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Central Hudson
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SMALL BUSINESS DIRECT INSTALL IMPACT EVALUATION DRAFT REPORT

PREPARED FOR CENTRAL HUDSON

DECEMBER 2022

CADMUS

Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

Contents

Executive Summary

Evaluation Overview:

- **Program:** Small Business Direct Install (SBDI)
- **Program period:** Q3 2021 – Q1 2022
- **Implementer:** Willdan
- **Prior evaluation:** the evaluation team conducted an impact evaluation of the 2019 SBDI program.[1] The program period for this evaluation was timed to re-evaluate the program after implementation of recommendations from the previous evaluation.

Realization Rates		
Component	**Energy (MWh)**	**Demand (MW)**
Lighting	0.71 ± 7%	0.77 ± 12%
Non-Lighting	0.75 ± 9%	0.84 ± 9%
Overall	0.71 ± 7%	0.78 ± 12%

Key Findings:

- The verified gross energy savings realization rate (RR) was 0.71 (71%)
  - The key driver of the RR being less than 1 was annual lighting hours of use (HOU)
  - Several sites had gross savings higher than pre-intervention energy usage
- The verified gross demand savings realization rate was 0.78 (78%)
- Central Hudson and Willdan are changing the approach lighting HOU in January 2023 based on these evaluation results
  - **We recommend an energy Alternative Prospective Realization Rate (APRR) of 0.86** to reflect expected improvements in the accuracy of gross savings claims due to known program delivery changes

Executive Summary

Comparison with Prior Evaluation

Findings from the prior evaluation

- COVID-19 pandemic prevented site visits and light logging in the prior evaluation.
  - Relied on self-reported operating hours from participant surveys.
- VGS energy realization rate for the 2019 impact evaluation was low.
  - The key driver of the differences was the annual hours of lighting use.
  - Several sites had gross savings higher than pre-intervention energy usage.
  - The current evaluation had these same findings

Comparison of Realization Rates

Metric	2019 VGS RR	2021-2022 VGS RR
Energy (MWh)	0.78 ± 4%	0.71 ± 7%
Demand (MW/year)	1.12 ± 1%	0.77 ± 12%

Recommendations From Prior Evaluation	Findings from Current Evaluation
Create a decision tree with high-level project flags for additional review • Are savings greater than 45% of annual billed kWh? • Are the annual lighting HOU greater than 5,000?	The implementer developed and integrated savings flags into the estimating tool, but instances of overstated gross savings were still present in the program data.
Use light loggers for future program evaluations.	This evaluation including light logging for 83 SBDI projects.

Executive Summary

Evaluation Objectives and Activities

Evaluation Objective	Evaluation Activities				
	Tracking Data Review	Desk Reviews	Site Visits	Metering	Engineering Model Analysis
Determine if lighting hours of use, coincidence factor, and HVAC interactive factors used to estimate gross savings align with the actual operating characteristics of the business	X	X	X	X	X
Validate that recommendations from the previous evaluation were integrated and are functioning	X	X	X	X	
Assess if tracking data captures quantities, equipment details, and baseline information used to calculate gross savings in a way that is accurate and unbiased	X	X	X		X
Assess if gross savings was calculated in accordance with the NYS TRM	X	X			X
Calculate program level verified gross savings (VGS) and VGS realization rate	X	X	X	X	X
Asses how metered lighting hours of use compare to TRM assumptions, and the values used by the implementation contractor to calculate gross savings	X	X	X	X	

Executive Summary

Alternative Prospective Realization Rate for Electric Energy Savings

Planned Program Delivery Changes

- Auditors will exclusively use assessed hours-of-use for lighting equipment – no TRM defaults.
- Willdan will use an enhanced tool for collecting operating hours that includes:
  - Separate schedules by lighting space, as appropriate, within the facility
  - Accounts for holidays
  - Considers when the lights may be off during business hours
  - Only assumed dusk-to-dawn hours for exterior lighting equipment controlled by photocell
- Lighting coincidence factors will still come from the NYS TRM
- Incorporation of evaluation-recommend HVAC interaction factors for interior lighting equipment
- Updated savings calculations for anti-condensation heater controls

Realization Rate Implications

- Appendix E examines the correlation of logged HOU to the detailed lighting schedules collected by the evaluation team
  - Reported schedules and logged hours show a high degree of alignment
  - Reported coincidence factors do not align as well with logged results
- If the implementer's auditors gather schedules with the same rigor, the energy realization rate should approach 100%
- Rather than assume all changes take effect immediately and resolve HOU discrepancies perfectly we recommend the midpoint of the VGS RR and 1.0
  - (0.71 + 1.00) / 2 = 0.86 effective Q1-2023
- APRR is exclusive to energy
  - VGS realization rate of 0.78 for demand effective Q1-2023
- The evaluation team will begin preparations for a new impact evaluation to be completed by mid-2024

Introduction

Program Description

The **SBDI** program provides small business customers a turn-key energy-efficient lighting and refrigeration retrofit service.

- **Customer eligibility criteria:** small commercial electric customers (those with less than 120 kW of peak demand over the last 12-month billing period).
- **Measures:** retrofit interior and exterior LED lighting, lighting controls, and refrigeration motors and controls.
- **Delivery:** the program uses a direct install delivery channel, which includes a facility assessment, project design and proposal, and, if the customer accepts the proposal, directly installs efficient measures.
- **Incentives:** customers receive an incentive that is proportional to the calculated energy savings, normally capped at 70% of the project cost.
- **Determination of savings:** gross savings are calculated based on the wattage reduction between existing and retrofit measures, the number of measures, and either reported or deemed hours of use.
- **Financing:** customers are offered financing with either 12- or 24-month terms to cover the un-incentivized portion of project costs.

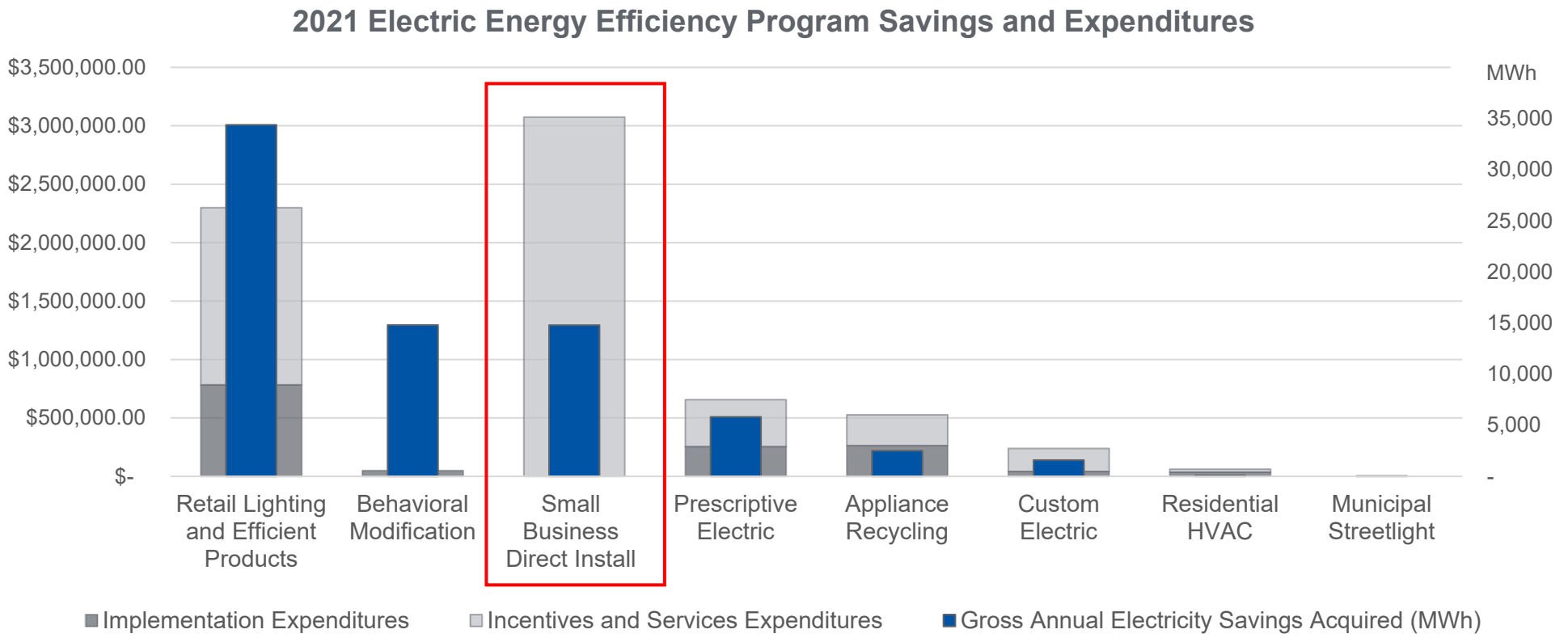
LED Lighting and Refrigeration Control Replacement

Introduction

Program Contributions

In 2021, the SBDI program contributed one fifth of Central Hudson's electric portfolio savings and accounted for over two fifths of portfolio costs.

2021 Electric Portfolio Contributions	Custom
Savings	20.0%
Expenditures	44.5%



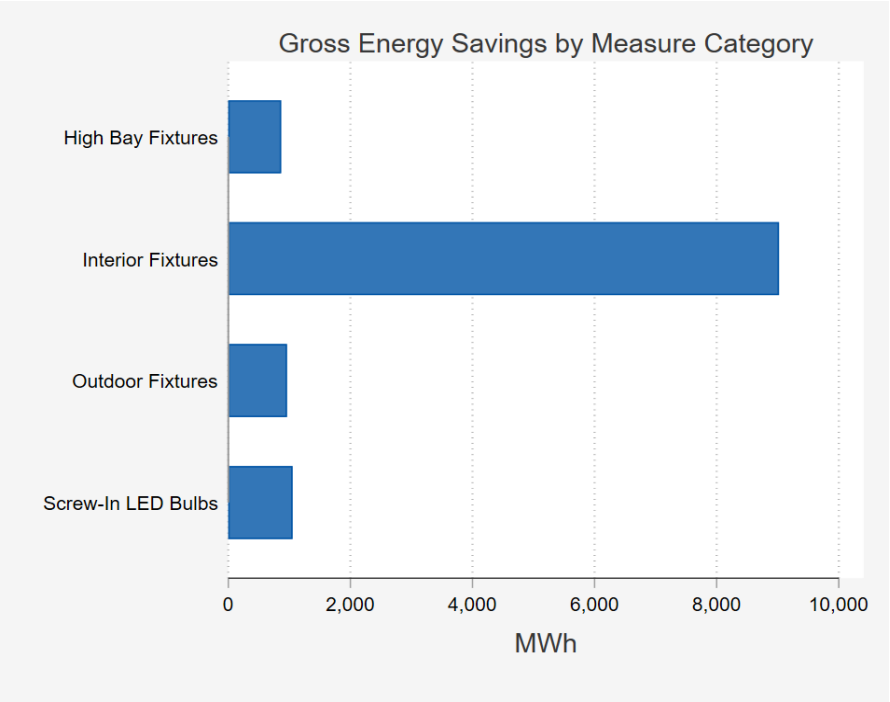
CADMUS Demand Side Analytics DATA DRIVEN RESEARCH AND INSIGHTS

Introduction

Program Measure Categories

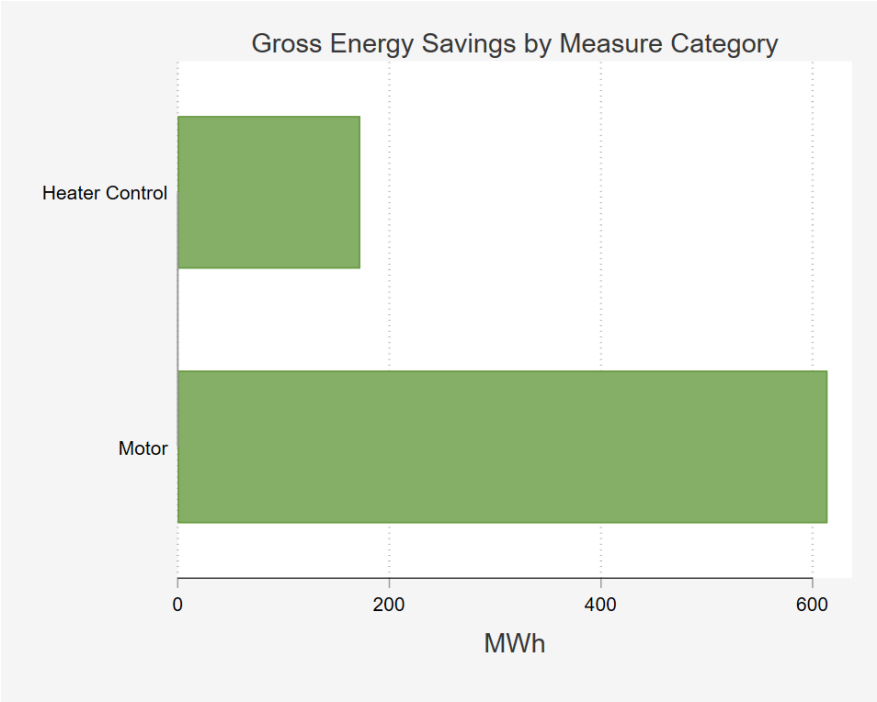
Lighting

- 94% of gross energy savings
- Mixture of interior and exterior fixtures and lamps
- 277 completed projects
  - 234 lighting only
  - 34 lighting and non-lighting



Non-Lighting

- 6% of gross energy savings
- Commercial refrigeration motors and controls
- 40 completed projects
  - 8 non-lighting only
  - 32 lighting and non-lighting



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Methodology

Evaluation Activities

Lighting Measures

- Tracking data and desk review
- Site visits
- Metering
- Engineering model analysis

Non-Lighting Measures

- Tracking data and desk review
- Nameplate photos
- TRM methodology

NYS TRM Algorithms for Lighting Savings

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times hrs \times (1 + HVAC_c)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times (1 + HVAC_d) \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times hrs \times HVAC_{ff}$$

Methodology

Data Collection: Sampling Lighting Projects

- Contact was attempted with all SBDI sites that installed lighting equipment between Q3 2021 and Q1 2022
  - Outreach took place across two distinct groups, or "waves"
    - Wave 1: Q3 2021
    - Wave 2: Q4 2021 – Q1 2022

Group	Projects (N)		Savings (MWh)	
	Sample	Population	Sample	Population
Wave 1	32	75	1,066	3,631
Wave 2	51	202	1,582	9,020
Total	**83***	**277**	**2,649**	**12,651**

* Two (2) of the site visits performed were composed of two lighting projects, meaning 81 site visits were completed.

Comparison of Sampled Projects and Full Population

Metric	Sample	Population	P-Value
Average Project Size	31,912	42,500	0.25
Weighted HOU	4,319	4,335	0.89

Methodology

Data Collection: On Site

- Engineers logged lighting inventory in an online system

Building

Link(s)	Building/Space
Building Menu	Stables

Building/Space Name:	Stables
Type of Space	BU=Regular Building
Year Built:	1960
Floors above Grade:	1
Square Footage:	15000
SQFT Surveyed:	15000

Lighting Space

Link(s)	Building/Space
Building Menu	Stables

Lighting Spaces Menu

Lighting Space:	Break room
Interior/Exterior Lighting	Interior
Hours Table	192=Normal hours
Square Footage	300
Air Conditioned:	N=No
Mechanically Heated:	Y=Yes
Heating Fuel Type:	FO=Fuel Oil

Lighting Inventory

Link(s)	Building/Space
Building Menu	Stables

Link(s)	Lighting Space	Sqft
Light Space Menu	Break room	300

Ignore this record?	N=No
Lamp Style	LBLI=Low Bay Linear
Application	INGS=Indoor General Service
Length	48=48 Inches
Fixture Wattage	35.0
Fixture Quantity	2
Control	SW=Switch
Rebated Control?	N=No
Secondary Control	NF=Not Filled
Program Measure	(2) 4 FOOT RLED 5000K LAMPS replaces 1X4, 2-LAMP T12 FLUORESCENT FIXTURE
Logged fixture?	Y=Yes
Logger Serial	10332256
Datetime Logger Installed	04/25/2022
Datetime Logger Retrieved	08/29/2022

- Lighting schedules were collected from the site contact
  - Records the typical hours on each day-of-week in each month

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Jan	ALL DAY	12:00AM to 07:59AM 08:00AM to 02:00PM 02:01PM to Midnight	12:00AM to 07:59AM 08:00AM to 02:00PM 02:01PM to Midnight	12:00AM to 07:59AM 08:00AM to 02:00PM 02:01PM to Midnight	12:00AM to 07:59AM 08:00AM to 02:00PM 02:01PM to Midnight	12:00AM to 07:59AM 08:00AM to 02:00PM 02:01PM to Midnight	ALL DAY
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Mar	12:00AM to 07:59AM 08:00AM to 04:00PM 04:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight
Apr	12:00AM to 07:59AM 08:00AM to 04:00PM 04:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight
May	12:00AM to 07:59AM 08:00AM to 04:00PM 04:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight
Jun	12:00AM to 07:59AM 08:00AM to 04:00PM 04:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight
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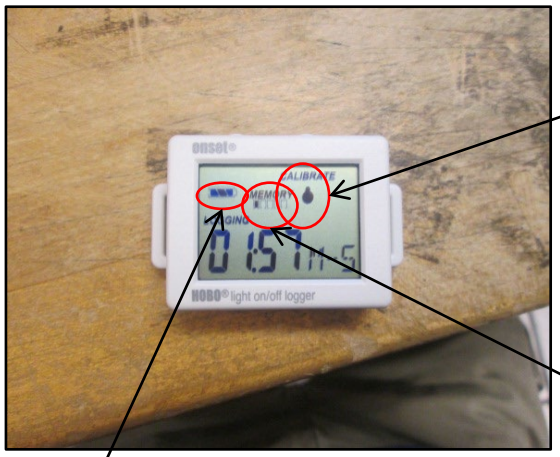
Aug	12:00AM to 07:59AM 08:00AM to 04:00PM 04:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight
Sep	12:00AM to 07:59AM 08:00AM to 04:00PM 04:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight
Oct	12:00AM to 07:59AM 08:00AM to 04:00PM 04:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight
Nov	12:00AM to 07:59AM 08:00AM to 04:00PM 04:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight	12:00AM to 05:59AM 06:00AM to 05:00PM 05:01PM to Midnight
Dec	ALL DAY	12:00AM to 07:59AM 08:00AM to 02:00PM 02:01PM to Midnight	12:00AM to 07:59AM 08:00AM to 02:00PM 02:01PM to Midnight	12:00AM to 07:59AM 08:00AM to 02:00PM 02:01PM to Midnight	12:00AM to 07:59AM 08:00AM to 02:00PM 02:01PM to Midnight	12:00AM to 07:59AM 08:00AM to 02:00PM 02:01PM to Midnight	ALL DAY

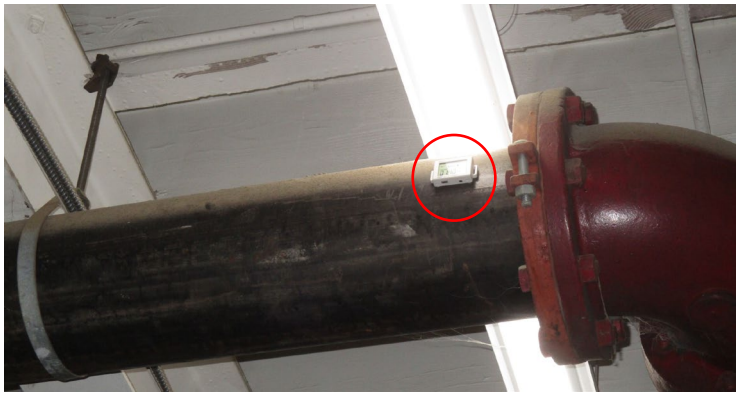
**Red indicates lights are off; green indicates they are on

Methodology

Data Collection: Lighting Logger Installation

- 483 lighting loggers in 81 sites
  - ~6 loggers per site
  - Prioritized logging of program-supported equipment
- Loggers are attached magnetically or using command strips
- During installation, the engineer calibrates the sensor to a lighting lumen level by making sure the light sensor is pointed towards the light source and light source is ON.
  - Lumen level > threshold = “On”
  - Lumen level < threshold = “Off”





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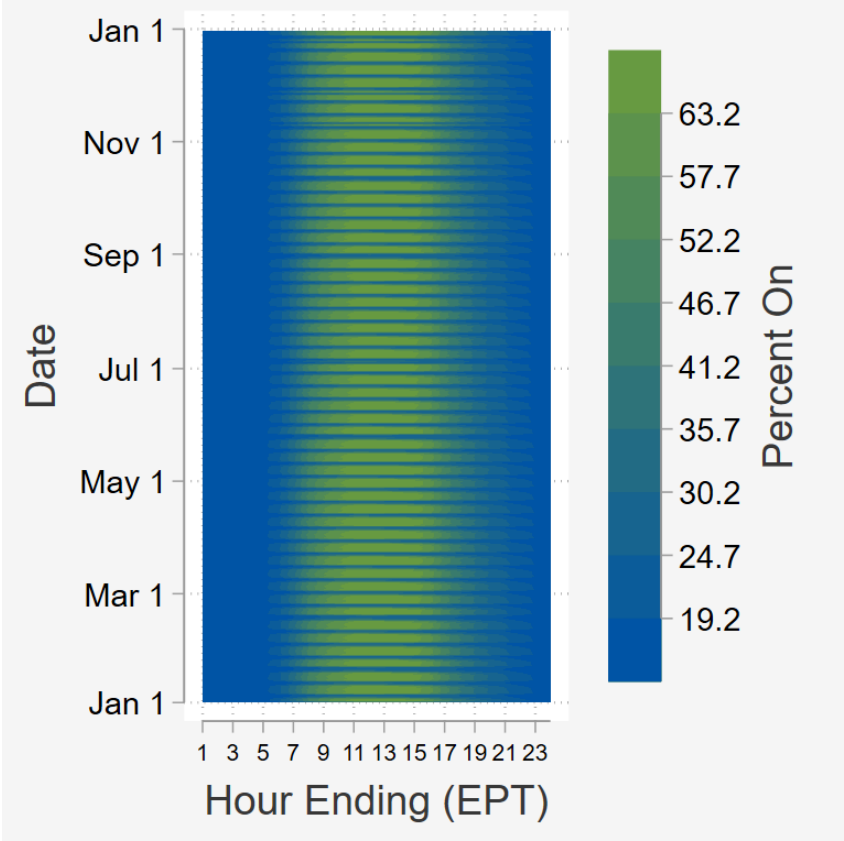
Methodology

Data Processing: Logger Annualization

- Loggers were installed at each site for a couple months of the year

Group	Installation	Retrieval	Length
Wave 1	December 2022	April 2022	124 days
Wave 2	April – May 2022	August 2022	116 days

- Process for expanding the observed data to a full year of data:
  1. In the observed data, calculate the percentage that the logger recorded the light ON for a given hour
  2. Construct a fractional regression for each logger based on:
     - Day-of-week
     - Hour
     - Season
     - Summer peak hour indicator
       - Hour-ending 17 on weekdays in June – August
  3. Predict the percentage that the lighting would be ON in each hour across a full year



CADMUS Demand Side Analytics DATA DRIVEN RESEARCH AND INSIGHTS

Methodology

HVAC Interactive Effects

LED lighting produces less waste heat, and this affects HVAC operation

- Algorithms in the NYS TRM call for inclusion of factors which account for increased heating loads and reduced cooling loads in conditioned spaces attributable to installation of LED lighting.
- Appendix D of the NYS TRM includes a complex set of lookup tables based on location, building type, and HVAC configuration
  - There are also default values by city (pictured right)
  - When the gross savings calculations are used, the factors come from the more complex lookup tables
- NYS TRM values are at least 10 years old and based on building simulations which may not reflect current building stock and HVAC efficiencies
- Our evaluation plan called for an independent assessment of interactive effects for interior lighting equipment
  - Exterior lighting measures have no interactive effects

Method for Calculating Annual Energy and Summer Peak Coincident Demand Savings

Annual Electric Energy Savings

$$\Delta kWh = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times hrs \times (1 + HVAC_c)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times (1 + HVAC_d) \times CF$$

Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times hrs \times HVAC_{ff}$$

DEFAULT VALUES

City	HVACc	HVACd	HVACff
Albany	0.054	0.174	-0.002
Binghamton	0.046	0.173	-0.002
Buffalo	0.049	0.174	-0.002
Massena	0.042	0.174	-0.002
Poughkeepsie	0.066	0.175	-0.002
Syracuse	0.057	0.174	-0.002
NYC	0.080	0.175	-0.002

Methodology

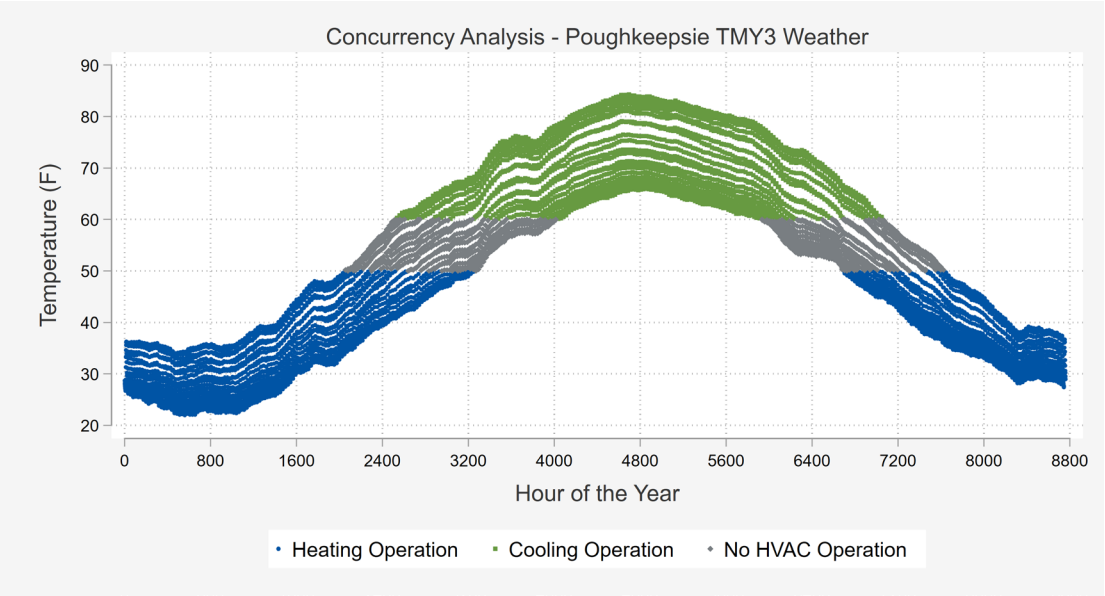
HVAC Interactive Effects

Algorithms

$$HVAC_c = \frac{IGC * A * C}{Eff_{HVAC}} * \%Electric$$

$$HVAC_d = \frac{IGC * A * C}{Eff_{HVAC}}$$

$$HVAC_{ff} = \frac{IGC * A * C}{Eff_{HVAC}} * 0.003412 * \%Fossil$$



Inputs

- **Internal Gain Contribution, (IGC):** the percent of waste heat that remains inside the building, contributing to the increased or decreased need for heating or cooling from the HVAC system.
- **Applicability, (A):** the percent of lighting that is installed in spaces that are heated or cooled by the HVAC system.
- **Concurrency, (C):** the percent of time that both lighting and HVAC systems are operating concurrently.
- **HVAC Efficiency, Eff_{HVAC}:** efficiency of the HVAC system at adding or rejecting heat.
- **% Fossil & % Electric:** the shares of each heating fuel type among program participants. 97.2% of heated square footage was fossil fuel and 2.8% was heated with electricity.

Methodology

HVAC Interactive Effects

Parameter Values and Description of Sources and Assumptions

Factor	$HVAC_c$ Calculation	$HVAC_d$ Calculation	$HVAC_{ff}$ Calculation	Reference
Internal Gain Contribution (IGC)	52.7%	52.7%	52.7%	Weighted average of installed lighting kW across the SBDI and Prescriptive evaluations. Engineering assumption of 60% for low-bay applications and 40% for high-bay applications.
Applicability (A)	69.6% (Cooling) 92.4% (Heating)	69.6%	92.4%	Share of program-supported lighting kW installed in heated or cooled spaces across the SBDI and Prescriptive evaluations.
Concurrency (C)	30.3% (Cooling) 35.4% (Heating)	100%	35.4%	Composite 8760 interior lighting profile from the SBDI and Prescriptive evaluations. TMY3 weather data from Poughkeepsie. Engineering assumption that heating requirement begins at 50 degrees (F) and cooling requirement begins at 60 degrees (F).
HVAC Efficiency (Eff_{HVAC})	286% (cooling) 200% (electric heat)	286%	80%	2019 Central Hudson Non-Residential Baseline Study.[2]
Calculated Value	**0.0364**	**0.1280**	**-0.00071**	Evaluation team calculation model

Methodology

HVAC Interactive Effects

Comparison with NYS TRM and Other Regional Values

- The evaluated HVAC interactive effects are smaller in magnitude than the NYS TRM defaults.
  - This means less added electricity and peak demand savings, and less of a fossil fuel penalty
  - The primary driver of the differences is likely IGC. Energy simulation software typically assumes all heat must be addressed by the HVAC system
- The table below compares the evaluated results to the NY TRM defaults and several other regional studies.

HVAC Interactive Effect Source	$HVAC_c$	$HVAC_d$	$HVAC_{ff}$
Central Hudson 2022 Prescriptive and SBDI Evaluations	0.0364	0.1280	-0.00071
NY TRM v9 Default Values	0.066	0.175	-0.002
Pennsylvania TRM and TRC Order	0.031	0.192	-0.00179
Mid-Atlantic TRM	0.080	0.350	-0.00077
PSEG Long Island	0.022	0.075	-0.00110

Methodology

Non-Lighting Measures

Electronically Commutated (EC) Fan Motor - Refrigerated Case or Walk-in Cooler/freezer

- Measure Definition: Replacement of Single-Speed Evaporator Fan Motor with Variable Speed Motor
- Followed NYS TRM to calculate savings
- Sample of nameplate pictures provided for review
- Key input: nameplate wattage of existing fan motor
- Reported measure description was horsepower, not wattage
- Reported wattage based on nameplate FLA

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{EFan} + \Delta kWh_{RH}$$

$$\Delta kWh_{EFan} = units \times \left(\frac{W_{EFan}}{1{,}000}\right) \times F_{PA} \times F_{EFan} \times hrs_{EFan}$$

$$\Delta kWh_{RH} = \Delta kWh_{EFan} \times COP_{ref} \times 0.284$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \Delta kW_{EFan} + \Delta kW_{RH}$$

$$\Delta kW_{EFan} = units \times \left(\frac{W_{EFan}}{1{,}000}\right) \times F_{PA} \times F_{EFan} \times CF$$

$$\Delta kW_{RH} = \Delta kW_{EFan} \times COP_{ref} \times 0.284$$

Annual Fuel Energy Savings

$$\Delta MMBtu = N/A$$

Summary of Variables and Data Sources

Variable	Value	Notes
W_{EFan}	$= Volts \times Amps \times \sqrt{Phase}$	Based on nameplate Volts, Amps, and Phase of existing evaporator fan.
F_{PA}	0.601	Oak Ridge National Laboratory.[1122]
hrs_{EFan}	On/Off Control: 5,571 Multistep Control: 6,062 No Cooler Control: 8,567	Based on refrigeration control type.[1123]
hrs_{CM}	8,573	PG&E.[1124]
F_{EFan}	0.65	Based on numerous pre and post meter readings conducted by NRM and supported by RLW Analytics evaluation.[1125]
F_{CM}	Shaded Pole: 0.44 PSC: 0.3	US DOE.[1126]
COP_{ref}		From application; COP = 3.517/(kW/ton), where kW/ton is the rated efficiency of the compressor in input kW per ton of refrigeration capacity.
CF	1.0	

ΔkWh_{EFan}	= Annual electric savings due to evaporator fan motor replacement
ΔkWh_{RH}	= Annual electric savings due to reduced heat from evaporator fan motor replacement
W_{EFan}	= Nameplate wattage of existing evaporator fan motor
F_{PA}	= Power adjustment factor
F_{EFan}	= Reduction of load by replacing evaporator fan motor
hrs_{EFan}	= Evaporator fan motor annual operating hours
COP_{ref}	= Coefficient of performance of refrigeration equipment
CF	= Coincidence factor
0.284	= Conversion factor from kW to Tons of refrigeration (Tons/kW)
1,000	= Conversion factor, one kW equals 1,000 W

Methodology

Non-Lighting Measures

Anti-Condensation Heater Controls

- Measure definition: Reduced runtime of anti-condensation heater controls on glass door reach-in refrigerated cases
- Followed NYS TRM to calculate savings
- 13 projects that included these measures (~0.5% of program savings)
- Key input: nameplate voltage and amperage of door heater
- Nameplate pictures not available
  - Tracking data review only
  - Evaluation team did not inspect this measure because relative low participation
- Evaluators used reported demand savings to calculate door heater power (kW_{DH})

Annual Electric Energy Savings

$$\Delta kWh = (kW_{DH} \times hrs_{baseline}) - (kW_{DH} \times F_{PA} \times hrs_{ee})$$

Summer Peak Coincident Demand Savings

$$\Delta kW = kW_{DH} \times F_{hrs} \times DF$$

Annual Fuel Energy Savings

$$\Delta MMBtu = N/A$$

where:

ΔkWh	= Annual electric energy savings
ΔkW	= Peak coincident demand electric savings
ΔMMBtu	= Annual fuel energy savings
kW_{DH}	= Total power of door heaters (in kW)
hrs	= Operating hours
baseline	= Baseline condition or measure
ee	= Energy efficient condition or measure
F_{PA}	= Power adjustment factor
F_{hrs}	= Operating hours reduction factor
DF	= Demand diversity factor

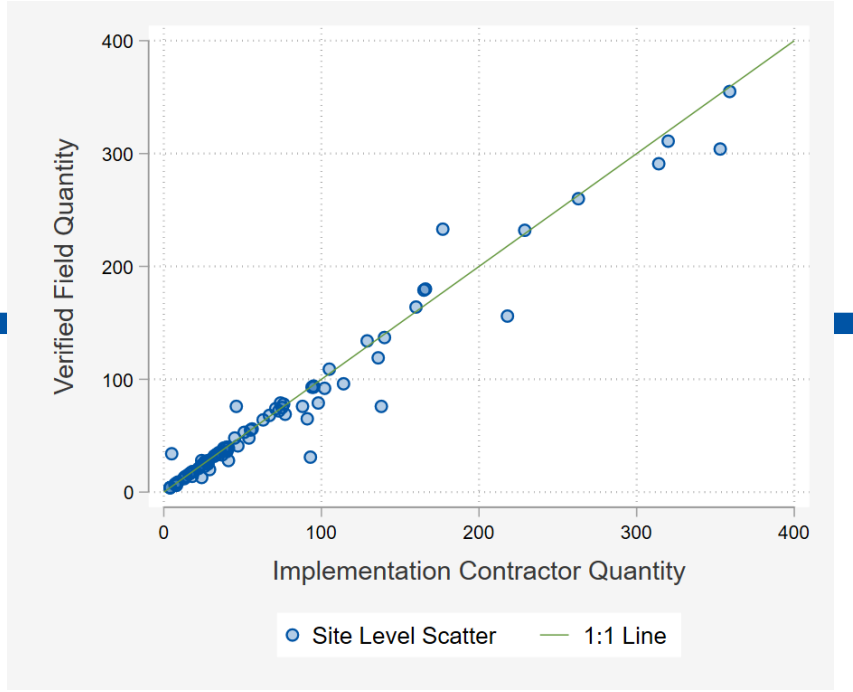
Summary of Variables and Data Sources

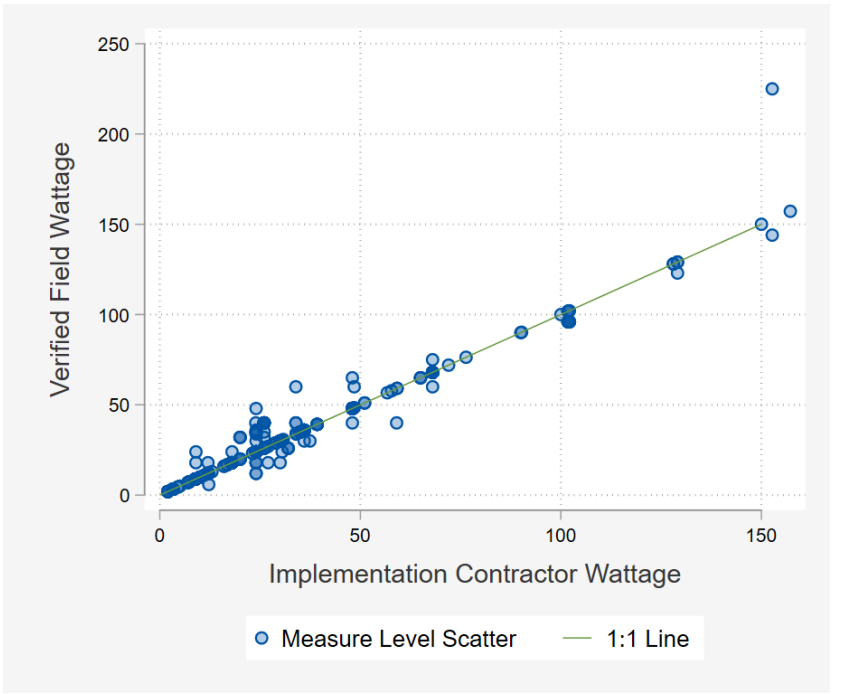
Variable	Value	Notes
kW_{DH}		From application, calculated based on door heater nameplate voltage and amperage.
$hrs_{baseline}$	8,760	Pre-installation operating hours; assumes 24/7, year-round operation of door heaters
hrs_{ee}	Coolers: 3,760 Freezers: 8,760	Post-installation operating hours. Freezer hours assume 24/7, year round operation of door heaters and varying power factors. Cooler hours estimated by National Resource Management (NRM) based on monitoring data collected of cooler door heater controls.[1143]
F_{PA}	Coolers: 0.60 Freezers: 0.54	Average operating percentage of total door heater power after installation. Estimated by NRM based on monitoring data collected of cooler and freezer door heater controls. F_{PA} for freezers is calculated based on 4,000 hours of operation at 40% power and 4,760 hours at 65%.[1144]
F_{hrs}	Coolers: 0.74 Freezers: 0.46	Annual operating hour reduction factor. Estimated by National Resource Management (NRM) based on monitoring data collected of cooler and freezer door heater controls.[1145]
DF	0.75	Estimated adjustment to account for diversity and peak coincidence.[1146]

Evaluation Results

Verified Equipment Counts and Wattages

- Verification of efficient equipment counts, and wattages were nearly perfect
  - Engineers counted the lighting equipment
  - Wattage was verified by checking the nameplate on the equipment
- While the efficient equipment can be observed, the baseline equipment that was replaced is unable to be verified on-site
- The implementation contractor accurately reports equipment characteristics, including the location of installation



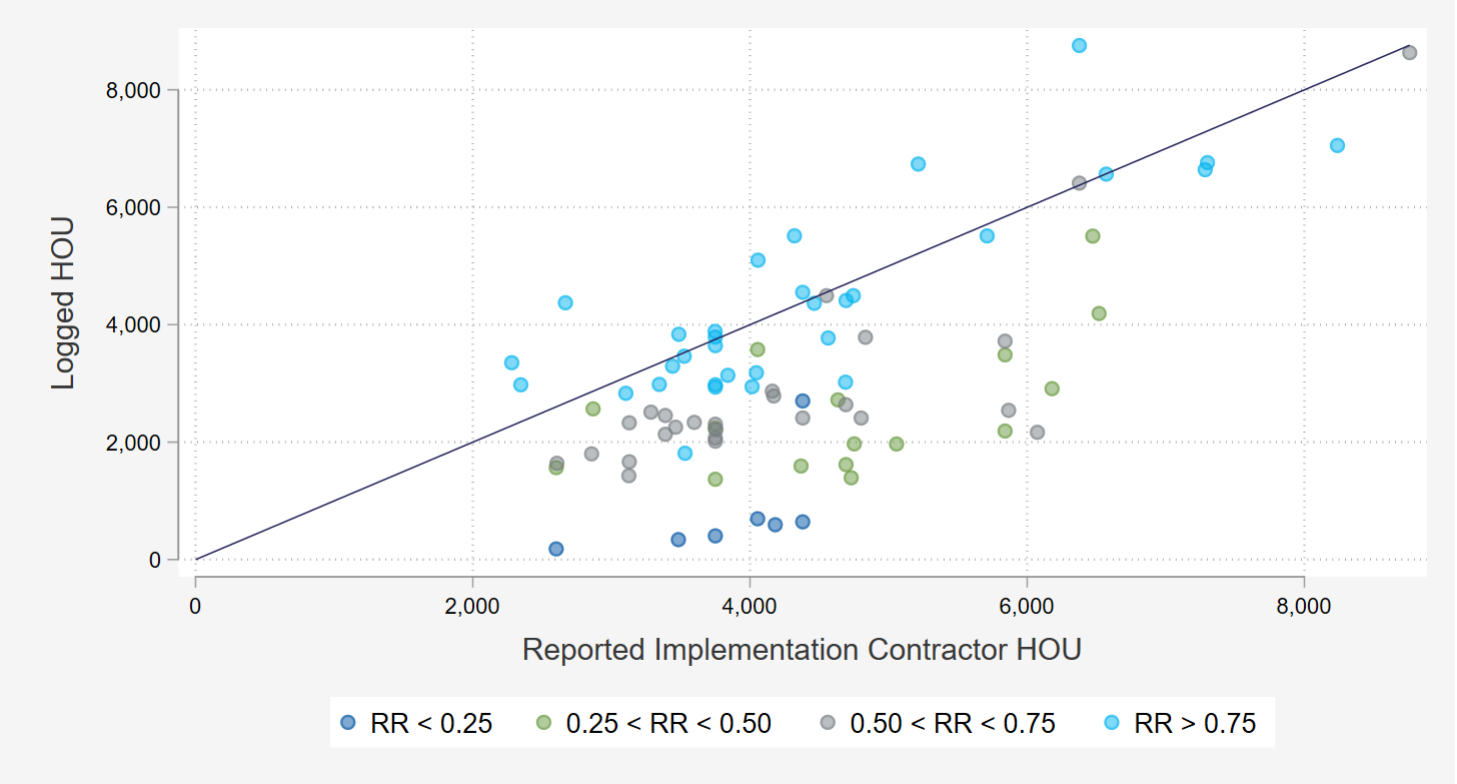


Evaluation Results

Verified Lighting Hours of Use

- Logged hours of use recorded from the site visits were lower than the annual hours reported by the implementation contractor
  - Our logged hours of use aligned more closely with the self-reported hours of use verbally collected during the site visit (92% correspondence)

- The graph shows an hours of use comparison for all 81 sites
- The HOU are a key driver of the low realization rate
- The larger the discrepancy in the hours of use; the smaller the realization rate



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Evaluation Results

Case Study: Lighting HOU Discrepancies

- The hours of use were further investigated for the 7 sites with realization rates less than 25% by checking the:
  - Google Business hours
  - Field notes from the engineers
  - TRM hours of use (if the building was able to be matched to a building type)
- DSA ID 1028 was one of the worst offenders with a realization rate of 11.5%
- This site is a nightclub
  - It is completely closed on certain days of the week (Monday & Tuesday)
  - It is mostly open at night
  - It is a dim environment
- The table below helps to solidify that the hours of use are the primary driver in the lower realization rates for DSAID 1028

	Implementation Contractor	Self-Reported	Logged
HOU	4,182	625	607
Savings	35,041	4,846	4,161
Realization Rate	96.5%	13.3%	11.5%

Evaluation Results

Comparison of Pre-Installation Annual Consumption to Realization Rate

- 71 of the 81 sites were matched to the Central Hudson billing data
  - The most recent 12-months of bills, prior to the lighting installation, were used to construct the annual consumption
- Percent savings are calculated as the gross lighting savings over the annual consumption
  - Percent savings > 100% indicate the site will save more than it consumes in a year

Sites with a percent savings over 100% tend to have lower realization rates

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Evaluation Results

The Lighting VGS Realization Rates

- Verified gross savings use the site visit results for measure quantities and lighting hours of use and include NY TRM HVAC interactive effects
- The VGS energy realization rate is **0.71 (71%)**
  - Driven by lower lighting hours of use
- The VGS demand realization rate is **0.77 (77%)**
- In the tracking data, fuel impacts for every record were missing
  - The evaluation team leveraging the savings algorithms in the New York TRM to calculate fuel savings as a function of energy savings
- Fuel savings were -0.00071 MMBtu per VGS kWh saved
  - This corresponds to a total increase in fuel usage of 5,778 MMBtu

Annual Electric Energy Savings

$$\Delta kWh = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times hrs \times (1 + HVAC_c)$$

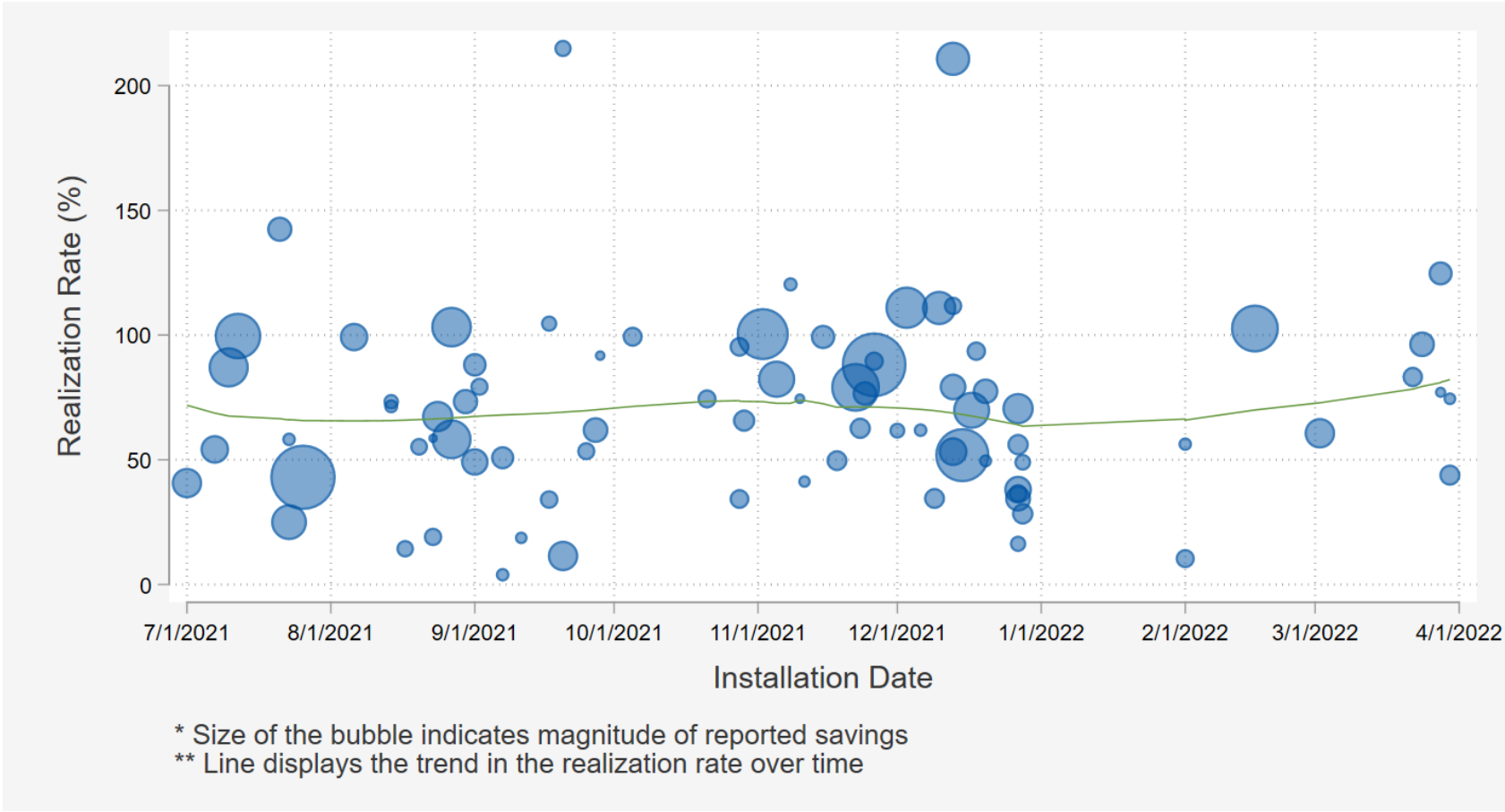
Annual Fossil Fuel Energy Savings

$$\Delta MMBtu = \left[\frac{(W \times units)_{baseline} - (W \times units)_{ee}}{1{,}000}\right] \times hrs \times HVAC_{ff}$$

Evaluation Results

Lighting Realization Rates Across Installation Dates

- The trend in energy realization rates were similar across time
- The relative size of projects vary over time, with no single site dominating the program savings



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Evaluation Results

Impact of Lighting Energy Realization Rate on Expected Useful Life

With a lighting energy realization rate below 100%, the expected useful life is higher

- Lighting EULs are the minimum of:
  - Annual hours of use
    - 50,000 (fixtures)
    - 25,000 (lamps)
  - 20 years
- Lower annual hours of use imply higher EULs
- The verified hours of use was 76% of the hours of use assumption reported by the implementation contractor
- PY 2021 Scorecard reports an EUL of 10.98 years
  - Since the annual hours of use are lower than reported, we divide this EUL by 76%
  - Yields an EUL of 14.4 years

Category	Commercial & Industrial Measures	Sector	EUL (years)	Source
Lighting	LED Screw-In Lamp	C&I	15,000 hours (decorative) or 25,000 hours (all other)/ annual lighting operating hours or 20 years (whichever is less)	ENERGY STAR®
	Refrigerated Case LED	C&I	16	DEER 2014 EUL ID: GrocDisp-FixtLtg-LED
Lighting	CFL Lamp	C&I	9,000 hours /annual lighting operating hours	See note below[918]
	CFL Light Fixture	C&I	12	DEER 2014 EUL ID: ILtg-CFLfix-Com
	HID	C&I	70,000 hours /annual lighting operating hours or 15 years (whichever is less)	DEER 2014 EUL ID: ILtg-HPS
	Linear Fluorescent	C&I	70,000 hours /annual lighting operating hours or 15 years, (whichever is less)	DEER 2014[919] EUL ID: ILtg-Lfluor-Elec
	LED Fixture (other than refrigerated case)	C&I	50,000 hours /annual lighting operating hours or 20 years (whichever is less)	DLC[920]
			35,000 hours /annual lighting operating hours or 20 years (whichever is less)	ENERGY STAR®[921]
			25,000 hours /annual lighting operating hours or 20 years (whichever is less)	Uncertified

Evaluation Results

Summary of Prior Evaluation Findings and Program Changes

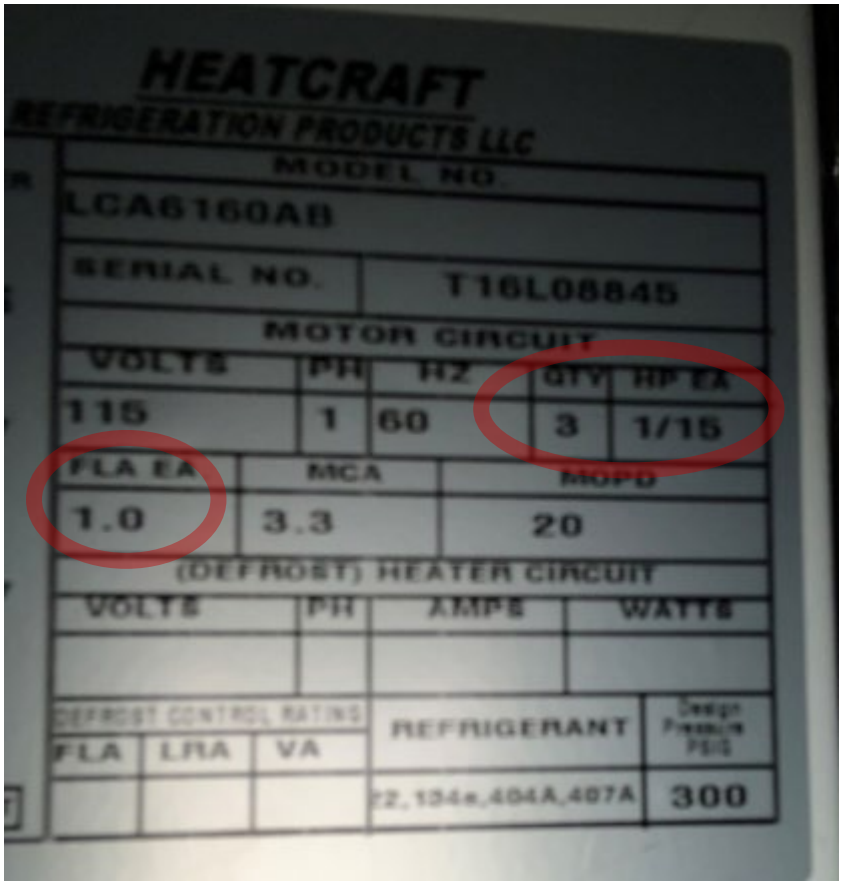
The main factors which led to a VGS realization rate less than 100% were not addressed

Key Finding From Prior Study	Program Design Change	Disposition From this Study
Billing analysis was not a suitable method to conduct the SBDI impact evaluation.	Deployed lighting loggers through 81 SBDI site visits to perform the impact evaluation.	The site visits allow the engineers to validate the lighting equipment and install the lighting loggers which produce an unbiased estimate of hours of use.
Some sites had higher lighting gross savings than whole-building pre-installation energy usage.	No change.	This issue still lowers the VGS realization rates slightly.
Self-reported lighting hours of use were lower than default values from the NY TRM and values used by the implementation contractor	No change.	This issue is still the primary driver of the VGS realization rate for energy.

Evaluation Results

Non-Lighting Measures

- Key input to NYS TRM algorithm are nameplate wattage of existing fan motor
- Reported measure description was horsepower, not wattage
  - Savings calculated using amperage (FLA) that was not in tracking database
- Implementers provided additional information
  - Sample of nameplate pictures provided for review
  - Supporting calculation workbooks
- Nameplate information is not always straightforward. See picture, showing:
  - Three 1/15 HP motors
  - “FLA EA” meaning full load amps for each motor
  - NYS TRM: kW for one motor = 115 V x 1.0 Amps = 0.115 kW
  - This is about 2.5x higher than horsepower equivalent: 1/15 HP x 0.746 kw/HP = 0.05
- NYS TRM was used to calculate savings
  - Some discrepancies due to double-counting quantity and using total amps, not individual motor amps



Evaluation Results

Energy and Demand Savings for Non-Lighting Measures

- Most projects included the EC fan motor measure
- Anti-condensation heater controls evaluated energy savings is based on reported demand savings. Nameplate information was not available and not collected because savings was relatively low

Energy Savings

Measure	# Projects with this Measure	kWh Reported	kWh Evaluated	RR
Anti-Condensation Heater Controls in Coolers	13	110,636	38,024	0.34
Anti-Condensation Heater Controls in Freezers	6	40,374	28,785	0.71
EC Fan Motor: Walk-in	36	581,862	477,332	0.82
EC Fan Motor: Reach-in	2	31,374	31,374	1.00
Total	**40**	**764,246**	**575,516**	**0.75**

Demand Savings

Measure	# Projects with this Measure	kW Reported	kW Evaluated	RR
Anti-Condensation Heater Controls in Coolers	13	3.2	3.2	1.00
Anti-Condensation Heater Controls in Freezers	6	0.7	0.7	1.00
EC Fan Motor: Walk-in	36	72.5	59.5	0.82
EC Fan Motor: Reach-in	2	3.9	3.9	1.00
Total	**40**	**80.4**	**67.3**	**0.84**

Conclusions and Recommendations

Key Drivers of Results	Recommendations
Logged lighting hours of use were lower than default values from the NYS TRM and values used by the implementation contractor.	Review and refine annual hours of use verification process to capture hours of use for each space included in a project.
Some sites had higher lighting gross savings than whole-building pre-installation energy usage.	Review and strengthen flagging tool and controls for unreasonable gross savings
Non-lighting measures: Incorrect motor quantity for some EC measures	Include nameplate volts, fan motor quantity, and individual motor amps in tracking database
Non-lighting measures: FLA may not be accurate representation of actual load for small motors	NYS TRM working group should review EC measure inputs for estimating actual amperage

APPENDICES

Appendix A – Recommended process improvements from the prior evaluation

Appendix B – Discrepancies in hours of use

Appendix C – Results using TRM assumptions

Appendix D – References

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APPENDIX A

- Recommended process improvements from the prior evaluation

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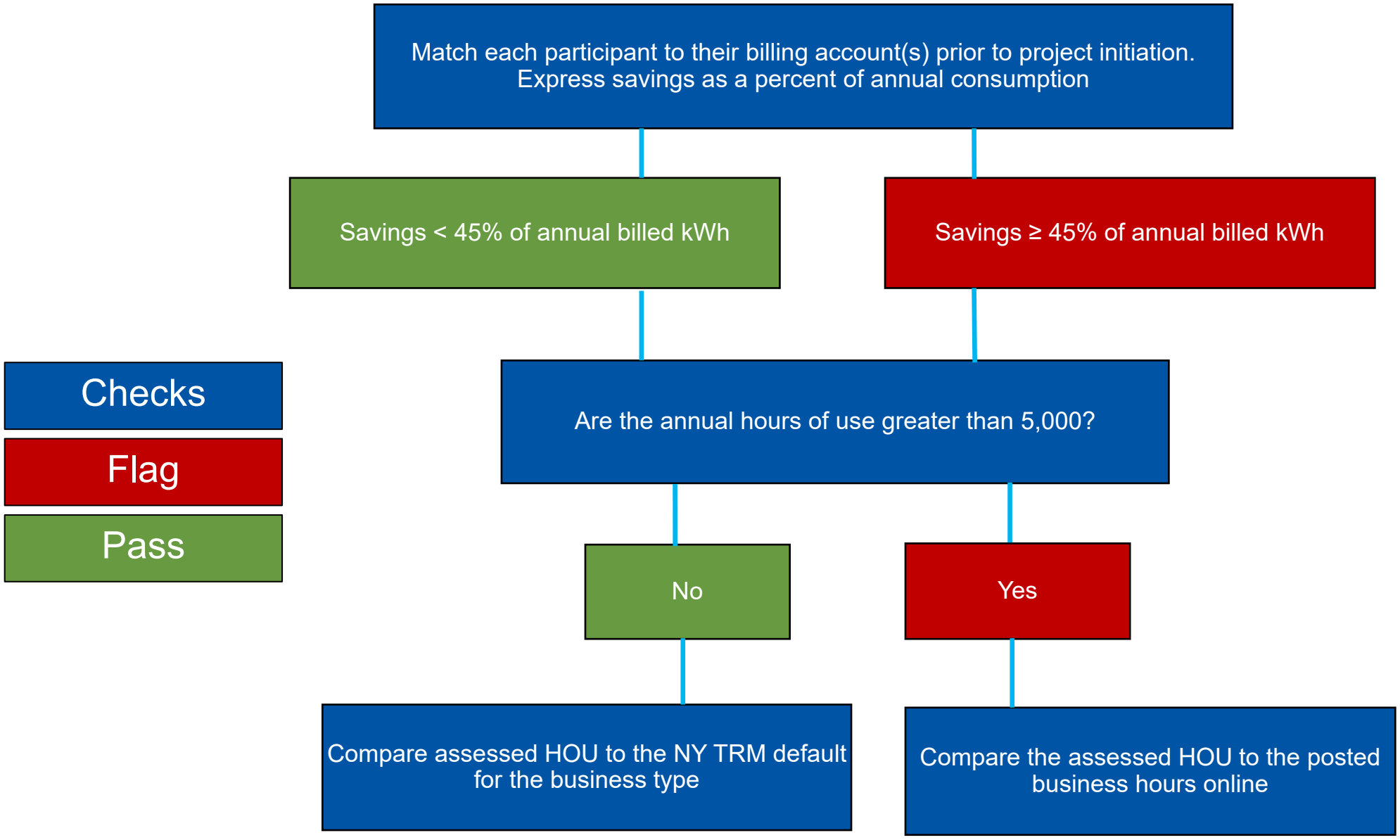
Recommended Process Improvements from the Prior Evaluation

Create a decision tree with high-level project flags for additional review



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Express Savings as a Percent of Annual Consumption

The gross savings exceeded the pre-installation consumption at the account level for 22% of participants

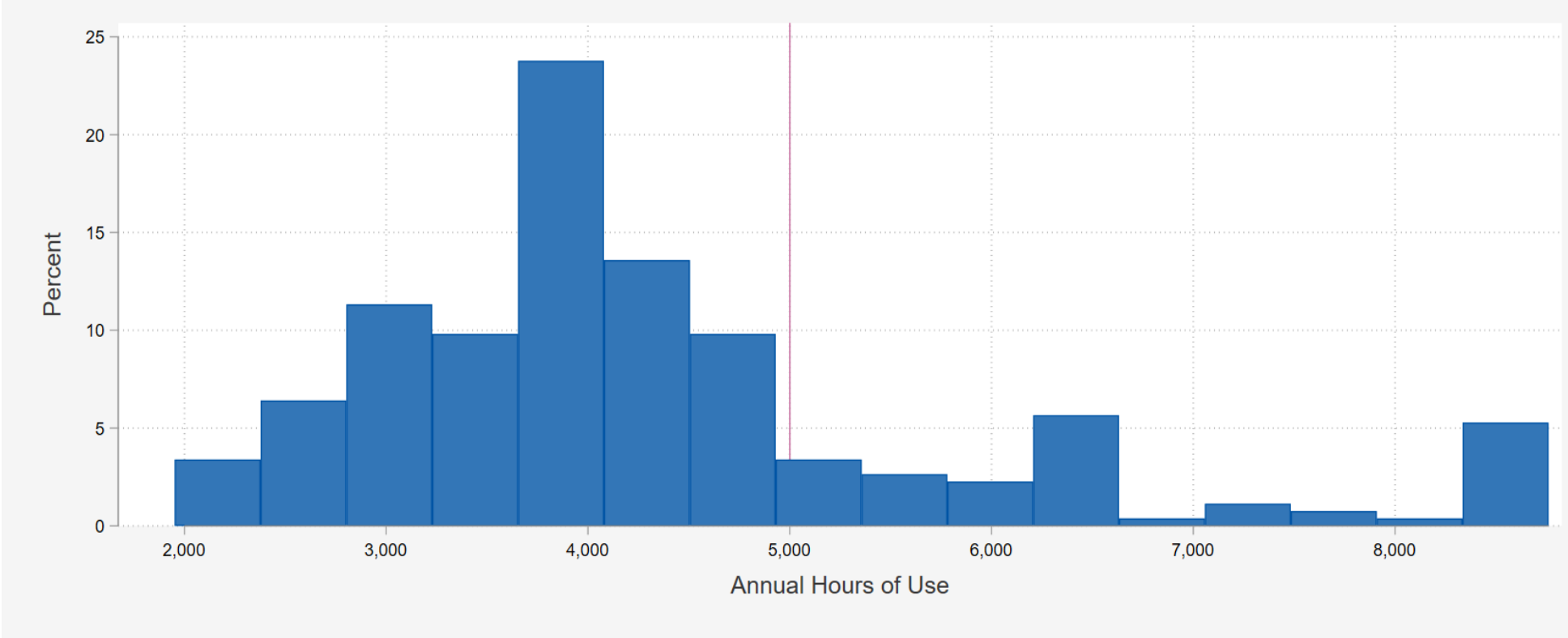
Percent Savings Category	Accounts	Gross Savings (MWh)	2020 Annualized Consumption (MWh)	Ratio
Savings < 45%	123	6,960	33,677	0.21
45% ≤ *Savings* < 100%	53	2,076	3,468	0.60
Savings ≥ 100%	51	1,988	1,110	1.79
Unable to be Matched	45	1,696	-	-
Total Matched	227	11,024	38,255	0.29

- **This analysis is based on matching the account number listed by the implementation contractor to the same account number in the Central Hudson billing data.**
- **There are a couple of caveats in calculating the pre-installation annual consumption:**
  - Missing the presence of multiple meters to comprise the whole-building consumption
    - The analysis found that the ratios were highest for small users
  - Presence of solar PV
  - The time period for pre-installation consumption includes the pandemic in 2020

Are the annual hours of use greater than 5,000?

The annual hours of use exceeded 5,000 for 22% of projects

- Analysis includes all 272 SBDI accounts within our period of interest
  - Comprised of 277 projects
- Weights the annual hours of use by the quantity reported from the implementation contractor
  - Excludes exterior installations
  - Includes interior fixtures that may be on 24/7



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APPENDIX B

- Discrepancies in hours of use

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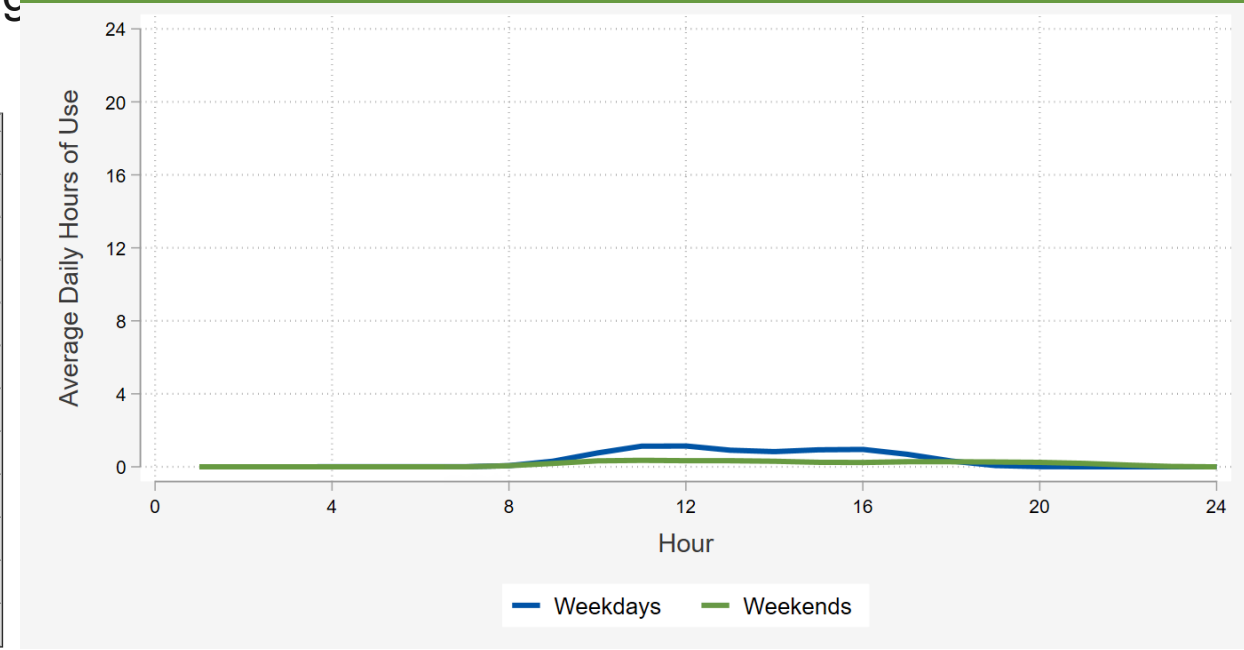
HOU Case Study – Migliorelli Farm

46 Freeborn Rd, Tivoli, NY

- Energy realization rate of 4.0%
- This site is a barn
  - It's only reported as having lig

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Jan	ALL DAY	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	ALL DAY
Feb	ALL DAY	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	ALL DAY
Mar	ALL DAY	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	ALL DAY
Apr	ALL DAY	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	ALL DAY
May	ALL DAY	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	ALL DAY
Jun	ALL DAY	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	ALL DAY
Jul	ALL DAY	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	ALL DAY
Aug	ALL DAY	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	ALL DAY
Sep	ALL DAY	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	ALL DAY
Oct	ALL DAY	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	ALL DAY
Nov	ALL DAY	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	ALL DAY
Dec	ALL DAY	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	12:00AM to 12:59PM 01:00PM to 02:00PM 02:01PM to Midnigh	ALL DAY

Logger Load Shape



	Implementation Contractor	Self-Report by Site Contact	Logged
HOU	2,602	264	99
Savings (kWh)	5,040	512	205
Realization Rate	97.2%	9.9%	4.0%

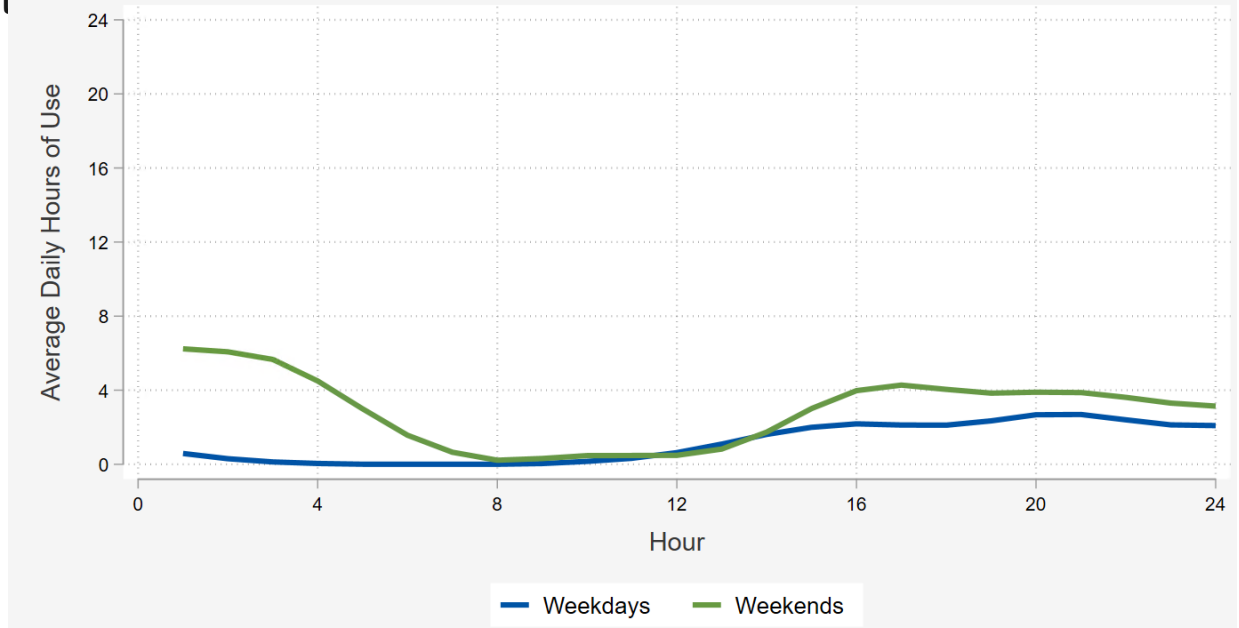
HOU Case Study – Mystic Cafe

189 Church St, Poughkeepsie, NY

- Energy realization rate of 11.5%
- This site is a nightclub
  - It is completely closed on cert
  - It is mostly open at night
  - It is a dim environment

Hours:	Monday	Closed
	Tuesday	Closed
	Wednesday	6PM–12AM
	Thursday	11AM–11:30PM
	Friday	11AM–4AM
	Saturday	11AM–4AM
	Sunday	11AM–11:30PM

Logger Load Shape



	Implementation Contractor	Self-Report by Site Contact	Logged
HOU	4,182	625	607
Savings (kWh)	35,041	4,846	4,161
Realization Rate	96.5%	13.3%	11.5%

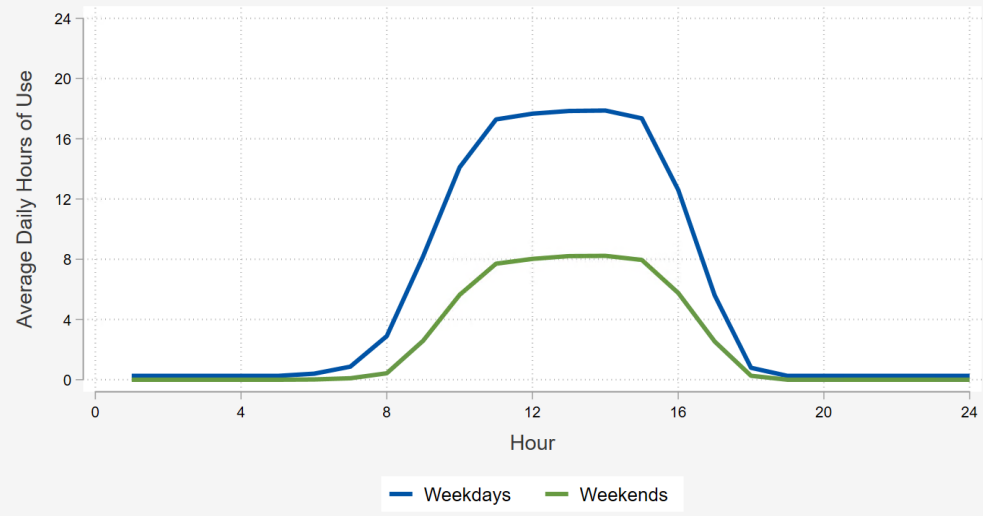
HOU Case Study – BC&N Carpet

1418 RT 300 Suite #103, Newburgh, NY

- Energy realization rate of 34.3%
- This site is a flooring store
  - It is open 7 hours a day for 6 days of the week
    - 7 hours * 6 days * 52 weeks = 2,184

Hours:	**Monday**	**10a.m.–5p.m.**
	Tuesday	10a.m.–5p.m.
	Wednesday	10a.m.–5p.m.
	Thursday	10a.m.–5p.m.
	Friday	10a.m.–5p.m.
	Saturday	10a.m.–5p.m.
	Sunday	Closed

Logger Load Shape



	Implementation Contractor	Self-Report by Site Contact	Logged
HOU	5,840	2,501	2,033
Savings (kWh)	11,802	6,584	4,570
Realization Rate	88.6%	49.4%	34.3%

APPENDIX C

- Results using TRM assumptions

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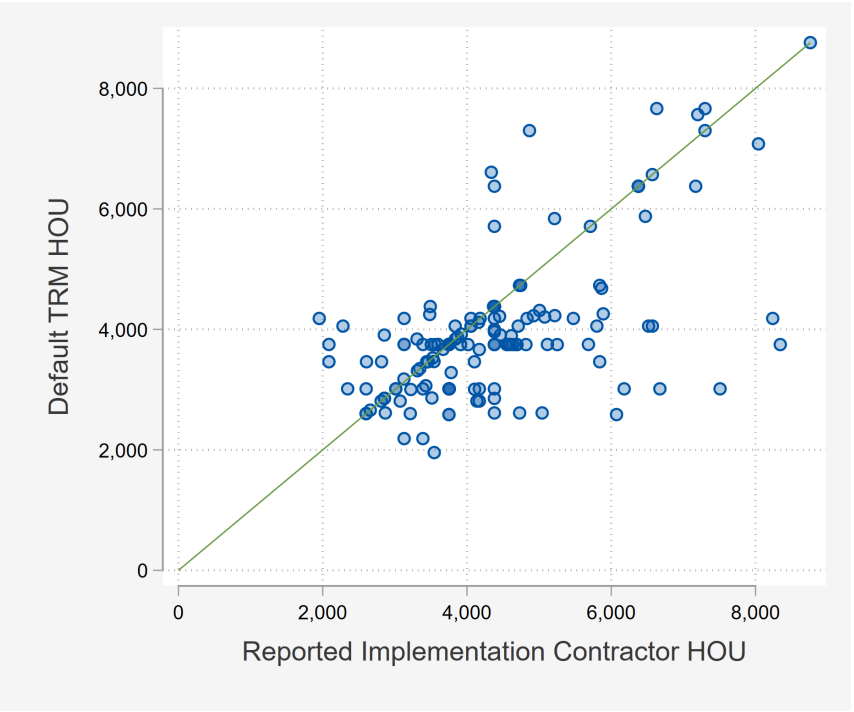
Results Using TRM Assumptions

If gross savings had been calculated exclusively with NYS TRM defaults, the VGS energy realization rate would have been 87%

- The gross savings did not always use TRM default values for HOU
  - 39% of all HOU values were values that appeared in the TRM
  - Acceptable if participants provide an alternative estimate of hours of use
- Using default hours of use and default coincidence factors based on TRM building type yields a verified gross energy savings realization rate of 87%
  - Gross verified demand savings remain similar

New York TRM Hours of Use by Building Type

Facility Type	Lighting Hours (hrs/yr)	CF[1183]	HVAC Int	Facility Type	Lighting Hours (hrs/yr)	CF 1184	HVAC Int
Auto Related*	2,810	0.89	AR	Manufacturing Facility	2,857	0.67	Ind
Automotive / Transportation Service or Repair Facility (24/7)	8,760	0.89	AR	Medical Offices	3,748	0.92	SOfc
Bakery	2,854	0.79	FS	Motion Picture Theatre	1,954	0.89	Asy
Banks	3,748	0.92	SOfc	Multi-Family (Common Areas)	7,665	0.98	MFL
Church	1,955	0.89	Rel	Museum	3,748	0.89	Asy
College–Cafeteria**	2,713	0.79	FS	Nursing Homes	5,840	0.92	MFL
College – Classes	2,586	0.54	CC	Office (General Office Types)**	3,013	0.92	SOfc/ LOfc
College - Dormitory	3,066	0.92	Dorm	Parking Garages	4,368	0.0	None



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References

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APPENDIX E

- Analysis and rationale for an Alternative Prospective Realization Rate

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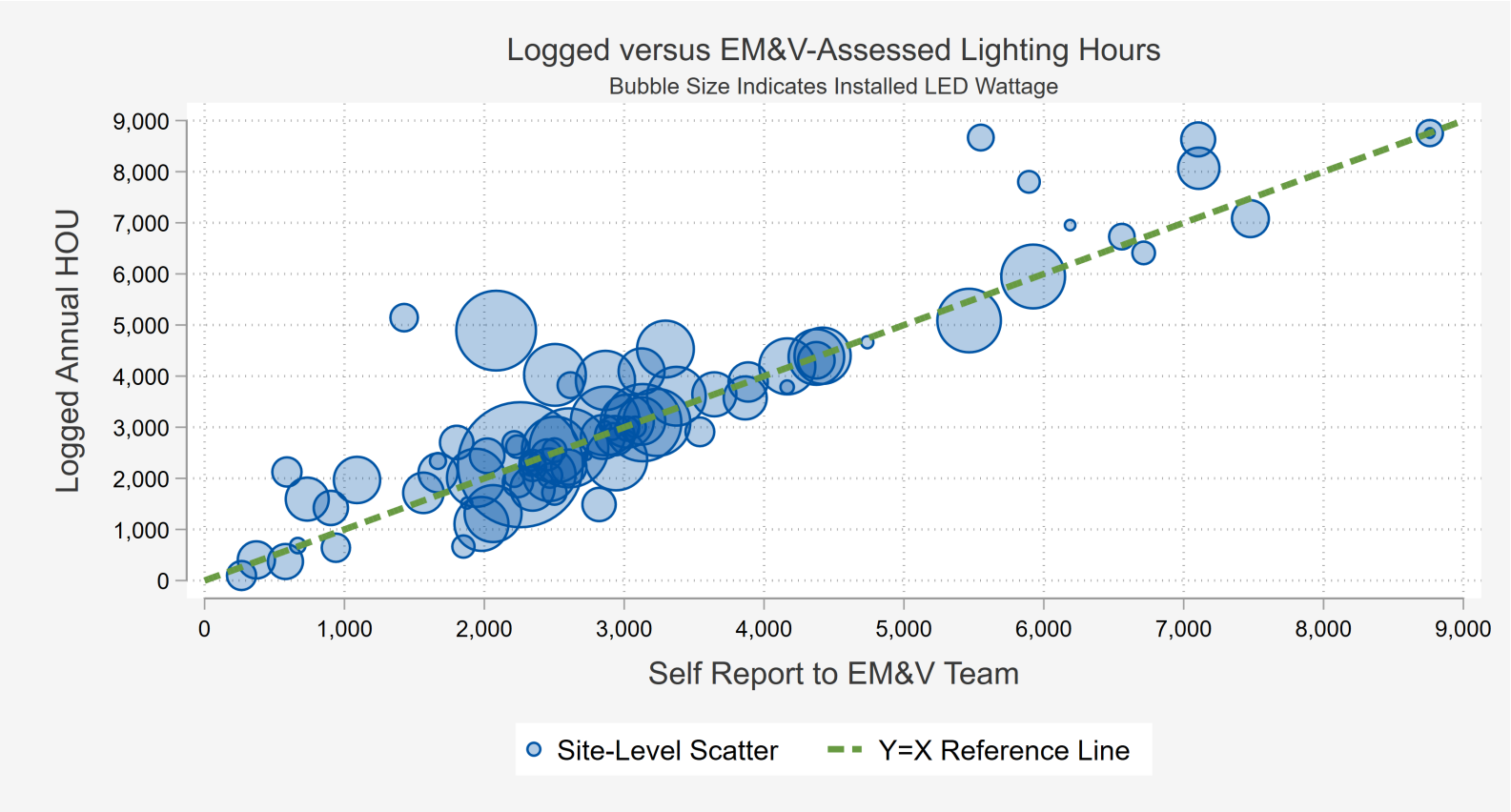
Alternative Prospective Realization Rate

Hours of Use – Energy Savings (kWh)

- Evaluators gathered detailed schedules for each lighting space during site visits. The figure below compares logged HOU to the self-reported HOU.
- The self-reported HOU was slightly higher on average with a correlation coefficient of 0.913. This exercise illustrates the potential for assessed hours to closely match measured hours
- Program auditors will mirror the EM&V team's procedure beginning in January 2023. The recommended APRR for energy is the midpoint of the VGS RR of 71% and 100%.



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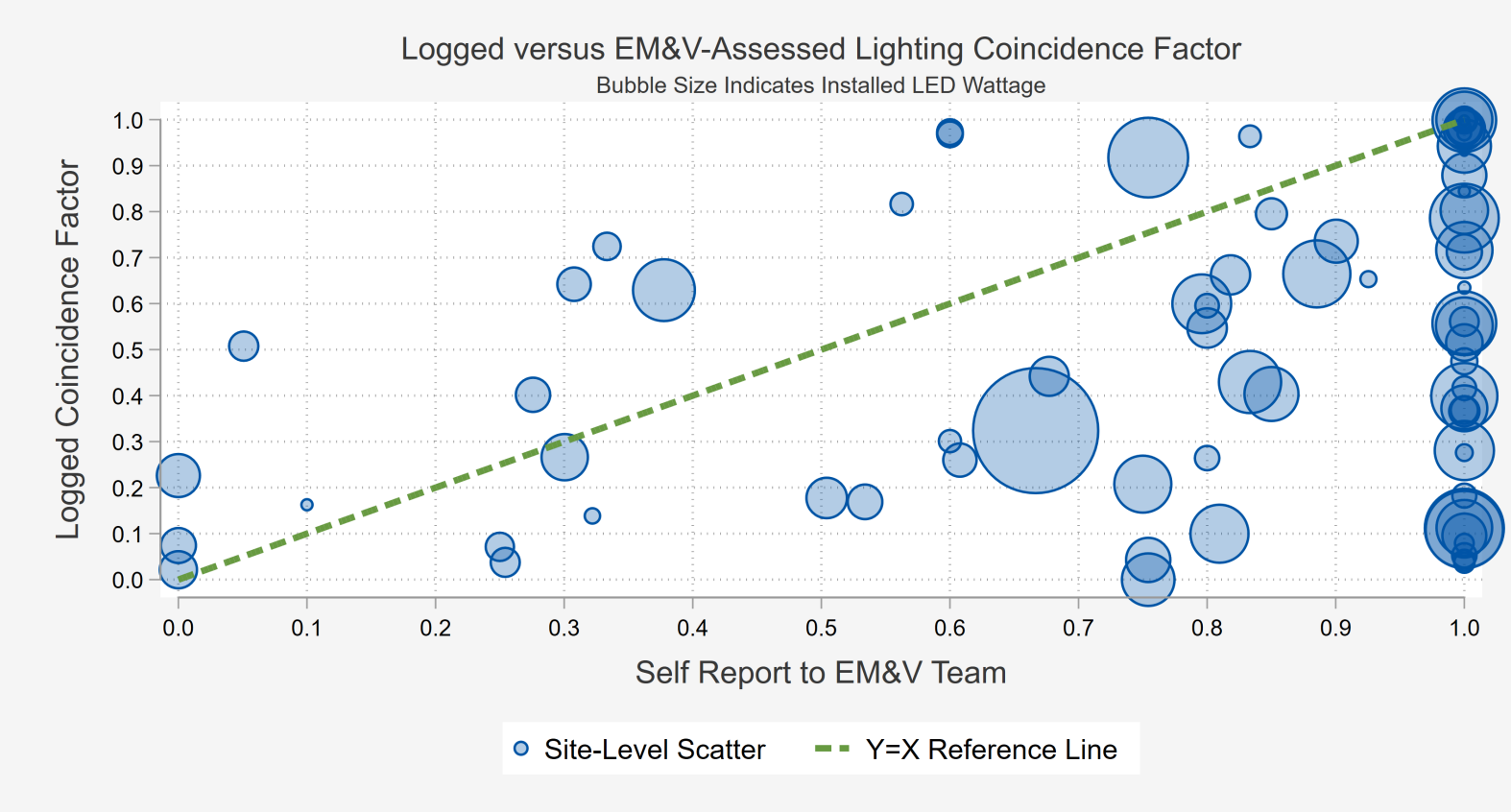
Alternative Prospective Realization Rate

Coincidence Factor – Peak Demand Savings (kW)

- Evaluators gathered detailed schedules for each lighting space during site visits. The figure below compares logged coincidence factor to implied coincidence factor in the self-reported schedule.
- The self-reported CF was substantially higher, on average, with a correlation coefficient of just 0.345. This illustrates the challenge with accurately collecting coincidence factors via self-report.
- Based on this exercise, gross savings will continue to rely on building-specific TRM defaults and no APRR is recommended for peak demand savings.



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