CATALYST



M&V Best Practices: Measuring & Verifying Energy Savings with Confidence



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Agenda



- What is M&V?
- Available IPMVP Options
- Benefits of Option B
- Case study of Option B
- Benefits of Option C
- Case study of Option C
- Live Example
- How to save now

What is M&V?

What is M&V?

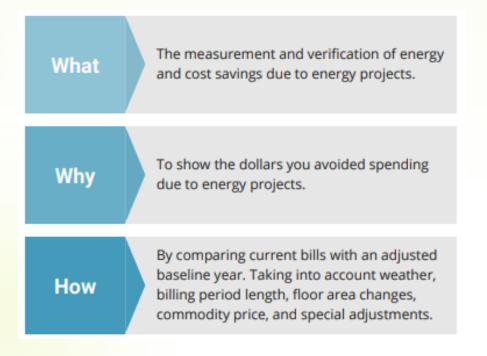
M&V is a standardized procedure, regulated by ISO 50015:2014 (Measurement and Verification of Energy Performance) and included in the framework of ISO 50001:

"ISO 50015:2014 establishes general principles and guidelines for the process of measurement and verification (M&V) of energy performance of an organization or its components. ISO 50015:2014 can be used independently, or in conjunction with other standards or protocols, and can be applied to all types of energy."

Why is M&V important?

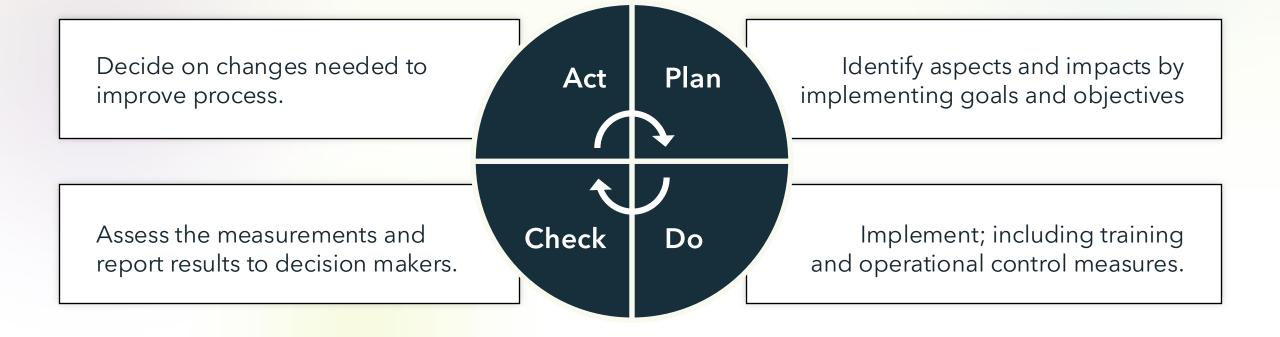
"Measurement and verification" (M&V) of energy and cost savings resulting from an energy efficiency initiative is necessary because you can't simply compare year-to-year out of pocket expenditures.

You have to compare **what you spent** with how much **you would have spent** in the absence of energy efficiency, in other words how much you avoided spending.



ISO 50001: 2011 Energy Management

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

ISO 50001 and IPMVP

ISO 50001 "does not specify calculation methods", it only establishes a common set of principles and guidelines.

The M&V practitioner selects the calculation methods and obtains approval by the parties involved via the M&V Plan.

Historically the most common calculation methods have been those in IPMVP, managed by an international nonprofit agency called The Efficiency Valuation Organization.

www.EVO-World.org

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**

Benefits of Option B

Option B // Retrofit isolation

All parameters associated with the energy conservation measure must be measured and cannot be estimated. In other words, you are creating an M&V project which focuses only on some appliances/circuits and not on the entire building's power consumption.

For example, consider the installation of a variable speed drive. The power drawn as well as the hours of operation will have to be measured in order to determine any energy savings.

Option B // Retrofit isolation pros and cons

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

Requires extensive metering

Case Study Option B

Success story // The project

Auckland University of Technology, WO Building (Student Association)

Area: 10,472 m2

Energy Usage: 1,302,821 kWh/year

Energy Cost: \$110,000/year (180k NZD/year)

Optimization Target: 10% savings



The ECMs

Replacement of chiller and cooling tower

Adjustments to Air Handling Units (AHU)

- Supply air pressure and temperatures setpoints reset
- Disabled after-hours AHU requirement during weekends
- AHU Modulation Controller changed from PI to PID



Results



20.4%

Energy and CO2e emission saved



\$23,000

Annual savings (NZD 34,440)



7.5 years

Est. Payback period

Next steps

Continue monitoring

Avoid slip backs

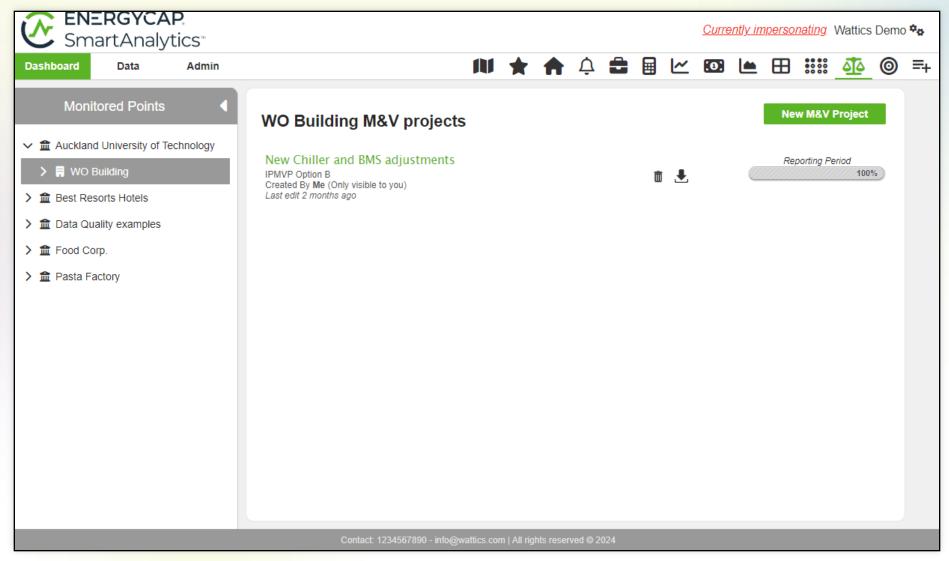
Investigate further energy saving opportunities

Maintain building performance

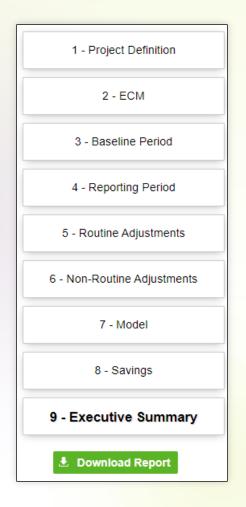
Commence work on other university buildings

Incorporate lessons learned

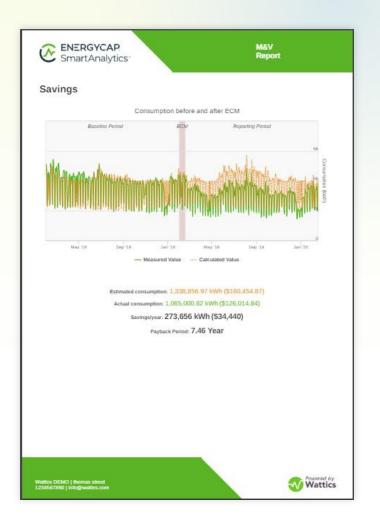
Option B (screenshots): Measurements & Verification Tool



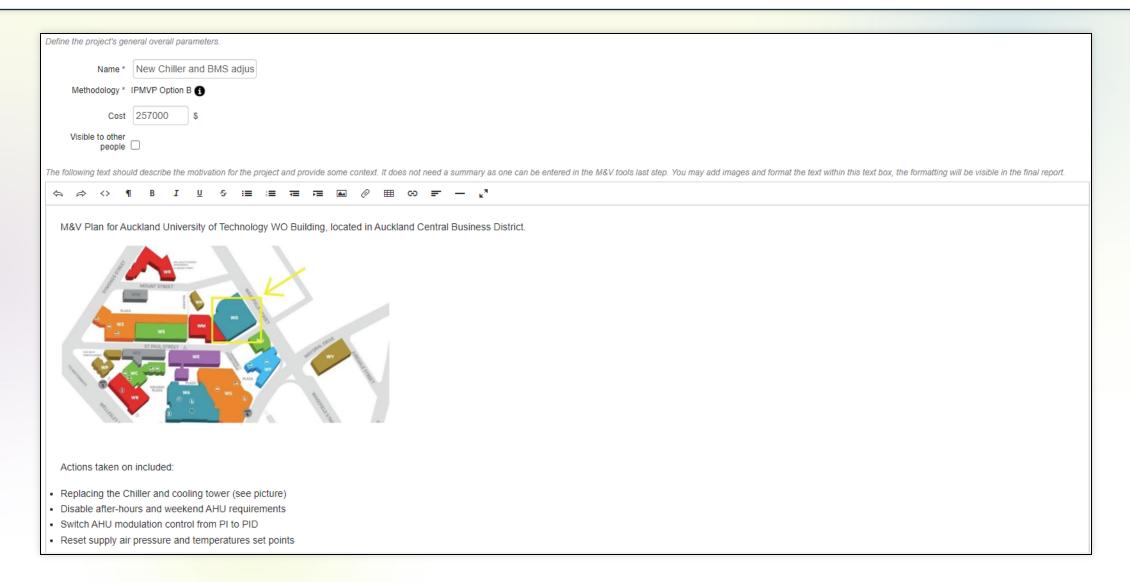
Option B (screenshots): Step by Step Process







Option B (screenshots): Step 1 - Project Definition



Option B (screenshots): Step 2 - ECM

Name *	Optimization and Efficiency Program	
Reference		
Start *	01/02/2019	
End *	17/02/2019	
De	escribe the work carried out. You may add images and format the text within this text-box, the formatting will be visible in	
the	escribe the work carried out. You may add images and format the text within this text-box, the formatting will be visible in the final report.	

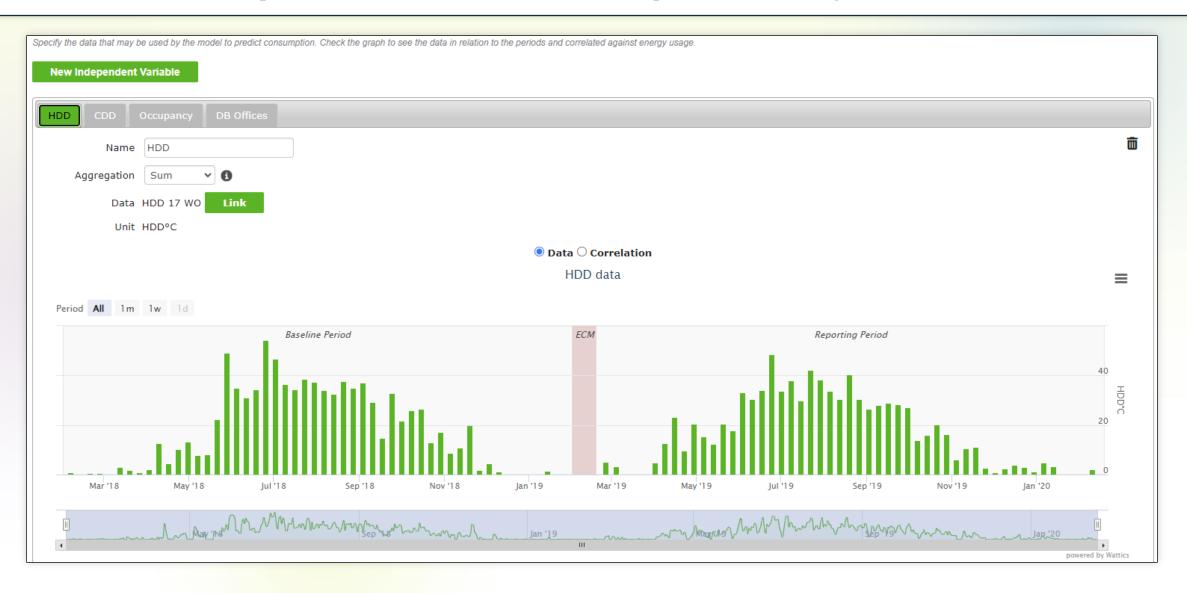
Option B (screenshots): Step 3 - Baseline Period



Option B (screenshots): Step 4 - Reporting Period



Option B (screenshots): Step 5 & 6 - Adjustments



Option B (screenshots): Step 7 - Model



Option B (screenshots): Step 8 - Savings



Option B (screenshots): Step 9 - Executive Summary

The energy conservation measures implemented resulted in savings that far exceed the initial target of 10% kWh savings per year. Project results demonstrate a 20% reduction in energy use after 1 year; NZ\$ 37,272 per annum (US\$ 23,477 / €21,446) in cost savings and a payback period for HVAC optimization of 6.9 years.

The personnel on site and energy analysts involved are dedicated toward maintaining the savings achieved so far, through continuous monitoring and analysis, also investigating further energy-using entities to improve savings while maintaining optimal performance within the WO building.

As a result of the savings achieved under the pilot project, AUT has committed to work on additional buildings located at the university campus.

Benefits of Option C

Option C // Whole facility

This approach is taken where the energy use of the whole facility needs to be measured. Several independent variables may need to be considered such as heating/cooling degree days, changes in floor area, hours of operation, use of spaces, occupancy, etc...

Option C is of value where several energy conservation measures have been introduced and the overall picture for the facility is required, or you only have utility bill information.

Easy to get started and to do portfolio-wide savings reporting.

Option C // Whole facility pros and cons

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

Easy access to utility bill data

Option C Methodology

Establish baseline from utility bills

Determine weather sensitivity

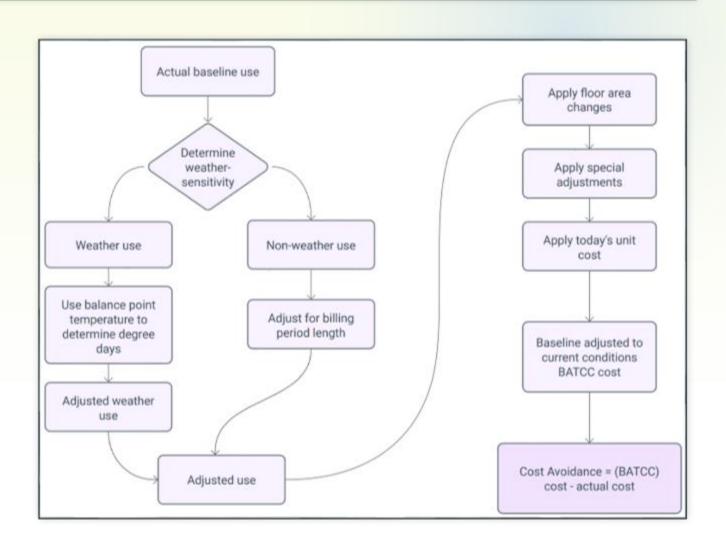
Calendarize bills - adjust for billing length

Adjust for floor area

Special adjustments

Apply cost - today's unit cost

Consider other savings - rebates, refund, demand response, rate reduction...



Case Study Option C

Neil Armstrong Elementary School

Utility Management M&V verifies energy savings from behaviour-based program for Virginia school district



Success story // The project

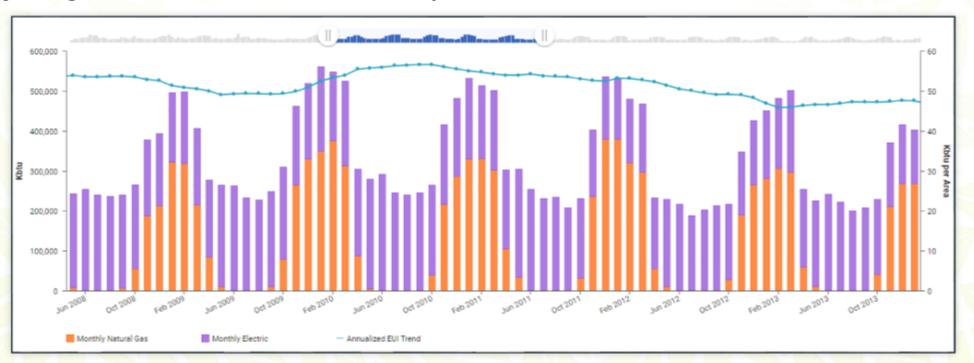
Neil Armstrong Elementary School

Area: 80,000 ft2 = ~7,432 m2

Energy Usage in Base Year: 3,805,228 Kbtu/year

Energy Cost in Base Year: \$81,608

Optimization Target: 15% savings



Success story // The project

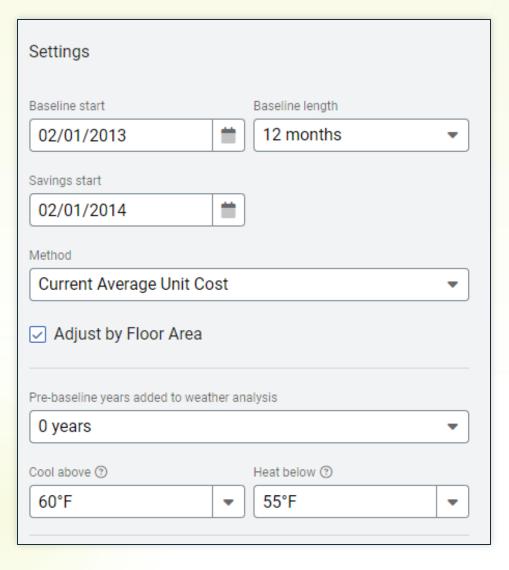
Zero-Cost Energy Conservation Opportunities

- 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

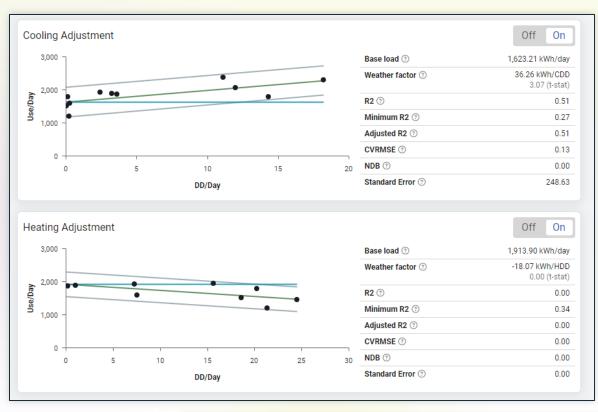
- Programmable thermostats
- Repair broken valves
- Occupancy sensors for lighting, HVAC
- Reduce lamps in over-lighted areas
- Use rebated programs for lighting upgrades
- Calibrate sensors

Establish Baseline

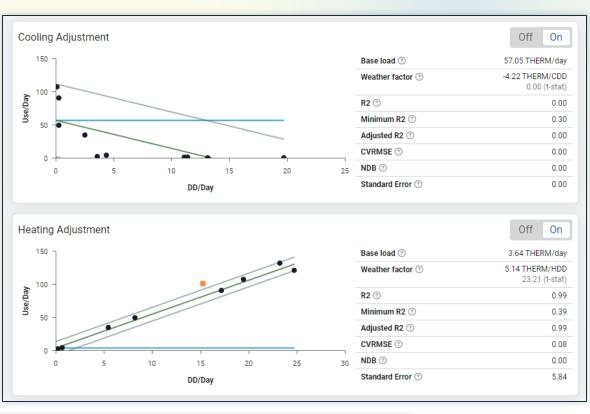


Adjust for weather

Electricity



Natural Gas

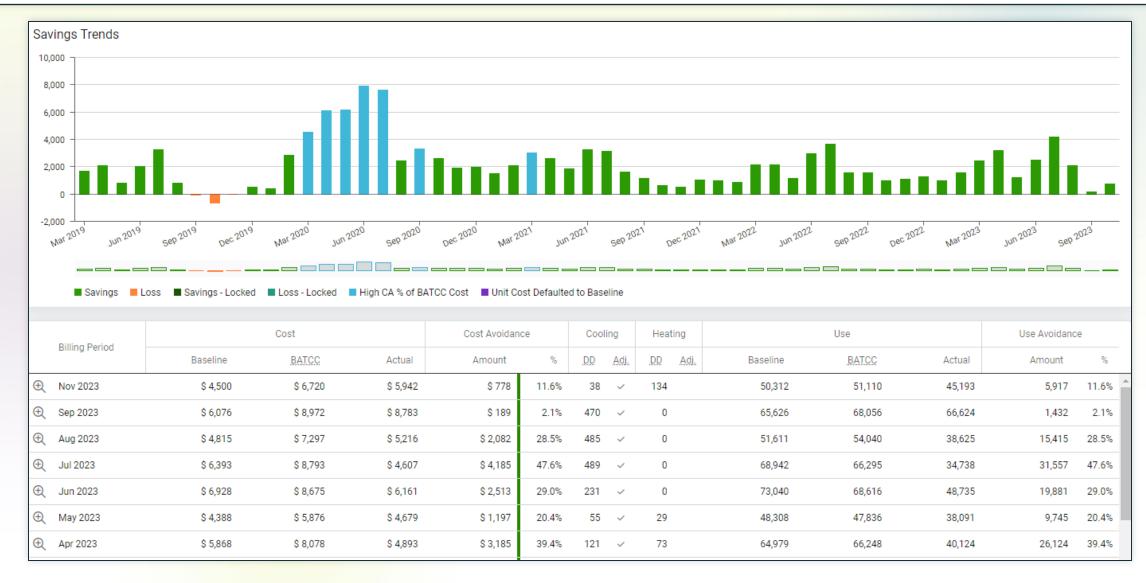




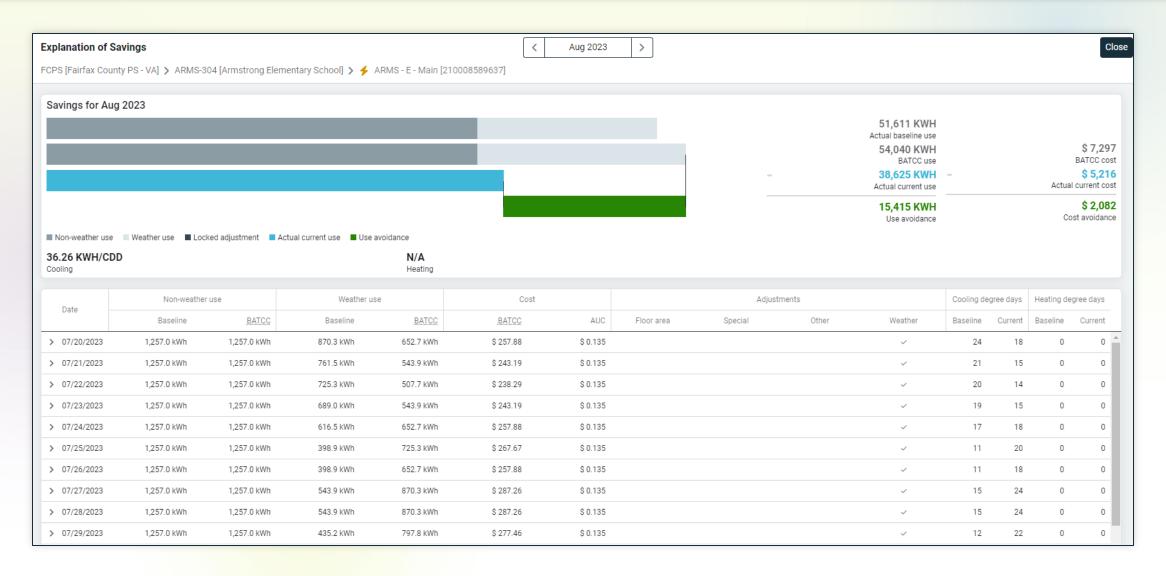
Make special adjustments

			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			
	AS	ST A	dditional Occu	pied 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	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										

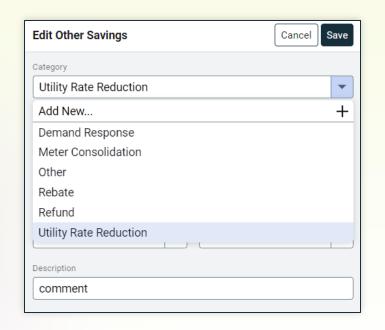
Calculate the savings

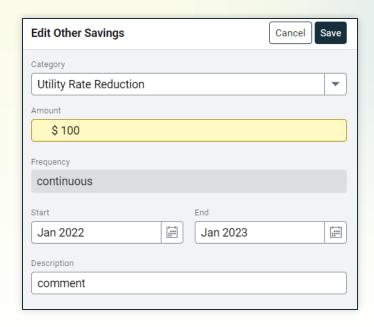


Calculate the savings



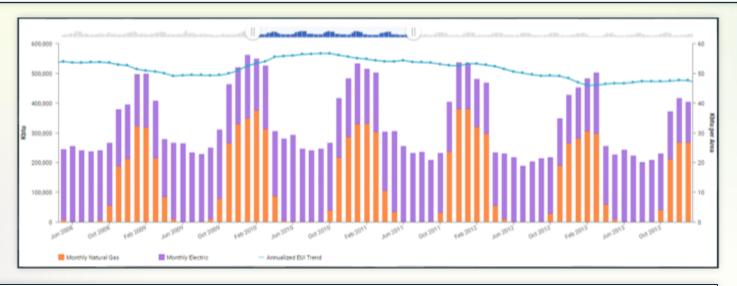
Other Savings



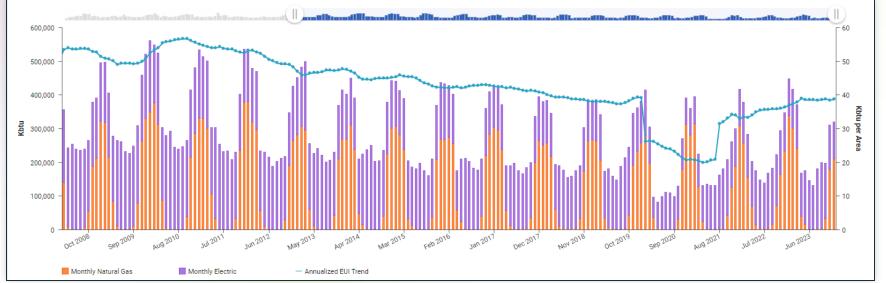


Date	Non-weather use		Weather use		Cost			Adjustments			Cooling degree days		Heating degree days	
Date	Baseline	BATCC	Baseline	BATCC	BATCC	AUC	Floor area	Special	Other	Weather	Baseline	Current	Baseline	Current
> 07/05/2022	2,069.2 kWh	2,654.2 kWh	2,318.8 kWh	0.0 kWh	\$ 282.98	\$ 0.107		~	~		10	0	0	0 👚
> 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

Report to stakeholders

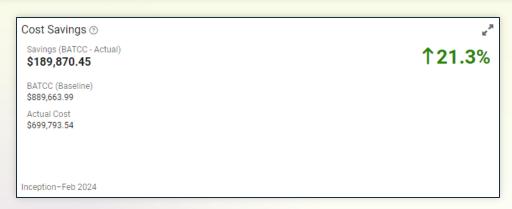


Historical & Baseline



Performance

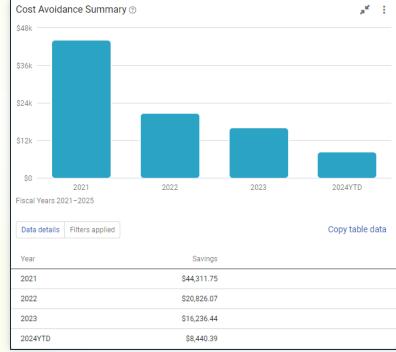
Report to stakeholders

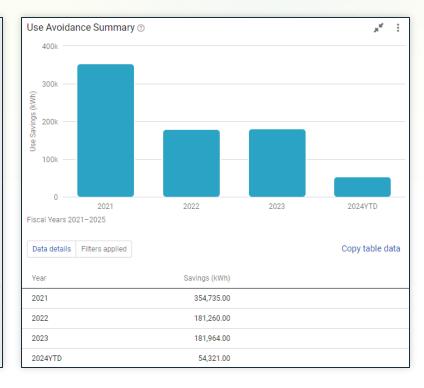


Optimization Target: 15% savings

Realized Savings: 21.3% savings, \$189,870

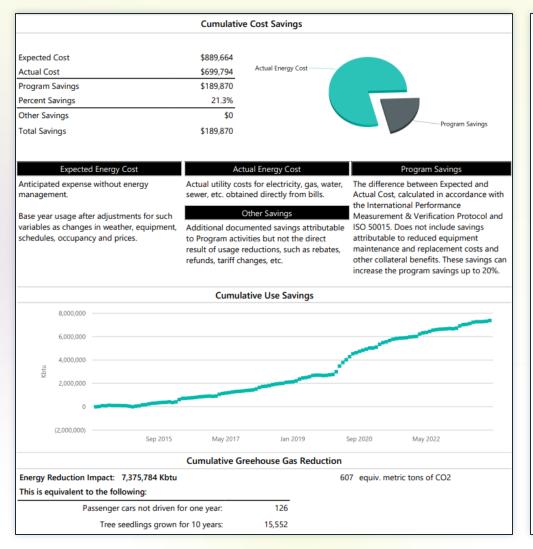






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Report to stakeholders



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%

Live Examples

Royal Mail // Southport Delivery Office

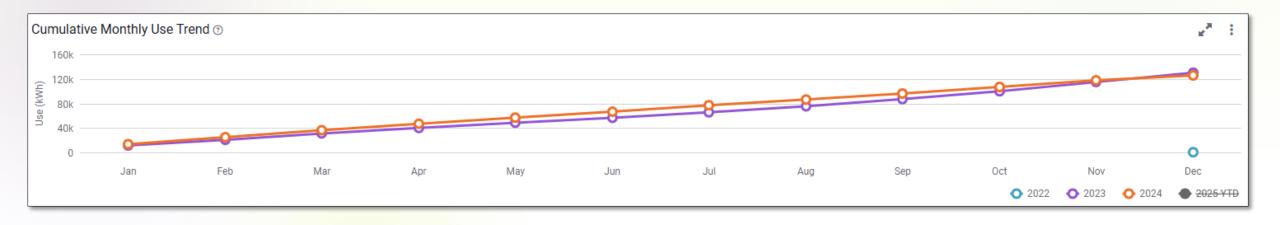
Project focus of LED lighting retrofit

Electric main has submeter and is collecting live interval data

Usage increasing or flat YOY

Project completed in December 2024

Was the project a success?



Penn State // Smeal School of Business

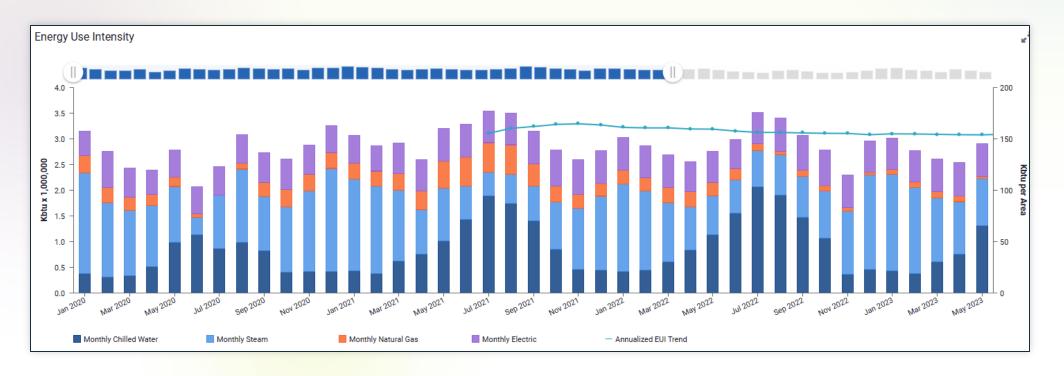
Project focus of controls retro commissioning to recalibrate the building to optimize settings

Building was dedicated in 2005 and is 225,427 ft²

Usage increasing or flat YOY

Project completed in July 2023

Was the project a success?



Start Today

Start today!

Start with the culture

Establish an energy policy and guidelines

Identify targets

Implement simple projects/strategies

- Align building HVAC operation with occupancy
- Standardize (within reason) heating and cooling set points
- Aggressively set back buildings during unoccupied time
- Identify broken HVAC equipment and develop a plan for repair

Track the projects, calculate the savings, report to stakeholders

Resources

Become a member of EVO (<u>www.EVO-World.org</u>)

Download IPMVP from EVO

Purchase ISO standards at iso.org

Become a CMVP-Certified Measurement & Verification Professional (<u>www.AEECenter.org</u>)

Check out EnergyCAP's resources and have a tour of ESA and EUM

Questions?