the estimated savings.

V. Establishing the Baseline

General Guidelines

The issue of baseline determination applies to all custom CIP projects. The basic question is whether the appropriate baseline for calculating energy savings is the energy use of existing equipment or standard practice. The following general guidelines apply:

- For early-retirement retrofits, the baseline is the existing equipment.
- When equipment is replaced on failure or near the end of its useful life, the baseline is standard practice.
- For new construction, the baseline is defined by the state energy code.

Increased Production Volume

For industrial projects, the appropriate baseline is dependent on whether the new energy efficient equipment will enable a production increase. If there will be no production increase, then the general guidelines above apply.

However, if the energy efficient equipment will enable increased production, it may not be reasonable to assume the pre-existing equipment, or additional units of the pre-existing equipment, would have been used to meet the higher production levels in the absence of a utility incentive. In such a case, it is more likely that the customer would

have installed new standard efficiency equipment that is more efficient than the pre-existing equipment.[6]

For small production volume increases, it may be reasonable to assume that the customer would have added production shifts in the absence of a utility incentive for the more efficient equipment. In these cases, the energy use per unit of production of the pre-existing equipment may be used for the baseline. For other projects where it is not reasonable to assume that production shifts could have been added, the utility may establish the baseline in one of two manners:

Preferred: assume the baseline is the existing equipment, but calculate the savings based on the original production level:

$$Savings = N_{orig} \times (E_{ex} - E_{eff})$$

E_{ex} = annual kWh or MCF use per unit of product for existing equipment
E_{eff} = annual kWh or MCF use per unit of product for efficient equipment
N_{orig} = original production quantity (e.g., tons per year)

This approach has the advantage of simplicity as the utility does not have to guess what standard equipment the customer would have adopted in the absence of the incentive.

Alternate: assume the baseline is a combination of the existing equipment (used to reach the original production level) and standard equipment (used to reach the new production level) and then calculate the energy savings based on the new production level:

$$Savings = \{N_{orig} \times E_{ex} + (N_{new} - N_{orig}) \times E_{std}\} - (N_{new} \times E_{eff})$$

E_{ex} = annual kWh or MCF use per unit of product for existing equipment
E_{std}= annual kWh or MCF use per unit of product for standard equipment
E_{eff} = annual kWh or MCF use per unit of product for efficient equipment
N_{orig} = original production quantity (e.g., tons per year)
N_{new} = new production quantity (e.g., tons per year)

[6] The following example illustrates this concept further: Minnesota Copying Company (MCC) copies 40,000 pages a year using a single copier. However, due to an increase in demand for copying, MCC now needs to make 200,000 copies a year. Utility X wants to encourage MCC to use efficient copiers. To measure energy savings, Utility X has to determine a baseline and so has to answer this question: What would a reasonable copy company invest in given that it has one working copier, but wants to expand and keep prices lower or make them lower due to competition? It's possible that MCC would purchase four copiers just like the existing one – the existing copier may be fairly new, not showing signs of wear or drops in efficiency, and the copiers may be used or may still be in stock. However, it is more likely that the Company would purchase a newer, larger machine to achieve economies of scale and lower its prices. The newer, larger machine is more likely to use less energy through its efficiencies. Therefore, a reasonable business decision could lead to more efficient energy use.

Adjustments to Measured Savings
To accurately calculate energy savings, it is necessary to make adjustments to the measured savings to account for changes to factors that are outside the control of the utility. For example, weather typically impacts the heating and cooling loads of buildings. The weather conditions during the post-project monitoring period will usually differ from the baseline monitoring period and therefore must be accounted for when calculating energy savings. This can be done through simple comparisons of utility billing data, regression analysis, or benchmarking tools such as ENERGY STAR® Portfolio Manager.

Other energy-impacting factors may change unexpectedly and must be accounted for as well. For example, consider a comprehensive efficiency project in a multi-tenant office building. If a floor that was unoccupied during baseline energy measurements becomes occupied by a new tenant, then the baseline would appropriately be adjusted upward to account for the energy use of the previously unoccupied floor.

Utilities should describe any adjustments made to the measured savings in their M&V reports.

VI. M&V Design Considerations

The goal of any M&V plan should be to minimize uncertainty in the measured energy savings. Uncertainty arises from a variety of sources, including sampling, measurement error, stipulated variables, unaccounted-for interactive effects, and modeling errors.[7] In general, as the level of rigor in the M&V plan increases – for example, through larger sample sizes or longer monitoring times – uncertainty is reduced. However, enhanced rigor comes at higher cost. M&V plans must therefore balance the goal of minimizing uncertainty with the goal of minimizing costs. Although there is no maximum limit for M&V expenditures, **utilities may limit their M&V expenditures per project to ten percent of the monetary value of the total annual savings (energy, demand, and O&M) to the customer**, in accordance with IPMVP guidelines.

In addition, Staff recognize that in some projects, potential negative impacts on customer operations or liability issues may limit the scope of M&V activities. Utilities should report such concerns in their M&V plan narratives.

VII. Rebate and Claimed Savings Policy

The utility's ability to recover rebates and claim the energy savings for M&V-qualified projects may be affected by the M&V results. Tables 1 and 2 summarize Office of Energy Security policy for rebate cost-recovery and claimed savings.

[7] See Appendix B of *International Performance Measurement and Verification Protocol, Volume I* for a detailed discussion on uncertainty and strategies to minimize it.

Table 1: Policy for Deviation in Measured Savings from Pre-Project Estimates

Measured savings relative to pre-project estimates	Policy
Less than 90%	- Additional analysis needed. See Table 2.
90 – 110%	- Recovery of rebate will be approved. - Utility will claim savings of preliminary estimate.
Greater than 110%	- Recovery of rebate will be approved. - Recovery of an additional post-project rebate will be approved. - Utility will claim measured savings.

Table 2: Policy for Negative Deviations of More Than 10 Percent

Result of additional analysis	Impact on cash incentive and reported savings
Project fails Societal Test with measured data and actual costs	- Recovery of rebate will be denied. - No savings will be claimed.
Project passes Societal Test with measured data and actual costs	- Recovery of rebate will be approved. - Utility will claim measured savings.

VIII. M&V Reporting Requirements

Staff request that all electric and natural gas utilities submit M&V plans and reports for individual qualifying projects using the following forms. The purpose of the M&V reporting requirements is two-fold: to demonstrate that the utility made a good faith effort to accurately measure and verify savings; and to build a knowledge base of M&V practices for future custom CIP projects.

There are no strict deadlines for submittal of the forms, though if possible, utilities should submit their M&V plans after baseline data collection but before ECM implementation to allow Staff a chance to comment on specific aspects of the plan. Utilities need not wait for Staff's approval before starting a project. Following completion of the M&V activities, Staff request that utilities submit an M&V report detailing any changes to the project, measured savings, and actual expenditures.

For investor-owned utilities, Staff will consider the thoroughness of the M&V plans submitted when determining whether to approve the CIP project savings, beginning with the CIP status reports for 2008.

CIP Measurement and Verification Plan Reporting Form

v. 1.0, April 2008

Adapted from FEMP *M&V Plan and Savings Calculations Methods Outline*, v. 1.0, Nov. 2004

Utility: **Date:**

Project Identifier:

(Provide a unique identifier for the project such that the M&V Results can be matched to the M&V Plan).

<u>Contact Information</u>

Name:

Email: **Phone:**

1 Executive Summary

1.1 Project Description

- Provide a brief description of the project in order to provide context for the intended M&V activities, including:

  - CIP project type (e.g., Custom Efficiency, EDA, Recommissioning, etc.)
  - Facility type
  - Total site and project square footage (for non-industrial projects only)
  - Description of energy conservation measures (ECM)
  - Description of utility incentives offered to customer

1.2 M&V Plan Summary

- Summarize the M&V plan for each ECM in the table below.

Table 2. M&V Plan Summary

ECM	ECM Description	M&V Option*	Summary of M&V Plan

* CIP M&V Option No. 1, 2, or 3.

1.3 M&V Budget

- Estimate the total budget for M&V, specifying estimated equipment and labor costs.

1.4 Proposed Annual Savings Overview

- Provide the proposed annual savings for each ECM in the table below.

Table 1. Proposed Savings Overview

ECM	Annual electric energy savings (kWh)	Annual electric demand savings (kW)	Annual natural gas savings (MCF)	Total annual energy cost savings ($)	Annual O&M savings ($)	Other cost savings ($)	Total annual cost savings ($)
Totals							

2 ECM [Name / #] M&V Plan and Savings Calculations Methods

- Develop section for each ECM

2.1 Overview of ECM, M&V Plan, and Savings Calculation for ECM

2.1.1 Summarize the scope of work and how savings are generated.

2.1.2 Specify the M&V Option used (No. 1, 2, or 3).

- If using Option No. 3, please include:
  - The percentage of energy the project consumes compared to total facility metered energy
  - Descriptions of non-project related loads and why they can be assumed to be constant

2.1.3 Provide an overview of M&V Activities for ECM.

- Explain intent of M&V plan, including what is being verified.
- Describe any customer impact or cost considerations that factored into the choice of M&V Option and activities.

2.1.4 Provide an overview of savings calculations methods for ECM.

2.1.5 Provide a general description of analysis methods used for savings calculations.

2.2 Baseline Establishment

2.2.1 Is the baseline the existing equipment, standard equipment, or a combination of both (in cases of increased production output)? Explain.

2.2.2 Describe in general terms how the baseline energy use will be established.

2.2.3 If annual production output will increase from pre- to post-project, please provide the following information:

- Pre- and post-production shifts employed in the operation of the equipment
- Pre- and post-production rates
- Alternatives to achieving the increased production levels
- Baseline and efficient energy consumption of these alternatives.

2.2.4 Describe variables affecting baseline energy use.

- Include variables such as weather, operating hours, set point changes, production output, etc.

- Describe how each variable will be quantified, i.e., measurements, monitoring, assumptions, maintenance logs, manufacturer data, etc.

2.2.5 Provide details of baseline data collection, including:

- Parameters monitored/measured
- Details of equipment monitored, i.e., location, type, model, quantity, etc.
- Sampling plan, including details of usage groups and sample sizes
- Duration, frequency, interval, and seasonal or other requirements of measurements
- Dates and times of measurements
- Monitoring equipment used
- Installation requirements for monitoring equipment (test plug for temperature sensors, straight pipe for flow measurements, etc.)
- Certification of calibration / calibration procedures followed
- Expected accuracy of measurements/monitoring equipment
- Quality control procedures

2.2.6 Provide details of baseline data analysis performed, including:

- Analysis using results of measurements
- Weather normalized regressions
- Weather data used and source of data

2.3 Proposed Energy Savings Calculations and Methodology

2.3.1 Provide detailed description of analysis methodology used.

- Describe any data manipulation or analysis that was conducted prior to applying savings calculations.

2.3.2 Detail all assumptions and sources of data, including all stipulated values used in calculations.

2.3.3 Include equations and technical details of all calculations made. (Use appendix if necessary. Electronic format preferred.) Include description of data format (headings, units, etc.).

2.3.4 Details of any savings or baseline adjustments that may be required.

2.3.5 Detail proposed annual energy savings for this ECM

- Summarize information in Table 3.

2.4 Operations and Maintenance and Other Cost Savings (if applicable)

2.4.1 If O&M savings represent a significant part of the justification for the project, please describe how savings are generated and detail savings calculations.

2.4.2 If other cost savings represent a significant part of the justification for the project, please describe how savings are generated and detail savings calculations.

2.5 Proposed Annual Savings for ECM

Table 3. Proposed annual savings for ECM

	Annual electric energy savings (kWh)	Annual electric demand savings (kW)	Annual natural gas savings (MCF)	Total annual energy cost savings ($)	Annual O&M savings ($)	Other cost savings ($)	Total annual cost savings ($)
Baseline use							
Post-installation use							
Savings							

2.6 Post-project M&V Activities

2.6.1 Describe the intent of post-project verification activities, including what will be verified.

2.6.2 Describe variables affecting post-project energy use.

- Include variables such as weather, operating hours, set point changes, production output, etc.
- Describe how each variable will be quantified, i.e., measurements, monitoring, assumptions, manufacturer data, maintenance logs, etc.

2.6.3 Provide details of post-project data collection, including:

- Parameters monitored/measured
- Details of equipment monitored, i.e., location, type, model, quantity, etc.
- Sampling plan, including details of usage groups and sample sizes
- Duration, frequency, interval, and seasonal or other requirements of measurements
- Dates and times of measurements
- Monitoring equipment used
- Installation requirements for monitoring equipment (test plug for temperature sensors, straight pipe for flow measurements, etc.)
- Certification of calibration / calibration procedures followed
- Expected accuracy of measurements/monitoring equipment
- Quality control procedures

CIP Measurement and Verification Post-Project Reporting Form

v. 1.0, April 2008

Adapted from FEMP *Post-Installation Report Outline*, v. 1.0, Nov. 2004

Utility: **Date:**
Project Identifier:
(Provide the unique identifier assigned to the project on the M&V Plan.)

<u>Contact Information</u>
Name:
Email: **Phone:**

1 Executive Summary

1.1 Brief Project and ECM Descriptions

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

1.1.2 Note any changes to the project from what was described in the M&V Plan.

1.2 Proposed and expected annual energy and cost savings

1.2.1 Summarize information in Tables 1 and 2.

1.3 M&V Budget

1.3.1 Provide the total budget for M&V, specifying estimated equipment and labor costs.

1.3.2 Provide the total M&V costs as a percentage of the annual energy cost savings to the customer.

1.4 Status of Incentives

1.4.1 Specify incentives paid or to be paid to the customer.

Table 1. Proposed annual savings
[Savings estimated pre-project]

ECM	Annual electric energy savings (kWh)	Annual electric demand savings (kW)	Annual natural gas savings (MCF)	Total annual energy cost savings ($)	Annual O&M savings ($)	Other cost savings ($)	Total annual cost savings ($)
Totals							

Table 2. Expected annual savings
[Estimated savings based on M&V activities]

ECM	Annual electric energy savings (kWh)	Annual electric demand savings (kW)	Annual natural gas savings (MCF)	Total annual energy cost savings ($)	Annual O&M savings ($)	Other cost savings ($)	Total annual cost savings ($)
Totals							

2 ECM [Name / #] M&V Activities and Expected Annual Savings

- Develop section for each ECM

2.1 Overview of ECM, M&V Plan, and Savings Calculation for ECM

2.1.1 Summarize the scope of work and how savings are generated.

2.1.2 State M&V Option used (No. 1, 2, or 3).

2.1.3 Provide an overview of M&V activities for ECM.

- Explain the intent of M&V plan, including what is being verified.

2.1.4 Provide an overview of savings calculation methods for ECM.

- Provide a general description of analysis methods used for savings calculations.

2.2 Post-Installation M&V Activities Conducted

- Detail measurements and monitoring conducted in accordance with M&V Plan:

2.2.1 Details of sampling plan (if applicable)

2.2.2 Include all post-installation measured values. Include periods of monitoring and durations and frequency of measurements. (Use appendix if necessary; electronic format preferred). Include description of data format (headings, units, etc.).

2.3 Expected Annual Savings Calculation and Methodology

2.3.1 Provide detailed description of analysis methodology used.

- Describe any data manipulation or analysis that was conducted prior to applying savings calculations.

2.3.2 Detail all assumptions and sources of data, including all stipulated values used in calculations.

2.3.3 Include equations and technical details of all calculations made. (Use appendix; electronic format preferred.) Include description of data format (heading, units, etc.).

2.3.4 Details of any baseline or savings adjustments made.

2.3.5 Detail expected annual savings for this ECM.

- Summarize information in Table 3.

5. Certification Statement (Option No. 1 Only)

- For projects using Option No. 1 (Third-party Engineering Review), an independent, licensed Professional Engineer must perform an on-site investigation and attach a signed statement certifying that all stipulated parameters and engineering calculations are reasonable, accurate, and in accordance with generally accepted engineering principles to the best of his or her knowledge.

6. Additional Analysis

- If measured energy savings for the project are less than 90% of the proposed savings submitted in the M&V Plan, attach results of the Societal benefit-cost test using the measured savings and actual costs.

Table 3. Expected Annual Savings for ECM [Name / #]

	Annual electric energy savings (kWh)	Annual electric demand savings (kW)	Annual natural gas savings (MCF)	Total annual energy cost savings ($)	Annual O&M savings ($)	Other cost savings ($)	Total annual cost savings ($)
Baseline use							
Post-installation use							
Savings							