Measurement and Verification Framework for Energy and Resource Conservation Projects

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Measurement and Verification

The university distinctly tracks, manages, and analyzes the financial and resource savings resulting from energy and resource efficiency projects in order to evaluate their performance. Savings realized are identified using measurement and verification (M&V) processes based on actual pre and post-project performance. M&V is a rigorous, accurate, and reliable process that accounts for conflating factors including weather and facility usage patterns allowing the university to have a high level of confidence in the savings reported. The UT Austin M&V framework accomplishes the following:

- **Improves project planning, design, and cost estimation:** via early development of M&V plans.
- **Ensures persistence of project components:** The M&V process is a long-term, detailed review of the performance of a project after it is implemented. This detailed review provides insight that is used to maintain a high level of performance for the life of the improvements.
- **Enhances credibility and performance of future projects:** The M&V process highlights additional energy and resource conservation opportunities and implementation best-practices that lead to improved financial performance of future projects.
- **Provides confidence in predicted savings:** The M&V process informs future savings estimates, reducing the gap between predicted and achieved savings.

The following M&V framework aligns with core concepts of and references specific practices within the International Performance Measurement and Verification Protocol (IPMVP). The IPMVP is a widely used protocol developed by a coalition of international organizations led by the United States Department of Energy.

This framework focuses on key M&V topics and standardizes those unique to UT Austin operations. For any topics not included or expanded upon in this document, see the IPMVP Core Concepts published in October 2016. The following aspects of M&V for energy and resource conservation projects are addressed during verification of savings. Details of these topics are included in later sections of this document:

- M&V Option based on Measurement Boundaries
- Selecting Measurement Periods
- Documenting Routine & Non-Routine Adjustments
- Determining Utility Rates
- Developing M&V Plans
- Publishing M&V Reports

M&V Options based on Measurement Boundaries

Savings are determined for either an entire facility or for a portion of a facility, depending upon the project characteristics. Measurement boundaries are drawn around the facility or equipment included, and measurement requirements within the selected boundary are then be determined. Energy consumption is determined by either direct measurement of energy-flow or by direct measurement of proxies of energy consumption that can reliably calculate energy consumption. The location of the measurement boundary indicates the IPMVP Option.

Typically, UT Austin utilizes one of the following two options.

Whole Facility - IPMVP Option C

Due to the deployed whole building meters across campus, the most often used option is whole facility M&V (IPMVP Option C). The energy and resource consumption of the entire facility is analyzed, thus this option is used for projects that affect a large portion of building energy and resource use, e.g. existing building commissioning.

Retrofit Isolation, Key Parameter Measurement - IPMVP Option A

For a smaller focus on a single system or component, Retrofit Isolation, Key Parameter Measurement (IPMVP Option A) is used. Key parameters are measured focusing on the energy and resource consumption of a single system or component. An example appropriate for this method is the conversion of a fan or series of fans from constant volume to variable volume through the installation of variable frequency drives.

Selecting Measurement Periods

There are two periods for performance measurement within the M&V process.

Baseline Period: The baseline period describes performance prior to a project and represents a normal operating cycle of the facility or equipment.

- **Reporting Period:** The reporting period describes performance after a project and encompasses at least one normal operating cycle of the equipment or facility after the implementation.

The following conditions are considered when selecting both periods:

- If weather is a variable affecting energy use, the period spans 12 consecutive months to capture seasonal variations.
- Baseline Period should be as close to project start date and Reporting Period should be as close to project completion date as possible. Periods further away from project dates have higher chances of introducing more required adjustments described in the next section.
- If less than 20% of data is missing or faulty for a selected period, the faulty data is excluded.
- If greater than 20% of data is missing or faulty for a selected period, a different period is selected.

Methods of Adjustment

Two types of adjustments are possible. Characteristics of these adjustments are described below.

Routine Adjustments

Multiple techniques may be used to define adjustments to account for any energy-governing factors that are expected to change routinely during the reporting period. These techniques will be determined on a case-by-case basis and specified in the M&V plan.

Typically, adjustments include multiple parameter regression to establish the dependence of energy usage on various conditions by modeling the baseline and reporting period. Valid regression techniques are used to derive the energy use models and the fit of each model is optimized using statistical measures such as coefficient of determination (R-squared).

Significant factors governing energy use in campus buildings are typically weather and occupancy, however there are other potential factors that are considered and included when appropriate. Typical strategies that are applied to maximize the statistical fit of the model to the data include:

- Utilizing weather data types such as daily degree days, hourly degree days, average daily dry-bulb temperature, and relative humidity
- When using degree days, adjusting the base temperature (the temperature below or above which the building needs heating or cooling, respectively) to fit the facility or system
- Using detailed occupancy data when affected spaces are occupied on schedules that differ from most campus buildings that have consistent weekday and weekend schedules.

Both baseline and reporting models are applied to Typical Meteorological Year[1] (TMY) data, in order to normalize savings to a typical year of weather. Normalized savings are unaffected by reporting period conditions since the fixed set of conditions are established once and are not changed. Pre and post-project performance is then compared directly and fairly with savings predicted under the same set of fixed weather conditions.

Non-Routine Adjustments

There are often building conditions that change during the M&V period and impact savings. These changes typically include the following activities and the impact of these activities on project performance is documented through non-routine adjustments:

- Square footage and space allocation changes
- Standard operating hours
- Building projects and equipment
- Laboratory & Kitchen equipment
- Billing adjustments

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[1] A typical meteorological year (TMY) data set provides designers and other users with a reasonably sized annual data set that holds hourly meteorological values that typify conditions at a specific location over a longer period of time, such as 30 years. TMY data sets are widely used by building designers and others for modeling renewable energy conversion systems. Although not designed to provide meteorological extremes, TMY data have natural diurnal and seasonal variations and represent a year of typical climatic conditions for a location. Commercial software packages supporting simulations using TMY data include EnergyPlus, eQuest, Trane TRACE, TRNSYS, and PV*SOL. The source data are available from the National Renewable Energy Laboratory.

– Building and Equipment Outages

Because each of the areas of non-routine changes are managed by different university organizations, communication is individually tailored according to the type and location of a project. Sources used to determine the impact of these activities are located in Appendix A: Non-Routine Adjustment Activities.

The effort, cost, and specific actions to document the impact of non-routine adjustments is unique to each project and will be determined based on the magnitude of savings and the M&V budget. All non-routine adjustments are tracked and documented by the project manager.

Cost Savings

Energy savings are first calculated as end-use savings at the building. For buildings served by the UT power plant, electricity, chilled water, steam, and hot water energy savings at the building are converted to natural gas source energy used by the plant, using the average respective plant production efficiency from the prior fiscal year.

Cost savings are determined from the perspective of the University using the prior fiscal year average rates per utility paid by UT. Utility rates are provided by University of Texas Utilities and Energy Management administrative staff.

Cost savings will be reported as an annual cash flow, a simple payback, and the Net Present Value (NPV). An escalation factor of 2% and a discount rate of 4% will be applied to calculate the NPV.

Measurement and Verification Plans

Based upon the scope, the project engineer will determine the appropriate components to include in each plan from the following options.

A short summary of the plan including:

- Project overview and list of energy conservation measures
- M&V option to be used and measurement boundary

Baseline period documentation including:

- Baseline period consumption and demand data, including notation of any data replacement or baseline period adjustments
- Baseline period measurements, if any
- Routine adjustments methodology, including any strategies applied to maximize statistical fit of the model to the data
- Non-routine adjustments that may be required, including data documented during the baseline period

Reporting period description including:

- Expected reporting period timeline
- Planned M&V activities

Projected savings calculation methodology including:

- Specific methods used to project potential savings including but not limited to utility billing data including adjustments, engineering spreadsheets, straight calculation, BIN analysis, regression, computer modeling, and other computation techniques.

Projected savings:

- The calculated annual projected savings for each utility and total projected savings of plant natural gas and water in dollars. The plant efficiency used to estimate plant natural gas consumption savings will be included.

Utility Rates:

- Document the utility rates applied to calculate projected savings.

Monitoring and Reporting Responsibilities:

- Describe responsibilities for measurement & verification during the reporting period
  - Review of reporting period consumption and demand data
  - Tracking and documenting routine and non-routine adjustments
  - Publishing and Review of M&V Report

M&V Costs:

- If there are associated costs to the M&V Plan and Execution, these costs will be documented with the initial development costs and any costs throughout the reporting period.

Measurement and Verification Reports

M&V reports are prepared as defined by the M&V plan and include the following minimum requirements.

Overview of M&V Plan:

- A short summary of the plan including project intent, M&V option used, and M&V activities conducted during the baseline and reporting period.

Observed Data of Reporting Period:

- Energy consumption and demand data
- Measurement period start and end point in date/time
- Routine and Non-Routine changes
- For Retrofit Isolation, Key Parameter Measurement, the measured and estimated parameters
- Description and justification for any corrections made to the observed data

Adjustment Methodology:

- Documented methods used for calculating the routine and non-routine adjustments.

Utility Rates:

- The previous fiscal year average utility rates.

Achieved Savings:

- Achieved annual energy, water, and cost savings.

Non-Energy Benefits:

- Overview of non-energy benefits (occupant comfort, maintenance reduction, etc.) observed during the reporting period.

Appendix A: Non-Routine Adjustment Activities

Square Footage and Space Allocation Changes

<u>Information requested</u>:

Large variations in square footage in a building during the baseline and reporting period.

Based on the scope, the percent variation of square footage may warrant additional investigation and this will be determined by the engineer. In addition, any large space use changes that have occurred in the building during the baseline and reporting period, for example, office space that is changed into a laboratory, will need to be tracked. For UT Austin, state legislature requires that space data is updated within 30 days of substantial completion.

<u>Primary contact</u>:

University of Texas Space Management

<u>Information Access</u>:

WORQS Space Updates

Standard Operating Hours

<u>Information requested</u>:

Standard open and closed hours of the buildings for public use and operations as determined by the building managers.

<u>Primary Contacts:</u>

Specific Building Managers

<u>Information Access</u>:

Facilities Services Building Information Webpage

Building Projects and Equipment

Information requested:

PMCS and CPC work occurring in a building at the same time as a project implementation.

If the PMCS or CPC project scope of work (SOW) includes mechanical, electrical and/or plumbing (MEP) work, further investigation may be warranted. Additional requested documentation include: as-built, specifications of equipment, and load calculations. Equipment changes resulting from PMCS and CPC projects are tracked by Engineering and Technical Support through EQ IDs and Add/Delete logs. The equipment changes should be monitored throughout a project lifecycle. Currently, there is a time delay in EQ IDs updates of approximately 5-6 months. If information regarding equipment in the building cannot be found, field verification may be necessary.

Primary contacts:

Project Management & Construction Services & Campus Planning & Construction

Information Access:

Project updates/Design Reviews sent directly to UEM Demand Side Energy Management

Laboratory & Kitchen Equipment

Information requested:

High-energy consumption laboratory and kitchen equipment that is moved in and out of the building.

Depending on the scope of the project and the M&V option chosen, laboratory and kitchen equipment inventory may need to occur throughout the M&V period. Lab and kitchen equipment that have a large energy and water impact are:

- Fume hoods
- Autoclaves
- Lasers (depending on size and frequency of use)
- Ultra-low freezers
- Bio safety cabinets (ducted cabinets only)
- Ovens (depending on size)

Labs 21 Wiki will also serve as a resource for efficiency levels of lab equipment.

Primary contact:

Building/Kitchen Manager, College Lab Manager, Building Manager, and/or Environmental Health & Safety

Information Access:

Refer to Appendix B: Documenting Non-Routine Adjustments

Billing Adjustments

Information requested:

Billing adjustments and meter errors/shutdowns during the reporting period.

Primary contacts:

UEM Demand Side Energy Management Monthly Meter Tolerance Report, UEM Thermal & Electrical Distribution Departments, and or Business & Financial Services UEM Representatives

Building and Equipment Outages

Information requested:

Building and equipment outages should also be tracked to determine if they impact the M&V analysis.

Primary contacts:

Project Management & Construction Services - Outages

Tools and Access:

Outage Calendar (Facilities Monitoring Log)