Measurement and Verification Overview

No energy efficiency project should be complete without a rigorous methodology for measuring and verifying energy savings, and BTune projects are no different.

The Efficiency Valuation Organization (EVO) defines Measurement and Verification (M&V) as “the process of planning, measuring, collecting and analyzing data for the purpose of verifying and reporting energy savings within an individual facility resulting from the implementation of Energy Conservation Measures (ECMs).” An accurate M&V method is not only important for measuring the avoidance of energy consumption and carbon emissions, but is an increasingly necessary approach for rebate programs and ESG performance reporting.

Put simply, savings are determined by comparing measured energy use before and after the implementation of ECMs, while making appropriate adjustments for changes in conditions, such as ambient temperature. The accuracy of this calculation is critical for services where projects are funded out of the energy cost savings generated, such as with BTune’s shared savings pricing model.

This document outlines BTune’s adoption of the International Performance Measurement and Verification Protocol (IPMVP®) for measuring and verifying energy savings for our customers.

Key Takeaways

- Measurement and Verification is a vital component of the energy efficiency journey and transparency of this process should be a requirement of any partner.
- BTune utilizes an internationally approved methodology – the International Performance Measurement and Verification Protocol (IPMVP) established by the Efficiency Valuation Organization (EVO).
- The reductions in energy use, costs, and associated carbon delivered by BTune are not theoretical or projected, but proven through a rigorous and objective M&V process.
- Utilization data improves the resiliency of energy baselines throughout periods of varying occupancy such as remote work schedules and the COVID-19 pandemic.

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At BTune, we believe transparency of the way we measure and verify energy savings is not only the right thing to do for our customers, but essential for the buildings industry to undertake the ambitious carbon reduction projects needed to meet sustainability goals and get closer to Net Zero.

How BTune Measures Energy Savings

Every BTune project has its own Measurement and Verification (M&V) plan, each reviewed and validated by our in-house Certified Measurement and Verification Professionals® (CMVP®).

What is IPMVP?

IPMVP ® is an internationally recognized, best practice standard for quantifying the effectiveness of energy and water efficiency, demand management, and renewable energy projects. The IPMVP was developed by a coalition of international organizations, led by the United States Department of Energy, starting in 1994. The Protocol has become the national measurement and verification standard in the United States and many other countries. The IPMVP aims to standardize the way in which energy efficiency projects are measured through the definition of standard terms and guiding principles.

The IPMVP defines four methods or 'Options' for quantifying savings as listed below.

- Option A – Retrofit Isolation: Key Parameter Measurement
- Option B – Retrofit Isolation: All Parameter Measurement
- Option C – Whole Facility
- Option D – Calibrated Simulation

Each method typically pertains to the scope of ECMs, the accessibility of measurement, and the needs of the M&V analysis and reporting. If performance reporting needs to be at the facility level, option C or D is favorable. If only the performance of an isolated ECM needs to be reported, such as the installation of LED lights or a variable speed fan, options A or B are more suitable.

As BTune projects target facility-wide HVAC Automated System Optimization, "Option C" is most commonly used. This approach requires the development of an energy baseline for all energy sources used at a site. Where Option C may not be suitable due to limitations of data acquisition or influential factors being unable to be adequately measured, Option B may be used and is facilitated by historic and real-time HVAC operational data being collected from the Building Automation System (BAS).

While savings cannot be directly measured, they can be determined by comparing measured consumption before and after the implementation of ECMs while accounting for changes in conditions. Regardless of the IPMVP option used, the following general M&V equation applies:

Savings = (Baseline Period Energy – Reporting Period Energy) +/- Adjustments

What is CMVP?

A Certified Measurement and Verification Professional (CMVP®) is an individual who has completed an independent IPMVP training program and been examined in its core principles. Such individuals are deemed qualified in measuring and verifying energy savings. The CMVP certification is issued by the Association of Energy Engineers (AEE) in cooperation with EVO. CMVPs may also be known as Performance Measurement and Verification Analysts (PMVA)TM under EVO.

What is an Energy Baseline?

An Energy Baseline establishes the typical energy use of a building for a period of time (typically 12 months) before efficiency measures are implemented. Using factors that influence energy use (e.g. outdoor air temperature) are used to build a statistically representative equation of baseline energy use. The baseline equation is used to calculate energy consumption under certain variable conditions. Said more simply, we create a predictive model of what the building's energy use would most likely have been, was it to continue operating as it currently does without BTune deployed.

How does BTune establish a suitable Energy Baseline?

BTune's baseline development process starts with identifying the factors which independently influence energy consumption in the building, such as outdoor weather conditions and building occupancy. These are known as Independent Variables. Energy consumption is then plotted against these independent variables to produce a line of best fit or equation which represents the relationship between energy consumption and independent variables.

The following summarizes BTune's process for establishing a suitable baseline:

Data Collection

1. For all BTune projects, local weather data for the site is collected as this is nearly always a driver which influences the amount of energy used.
2. If available, utilization data is collected for the building to help us understand how the building's energy consumption may be driven by building occupants. Utilization data is a proxy for occupancy as it may not always be a direct measure of building occupants. For example, utilization data may include:
    a. Occupancy data from Wi-Fi logins, door clicks, or another metric
    b. Water meter or sewerage data
    c. Independent energy meters onsite, such as café energy bills or Lift energy meter data not captured by the assessed energy meter
    d. Hours of operation, days per week, public holidays
        i. Utilization data has become an increasingly important part of M&V, adding resiliency to energy baselines throughout periods of varying occupancy such as the COVID-19 pandemic.

M&V Tooling

1. Using the aggregated data, a baseline model is developed using suitable tooling, dependent on the complexity of the baseline. BTune has developed an in-house M&V tool within Microsoft Excel which supports the development of an energy baseline with a single independent variable such as ambient temperature. Where energy baselines have more than one driver of energy consumption such as ambient temperature and occupancy (multiple independent variables), M&V-specific tooling such as RETScreen®* may be used.
    a. Regardless of the tool used, each energy baseline is assessed against the statistical requirements as defined by the IPMVP to ensure the baselines are considered accurate or a 'good-fit'.
2. Below is an example of a baseline created via RETScreen®. In this example, the blue line represents the baseline and the green line represents actual energy use. The difference between the blue and green points indicates the error of the baseline from actual consumption.

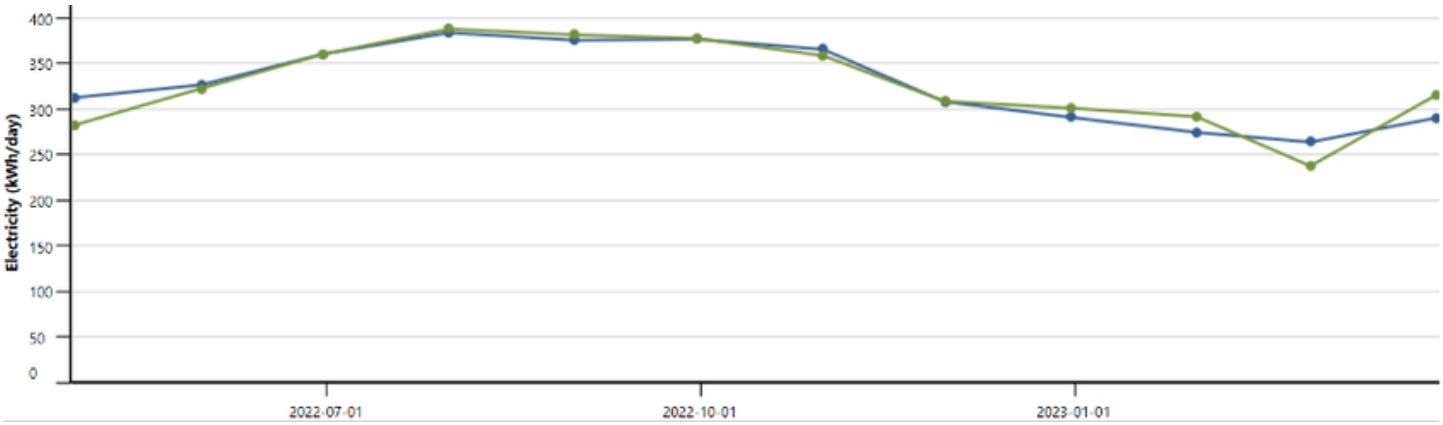

Figure 1: RETScreen example of the Predicted Monthly Energy Baseline Consumption (Green) compared to the Measured Energy Consumption (Blue) over the 12-month baseline period.

Baseline Statistical Validation

1. Once the baseline model is created, further validation is conducted to ensure it is an accurate representation of energy use in your building. This test is undertaken using IPMVP-approved statistical tests.
2. A "passing" baseline will have calculated values that are close to actual values, while a failing baseline may be deemed to be too inaccurate to be used. Below is an example of the validation run on the Figure 1 baseline example. As noted in the results, this baseline received a "Pass" and was deemed to be accurate.

*RETScreen® Clean Energy Management is a software developed by the Government of Canada that allows for the measurement and verification of the actual performance of facilities. This is a common tool used to verify energy savings under IPMVP.

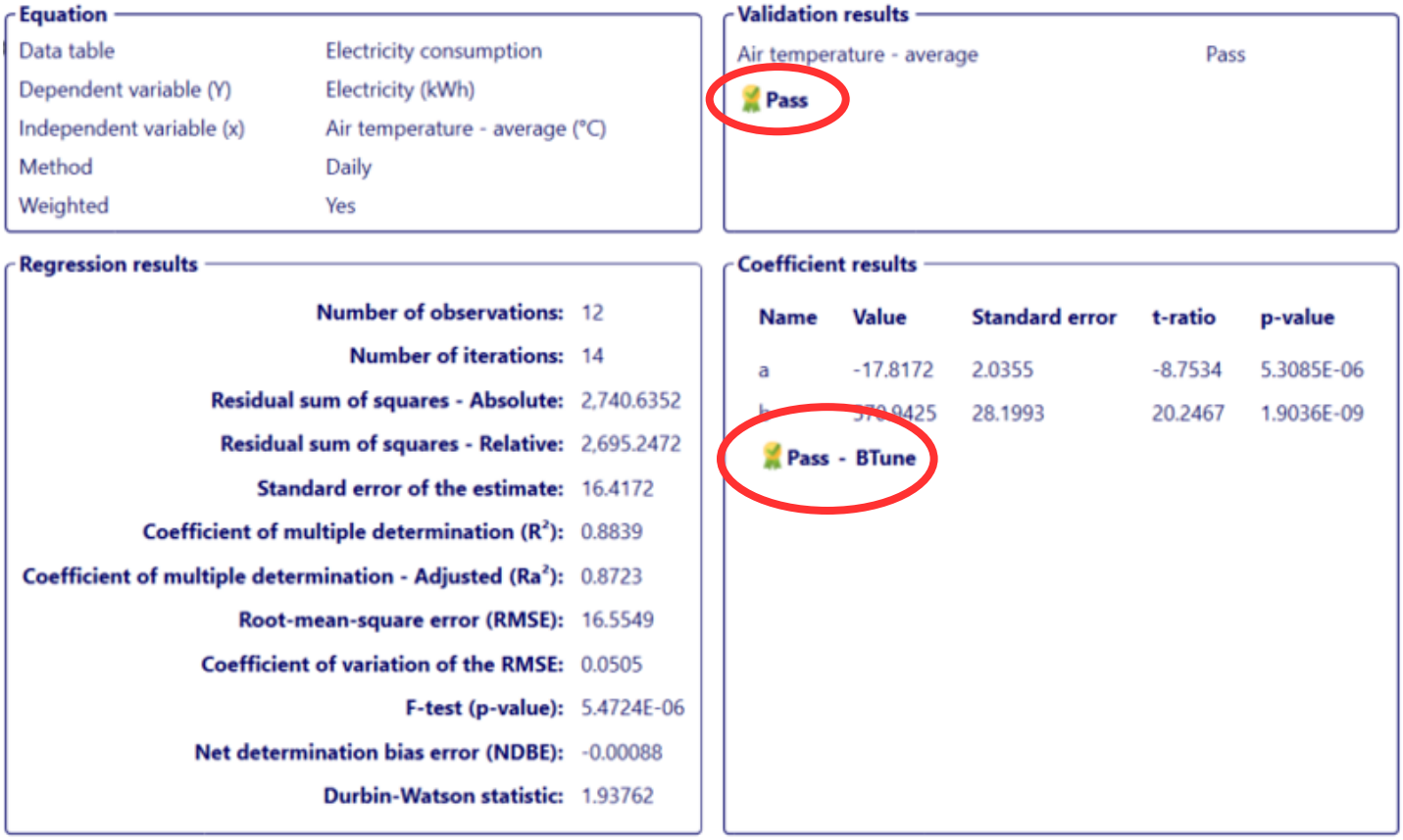

Figure 2: Example of a RETScreen Statistical Tests performed on a typical Energy Baseline

How certain are the savings?

Investing more money and time in the Measurement and Verification (M&V) of energy savings can decrease the uncertainty, but in all projects, there will always be some uncertainty as the method of determining savings is by calculating energy use avoided and the quality of data depends on the equipment in place.

At BTune, we make all efforts to remove as much uncertainty as possible and improve accuracy while providing the most efficient M&V process we can. At a minimum, we target the IPMVP recommended statistical test criteria* for baseline construction as follows:

- Adequate Sample Size (e.g., at least three to five times as many data points as the number of independent variables)

- To assess the model 'goodness of fit':
  - R2 > 75%,
  - Adjusted R2

*As recommend by IPMVP: https://www.bpa.gov/-/media/Aep/energy-efficiency/measurement-verification/3-bpa-mv-regression-reference-guide.pdf page 12 and section 5

- To assess the significance of contributions made by different independent variables:
  - T stat (for all coefficients except the intercept) > |2|
  - p value < 0.1

- To assess the model accuracy:
  - Coefficient of Variation of the Root Mean Squared Error CV(RMSE) < 0.2
  - Net Determination Bias (NDBE) < 0.005%

- Independence: each variable should be independent of other variables.

How do we prove savings?

Once ECMs have been implemented, the project enters what is called the “reporting period”. This is the period where the baseline is used to calculate what the energy use would have been if the energy efficiency measures had not been implemented. The savings calculated are the “avoided energy,” the difference between measured consumption and what would have been consumed if the energy efficiency measures/BTune had not been implemented (the Energy Baseline).

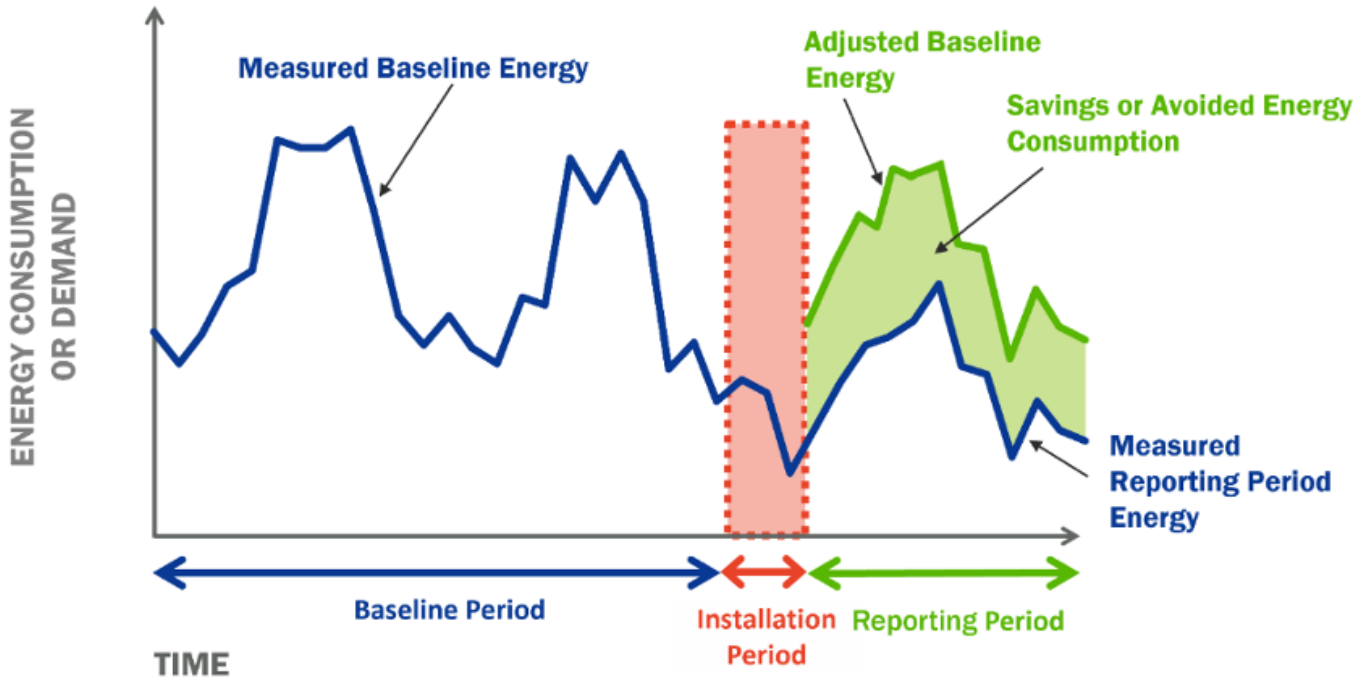

Figure 3: Savings or Avoided Energy Consumption or Demand IPMVP Core Concepts 2022 page 22

How do we prove savings?

The energy savings are equal to the Baseline energy consumption minus the Measured energy consumption. The energy consumption is expressed in kilowatt-hours (kWh). Energy demand savings are equal to the baseline energy demand minus the measured energy demand. The energy demand is

expressed in kilowatts (kW). BTune obtains energy consumption and demand directly from the energy meter or energy bills.

The cost savings are calculated by multiplying the energy and/or demand savings (in kWh or kW) by the average unit cost rate per unit of energy (in $/kWh or $/kW).

The carbon emission reductions are calculated by multiplying the energy savings (in kWh) by the average emissions factor of the energy source (T CO_2-e / kWh). The local default emissions factor for the location of your building is used.

What if a suitable baseline is not formed?

Typically, the IPMVP method BTune uses allows us to account for energy reductions achieved by BTune, while also accounting for energy reductions or increases created by other initiatives undertaken independently of BTune, such as plant being manually overridden to run 24/7, or plant replacements and upgrades taking place throughout the baseline or reporting period. In some cases, a Non-Routine Adjustment (NRA) can be made to adjust the baseline or reporting period consumption to account for such events. An NRA is an IPMVP supported method for accounting for non-routine events.

In the event a suitable baseline cannot be achieved and an NRA does not adequately account for site events, BTune will meet with you to discuss the outcome of the M&V process and determine the best path forward for the energy savings project. Reasons for a compliant baseline not being formed may include changes or inconsistencies in daily, weekly or monthly building usage that cannot be logically accounted for. In this circumstance, energy savings can still be calculated with reasonable assumptions but agreement would be sought from all parties. There are other IPMVP aligned methods for measuring and verifying energy savings that can provide confidence in energy savings being achieved and give an estimated range of savings being achieved.

In some cases, a shared savings business model agreement may be renegotiated to a fixed fee subscription model and energy savings reported against the non-compliant baseline.