CATALYST converge '26

Introduction to Measurement and Verification (M&V) with the University of Arizona

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Agenda

1. The what, who, and when of Measurement & Verification (M&V)?
2. Four options A, B, C, & D
3. Importance of baselines
4. Establish the M&V boundary and scope
5. Weather normalization
6. Adjusted baselines
7. Best practices
8. Key takeaways

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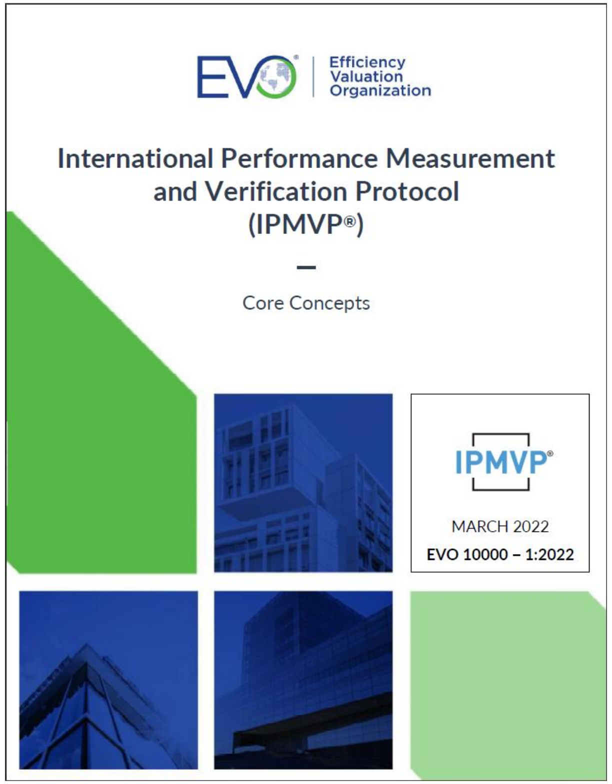
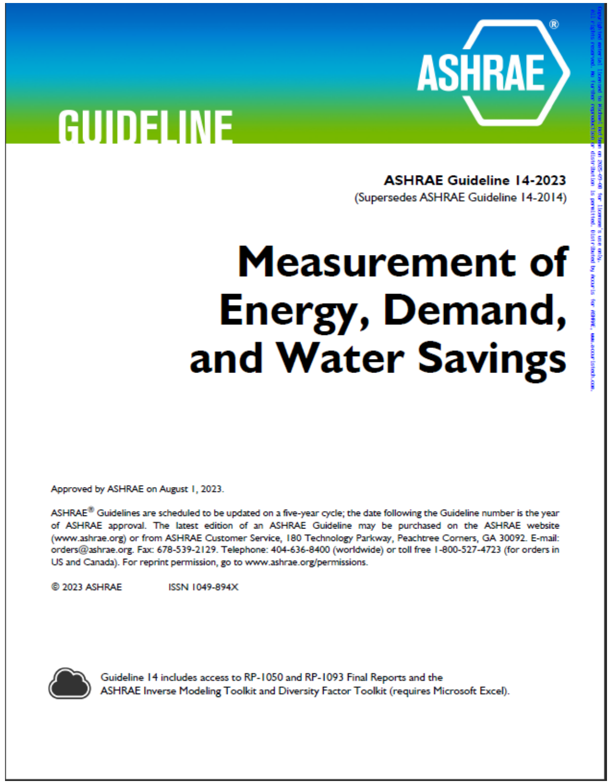
The what, who, and when of M&V

- **What:** A process of establishing how a system performs BEFORE you change it and comparing that to how it performs AFTER you change, accounting for differences in WHEN you look at it.
- **Who:** Operators, Engineers, Energy Managers, Cx Agents, Financial Decision-makers. Performed by specialists who understand building systems, data collection and statistical analysis and can do the math (or enter values and understand the results). Integral to managing implications of 3rd party financing, ESCOs, Revolving Funds, etc.
- **When:** Think about it at (before) the start of a project. "Keep the end in mind".
- **Where:** Any project where you're expecting a change in utility consumption or performance.
- **Why:** M&V is the only process that can tell you whether what you think you accomplished actually worked.

International Performance Measurement and Verification Protocol



International Performance Measurement and Verification Protocols (IPMVP)



ASHRAE Guideline 14-2023

(IPMVP) – The global framework used to reliably measure, calculate, and verify energy and water savings

IPMVP options

Retrofit Isolation

OPTION A
Retrofit Isolation:
Key Parameter(s) Measurement

OPTION B
Retrofit Isolation:
All Parameter Measurement

Whole Facility

OPTION C
Whole Facility

OPTION D
Calibrated Simulation

IPMVP options – retrofit isolation

Option A – one parameter

PROS:

- Savings reports correlate closely with the actual realized changes
- Relatively inexpensive and easy to execute

CONS:

- Most projects involve the implementation of many different ECMs at once

Example: Lighting Retrofit

Option B – all parameter

PROS:

- Savings reports correlate closely with production changes
- Actual savings determined from direct metered usage

CONS:

- Not reconciled to total facility utility costs
- The calculation of baselines for complex processes can be challenging
- Can require extensive metering

Example: Adding a VFD and controls to a cooling tower

IPMVP options – whole facility

Option C – whole facility

PROS:

- Evaluates performances of the entire facility
- Factors in interactions amongst ECMs and between ECMs and the rest of the facility

CONS:

- No separation of impacts from different ECMs
- Impact on savings coming from unexplained variations of energy usage can be difficult to capture

Example: Measuring operational changes

Option D – calibrated simulation

PROS:

- Suitable for new construction and lack of baseline data
- Accounts for changes in operating conditions. Allows for adjustments to be made for significant changes to weather or building changes
- Provides transparency and credibility in complex situations

CONS:

- Higher cost and complexity
- Requires accurate data for calibration
- Potential for manipulation
- Time sensitive

Example: Deep retrofit involving HVAC, lighting, building envelope

Importance of baselines

How baseline data Is collected

- Utility bills and interval data
- Submetering and sensors
- Building management systems
- Data logging (if all else fails)

The baseline is

- Reference point for comparison – needs to represent "normal"
- Defines what success looks like
- Supports transparent adjustments – both routine and non-routine adjustments
  - Weather normalization
  - Occupancy or production changes
  - Operating schedule variations
  - Changes in building square footage
  - Special events

Establish the M&V boundary and scope

Questions that need answers before starting

- How much time and financial resources do you have for analysis?
- Which IPMVP option fits your objective – whole building or specific equipment?
- Is interval data available to help with overall data accuracy?
- What are assumptions are you willing to accept?
- What is the level of bias and the extend of potential error?
- Do you need a full year of baseline data or is seasonal data enough?

Important implementation principles

- Select the right IPMVP Option
- Balance cost, accuracy, and risk
- Match rigor to project complexity
- Align expectations early

Weather normalization

What are heating and cooling degree days?

Heating Degree Days (HDD) is a measure of how *cold* a location is over a period of time, specifically used to quantify the energy needed to heat a building.

Example:

Average daily temperature = 40 degrees

Base temperature = 55 degrees

HDD = 55 – 40

HDD = 15

Cooling Degree Days (HDD) is a measure of how *warm* a location is over a period of time, specifically used to quantify the energy needed to cool a building.

Example:

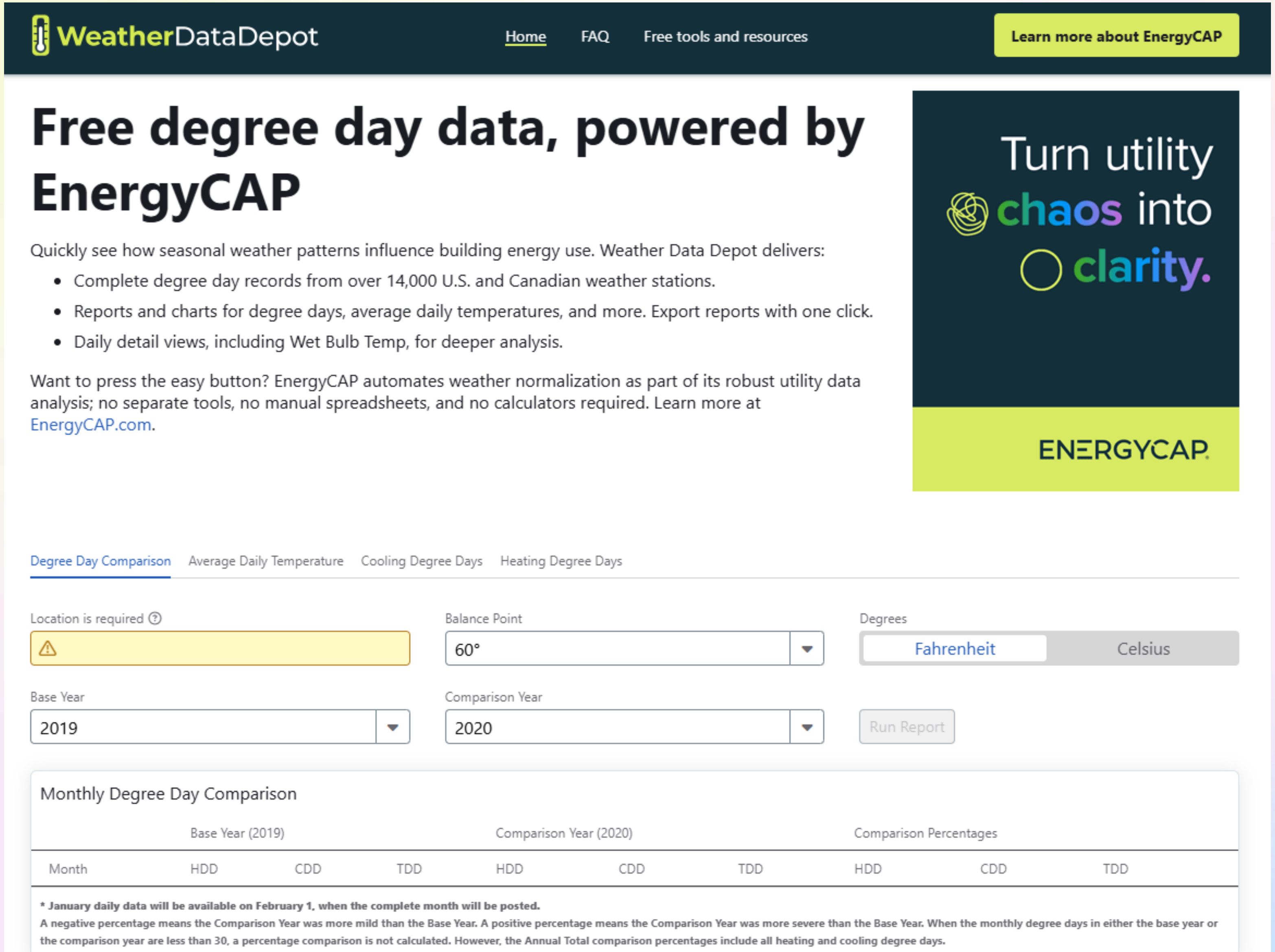
Average temperature = 65 degrees

Base temperature = 55 degrees

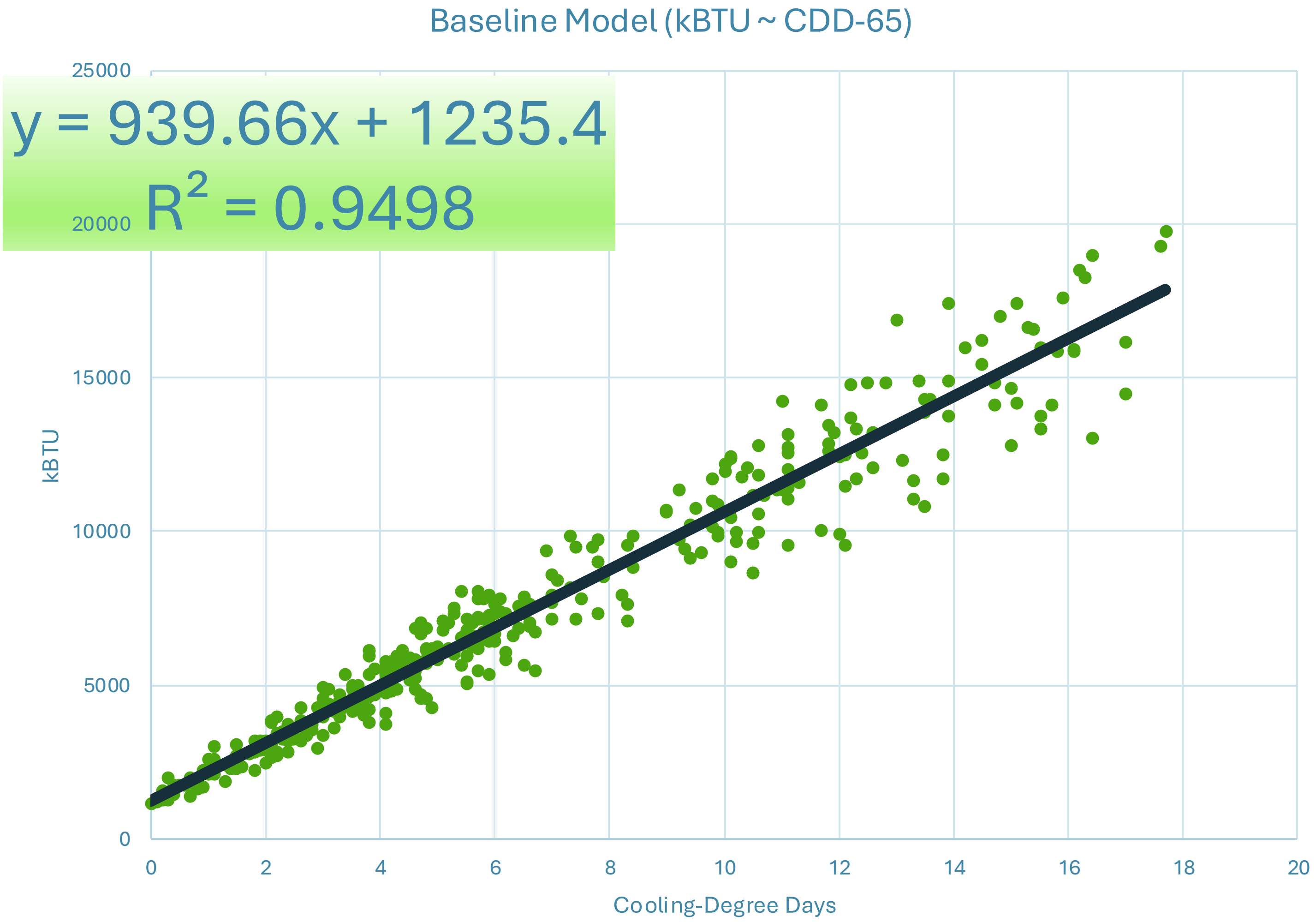
CDD = 65 – 55

CDD = 10

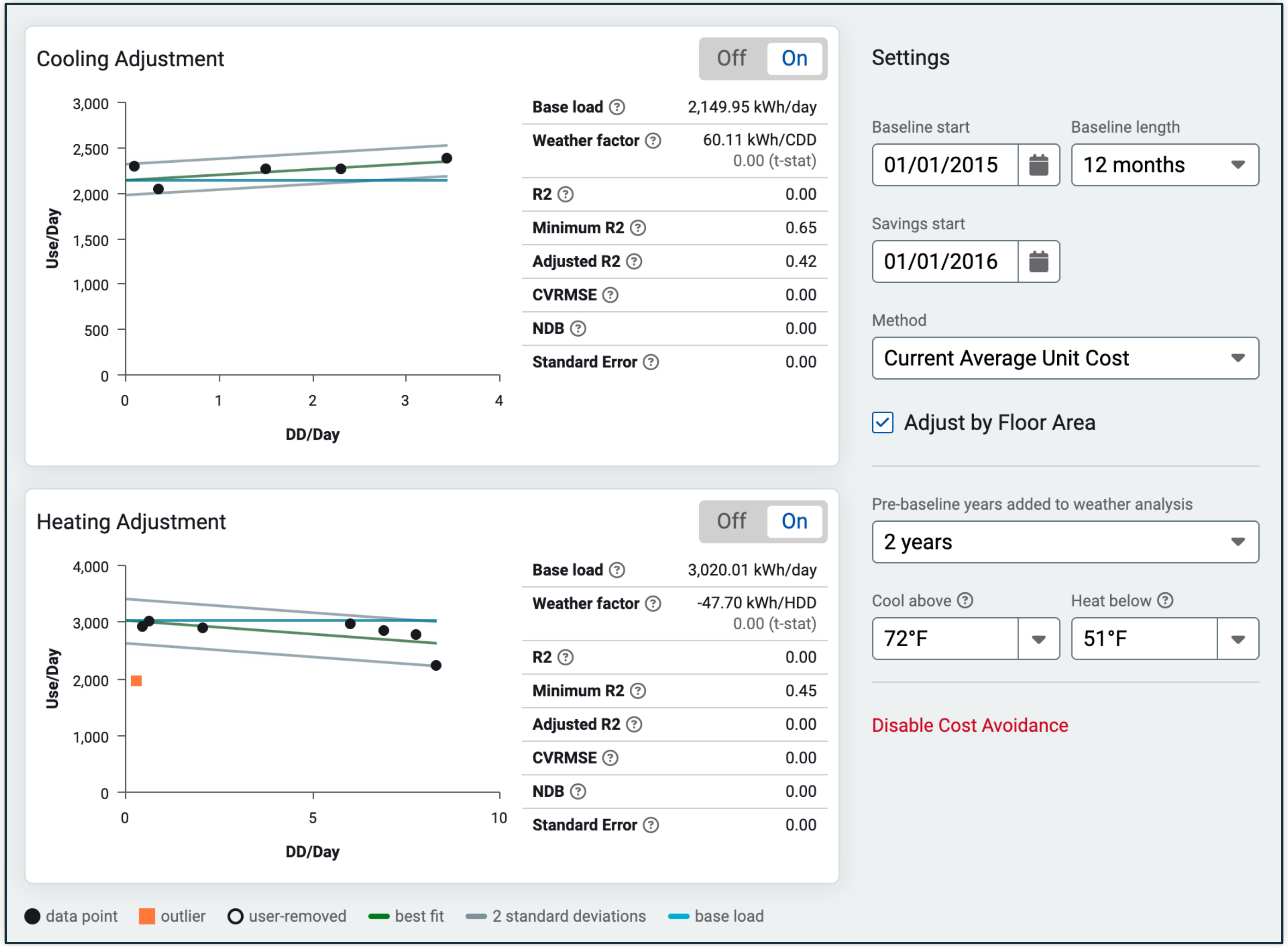
WeatherDataDepot



Regression models



Baseline Adjusted to Current Conditions (BATCC)



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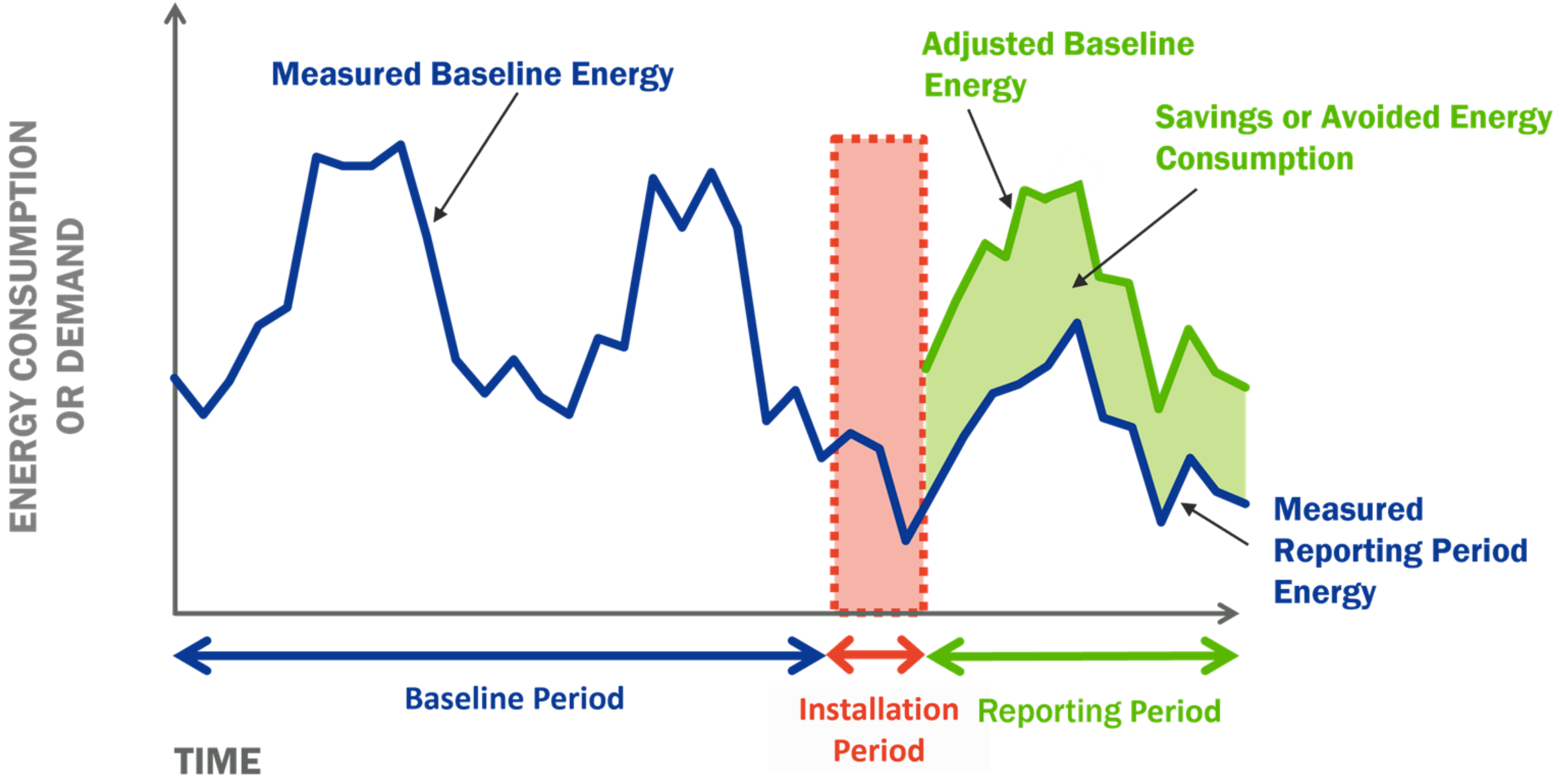

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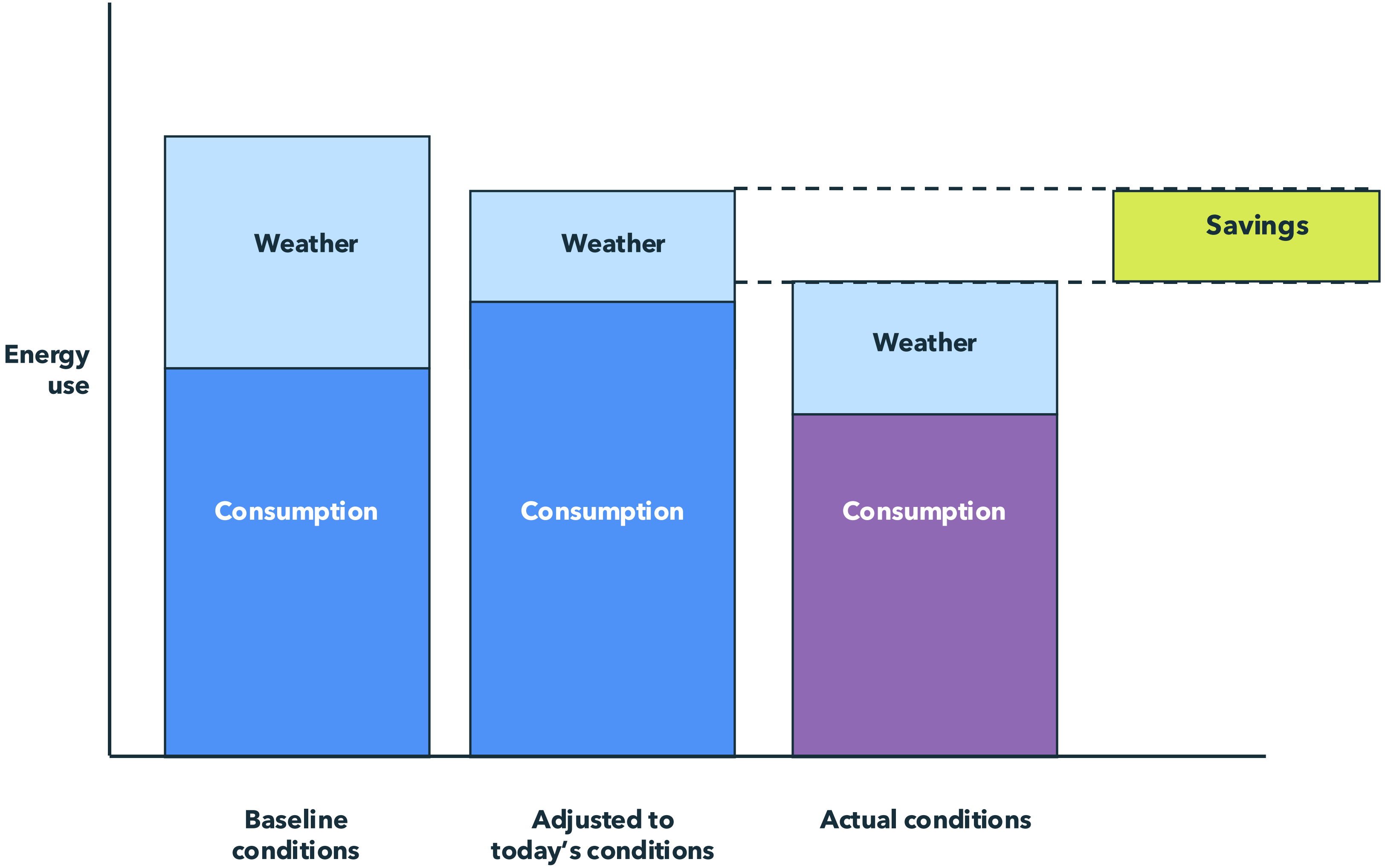

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Best practices

- Plan M&V early
- Document assumptions
- Use automation where possible
- Communicate results clearly
- Continue to track any variables that might "contaminate" the data

Key takeaways

- M&V turns claims into facts by eliminating guesswork
- Good measurement enables good decisions
- M&V boosts financial credibility
- Right-sized M&V delivers maximum value
- Provides methodological flexibility
- Encourages continuous improvement

Questions