Partners in Project Green

A Program of Toronto and Region Conservation Authority

Energy Leaders Consortium
Energy Management with PDSB

January 31st, 2024

We respectfully acknowledge that we are situated on the Traditional Territories and Treaty Lands, in particular those of the Mississaugas of the Credit First Nation, as well as the Anishinaabe of the Williams Treaty First Nations, the Huron Wendat, the Haudenosaunee, and the Metis Nation.

As stewards of land and water resources within the Greater Toronto Region, Toronto and Region Conservation Authority appreciates and respects the history and diversity of the land and is grateful to have the opportunity to work and meet on this territory.

Additional Resources

- yrnature.ca/acknowledging_land
- edgeofthebush.ca
- native-land.ca
- Text 1-855-917-5263 with your City and Province to learn whose traditional territory you're on
(standard text messaging rates may apply)

A Collaborative Space for All

Proposed Operative Values for ELC meetings:

1. Balance airtime to hear from as many voices as possible
2. Be curious and challenge our own assumptions and biases
3. Be open to building on each other's suggestions or taking the conversation in another direction

Agenda

Time	Activity
1:00pm – 1:15pm	Introduction and Updates (PPG)
1:15pm – 1:45pm	Energy Management: Dealing with Data (PDSB)
1:45pm – 2:30pm	Q & A and Discussion Period (all)

Introduction

New ELC Members

- ✓ **Welcome Terry and Sahar from TELUS!**
- ✓ **An official welcome to Adam from Region of Peel!**

Participant Introductions

- To introduce ourselves to presenters, special guests, or for new ELC members
  - Please turn on your camera if you can
  - Name
  - Position
  - Organization

Updates and Reminders

- **ELC Member Reporting for 2023**
  - 2023 savings for electricity, natural gas, and water projects/ upgrades
  - Tracking helps us celebrate our impact as a consortium of energy leaders!
  - **Complete and return spreadsheet to Matt ASAP**

Example of tracking form:

Energy Conservation Measure Description	Utility	Annual Consumption Savings		Monetary Savings ($)
			kWh	
			m3	
			L	
			kW	

Updates and Reminders

Funding opportunities through Centennial College:

- **Green mobility-** connected, autonomous, smart, cybersecurity- software and hardware, feasibility studies for electrification
  - $ 400,000 available for 2024

- **Other funding** - Green buildings, renewable energy, energy audits and GHG- software and hardware
  - $400,000 for 2024

For more information, please contact our ELC member Wenzi Ckurshumova at wckurshumova@centennialcollege.ca

Updates and Reminders: Member Perks

Division/Program	PPG Member Perks	PPG Membership Tiers			
		Community Access	General Member	Member Plus	All Access
Black Creek Pioneer Village	10% off the team-building Corporate Groups Programs			X	X
	General entry for free admission for PPG member employees and up to 5 guests				X
Kortright Centre	10% off corporate booking		5% off	X	X
	10% off adult nature-based workshops and health and wellness		5% off	X	X
	General entry for free admission for PPG member employees and up to 5 guests				X
Young Conservation Professionals Leadership Program	15% off the program		X	X	X
Professional Access Into Employment (PAIE)	Access the PAIE program to hire skilled professionals and receive free training on integrating New Canadian professionals into your workforce		X	X	X
Look After Where You Live	10% discount on Stewardship of Tommy Thompson Park		X	X	X
	10% discount on Stewardship of The Meadoway programs		X	X	X

Today’s Speaker

Benjamin Ratcliffe

Energy Coordinator, Peel District School Board

Benjamin Ratcliffe BACSc., CEM, is an Energy Coordinator at Peel District School Board (PDSB) since 2015. He has expertise in building automation system optimization and whole building facility electricity baseline modeling. With his small team of experts, PDSB’s portfolio of schools covering 21.5 million ft² has seen a reduction in electricity use by 20 MWh per year and annual CO2 emissions reduced by 34% since 2015.

JK

Peel District School Board

Energy Performance Modelling

Benjamin Ratcliffe CEM, BACSc.

Energy Coordinator

Peel District School Board

Energy Performance Modelling

WHY MAKE A BASELINE MODEL?

THE IPMVP STANDARD FOR ENERGY PERFORMANCE MEASUREMENT

USING YOUR DATA

PREPARING BAS DATA FOR MODELLING

THE REGRESSION MODEL

The Case for Performance Modelling

Verify the project saved what you expected, and capture under performance or operating changes.

Enables measurement of difficult-to-capture behavioural campaigns to reduce energy consumption.

Benchmark your facilities and compare against other similar facilities *daily*.

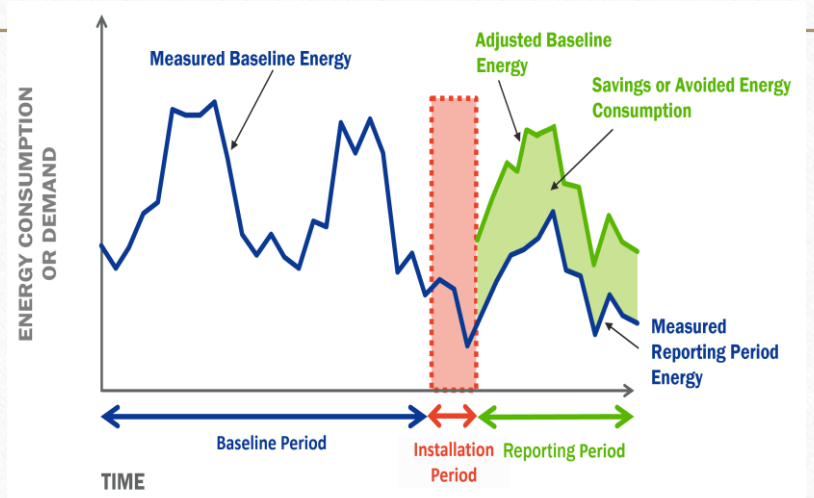


Image credit: *Efficiency Valuation Organization, https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp*

Enables the potential for *predicting energy consumption* by estimating model parameters.

Capture impacts from ECMs which have multiple interactive effects.

Do something with those meters you spent so much money on!

Enables competition between similar facilities.

The IPMVP Standard

International Performance Measurement & Verification Protocol

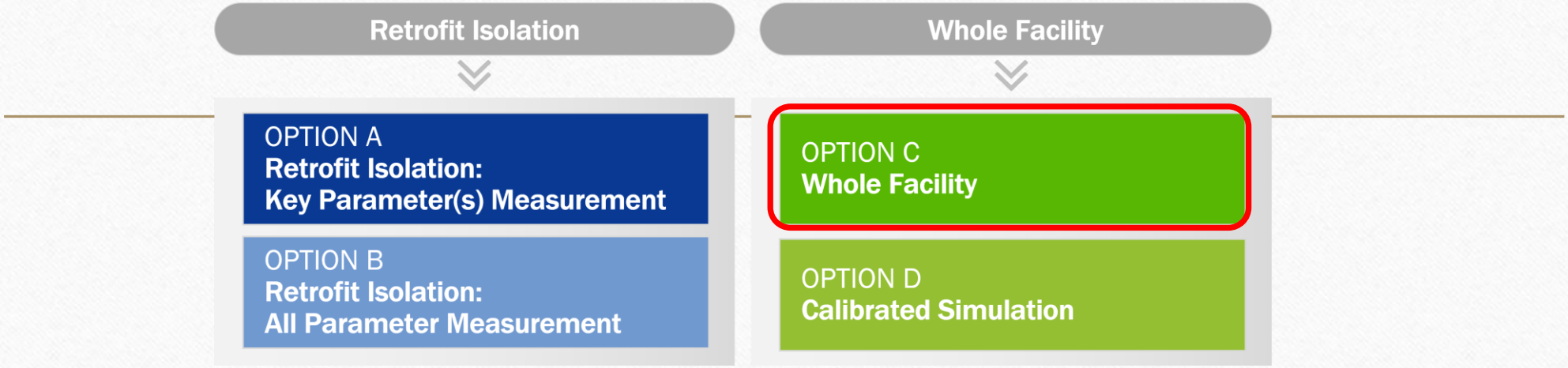


Image credit: *Efficiency Valuation Organization, https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp*

Model Requirements (Option C):

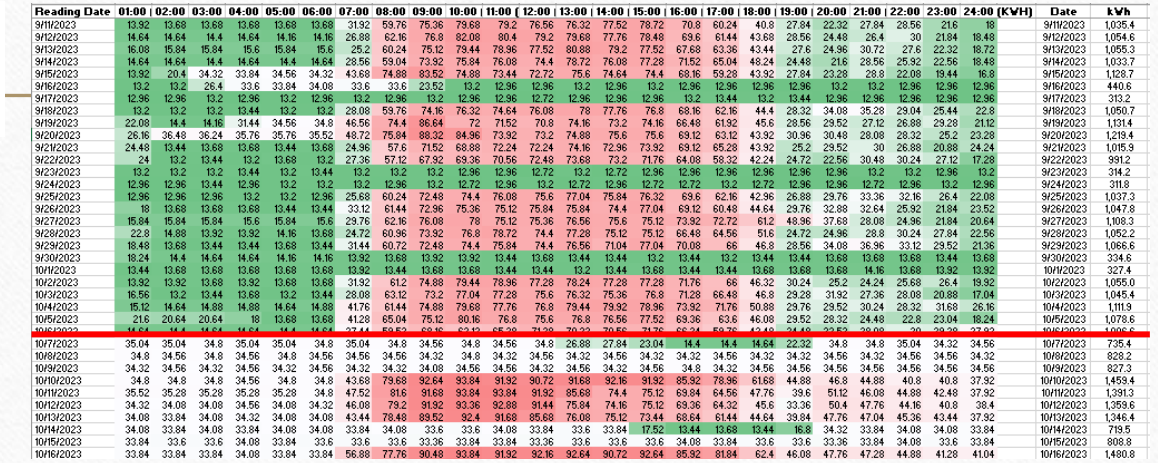
- Minimum one year of electricity meter data, recorded with intervals at least hourly or smaller.
- Independent energy drivers (parameters) which are **continuously** and **automatically** recorded.
- Clearly define electricity consumption scope (School example: are the portables included or not?)

Make use of your data sources

By themselves, energy meters **DO NOT** save energy.

Meters only reduce energy use when the data is observed, analyzed and acted upon.

A simple heatmap can highlight weather a change in energy use is expected, or unusual.

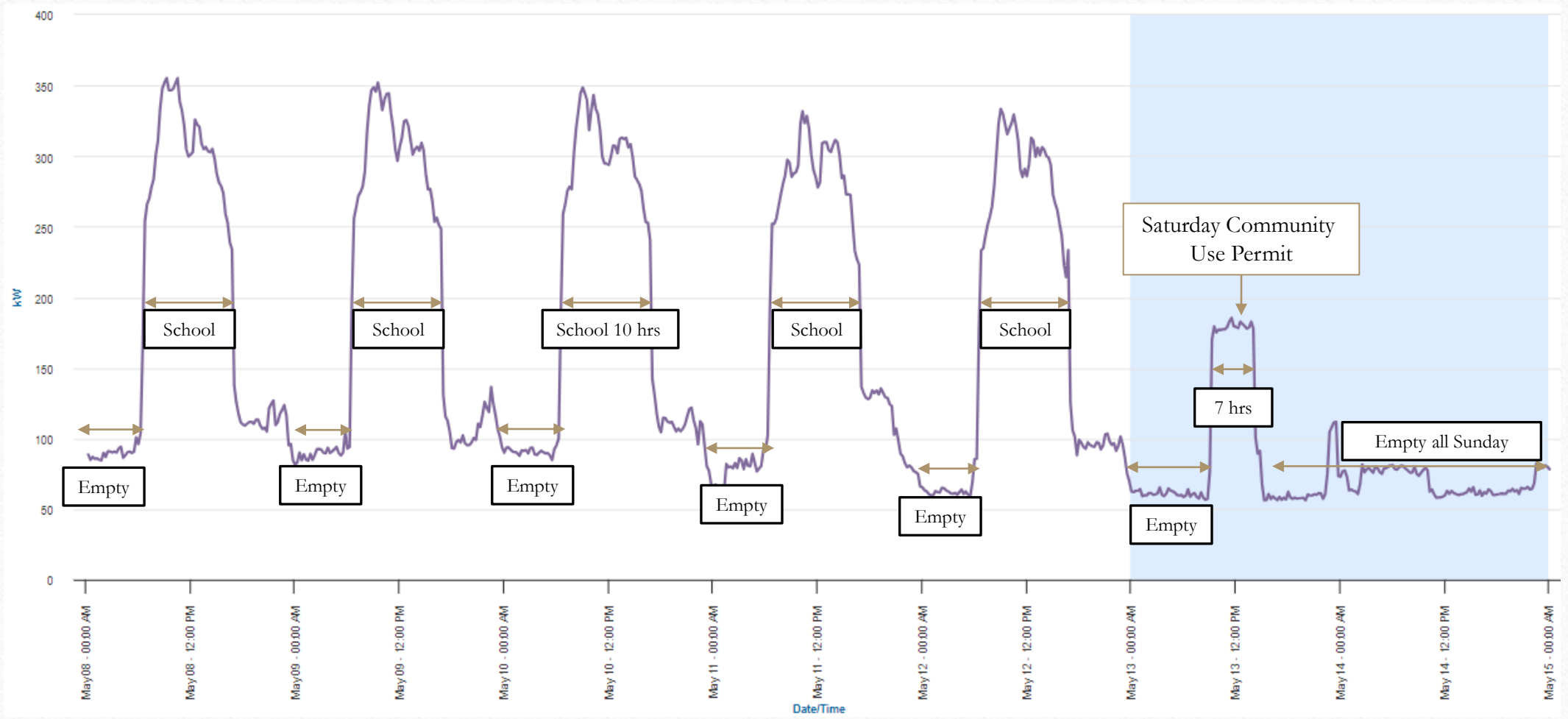


Reading Date	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	24:00 (KWH)	Date	kWh
9/11/2023	13.92	13.68	13.68	13.68	13.68	13.68	31.92	59.76	75.36	79.68	79.2	76.56	76.32	77.52	78.72	70.8	60.24	40.8	27.84	22.32	27.84	28.56	21.6	18	9/11/2023	1,035.4
9/12/2023	14.64	14.64	14.4	14.64	14.16	14.16	26.88	62.16	76.8	82.08	80.4	79.2	79.68	77.76	78.48	69.6	61.44	43.68	28.56	24.48	26.4	30	21.84	18.48	9/12/2023	1,054.6
9/13/2023	16.08	15.84	15.84	15.6	15.84	15.6	25.2	60.24	75.12	79.44	78.96	77.52	80.88	79.2	77.52	67.68	63.36	43.44	27.6	24.96	30.72	27.6	22.32	18.72	9/13/2023	1,055.3
9/14/2023	14.64	14.64	14.4	14.64	14.4	14.64	28.56	59.04	73.92	75.84	76.08	74.4	78.72	76.08	77.28	71.52	65.04	43.24	24.48	21.6	28.56	25.92	22.56	18.48	9/14/2023	1,033.7
9/15/2023	13.92	20.4	34.32	33.84	34.56	34.32	43.68	74.88	83.52	74.88	73.44	72.72	75.6	74.64	74.4	68.16	59.28	43.92	27.84	23.28	28.8	22.08	19.44	16.8	9/15/2023	1,128.7
9/16/2023	13.2	13.2	26.4	33.6	33.84	34.08	33.6	33.6	23.52	13.2	12.96	12.96	13.2	12.96	13.2	12.96	12.96	12.96	12.96	13.2	13.2	12.96	12.96	12.96	9/16/2023	440.6
9/17/2023	12.96	12.96	13.2	12.96	13.2	12.96	13.2	12.96	13.2	12.96	12.96	12.72	12.96	12.96	12.96	13.2	13.44	13.2	13.44	12.96	12.96	12.96	12.96	12.96	9/17/2023	313.2
9/18/2023	13.2	13.2	13.2	13.44	13.2	13.2	28.08	59.76	74.16	76.32	74.64	76.08	78	77.76	76.8	68.16	62.16	44.4	28.32	34.08	35.28	29.04	25.44	22.8	9/18/2023	1,050.7
9/19/2023	22.08	14.4	14.16	31.44	34.56	34.8	46.56	74.4	86.64	72	71.52	70.8	74.16	73.2	74.16	66.48	61.92	45.6	28.56	29.52	27.12	26.88	29.28	21.12	9/19/2023	1,131.4
9/20/2023	26.16	36.48	36.24	35.76	35.76	35.52	48.72	75.84	88.32	84.96	73.92	73.2	74.88	75.6	75.6	69.12	63.12	43.92	30.96	30.48	28.08	28.32	25.2	23.28	9/20/2023	1,219.4
9/21/2023	24.48	13.44	13.68	13.68	13.44	13.68	24.96	57.6	71.52	69.88	72.24	72.24	74.16	72.96	73.92	69.12	65.28	43.92	25.2	29.52	30	26.88	20.88	24.24	9/21/2023	1,015.9
9/22/2023	24	13.2	13.44	13.2	13.68	13.2	27.36	57.12	67.92	69.36	70.56	72.48	73.68	73.2	71.76	64.08	58.32	42.24	24.72	22.56	30.48	30.24	27.12	17.28	9/22/2023	991.2
9/23/2023	13.2	13.2	13.2	13.44	13.2	13.44	13.2	13.2	13.2	12.96	12.96	12.72	13.2	12.72	12.96	12.96	12.96	12.96	12.96	12.96	13.2	13.2	12.96	13.2	9/23/2023	314.2
9/24/2023	12.96	12.96	13.44	12.96	13.2	13.2	13.2	12.96	13.2	12.72	12.96	13.2	12.72	12.96	12.72	12.72	13.2	12.72	12.96	12.96	12.72	12.96	13.2	12.96	9/24/2023	311.8
9/25/2023	12.96	12.96	12.96	13.2	13.2	12.96	25.68	60.24	72.48	74.4	76.08	75.6	77.04	75.84	76.32	69.6	62.16	42.96	26.88	29.76	33.36	32.16	26.4	22.08	9/25/2023	1,037.3
9/26/2023	18	13.68	13.68	13.68	13.44	13.44	33.12	61.44	72.96	75.36	75.12	75.84	75.84	74.4	77.04	69.12	60.48	44.64	29.76	32.88	32.64	25.92	21.84	23.52	9/26/2023	1,047.8
9/27/2023	15.84	15.84	15.84	15.6	15.84	15.6	29.76	62.16	76.08	78	75.12	75.36	76.56	75.6	75.12	73.92	72.72	61.2	48.96	37.68	28.08	24.96	21.84	20.64	9/27/2023	1,108.3
9/28/2023	22.8	14.88	13.92	13.92	14.16	13.68	24.72	60.96	73.92	76.8	78.72	74.4	77.28	75.12	75.12	66.48	64.56	51.6	24.72	24.96	28.8	30.24	27.84	22.56	9/28/2023	1,052.2
9/29/2023	18.48	13.68	13.44	13.44	13.68	13.44	31.44	60.72	72.48	74.4	75.84	74.4	76.56	71.04	77.04	70.08	66	46.8	28.56	34.08	36.96	33.12	29.52	21.36	9/29/2023	1,066.6
9/30/2023	18.24	14.4	14.64	14.64	14.16	14.16	13.92	13.68	13.92	13.92	13.44	13.68	13.44	13.44	13.2	13.44	13.2	13.44	13.44	13.68	13.68	13.68	13.44	13.68	9/30/2023	334.6
10/1/2023	13.44	13.68	13.68	13.68	13.68	13.68	13.92	13.44	13.68	13.68	13.44	13.44	13.2	13.44	13.68	13.44	13.44	13.68	13.68	13.68	14.16	13.68	13.92	13.92	10/1/2023	327.4
10/2/2023	13.92	13.92	13.68	13.92	13.68	13.68	31.92	61.2	74.88	79.44	78.96	77.28	78.24	77.28	77.28	71.76	66	46.32	30.24	25.2	24.24	25.68	26.4	19.92	10/2/2023	1,055.0
10/3/2023	16.56	13.2	13.44	13.68	13.2	13.44	28.08	63.12	73.2	77.04	77.28	75.6	76.32	75.36	76.8	71.28	66.48	46.8	29.28	31.92	27.36	28.08	20.88	17.04	10/3/2023	1,045.4
10/4/2023	15.12	14.64	14.88	14.88	14.64	14.88	41.76	61.44	74.88	79.68	77.76	76.8	79.44	79.92	78.96	73.92	71.76	50.88	29.76	29.52	30.24	28.32	31.68	26.16	10/4/2023	1,111.9
10/5/2023	21.6	20.64	20.64	18	13.68	13.68	41.28	65.04	75.12	80.16	76.8	75.6	76.8	76.56	77.52	69.36	63.6	46.08	29.52	28.32	24.48	22.8	23.04	18.24	10/5/2023	1,078.6
10/6/2023	14.64	14.4	14.64	14.64	14.4	14.64	27.44	59.52	69.12	69.12	65.28	71.28	70.32	70.56	71.76	66.24	59.76	43.44	24.48	23.52	28.08	28.08	28.08	22.32	10/6/2023	1,005.6
10/7/2023	35.04	35.04	34.8	35.04	35.04	34.8	35.04	34.8	34.56	34.8	34.56	34.8	26.88	27.84	23.04	14.4	14.4	14.64	22.32	34.8	34.8	35.04	34.32	34.56	10/7/2023	735.4
10/8/2023	34.8	34.56	34.8	34.56	34.8	34.56	34.56	34.56	34.32	34.8	34.32	34.56	34.32	34.56	34.32	34.32	34.56	34.32	34.32	34.56	34.32	34.56	34.56	34.32	10/8/2023	828.2
10/9/2023	34.32	34.56	34.32	34.56	34.32	34.56	34.32	34.32	34.08	34.56	34.56	34.32	34.56	34.32	34.56	34.8	34.32	34.56	34.56	34.56	34.56	34.56	34.56	34.56	10/9/2023	827.3
10/10/2023	34.8	34.8	34.8	34.56	34.8	34.8	43.68	79.68	92.64	93.84	91.92	90.72	91.68	92.16	91.92	85.92	78.96	61.68	44.88	46.8	44.88	40.8	40.8	37.92	10/10/2023	1,459.4
10/11/2023	35.52	35.28	35.28	35.28	35.28	34.8	47.52	81.6	91.68	93.84	93.84	91.92	85.68	74.4	75.12	69.84	64.56	47.76	39.6	51.12	46.08	44.88	42.48	37.92	10/11/2023	1,391.3
10/12/2023	34.32	34.08	34.08	34.56	34.08	34.32	46.08	79.2	91.92	93.36	92.88	91.44	75.84	74.16	75.12	69.36	64.32	45.6	33.36	50.4	47.76	44.16	40.8	38.4	10/12/2023	1,359.6
10/13/2023	34.08	33.84	34.08	34.32	34.08	34.08	43.44	78.48	89.52	92.4	91.68	85.68	76.08	75.12	73.44	68.64	61.44	44.64	39.84	47.76	47.04	45.36	43.44	37.92	10/13/2023	1,346.4
10/14/2023	34.08	33.84	34.08	33.84	34.08	34.08	33.84	34.08	33.6	33.6	34.08	33.84	33.6	33.84	17.52	13.44	13.68	13.44	16.8	34.32	33.84	34.08	34.08	33.84	10/14/2023	719.5
10/15/2023	33.84	33.6	33.6	34.08	33.84	33.6	33.6	33.6	33.36	33.84	33.84	33.36	33.6	33.6	33.6	34.08	33.84	33.6	33.6	33.36	33.84	34.08	33.6	33.84	10/15/2023	808.8
10/16/2023	33.84	33.84	33.84	34.08	33.84	33.84	56.88	77.76	90.48	93.84	91.92	92.16	92.64	90.72	92.64	85.92	81.84	62.4	46.08	47.76	47.28	44.88	41.28	41.04	10/16/2023	1,480.8

A baseline model can use *any independently measured parameters* (energy driver): weather, production levels, occupant counts, key HVAC system operations, operating hours, water usage, or other data sources.

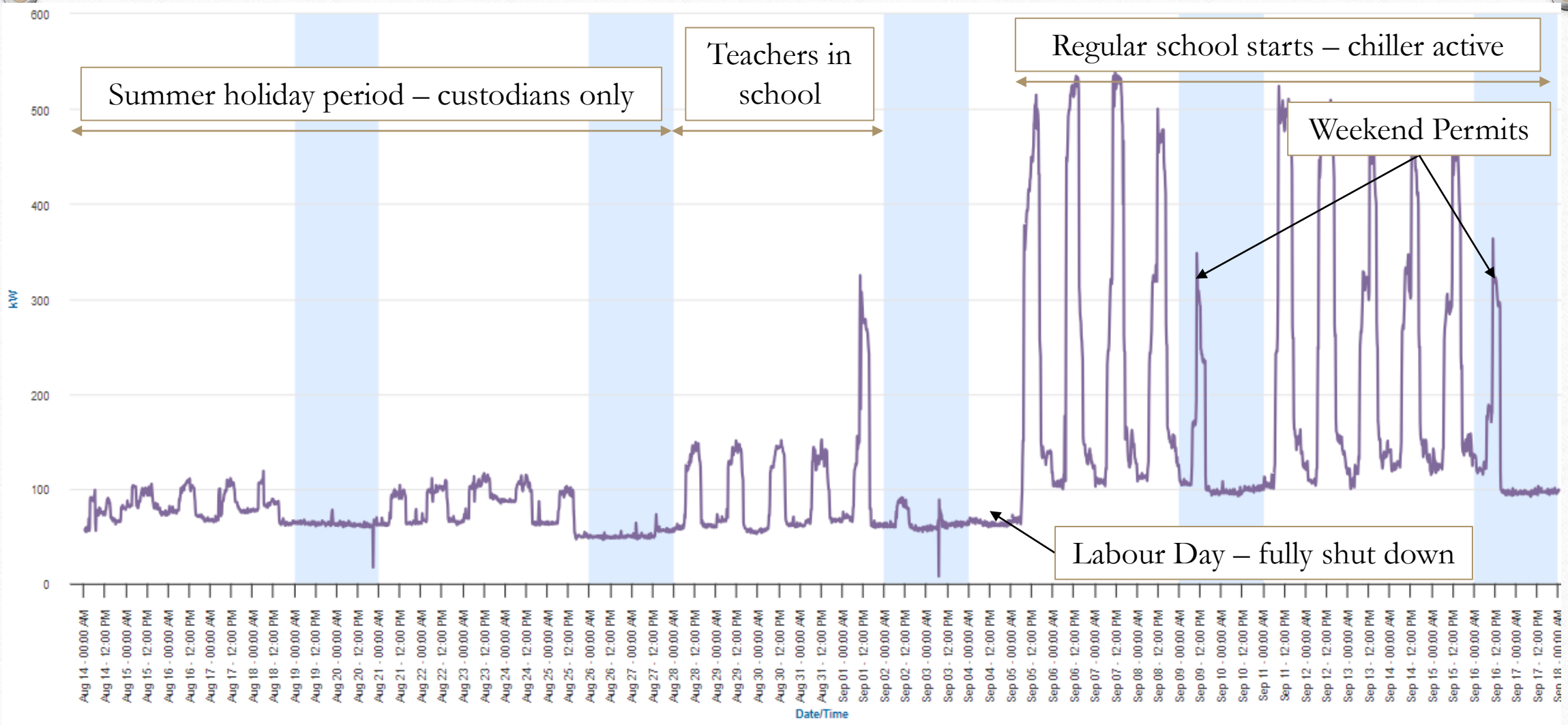
Most schools do not have any data sources that are measured hourly, like the electricity data, other than **building automation system** data that is continuously and automatically monitored.

Facility Load Profile



In a given week, a school spends more time either minimally occupied or completely *unoccupied,* than it spends fully occupied with students.

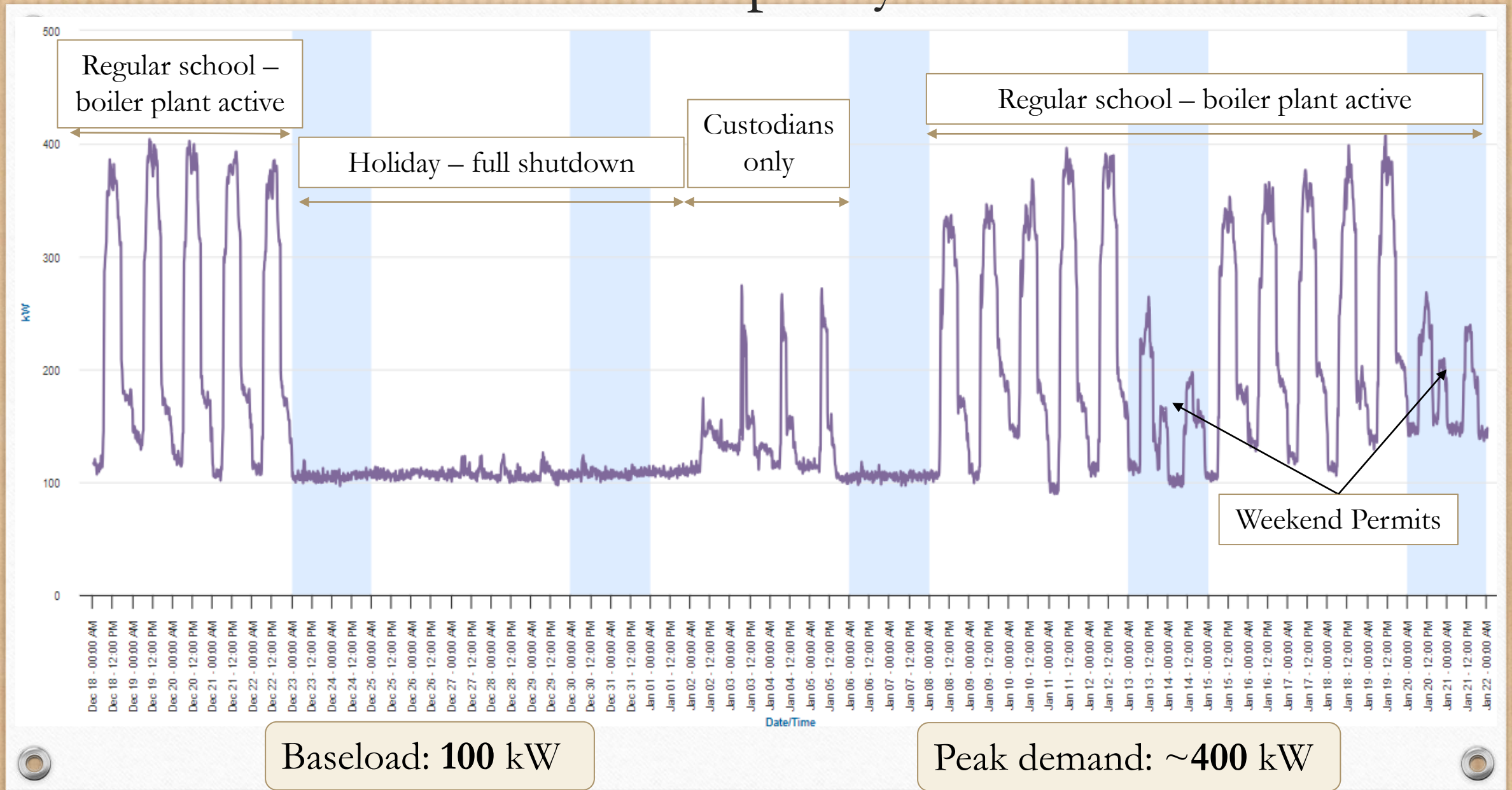
Variable Occupancy: Summer



Baseload: **50** kW

Peak demand: ~**535** kW

Variable Occupancy: Winter

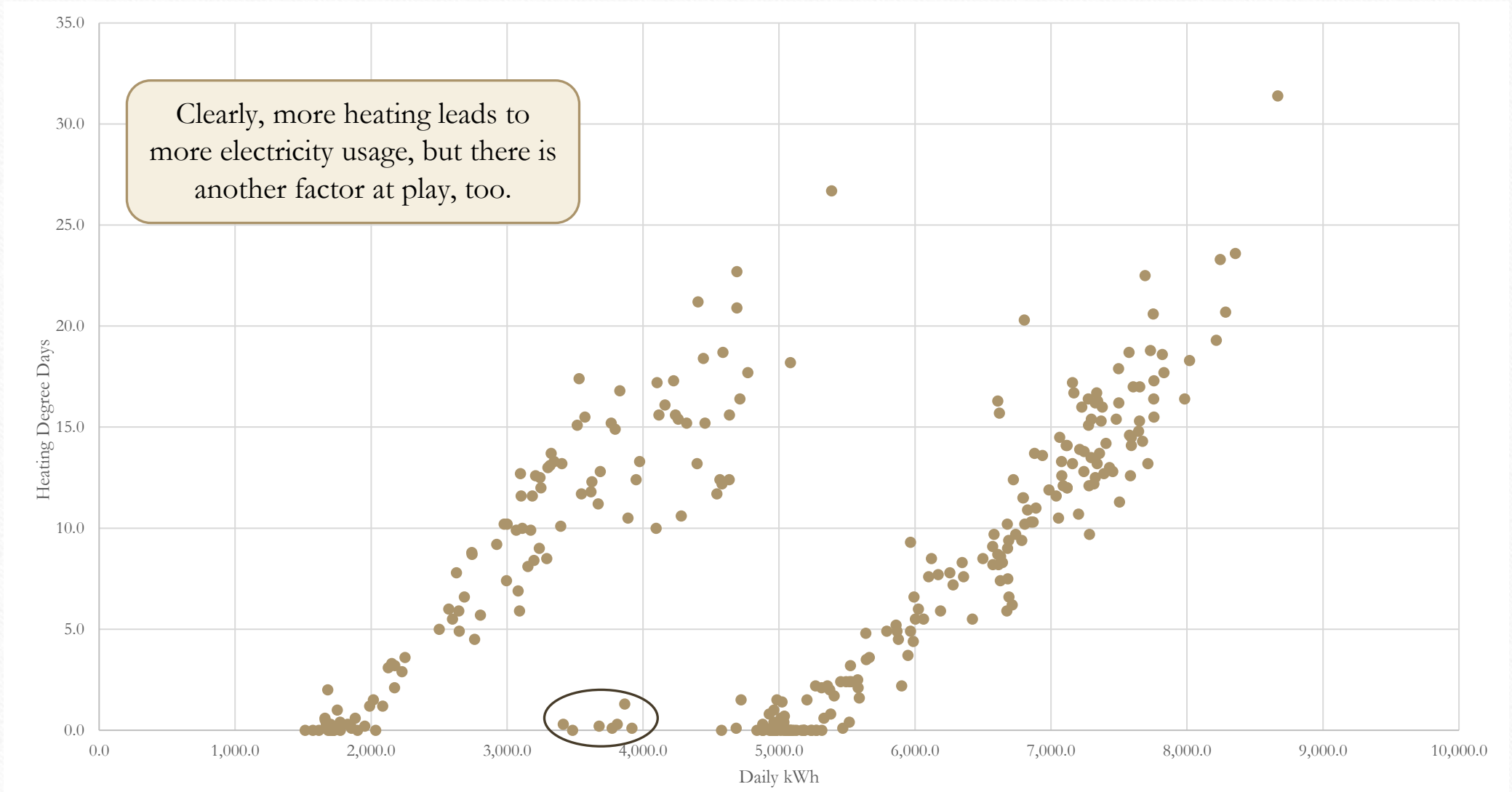


Baseload: **100** kW

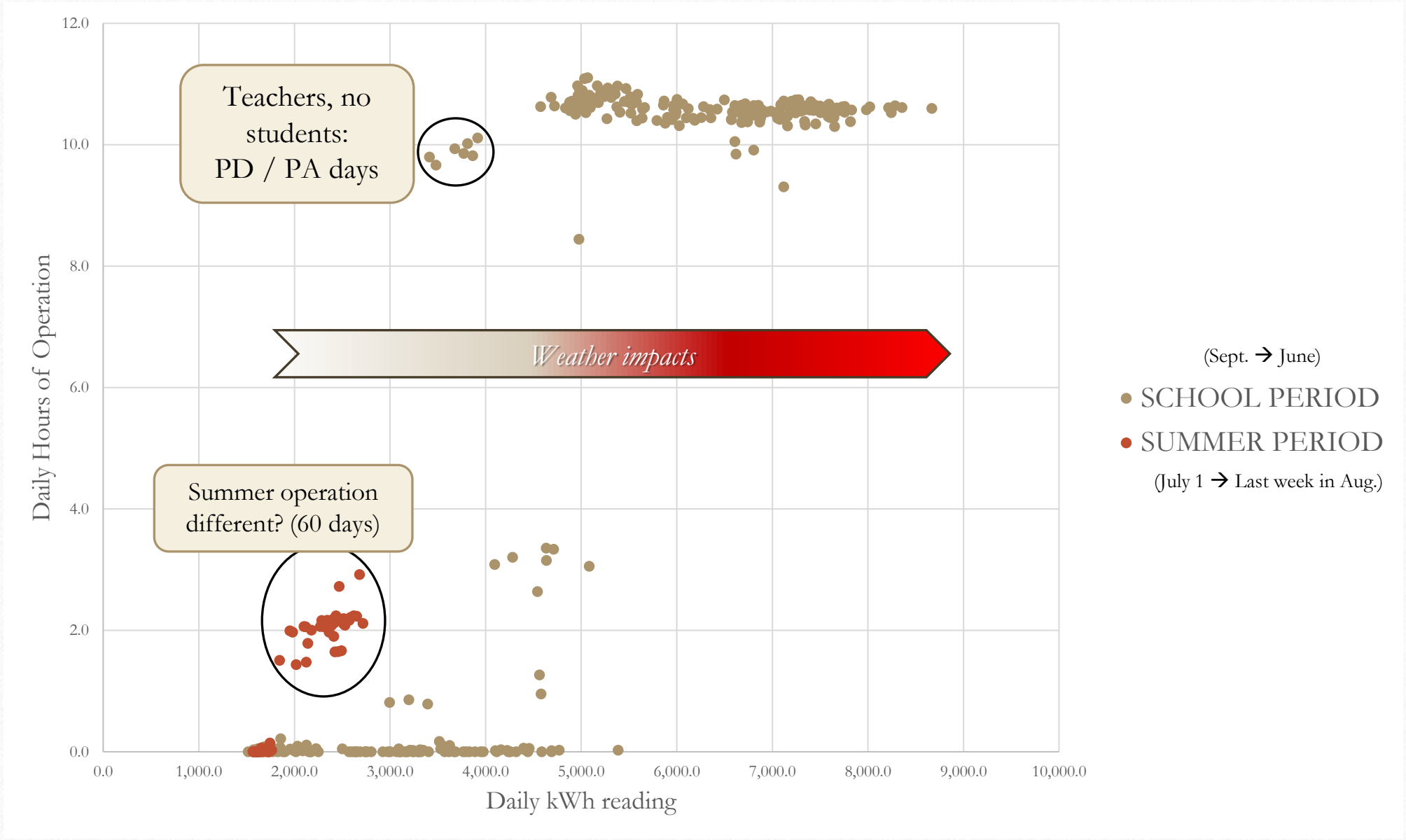
Peak demand: ~**400** kW

Weather Impacts

A simple **scatter graph** can display whether your independent parameters impact electricity use



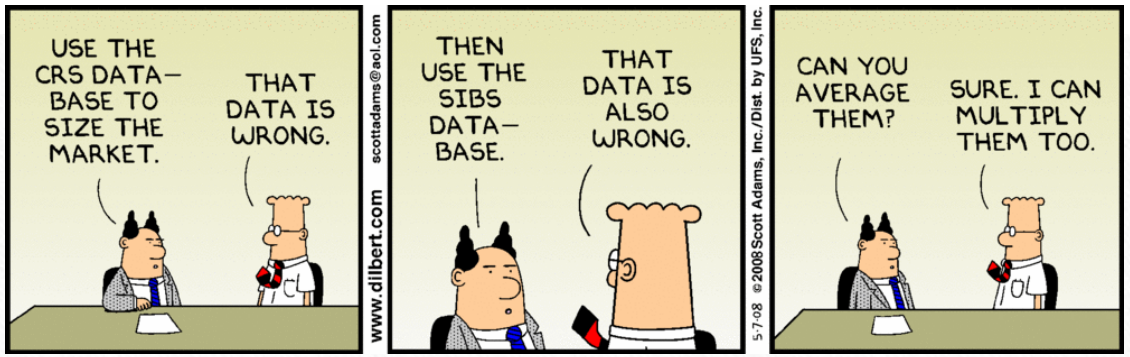
Operating Hours Impact



Building Automation System Data

BAS Data

- All necessary fan trends are configured with a "change of value" (COV) trend.
- Trends are configured & archived to hold at least 2 year of data; archiving happens weekly.
- BAS data is pulled as a *multi-trend* – multiple COV trends pulled as a single object.
- Process is currently manual but could be automated for processing by a downstream script or AI.



...	HV-1 Double Gym - Change of Value...	GymAB STOcc	HV-2 Gym C - Change of Value Tren...	HV-2 GymC STOcc	HV-3
00	0.00	1.00	0.00	1.00	
00	0.00	1.00	0.00	0.00	
00	0.00	1.00	0.00	1.00	
00	0.00	1.00	0.00	0.00	
00	0.00	1.00	0.00	1.00	
00	0.00	1.00	0.00	0.00	
00	0.00	1.00	0.00	1.00	
00	1.00	1.00	1.00	1.00	
00	1.00	1.00	1.00	1.00	
00	1.00	1.00	1.00	0.00	
00	1.00	0.00	1.00	0.00	
00	0.00	0.00	0.00	0.00	
00	0.00	0.00	0.00	0.00	
00	0.00	0.00	0.00	0.00	
00	0.00	0.00	0.00	1.00	
00	0.00	0.00	0.00	0.00	
00	0.00	1.00	0.00	0.00	
00	0.00	0.00	0.00	0.00	
00	0.00	1.00	0.00	0.00	
00	0.00	0.00	0.00	0.00	
00	0.00	1.00	0.00	0.00	
00	0.00	1.00	0.00	1.00	
00	0.00	0.00	0.00	1.00	
00	0.00	1.00	0.00	1.00	
00	0.00	1.00	0.00	1.00	
00	0.00	1.00	0.00	1.00	
00	0.00	1.00	0.00	1.00	
00	0.00	1.00	0.00	0.00	

BAS Data

Sometimes, your data can be neatly laid out within the BAS itself.

Timestamp	GeneralHV-...	GymHV-2 -...	HV-2 STOcc	2008Additio...	2008GymH...	HV-4 STOcc	ComputerR...	WorkRoom...	GuidanceA...	OfficeAC-4...	ResourceA...	ExhaustFan...
1/20/2023 6:38:19 PM	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
1/20/2023 6:35:44 PM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1/20/2023 6:00:00 PM	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1/20/2023 5:05:40 PM	1.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1/20/2023 5:00:00 PM	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1/20/2023 4:52:44 PM	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00
1/20/2023 2:50:34 PM	1.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00
1/20/2023 1:45:31 PM	1.00	0.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	1.00
1/20/2023 1:11:54 PM	1.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00

Filled by BAS

- → Dates are in a recognized formatting which Excel accepts.
- → Values are all in numbers rather than text values.
- → This BAS fills in the missing values for each COV trend, rather than leaving it blank.
- → Little to no error data.

Fan status points are <u>not</u> used for this calculation, to avoid issues of systems being placed on bypass or local control.

BAS Data

Or… your data can look like this...

Time	AHU-1 Schedule.Trend - Present Value ()	AHU-2 Schedule.Trend - Present Value ()	AHU-3 Schedule.Trend - Present Value ()	Castle Oaks PS.OCC1-S.Trend - Present Value ()	Castle Oaks PS.OCC2-S.Trend - P
7/12/23, 1:03:14 PM EDT					Unoccupied
7/12/23, 1:03:22 PM EDT				Unoccupied	
7/12/23, 3:00:00 PM EDT					
7/12/23, 4:30:49 PM EDT					Occupied
7/12/23, 4:33:06 PM EDT				Occupied	
7/12/23, 5:03:28 PM EDT				Unoccupied	
7/12/23, 5:33:59 PM EDT					Unoccupied
7/13/23, 5:22:57 AM EDT	False	False	False	Unoccupied	Occupied
7/13/23, 5:23:15 AM EDT	??? False	??? False	??? False		
7/13/23, 5:23:16 AM EDT	??? UnOccupied	??? UnOccupied	??? UnOccupied		
7/13/23, 5:23:17 AM EDT			UnOccupied		
7/13/23, 5:23:18 AM EDT	UnOccupied				
7/13/23, 5:23:20 AM EDT		UnOccupied			
7/13/23, 5:34:56 AM EDT				Occupied	
7/13/23, 5:48:45 AM EDT					Unoccupied
7/13/23, 6:13:27 AM EDT				Unoccupied	
7/13/23, 6:30:00 AM EDT					
7/13/23, 8:00:00 AM EDT	Occupied	Occupied			
7/13/23, 9:40:27 AM EDT				Occupied	
7/13/23, 9:41:48 AM EDT					Occupied
7/13/23, 11:33:04 AM EDT					Unoccupied
7/13/23, 11:33:29 AM EDT				Unoccupied	
7/13/23, 12:30:34 PM EDT				Occupied	
7/13/23, 1:00:00 PM EDT	UnOccupied	UnOccupied			
7/13/23, 1:00:47 PM EDT				Unoccupied	
7/13/23, 3:00:00 PM EDT					

Error data is entered in the trends, even if the interval is one second

A COV trend only records an entry on a change of value, so blanks are entered where other trends have an entry

→ This date format is recognized as <u>text</u> by Excel, so it can't be sorted by date without some work.
→ Blank spaces in each column need to be filled with the value from the previous timestamp.
→ Error data needs to be cleaned up (False / ??? False / ??? UnOccupied all turn into zeroes).
→ Occupied turns into one, and Unoccupied into zero.

Hours of Operation Calculation

With a list of ones and zeroes, and a timestamp, calculations can be performed.

Timestamp	GroundFloor AHU-1 - Change of Value Trend Log	SecondFloor AHU-2 - Change of Value Trend Log	Gym AHU-3 - Change of Value Trend Log	STGymAOcc	STGymBOcc	AHU-3 Gym	Minutes in Interval	Date	GroundFloor AHU-1 minutes	SecondFloor AHU-2 minutes	Gym AHU-3 minutes
1/6/2023 6:30	1	1	1	0	0	1	120.0	1/1/2023	0.0	0.0	0.0
1/6/2023 8:30	1	1	0	0	0	0	20.3	1/2/2023	0.0	0.0	0.0
1/6/2023 8:50	1	1	0	1	1	1	23.3	1/3/2023	0.0	0.0	198.0
1/6/2023 9:13	0	0	0	1	1	1	17.5	1/4/2023	0.0	0.0	284.5
1/6/2023 9:31	0	0	0	0	1	1	1.0	1/5/2023	107.8	107.7	125.7
1/6/2023 9:32	0					0	153.7	1/6/2023	163.6	163.6	240.7
1/6/2023 12:05	0					1	1.1	1/7/2023	0.0	0.0	0.0
1/6/2023 12:06	0	0	0	1	1	1	33.8	1/8/2023	0.0	0.0	0.0
1/6/2023 12:40	0	0	0	0	0	0	11.8	1/9/2023	690.0	620.0	945.1
1/6/2023 12:52	0	0	0	1	1	1	44.0	1/10/2023	690.0	620.0	859.4
1/6/2023 13:36	0	0	0	0	0	0	83.5	1/11/2023	690.0	620.0	954.8
1/6/2023 15:00	0	0	0	0	0	0	540.0	1/12/2023	690.0	620.0	851.2
1/7/2023 0:00	0	0	0	0	0	0	1440.0	1/13/2023	690.0	620.0	968.3
1/8/2023 0:00	0	0	0	0	0	0	1440.0	1/14/2023	0.0	0.0	0.0
1/9/2023 0:00	0	0	0	0	0	0	390.0	1/15/2023	0.0	0.0	33.3
1/9/2023 6:30	1	1	1	0	0	1	35.6	1/16/2023	690.0	620.0	866.9
1/9/2023 7:05	1	1	1	1	1	1	84.4	1/17/2023	690.0	620.0	812.8
1/9/2023 8:30	1	1	0	1	1	1	375.0	1/18/2023	690.0	620.0	1001.4
1/9/2023 14:45	1	1	1	1	1	1	83.8	1/19/2023	690.0	620.0	849.4
1/9/2023 16:08	1	1	1	0	0	1	3.1	1/20/2023	690.0	620.0	915.7
1/9/2023 16:11	1	1	1	1	1	1	38.1	1/21/2023	0.0	0.0	0.0
1/9/2023 16:50	1	0	1	1	1	1	25.3	1/22/2023	0.0	0.0	0.0
1/9/2023 17:15	1	0	1	0	1	1	6.6	1/23/2023	690.0	620.0	693.0
1/9/2023 17:21	1	0	1	0	0	1	16.4	1/24/2023	690.0	620.0	811.9
1/9/2023 17:38	1	0	1	1	1	1	21.7	1/25/2023	690.0	620.0	794.2
1/9/2023 18:00	0	0	0	1	1	1	255.1	1/26/2023	690.0	620.0	815.2

Occupancy sensors can be included

Hours of Operation Calculation

Day of Week	Date	SF-1 South West minutes	SA-1 Admin minutes	SA-1 Cafeteria minutes	SA-5 Auditorium minutes	HV-1 Double Gym minutes	HV-2 Gym C minutes	Exhaust Fans minutes	Hours of Operation	Operating condition
Sunday	1/1/2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	New Years Day
Monday	1/2/2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Statutory Holiday
Tuesday	1/3/2023	0.0	0.0	0.0	0.0	30.5	129.0	590.0	1.0	Low occupancy - custodians only
Wednesday	1/4/2023	0.0	0.0	0.0	600.0	12.4	264.8	590.0	2.0	Low occupancy - custodians only
Thursday	1/5/2023	107.6	107.6	107.6	600.0	330.0	239.5	590.0	3.3	Low occupancy - custodians only
Friday	1/6/2023	193.7	193.7	193.7	183.7	487.5	139.7	590.0	3.5	Low occupancy - custodians only
Saturday	1/7/2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Weekend, closed
Sunday	1/8/2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Weekend, closed
Monday	1/9/2023	635.0	635.0	635.0	625.0	1066.3	607.4	625.0	9.5	Normal school day + evening permits
Tuesday	1/10/2023	625.0	625.0	625.0	625.0	1069.9	599.5	625.0	9.5	Normal school day + evening permits
Wednesday	1/11/2023	625.0	625.0	625.0	625.0	1071.5	841.1	625.0	9.8	Normal school day + evening permits
Thursday	1/12/2023	625.0	625.0	625.0	625.0	1072.5	588.1	625.0	9.4	Normal school day + evening permits
Friday	1/13/2023	625.0	625.0	625.0	625.0	1074.6	877.0	625.0	9.8	Normal school day + evening permits
Saturday	1/14/2023	0.0	0.0	0.0	0.0	233.5	7.9	0.0	0.3	Low occupancy - weekend permit
Sunday	1/15/2023	0.0	0.0	0.0	540.0	0.0	0.0	0.0	0.8	Low occupancy - weekend permit
Monday	1/16/2023	625.0	625.0	625.0	625.0	1070.0	892.3	625.0	9.9	Normal school day + evening permits
Tuesday	1/17/2023	625.0	625.0	625.0	625.0	1226.6	657.0	625.0	9.7	Normal school day + evening permits
Wednesday	1/18/2023	625.0	625.0	625.0	625.0	1127.4	684.3	625.0	9.6	Normal school day + evening permits
Thursday	1/19/2023	625.0	625.0	625.0	625.0	1081.9	633.5	625.0	9.5	Normal school day + evening permits
Friday	1/20/2023	625.0	625.0	625.0	625.0	1277.9	654.6	625.0	9.8	Normal school day + evening permits
Saturday	1/21/2023	0.0	0.0	0.0	0.0	17.6	0.0	0.0	0.0	Weekend, closed
Sunday	1/22/2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Weekend, closed

No “flags” used to mark special days like holidays, PD days, examination days, etc.
All primary fans are **averaged** to calculate a daily “Hours of Operation”

The Regression Model


(AI generated)

Model Equation

$$y = m_1 x_1 + m_2 x_2 + b$$

This is a simple equation of a straight line with two independent parameters.

$y =$ *predicted daily kWh*

$m_1 =$ *Hours of operation coefficient*

$x_1 =$ *Calculated daily hours of operation*

$m_2 =$ *Heating or cooling degree day coefficient*

$x_2 =$ *HDD or CDD value*

$b =$ *y − intercept, or baseload kWh*

Key Statistical Indicators

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.982
R Square	0.963
Adjusted R Square	0.963
Standard Error	366.866
Observations	217

CV(RMSE)	NDBE
6.06%	4.12E-16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	759571297.9	379785649	2821.790188	1.6159E-154
Residual	214	28802328.82	134590.3216		
Total	216	788373626.7			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2779.198	67.551	41.142	0.000	2646.047	2912.349	2646.047	2912.349
Hours of Operation	361.635	4.875	74.174	0.000	352.025	371.246	352.025	371.246
HDD	61.879	4.536	13.641	0.000	52.938	70.821	52.938	70.821

RESIDUAL OUTPUT

Observation	*Predicted kWh*	*Residuals*	*Standard Residuals*
1	6644.005	315.306	0.863
2	3025.894	-209.288	-0.573
3	3784.493	-19.021	-0.052
4	3145.661	-136.661	-0.374
5	6992.679	89.410	0.245

t-stat calculated per coefficient by dividing standard error by coefficient itself.

- Adjusted R^2 when more than one independent parameter.
- CV(RMSE) calculated using standard error divided by average of daily kWh readings in sample period.
- NDBE calculated from sum of residuals divided by sum of daily kWh readings in sample period.

CV(RMSE) = Coefficient of the Variation of the Root Mean Square Error
NDBE = Net Determination Bias Error
CUSUM = Cumulative Sum of differences

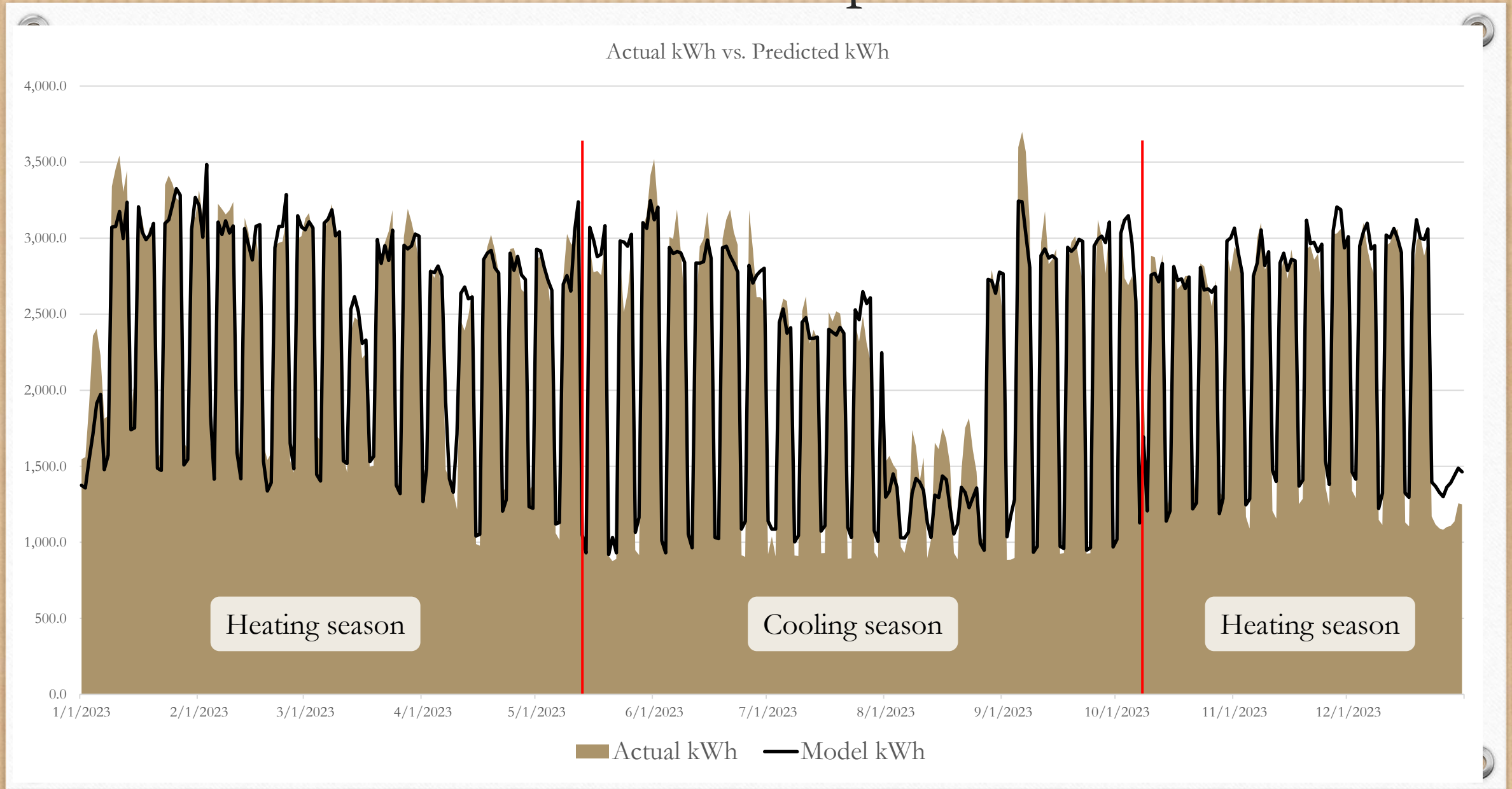
Key Statistical Indicators

Parameter	Threshold Desired
Coefficient of Determination (R^2 or Adjusted R^2)	> 0.75
t-statistic (per coefficient)	> 2
CV(RMSE)	< 25% *
NDBE	< 0.005
CUSUM variance	Less than +/-1.5%
R^2 + CV(RMSE)	= 1

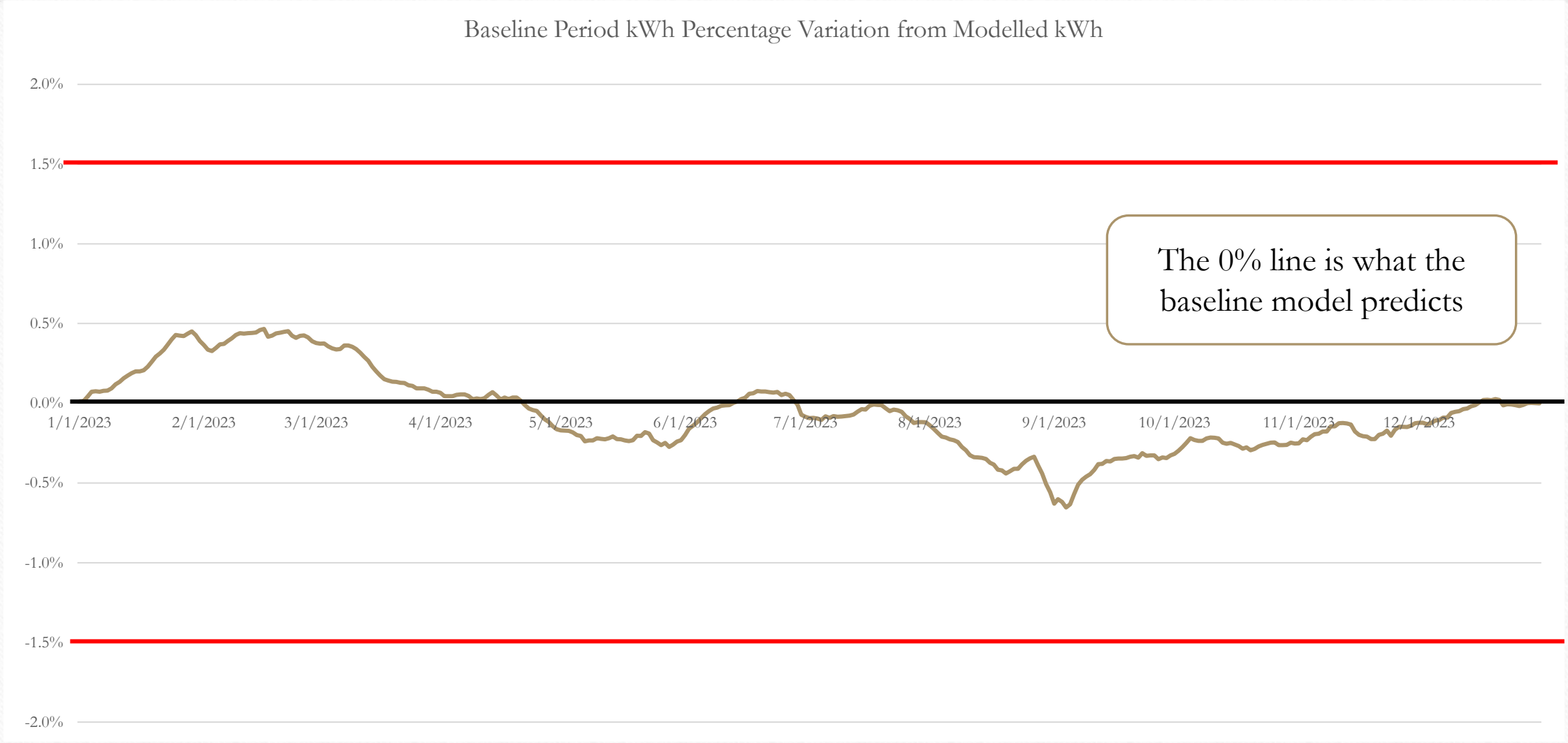
CV(RMSE) = Coefficient of the Variation of the Root Mean Square Error
NDBE = Net Determination Bias Error
CUSUM = Cumulative Sum of differences

* The appropriate threshold for CV(RMSE) is under some debate in the EM community, and the threshold varies depending on the model interval.

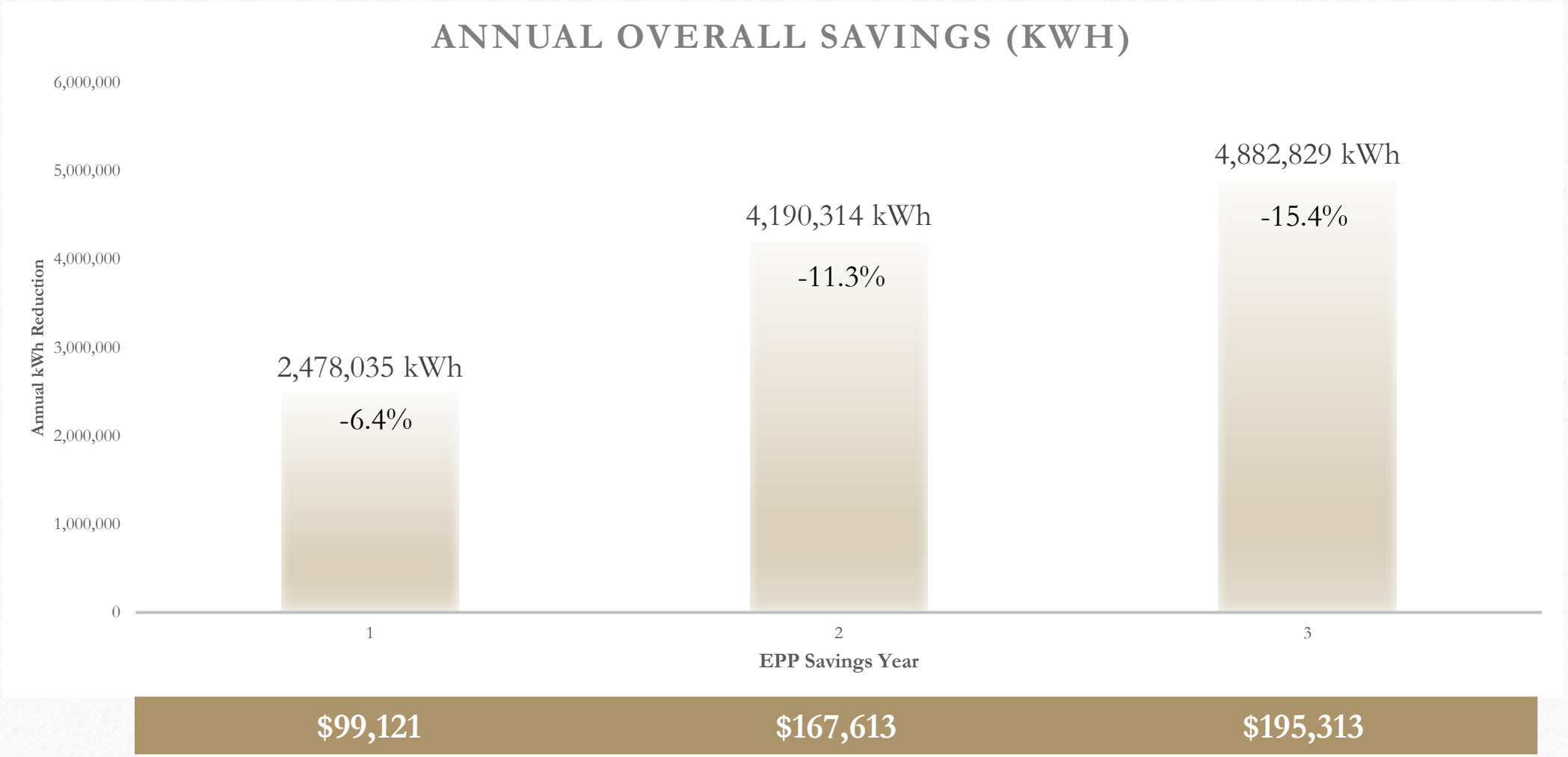
Model Outputs



Cumulative Sum (CUSUM)



Energy Performance Program – Round 1 Results



$462,047 total EPP incentive over three years!

Implemented Measures – EPP Round 1

Measure	Impacts	Expected Savings
Voltage harmonizers	• Reduces all building kW by stepping down voltage levels	3-5% per building
BAS Security Interlocks	• Interior & exterior lighting tied to security status • AHU fan operation tied to security status (with exceptions)	50-200 kWh per day, per school
Scheduling	• Established scheduling standards for all facilities based on school bell times • Establish holiday operating procedures • Improves ventilation & comfort	Varies
BAS Upgrades	• More precise HVAC scheduling • Better trending & monitoring capabilities • Improved operating sequences • Alarming and fault detection	Varies
Monitoring-based Commissioning	• Captures energy waste more rapidly • Improves occupant comfort • Reduces maintenance costs	1-3% per year, per building
Policy & operational changes	• Summer holiday cooling policies • Small Appliances policies • Facility Rentals scheduling	Varies

Future Uses for Performance Models

Daily / weekly benchmarking

- Schools can be given weekly or daily targets for electricity use
- Behaviour campaigns to reduce usage can be measured & quantified daily

Analytical displays

- Public displays with meter & baseline or "expected" kWh readings for live comparison
- Data tool for student learning & teacher use

Automate It

- AI technologies could potentially incorporate expected electricity use for daily automated targeting of electricity use
- Automated alarming from meters could dynamically adjust alarm thresholds based on expected use

Natural Gas Performance Modelling

Enbridge Gas is pilot testing an incentive program based on modelled natural gas performance, akin to the EPP

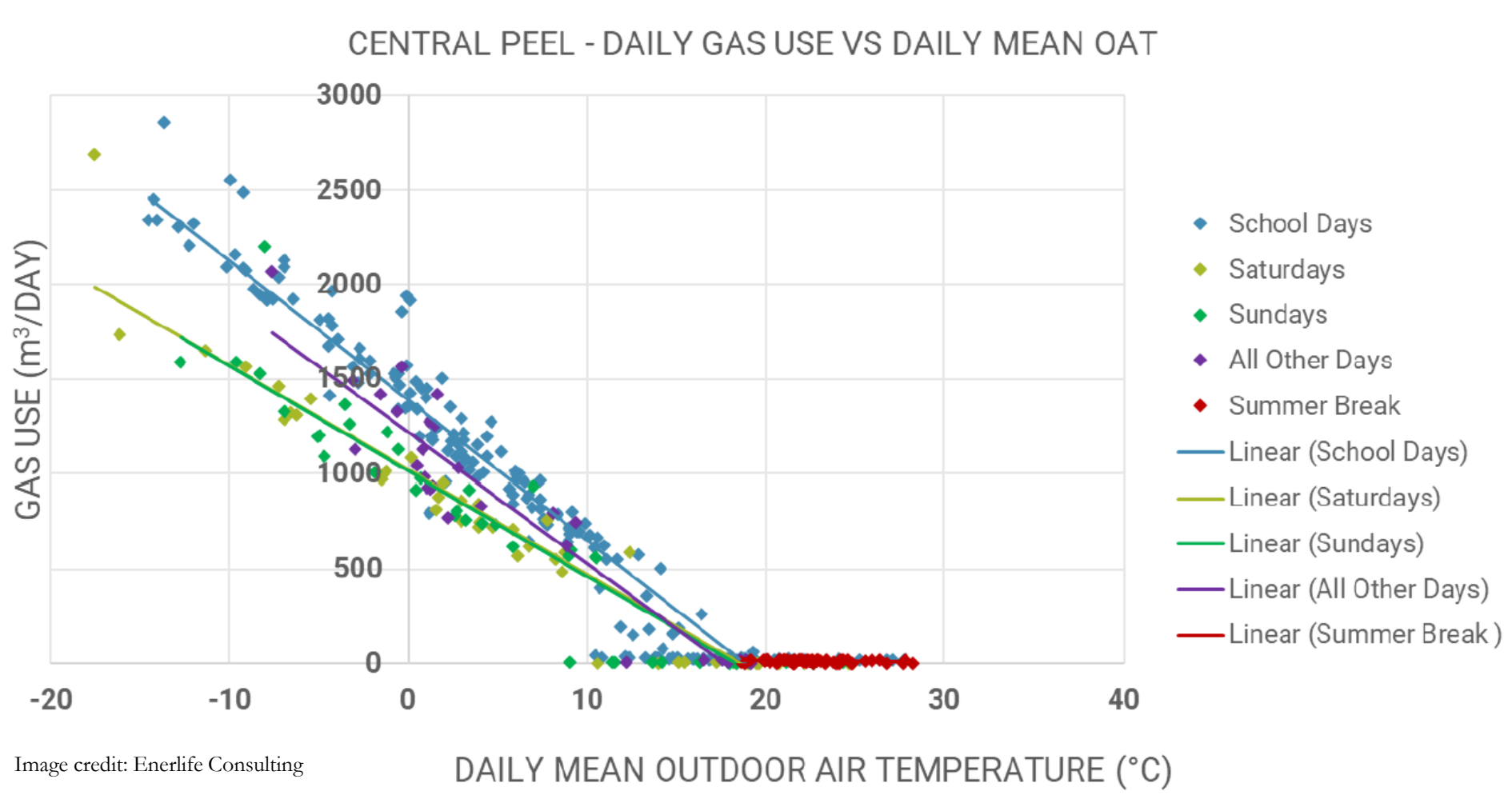


Image credit: Enerlife Consulting

Energy Performance Modelling

Put your meters and data to use.

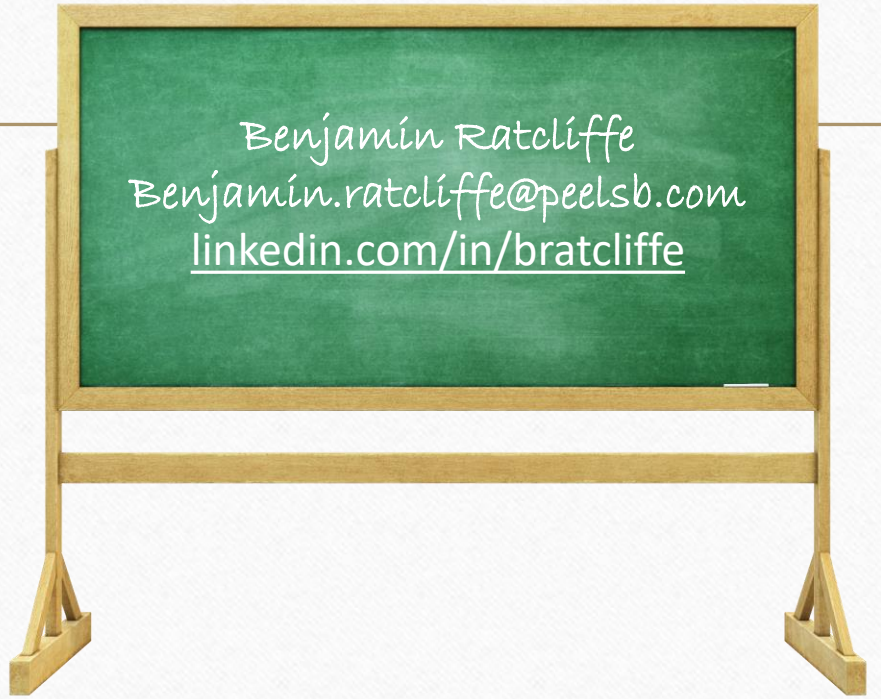
Determine your energy drivers and configure data sources for trending & archiving.

Develop a model template that quickly models a building with data automatically filled.

(AI generated)

Track energy consumption in real time and spend less time evaluating energy performance.

Thank you for your attention!



Q&A

Upcoming ELC Sessions & PPG Events

Date	Topic
Feb 6th 9:00am –1:00pm	Futureproof Your Fleet @ Cummins Sales and Service (waitlist only) Learn how to decarbonize your heavy-duty fleet vehicles
February 22nd 1:00pm – 2:30 pm	**ELC Roundtable Discussion**
Feb 29th 9:00am – 2:00pm	Futureproof Your Fleet @ Centennial College Learn how to decarbonize your heavy-duty fleet vehicles, includes tour of their School of Transportation. Register today!
March 5th 9:00am – 11:00am	GreenBiz Caledon Climate Partnership - Stormwater Management & Low Impact Development (for businesses with facilities in the Caledon municipality)
March TBD	**ELC Site visit** - TBD

Topic suggestions? Want to host a site visit or start a roundtable discussion? Please contact Julia Kole!


Partners in
Project Green
A Program of Toronto and Region Conservation Authority

Thank You!