NOVEMBER 14, 2023

Introduction to Measurement and Verification (M&V)

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Save on Energy Program Updates

Retrofit Program spring 2023 changes

- **Custom track** introduced in May 2023
- Updated incentive structure
  - New and increased incentives
  - Same incentive rate for lighting and non-lighting projects (**$1,200/kW or $0.13/kWh**, whichever is higher)
  - $1 million incentive cap for Retrofit projects has been removed
  - Incentives continue to be capped at 50% of project costs
- Changes to **networked lighting** control incentives
  - Incentives now calculated on **$/kWh** (moving away from $/sq. ft.)
  - An incentive offering for networked lighting controls — from $0.15/sq. ft. to **$0.35/kWh**

Retrofit Program fall 2023 changes

- Prescriptive incentives for most **non-lighting** measures have increased as of October 30, 2023
- Most non-lighting incentives have **doubled,** and some have increased three- or fourfold, including air source heat pumps
- The **last day to apply for lighting** projects (prescriptive or custom) in the Retrofit program is **December 17, 2023**
- The **Instant Discounts Program** for lighting launches **December 18, 2023**
- In this program, incentives will be paid directly to distributors, enabling them to offer instant point-of-sale discounts on energy-efficiency lighting to customers
- Visit the Retrofit program website for the updated measures and incentives.

Retrofit regional adders

In certain areas of Ontario where electricity constraints exist, the IESO introduced Retrofit regional adders that **double the incentive for non-lighting prescriptive measures**, to further encourage uptake in the Retrofit program. The target areas are:

- Niagara region
- Kingston area
- Southern Huron Perth
- Pembroke area
- Kenora
- Waubaushene
- Barrie/Muskoka
- Elmira
- Peterborough/Belleville

Postal codes for each eligible target area are available on the Save on Energy website

Industrial Energy Efficiency Program (IEEP)

- The IEEP offers overall funding of nearly $80 million to qualifying industrial participants over competitive rounds of funding
- Applications are scored and ranked
- Highest-ranked applications are selected first
- Successful applications are eligible for up to **$5M** in incentives
- Rounds 1, 2 and 3 are now closed.
- **New: Round 4 open now, closing at the end of March 2024**

Small Business Program

- Provides opportunities for small businesses to make lighting and non-lighting equipment improvements, reducing their energy consumption at **no cost**
- Direct-install incentives for a broad range of equipment
- Up to **$3,000 in lighting** upgrades (recently increased by $1,000) and up to **$2,500 for non-lighting** measures, including HVAC and refrigeration

Learn more at SaveOnEnergy.ca/SBP

New training courses

Save on Energy offers incentives of up to 50% for ~20 training courses, plus certification exam fees, including:

- Achieving Net-Zero Buildings
- Energy Management and the ISO 50001 Standard
- HVAC Optimization for High Performance Sustainable Buildings
- Certified Energy Manager (CEM)
- Certified Measurement & Verification Professional® (CMVP)

To register, visit: https://saveonenergy.ca/Training-and-Support/Training-Courses

Introduction to M&V: objectives & agenda

Learning Objectives: attendees to be able to …

Explain what M&V is (and is not), why it is useful, and how M&V is used in energy efficiency projects.

Describe the four basic M&V methods (options), and sample applications where each method has advantages.

Understand what adjustments are, why they are critical in M&V.

Develop an M&V strategy for projects which utilizes the best M&V practices.

Abbreviations

ASHRAE	American Society of Heating Refrigeration and Air Conditioning Engineers
CDD	Cooling Degree Days
CMVP	Certified Measurement and Verification Professional
Cv(RMSE)	Coefficient of Variation of Root Mean Square Error
CUSUM	Cumulative Sum of Differences
EEM	Energy Efficiency Measure
EMIS	Energy Management Information System
EVO	Efficiency Valuation Organization
FEMP	U.S. Federal Energy Management Program
GJ	Gigajoule
HDD	Heating Degree Days
IPMVP	International Performance Measurement and Verification Protocol
HVAC	Heating, Ventilation and Air Conditioning
kW	kilowatt(s)
kWh	kilowatt-hour(s)
M&V	Measurement & Verification
MT&R	Monitoring, Targeting & Reporting
OAT	Outdoor Air Temperature
PMVA	Performance Measurement & Verification Analyst
TOU	Time of Use rate schedule
TMY	Typical Meteorological Year

Course outline

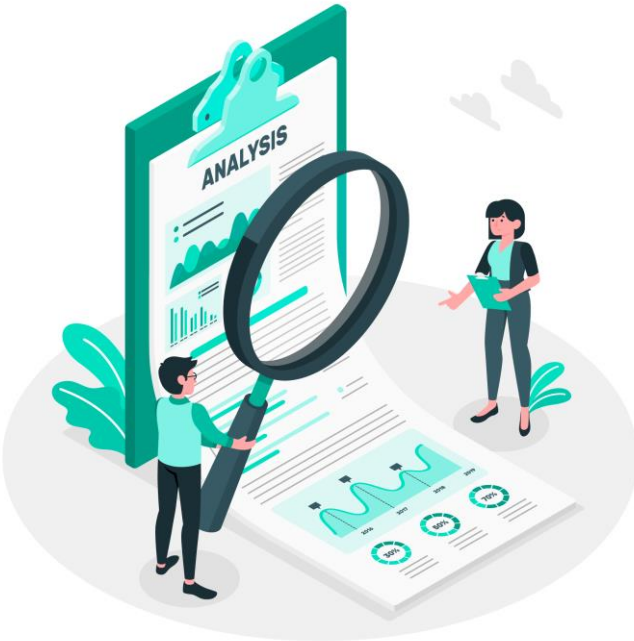
Module	Title
Module 1	What is M&V and why invest in it?
Module 2	M&V methods & Best Practices
Module 3	Menti.com Questions
Module 4	Ask us anything: Q&A

What is M&V and why invest in it?

Definition

"Measurement and verification (M&V) is the process of planning, measuring, collecting, and analyzing data to verify and report energy savings resulting from the implementation of energy efficiency measures (EEMs) in one or more facilities."

Source: International Performance Measurement and Verification Protocol (IPMVP), CORE CONCEPTS 2022



What is M&V? Measure something, or it's not M&V

- Measure directly on the system or EEM
- Measurement on similar systems at another location or time (e.g., lab or manufacturer data) does not count for M&V.
- "Deemed savings" is not IPMVP-adherent M&V (but "deemed" is useful for evaluation or other purposes)

https://evo-world.org/en/news-media/m-v-focus/868-m-v-focus-issue-5/1154-evo-deemed-savings-statement \

What is M&V used for?

- Types of measures:

- Note: in this presentation "energy savings" is generally attributable to **energy efficiency**, but the concepts and methods apply equally to all measure types.

When is M&V used?

ENERGY PERFORMANCE CONTRACTS

DSM PROGRAMS

GREEN LOANS

BUILDING CERTIFICATION

EMISSION-REDUCTION TRADING PROGRAMS

ISO 50001 CERTIFICATION

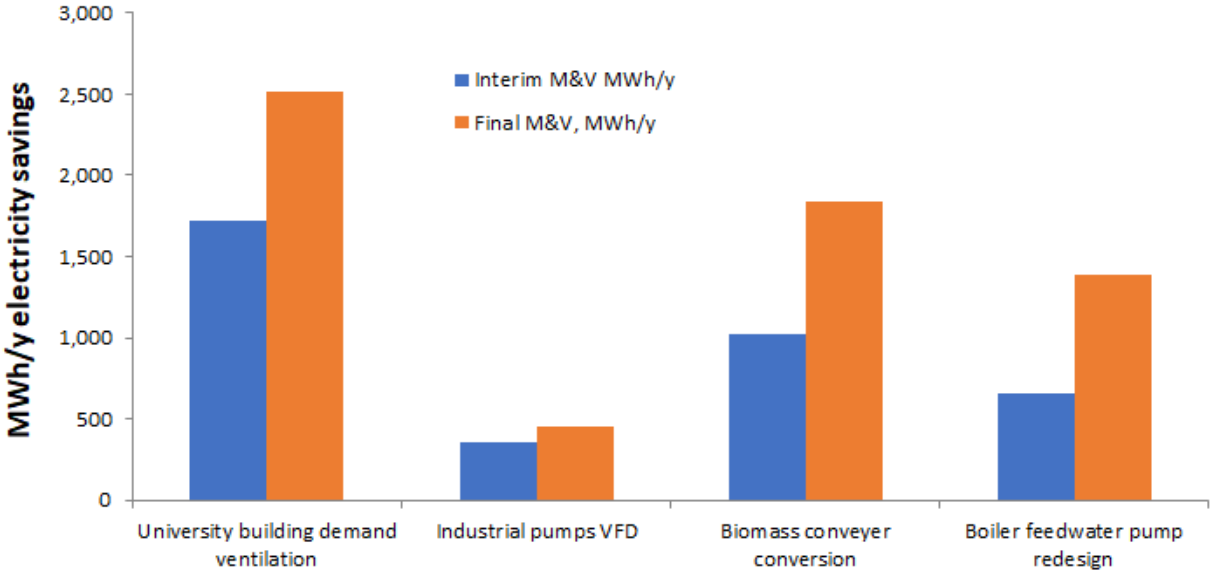
Purposes of M&V

Increase energy savings	•Accurate determination of energy savings enables facility owners and managers to adjust their energy-efficiency measures for improved, persistent, and consistent energy savings.
Document financial transactions	•Energy-efficiency savings serve as the foundation for performance-based financial payments and/or a guarantee in a performance contract.
Enhance financing for energy-efficiency projects	•A robust M&V plan enhances both the transparency and credibility of reports on efficiency investment outcomes and projection.
Improve engineering design and facility operations and maintenance	•A well-executed M&V process helps managers in identifying and mitigating maintenance and operational issues, enabling them to enhance the efficiency of facility management, M&V meters and models can be rolled into EMIS.

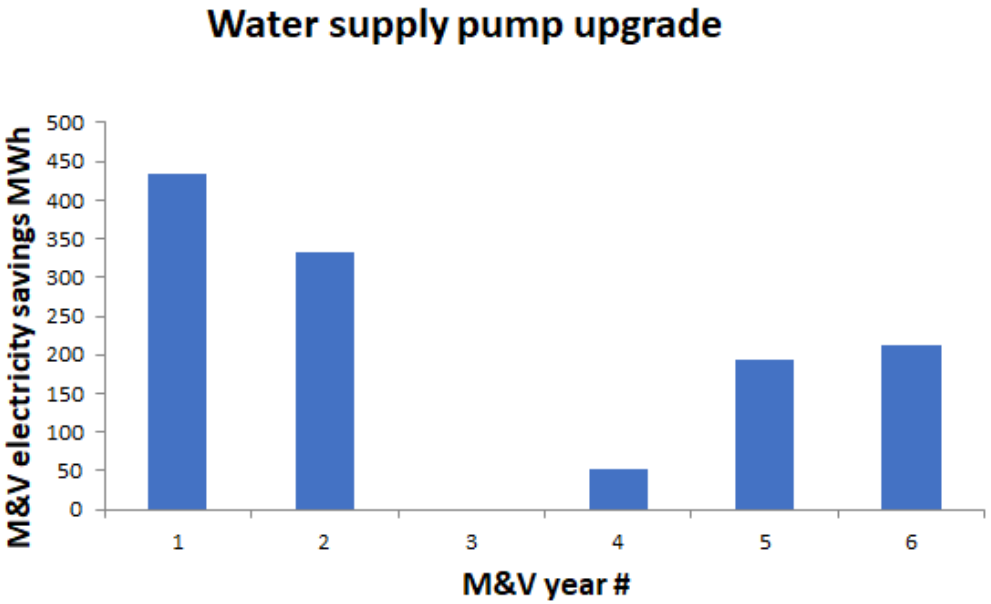
Purposes of M&V

Manage energy budgets	•M&V techniques adapt for facility-operating changes to establish accurate budgets and address budget variances.
Enhance the value of emission-reduction credits	•Accounting for emission reductions provides additional value to efficiency projects.
Support evaluation of regional efficiency programs	•Utility or government programs overseeing energy supply systems can employ M&V techniques to assess savings achieved at specific energy user facilities.
Increase public understanding of energy management as a public policy tool	•Improving the credibility of energy management projects through M&V fosters greater public support for emission reduction efforts and energy savings.

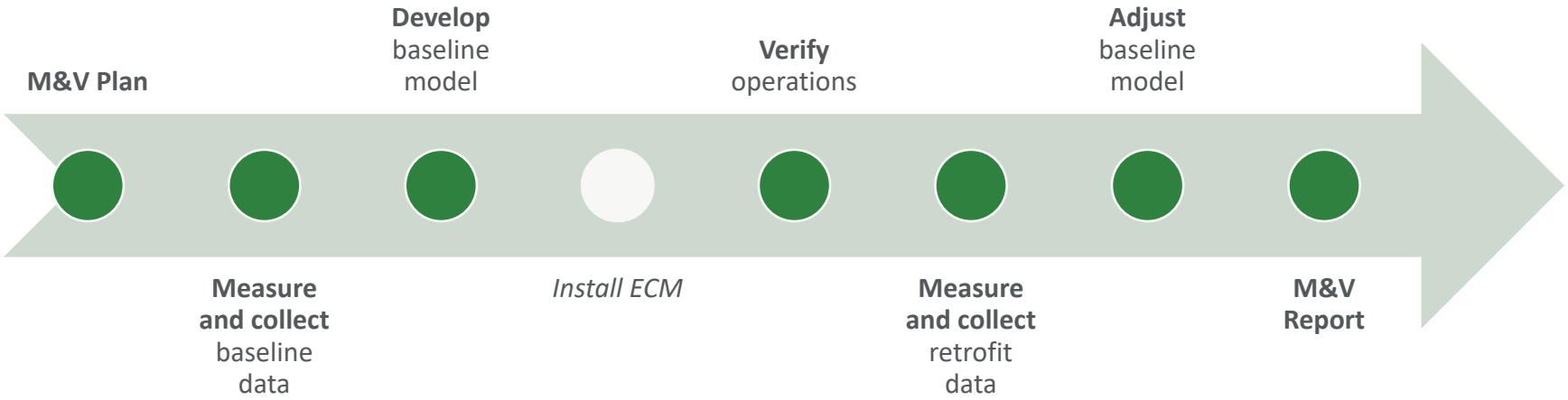
M&V can improve EEM performance: Sample of interim vs. final M&V results



M&V can improve EEM performance: Example project for multiple year M&V



M&V activities



How do we calculate the energy savings?

Baseline system

Efficient system

15,000 kWh annually

10,000 kWh annually

What are the energy savings attributed to this project?

How do we calculate the energy savings?

Consumption is influenced by many factors that often change from baseline to efficient.

The M&V professional must make **adjustments** for these factors.

Weather (OAT)

Occupancy

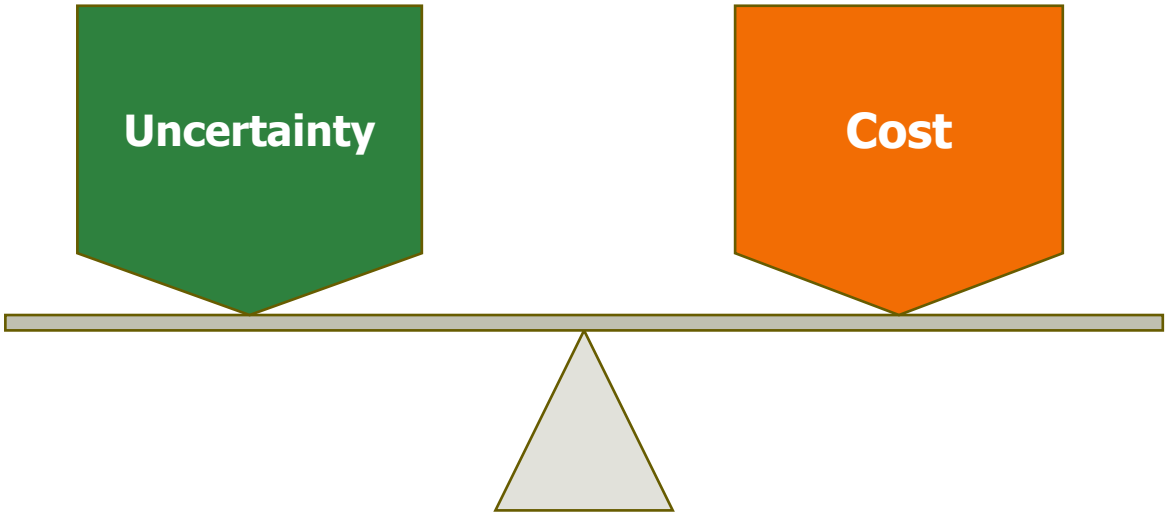
Production rate

Product quality

Equipment change-out

Behaviour

M&V balance: uncertainty (accuracy) vs. M&V cost



International protocols

The modern M&V practices of energy end users are documented in various international protocols.

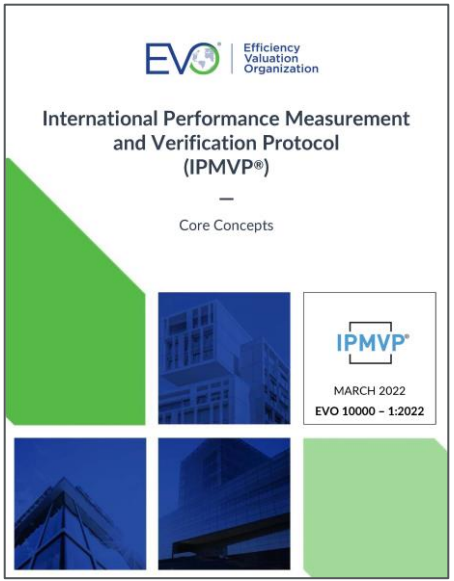
- International Performance Measurement and Verification Protocol (EVO 10000 – 1:2022)
- ASHRAE Guideline 14-2023 – Measurement of Energy, Demand, and Water Savings
- Other protocols produced by utilities or government agencies for specific programs (FEMP)
- ISO/TC 257 - General Technical Rules for Determination of Energy Savings in Renovation Projects

International Performance Measurement and Verification Protocol (IPMVP)

Defines the terms used for M&V activities in energy-efficiency projects.

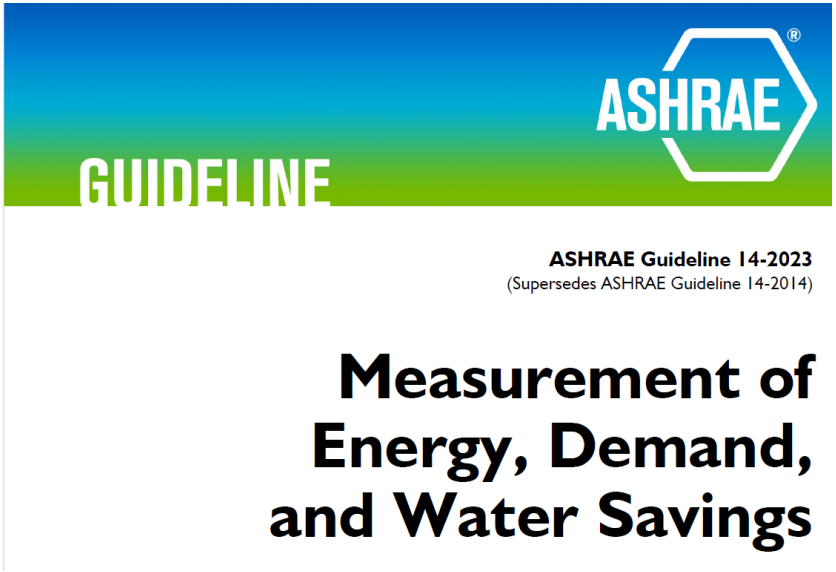
Defines standardized approaches to measure generated savings.

Defines the content of M&V plans that document entire initiatives/undertakings.



ASHRAE 14-2023

Excellent procedures and calculations for regression model validations and uncertainty.



M&V Certifications

CMVP (AEE)

ENERGY EFFICIENCY PERFORMANCE MEASUREMENT AND VERIFICATION *ANALYST*

TRAINING AND CERTIFICATION PROGRAM

IPMVP® INTERNATIONAL PERFORMANCE MEASUREMENT & VERIFICATION PROTOCOL

PMVA™ PERFORMANCE MEASUREMENT AND VERIFICATION ANALYST

PMVA and PMVE (IPMVP)

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Free M&V Resources

Efficiency Valuation Organization www.evo-world.org Free account (user & password)

- IPMVP protocols:

  e.g. IPMVP Core Concepts (2022)

  e.g. forthcoming new version of Uncertainty Assessment Guide

Bonneville Power Authority: www.bpa.gov/energy-and-services/efficiency/measurement-and-verification

- Application Guides (e.g. peak demand)
- Reference Guides (e.g. regression modelling for M&V)

M&V Methods and Best Practices

M&V – Measuring savings?

The savings generated cannot be directly measured, because they represent **the absence of energy consumption**.

Savings are **determined** by calculations using measured data before and after project implementation.

Three approaches to M&V

"Avoided energy": reference conditions are the reporting period conditions (e.g., occupancy rates, OAT profile). Most common approach.

"Backcasting": reference conditions are the baseline period conditions. Rarely used.

"Normalized": reference conditions are a common set of conditions, neither baseline or reporting period conditions. (e.g., use TMY temperatures instead of actual OAT data). Second most common approach.

BEFORE measuring: write an M&V plan

Why and for whom do M&V?

What is (and is *not*) measured, and why?

Who will be the responsible M&V professional?

How will savings be calculated, including **adjustments**?

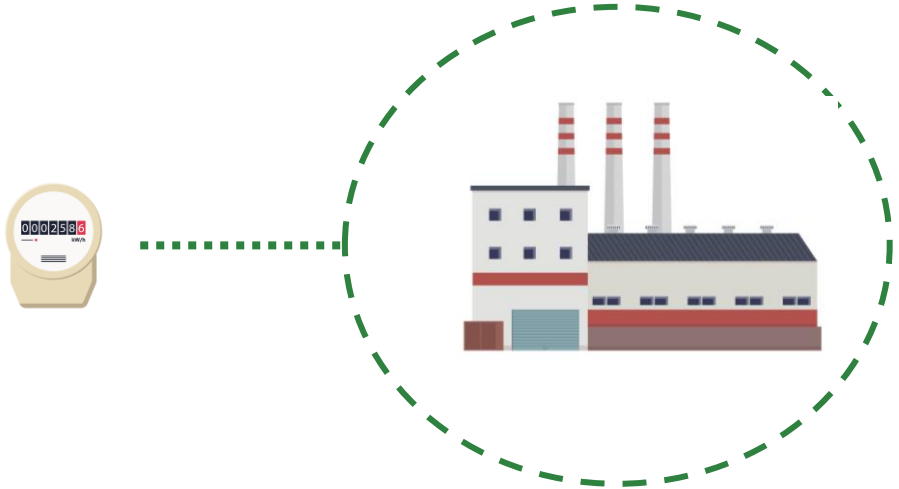
Measurement boundary

The measurement boundary is a notional perimeter drawn around the equipment, system, or facility relevant to savings calculations.

Measurement boundary: whole facility

An entire facility

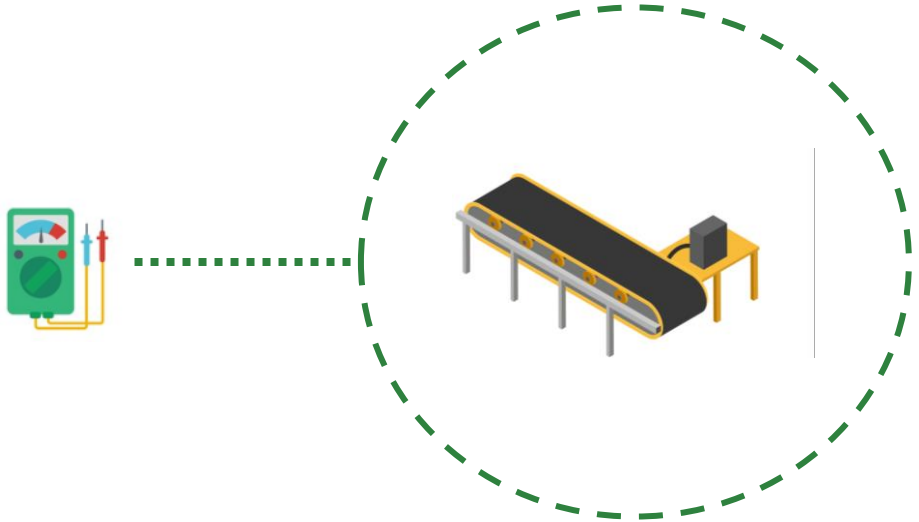
Meters that measure the energy supply of the entire facility can be used to evaluate performance and savings.



Measurement boundary: project isolation

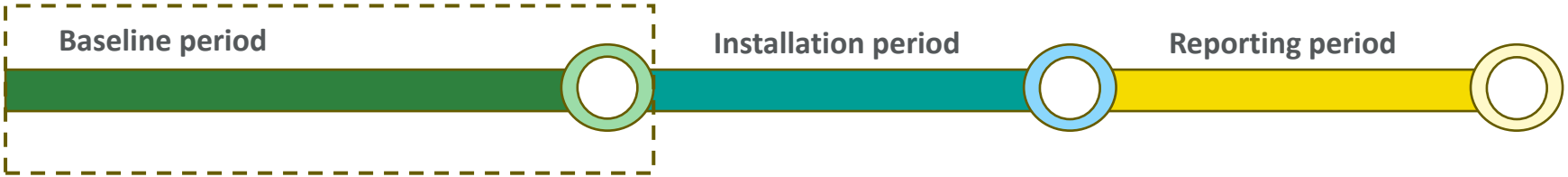
A portion of the facility, such as equipment or systems.

For equipment or systems, the measurement boundary is established around the given equipment or system.



Baseline period

The baseline period is the time interval selected to represent facility operations before project implementation. Long enough to **capture important process variations**.



The baseline period should:

Represent all operating modes of the facility or the equipment during a normal operating cycle.

Include only time periods for which factors that impact energy use of the facility are known

Coincide with the time that immediately precedes the upgrade.

Baseline period conditions

All reference elements that characterize the equipment, systems, or facilities on/in which the energy efficiency measures (EEMs) will be installed have to be collected.

- Factors that have an impact on energy consumption. E.g. product quality mix, production rate, occupancy.
- Information on existing equipment and systems **before** EEM implementation
- The operating modes **before** EEM implementation

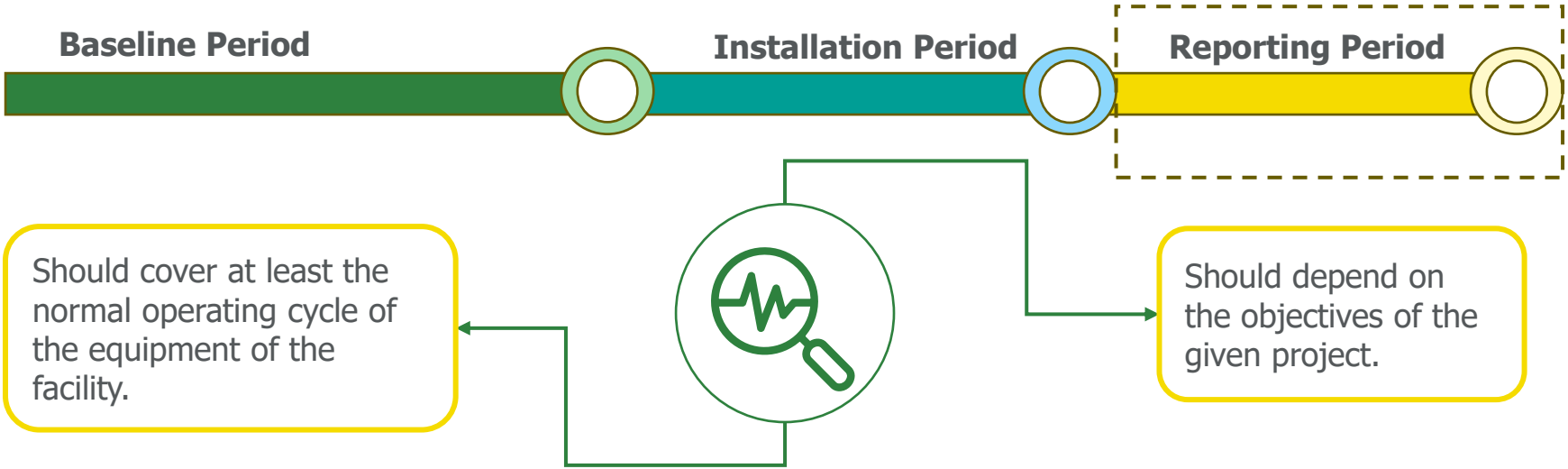
These conditions are a critical element of the M&V and **become unavailable once EEM is implemented.**

Installation period

The installation period refers to the timeframe during which the planned energy conservation measures are physically implemented or installed, **including commissioning, tuning, and training which are essential to achieve savings**.

Reporting period

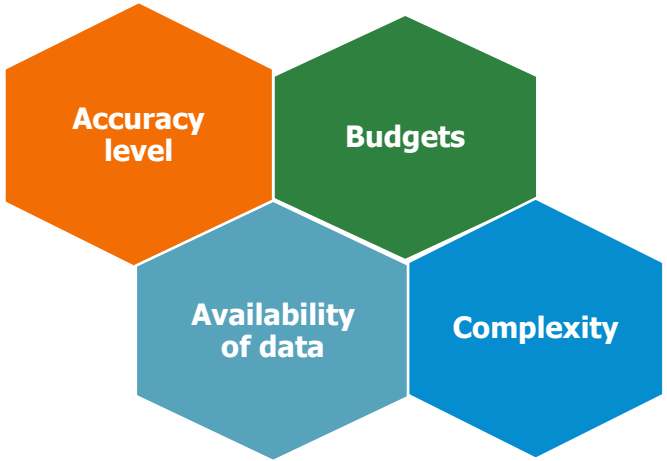
The selected time period during which generated savings are verified after the implementation of an action that improves energy performance.



IPMVP options

IPMVP offers several options which specify different approaches for measuring and verifying the performance of projects.

Factors to consider to select an IPMVP option:

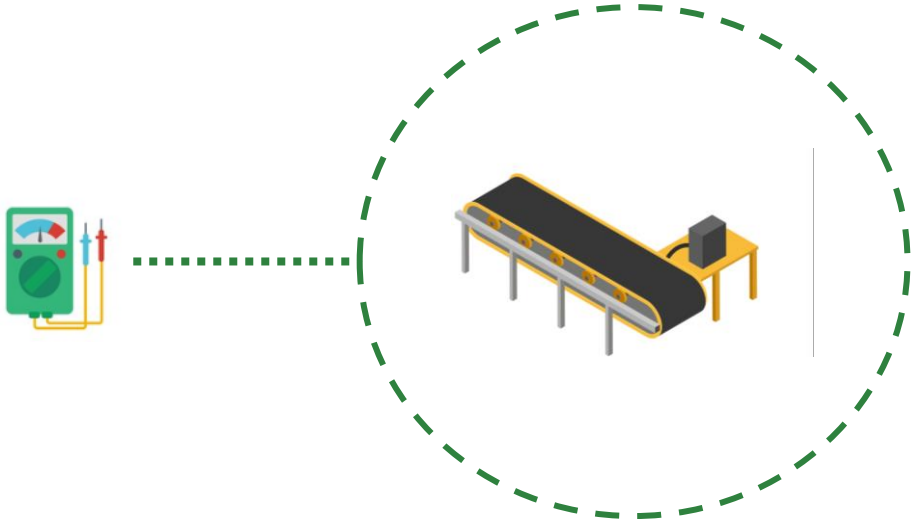


IPMVP options

OPTION A: KEY PARAMETER(S) MEASUREMENT

OPTION B: ALL PARAMETER MEASUREMENT

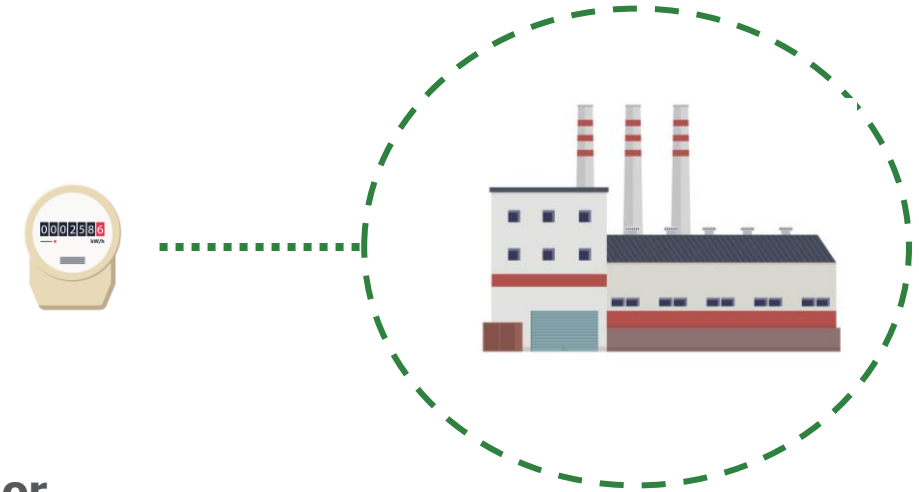
Retrofit Isolation



IPMVP options

OPTION C: Whole facility

Whole facility approach



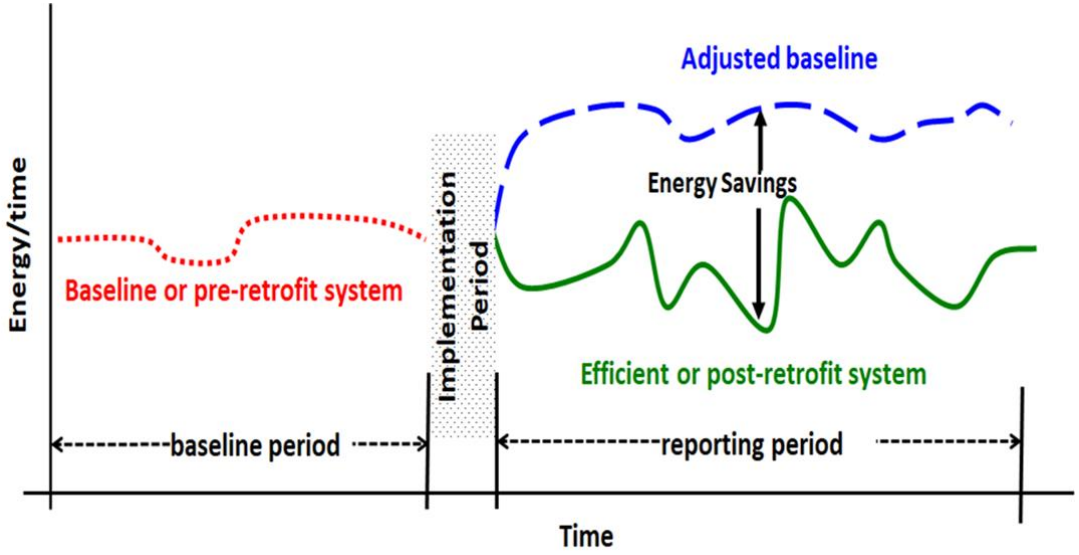
OPTION D: Calibrated simulation

Option D can be Whole Facility or Retrofit Isolation (depends)

M&V basic equation for energy savings

Savings = Baseline Energy – Reporting Period Energy +/- Energy Adjustment

Usual approach: Savings = Adjusted Baseline Energy – Reporting Period Energy



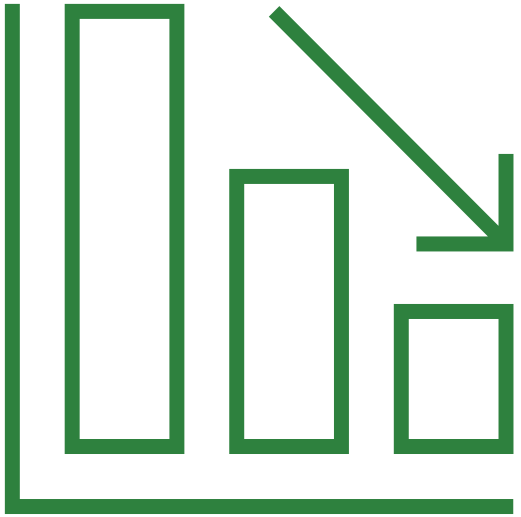
Adjustments

What is the cause of the reduction in energy consumption?

Example

An energy renovation was carried out in a factory, but the operating hours have been reduced compared to the baseline period due to lower demand in the market.

- **What portion of the energy reduction is due to the EEMs?**
- **What portion is caused by a change in production?**



Adjustments

Routine adjustments: Factors that influence energy consumption and likely to vary regularly during the reporting period. **Example**: weather (OAT), operating hours for industrial.

Non-routine adjustments: Factors capable of impacting energy consumption but that, in principle, should not vary between the baseline and reporting periods. **Example**: building expansion, hours of operation

Savings calculations and methodology

When reporting the savings, the designated M&V professional is required to provide:

- A description of the data analysis and methodology.
- A list of assumptions and sources of data used in calculations.
- A description of the baseline period, adjustments, and options selected.

Reporting savings: energy, GHG emissions, costs

Results can be presented in various ways and can include:

- Energy (kWh, m3, L, GJ)
- Water (L)
- Costs ($), NPV, Payback
- GHG Emissions (tCO2e)

ECM Description	Budget $	Investment $	Saving MWh	Saving $	Payback Years
Chiller replacement - 2 chillers	$ 1,800,000	$ 1,257,800	1,173	$ 156,633	8.0
Boiler replacement - 1 low load boiler	Nil	$ 235,000	46	$ 23,911	9.8
LED lighting upgrade - non critical area	Nil	$ 608,191	801	$ 135,299	4.5
LED lighting upgrade - critical area	Nil	$ 174,570	160	$ 26,965	6.5
LED lighting upgrade - outdoor	Nil	$ 66,400	52	$ 8,710	7.6
Solar PV - 500kW (large scale)	Nil	$ 721,875	813	$ 161,631	4.5
Cogeneration	$1.5mil all mech $0.8mil DHW	$ 1,105,769	975	$ 100,955	11.0
HVAC commisioning/BMS fine tuning		$ 92,045	195	$ 36,596	2.5
Building Analytics		$ 67,231	210	$ 32,298	2.1
TOTAL		$4,328,881	4,425	$682,999	6.3

Statistics for M&V

In M&V, there are many potential sources of uncertainty:

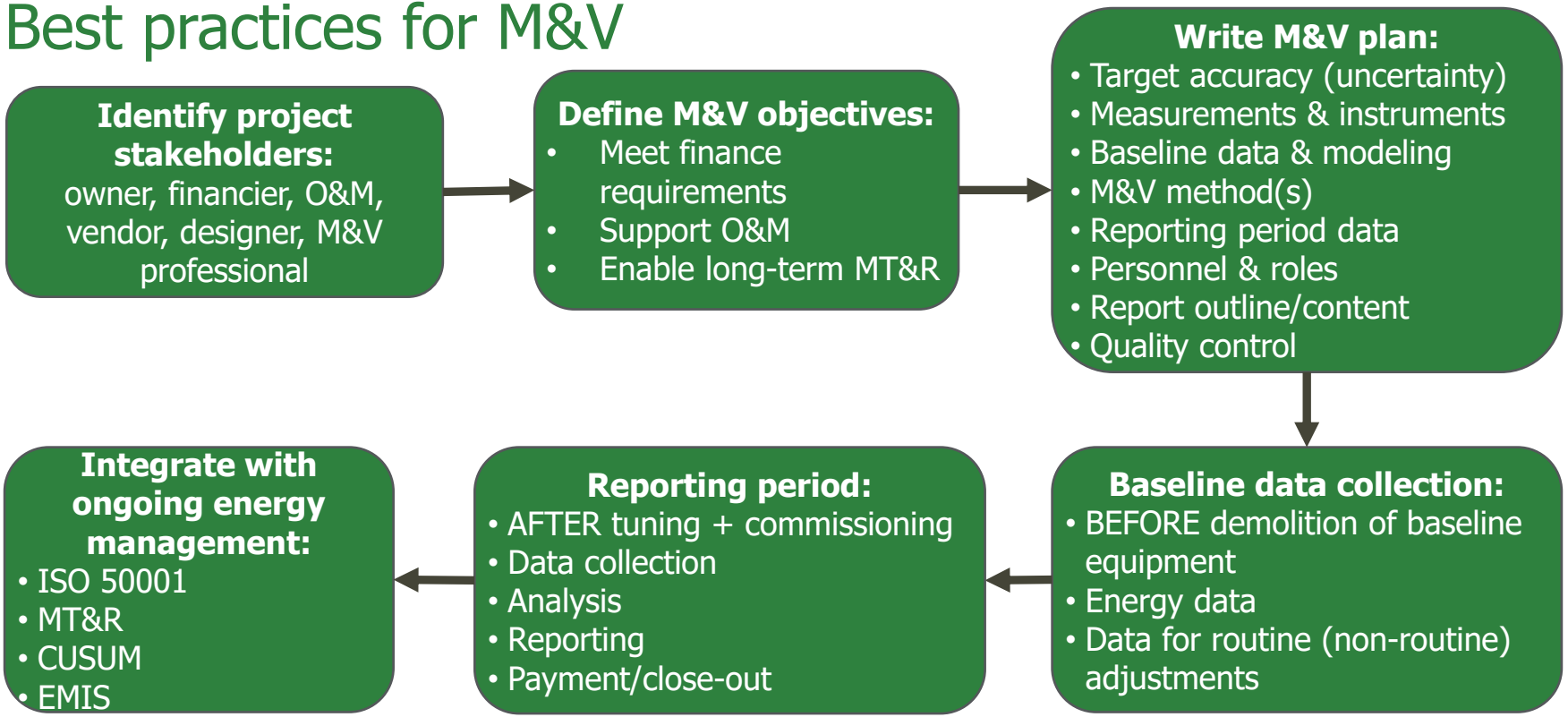
Modeling | **Sampling** | **Measurement**

Statistics are therefore necessary to **summarize**, **analyze**, **interpret data** when evaluating results.

Valuation of energy savings

- Utility bill savings:
  - **marginal rates** for energy (e.g., fixed monthly charges are not avoided, so blended utility rates should not be used)
  - Avoided demand costs (kW, kVA)
  - Consider timing: if seasonal or TOU rate schedule
  - Specify rates in the M&V plan
- GHG emission reductions and carbon tax

Best practices for M&V



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Q&A: Ask anything (related to M&V)!

Thank you

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