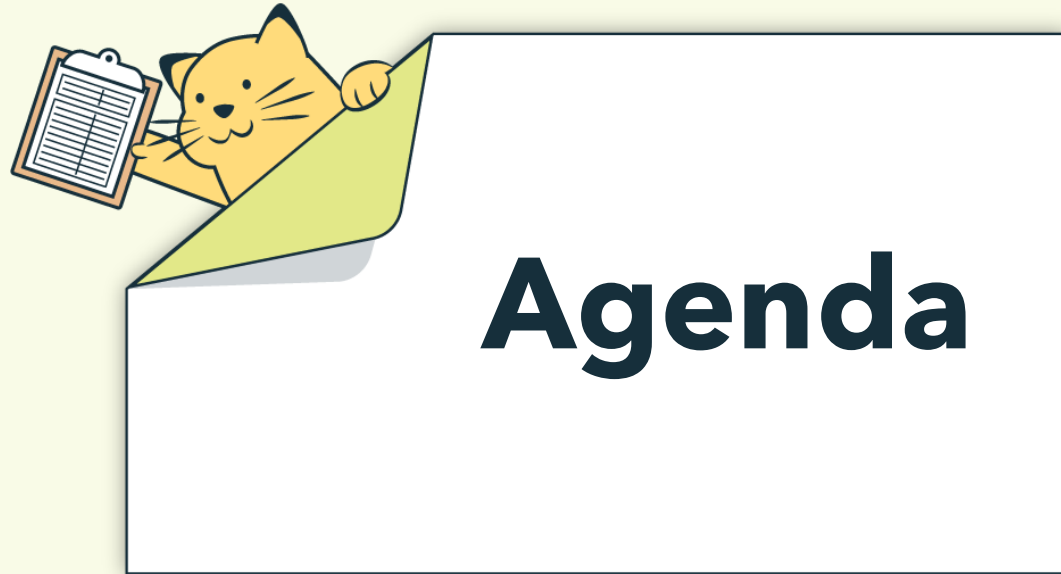




# M&V 201: Target, measure, and verify



**John Heinz** // VP, Strategic Accounts



- ✓ 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

**What is M&V?**

## What is M&V?

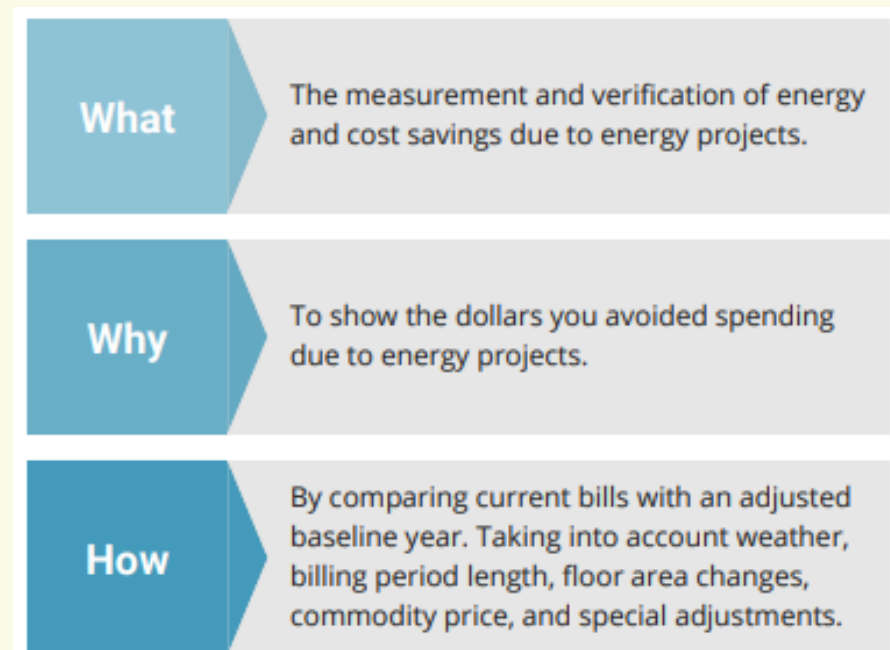
M&V is a standardized procedure, regulated by ISO 50015:2014 (Measurement and Verification of Energy Performance) and included in the framework of ISO 50001:

*“The purpose of M&V is to provide confidence to interested parties that reported results are credible... [including] appropriate accuracy and management of uncertainty” (ISO 50015)*

## Why is M&V important?

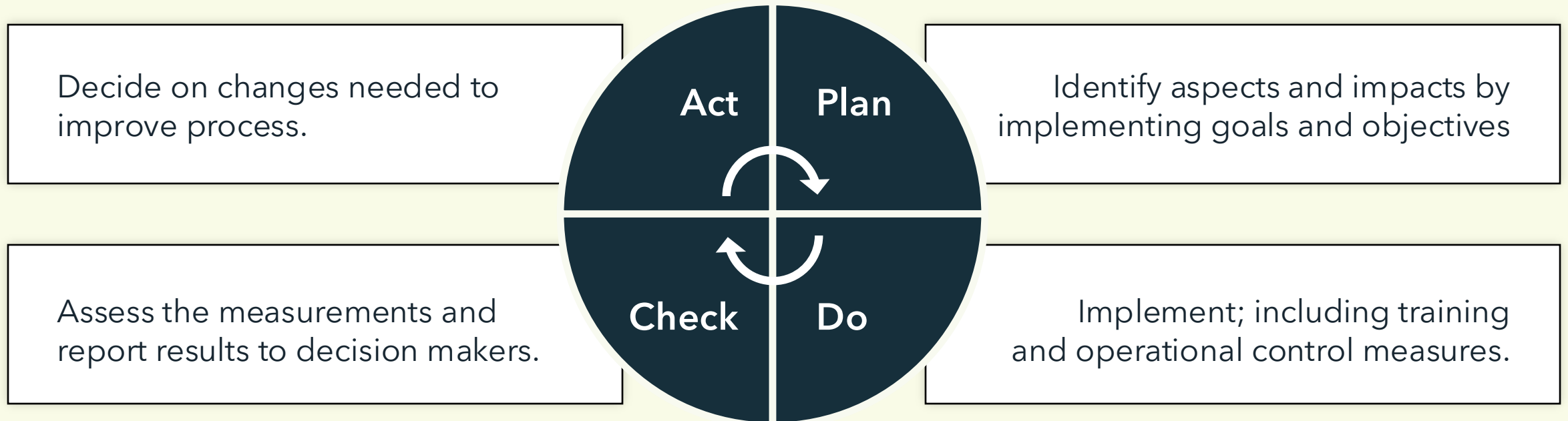
“Measurement and verification” (M&V) of energy and cost savings resulting from an energy efficiency initiative is necessary because you can’t simply compare year-to-year out of pocket expenditures.

You have to compare **what you did spend** 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 50015 and IPMVP

ISO 50015 “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](http://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**

## New Zealand based BMS specialist

SmartAnalytics M&V streamlines ECM evaluation and reporting for New Zealand based BMS specialist



## Success story // The project

Auckland University of Technology, WO Building

**Area:** 10,472 m<sup>2</sup> - ~113k sq ft

**Energy Usage:** ~1,302,821 kWh/year

**Energy Cost:** ~180k NZD/year (~110k\$)

**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



**NZD 34,440**

Annual savings  
(~23k\$)



**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: Measurements & Verification Tool

The screenshot displays the ENERGYCAP SmartAnalytics web application. The interface includes a top navigation bar with the logo, user status ('Currently impersonating Wattics Demo'), and tabs for 'Dashboard', 'Data', and 'Admin'. A secondary navigation bar contains various icons for different functions. On the left, a 'Monitored Points' sidebar lists several locations, with 'WO Building' currently selected. The main content area is titled 'WO Building M&V projects' and features a 'New M&V Project' button. A project entry for 'New Chiller and BMS adjustments' is shown, including details like 'IPMVP Option B', creation and edit history, and a 'Reporting Period' progress bar at 100%. The footer contains contact information and a copyright notice.

**ENERGYCAP SmartAnalytics™**

Currently impersonating Wattics Demo

Dashboard Data Admin

Monitored Points

- ✓ Auckland University of Technology
  - > **WO Building**
  - > Best Resorts Hotels
  - > Data Quality examples
  - > Food Corp.
  - > Pasta Factory

### WO Building M&V projects

**New M&V Project**

**New Chiller and BMS adjustments**

IPMVP Option B  
Created By Me (Only visible to you)  
Last edit 2 months ago

Reporting Period 100%

Contact: 1234567890 - info@wattics.com | All rights reserved © 2024

# Option B: Step by Step Process

1 - Project Definition

2 - ECM

3 - Baseline Period

4 - Reporting Period

5 - Routine Adjustments

6 - Non-Routine Adjustments

7 - Model

8 - Savings

9 - Executive Summary

 Download Report

WO Building  
Auckland, New Zealand

New Chiller and BMS adjustments

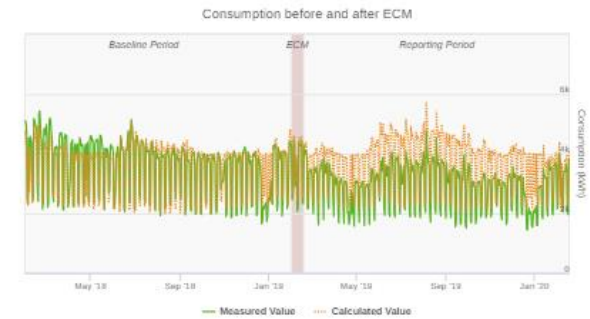
Measurement and Verification Report

April 2024



© 2024 Wattics Ltd

## Savings



Estimated consumption: 1,338,656.97 kWh (\$160,454.87)

Actual consumption: 1,065,000.82 kWh (\$126,014.84)

Savings/year: 273,656 kWh (\$34,440)

Payback Period: 7.46 Year

## Option B: Step 1 - Project Definition

Define the project's general overall parameters.

Name \*

Methodology \* IPMVP Option B ⓘ


Cost  \$

Visible to other people ☐

The following text should describe the motivation for the project and provide some context. It does not need a summary as one can be entered in the M&V tools last step. You may add images and format the text within this text box, the formatting will be visible in the final report.

---

M&V Plan for Auckland University of Technology WO Building, located in Auckland Central Business District.



Actions taken on included:

- Replacing the Chiller and cooling tower (see picture)
- Disable after-hours and weekend AHU requirements
- Switch AHU modulation control from PI to PID
- Reset supply air pressure and temperatures set points

## Option B: Step 2 - ECM

Optimization and Efficiency Program

Name \*

Optimization and Efficiency Program

Reference

Start \*

01/02/2019

End \*

17/02/2019

*Describe 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.*

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Renovations were carried on during the cooling season, as soon as works got authorized.

The new chiller was installed in parallel to the previous so to ensure continuity in the service, then the existing one was decommissioned.

# Option B: Step 3 - Baseline Period

Specify the dates that represent typical energy usage before the ECMs for the selected project. Add the energy data to your project in this step.

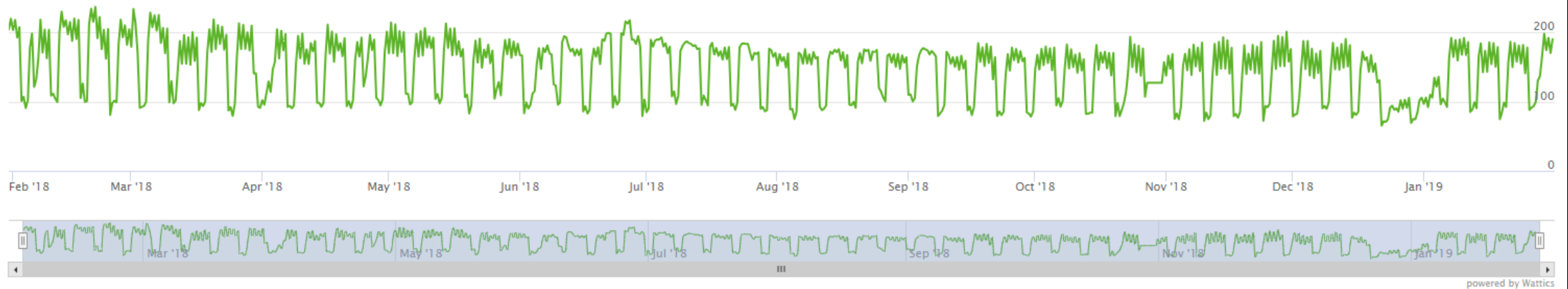
Energy Data **Main Incomer** [Link](#)

Start 31/01/2018

End 31/01/2019

Baseline Period – Energy Data

Period **All** 1m 1w 1d



Describe why this period of time was selected.

← → <> ¶ B I U ↺ ⋮ ⋮ ⋮ ⋮ 🖼️ 🔗 📅 ⚙️ — ↗️

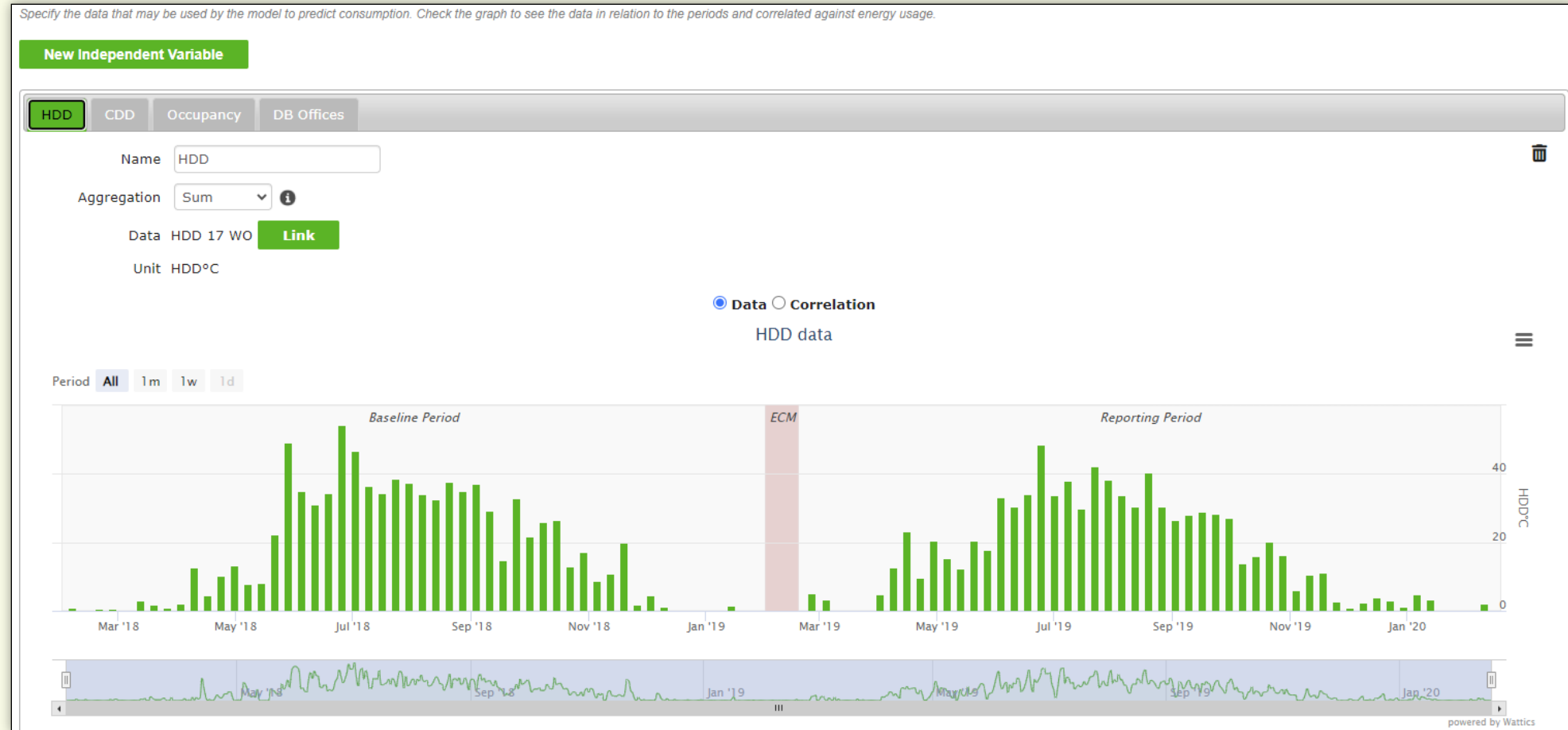
Baseline period was set to one full year to take seasonality into account

## Option B: Step 4 - Reporting Period





# Option B: Step 5 - Routine Adjustments



## Option B: Step 6 - Non-Routine Adjustments

### 6 – Non-Routine Adjustments

*Specify adjustments that need to be performed to the predicted consumption according circumstances or events not trackable through the routine adjustments.*

**New Static Factor**



No static factors set in this project.

# Option B: Step 7 - Model

Define the model by which consumption during the reporting period will be estimated. This estimation is the basis for determining how the consumption would have continued had the ECMs not been implemented.

Type Linear Regression

days grouping

All days (1 model)

Variable(s) to use:

☒ HDD

☒ CDD

☒ Occupancy

☒ DB Offices

Generate Model

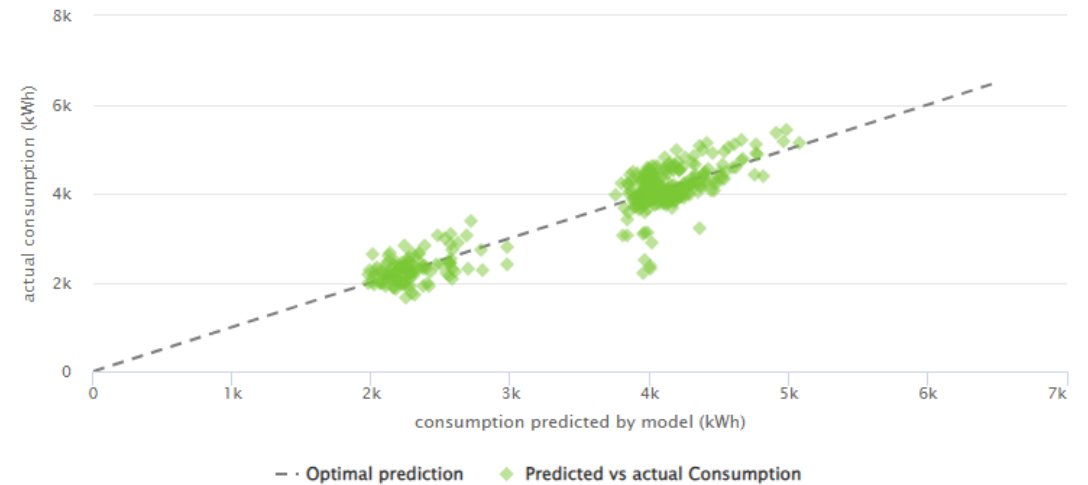
Output

Formula:  $-42.28 * \text{HDD} + 320.33 * \text{CDD} + 30.91 * \text{Occupancy} + 1.26 * \text{DB Offices} + 2176.13$

$R^2: 0.86$

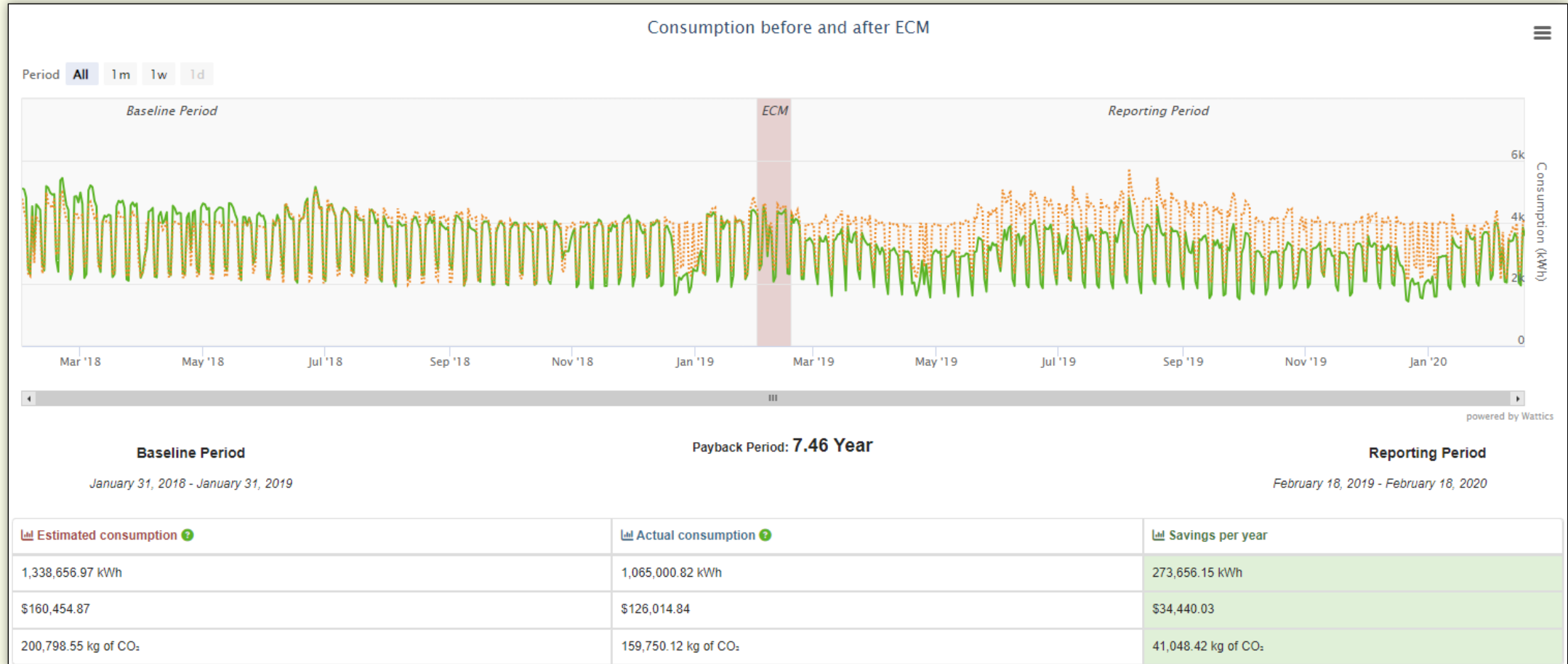
$R^2: 0.86$

Relationship between predicted and actual consumption



powered by Wattics

# Option B: Step 8 - Savings



## Option B: 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 in Utility Management

Establish baseline from utility bills

Determine weather sensitivity

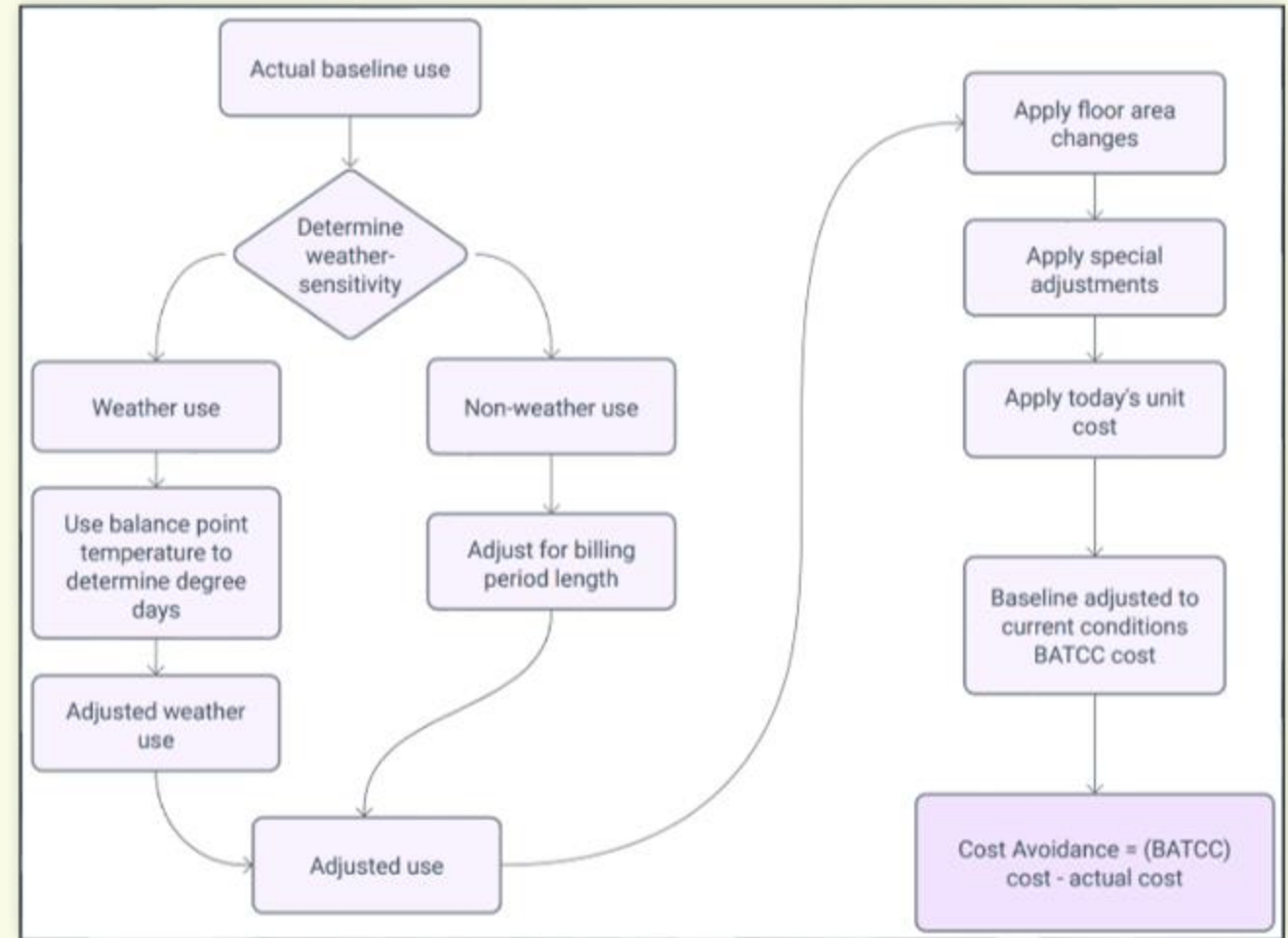
Calendarize bills – adjust for billing length

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

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



## Success story // The project

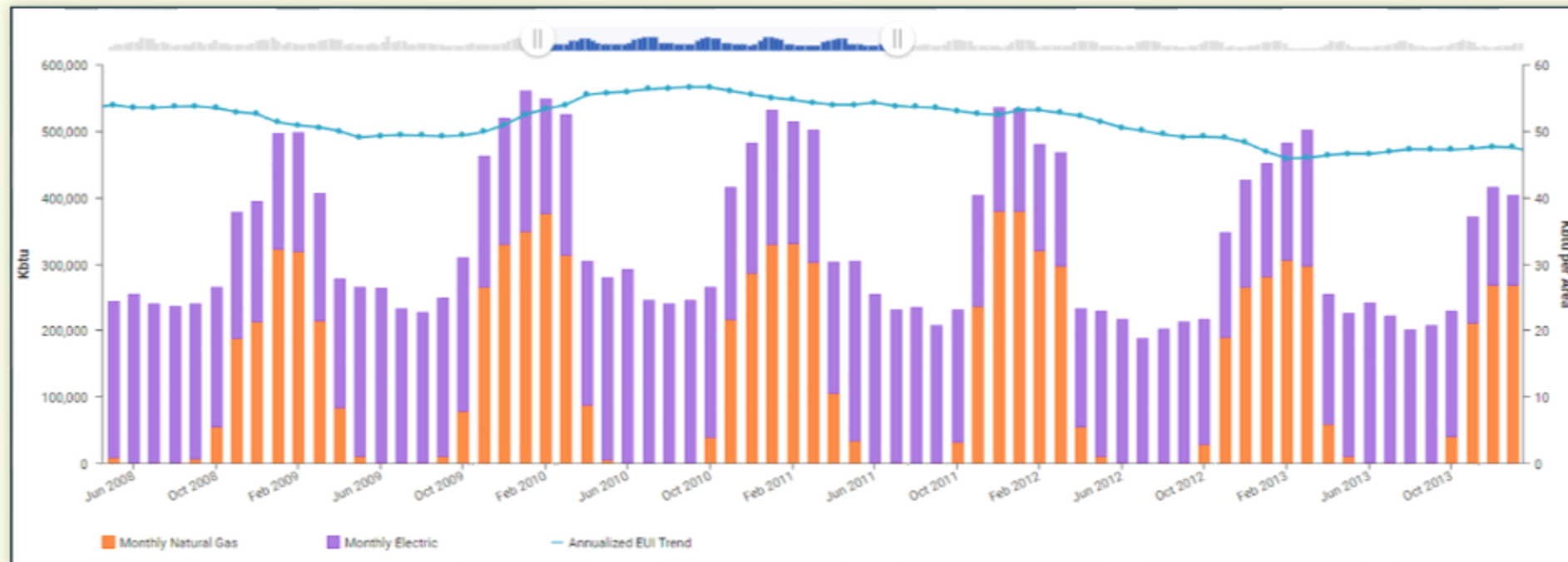
### Neil Armstrong Elementary School

**Area:** 80,000 ft<sup>2</sup> = ~7,432 m<sup>2</sup>

**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

## 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



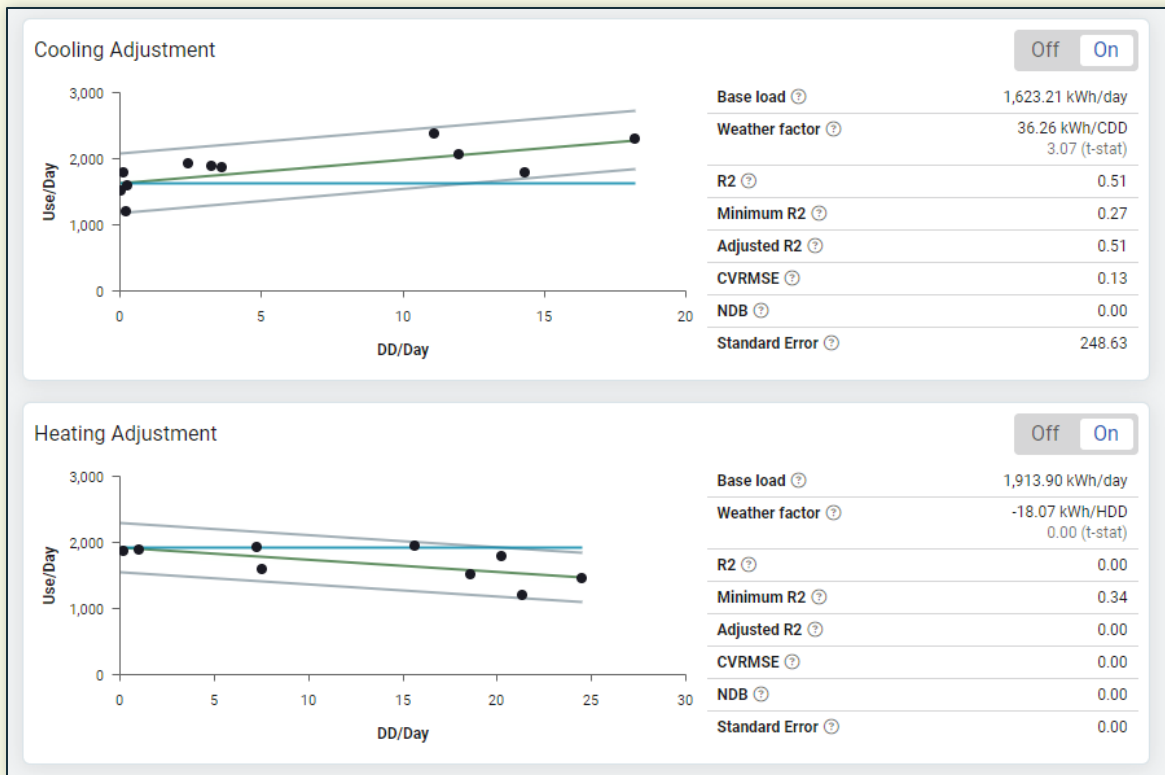
Heat below ?

55°F

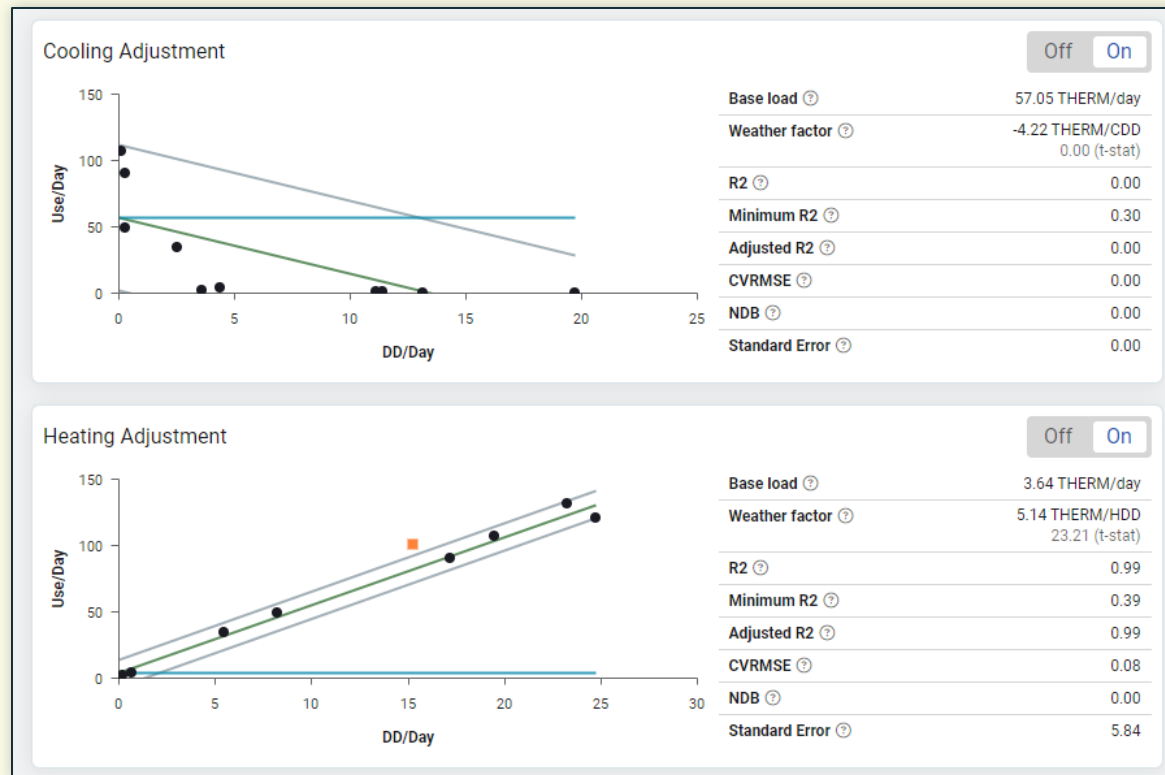


# Adjust for weather

## Electricity



## Natural Gas



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

**i** Statistics are compliant with **IPMVP Option C**

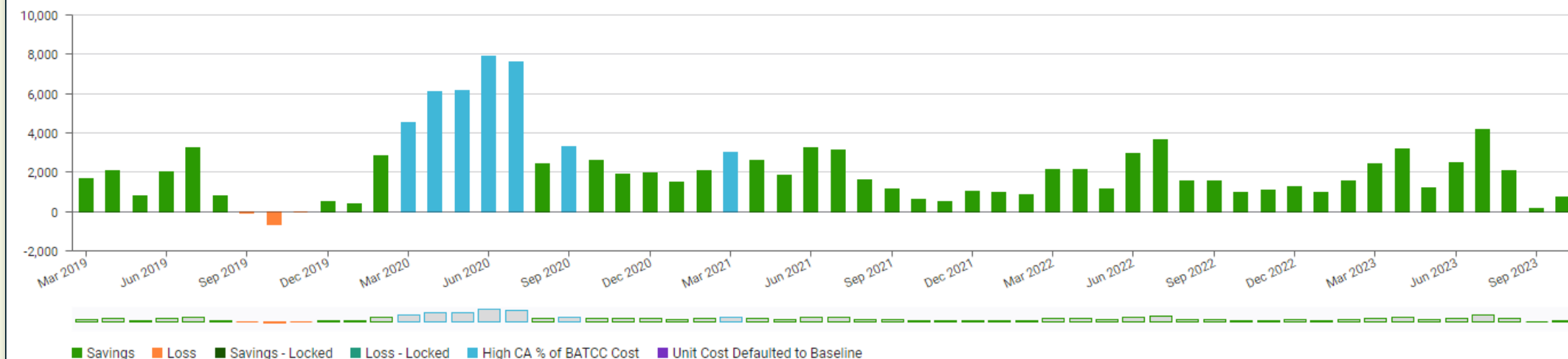
## Make special adjustments

	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 the savings

Savings Trends



Billing Period	Cost			Cost Avoidance		Cooling		Heating		Use			Use Avoidance	
	Baseline	BATCC	Actual	Amount	%	DD	Adj.	DD	Adj.	Baseline	BATCC	Actual	Amount	%
⊕ Nov 2023	\$ 4,500	\$ 6,720	\$ 5,942	\$ 778	11.6%	38	✓	134		50,312	51,110	45,193	5,917	11.6%
⊕ Sep 2023	\$ 6,076	\$ 8,972	\$ 8,783	\$ 189	2.1%	470	✓	0		65,626	68,056	66,624	1,432	2.1%
⊕ Aug 2023	\$ 4,815	\$ 7,297	\$ 5,216	\$ 2,082	28.5%	485	✓	0		51,611	54,040	38,625	15,415	28.5%
⊕ Jul 2023	\$ 6,393	\$ 8,793	\$ 4,607	\$ 4,185	47.6%	489	✓	0		68,942	66,295	34,738	31,557	47.6%
⊕ Jun 2023	\$ 6,928	\$ 8,675	\$ 6,161	\$ 2,513	29.0%	231	✓	0		73,040	68,616	48,735	19,881	29.0%
⊕ May 2023	\$ 4,388	\$ 5,876	\$ 4,679	\$ 1,197	20.4%	55	✓	29		48,308	47,836	38,091	9,745	20.4%
⊕ Apr 2023	\$ 5,868	\$ 8,078	\$ 4,893	\$ 3,185	39.4%	121	✓	73		64,979	66,248	40,124	26,124	39.4%

# Calculate the savings

## Explanation of Savings

< Aug 2023 >

Close

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

### Savings for Aug 2023



■ Non-weather use ■ Weather use ■ Locked adjustment ■ Actual current use ■ Use avoidance

36.26 KWH/CDD

Cooling

N/A

Heating

51,611 KWH

Actual baseline use

54,040 KWH

BATCC use

38,625 KWH

Actual current use

15,415 KWH

Use avoidance

\$ 7,297

BATCC cost

\$ 5,216

Actual current cost

\$ 2,082

Cost avoidance

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
> 07/20/2023	1,257.0 kWh	1,257.0 kWh	870.3 kWh	652.7 kWh	\$ 257.88	\$ 0.135				✓	24	18	0	0
> 07/21/2023	1,257.0 kWh	1,257.0 kWh	761.5 kWh	543.9 kWh	\$ 243.19	\$ 0.135				✓	21	15	0	0
> 07/22/2023	1,257.0 kWh	1,257.0 kWh	725.3 kWh	507.7 kWh	\$ 238.29	\$ 0.135				✓	20	14	0	0
> 07/23/2023	1,257.0 kWh	1,257.0 kWh	689.0 kWh	543.9 kWh	\$ 243.19	\$ 0.135				✓	19	15	0	0
> 07/24/2023	1,257.0 kWh	1,257.0 kWh	616.5 kWh	652.7 kWh	\$ 257.88	\$ 0.135				✓	17	18	0	0
> 07/25/2023	1,257.0 kWh	1,257.0 kWh	398.9 kWh	725.3 kWh	\$ 267.67	\$ 0.135				✓	11	20	0	0
> 07/26/2023	1,257.0 kWh	1,257.0 kWh	398.9 kWh	652.7 kWh	\$ 257.88	\$ 0.135				✓	11	18	0	0
> 07/27/2023	1,257.0 kWh	1,257.0 kWh	543.9 kWh	870.3 kWh	\$ 287.26	\$ 0.135				✓	15	24	0	0
> 07/28/2023	1,257.0 kWh	1,257.0 kWh	543.9 kWh	870.3 kWh	\$ 287.26	\$ 0.135				✓	15	24	0	0
> 07/29/2023	1,257.0 kWh	1,257.0 kWh	435.2 kWh	797.8 kWh	\$ 277.46	\$ 0.135				✓	12	22	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

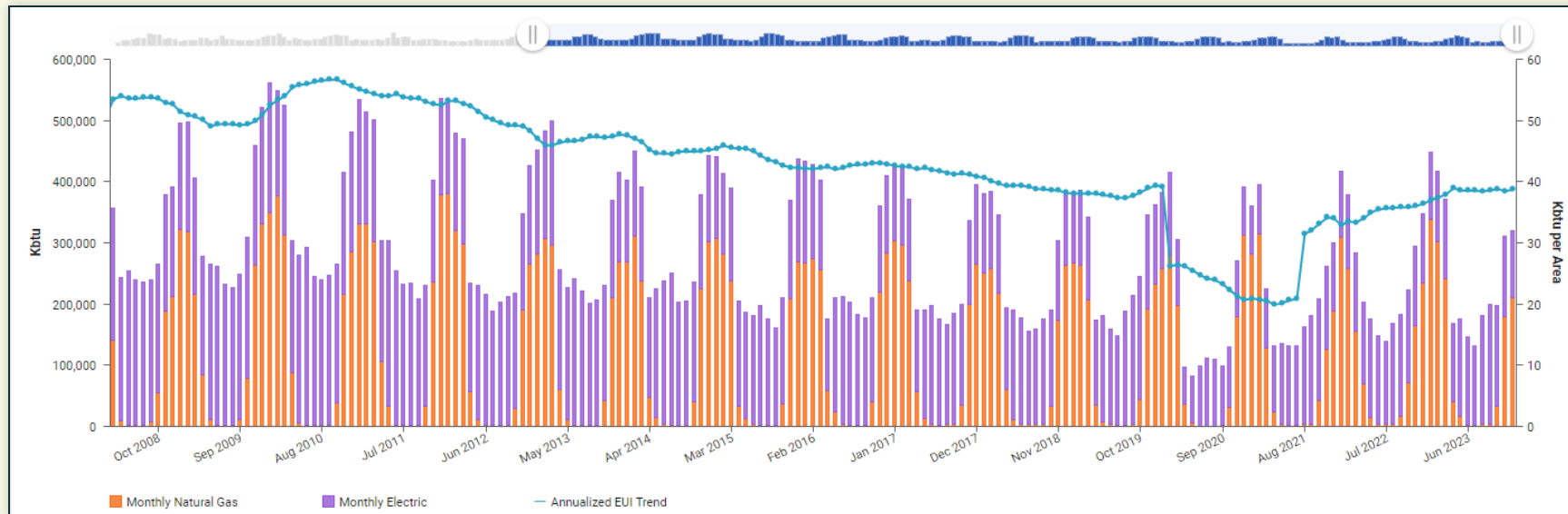
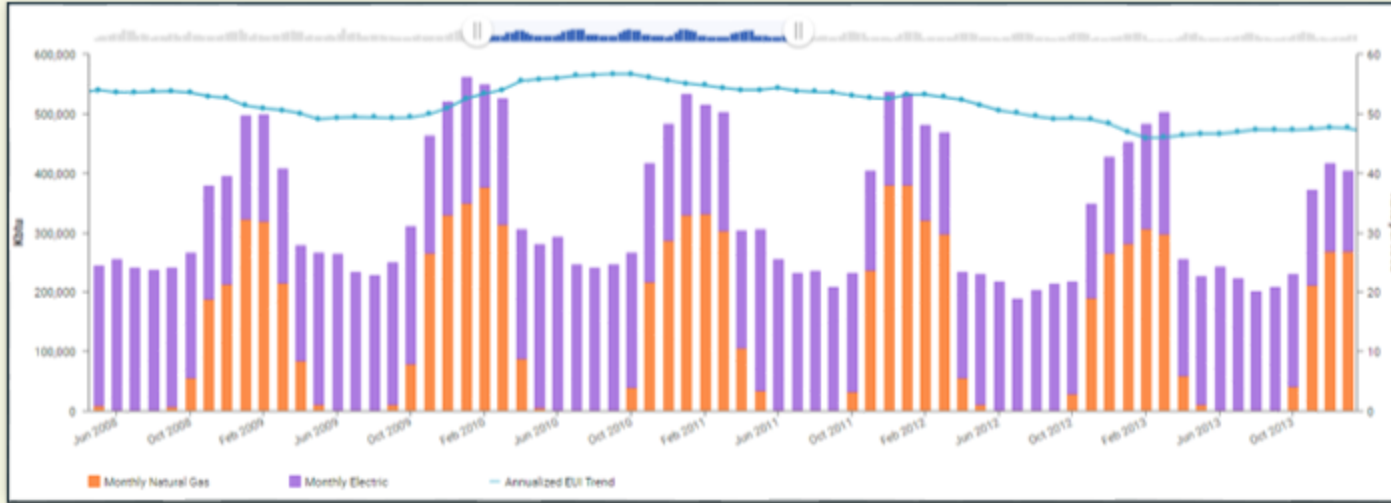
Start
Jan 2022
End
Jan 2023

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

# Report to stakeholders

## Historical & Baseline



## Performance

# Report to stakeholders

## Cost Savings

Savings (BATCC - Actual)

**\$189,870.45**

BATCC (Baseline)

\$889,663.99

Actual Cost

\$699,793.54

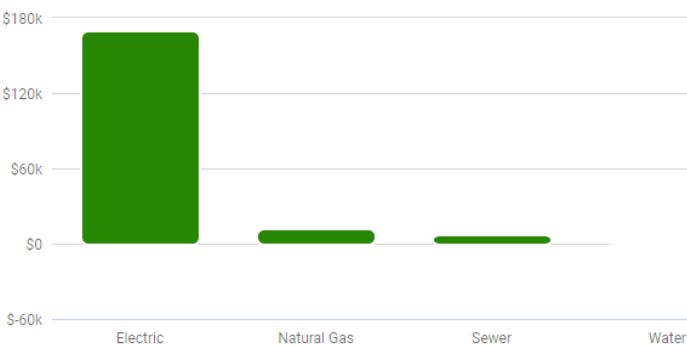
↑21.3%

Inception–Feb 2024

**Optimization Target:** 15% savings

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

## Cost Avoidance by Commodity



Fiscal Years 2021–2024

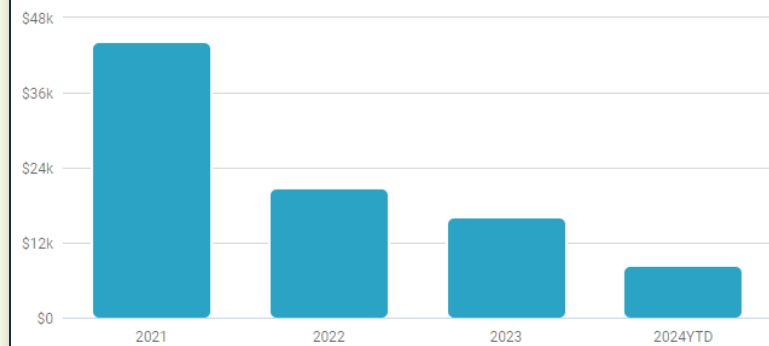
Data details Filters applied

Copy table data

Commodity ↓ Savings

⚡ Electric	\$170,492.51
🔥 Natural Gas	\$12,759.28
🚰 Sewer	\$8,147.71
💧 Water	⚠️ \$-1,529.06

## Cost Avoidance Summary



Fiscal Years 2021–2025

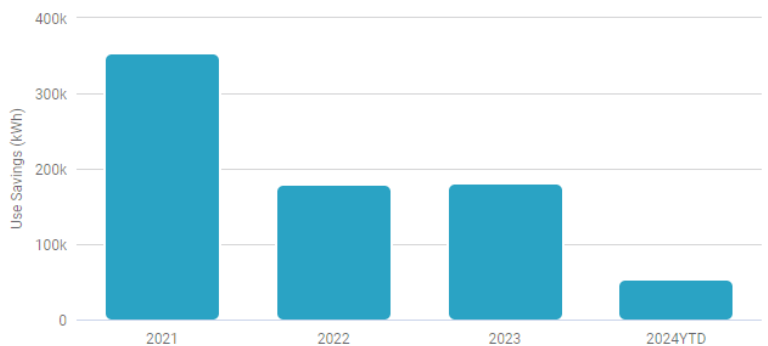
Data details Filters applied

Copy table data

Year Savings

2021	\$44,311.75
2022	\$20,826.07
2023	\$16,236.44
2024YTD	\$8,440.39

## Use Avoidance Summary



Fiscal Years 2021–2025

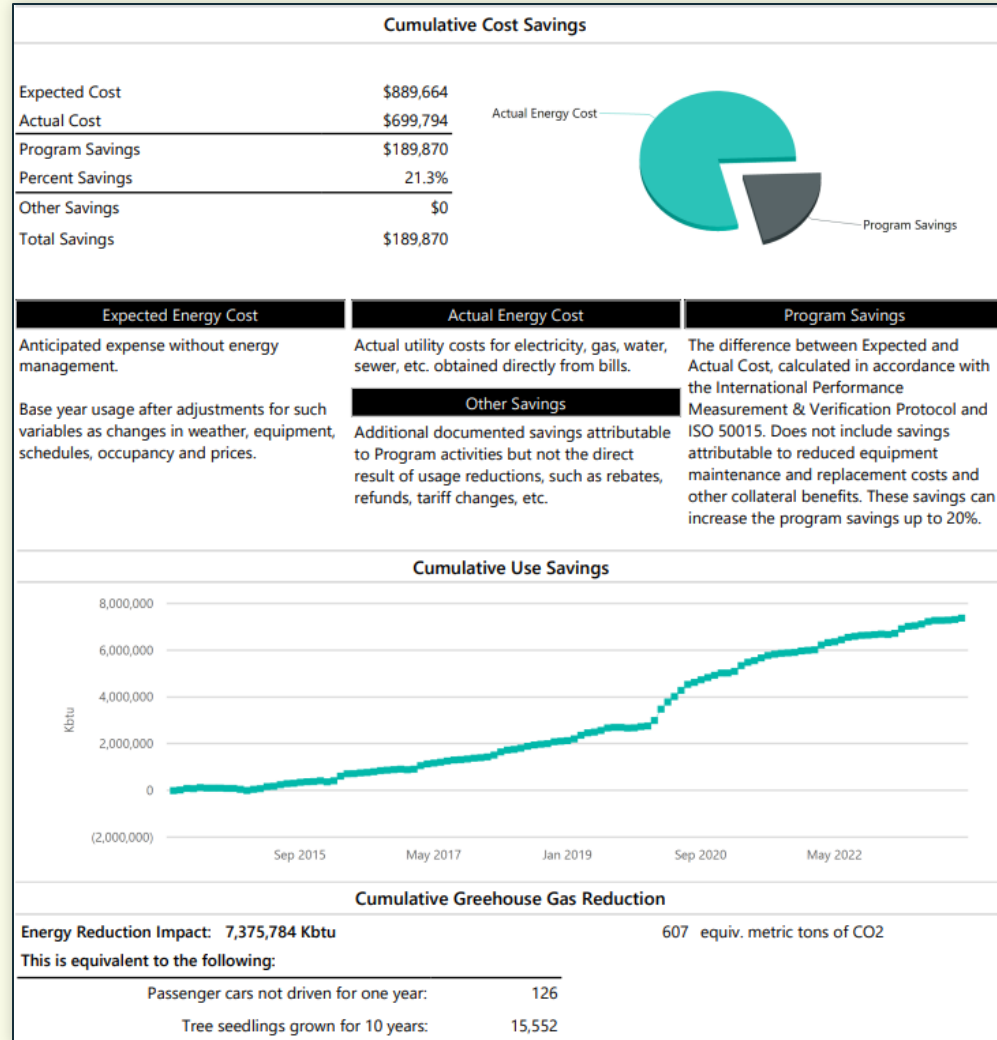
Data details Filters applied

Copy table data

Year Savings (kWh)

2021	354,735.00
2022	181,260.00
2023	181,964.00
2024YTD	54,321.00

# 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%

## Resources

Become a member of EVO ([\*\*www.EVO-World.org\*\*](http://www.EVO-World.org))

Download IPMVP from EVO

Purchase ISO standards at [iso.org](http://iso.org)

Become a CMVP-Certified Measurement & Verification Professional ([\*\*www.AEECenter.org\*\*](http://www.AEECenter.org))

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

**Questions?**



Take the session survey:  
**M&V 201: Target, measure,  
and verify**

