



M&V for energy conservation measures



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Agenda



1. What is M&V?
2. IPMVP options
3. Case study and live examples
4. Identifying targets with EUI reporting and benchmarking
5. Setting EUI targets to trend toward
6. Other tools
7. Start today

What is M&V?

What is M&V?

Measurement and Verification of Savings

A standardized procedure, regulated by ISO (International Organization for Standardization).

Examples:

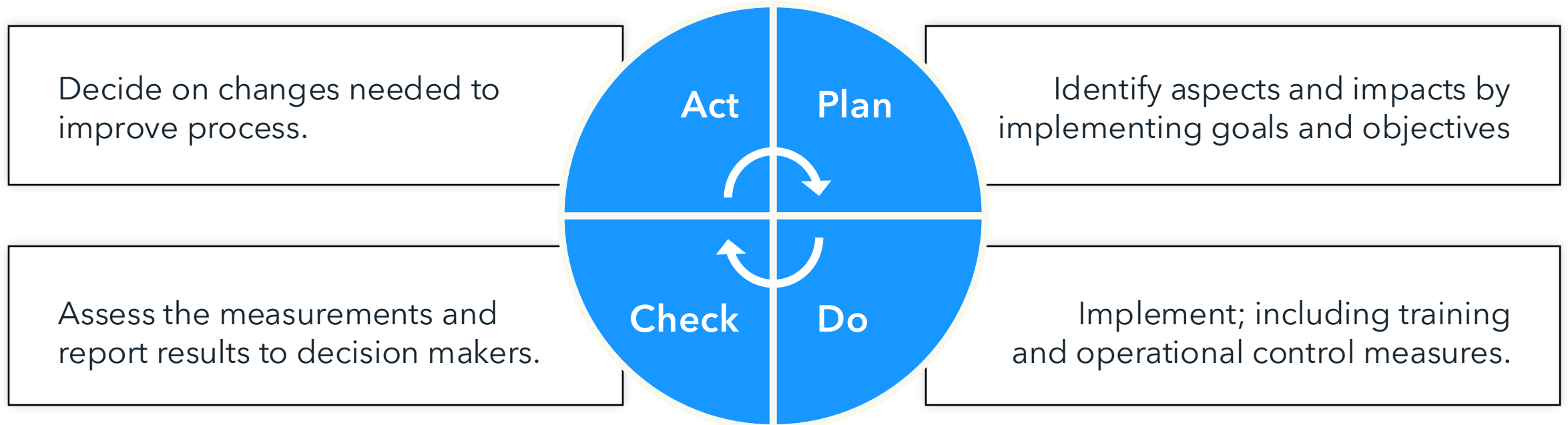
- ISO 9001 – Quality Management Systems
- ISO 27001 – Information Security Management Systems
- ISO 14001 – Environmental Management Systems
- **ISO 50001 – Energy Management Systems**

Purpose: give stakeholders confidence that reported savings are credible, with appropriate accuracy and management of uncertainty

You can't just compare year-to-year spend — you have to compare actual spend to what you would have spent without the efficiency measure (avoided spend)

ISO 50001: the PDCA cycle

ISO 50001 creates a broad framework for an organization to implement an energy reduction program using the ISO PDCA continuous improvement process.



Available IPMVP options

IPMVP options overview

ISO 50001 doesn't specify calculation methods — it sets principles and guidelines

The M&V practitioner selects the method and gets sign-off through the M&V Plan

IPMVP, from the Efficiency Valuation Organization (EVO-World.org), is historically the most common set of calculation methods

This session focuses on Option C: whole facility

Option	IPMVP name	What you're measuring	Simple description
A	Retrofit Isolation, Key Parameter Measurement	Individual ECM/equipment	Measure the important variables, estimate others
B	Retrofit Isolation, All Parameter Measurement	Individual ECM/equipment	Measure all parameters needed to determine energy use
C	Whole Facility	Entire building/facility	Compare whole-building energy before vs. after
D	Calibrated Simulation	Equipment or whole facility	Use a calibrated engineering/computer model

Option C // Whole facility

- Used when the energy use of the whole facility needs to be measured
- Several independent variables may need to be considered—
heating/cooling degree days, floor area changes, hours of operation, occupancy
- Best suited when several ECMs have been introduced and you need the overall facility picture, or you only have utility bill data
- Easy to get started and to do portfolio-wide savings reporting

Option C // Pros and cons



PROS

- Evaluates performance of the entire facility
- Factors in interactions among ECMs and between ECMs and the rest of the facility
- Easy access to utility bill data



CONS

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

Option C methodology

Establish baseline from utility bills

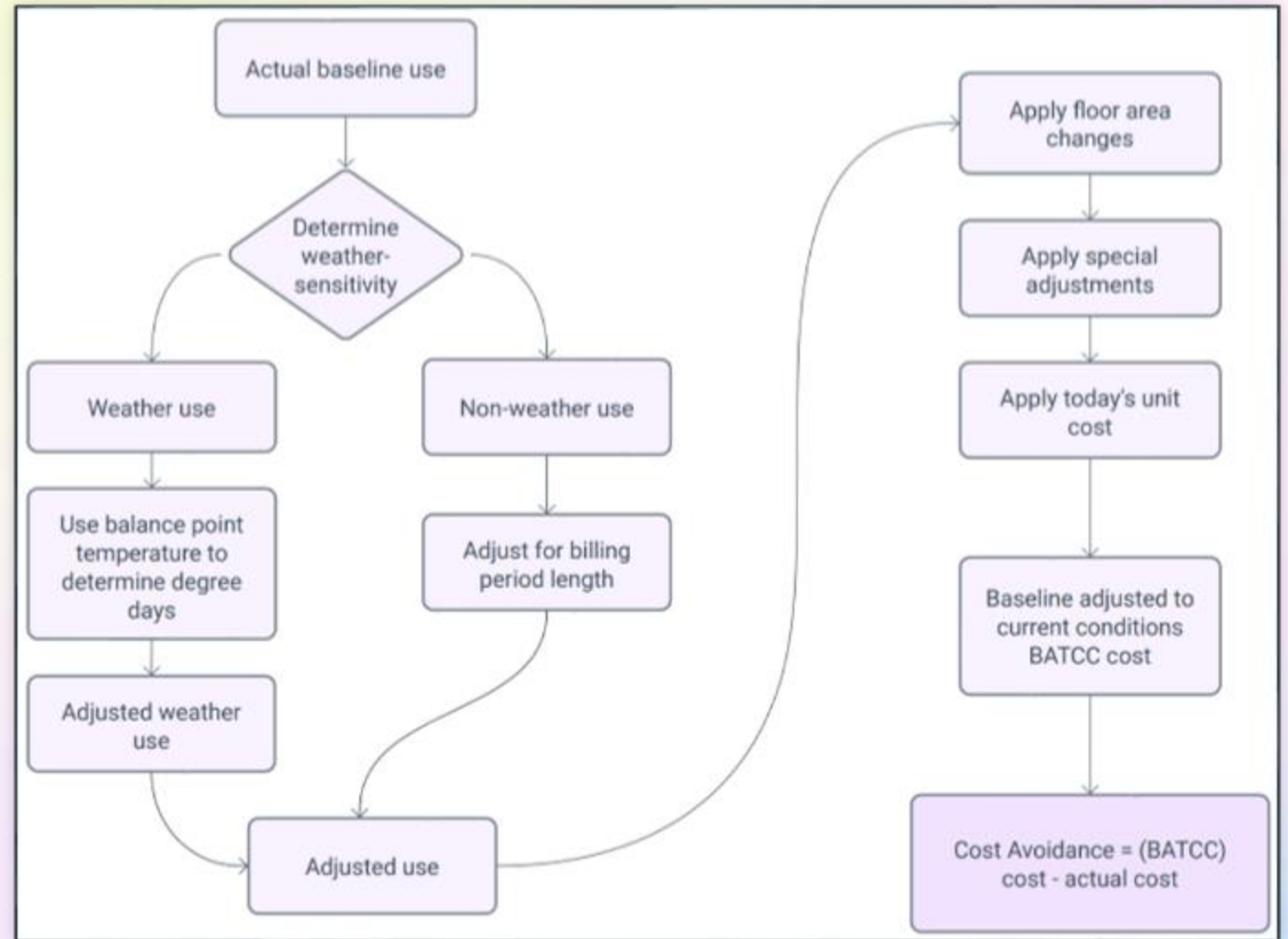
Determine weather sensitivity

Calendarize bills—adjust for billing length

Adjust for floor area and other special adjustments

Apply cost—today's unit cost

Consider other savings—rebates, refunds, demand response, rate reduction



Example in Practice

Neil Armstrong Elementary School

The project

Neil Armstrong Elementary School — 118,589 ft²

Base year energy usage: 3,903,483 kBtu/year

Base year energy cost: \$82,043

Optimization target: 15% savings



Zero-cost and low-cost ECMs



Zero-Cost Energy Conservation Opportunities

- System schedules
- Turn off lights
- Turn off computers and monitors
- Seasonal water temperature adjustments
- Economizers
- Take advantage of natural light



Low-Cost Energy Conservation Opportunities

- Programmable thermostats
- Repair broken valves
- Occupancy sensors for lighting, HVAC
- Reduce lamps in over-lighted areas
- Use rebated programs for lighting upgrades
- Calibrate sensors

Establish baseline

Settings

Baseline start

02/01/2013



Baseline length

12 months



Savings start

02/01/2014



Method

Current Average Unit Cost



☒ Adjust by Floor Area

Pre-baseline years added to weather analysis

0 years



Cool above 

60°F



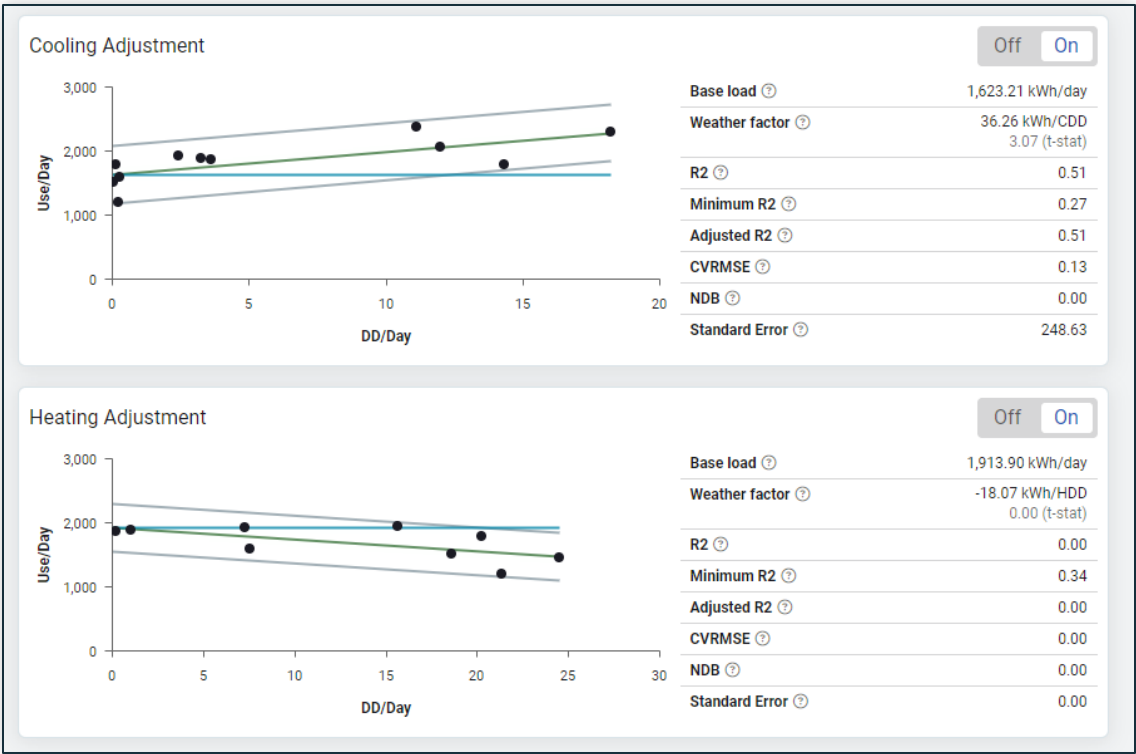
Heat below 

55°F

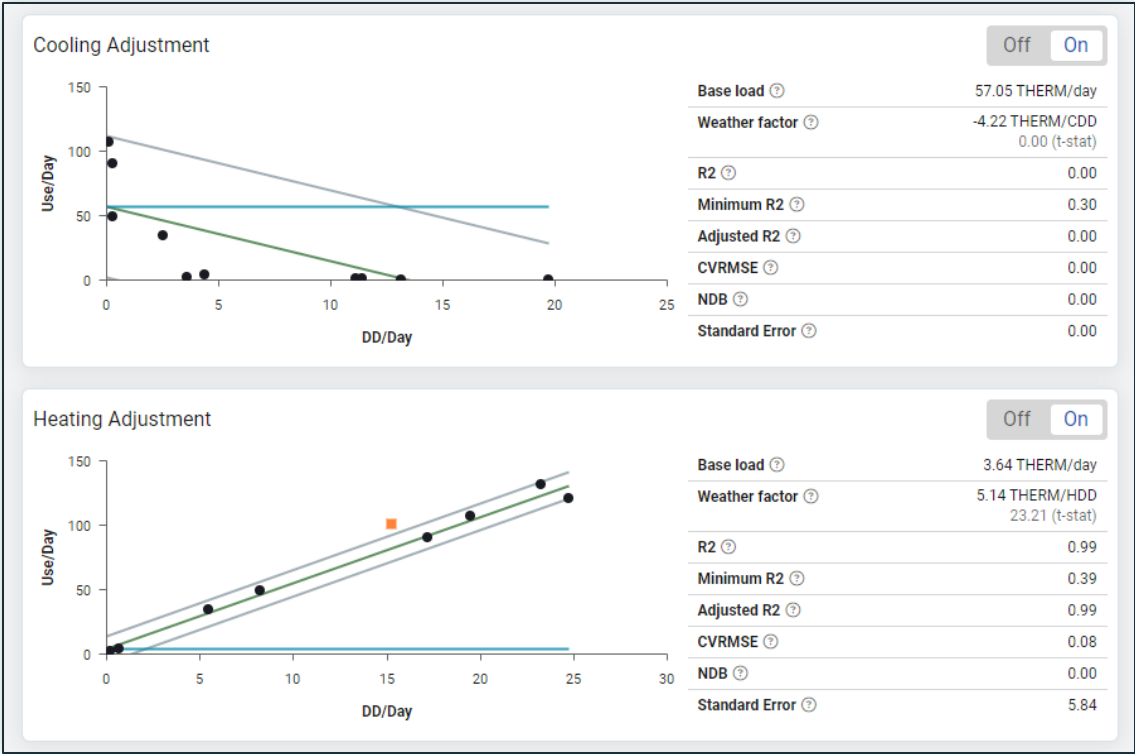


Adjust for weather

Electricity



Natural Gas



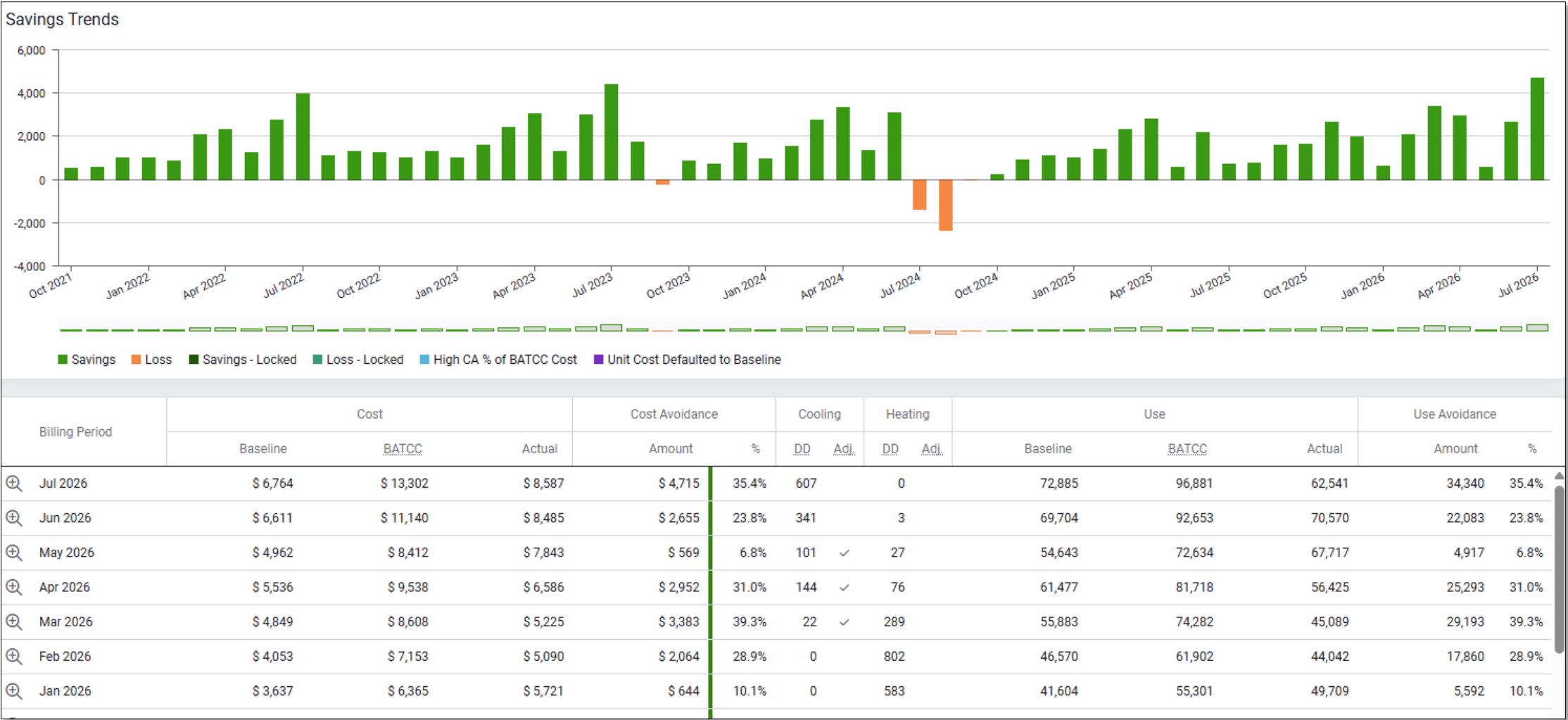
● data point
■ outlier
○ user-removed
— best fit
— 2 standard deviations
— base load

i Statistics are compliant with IPMVP Option C

Make special adjustments

	Start	End	Frequency	Value	Category	Method
▼ 1	06/01/2014	06/30/2014	Continuous	15.5000	Schedule Change	Add 15.5% to the total BATCC use
AST Additional Occupied Days - CE						
▼ 2	10/01/2016	12/31/2016	Continuous	1.7000	Occupancy	Add 1.7% to the total BATCC use
A-170727-4777 Community Use JWN 170727*updated per FCPS. Ssmith 05142019						
▼ 4	01/01/2018	01/31/2018	Continuous	160.0300	Extreme Weather	Add 160.03 per day to the BATCC non-weather use
January 2018 additional runtime						

Calculate savings



Calculate savings

Explanation of Savings

< Jul 2026 >

Close

FCPS [Fairfax County PS - VA] > ARMS-304 [Armstrong Elementary School] > ⚡ ARMS - E - Main [210008589637]

Savings for Jul 2026

72,885 KWH

Actual baseline use

96,881 KWH

BATCC use

62,541 KWH

Actual current use

34,340 KWH

Use avoidance

\$ 13,302

BATCC cost

\$ 8,587

Actual current cost

\$ 4,715

Cost avoidance

■ Non-weather use

■ Weather use

■ Locked adjustment

■ Actual current use

■ Use avoidance

N/A

Cooling

N/A

Heating

Manually Adjust Savings

Date	Non-weather use		Weather use		Cost		Adjustments				Cooling degree days		Heating degree days	
	Baseline	BATCC	Baseline	BATCC	BATCC	AUC	Floor area	Special	Other	Weather	Baseline	Current	Baseline	Current
06/18/2026	2,372.6 kWh	3,153.7 kWh	0.0 kWh	0.0 kWh	\$ 433.01	\$ 0.137	✓		✓		0	0	0	0
06/19/2026	2,291.2 kWh	3,045.5 kWh	0.0 kWh	0.0 kWh	\$ 418.16	\$ 0.137	✓		✓		0	0	0	0
06/20/2026	2,291.2 kWh	3,045.5 kWh	0.0 kWh	0.0 kWh	\$ 418.16	\$ 0.137	✓		✓		0	0	0	0
06/21/2026	2,291.2 kWh	3,045.5 kWh	0.0 kWh	0.0 kWh	\$ 418.16	\$ 0.137	✓		✓		0	0	0	0
06/22/2026	2,291.2 kWh	3,045.5 kWh	0.0 kWh	0.0 kWh	\$ 418.16	\$ 0.137	✓		✓		0	0	0	0
06/23/2026	2,291.2 kWh	3,045.5 kWh	0.0 kWh	0.0 kWh	\$ 418.16	\$ 0.137	✓		✓		0	0	0	0
06/24/2026	2,291.2 kWh	3,045.5 kWh	0.0 kWh	0.0 kWh	\$ 418.16	\$ 0.137	✓		✓		0	0	0	0
06/25/2026	2,291.2 kWh	3,045.5 kWh	0.0 kWh	0.0 kWh	\$ 418.16	\$ 0.137	✓		✓		0	0	0	0
06/26/2026	2,291.2 kWh	3,045.5 kWh	0.0 kWh	0.0 kWh	\$ 418.16	\$ 0.137	✓		✓		0	0	0	0
06/27/2026	2,291.2 kWh	3,045.5 kWh	0.0 kWh	0.0 kWh	\$ 418.16	\$ 0.137	✓		✓		0	0	0	0

Other savings

Edit Other Savings

Cancel

Save

Category

Utility Rate Reduction

▼

Add New...

+

Demand Response

Meter Consolidation

Other

Rebate

Refund

Utility Rate Reduction

Description

comment

Edit Other Savings

Cancel

Save

Category

Utility Rate Reduction

▼

Amount

\$ 100

Frequency

continuous

Start

Jan 2022

End

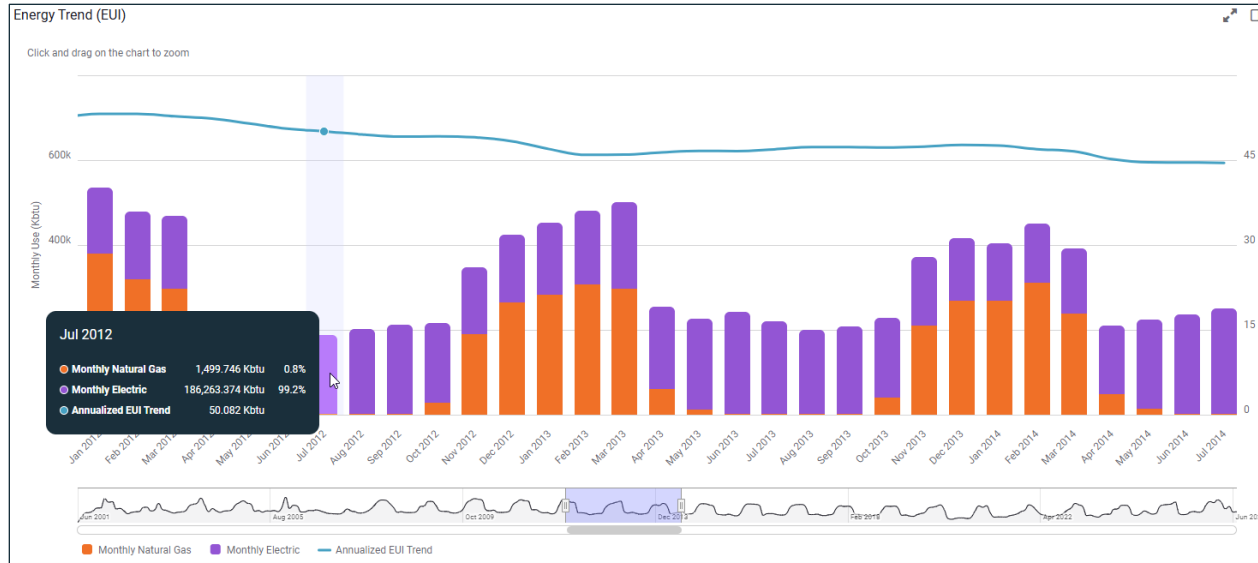
Jan 2023

Description

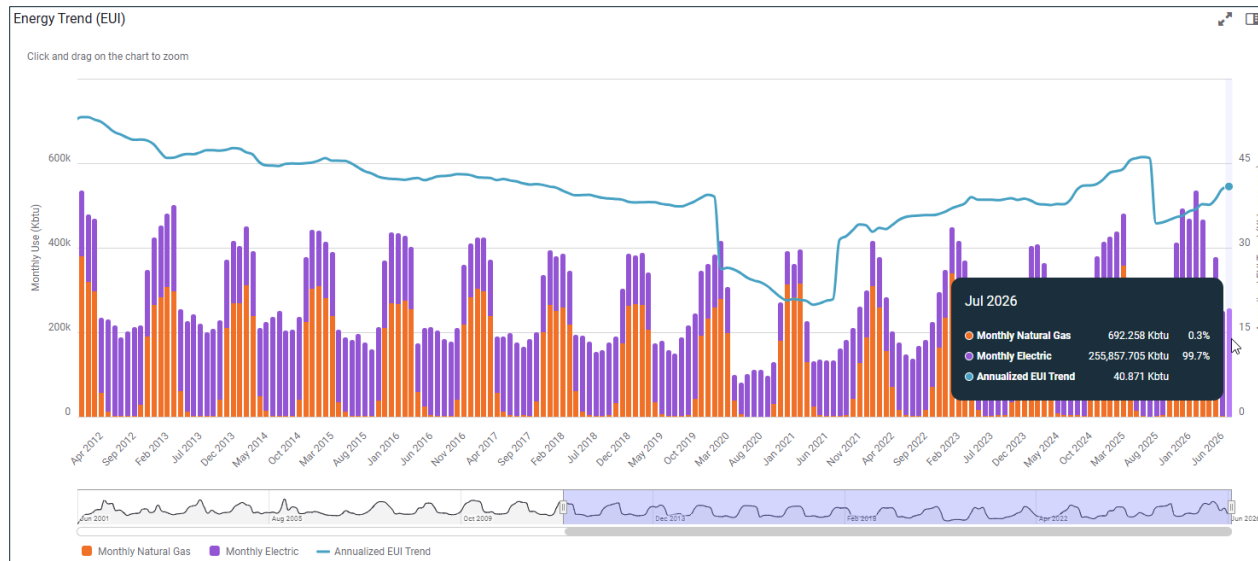
comment

Date	Non-weather use		Weather use		Cost		Floor area	Adjustments		Weather	Cooling degree days		Heating degree days	
	Baseline	BATCC	Baseline	BATCC	BATCC	AUC		Special	Other		Baseline	Current	Baseline	Current
07/05/2022	2,069.2 kWh	2,654.2 kWh	2,318.8 kWh	0.0 kWh	\$ 282.98	\$ 0.107		✓	✓		10	0	0	0
07/06/2022	2,069.2 kWh	2,654.2 kWh	1,159.4 kWh	0.0 kWh	\$ 282.98	\$ 0.107		✓	✓		5	0	0	0
07/07/2022	2,069.2 kWh	2,654.2 kWh	463.8 kWh	0.0 kWh	\$ 282.98	\$ 0.107		✓	✓		2	0	0	0
07/08/2022	2,069.2 kWh	2,654.2 kWh	927.5 kWh	0.0 kWh	\$ 282.98	\$ 0.107		✓	✓		4	0	0	0
07/09/2022	2,202.1 kWh	2,787.1 kWh	695.6 kWh	0.0 kWh	\$ 297.14	\$ 0.107		✓	✓		3	0	0	0
07/10/2022	2,202.1 kWh	2,787.1 kWh	0.0 kWh	0.0 kWh	\$ 297.14	\$ 0.107		✓	✓		0	0	0	0

Visual proof of savings

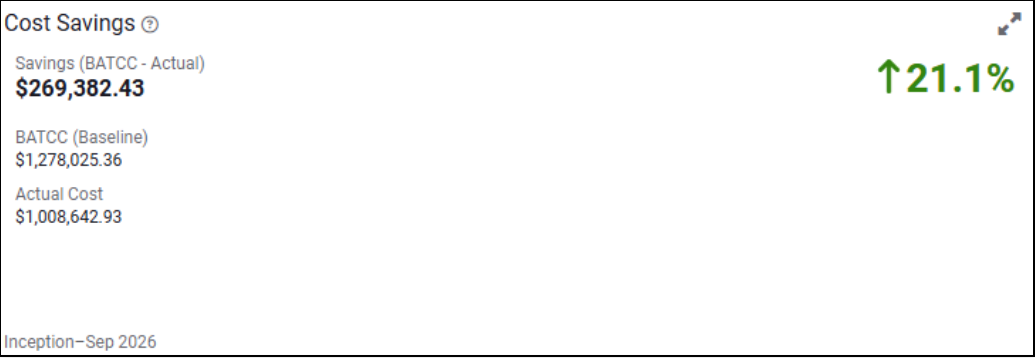


**Baseline –
50 kbtu/ft²**



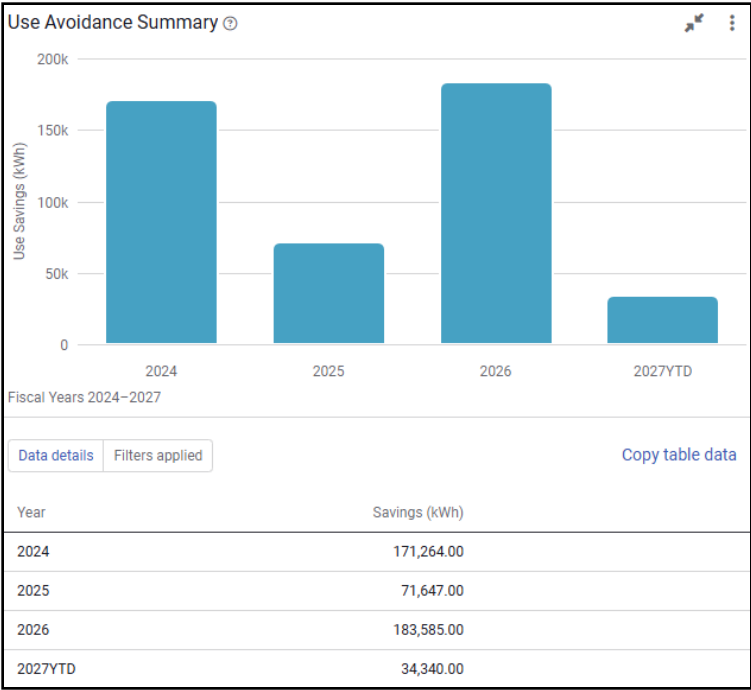
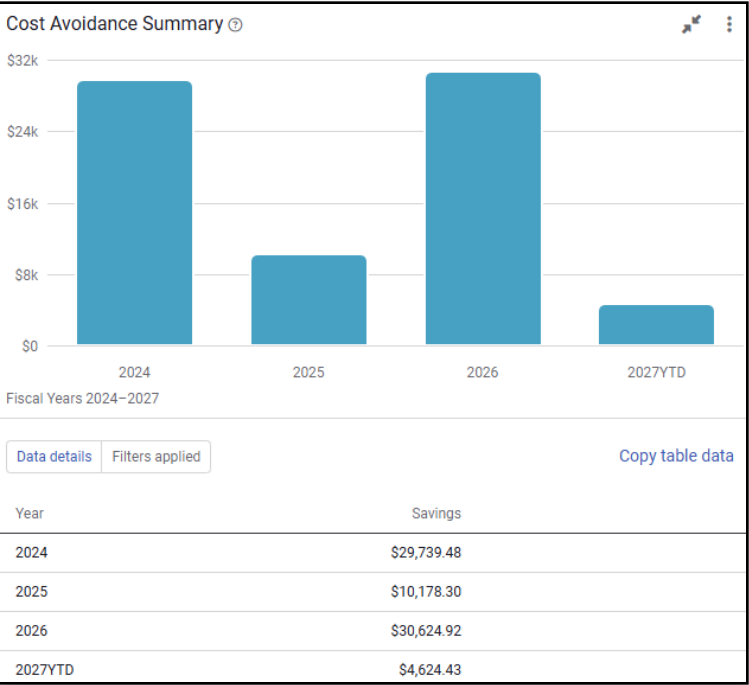
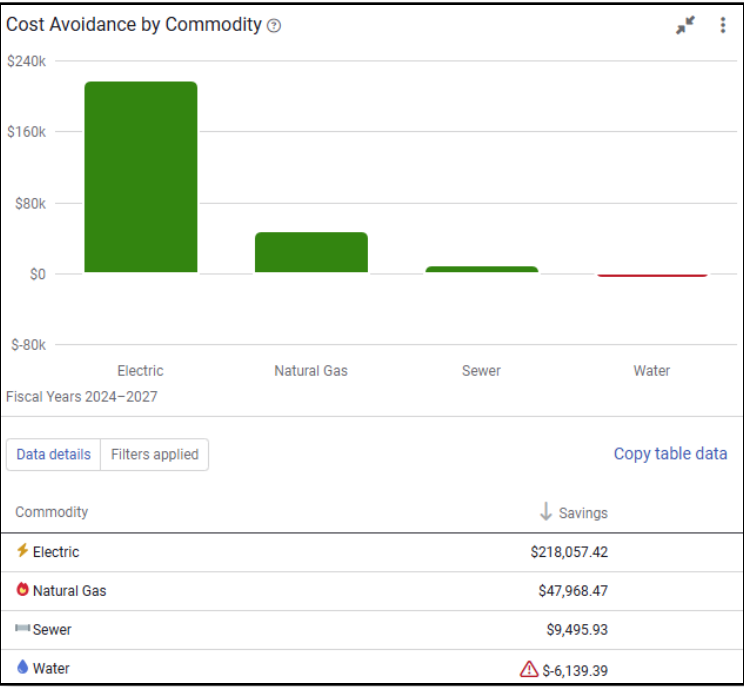
**Performance –
40 kbtu/ft²**

Proving Cost Avoidance!



Optimization Target: 15% savings

Realized Savings: 21.1% savings, \$269,382.43



Report to stakeholders

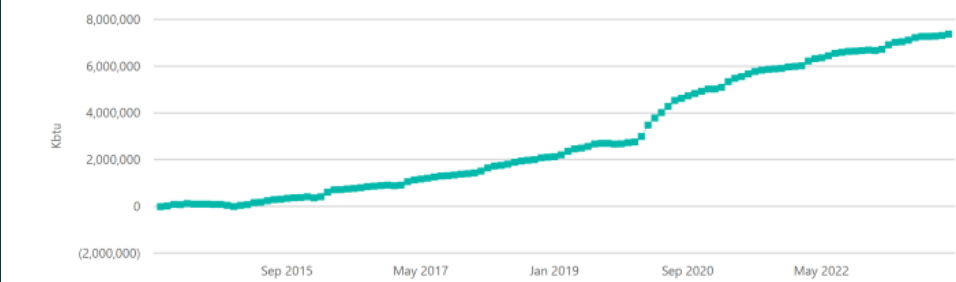
Cumulative Cost Savings

Expected Cost	\$889,664
Actual Cost	\$699,794
Program Savings	\$189,870
Percent Savings	21.3%
Other Savings	\$0
Total Savings	\$189,870



Expected Energy Cost	Actual Energy Cost	Program Savings
Anticipated expense without energy management.	Actual utility costs for electricity, gas, water, sewer, etc. obtained directly from bills.	The difference between Expected and Actual Cost, calculated in accordance with the International Performance Measurement & Verification Protocol and ISO 50015. Does not include savings attributable to reduced equipment maintenance and replacement costs and other collateral benefits. These savings can increase the program savings up to 20%.
Base year usage after adjustments for such variables as changes in weather, equipment, schedules, occupancy and prices.	Other Savings Additional documented savings attributable to Program activities but not the direct result of usage reductions, such as rebates, refunds, tariff changes, etc.	

Cumulative Use Savings



Cumulative Greenhouse Gas Reduction

Energy Reduction Impact: 7,375,784 Kbtu	607 equiv. metric tons of CO2
This is equivalent to the following:	
Passenger cars not driven for one year:	126
Tree seedlings grown for 10 years:	15,552

Cost Avoidance by Building

	BATCC Cost	Actual Cost	Cost Avoidance	Cost Avoidance %
Hayfield Secondary School [HAYFS-180]	\$8,805,768	\$5,799,630	\$3,006,138	34.1%
Woodson High School [WO-130]	\$8,498,292	\$6,053,448	\$2,444,844	28.8%
Lake Braddock Secondary School [LAKEB-400]	\$10,642,732	\$8,249,676	\$2,393,056	22.5%
Chantilly High School [CHAN-250]	\$7,492,762	\$5,307,614	\$2,185,148	29.2%
Westfield High School [WESTFHS-240]	\$7,912,566	\$5,780,307	\$2,132,259	26.9%
Fairfax High School [FAIR-500]	\$7,527,953	\$5,469,121	\$2,058,832	27.3%
Sandburg Middle School [SAND-231]	\$4,803,949	\$2,901,226	\$1,902,723	39.6%
South County High School [SOCOHS-420]	\$6,637,646	\$5,028,835	\$1,608,811	24.2%
Robinson Secondary School [ROBI-390]	\$8,437,283	\$6,832,473	\$1,604,809	19.0%
Edison High School [ED-120]	\$6,233,094	\$4,710,029	\$1,523,065	24.4%
West Potomac High School [WESTP-200]	\$6,712,666	\$5,286,071	\$1,426,596	21.3%
Kilmer Middle School [KILM-071]	\$3,452,068	\$2,026,381	\$1,425,687	41.3%
Mount Vernon High School [MTVE-220]	\$6,891,600	\$5,474,620	\$1,416,980	20.6%
South Lakes High School [SOUT-320]	\$6,548,885	\$5,177,641	\$1,371,244	20.9%
Liberty Middle School [LIBER-411]	\$3,494,269	\$2,190,545	\$1,303,724	37.3%
Marshall High School [MARS-070]	\$5,327,331	\$4,024,304	\$1,303,027	24.5%
Annandale High School [ANNA-140]	\$5,404,948	\$4,264,075	\$1,140,874	21.1%
Poe Middle School [POE-141]	\$3,245,123	\$2,158,872	\$1,086,251	33.5%
Jefferson High School for Science and Technology [JEFF-340]	\$4,891,405	\$3,841,085	\$1,050,320	21.5%
Lewis High School [LEWI-160]	\$5,240,593	\$4,260,360	\$980,233	18.7%
Centreville High School [CENTHS-410]	\$4,609,621	\$3,689,946	\$919,676	20.0%
Whitman Middle School [WHITM-221]	\$2,924,856	\$2,017,082	\$907,774	31.0%
McLean High School [MCLE-030]	\$4,699,894	\$3,819,481	\$880,413	18.7%
Carson Middle School [CARS-171]	\$3,464,641	\$2,624,765	\$839,876	24.2%
Madison High School [MADI-060]	\$5,013,273	\$4,196,451	\$816,822	16.3%
Fort Belvoir Primary Elementary School [FTBV-197]	\$2,465,178	\$1,685,886	\$779,292	31.6%
Franklin Middle School [FRANM-331]	\$2,193,648	\$1,443,207	\$750,441	34.2%
Holmes Middle School [HOLM-111]	\$2,941,223	\$2,234,403	\$706,820	24.0%

Results

Baseline established, then adjusted for weather, floor area, and other special factors

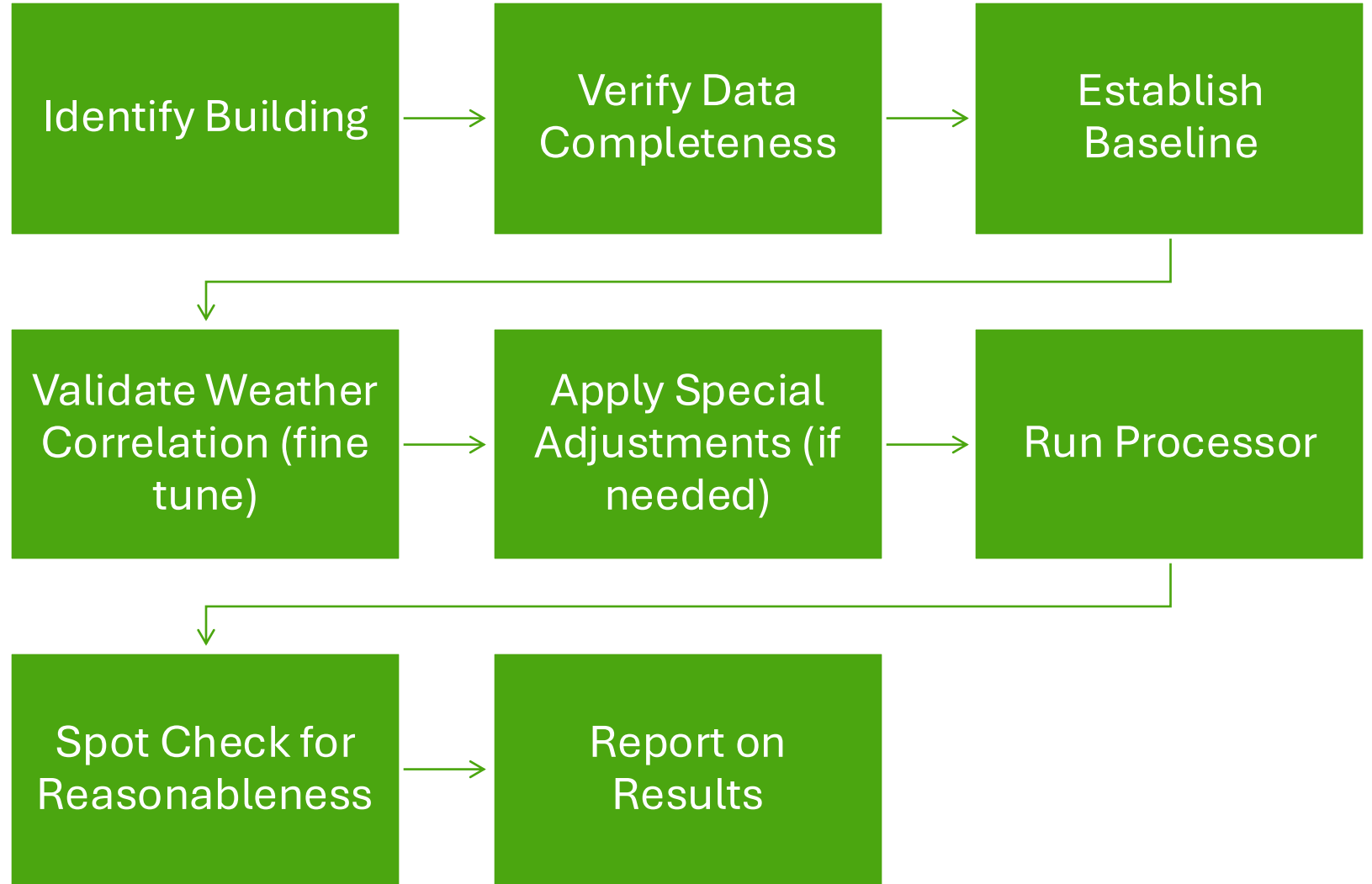
Savings calculated and reported to stakeholders

Optimization target: 15% savings

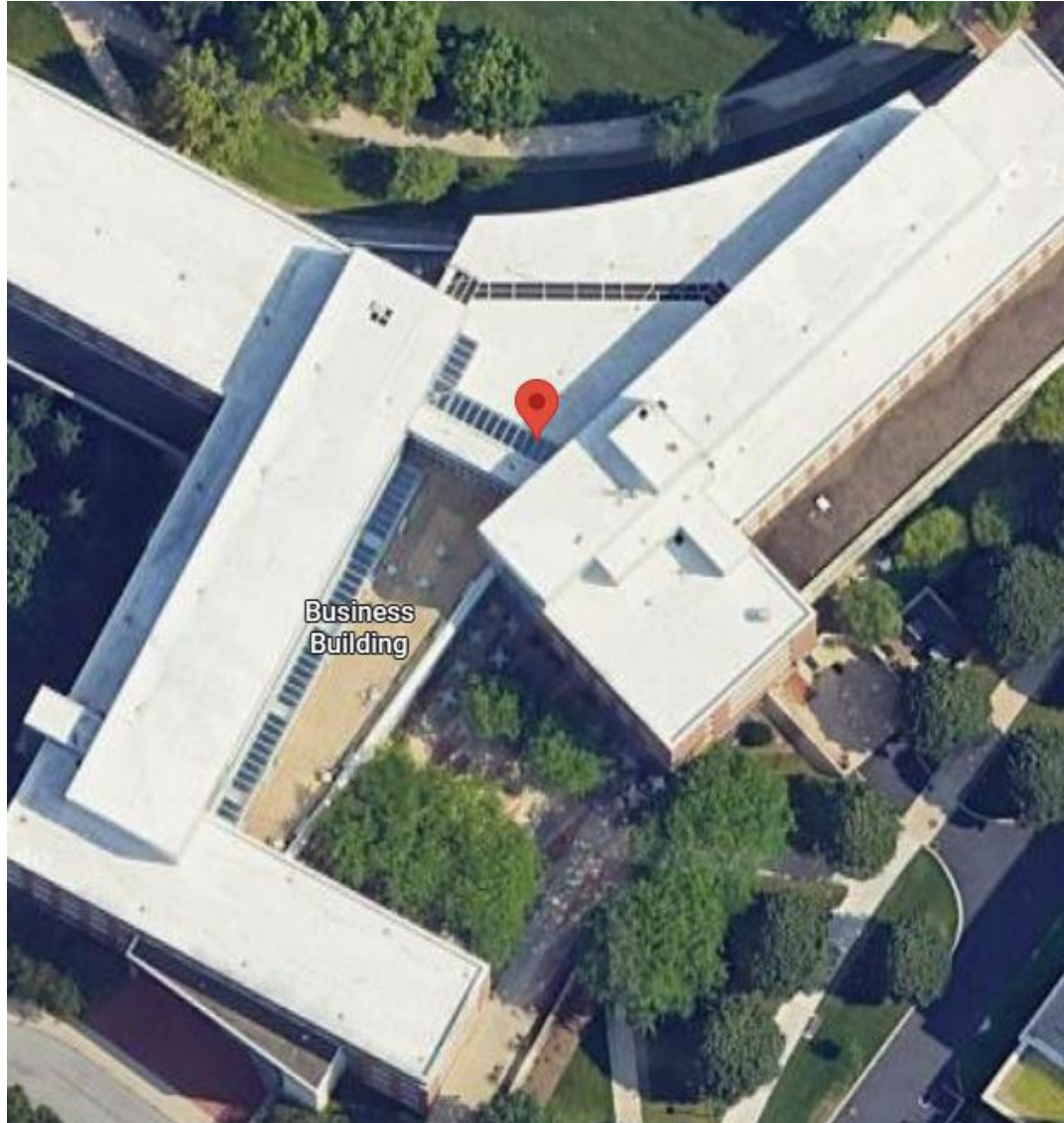
Realized savings: 21.1%, \$270k and still going...

Live Examples

Steps



Penn State // Smeal College of Business



Controls retro-commissioning project to recalibrate the building and optimize settings

Building dedicated in 2005, 225,427 ft²

Usage increasing or flat year-over-year going in

Project completed October 2023

Was the project a success?

EnergyCAP // Headquarters

Controls retro-commissioning project to recalibrate the building and optimize settings

Building dedicated in 2020, 19,332 ft²

Adjust settings post COVID and post change to work from home environment

Project completed August 2024

Was the project a success?



Identifying Targets and Watts Chat AI

Identifying targets with EUI reporting and benchmarking

EUI (Energy Use Intensity) normalizes energy use by square footage, making buildings and portfolios comparable

Benchmarking EUI against peer buildings or a portfolio baseline highlights which buildings are underperforming

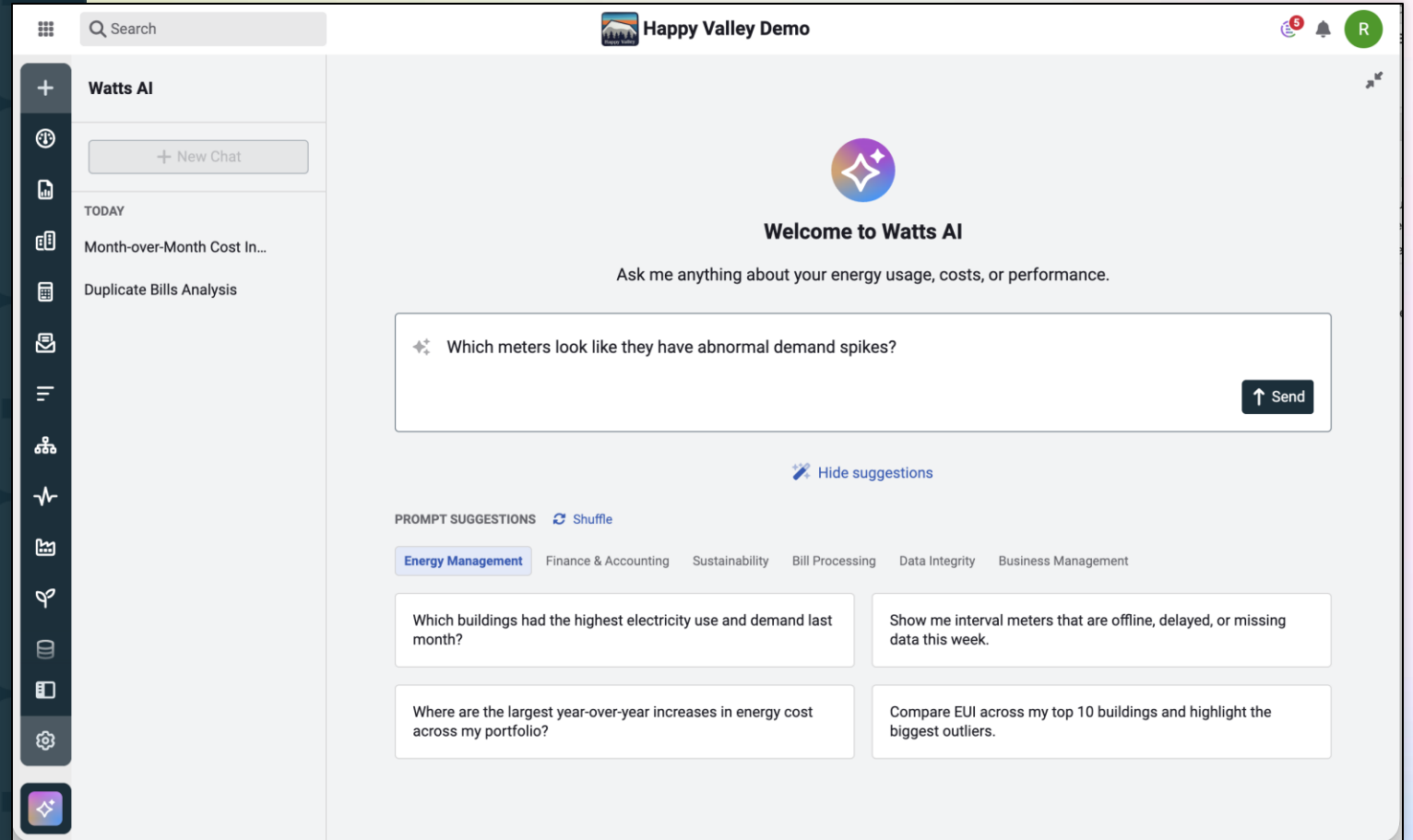
Those outliers become your next round of ECM targets—shifting M&V from reporting on past projects to prioritizing what's next

Building	Kbtu/ft ²	Total Use
APPLIED RESEARCH LAB	315.491	20,848,587 Kbtu
COMPUTER	275.597	17,897,295 Kbtu
FOOD SCIENCE (ERICKSON)	265.526	33,986,297 Kbtu
PROCUREMENT SERVICES	193.875	2,126,028 Kbtu
WALKER	159.466	18,657,891 Kbtu
HOUSING AND FOOD SERVICE	121.102	13,839,828 Kbtu
HEALTH AND HUMAN DEVELOPMENT	104.172	13,448,606 Kbtu
CARNEGIE	102.184	3,896,477 Kbtu
CAREER SERVICES (BANK OF AMERICA)	96.606	4,276,942 Kbtu
CENTER FOR EDUCATIONAL DIAGNOSIS AND REMEDIATION	96.026	3,381,262 Kbtu
POND LABORATORIES	93.748	4,337,051 Kbtu
BUSINESS (SMEAL)	93.548	21,088,236 Kbtu
UNIVERSITY SUPPORT BUILDING I	93.194	3,052,665 Kbtu
RITENOUR	92.507	4,643,594 Kbtu
BOUCKE	88.566	8,530,816 Kbtu
TELECOMMUNICATIONS BUILDING	88.303	1,346,175 Kbtu

Using Watts chat

Ask Watts chat natural-language questions about your buildings' EUI and benchmarking data

Speeds up the path from raw data to a prioritized list of ECM targets



Setting EUI targets to trend toward

Turn benchmarking insight into a forward-looking EUI target for each building

Track actual EUI against that target over time, not just a one-time savings report

Use the trend line to catch slip-back early and to justify the next ECM investment

View
Goal Tracking

Topmost
University Park

Target Year
Search

Status
All

Created By
Search

Reset

EUI Goal Tracker

Site ↑

Topmost

Total Goals

Status ⓘ

Energy Projects

Current EUI

Created by

BUSINESS (SMEAL)
University Park
1

✓ On Track

3

View chart

ECI

SITE GOALS

Target year	EUI goal	Actual EUI
2023 Baseline	--	137.979 Kbtu/ft²/yr
2025	117.282 Kbtu/ft²/yr ↓ 15%	102.984 Kbtu/ft²/yr ↓ 25%

Start today

Start today

- Establish an energy policy and guidelines
- Identify targets
- Implement simple projects/strategies—align HVAC with occupancy, standardize setpoints, aggressively set back unoccupied buildings, repair broken equipment
- PDCA
- Track the projects, calculate the savings, report to stakeholders



Resources

- Become a member of EVO (www.EVO-World.org)
- Download IPMVP from EVO
- Purchase ISO standards at iso.org
- Become a CMVP — Certified Measurement & Verification Professional (www.AEECenter.org)

Questions?