BEFORE THE PUBLIC UTILITIES COMMISSION OF NEVADA

Joint Application of Nevada Power Company d/b/a NV Energy and Sierra Pacific Power Company d/b/a NV Energy for approval of their joint 2025-2044 integrated resource plan, for the three year Action Plan period 2025-2027, and the Energy Supply Plan period of 2025-2027.	Docket No. 24-05___

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NEVADA POWER COMPANY D/B/A NV ENERGY AND
SIERRA PACIFIC POWER COMPANY D/B/A NV ENERGY

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DSM-21

Energy Smart Schools Program
NV Energy
Program Year 2023

Measurement and Verification Report
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1 EXECUTIVE SUMMARY

Under contract with Sierra Pacific Power Company ("SPPC") and Nevada Power Company ("NPC") (collectively, "NV Energy"), ADM Associates, Inc. ("ADM") performed measurement and verification ("M&V") activities to confirm the energy savings attributable to the energy efficiency programs that NV Energy implemented in Nevada in 2023. This M&V report provides verified ex-post energy and demand impacts achieved by the Energy Smart Schools program ("Program") that NV Energy offered in the NPC and SPPC service territories during the 2023 program year ("PY2023").

ADM Associates prepared this M&V report as an independent, third-party evaluation contractor.

1.1 Overview of Program

The 2023 Program targeted public K-12 and higher educational institutions and facilities throughout the NPC and SPPC service territories. In this M&V report, "NPC Program" will be used to denote the NPC component of the state-wide Program; similarly, "SPPC Program" will denote the SPPC component of the state-wide Program.

For the NPC and SPPC service territories, the 2023 Program had two different delivery channels: (1) behavioral projects and (2) capital improvement projects.

Behavioral projects provided performance-based incentives to participating schools for achieving energy savings through low-cost or no-cost customer actions and behavioral changes.

- For the NPC service territory, behavioral projects are called Continuous Energy Improvement ("CEI")[1]. CEI was introduced in the Clark County School District ("CCSD") during program year 2019 ("PY2019").
- For the SPPC service territory, behavioral projects are called Strategic Energy Management ("SEM"), which was introduced in Washoe County School District ("WCSD") in the last quarter of 2020. In PY2022, the SEM program continued in WCSD[2] and was expanded to the Carson City School District ("Carson SD"). In PY2023, SEM savings were claimed only for WCSD (i.e., not for Carson SD).

Capital improvement projects implemented in 2023 included HVAC equipment replacements, lighting retrofits, building controls, engine block heater controllers, and new construction projects.

[1] NV Energy CCSD CEI Final Report 2023, attached as Appendix C.

[2] NV Energy WCSD CEI Final Report 2023, attached as Appendix D.

1.2 Overview of M&V Approaches

1.2.1 M&V Sampling

The M&V analyses for the PY2023 Program are required to achieve a sampling precision of ±10 percent at the 90 percent confidence level (also called 90/10 confidence). Given that the Program implementation was not uniform across NPC and SPPC service territories, and various measures are weather sensitive, the 90/10 confidence requirement applies individually to NPC and SPPC service territories. For the NPC Program, ADM executed a sampling plan that achieved relative precision of ±0.1 percent at the 90 percent confidence level. For the SPPC Program, ADM executed a sampling plan that achieved relative precision of ±7.7 percent at the 90 percent confidence level.

1.2.2 M&V Analysis for Behavioral Projects

Ex-ante analyses of savings for CEI and SEM behavioral projects used whole building pre- and post-regression models that incorporated facility meter data, local weather, school calendars, and information on any changes to the facility, such as new additions, extended hours, and other energy efficiency projects. ADM's ex-post analyses for CEI and SEM projects included a thorough review of the ex-ante regression models and participant data. ADM's analyses also ensured that savings claimed through capital improvement projects were not being double counted in the regression models.

1.2.3 M&V Analysis for Capital Improvement Projects

The M&V analyses for capital improvement projects included desk reviews to verify measure installation and engineering analyses to calculate ex-post energy savings. ADM used documentation provided by the program implementation contractor to determine measure operating parameters, ex-post verified energy (kilowatt-hours ("kWh") savings, and critical peak demand (kilowatt ("kW") savings.

1.3 Summary of Program-Level Energy Savings Impacts for PY2023

For the PY2023 NPC Program, ex-post verified energy impacts are provided in Table 1-1 below. Ex-post verified energy impacts include 26,472,776 kWh of first-year savings (i.e., savings achieved during the 2023 calendar year). Ex-post annual savings are 27,705,052 kWh, representing 101 percent realization rate ("RR"). Ex-post summer critical peak demand savings are 6,233.1 kW.

ADM verified that there was no double-counting of savings in PY2023.

Table 1-1. NPC Summary of Energy Impacts

Delivery Channel	First-Year Ex-Post Energy Savings (kWh)	Project Count	Annual Ex-Ante Estimated Energy Savings (kWh)	Annual Ex-Post Verified Energy Savings (kWh)	Realization Rate, (ex-post kWh / ex-ante kWh)	Ex-Post Summer Critical Peak Demand Savings (kW)	EUL (years)	Lifetime Energy Savings (kWh)
CEI (Behavioral)	25,875,047	407	25,692,826	25,798,476	100.41%	5,658.4	1	25,798,476
Capital Improvement Projects	597,729	5	1,772,429	1,906,576	107.57%	574.7	11.57	22,054,297
Total	**26,472,776**	**412**	**27,465,255**	**27,705,052**	**100.87%**	**6,233.1**	**1.73**	**47,852,773**

For the PY2023 SPPC Program, ex-post verified energy impacts are provided in Table 1-2 below. Ex-post verified energy impacts include 2,234,481 kWh first-year savings and annual savings of 3,191,849 kWh, which equate to about 95 percent RR. Ex-post summer critical peak demand savings are 741.2 kW.

ADM verified that there was no double-counting of savings in PY2023. Moreover, no savings for Carson SD were claimed for PY2023.

Table 1-2. SPPC Summary of Energy Impacts

Delivery Channel	First-Year (2023) Ex-Post Energy Savings (kWh)	Project Count	Annual Ex-Ante Estimated Energy Savings (kWh)	Annual Ex-Post Verified Energy Savings (kWh)	Realization Rate, (ex-post kWh / ex-ante kWh)	Ex-Post Summer Critical Peak Demand Savings (kW)	EUL (years)	Lifetime Energy Savings (kWh)
SEM (Behavioral)	1,770,987	130	1,676,568	1,770,987	105.63%	536.6	1	1,770,987
Capital improvement projects	463,494	11	1,675,957	1,420,862	84.78%	204.6	12.73	18,087,156
Total	**2,234,481**	**141**	**3,352,525**	**3,191,849**	**95.21%**	**741.2**	6.22	**19,858,143**

1.4 M&V Recommendations:

Based on the M&V findings, ADM provides recommendations that are designed to reduce the uncertainty associated with ex-ante savings calculations. M&V recommendations are intended to help improve alignment between ex-ante and ex-post savings, increase the accuracy of measure-level findings (e.g., ex-post savings and EUL), and improve the efficiency of Program evaluation. ADM's recommendations are summarized below and detailed in Chapter 1 of this M&V report.

1) The Program could benefit from efforts to diversify geographically and with respect to measure mix; diversification efforts could counter the Program's increasing dependence on savings generated from behavioral channels and ESCO projects.

2) The Program should consider removing COVID-19 related impacts from the modeling structure for CEI as much as possible. The close alignment between the ex-ante and ex-post CEI models indicates that COVID-19 related impacts are not needed for estimating CEI savings.

3) The Program should work with CCSD to reduce HVAC-related energy loads in both May, and August—October. ADM found that HVAC-related energy efficiency measures are likely to have a greater impact on energy savings during the late Spring, late Summer, and early Fall compared to the rest of the year.

4) The Program should consider using the same post-period durations for both the CEI and SEM models. The ex-ante CEI models included all non-baseline weeks in the post -period, whereas the ex-ante SEM models excluded November 2, 2020 – January 2, 2022, from the post-period. ADM recommends that the Program should align the ex-ante CEI and SEM modelling approaches wherever possible.

5) For capital improvement projects, the Program could benefit from a pre-construction review process similar to the process that has been in place for the NV Energy Business Energy Services Program since 2013. A pre-construction review process would enable the Program and ADM to review large projects before implementation, provide ADM insights regarding ex-ante claimed energy savings, and facilitate ongoing coordination between implementation and M&V activities.

6) For the Capital Improvement engine block heater controller projects, the calculations should use a curve which is based on manufacturer data, if available, instead of using a generic curve used in the Regional Technical Forum[3] (RTF) calculator for the engine-mounted or wall-mounted controller. Also, actual bus schedules for those days when school is in session should be used, instead of seven days a week schedule.

[3] https://rtf.nwcouncil.org/

2 PROGRAM BACKGROUND

This chapter provides an overview description of the structure of the Program.

The Program is designed to facilitate energy efficiency improvements and peak demand reductions in Nevada's public schools, educational institutions, and related facilities. The Program's approach is to identify existing barriers to energy reduction in the participating school districts and recommend and implement solutions to overcome those barriers. Services provided by the Program include:

- Benchmarking school energy performance;
- Conducting workshops to develop master plans;
- Providing training and technical assistance to identify efficiency improvements in existing buildings;
- Disseminating best practices from highly energy-efficient school districts; and
- Designing and building energy-efficient schools through both new construction and retrofit projects.

The CEI behavioral channel offers walk-through energy assessments, energy benchmarking, and energy efficiency training to participating schools. CEI was initially implemented at 12 CCSD sites during PY2019, then expanded to over 400 CCSD sites between PY2020 and PY2023. CEI training focuses mainly on low-cost or no-cost improvements to facilities' energy usage and energy management systems, while also assisting facility staff in identifying capital projects that can lead to long-term energy efficiency improvements.

In PY2023 in the NPC service territory, CEI behavioral treatment was implemented at 407 CCSD school facilities for which the Program's ex-ante claimed savings of 25,692,826 kWh. As indicated in Table 2-1, approximately 94 percent of the Program's ex-ante claimed savings in NPC were associated with CEI projects. In addition, five capital improvement projects were implemented, which included lighting, HVAC thermostats, and new construction projects.

Table 2-1. NPC Program Ex-Ante Expected Savings

Measure Category	Project Count	Ex-Ante Annual Savings (kWh)	Percent of Total Ex-Ante Savings
CEI	407	25,692,826	93.5%
Lighting	2	964,275	3.5%
New Construction	2	432,351	1.6%
T-Stats	1	375,803	1.4%
Total	412	27,465,255	100%

The Program expanded its behavioral channel to the SPPC service territory in the fourth quarter of 2020. Although an ESCO contractor was engaged in similar activities for WCSD, the Program asserts that it provided behavioral treatment expertise to support the ESCO's activities. The Program calls the SPPC behavioral offering SEM to differentiate it from the CEI behavioral offering in the NPC service territory.

In PY2023, SEM savings were claimed for 130 WCSD sites and for 11 capital improvement projects, which included lighting, HVAC, building controls, engine block heater controllers, pump motor retrofits and new construction projects. For the 141 projects that the Program implemented in PY2023 in the SPPC service territory, ex-ante claimed savings were 3,352,525 kWh. As indicated in Table 2-2 below, approximately 50 percent of the Program's ex-ante claimed savings in SPPC were associated with SEM projects.

Table 2-2. SPPC Program Ex-Ante Expected Savings

Measure Category	Project Count	Ex-Ante Annual Savings (kWh)	Percent of Total Ex-Ante Savings
SEM	130	1,676,568	50.0%
Building Controls	1	318,375	9.5%
Engine Block Heater Controller	2	412,801	12.3%
HVAC	1	85,112	2.5%
HVAC NC	1	47,061	1.4%
Lighting	5	810,962	24.2%
Pump Motors	1	1,646	0.0%
Total	**141**	**3,352,525**	**100%**

3 M&V METHODOLOGY

The objective of the impact evaluation for the PY2023 Program was to determine the energy savings (kWh) and summer critical peak demand (kW) reductions resulting from activities during PY2023 for NPC and SPPC. This chapter describes the methods that ADM used to determine ex-post verified annual energy (kWh) savings and summer critical peak demand (kW) savings resulting from measures that the PY2023 Program implemented in participating educational institutions and facilities.

3.1 Sampling Plan

Data used to calculate the gross savings achieved by the Program were collected for a sample of sites at which projects were completed during 2023. Program data indicated that a total of 412 projects were completed in the NPC service territory, providing ex-ante estimated annual savings of 27,429,778 kWh. In the SPPC service territory, a total of 141 projects were completed, providing ex-ante estimated annual savings of 3,352,525 kWh.

ADM's sample design for selecting projects for M&V analyses utilized the Dalenius-Hodges stratified random sampling method to ensure that ex-post verified savings were determined with ±10 percent relative precision (or better) at the 90 percent confidence level. Sampling was performed at the project level, with projects grouped into the sampling strata indicated in Table 3-1 and Table 3-2. The NPC sample achieves relative precision of ±0.1 percent, while the SPPC sample achieves relative precision of ±7.7 percent. For sites included in the M&V sample, every project implemented at the site was included in the M&V impact analysis.

For capital improvement projects, M&V sampling and data collection were approximately concurrent with Program implementation. ADM used a near real-time process whereby a portion of the sample was selected periodically as projects were completed. The timing of sample selection was contingent upon the timing of the completion of the projects.

Projects incentivized through the Program are assigned to strata based on their ex-ante estimated energy (kWh) savings or specific project type.

Table 3-1 provides statistical characteristics for the NPC sampling plan. Capital improvement projects were assigned to sampling strata 1, 2, or 3 according to the magnitude of ex-ante kWh savings. The NPC sampling plan assigns CEI projects to stratum 4.

Table 3-1. NPC Population Statistics and Sampling Plan

↓Sampling Criteria	Stratum 1	Stratum 2	Stratum 3	Stratum 4	Total
Strata Max	64,792	383,386	899,483	484,807	n/a
Number of Projects	2	2	1	407	412
Total Ex-Ante Savings (kWh)	113,757	759,189	899,483	25,692,826	27,465,255
Average Ex-Ante Savings (kWh)	56,879	379,595	899,483	63,127	66,663
Standard Deviation of Ex-Ante Savings (kWh)	11,191	5,362	n/a	61,369	n/a
Coefficient of Variation	0.20	0.01	n/a	0.97	n/a
Sample n	1	1	1	407	410
Statistical Precision of kWh Savings Estimation at the 90% Confidence Level:					+/-0.10%

Table 3-2 provides statistical characteristics for the SPPC sampling plan. The SPPC sampling plan assigns SEM projects to stratum 5. Capital improvement projects were assigned to strata 1 through 4.

Table 3-2. SPPC Population Statistics and Sampling Plan

↓Sampling Criteria	Stratum 1	Stratum 2	Stratum 3	Stratum 4	Stratum 5	Total
Strata Max	47,061	85,112	384,334	599,895	151,093	n/a
Number of Projects	4	4	2	1	130	141
Total Ex-Ante Savings (kWh)	80,108	293,245	702,709	599,895	1,676,568	3,352,525
Average Ex-Ante Savings (kWh)	20,027	73,311	351,355	599,895	12,897	23,777
Standard Deviation of Ex-Ante Savings (kWh)	21,849	9,770	46,640	n/a	25,727	n/a
Coefficient of Variation	1.09	0.13	0.13	n/a	1.99	n/a
Sample n	2	2	1	1	130	136
Statistical Precision of kWh Savings Estimation at the 90% Confidence Level:						+/-7.7 %

ADM selected an M&V sample of three NPC capital improvement projects and six SPPC capital improvement projects. ADM requested data for a census of all CEI and SEM sites. ADM reviewed all available documentation (e.g., audit reports, savings calculation work papers, and site-specific energy usage data) for M&V sample sites, with attention to procedures and documentation of savings calculations. Detailed descriptions of M&V methodologies are provided in the following chapter.

3.2 Review of Documentation

After the sample was selected, the implementation contractor provided documentation pertaining to the sampled projects. The first step in the evaluation effort was to review this documentation and other Program materials that were relevant to the evaluation effort.

For each project, the available documentation (e.g., audit reports, savings calculation work papers, etc.) for each rebated measure was reviewed, with close attention to procedures and documentation pertaining to ex-ante calculated savings. Documentation reviewed for all projects in the sample included Program forms, databases, reports, billing system data, weather data, and any other potentially useful data. Each project was reviewed to determine whether the following types of information had been provided:

- Documentation for the pre-existing equipment, including descriptions, schematics, performance data, and other supporting information.
- Documentation for the new energy-efficient equipment, including descriptions, schematics, performance data, and other supporting information.
- Information about the savings calculation methodology, including assumptions, specifications, sources for specifications, and correctness of calculations.
- For CEI and SEM projects, the implementation contractor provided documentation outlining the changes in energy consumption, actions taken by the Program to ensure

optimization of energy savings, excluded sites, and other behavioral changes relevant to the energy models.

Where there was uncertainty regarding Program project specifications or incomplete project documentation, ADM analysts communicated with the implementation contractor staff. ADM provided the implementation contractor with various data requests for additional information and clarification. ADM and the implementation contractor communicated and collaborated throughout all the M&V activities related to the PY2023 Program.

3.3 Verification Procedures

When sites were selected for the M&V sample, ADM notified NV Energy Program management and concurrently provided the implementation contractor with a list of projects for which ADM needed documents. ADM utilized engineering desk reviews of the Program-level and project-level data. During 2023, ADM determined that appropriate M&V rigor could be achieved without conducting in-person visits to participating Program sites.

3.4 Methodologies for Calculating kWh Savings

ADM uses measure-specific methodologies to analyze and determine gross savings per project. Table 3-3 below provides a summary of the M&V methodologies used for determining energy savings.

Table 3-3. Typical M&V Methodologies for Determining Energy Savings

Type of Measure	Method to Determine Savings
Retrofit Lighting	ADM's custom-designed Lighting Evaluation Model, which uses data on wattages before and after installation of measures and fixture hours-of-use ("HOU").
HVAC Equipment Replacement	Equivalent full load hours ("EFLH") method for determining savings from HVAC measures; EFLH were determined using DOE-2 models that incorporated the corresponding weather files.[4]
Engine Block Heater Controller	A calculator adapted from "VehicleEngineBlockHeaterControls_v3_0.xlsm[5]" is used for savings calculations. This tool is developed for the Regional Technical Forum's Vehicle Engine Block Heater Controls UES Measure. It utilizes region-specific TMY3 data, a set temperature threshold, Owner-provided bus schedules and annual start and end months to calculate the estimated hourly kWh usage of deployed engine block heaters with and without controls. ADM customized the calculator by developing a regression curve, based on the specific controller's manufacturing data.
CEI/SEM	Pre and post energy consumption regression analysis.

Energy savings realization rates were calculated for each project. The realization rate is the ratio of ex-post verified energy (kWh) savings to ex-ante expected energy (kWh) savings. At the project

[4] A calculation of pre- and post-energy consumption using full load hours which represent the equivalent time a unit will spend operating at its peak capacity during a typical year.

[5] https://rtf.nwcouncil.org/measure/engine-block-heater-controls/

level, ex-post verified energy (kWh) savings are the achieved savings that have been measured and verified for each M&V site. Ex-ante expected energy savings (kWh) were provided by the Program.

After determining ex-post energy savings for the sampled sites, ADM calculated program-level kWh savings by applying the realization rate ratio for the M&V sample sites to the stratified population of Program participants.

The following discussion describes procedures used for calculating savings from various measure types. Site-specific savings and realization rate explanations are provided in the following chapter.

3.4.1 Analyzing Savings from Lighting Measures

Lighting measures that were examined included retrofits of existing fixtures and lamps and/or ballasts with energy-efficient fixtures. These lighting measures reduce demand, while not affecting hours of use. Lighting control strategies that might include the addition of energy-conserving control technologies such as motion sensors or daylighting controls were also examined. These measures typically involve a reduction in HOU and/or dimming which causes a reduction in power usage by the fixtures.

Annual lighting HOU were determined by a comprehensive lighting study performed by ADM in PY2011. That study has been described in detail in several previous M&V reports for the Program.

For projects that include the installation of occupancy sensor controls, the post-installation HOU was reduced by 30 percent. The combination of occupancy and daylight sensors reduces the HOU by 34 percent. These are based on engineering calculations that are consistent with industry literature.[6,78]

During PY2015, ADM initiated a study to determine annual lighting HOU for colleges and universities by territory and by space type. ADM had planned to continue this study; however, the continued study was deferred due to the COVID-19 pandemic. If possible, the higher education hours of use study will continue in 2024, i.e., ADM will monitor HOU for appropriate projects

[6] Study referenced for lighting occupancy sensor hours reduction of 30 percent: Levine, M., Geller, H., Koomey, J., Nadel S., Price, L., *"Electricity Energy Use Efficiency: Experience with Technologies, Markets and Policies"* ACEEE, 1992. Lighting control savings fraction of 30 percent is consistent with current programs offered by National Grid, Northeast Utilities, Long Island Power Authority, NYSERDA, and Energy Efficiency Vermont.

[7] Technical reference manual used for lighting occupancy and lighting sensors decreasing hours of use by 34 percent: "*California Municipal Utilities Association Savings Estimation Technical Reference Manual 2017 Third Edition"* CMUA, 2017.

[8] 2019 California Building Energy Efficiency Standards for Residential and Nonresidential Buildings; Lighting Power Adjustment Factors, page 227.

that are selected as M&V sample sites. Approximately 50 more sample points will need to be collected to conclude the study; ideally, the study will conclude by the end of 2024.

Analyzing the savings from lighting measures requires data for retrofitted fixtures on (a) wattages before and after retrofit and (b) HOU before and after the retrofit. ADM uses per-fixture baseline demand, retrofit demand, and appropriate post-retrofit HOU to calculate annual energy savings for sampled fixtures of each usage type. Annual energy savings for each sample fixture is calculated using the following formula:

$$Annual\ Energy\ Savings = kWh_{pre} - kWh_{post}$$

Equation 3-1

Where:

kWh_{pre} = *amount of kWh used by preexisting fixtures*

kWh_{post} = *amount of kWh used by post-installation fixtures*

To calculate total savings attributable to lighting measures, including impacts on HVAC operation, savings from lighting measures in conditioned spaces are adjusted by region-specific and building type-specific heating and cooling interaction factor.

3.4.2 Heating and Cooling Interaction Factor ("HCIF")

Installing energy-efficient lighting in air-conditioned spaces saves electricity in two ways: first, by reducing lighting electrical loads; and second, by introducing less heat in conditioned spaces, hence incrementally decreasing space cooling loads. The relatively low heat output from energy-efficient lighting also incrementally increases space heating loads. Space heating and cooling impacts of energy-efficient lighting are described using a ratio that is known as the HCIF. The HCIF was included in the calculations to determine energy savings (kWh) associated with the facility's HVAC equipment. HCIF was incorporated into the energy impact analysis for each M&V sample site. ADM uses a bin analysis method to calculate the HCIF for each site based on the Typical Meteorological Year 3 ("TMY3") data. The bin analysis accounts for the average hourly temperature, coefficient of performance for both heating and cooling equipment, and percent air leakage for the space.

The HCIF value represents the ratio of (a) total post-retrofit kWh savings and (b) lighting-only kWh savings. For example, if HCIF = 1.01, then post-retrofit kWh usage for heating and cooling decreased overall, thus improving, by one percent, the overall kWh savings provided by the energy-efficient lighting measure. Conversely, if HCIF = 0.99, then post-retrofit kWh usage for heating and cooling increased overall, thus reducing, by one percent, the overall kWh savings provided by the energy-efficient lighting measure. HCIF for the Program was developed in tandem with the energy savings curves; the development of both methods is explained in Section 3.5 below.

3.4.3 Analyzing Savings from HVAC Equipment Replacement Measures

Savings for HVAC equipment replacement measures installed at a facility are derived by using EFLHs developed through DOE-2 simulations. DOE-2 is an industry-standard building energy analysis and load simulation software program that combines a description of the building layout, construction, usage, and conditioning systems with hourly weather data to perform an hourly simulation of building energy use. The DOE-2 simulations also allow the calculation of the primary and secondary effects of lighting measures on energy use. Each simulation calculates HVAC energy and demand usage to be expected under different assumptions about equipment and/or construction conditions.

HVAC equipment replacement measures use the following algorithm for determining ex-post cooling energy savings:

$$kWh_{Savings_c} = CAP_C \times \frac{1kW}{1{,}000W} \times EFLH_C \times \left(\frac{1}{EER_{base}} - \frac{1}{EER_{post}}\right)$$

Equation 3-2

Where:

CAP_C = *Rated equipment cooling capacity of the new unit (BTU/hr.)*

$EFLH_C$ = *Equivalent full-load hours for cooling*

EER_{base} = *Full Load baseline energy efficiency rating of the baseline cooling equipment*

EER_{post} = *Full Load nameplate energy efficiency rating of the installed cooling equipment*

3.4.4 Analyzing Savings from Installing Engine Block Heater Controller Measures

ADM calculated savings for the engine block heater controller measure using a calculator adapted from "VehicleEngineBlockHeaterControls_v3_0.xlsm ". This tool is developed for the Regional Technical Forum's Vehicle Engine Block Heater Controls UES Measure. It utilizes region-specific TMY3 data, a set temperature threshold, Owner-provided vehicle operating schedules and annual start and end months to calculate the estimated hourly kWh usage of deployed engine block heaters with and without controls. The engine block heater controller measures use the following algorithm for determining ex-post cooling energy savings for each hour and then summed to get annual kWh savings:

$$kWh_{Savings_ebh} = \sum_{n=1}^{8760} [CAP_{ebh} \times (Duty\ Cycle_{base} - Duty\ Cycle_{post})]$$

Equation 3-3

Where:

CAP_{ebh} = *Rated capacity of the engine block heater (kW)*
$Duty\ Cycle_{base}$ = *Heater duty cycle without the controller installed*
$Duty\ Cycle_{post}$ = *Heater duty cycle is on with the controller installed*

Under the baseline conditions, the heater is always on when it is plugged in. However, with the controller installed put into "Maintain Ready" mode, the microprocessor senses the outside temperature and calculates a duty cycle for the heater. It divides the hour into 6 cycles (of ten total minutes each) and calculates how much of that ten minutes duration will be the heater on and off. Example: at 28°F the unit would be at a 50% duty cycle. A 50% duty cycle would mean that the controller turns the heater on for 5 minutes on then off for 5 minutes repeating that cycle for 6 duty cycles every hour.

The RTF calculator uses a generic curve to develop a correlation between outside air temperature and the duty cycle. ADM customized the calculator by developing a regression curve based on data provided by the manufacturer. ADM developed the following regression curves, presented in Table 3-4 below for the "maintain ready" and "timed ready" modes, using manufacturer's data to determine the duty cycle, where y is the duty cycle and x is outside air dry-bulb temperature for a particular hour in a day (dependent variable). ADM calculated savings for the maintain ready mode. Weather data for Elko Municipal Airport h used for Elko CSD projects and Winnemucca Municipal Airport h used for Lander CSD projects.

Table 3-4. Engine Block Heater Controller Curves

Maintain Ready Mode			**Timed Ready Mode**	
a	-0.0008		a	-0.113
b	0.0135		b	4.565
c	0.1974			
d	93.286			
$y = -0.0008x^3 - 0.0135x^2 - 0.1974x + 93.286$			$y = -0.1134x + 4.565$	

3.4.5 Analyzing Savings from CEI and SEM Measures

During the M&V process, ADM first reviewed the ex-ante regression models provided by the implementer for the CEI and SEM savings estimates. To verify savings, ADM developed IPMVP Option C analysis models using interval billing data, school schedules, at-home learning schedules, and weather data. For cohorts containing more than one school building, linear mixed-effects

models ("LMEM") were used. Generalized linear models ("GLM") were used for CCSD cohorts containing only one school building.[9]

ADM used hourly billing data provided by NV Energy for each school in the Program. ADM estimated CDD and HDD to account for the impact of temperature on school energy consumption. Using available resources, ADM also accounted for student and staff schedules, in-person learning days, and school closures.

The documentation provided by the implementer noted that CCSD operated all schools at 100% occupancy seven days per week during the summer break indicated on the CCSD school calendar. There were also additional changes made to HVAC operations beginning October 4, 2021. ADM included additional dummy variables to the CCSD models to account for these operational changes.

For CEI and SEM participants, ADM evaluated savings using two savings periods—the baseline and PY2023. The baseline and measurement periods used are shown in Table 3-5.

Table 3-5. CEI and SEM Baseline and Measurement Periods

Territory	Cohort	Baseline Period	PY2023 Measurement Period
NPC	Alumni Participants	6/4/2018 – 6/2/2019	1/1/2023 – 12/31/2023
NPC	Non-Alumni Participants	1/7/2019 – 1/5/2020	1/1/2023 – 12/31/2023
SPPC	N/A	7/1/2019 – 11/1/2020	1/1/2023 – 12/31/2023

For the CEI program, 13 sites were not treated by the implementor in PY2023 and therefore were removed from the ex-ante models and both the ex-post models and the ex-post savings calculation. A breakdown of these sites is in Table 3-6. For the SEM program, 30 sites were not treated by the implementor in PY2023 and therefore were removed from the ex-ante models and both the ex-post models and the ex-post savings calculation. A breakdown of these sites is in

Table *3-7*.

Table 3-6: Number of NPC Sites Not Treated in the CEI Program for PY2023

School Type	Number of Sites Not Treated
Elementary School	9
High School	1
Middle School	1
Other	2
Total	**13**

[9] The "Alumni Other" cohort.

Table 3-7: Number of SPPC Sites Not Treated in the SEM Program for PY2023

School Type	Number of Sites Not Treated
Elementary School	22
High School	5
Middle School	3
Total	**30**

Additionally, 22 sites in the NPC service territory and 4 sites in the SPPC service territory were removed from the ex-post models due to having data range or quality issues. These sites were included in the facility count used as a multiplier for the ex-post savings calculations because they were treated in the ex-ante models in PY2023. These sites—and the reasons for removal from the ex-post models—are listed in Table 3-8.

Table 3-8: Sites Removed from the Ex-Post Models that were in the Ex-Ante Models

Territory	Cohort	School	Reason
NPC	Elementary School	Alamo, Tony ES	Insufficient Post-Period Data
NPC	Elementary School	Beatty, John R. ES	Insufficient Post-Period Data
NPC	Elementary School	Beckley, Will ES	Insufficient Post-Period Data
NPC	Elementary School	Bendorf, Patricia A. ES	Insufficient Post-Period Data
NPC	Elementary School	Cahlan, Marion ES	Insufficient Post-Period Data
NPC	Elementary School	Gray, R. Guild ES	Insufficient Post-Period Data
NPC	Elementary School	Hickey, Liliam Lujan ES	Insufficient Post-Period Data
NPC	Elementary School	Keller, Charlotte, and Jerry ES	Insufficient Post-Period Data
NPC	Elementary School	Mathis, Dr. Beverly S. ES	Insufficient Post-Period Data
NPC	Elementary School	Mendoza, John F. ES	Insufficient Post-Period Data
NPC	Elementary School	Tartan, John ES	Insufficient Post-Period Data
NPC	Elementary School	Taylor, Glen C. ES	Insufficient Post-Period Data
NPC	Elementary School	Ward, Kitty McDonough ES	Insufficient Post-Period Data
NPC	Elementary School	Wolff, Elise L. ES	Insufficient Post-Period Data
NPC	High School	Legacy HS	Insufficient Post-Period Data
NPC	High School	Palo Verde HS	Insufficient Post-Period Data
NPC	Middle School	Canarelli, Lawrence and Heidi MS	Insufficient Post-Period Data
NPC	Middle School	Johnson, Walter JHS	Insufficient Post-Period Data
NPC	Middle School	Webb, Del E. MS	Insufficient Post-Period Data
NPC	Other	Telecom	Insufficient Post-Period Data
NPC	Other	Walker, J. Marlan International School	Insufficient Post-Period Data
NPC	Other	Food Svc.	Average kWh was >3 SD away from the average kWh for its school type
SPPC	Elementary School	Bohach ES	Insufficient Post-Period Data
SPPC	Elementary School	Palmer ES	Average kWh was >3 SD away from the average kWh for its school type
SPPC	Elementary School	Sun Valley ES	Average kWh was >3 SD away from the average kWh for its school type
SPPC	Middle School	Incline MS	Average kWh was >3 SD away from the average kWh for its school type

Weather data from the McCarran International Airport, Las Vegas ("KLAS") and Reno/Tahoe International Airport, Reno ("KRNO") weather stations were used to normalize ADM's ex-post regression models. ADM applied a regression analysis using hourly interval meter data and weather data, utilizing CDD, HDD, and the school occupancy schedules.

For the WCSD regression modeling, CDD and HDD values were optimized by comparing the RMSE between measured kWh and predicted kWh produced using the linear model depicted in Equation 3-4. Each linear model was produced using base CDD values ranging from 50°F to 80°F and base HDD values ranging from 40°F to 70°F with increments of 5°F. The CDD and HDD bases that resulted in the lowest RMSE score are shown in Table 3-9.

$$kWh_i = \beta_1(CDD) + \beta_2(HDD) + \beta_3(WDAY) + \sum_{k=0}^{23} \gamma_k(HourOfTheDay_k)$$

Equation 3-4. M&V Regression Equation used to predict kWh for CDD and HDD optimization for WCSD.

Where:

kWh	= Predicted daily kWh consumption
CDD	= Predicted cooling degree days for a given day and hour
HDD	= Predicted heating degree days for a given day and hour
WDAY	= Day of the week as a categorical numerical value (1=Sunday through 7=Saturday)
HourOfTheDay	= An adjustment factor for varying consumption during different hours of the day.

Table 3-9. CDD and HDD Base Values used for WCSD Ex-ante and Ex-post Models

			Ex-Ante		Ex-Post	
School District	**Cohort/School**	**School Type**	**CDD Base (°F)**	**HDD Base (°F)**	**CDD Base (°F)**	**HDD Base (°F)**
WCSD	Non-Alumni	Elementary School	70	45	70	50
WCSD	Non-Alumni	High School	65	-	75	40
WCSD	Non-Alumni	Middle School	65	55	75	50
WCSD	Non-Alumni	Other	65	50	70	40

For CCSD, a base CDD of 60°F was used, as was the case in program years 2021 and 2022.[10]

[10] For CCSD, only CDD were used in the analysis because average daytime temperatures, even in the winter, are above 50°F.

In addition to weather variables, dummy variables were also included to represent changes to WCSD school occupancy due to the COVID-19 pandemic, HVAC changes for CCSD after October 2021, and post-COVID-19 summer programming for grades K-7 in WCSD. Regression equations that ADM used to determine CEI and SEM ex-post verified energy savings are provided in Equation 3-5 through Equation 3-10. Table 3-10 shows key differences between the model equations and the equation used for the "Elementary School" cohort (Equation 3-6 for the CEI Alumni and Non-Alumni cohorts and Equation 3-7 for the SEM cohort).

Table 3-10. Differences Between CCSD and WCSD LMEM and GLM with the "Elementary School" Model

Territory	Cohort	School Type	Difference(s) Between This Model and the "Elementary School" Model for its Territory and Cohort
NPC	Alumni	Other	The "Student Day" variable is excluded, as this cohort contains a single administrative building.
NPC	Non-Alumni	Other	The "Student Day" variable is excluded, as this cohort contains mostly administrative buildings.
SPPC	Non-Alumni	High School	The "Summer School" term was removed because the post-COVID summer programming was not implemented in high schools.
SPPC	Non-Alumni	Middle School	The "TeacherAtHome*COVID Shutdown" intersection term was not included, as it was colinear with other terms (see Section 7.2 for how collinearity was tested).
SPPC	Non-Alumni	Other	The "Student Day" variable and "Student Day * Student at Home") intersectional variable are both excluded, as this cohort contains mostly administrative buildings.

$$kWh_i = \alpha_{ij} + \beta_1(Post) + \beta_2(CDD) + \beta_3(StaffDay) + \beta_4(Op.Change) + \sum_{k=0}^{23} \gamma_k(HourOfTheDay_k) + (1|School)$$

Equation 3-5: M&V LMEM Regression Equation used to Evaluate CCSD Facilities in the "Other" Category

$$kWh_i = \alpha_{ij} + \beta_1(Post) + \beta_2(CDD) + \beta_3(StudentDay) + \beta_4(StaffDay) + \beta_5(Op.Change) + \sum_{k=0}^{23} \gamma_k(HourOfTheDay_k) + (1|School)$$

Equation 3-6: M&V LMEM Regression Equation used to Evaluate all other CCSD Schools

$$kWh_i = \alpha_{ij} + \beta_1(Post) + \beta_2(CDD) + \beta_3(HDD) + \beta_4(StudentDay) + \beta_5(StaffDay) + \beta_6(StudentAtHome * StudentDay) + \beta_7(COVID\ Shutdown) + \beta_8(TeacherAtHome * COVID\ Shutdown) + \beta_9(SummerSchool) + \sum_{k=0}^{23} \gamma_k(HourOfTheDay_k) + (1|School)$$

Equation 3-7: M&V Regression Equation used to Evaluate WCSD Elementary Schools

$$kWh_i = \alpha_{ij} + \beta_1(Post) + \beta_2(CDD) + \beta_3(HDD) + \beta_4(StudentDay) + \beta_5(StaffDay) + \beta_6(StudentAtHome * StudentDay) + \beta_7(COVID\ Shutdown) + \beta_8(SummerSchool) + \sum_{k=0}^{23} \gamma_k(HourOfTheDay_k) + (1|School)$$

Equation 3-8: M&V Regression Equation used to Evaluate WCSD Middle Schools

$$kWh_i = \alpha_{ij} + \beta_1(Post) + \beta_2(CDD) + \beta_3(HDD) + \beta_4(StudentDay) + \beta_5(StaffDay) + \beta_6(StudentAtHome * StudentDay) + \beta_7(COVID\ Shutdown) + \beta_8(TeacherAtHome * COVID\ Shutdown) + \sum_{k=0}^{23} \gamma_k(HourOfTheDay_k) + (1|School)$$

Equation 3-9: M&V Regression Equation used to Evaluate WCSD High Schools

$$kWh_i = \alpha_{ij} + \beta_1(Post) + \beta_2(CDD) + \beta_3(HDD) + \beta_4(StaffDay) + \beta_5(StudentAtHome * StudentDay) + \beta_6(COVID\ Shutdown) + \sum_{k=0}^{23} \gamma_k(HourOfTheDay_k) + (1|School)$$

Equation 3-10: M&V Regression Equation used to Evaluate WCSD Facilities in the "Other" Category

Where:

kWh	= Monthly kWh consumption
Post	= A dummy variable that represents if the data point is in the baseline period (post = zero) or the PY2023 reporting period (post = one). The intervals for these variables are in Table 3-5.
CDD	= Cooling degree days for a given day and hour calculated using a base temperature of 60°F for CCSD; values for WCSD are depicted in Table 3-9.
HDD	= Heating degree days for a given day and hour. Values for WCSD are depicted in Table 3-9.
StudentDay	= A dummy variable that is either zero if the data point indicates a time interval during which students do not attend school[11] (virtual or otherwise) or one otherwise.
StudentAtHome	= A dummy variable that is either one if the data point indicates a time interval during which students were conducting virtual learning or zero otherwise.
StaffDay	= A dummy variable that is either one if the data point indicates a time interval during which staff are working or zero otherwise.
TeacherAtHome	= A dummy variable that is either one if the data point indicates a time interval during which staff worked virtually from home or zero otherwise.
Op. Change	= A dummy variable added to the CCSD model that is one between both 5/1/2023 – 5/22/2023 and 8/2/2023 – 10/31/2023.
COVID Shutdown	= A dummy variable for WCSD that represents low building occupancy from 3/30/2020 – 8/1/2020. It is one during that interval and zero otherwise.
SummerSchool	= A dummy variable for WCSD Elementary and Middle School models that is one during the weekdays affected by post-pandemic summer programming (6/20/2023 — 7/13/2023) and zero otherwise.

[11] During the CCSD summer calendar, this variable was set to "1" seven days per week to reflect operational changes documented by the implementer.

HourOfTheDay	= An adjustment factor for varying consumption during different hours of the day.
(1|School)	= A variable representing the "randomness" caused by correlations between variables across each site in the cohort that is being modeled. For the GLM models, this variable was not included.

Models for PY2023 (both GLM and LMEM) were created with a time range beginning at the start of the baseline (see Table 3-5) through December 26, 2023. The models were annualized by multiplying the post-period coefficient by the number of hours in the PY2023 reporting year (365*24 or 8760 hours).

3.5 Determining Energy Savings Curves

ADM utilized measure-specific energy savings curves to determine program-level energy (kWh) savings per month per rate class and program-level critical peak demand (kW) savings per month per rate class. The energy savings curves were derived from curves published through the California End Use Survey ("CEUS") ("CEUS Curves") and hourly billing data.

To adapt CEUS Curves to Nevada's schools, ADM modified the CEUS Curves as follows:

- CEUS Curves applicable to K-12 schools were aligned with the CCSD instructional calendar for NPC and aligned with the WCSD instructional calendar for SPPC.
- HCIF specific to each region was incorporated into the CEUS Curve for interior lighting measures. This modification improves the shape and accuracy of the interior lighting energy savings curve but does not change annual energy (kWh) savings given that the energy savings curve was normalized before being employed to disaggregate kWh savings into 8,760 hourly bins per rate class.

For higher education facilities, ADM utilized the unmodified CEUS Curve. ADM is conducting a multi-year monitoring effort across various higher education facilities throughout the state. Once that study is complete, a custom curve will be created based on the primary data collected and compared to the CEUS Curve to determine the most accurate methodology for future program years.

3.5.1 Assessing the Applicability of CEUS Curves

Appropriate energy savings curves are essential to allocate kWh and critical peak kW savings to both hourly and monthly bins, for each rate class that participated in the 2023 Program. ADM explored using an energy savings curve that was specific to the 2023 Program. ADM conducted a monitoring study in Nevada schools in PY2011; ADM examined the feasibility of using the monitored lighting and HVAC schedules to create appropriate curves. After examining the logger data from the PY2011 study, ADM found that the monitored lighting and HVAC schedules closely matched the respective CEUS Curves for schools. ADM determined that the CEUS Curves, after

being modified to align with the actual instructional calendar for CCSD and WCSD, provide the most accurate energy savings curves for the 2023 Program.

3.5.2 Alignment of CEUS Curves with School Districts' Calendars

Ninety percent of the schools in the 2023 Program follow a traditional nine-month schedule. CEUS Curves for lighting and HVAC measures were based predominantly on traditional nine-month schedules. For example, the CEUS curve for interior lighting depicts monthly energy usage declines in June and reaches the lowest point in July, then increases during August and September until it reaches a peak in October.

Given that the CEUS data indicates that all schools were out-of-session during at least part of July, and 90 percent of schools were out-of-session during all of July, ADM used CEUS data for July to "model" all out-of-session weekdays for summer vacation weeks. In other words, ADM modified the CEUS Curves to incorporate the actual summer schedule for CCSD and WCSD. Because the CEUS lighting schedules during July weekdays closely match ADM's PY2011 lighting study data for summertime non-instructional days, ADM created each energy savings curve for the PY2023 Program by transposing weekday savings from the corresponding July CEUS Curve onto all out-of-session summer days. Therefore, compared to the corresponding CEUS Curves, ADM's PY2023 Program curves have lower summertime kWh savings.

For the interior lighting energy savings curve, Figure 3-1 below depicts the difference in kWh savings when comparing an in-session weekday (e.g., the lighter line represents September 10, 2010) versus an out-of-session weekday (e.g., the darker line represents July 15, 2010).

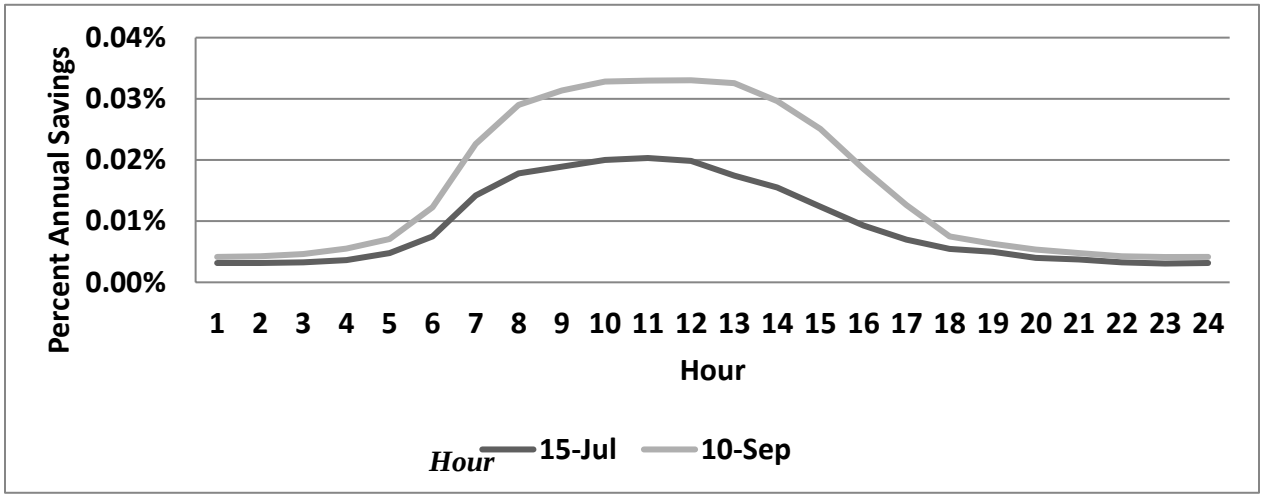


Figure 3-1. CEUS Interior Lighting Savings Curve, Out-of-Session vs. In-Session Weekday

Figure 3-2 below compares the CEUS interior lighting curve to the energy savings curve that ADM developed to more accurately represent the CCSD Calendar. The two energy savings curves are similar; ADM's energy savings curve shows lower lighting energy savings during June and July.

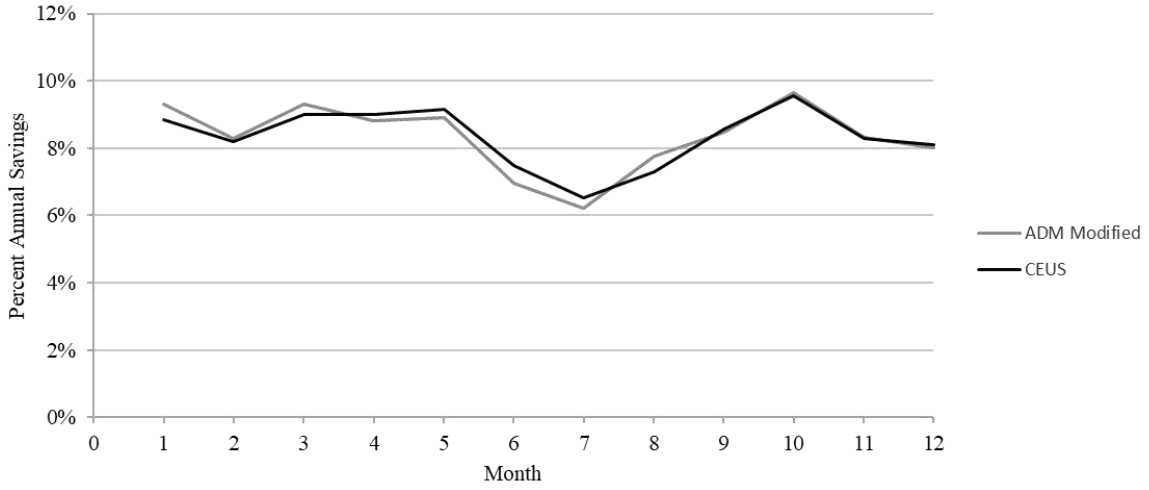


Figure 3-2. Comparison of Original CEUS Curve to ADM-Modified Curve for CCSD

3.5.3 Incorporating HCIF Factors into the Energy Savings Curve

The HCIF was incorporated into the energy impact analysis for each M&V sample site. The overall energy savings curve also reflects secondary heating and cooling impacts in a manner that is consistent with the site-specific HCIF calculations. ADM's methodology, which has been described in M&V reports since 2012, calculates HVAC impacts by estimating cooling and heating equipment efficiencies and then applying specific thermal fractions for cooling and heating.[12] These same variables that are used in the equations below are also used to calculate HCIF.

$$kWh\ impact_{AC} = kWh\ savings_{Lighting} \times Thermal\ Fraction_{AC} \div MCOP_{Electric\ AC}$$

Equation 3-11

$$kWh\ impact_{Heating} = kWh\ savings_{Lighting} \times Thermal\ Fraction_{Heat} \div MCOP_{ElectricHeat}$$

Equation 3-12

Where:

$kWh\ savings_{Lighting}$ = Verified annual energy savings from lighting retrofits.

$Thermal\ Fraction_{AC}$ = Fraction of lighting impact that results in avoided cooling; ADM uses bin calculators to determine this fraction.[13]

$Thermal\ Fraction_{Heat}$ = Fraction of lighting impact that results in increased heating load for the affected space; ADM uses bin calculators to determine this fraction.

[12] Thermal fraction is the ratio of annual lighting energy contributing to cooling (or heating) load.

[13] Bin calculators determine hourly fractions of avoided or increased thermal load due to the efficient lighting measure.

$MCOP_{ElectricAC}$ = Marginal coefficient of performance, A/C system. Only the electric portion of cooling energy usage informs MCOP.

$MCOP_{ElectricHeat}$ = Marginal coefficient of performance, heating system. Only the electric portion of heating energy usage informs MCOP[14].

All variables related to heating and air conditioning are modified for the Las Vegas valley climate, categorized as a "warm" climate zone. In Figure 3-3, the modified CEUS lighting shape depicted by gray dashes ("- - -") is normalized to unity after the interactive effects are incorporated.

A total of ten energy savings curves were used to calculate critical peak demand (kW) savings for the Program. Six energy savings curves, three for NPC and three for SPPC, (interior lighting, exterior lighting, and HVAC) were derived by modifying CEUS Curves to fit the school district calendars. The modified energy savings curves are appropriate for CCSD and WCSD.

Two more energy savings curves were used for higher education facilities based on the CEUS Curve for interior lighting in colleges/universities. These energy savings curves were then modified to match the cooling loads associated with the NPC and SPPC territories.

The last two energy savings curves used are for the CEI measures in NPC and the SEM measures in the SPPC. CEI and SEM measure energy savings curves were determined using average hourly consumption data for the schools in the NPC and SPPC program populations.

Figure 3-3 below provides an example of the modified energy savings curves; the depiction represents average daily energy savings curves for interior lighting, exterior lighting, HVAC, and interior lighting for higher education facilities in Nevada.

[14] For example, $MCOP_{ElectricHeat}$ may have approximate values near unity for electric resistive heating, near two for electric heat pumps, and 15 for forced air gas furnaces/boilers. The 1/15, in the latter case, represents the electric energy usage of the air handlers, but is cast in the form of COP.

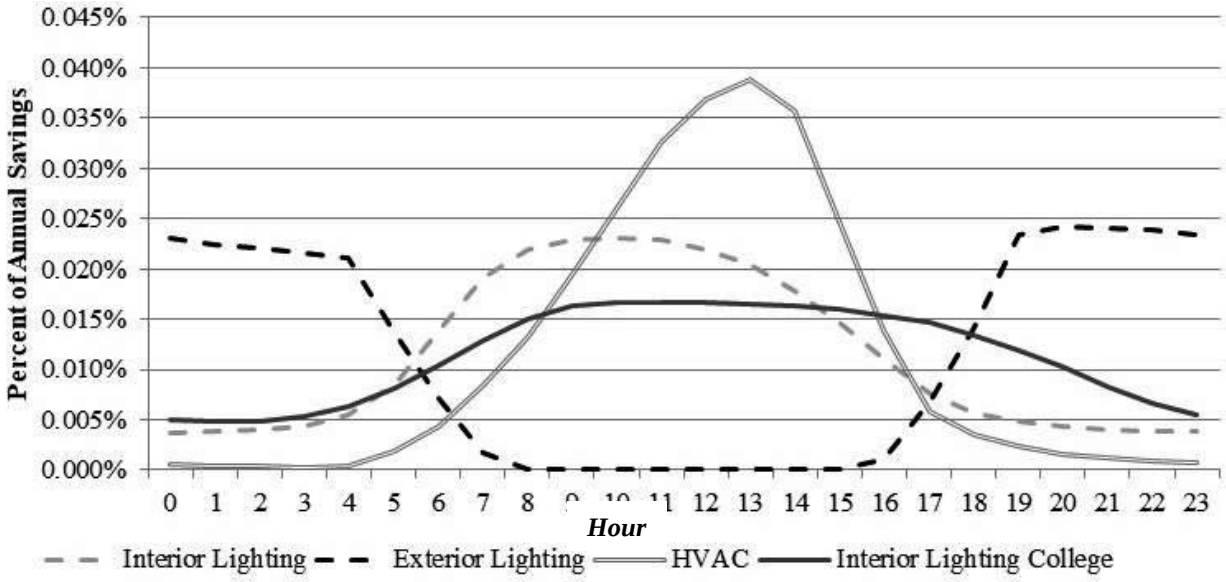


Figure 3-3: Average Daily Savings Curves for Higher Education Facilities

Figure 3-4 shows the final program-level annual energy savings curve for PY2023.

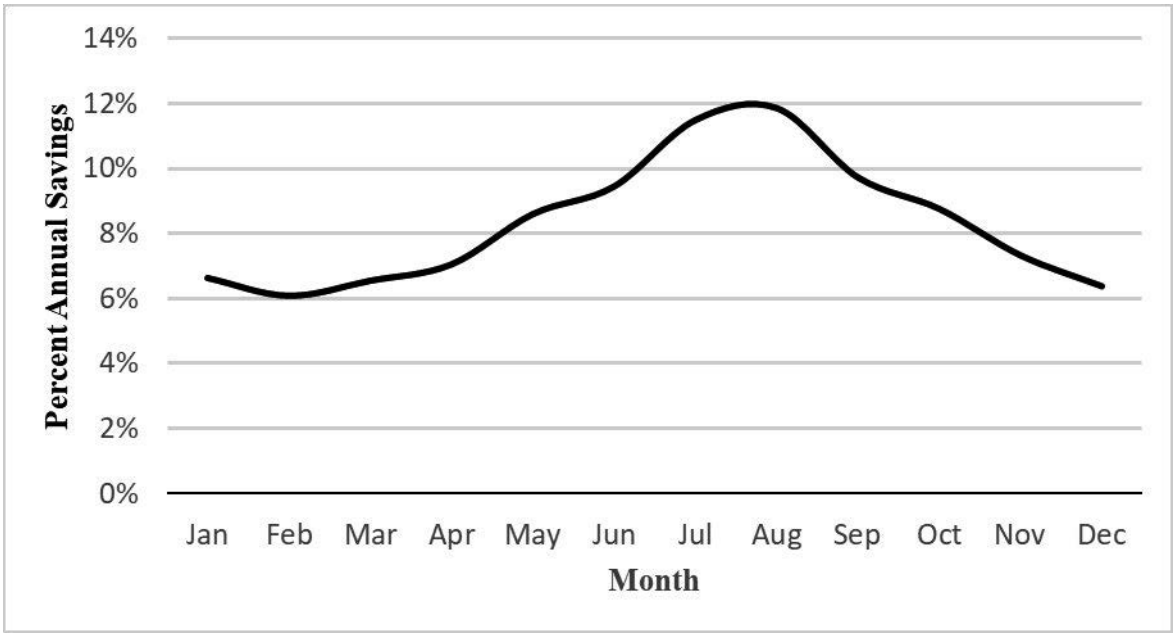


Figure 3-4: Program-Level Annual Energy Savings Curve

Table 3-11 below lists the energy savings curves and the data sources that were employed to allocate kWh and critical peak kW savings per month, by rate class for the Program.

Table 3-11. Curves Specific to the 2023 Program

Energy Savings Curve	Source / Modification	Applicability
Program-level energy savings curve, PY2023 NPC Program	CEUS interior lighting, exterior lighting, cooling, and interior lighting higher education savings curves, modified to represent the CCSD calendar.	NPC on the CCSD calendar. Higher education schools in NPC
Program-level energy savings curve, PY2023 SPPC Program	CEUS interior lighting, exterior lighting, cooling, and interior lighting for higher education savings curves, modified to represent the WCSD calendar.	SPPC schools on the WCSD calendar. Higher education schools in SPPC
Measure-level energy savings curve, PY2023 CEI	Hourly billing data, CCSD schools.	NPC schools, PY2023 CEI behavioral program
Measure-level energy savings curve, PY2023 SEM	Hourly billing data, WCSD schools.	SPPC schools, PY2023 SEM behavioral program

3.6 Determining First-Year kWh Savings

First-year kWh savings were calculated by determining the percentage of the year remaining when each measure was installed. ADM used measure startup data from NV Energy's tracking database to calculate the number of days left in the calendar year. For each measure, the number of days remaining in the year was used, including the normalized energy savings curve described above, to determine the annualized kWh savings realized during the 2023 calendar year. First-year kWh savings were summed by month across each customer rate class in the program population to determine first-year kWh savings per month per rate class. The first-year kWh savings table is provided in Appendix A: Savings Per Month and Per Rate Class.

For the CEI and SEM Program components, which ADM evaluates every year throughout the life of a CEI or SEM cohort, first-year savings are the same as annual savings.

3.7 Determining Critical Peak Demand (kW) Savings

The critical peak demand (kW) provided in Table 3-12, is the hourly period per month during which NV Energy has historically experienced maximum system-level demand.

Table 3-12. Critical Peak Demand Period per Month

Month	Critical Peak Hours	
	NPC	SPPC
January	18, 19, 20	18, 19
February	19, 20	19, 20
March	20	20, 21
April	20	21
May	17, 18	21
June	17, 18	17, 18
July	16, 17, 18	17, 18
August	16, 17	17, 18
September	17	17, 18
October	18, 19	19, 20
November	18, 19	18, 19
December	18, 19	18, 19

Critical peak demand (kW) savings are calculated per month, by per rate class utilizing ex-post program savings determinations and appropriate measure-level 8,760-hour energy savings curves.

For each 2023 participant and measure, the ex-post annualized energy savings were allocated to the participant's rate class and the appropriate measure-level energy savings curve. This provided a two-dimensional matrix of hourly savings per rate class for 8,760 hours of a typical (non-leap year) calendar year. The results were then inspected for each month to identify the maximum average hourly demand (kW) savings during each month's designated peak demand hour.

Summer critical peak demand (kW) savings are defined as the maximum kW reduction that could be expected in a typical year during the July or August peak demand hours indicated in Table 3-12 above. The average hourly kWh savings of the PY2023 Program for a typical weekday in July or August is shown in Figure 3-5. As demonstrated in Figure 3-4, the largest program-level savings fractions were in July and August. On weekdays in July and August, average hourly savings peaked at 13:00—earlier than the critical demand period (Table 3-12). The shape of the hourly savings curve during the summer peak aligns with when schools are typically in session, with almost 50 percent of average savings occurring between 8:00 and 16:00 (Figure 3-5).

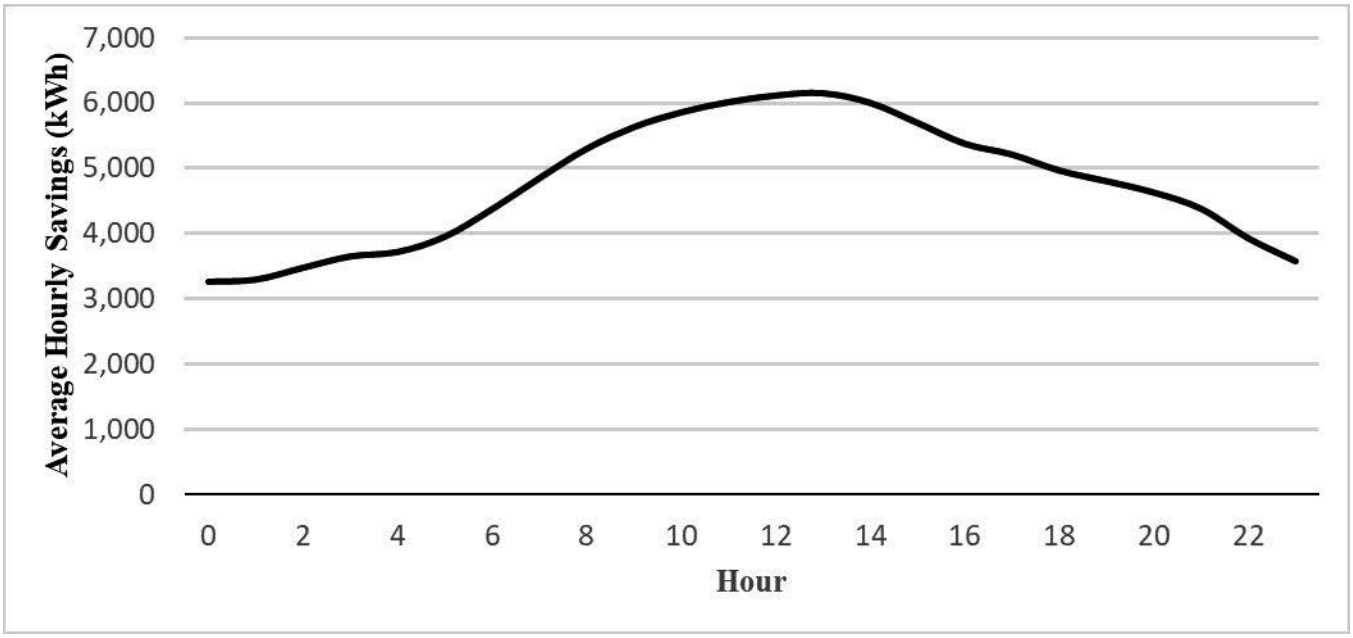


Figure 3-5: Typical Hourly Energy Savings Curve (2023 July and August, weekday)

The complete ex-post critical peak demand savings per month, by rate class, are provided in Appendix A: Savings Per Month and Per Rate Class. For a detailed discussion of ADM's analytical steps for determining critical peak demand (kW) savings, please refer to "ADM's M&V Technical Appendix 1."

3.8 Determining Effective Useful Life and Lifetime Savings

ADM analyzed various data to determine the EUL for each category of measures installed by NV Energy's 2023 Program. ADM subsequently employed its EUL determinations to calculate lifetime energy (kWh) savings per measure category and at the program level. To determine EUL values for the retrofit lighting and HVAC equipment replacement measure categories, ADM utilized the California Database for Energy Efficient Resources ("DEER").[15] The following are measure-specific items that affect EUL values:

- For the "HVAC Equipment Replacement" category, all measures installed in the PY2023 Program have the same EUL value as in DEER, i.e., 15.0 years. Every NPC HVAC measure was determined to be a new construction HVAC equipment installation. Under SPPC, the HVAC measures were determined to be new construction HVAC equipment installation or HVAC Retrofit.

[15] http://deeresources.com/files/deerchangelog/Updated-EULrecords_02-07-2014.xls

- The "VFD Retrofit" measures installed in the PY2023 Program have the same EUL value as in DEER, i.e., 15.0 years.
- For the lighting measures installed, the DEER provides a methodology for calculating EUL using the lamp or fixture rated life divided by HOU. Rated life is typically available on submitted specification sheets, but in the case that rated life is not available, ADM defaults to the DEER assumptions for lamp or fixture rated life: 50,000 for LED fixtures and 70,000 for ballasted fixtures.

  For a given energy efficiency program, the program-level EUL is calculated as the quotient of lifetime kWh savings (numerator) and annual kWh savings (denominator). If a program achieves lifetime kWh savings of 1,500 MWh and annual savings of 100 MWh, the program-level EUL would be the quotient of 1,500 and 100, or 15 years, whichever is less. For PY 2023, the weighted average EUL values for the lighting retrofits measure category were 9.7 years for NPC and 14 years for SPPC. The reason for lower EUL under NPC was high hours of use for the lighting projects, especially in areas where lighting is on for 8,760 hours per year.
- For the Engine Block Heater Controller measures, EUL of 10 years was considered. This is based on the recommendation made by the Regional Technical Forum.[16]
- New Construction EULs were the result of taking a weighted average of the site level EUL: 14.8 years for NPC and 15 years for SPPC.
- For CEI and SEM, the EUL is typically one year because ADM evaluates a census of participant sites each year that the sites are actively enrolled in the Program.
    - For SEM, the Program claimed 12 months of savings and the EUL is 1.0 years.
    - For CEI, the Program claimed 12 months of savings and the EUL is 1.0 years.

For any given program, the program-level EUL is calculated as the quotient of (i) lifetime kWh savings for all projects, and (ii) annual kWh savings for all projects. In other words, the numerator is (i) and the denominator is (ii); if a program had lifetime savings of 1,200 GWh and annual savings of 120 GWh per year, the program-level EUL would be the quotient of 1,200 and 120, or 10.0 years.

[16] https://nwcouncil.app.box.com/v/vehicleengblckhtrv3-1

4 ENERGY IMPACT RESULTS

This chapter presents the energy impact results and findings from the desk reviews and energy savings analyses for the NPC and SPPC Programs.

4.1 Results of Ex-Post Verified Savings Calculations

The ex-post verified kWh savings for the Program are summarized by service territory and sampling stratum in Table 4-1 below. NPC ex-post verified savings of 27,705,052 kWh was 101 percent of ex-ante savings. SPPC ex-post verified savings of 3,191,849 kWh was 95.2 percent of ex-ante savings.

Table 4-1. Summary of Annual Energy (kWh) Savings by Stratum

	NPC			SPPC		
Stratum	Ex-Ante kWh Savings	Ex-Post kWh Savings	Realization Rate	Ex-Ante kWh Savings	Ex-Post kWh Savings	Realization Rate
Stratum 1	113,757	136,882	120.3%	80,108	70,739	88.3%
Stratum 2	759,189	793,685	104.5%	293,245	293,243	100.0%
Stratum 3	899,483	976,009	108.5%	702,709	456,986	65.0%
Stratum 4	25,692,826	25,798,476	100.4%	599,895	599,894	100.0%
Stratum 5	na	na	na	1,676,568	1,770,987	105.6%
Total	**27,465,255**	**27,705,052**	**100.9%**	**3,352,525**	**3,191,849**	**95.2%**

For NPC, Table 4-2 below provides site-level ex-ante and ex-post savings for M&V sample sites.

Table 4-2. NPC Ex-Ante and Ex-Post kWh Savings for Sampled Projects

NPC Channel or Facility Name	Ex-Ante kWh Savings	Ex-Post kWh Savings	Realization Rate
CEI	25,692,826	25,798,476	100.4%
William H. Bailey Middle School	899,483	976,009	108.5%
Northeast Career and Technical Academy	383,386	400,806	104.5%
Southeast Career and Technical Academy Gym	48,965	58,919	120.3%
Subtotal for M&V Sample	**1,331,834**	**1,435,734**	**107.8%**
Not Sampled	**440,595**	**470,842**	**106.9%**
Total	**27,465,255**	**27,705,052**	**100.9%**

For SPPC, Table 4-3 provides site-level ex-ante and ex-post savings for M&V sample sites.

Table 4-3 . SPPC Ex-Ante and Ex-Post kWh Savings for Sampled Projects

Facility Name	Ex-Ante kWh Savings	Ex-Post kWh Savings	Project Realization Rate
SEM	**1,676,568**	**1,770,987**	**105.6%**
UNR Campus	47,061	47,005	99.9%
Procter R Hug High School	65,150	65,149	100.0%
William O'Brien Middle School	77,570	77,570	100.0%
Fernley High School Gym	384,334	249,940	65.0%
Eagle Valley Middle School	28,467	19,690	69.2%
TMCC Sierra Building	599,895	599,894	100.0%
Subtotal for M&V Sample	**1,202,477**	**1,059,248**	**88.1%**
Not Sampled	473,480	361,614	76.4%
Total	**3,352,525**	**3,191,849**	**95.2%**

First-year savings were calculated using the methodology presented in Section 3.6 above. First-year energy savings for projects implemented in the Program totaled 26,300,937 kWh for NPC and 2,737,271 kWh for SPPC. First-year and annual ex-post kWh savings of the Program are summarized in Table 4-4 below.

Table 4-4. First Year and Annual kWh Savings

Service Territory	First Year (2023) Ex-Post kWh Savings	Annual Ex-Post kWh Savings
NPC	26,396,205	27,705,052
SPPC	2,234,481	3,191,849

See Appendix A: Savings Per Month and Per Rate Class for tables depicting Program ex-post verified energy savings by month, by rate class for calendar years 2023 through 2024.

4.2 Review of Variances

This section provides brief descriptions of the causes of significant variances between ex-ante expected savings and ex-post verified savings for channels or projects.

4.2.1 NPC Variances

William H. Bailey Middle School (109 percent RR):

This site is under the lighting retrofit measure category. The difference is ex-ante and ex-post savings is due to different calculation methods used for the energy-saving calculations. ADM estimated higher savings for the lighting measure for this site.

Northeast Career and Technical Academy (105 percent RR):

This site is under the new construction measure category, which includes a mixture of HVAC and interior and exterior lighting projects. The higher RR is a result of the interior lighting measure. The difference is ex-ante and ex-post savings is due to different calculation methods used for the energy-saving calculations. ADM estimated higher savings for the interior lighting measure for this site.

Southeast Career and Technical Academy Gym (120 percent RR):

This site is under the new construction measure category, which includes a mixture of interior and exterior lighting projects. The difference in ex-ante and ex-post savings is due to different calculation methods used for the energy-saving calculations. ADM estimated higher savings for interior lighting for this site.

4.2.2 SPPC Variances

SEM (106 percent RR):

Ex-ante and ex-post regression models vary in modeling structure and assumptions. ADM's model uses hourly data together with multiple variables that characterize school operations in baseline and measurement periods. Using LMEM reduces the impact of correlations between variables for WCSD school buildings within the same cohort. ADM also modeled the impact of WCSD's five-week post-COVID summer school program as a variable in the Elementary and Middle Schools models. In ADM's judgment, the ex-post regression models provide the most accurate representation of school operations and energy savings resulting from SEM intervention.

Elko CSD District-Wide Diesel Block Heater Controller (65 percent RR):

This measure involves installing engine block heater controllers on school buses throughout the Elko County School District. The difference in ex-ante and ex-post savings is due to different calculation methods used for the energy-saving calculations. ADM estimated lower savings for this measure. The main reason which contributed to the lower RR is that the ex-post calculations are based on a curve that was developed based on the manufacturer data, whereas the curve used for ex-ante calculations is not specific to the installed controller and is quite different. Another difference is that the ex-ante calculations had the same bus operating schedule for 7 days a week. However, buses operate 4 days a week when schools are in session. So, the bus departure, return and time delay schedules are applicable to only 4 days rather than 7 days a week.

Lander CSD District-Wide Diesel Block Heater Controller (69 percent RR):

This measure involves installing engine block heater controllers on school buses throughout the Lander County School District. The difference in ex-ante and ex-post savings is due to different calculation methods used for the energy-saving calculations. ADM estimated lower savings for this measure for the same reasons mentioned above for Elko CSD.

4.3 Ex-Post Verified kW Savings

When evaluating the Program, an hourly savings curve was developed as described in Section 3.5. The hourly energy savings curve is used to calculate peak demand (kW) savings for the Program. The program-level energy savings curve is also used as an input in NV Energy's cost-effectiveness testing. Ex-post verified summer critical peak demand savings are 6,233 kW for NPC and 741 kW for SPPC. The complete ex-post determination for critical peak demand savings (kW) per month, by rate class are provided in Appendix A: Savings Per Month and Per Rate Class. Further information on ADM's methodology for calculating critical peak demand savings can be found in "ADM's M&V Technical Appendix 1."

4.4 Effective Useful Life and Lifetime Energy (kWh) Savings

As described in Section 3.8 above, ADM determined the EUL for each measure implemented by the Program. ADM subsequently employed EUL values to calculate lifetime energy (kWh) savings per measure. As shown in Table 4-5 below for NPC, ADM determined program-level lifetime savings of 47,852,773 kWh. NPC program-level EUL was then taken to be lifetime kWh divided by annual kWh, or 47,852,773 divided by 27,705,052, which equals 1.7 years.

Table 4-5. EUL and Lifetime Energy Savings, PY2023 NPC Program

Measure Category	Ex-Post Verified Annual kWh Savings	EUL (years)	Ex-Post Verified Lifetime kWh Savings
Lighting	1,053,972	9.0	9,477,822
New Construction	459,725	14.8	6,788,523
T-Stats	392,879	14.7	5,787,952
Subtotal, Capital Improvement Projects	**1,906,576**	**11.6**	**22,054,297**
CEI	25,798,476	1.0	25,798,476
Total, All PY2023 NPC Projects	27,705,052	1.7	47,852,773

As shown in

Table 4-6 for SPPC, ADM determined program-level lifetime savings of 19,858,143 kWh. SPPC program-level EUL was then taken to be lifetime kWh divided by annual kWh, or 19,858,143 divided by 3,191,849, which equals 6.2 years.

Table 4-6. EUL and Lifetime Energy Savings, PY2023 SPPC Program

Measure Category	Ex-Post Verified Annual kWh Savings	EUL (years)	Ex-Post Verified Lifetime kWh Savings
Building Controls	207,046	10.0	2,070,456
Diesel Block Heat Controller	269,630	10.0	2,696,300
HVAC	85,111	15.0	1,276,667
HVAC NC	47,005	15.0	705,080
Lighting	810,616	14.0	11,318,996
Pump Motors	1,454	13.5	19,657
Subtotal, Capital Improvement Projects	**1,420,862**	**12.7**	**18,087,156**
SEM	1,770,987	1.0	1,770,987
Total, All PY2023 SPPC Projects	**3,191,849**	**6.2**	**19,858,143**

5 FINDINGS AND RECOMMENDATIONS

This chapter presents key findings and recommendations from M&V analyses of the PY2023 Program.

5.1 Findings

The ex-post verified energy (kWh) savings determined by ADM varied from ex-ante estimated kWh savings reported by the Program. Variances resulted from the use of different values for baseline and efficient HVAC units, hour-of-use reductions for various lighting controls, methodologies for determining savings from capital improvement projects, and modeling assumptions in CEI and SEM models. The following are our major findings, including issues that contributed to variances between ex-ante estimated savings and ex-post verified savings.

- The CEI and SEM ex-ante and ex-post findings had greater alignment than in PY2022. The CEI and SEM realization rates were approximately 101% and 104%, respectively.
- Year-over-year ex-post CEI savings increased by 4,575,268 kWh. The likely cause of this is improved coordination between the implementation team and the district, particularly in the summer months (see Appendix C: "Measurement and Verification Report Continuous Energy Improvement (CEI)" prepared by CLEAResult for Clark County School District). SEM savings were a greater proportion of ex-ante SPPC savings compared to last year (50.0% compared to 38.8%) and SEM ex-post savings are consistent with last year's savings.
- ADM found that the ex-ante calculator was only applying HCIF to the lighting fixture replacement savings and not to the savings associated with lighting controls. ADM's calculator for ex-post verified savings applies HCIF to lighting fixtures and controls.

- ADM found that the ex-ante calculations were done using a calculator that was adapted from "VehicleEngineBlockHeaterControls_v3_0.xlsm", a tool developed for the Regional Technical Forum's Vehicle Engine Block Heater Controls UES Measure. It utilizes region-specific TMY3 data, a set temperature threshold, Owner-provided bus schedules and annual start and end months to calculate the estimated hourly kWh usage of deployed engine block heaters with and without controls. The savings claim is the difference between these two figures, summed for the entire year. However, the calculations were done based on the option of wall-mount Control Settings, which uses a generic curve to establish a correlation between the outside air temperature and the percentage of time the controller is on. ADM updated this curve for the specific installed controller. A curve was fitted based on the data provided by the manufacturer and calculated lower energy savings.
- For the engine block heater controller measure, ADM also found that ex-ante savings were assuming seven days a week schedule for the bus operation, while schools are open only four days a week. The buses are occasionally used over the weekend, whenever there are any sports events.

5.2 Status of 2022 Recommendations

Table 5-1 below provides a summary of recommendations that were made in the PY2022 M&V report, the status, and applicable notes describing how the recommendations were incorporated into the 2023 management and operations of the Program.

Table 5-1. Recommendations from the 2022 Schools Program M&V Report

2022 M&V Report Recommendation	2023 Status	Notes
The Program should consider removing COVID-19 related impacts from the modeling structure for CEI as much as possible. PY2022 was the first calendar year without any COVID-19 related scheduling changes at schools that were treated by the Program since PY2019. Therefore, both the ex-ante and ex-post models accounted for COVID-19 related operational changes through PY2020 and PY2021 even when these years were not included in either the baseline or the reporting year. Beginning PY2023, COVID-19 related impacts, particularly for the CEI program, will begin to become less relevant for estimating reporting year savings. Most of ADM's pre-post models for evaluating behavioral programs include only the baseline (post = 0) and year being evaluated (post = 1). Next year, we plan to assess this approach for the CEI Program and believe the ex-ante models should incorporate a similar approach.	Ongoing	The ex-ante CEI models continued to include both COVID variables and the post-period years that were impacted by the pandemic.

2022 M&V Report Recommendation	2023 Status	Notes
If the years that were impacted by COVID-19 are excluded from the CEI modeling structure, then the program should not model schools that had food service during PY2020 separately from schools that did not. In the spirit of incorporating fewer COVID-19 related impacts to the CEI Program's evaluation methodology, the "Food Service" and "No Food" school groups should be modeled together for PY2023. Modeling the schools together will reduce the overall number of models needed for estimating savings within this large program and save time and budget for both the implementation contractor and evaluation team. In the ex-ante models, there were inconstancies between how variables representing operational changes in PY2021 and PY2022 were modeled due to some of those schools having food service in PY2020 (see Appendix B: Review of Ex-Ante Regression Models in the PY2022 report). Schools with the same baseline and grade level should be modeled together wherever possible. If there are consistent, tangible differences between groups of schools that otherwise have the same baseline and grade level, and these differences lead to reduced quality of the overall savings estimate, cluster analysis should be used to analytically quantify which schools should be separated into which subcategories.	Ongoing	The ex-ante CEI models continued to separate facilities based on whether food service was provided during PY2020 or not.
The CEI program should have clear documentation of what operational changes were implemented beginning October 4, 2021, and how implementation differed by school, season, and building occupancy. According to the implementation contractor, the implementation of HVAC-related operational changes varied for each individual school beginning October 4, 2021 (see Section 7.1 of the PY2022 report). In PY2023, these variations should be documented, documentation should be included in conjunction with the ex-ante models, and adjustments to how these changes are modeled should be made accordingly.	Ongoing	Clear documentation of current and future HVAC operational changes is part of the 50001 Ready Certification process.[17] While the 50001 Ready initiative was put on hold during 2023 due to the departure of Director of Sustainability Mark [redacted] from CCSD, the initiative will resume in PY2024 (see Appendix C: "Measurement and Verification Report Continuous Energy Improvement (CEI)" prepared by CLEAResult for Clark County School District).
The Program could benefit from efforts to diversify geographically and with respect to measure mix; diversification efforts could counter the Program's increasing dependence on savings generated from behavioral channels (CEI/SEM behavioral treatments provided 89 percent of PY2022 ex-ante claimed savings) and ESCO projects.	Ongoing	CEI/SEM behavioral treatments were 89% of PY2023 ex-ante claimed savings. More diversification is still needed, particularly in the NPC service territory where 94% of savings were from the CEI program.
ADM found that the ex-ante calculator was applying HCIF to the lighting fixture replacement savings only and not to the savings associated with lighting controls. It is recommended	Ongoing	This issue persists, which is why ADM calculated higher RR for 2023 lighting projects.

[17] https://www.energy.gov/eere/iedo/50001-ready-program

2022 M&V Report Recommendation	2023 Status	Notes
that the ex-ante calculator should apply the HCIF to both components for accuracy and to align with ADM's ex-post saving calculations.		
For capital improvement projects, the Program could benefit from a pre-construction review process similar to the process that has been in place for the NV Energy Business Energy Services Program since 2013. A pre-construction review process would enable the Program and ADM to review large projects before implementation, provide ADM insights regarding ex-ante claimed energy savings.	Ongoing	This will help facilitate ongoing coordination between implementation and M&V activities.

5.3 Recommendations Resulting from M&V Findings for PY2023

This section presents recommendations resulting from PY2023 M&V activities and analyses. ADM provides several recommendations, each of which relates to the M&V findings described in this report. ADM looks forward to collaborating with NV Energy and the implementation team to help all Program stakeholders benefit from enacting the following recommendations.

5.3.1 Recommendation 1

The Program could benefit from efforts to diversify geographically and with respect to measure mix; diversification efforts could counter the Program's increasing dependence on savings generated from behavioral channels (CEI/SEM behavioral treatments provided 89 percent of PY2023 ex-ante claimed savings) and ESCO projects.[18]

5.3.2 Recommendation 2

The Program should consider removing COVID-19 related impacts from the modeling structure for CEI as much as possible. The close alignment between the ex-ante CEI models, which separated facilities based on PY2020 food service and included COVID-impacted years in the post-period, and the ex-post CEI models, which separated facilities by grade level only and used PY2023 as the sole post-period year, indicate that COVID-19 related impacts are not needed for estimating CEI savings.

5.3.3 Recommendation 3

The Program should work with CCSD to reduce HVAC-related energy loads in both May, and August—October. ADM modeled energy consumption due to HVAC related operational changes between the baseline and post-period during those months only (see Equation 3-5 and Equation 3-6). Nevertheless, ADM found ex-post energy savings that were close to the ex-ante values, which

[18] The SPPC Program works with an energy services company ("ESCO") that implements a "powerED" program for WCSD. See, https://www.mckinstry.com/engaging-students-and-staff-in-energy-use-goals-yields-big-savings-in-second-largest-school-district-in-nevada/.

modeled this term from October 1, 2021, through the duration of the post-period. That finding suggests that HVAC-related energy efficiency measures are likely to have a greater impact on energy savings during the late Spring, late Summer, and early Fall compared to the rest of the year.

5.3.4 Recommendation 4

The Program should consider using the same post-period durations for both the CEI and SEM models. The ex-ante CEI models included all non-baseline weeks in the post -period, whereas the ex-ante SEM models excluded November 2, 2020 – January 2, 2022, from the post-period. ADM recommends that the Program should align the ex-ante CEI and SEM modelling approaches wherever possible.

5.3.5 Recommendation 5

For capital improvement projects, the Program could benefit from a pre-construction review process similar to the process that has been in place for the NV Energy Business Energy Services Program since 2013. A pre-construction review process would enable the Program and ADM to review large projects before installation, provide ADM insights regarding ex-ante claimed energy savings, and facilitate ongoing coordination between implementation and M&V activities.

5.3.6 Recommendation 6

For the Capital Improvement engine block heater controller projects, the calculations should be based on a curve which is specific to the controller installed, when manufacturer data is available, instead of using a generic curve available in RTF calculator. Also, actual bus schedules for those days when school is in session should be used instead of seven days a week schedule.

6 APPENDIX A: SAVINGS PER MONTH AND PER RATE CLASS

The savings tables presented below are a result of ADM's evaluation of the PY2023 Program. First-year savings include all measures implemented during the 2023 program year. CIP, which by definition has multi-year EUL, will continue saving energy for multiple years in the future. In contrast, CEI/SEM savings have a one-year EUL and all CEI/SEM savings occurred in the 2023 calendar year. To show the difference more clearly between CEI/SEM projects and CIP, ADM provides separate tables for CEI/SEM versus CIP in sections 6.1 and 6.2 below.

6.1 NPC Savings per Month by Rate Class

Table 6-1. Capital Improvement Projects – Monthly Energy Savings in Calendar Year 2023 (units are kWh)

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
GS	0	0	0	0	0	0	0	0	0	34,180	28,392	26,883	89,455
LGS1	0	0	0	0	0	0	0	0	0	12,249	10,574	10,549	33,372
LGS2	0	0	0	0	0	2,554	58,721	74,725	85,735	90,440	80,124	82,602	474,902
Total	**0**	**0**	**0**	**0**	**0**	**2,554**	**58,721**	**74,725**	**85,735**	**136,870**	**119,091**	**120,034**	**597,729**

Table 6-2. Capital Improvement Projects – Monthly Energy Savings in Calendar Year 2024 (and subsequent calendar years) (kWh)

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
GS	34,567	38,607	49,072	55,203	94,661	73,330	96,306	111,942	109,370	60,285	38,281	32,062	793,685
LGS1	11,755	10,587	11,480	11,593	12,885	9,760	10,119	11,982	13,255	12,242	10,356	10,868	136,882
LGS2	92,903	81,873	87,168	87,508	88,059	64,900	60,657	73,219	85,916	90,432	78,565	84,811	976,009
Total	**139,225**	**131,067**	**147,720**	**154,304**	**195,604**	**147,990**	**167,082**	**197,142**	**208,541**	**162,958**	**127,202**	**127,741**	**1,906,576**

Table 6-3. Capital Improvement Projects – Monthly Critical Peak Demand Savings Full Year (kW)

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GS	54.4	40.0	47.5	40.6	239.2	220.7	433.7	407.1	298.0	75.1	74.1	48.5
LGS1	16.6	11.5	10.0	8.5	20.1	14.5	24.9	27.6	22.2	15.4	17.6	16.7
LGS2	122.5	74.4	57.3	49.8	120.6	72.0	105.0	140.0	122.5	122.5	122.5	122.5
Total	**193.5**	**125.9**	**114.8**	**98.8**	**379.9**	**307.1**	**563.6**	**574.7**	**442.7**	**212.9**	**214.1**	**187.7**

Table 6-4. CEI Monthly Energy Savings in Calendar Year 2023 (kWh)

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
GS	288,124	264,516	287,775	309,803	378,681	414,024	499,576	502,681	403,869	362,893	282,856	245,022	4,239,818
LGS1	457,655	420,157	457,101	492,090	601,495	657,635	793,525	798,456	641,504	576,418	449,287	389,193	6,734,517
LGS2	811,730	745,220	810,748	872,807	1,066,855	1,166,428	1,407,453	1,416,200	1,137,817	1,022,376	796,888	690,300	11,944,822
LGS3	195,669	179,637	195,432	210,391	257,167	281,169	339,269	341,377	274,273	246,445	192,091	166,398	2,879,319
Total	**1,753,178**	**1,609,529**	**1,751,056**	**1,885,091**	**2,304,198**	**2,519,256**	**3,039,824**	**3,058,714**	**2,457,463**	**2,208,131**	**1,721,122**	**1,490,914**	**25,798,476**

Table 6-5. CEI Monthly Critical Peak Demand Savings (kW)

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GS	486.8	480.9	479.3	623.0	763.2	920.7	890.1	929.9	725.6	674.0	585.1	477.2
LGS1	773.2	763.9	761.3	989.6	1,212.2	1,462.4	1,413.8	1,477.1	1,152.5	1,070.5	929.4	758.0
LGS2	1,371.4	1,354.9	1,350.4	1,755.3	2,150.1	2,593.7	2,507.6	2,619.9	2,044.1	1,898.7	1,648.4	1,344.5
LGS3	330.6	326.6	325.5	423.1	518.3	625.2	604.5	631.5	492.7	457.7	397.3	324.1
Total	**2,961.9**	**2,926.4**	**2,916.5**	**3,791.0**	**4,643.7**	**5,602.0**	**5,416.0**	**5,658.4**	**4,414.9**	**4,100.9**	**3,560.2**	**2,903.9**

6.2 SPPC Savings per Month by Rate Class

Table 6-6. Capital Improvement Projects – Monthly Energy Savings in Calendar Year 2023 (kWh)

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
GS1	0	0	0	0	0	0	6,021	8,920	20,345	16,661	16,182	15,405	83,535
GS2	0	0	0	12,838	18,771	16,318	15,679	19,926	21,117	20,573	109,989	102,503	337,714
GS3	0	0	0	73	5,930	4,586	3,936	5,008	5,746	6,061	5,370	5,536	42,245
Total	**0**	**0**	**0**	**12,911**	**24,700**	**20,904**	**25,635**	**33,854**	**47,208**	**43,296**	**131,541**	**123,444**	**463,494**

Table 6-7. Capital Improvement Projects – Monthly Energy Savings in Calendar Year 2024 (and subsequent calendar years) (kWh)

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
GS1	17,162	16,755	19,098	15,553	18,123	15,654	14,137	19,446	20,886	20,274	16,625	15,700	209,414
GS2	112,878	113,320	123,118	75,030	79,047	68,930	69,186	81,491	89,318	119,927	107,622	106,169	1,146,035
GS3	6,226	5,487	5,842	5,865	5,902	4,350	4,065	4,907	5,758	6,061	5,265	5,684	65,413
Total	**136,267**	**135,562**	**148,058**	**96,448**	**103,072**	**88,933**	**87,389**	**105,844**	**115,962**	**146,262**	**129,513**	**127,553**	**1,420,862**

Table 6-8. Capital Improvement Projects – Monthly Critical Peak Demand Savings Full Year (kW)

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GS1	28.0	20.9	19.0	10.4	8.1	32.4	28.6	33.8	42.7	20.7	29.5	19.3
GS2	280.6	266.1	248.3	139.9	88.4	148.8	150.1	165.0	197.1	266.4	284.3	251.5
GS3	8.3	4.9	3.8	2.8	3.0	7.3	4.7	5.7	8.2	5.0	8.2	4.3
Total	**316.8**	**291.9**	**271.1**	**153.0**	**99.4**	**188.4**	**183.4**	**204.6**	**248.1**	**292.1**	**322.0**	**275.1**

Table 6-9. SEM Monthly Energy Savings in Calendar Year 2023 (kWh)

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
GS1	109,369	99,618	92,232	90,295	99,543	121,407	124,596	171,511	145,455	89,650	94,409	68,979	1,307,063
GS2	38,819	35,358	32,737	32,049	35,332	43,092	44,224	60,876	51,627	31,820	33,509	24,483	463,924
GS3	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**148,189**	**134,976**	**124,969**	**122,343**	**134,875**	**164,498**	**168,820**	**232,387**	**197,082**	**121,470**	**127,918**	**93,462**	**1,770,987**

Table 6-10. SEM Critical Peak Demand Savings/Month/Rate Class (kW)

Rate Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GS1	201.3	140.5	125.5	109.9	113.3	295.2	305.6	396.0	339.8	133.4	152.9	120.8
GS2	71.5	49.9	44.6	39.0	40.2	104.8	108.5	140.6	120.6	47.4	54.3	42.9
GS3	0	0	0	0	0	0	0	0	0	0	0	0
Total	**272.7**	**190.4**	**170.1**	**148.9**	**153.6**	**399.9**	**414.0**	**536.6**	**460.5**	**180.7**	**207.2**	**163.6**

7 APPENDIX B: STATISTICAL VALIDATION OF LINEAR MIXED EFFECTS MODELS

This section includes the R^2, *t*-statistics, and analysis of variance ("ANOVA") tests for the ex-post LMEM used to verify savings. The ANOVA tests were performed with the lmerTest package in R[19] using Satterthwaite's approximation.[20]

7.1 Model Statistics for Program Year 2023

In this section, we will present the R^2 and *t*-statistics for our PY2023 models. Table 7-1 presents the statistics for CCSD and Table 7-2 presents the statistics for WCSD. Robust LMEM models have R^2 values above 0.50 and t-statistics above 1.645. If the models do not meet both of these criteria, steps are taken to resolve the issue such as removing colinear variables, or other factors are considered. The CCSD Alumni High School model, which had an R^2 of below 0.50, made a low contribution to CEI savings because it had three facilities. The WCSD High School model, which had an R^2 of below 0.50, did not yield SEM savings.

Table 7-1. R^2 and t-statistics for PY2023 CCSD LMEM

Cohort	School Type	R^2 PY2023	t-statistic PY2023[21]
Alumni	Elementary School	0.56	71.99
Alumni	Middle School	0.62	17.84
Alumni	High School	0.40	39.06
Alumni	Other	0.80	23.94
Non-Alumni	Elementary School	0.64	114.11
Non-Alumni	High School	0.69	92.63
Non-Alumni	Middle School	0.58	18.73
Non-Alumni	Other	0.87	76.39

Table 7-2. R^2 and t-statistics for PY2023 WCSD LMEM

Territory	School Type	R^2 PY2023	t-statistic PY2023[21]
SPPC	Elementary School	0.53	36.22
SPPC	High School	0.47	2.65
SPPC	Middle School	0.51	88.27
SPPC	Other	0.90	27.33

[19] Kuznetsova A, Brockhoff PB, Christensen RHB (2017). "lmerTest Package: Tests in Linear Mixed Effects Models." Journal of Statistical Software, 82(13), 1–26. doi:10.18637/jss.v082.i13.
[20] Satterthwaite, F. E. (1946), "An Approximate Distribution of Estimates of Variance Components.", Biometrics Bulletin, 2 (6): 110–114.
[21] Absolute value

7.2 Analysis of Variance Tests for Linear Mixed Effects Models

In this section, we will present the results of the analysis of variance ("ANOVA") tests used to evaluate the PY2023 LMEM (Figure 7-1 through Figure 7-11). The variable definitions for these results correspond to those outlined in Equation 3-5 through Equation 3-10. All F values need to be statistically significant (i.e., the value shown in the "Pr (>F)" column needs to be below 0.05) to demonstrate that the predictor variables have a statistically significant contribution to the model results and are independent from one another.

```
Type III Analysis of Variance Table with Satterthwaite's method
                   Sum Sq  Mean Sq NumDF  DenDF  F value    Pr(>F)
post              10100462 10100462     1 190194  5182.40 < 2.2e-16 ***
CDD               91058027 91058027     1 190194 46720.51 < 2.2e-16 ***
`Elementary Day`    502900   502900     1 190194   258.03 < 2.2e-16 ***
`Staff Day`        2991057  2991057     1 190194  1534.67 < 2.2e-16 ***
`Op Change`        1242157  1242157     1 190194   637.33 < 2.2e-16 ***
hour             108737247  4727706    23 190194  2425.72 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Figure 7-1. LMEM ANOVA Results for the CCSD Alumni "Elementary School" Model

```
Type III Analysis of Variance Table with Satterthwaite's method
                    Sum Sq   Mean Sq NumDF DenDF  F value    Pr(>F)
post               4716484   4716484     1 51794   318.33 < 2.2e-16 ***
CDD              338315626 338315626     1 51794 22833.91 < 2.2e-16 ***
`Middle-High Day`  1916172   1916172     1 51794   129.33 < 2.2e-16 ***
`Staff Day`        9083840   9083840     1 51794   613.09 < 2.2e-16 ***
`Op Change`       32806111  32806111     1 51794  2214.18 < 2.2e-16 ***
hour             342818566  14905155    23 51794  1005.99 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Figure 7-2. LMEM ANOVA Results for the CCSD Alumni "High School" Model

```
Type III Analysis of Variance Table with Satterthwaite's method
                   Sum Sq  Mean Sq NumDF DenDF  F value    Pr(>F)
post              16740827 16740827     1 34163 1526.034 < 2.2e-16 ***
CDD               38539076 38539076     1 34163 3513.084 < 2.2e-16 ***
`Middle-High Day`   768307   768307     1 34163   70.036 < 2.2e-16 ***
`Staff Day`        1794420  1794420     1 34163  163.573 < 2.2e-16 ***
`Op Change`       20235523 20235523     1 34164 1844.598 < 2.2e-16 ***
hour              74827756  3253381    23 34163  296.567 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Figure 7-3. LMEM ANOVA Results for the CCSD Alumni "Middle School" Model

```
Type III Analysis of Variance Table with Satterthwaite's method
                    Sum Sq    Mean Sq NumDF   DenDF  F value    Pr(>F)
post                21961373   21961373     1 2566970  13021.1 < 2.2e-16 ***
CDD               1331570121 1331570121     1 2566970 789500.8 < 2.2e-16 ***
`Elementary Day`     3736865    3736865     1 2566970   2215.6 < 2.2e-16 ***
`Staff Day`         39590951   39590951     1 2566970  23473.9 < 2.2e-16 ***
`Op Change`         32795565   32795565     1 2566970  19444.8 < 2.2e-16 ***
hour              1412435472   61410238    23 2566970  36410.7 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure 7-4. LMEM ANOVA Results for the CCSD Non-Alumni “Elementary School” Model

```
Type III Analysis of Variance Table with Satterthwaite's method
                     Sum Sq    Mean Sq NumDF  DenDF   F value    Pr(>F)
post                133052395  133052395     1 565621   8579.53 < 2.2e-16 ***
CDD                1698827200 1698827200     1 565621 109544.40 < 2.2e-16 ***
`Middle-High Day`     8262339    8262339     1 565621    532.78 < 2.2e-16 ***
`Staff Day`          50165848   50165848     1 565621   3234.81 < 2.2e-16 ***
`Op Change`          67337694   67337694     1 565621   4342.09 < 2.2e-16 ***
hour               2413306608  104926374    23 565621   6765.90 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure 7-5. LMEM ANOVA Results for the CCSD Non-Alumni “High School” Model

```
Type III Analysis of Variance Table with Satterthwaite's method
                     Sum Sq   Mean Sq NumDF  DenDF   F value    Pr(>F)
post                 1803955   1803955     1 587273    350.95 < 2.2e-16 ***
CDD                667770107 667770107     1 587273 129910.77 < 2.2e-16 ***
`Middle-High Day`    3960059   3960059     1 587273    770.41 < 2.2e-16 ***
`Staff Day`         26822321  26822321     1 587273   5218.13 < 2.2e-16 ***
`Op Change`         55812803  55812803     1 587273  10858.05 < 2.2e-16 ***
hour              1191822121  51818353    23 587273  10080.96 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure 7-6. LMEM ANOVA Results for the CCSD Non-Alumni “Middle School” Model

```
Type III Analysis of Variance Table with Satterthwaite's method
               Sum Sq   Mean Sq NumDF  DenDF  F value    Pr(>F)
post         13181152  13181152     1 399437  5835.85 < 2.2e-16 ***
CDD         147260047 147260047     1 399437 65198.26 < 2.2e-16 ***
`Staff Day`  42505155  42505155     1 399437 18818.83 < 2.2e-16 ***
`Op Change`    661291    661291     1 399437   292.78 < 2.2e-16 ***
hour         57413847   2496254    23 399437  1105.20 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure 7-7. LMEM ANOVA Results for the CCSD Non-Alumni “Other” Model

```
Type III Analysis of Variance Table with Satterthwaite's method
                                          Sum Sq Mean Sq NumDF   DenDF  F value    Pr(>F)
post                                      516283  516283     1 1164429  1312.15 < 2.2e-16 ***
CDD                                      9763169 9763169     1 1164429 24813.46 < 2.2e-16 ***
HDD                                      4807151 4807151     1 1164429 12217.55 < 2.2e-16 ***
`School Day`                              153154  153154     1 1164429   389.25 < 2.2e-16 ***
`Staff Day`                              5113787 5113787     1 1164429 12996.88 < 2.2e-16 ***
`COVID Shutdown`                         2855220 2855220     1 1164429  7256.65 < 2.2e-16 ***
`Summer School`                           335244  335244     1 1164429   852.03 < 2.2e-16 ***
hour                                   121068488 5263847    23 1164429 13378.26 < 2.2e-16 ***
`School Day`:`Student at home learning`  3775522 3775522     1 1164429  9595.63 < 2.2e-16 ***
`COVID Shutdown`:`Teacher at home teaching`  434280  434280     1 1164429  1103.74 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure 7-8. LMEM ANOVA Results for the WCSD “Elementary School” Model

```
Type III Analysis of Variance Table with Satterthwaite's method
                                          Sum Sq  Mean Sq NumDF  DenDF   F value    Pr(>F)
post                                       57661    57661     1 222572    7.0127  0.008094 **
CDD                                     25243743 25243743     1 222572 3070.1513 < 2.2e-16 ***
HDD                                      2368826  2368826     1 222572  288.0973 < 2.2e-16 ***
`School Day`                             2573081  2573081     1 222572  312.9388 < 2.2e-16 ***
`Staff Day`                              8883734  8883734     1 222572 1080.4423 < 2.2e-16 ***
`COVID Shutdown`                         3151873  3151873     1 222572  383.3317 < 2.2e-16 ***
hour                                   484234755 21053685    23 222572 2560.5552 < 2.2e-16 ***
`School Day`:`Student at home learning`  16066360 16066360     1 222572 1953.9953 < 2.2e-16 ***
`COVID Shutdown`:`Teacher at home teaching`  964772   964772     1 222572  117.3358 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure 7-9. LMEM ANOVA Results for the WCSD “High School” Model

```
Type III Analysis of Variance Table with Satterthwaite's method
                                        Sum Sq  Mean Sq NumDF  DenDF  F value    Pr(>F)
post                                  16292481 16292481     1 270661 7791.525 < 2.2e-16 ***
CDD                                    7836587  7836587     1 270658 3747.677 < 2.2e-16 ***
HDD                                   12647958 12647958     1 270658 6048.611 < 2.2e-16 ***
`School Day`                           1206435  1206435     1 270658  576.951 < 2.2e-16 ***
`Staff Day`                            4788734  4788734     1 270658 2290.108 < 2.2e-16 ***
`COVID Shutdown`                      10913101 10913101     1 270658 5218.954 < 2.2e-16 ***
`Summer School`                         172976   172976     1 270658   82.722 < 2.2e-16 ***
hour                                  205334816  8927601    23 270658 4269.431 < 2.2e-16 ***
`School Day`:`Student at home learning`  11513850 11513850     1 270658 5506.248 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure 7-10. LMEM ANOVA Results for the WCSD “Middle School” Model

```
Type III Analysis of Variance Table with Satterthwaite's method
                                       Sum Sq Mean Sq NumDF  DenDF  F value    Pr(>F)
post                                   165085  165085     1 304464   747.11 < 2.2e-16 ***
CDD                                   4728779 4728779     1 304464 21400.57 < 2.2e-16 ***
HDD                                     96535   96535     1 304464   436.88 < 2.2e-16 ***
`Staff Day`                           4419446 4419446     1 304464 20000.66 < 2.2e-16 ***
`COVID Shutdown`                        40115   40115     1 304464   181.54 < 2.2e-16 ***
hour                                  8321479  361803    23 304464  1637.38 < 2.2e-16 ***
`School Day`:`Student at home learning`  334828  334828     1 304464  1515.30 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure 7-11. LMEM ANOVA Results for the WCSD “Other” Model

7.3 Statistical Tests for the Alumni Generalized Linear Model

For the one Alumni cohort school group with only one site,[22] *t*-statistics were used to evaluate all variables. A p-value (“Pr(|>t|)”) of 0.05 or less meant that the variable had a significant independent contribution to the model. Equation 3-5 was used to model this site. The results for this site are in Figure 7-12. All variables were statistically significant at $p < 0.05$ with the exception of individual hours within the hourly adjustment variable; some hours were colinear with other hours, which is expected.

[22] Alumni “Other”

```
Call:
glm(formula = formula(formula), data = curr_clean)

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  71.5022     1.3418  53.287  < 2e-16 ***
post1       -14.5004     0.6056 -23.944  < 2e-16 ***
CDD         101.8292     0.4529 224.822  < 2e-16 ***
`Staff Day`  28.1178     0.5483  51.285  < 2e-16 ***
`Op Change` -15.7618     0.8127 -19.395  < 2e-16 ***
hour1         1.5034     1.7953   0.837  0.40240
hour2         5.1561     1.7968   2.870  0.00412 **
hour3        12.7839     1.7958   7.119 1.13e-12 ***
hour4        27.2424     1.7961  15.168  < 2e-16 ***
hour5        38.5232     1.7964  21.444  < 2e-16 ***
hour6        36.9314     1.7967  20.556  < 2e-16 ***
hour7        39.6817     1.7963  22.090  < 2e-16 ***
hour8        47.0678     1.7956  26.213  < 2e-16 ***
hour9        51.7385     1.7959  28.809  < 2e-16 ***
hour10       57.0864     1.7962  31.781  < 2e-16 ***
hour11       60.6892     1.7978  33.757  < 2e-16 ***
hour12       59.9081     1.7992  33.297  < 2e-16 ***
hour13       57.4705     1.8008  31.914  < 2e-16 ***
hour14       47.8812     1.8022  26.569  < 2e-16 ***
hour15       32.7544     1.8031  18.165  < 2e-16 ***
hour16       18.9240     1.8034  10.494  < 2e-16 ***
hour17       12.1477     1.8029   6.738 1.66e-11 ***
hour18        8.5435     1.8024   4.740 2.16e-06 ***
hour19        9.4758     1.8002   5.264 1.43e-07 ***
hour20       13.1155     1.7988   7.291 3.21e-13 ***
hour21        8.0113     1.7976   4.457 8.38e-06 ***
hour22        2.2705     1.7970   1.264  0.20642
hour23       -0.9797     1.7967  -0.545  0.58556
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure 7-12. GLM t-statistic Results for the Alumni “Other” Model

8 APPENDIX C: "MEASUREMENT AND VERIFICATION REPORT CONTINUOUS ENERGY IMPROVEMENT (CEI)" PREPARED BY CLEARESULT FOR CLARK COUNTY SCHOOL DISTRICT

The following report, which was created by the 2023 Energy Smart Schools Program's implementation contractor, was prepared for Clark County School District (**58** pages including the title page).

CLEAResult

Measurement and Verification Report Continuous Energy Improvement (CEI)

December 2023

PREPARED BY

CLEAResult

PREPARED FOR

CCSD
CLARK COUNTY
SCHOOL DISTRICT

SPONSORED BY

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1.0 Executive Summary

2023 marked the fifth year for Clark County School District's (CCSD) engagement with the NV Energy Smart Schools CEI program. The CEI schools program team continued to track 289 sites for 2023, supporting the District in every way possible.

2023 began with Mark [redacted] CCSD's Director of Sustainability, Energy, and Environmental Services and the interim VP of Facilities, continued support of our efforts, while balancing the many responsibilities of his position. However, Mark left the district in early August which was a major change as he has been the only point of contact for us over the past four years. Fortunately, Mark made us aware of this change in mid-July and ensured we had a positive hand off to several CCSD employees so momentum would not be lost. Another major challenges this year was the break in data delivery between NV Energy and CLEAResult systems due to a worldwide data breach. This impacted our ability to, on a more "live" basis, track energy savings but fortunately we restored this connection and got data updated prior to end of year reporting. Major energy impacting events that took place in 2023 included, a now standardized approach of schedule changes from June through the beginning of October, dedicated efforts to energy savings and preventative maintenance improvements by the District, the replacement of 1,627 thermostats in portables, and the commencement of a major lighting upgrade project.

The CEI team continued to combine regular check-ins, brainstorming, and model tracking (at beginning of the year) with support of capital and low- and no-cost activities around the District. Mark and his team continued their efforts to increase preventative maintenance and sustainability/efficiency initiatives that have improved savings and reduced costs at the District. At the end of 2022, CCSD was committed to take on and achieve 50001 Ready recognition, a US DOE program that is a self-paced, no-cost way for organizations to build a culture of structured energy improvement that leads to deeper and sustained savings. Engagement and initial planning for completing 50001 Ready started mid-October 2022 and we came up with initial plans for a subset of schools. Unfortunately, with Mark's departure, this venture has been put on hold. In 2023 the 289 target facilities achieved a total energy savings of 25,692,826 kWh which equals 6.2% of their baseline electrical energy consumption. Table 1 summarizes the program savings for 2023 and Table 2 outlines the 2023 CEI parameters.

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Table 1. 2023 CEI Program Savings Summary

Number of Participating Schools	289
Measurement Period	12/26/2022-12/24/2023
Predicted Electricity Usage (kWh)	400,226,351 kWh
Actual Electricity Usage (kWh)	371,479,259 kWh
Projects Incentivized Outside of CEI (kWh)	3,931,963 kWh
Measured Electricity Savings (kWh)	25,692,826 kWh

Table 2. 2023 CEI Program Parameters

Sponsoring Utility	**NV Energy**
Program Name	Continuous Energy Improvement (CEI)
Implementation Contractor	CLEAResult Consulting Inc.
Energy Type(s)	Electricity (kWh)
Program Engagement	December 15, 2019 – December 24, 2023
Customer	Clark County School District
Location	Maintenance and Operations Service Center: 1180 Military Tribute Place, Henderson, NV 89074
Classification	K-12 Schools, Public Education
Energy Champion - CCSD Energy Manager	
Back-up Energy Champion - Director, Environmental Services	
CEI Program Director	
CEI Energy Coach	
Program Manager	
Energy Model Specialist	

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2.0 CEI Scope of Work

Previous years work with CCSD included a focus on expanding the energy team outside of Mark's responsibilities, working on different phases of actions/energy management activities, and dialing in BAS opportunities. 2023 followed a similar path but our plan was disrupted with Mark's departure. While this put a pause on certain activities like 50001 Ready energy management tasks and conducting training for CCSD facilities staff, it did allow us to expand the energy team and set ourselves up for success for 2024.

Our scope of work involved a bringing the new team members up to speed, focused follow ups on opportunity register items that were developed from 2021 phases, improved strategies for 24/7 building HVAC scheduling to reduce the impact on energy use, collaboration on operational efficiency strategies, collaboration on energy efficiency upgrade project opportunities, and the completion of an energy management assessment (EMA).

3.0 Engagement and Energy Saving Actions

3.1 Program Team Support

The highlight of the 2023 program year has been the ongoing strong relationship with Mark, Doug and Lori, who have picked up where Mark left off and continue to guide CCSD in energy efficiency and energy management measures. With their leadership and support, the CEI programs team and District continued to make progress on the CEI program and several other activities. These included:

- Monthly Opportunity Register reviews and operations calls
- Support and collaboration on energy efficiency project prioritization
- Operational strategy reviews
- Recommendations on building scheduling strategies
- 50001 Ready EnMS discussions
- Energy Management Assessment integration into future planning

Mark continued to embrace the importance of change management and organizational change as a part of energy management and worked with the CEI schools program team to evaluate opportunities to engage the District in energy saving behavior and opportunities. 50001 Ready was a focus early in the year and Mark and Patrick discussed several focus areas and specific schools to begin to utilize the 50001 Ready structure to have a real impact on energy savings and organizational change. Due to Mark's departure, this initiative was put on hold, but we hope to pick it up in 2024 and Doug and Lori have expressed interest in the same. On a building scheduling note, continuing from 2021/22, CCSD struggled with a backlog of maintenance items, shortage of staff, and energy management system issues. These challenges made it difficult for the District to dedicate a large amount of time to the program, but building on the trust and effectiveness of the program, the program team continued to provide Mark and CCSD with critical information and support throughout the year to make progress. This teamwork contributed to much of the success CCSD saw around their energy savings. While our models were out of commission for the second half of the year, we knew the actions taken from previous years would result in savings, especially with additional scheduling corrections.

For 2023, Mark, Doug and Lori and his team focused on the recommendations and lessons learned from the past several years to prioritize their efforts for energy efficiency including continuation of increased and more robust preventative maintenance (PM) measures specific to HVAC filter changeouts, coil cleaning, and a robust water treatment program. Building on 2021 and 2022, a major improvement of 24/7 HVAC scheduling over the summer

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months included actual scheduling of sites and buildings across the school. The CCSD team programmed in schedules and setbacks across sites that reduced the impact of 24/7 operations on energy consumption. This was a major improvement over previous years and is discussed in section 3.2 Operational States below.

Collaboration on items like these continue to demonstrate the value of the CEI and schools program for CCSD. Another example is CCSD's pursuit of 50001 Ready recognition. As part of the CCSD master planning and goal setting for Focus 2024, the District wide planning process for the years to come, Mark determined 50001 Ready would offer significant value, tools, and resources for the District. As such, 50001 Ready will serve as the framework for CCSD to continue their efforts around energy management and sustainability. At the end of 2022, CEI coaches, program staff, and Lawrence Berkeley National Lab staff supported Mark in the completion of an energy management assessment to benchmark where the District is presently at with their energy management program. Doug and Lori are prepared to engage on this in 2024 and our hope is to further integrate the 50001 standard into CCSD operations and continue to drive energy use down. As an official DOE 50001 Ready partner, CLEAResult will continue to help guide and support CCSD in these efforts to holistically engage the organization and integrate energy management as a standard practice.

Looking toward 2024, the schools program team will continue to support CCSD in evaluating opportunities, specifically focused on 50001 Ready, no-cost and low-cost projects, operational changes, and major capital improvement projects.

3.2 Operational States

CCSD's school and support buildings are subject to varying hours and types of uses based on seasons, occupation status, and usage requirements. The operational state of each building refers to the combination of these factors and their relationship with building schedules, primarily for lighting and HVAC. Changing the scheduled hours of building systems has a significant impact on energy usage and is directly related to energy costs.

Building on successful building scheduling and maintenance practices from 2021 and 2022, Mark and Doug guided their team to build additional scheduling into their normal and summer building operations. Schools continued to operate at 100% occupancy settings throughout the year, scheduled from 5:30 AM to 10:00 PM from around January 1 to May 31, 2023. On June 1 through mid-October, 2023, the hottest months of the year, Clark County SD operated their HVAC systems in a similar fashion to previous years, which allowed them to significantly reduce downtime, maintain temperatures in buildings/classrooms and allow their maintenance team to address workorders in a more planned manner rather than spending the majority of their time reacting to maintenance requests. To build on this third year of "24/7" operations, the district took the lessons learned from more strategic scheduling from 2022 and 2021 and applied much more standardized scheduling and setback approaches to their systems across the district. In 2022, to try and reduce the consumption increase and this cost, in collaboration with CEI coaches and engineers, the maintenance team updated their programming at high schools and some middle schools to include a setback for overnight hours by setting cold deck temperature setpoints to a point that allowed AHUs to blow higher temperatures so the load on chillers was less overnight. These changes were implemented from 10pm to 5am at the respective HS and MS sites. Elementary schools, admin buildings and about half of middle schools were not scheduled with a cold deck adjustment; as such the energy loads kept on the chillers and system were higher relative to the adjusted high school and middle schools. For 2023, the district put in these setbacks across all sites, implemented custodial modes, and identified where temperature setpoints could float higher.

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CCSD stopped operating their buildings 24/7 on October 14, 2022 and resumed a normal 5:30 AM to 10:00 PM building schedule. The CEI program team's models accurately reflect these operating states and allowed Mark to see, with about a month lag, the effects of the operational changes. As a part of these mode of operations, CCSD maintained an EMS operations watch stander to start at 4:00 AM to go through the system and identify any issues by the time the rest of the staff showed up. This allowed the District to get ahead of any problem areas and correct them before staff, faculty, and students showed up. While these operational states had a big impact on the energy consumption of CCSD in 2022, they resulted in reduced down time and improved workorder completion for the CCSD facilities and maintenance staff. During the 2023 school year summer, the schools were operating buildings on weekends to avoid the build up of heat similar to the last two years. The sites were also running the non-occupied buildings every day with HVAC to curtail temperature build up and avoid excess work orders. This was accounted for in the models by indicating for typical school days as the sites were operating the same during the summer as they were during the school year. This data set is outlined in the "Site Data" tabs of each model.

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4.0 MT&R Baseline Model and Measured Savings

4.1 Introduction

CEI savings are determined using statistical energy models. The energy model compares baseline energy consumption, using a best fit linear regression equation, with actual energy use over the measurement period. Energy savings occur when the actual energy consumed is less than the predicted energy usage. CEI program savings are the total observed model savings summed up over the program measurement period minus any savings from incentivized projects reported under different programs.

The baselines for the energy models are developed in JMP statistical software. The baseline information is then transferred to an Excel file, consisting of multiple tabs, that contains the CEI energy model. The Excel model file is the primary information source and documentation for energy savings for this report. The various aspects of the Excel energy model are explained in the sections below. The reader should refer directly to the Excel CEI Model Tracking file, which contains the detailed and specific information for each model. In addition, the following sections contain a high-level summary of the model plus explanations for any unique or special factors to be considered in interpreting the models and savings.

Preliminary modeling employed stepwise regression. This was followed by successive manual changes to the model's specification to identify a model with good predictive performance and a reasonable number of predictors given the sample size. The distribution of each variable in the model was examined for suitability in regression modeling. A time series plot of each variable was analyzed. Outliers were investigated on a univariate basis (through examination of standardized Z-scores) and on a multivariate basis (through analysis of Cook's Distances and leverage plots to identify excessively influential cases or points). The strength of association between variables was evaluated using bivariate correlations as well as partial correlations and associated scatter plots.

The performance of the model was assessed through a variety of statistical measures including overall fit (R2), coefficient of variance, autocorrelation of the regression residuals, X-Y plot of actual vs. predicted values, and a time series plot of actual vs. predicted values superimposed.

The residuals (prediction errors) were examined for normality (via an omnibus normality test) and to identify outlier predictions. The residuals were also examined graphically for statistical homoscedasticity (equal variance) across the range of predicted energy values. The cumulative sum of the differences between actual and predicted energy use over time is defined as the CUSUM. As such, CUSUM was plotted as a time series to evaluate the model's predictive consistency.

4.2 Baseline Energy Model Discussion

The baseline energy model development discussion and rationale can be found on the various Model Validation tabs (ES NF Validation, MS NF Validation, HS NF Validation, Other NF Validation, ES FS Validation, MS NF Validation, and HS FS Validation) in both the Alumni and Non-Alumni site Excel model files and Appendix B of this report. Parameters used to define the model specifications are shown on the various Electricity Model tabs (Elementary_No Food, Middle_No Food, High_No Food, Other_No Food, Elementary_Food Service, Middle_Food Service, and High_Food Service) in the "Parameter Estimates" table that lists the energy consumption predictors and their accompanying coefficients. All parameters meet the standard criteria for statistical significance, unless explained otherwise.

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4.3 Measurement Period Discussion

Further discussion of any measurement period adjustments, modifications, or discussion can be found on the Model Validation tabs (ES NF Validation, MS NF Validation, HS NF Validation, Other NF Validation, ES FS Validation, MS NF Validation, and HS FS Validation) in both the Alumni and Non-Alumni site Excel model files for each specified model and Appendix B of this report.

4.4 Raw Data

Raw data is contained in up to four separate Data tabs in the model. The Billing Energy Data and Interval Energy Data tabs contains either billing or daily interval Electricity data obtained from the supplying utility for the participant. The Weather Data tab contains weather data from the Weather Underground API database based on the weather station closest to the participant site. The Production Data tab contains specific occupancy and site information, provide by the participant, used in the model.

4.5 Baseline Period and Model Interval

The Model tabs (Elementary_No Food, Middle_No Food, High_No Food, Other_No Food, Elementary_Food Service, Middle_Food Service, and High_Food Service) indicate the baseline period in the "Program Dates" table, as well as the model interval – typically monthly or weekly. The rational for baseline duration can be found on the Model Validation tabs (ES NF Validation, MS NF Validation, HS NF Validation, Other NF Validation, ES FS Validation, MS NF Validation, and HS FS Validation).

4.6 Model Parameters

The model parameters are shown on the Electricity Model tabs (Elementary_No Food, Middle_No Food, High_No Food, Other_No Food, Elementary_Food Service, Middle_Food Service, and High_Food Service) in the "Parameter Estimates" table that lists the energy consumption predictors and their accompanying coefficients. The rationale for a parameter's validity can be found in the gray Model Validation tabs (ES NF Validation, MS NF Validation, HS NF Validation, Other NF Validation, ES FS Validation, MS NF Validation, and HS FS Validation), along with the baseline minimum and maximum values for each parameter. All parameters meet the standard criteria for statistical significance, unless explained otherwise.

4.7 Model Validity

Model validity is portrayed in the Electricity Model tabs (Elementary_No Food, Middle_No Food, High_No Food, Other_No Food, Elementary_Food Service, Middle_Food Service, and High_Food Service) using "Regression Statistics" and "Parameter Estimates" tables which indicate the statistical values obtained compared to the target ranges (listed to the right of the value obtained). The "Time Series Graphs" also provide a visual assessment of correlation of the variables. Model validity is also portrayed in the Model Validation tabs (ES NF Validation, MS NF Validation, HS NF Validation, Other NF Validation, ES FS Validation, MS NF Validation, and HS FS Validation) using the "Residual Time Series" graph along with discussion about the model baseline and model variables.

4.8 Cumulative Sum (CUSUM) Table

The CUSUM table is shown in the Electricity Model tabs (Elementary_No Food, Middle_No Food, High_No Food, Other_No Food, Elementary_Food Service, Middle_Food Service, and High_Food Service) to the right of the model statistics information. It contains the formulas and quantities for calculating actual energy, predicted energy, the

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difference between actual and predicted energy, and the cumulative sum of the energy usage differential for each model interval period.

4.9 Excluded Points

Excluded points are indicated in the CUSUM Table in the Electricity Model tabs (Elementary_No Food, Middle_No Food, High_No Food, Other_No Food, Elementary_Food Service, Middle_Food Service, and High_Food Service). The rationale for excluded points is given in the "Notes" column of the table. Points may be excluded during both the baseline and measurement periods.

The variable values during the measurement period that are outside the range experienced in the baseline are highlighted and examined further for accuracy. In addition, any residuals in the measurement period that fall outside of ±3 standard deviations of the baseline residual population are highlighted to be examined. If a data point has both a variable value and residual highlighted, an extrapolation analysis is conducted to determine if extrapolation is causing the model to predict inaccurately. This analysis determines if the points are to be excluded, capped, or kept in the model. Analysis of these points (if applicable) can be found in Appendix D for more details of this evaluation and the recommended outcome(s).

4.10 CUSUM Graph

The CUSUM graphs are shown in the Electricity Model tabs (Elementary_No Food, Middle_No Food, High_No Food, Other_No Food, Elementary_Food Service, Middle_Food Service, and High_Food Service) tab below the model statistics information, and graphically depicts the CUSUM value from the CUSUM table. It also shows and describes key points in the CUSUM history.

4.11 Energy Savings Summary

The energy savings summary is contained in the Electricity Savings tab. It shows a summary of the measurement period and the savings achieved.

4.12 Incentivized Projects Table

The incentivized projects table is contained in the Capital Projects tab. The table lists incentivized projects conducted during the measurement period and calculates the prorated energy savings to be deducted from the CUSUM savings, ensuring that no incentivized projects outside of the CEI program are incentivized twice.

5.0 Conclusions and Future for CEI

CCSD carried their success with the CEI program into 2023 and continued to capture significant energy savings by implementing strategic and simple, no- and low-cost measures across their repertoire of buildings. Mark and then Doug and Lori, with the support of the CEI and schools program team, had a significant impact on the school budget, efficiency of building equipment, and health of CCSD buildings. Building on BMS scans, on-site visits, and improved preventative maintenance, the CEI schools program team found continued success through more strategic scheduling and continued monitoring and feedback for the CCSD team. This collaboration provided Mark with tools and support and allowed CCSD to realize a high savings amount and continue to reduce wear on their building systems. The program team looks forward to the continued partnership with CCSD in 2024 to help further engage the District and implement strategic and impactful energy efficiency projects.

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Appendix A: 2023 Opportunity Register

CCSD OPPORTUNITY REGISTER

#	Opportunity Area	School	Equipment #	Recommended Project	Type	Apply	Existing condition	Project Details
1	HVAC	All	All units	Schedule off on holidays	BMS	All	Found no holiday schedule in place @ Faiss MS. Unable to review other schools schedule. (Verified with Tim A 6/19)	Units should be set to unoccupied on holidays to reduce energy use. This may have to be entered every year for specific days. Recommend do so when school schedule comes out.
2	HVAC	All	OAT sensor	Replace sensor	Onsite	All	See sheet 'tracker for opps - all schools for per school findings.	Check against calibrated handheld. If not within 2F, calibrate/replace sensor. Ensure OAT sensor is in a shady spot on north side of building so not influenced by sun. If more than one sensor recommend replacing with one weather station and tying all equipment to it to reduce maintenance requirements. This is probably the most important sensor as it is used for control of various systems. Add sensor checks to regular PMs especially this one.
3	Chiller plant	Cortez ES	Cooling Plant	Add CHWST reset	BMS	N/A	Says future chilled water reset, so assuming setpoint is fixed now at 45F.	Add chilled water temperature reset to reduce wasting cooling energy during periods of low load. Also recommend showing setpoint and control variable (OAT?) on BMS graphics so able to compare actual to setpoint to identify times when the system might not be able to keep up.
4	Chiller plant	Cortez ES	Chiller 1	Fix equipment	OnSite	Site	Chiller 1 is in alarm and on but enable is set to off.	Looks like this is overridden to on. May be on 24/7, check trends. Correct issue so chiller comes on only when a call for cooling. The cooling tower and tower pumps however are off. How is the chiller dissipating heat to the outside if the CT are off while the chiller is on?
5	HVAC	Cortez ES	MZU: 1, 2, 5	Fix CW valve	BMS	Site	Cold deck temp is way lower than setpoint and chilled water valve is 100% open.	Valve may be stuck at 100% open or leaking, investigate & repair: Look at trends to see if always overshoots or if always at 100% open. May need to verify temp at unit.
6	HVAC	Cortez ES	All MZ units	Economizers: Check setpoint, ensure functional.	BMS	Site	Economizer issues identified based on damper position and temperatures. e.g. for MZU-1: OA is open 78% and RAD is also open. Based on RAT (70.1F) and MAT (72.1F), and actual OAT of ~69F suspect OAD is mostly shut not at 78% open.	What is the economizer setpoint? It is recommended for the climate zone to use either: OA dry bulb highlimit with a setpoint of 73F or OAT vs RAT. This will enable the economizer when OAT is less than 73F or RAT respectively. Also verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality. If economizers are not checked regularly add to PMs as besides humidity sensors they are the most common failure.
7	HVAC	Cortez ES	MZU-2, 3, 4, 5, 6	OA flow station and/or damper repair	BMS	Site	OA damper position and flow station cfm do not jive.	Check OA damper position, and verify flow using calibrated handheld if doesn't match BMS, replace flow station or damper actuator as needed.
8	Boiler plant	Cortez ES	Boiler	Reduce boiler enable setpoint	BMS	Site	Hot deck temp (72.7F) is way lower than setpoint (119.9F), and very close to MAT (72.1F) but HW valve is 75% open. Boiler & pumps are off, water temp is ~79F. Boiler enable setpoint is 95F which is high. However with the inaccurate OAT sensor the boiler plant may be being kept off when it should be enabled.	How is boiler enabled? Should it be on? Fix OAT sensor (described elsewhere) and decrease the boiler enable setpoint so the boiler plant doesn't come on when warm outside (adjust lower to perhaps 65F).
9	HVAC	Cortez ES	EF-5	Schedule off when not needed	BMS	Site	On the central plant sheet it shows EF-5 as on, its 7am.	Does EF-5 need to be on, what does it serve? Could it be scheduled on as needed?

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10	HVAC	Cortez ES	All MZ units	Schedule off when not needed	BMS	Site	Unoccupied setpoints are 42F heating, 120F cooling. If this represents space setpoints and the unit goes into unoccupied mode, this is too wide to trigger the unit on most all of the year. This could lead to a huge delta T to overcome in the space when switching into occupied mode and having to start the unit up early.	What is the occupied schedule? Does this align with the space use schedule? Could equipment on time be further reduced? Adjust unoccupied setpoints to =occupied setpoint +/-10F and tighten time-based schedule to match space use schedule. Trial and error to balance unoccupied setpoints with the time schedule to minimize time on. Reviewing trends of supply fan status, cold and hot deck temperatures vs setpoints on extreme temperature days could help determine if equipment is started too early or comes on too often during the unoccupied periods.
11	HVAC	Faiss MS	All MZ units	Economizers: Check setpoint, ensure functional.	Onsite	Site	OA damper position was at minimum on all MZUs because it was hot outside (100F). It is not clear what the economizer setpoint is and if economizers are working.	What is the economizer setpoint? It is recommended for the climate zone to use either: OA dry bulb highlimit with a setpoint of 73F or OAT vs RAT. This will enable the economizer when OAT is less than 73F or RAT respectively. Also verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality. If economizers are not checked regularly add to PMs as besides humidity sensors they are the most common failure.
12	HVAC	Faiss MS	MZU 11 zone 5, 6, 7, 8	Fix equipment	Onsite	Site	In Alarm, based on temperatures, looks like the hot air damper might be broken.	Investigate, repair, and release alarm.
13	HVAC	Faiss MS	Central plant	Fix equipment	Onsite	Site	Both boilers, HW LO temp, and chiller 2 are in alarm	Investigate, repair, and release alarm.
14	HVAC	Faiss MS	Outdoor relative humidity sensor	Fix sensor	Onsite	Site	RH sensor reading 100% on 6/6/2019 when the actual RH is much lower.	Is RH controlling anything? I'd suspect the only thing its used for could be economizer control. If it is used for something, repair or replace sensor.
15	Boiler plant	Faiss MS	Boiler plant	Turn off pumps when not needed	BMS	Site	Boiler pumps SHWP1 & SHWP2 are on, boilers are off, and it is 100F outside.	Do the boiler pumps need to be running all the time? If not, program to turn these off when the boilers are off.
16	HVAC	Faiss MS	All MZ units	Schedule off when not needed	BMS	Site	Night setback setpoint is 55F. I assume this is the heating setpoint, not sure what unoccupied cooling setpoint is and how set.	Show night heating and cooling setpoints in BMS. Verify unoccupied setpoints are =occupied setpoint +/-10F and tighten time-based schedule to match space use schedule. Trial and error to balance unoccupied setpoints with the time schedule to minimize time on.
17	HVAC	All	All units	Occupied temperature setpoint adjustment	BMS	All	Across schools low and high occupied setpoints vary (tstat slider): 72F/74F global Faiss, 71F/74F global Goolsby, 70F/73F global Heweston, 73F/76F zone McMillan, 75F/75F global Bartlett, 75F/75F global Bracken, 71F zone (only 1 SP shown) Chappel Theater add , 70F/73F global Diaz, 72F/73F zone Carl, 72/73F global Reedom, 71F/73F global Dooley 0-2F deadband, 68F or 73F zone Foothill (for single zone AHUs), 71F/75F zone Foothill (for MZUs). Global setpoints (if enabled) override the zone setpoints as the allowed range for the slider in the thermostat. offsets/differentials between the heating and cooling setpoint vary across schools in	Recommend standardize slider range across all schools to minimize occupant adjustment (2F max differential) (72F/74F) using the global setpoints, and standardize the offset to 4F (i.e. the deadband between heating and cooling setpoints) for all schools except for Cortez ES. For the schools with tighter slider control (Bracken, Bartlett, Chappel Theater add(?), Carl) recommend reduce to around the same temp ~73F and leave differential as is to minimize energy use increase.

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							how programmed and if shown on graphic.	
18	HVAC	Goolsby ES	All MZ units	Economizers: Verify min OA & add to BMS, check setpoint, ensure functional.	BMS	Site	Goolsby OA damper = yes. Carl ES OA damper=enabled. It is not clear what this represents and if economizers exist and are functioning correctly.	Goolsby: What does yes mean? Economizer enabled? If so, recommend rename this economizer enabled. Also recommend update BMS screens to: add OAD % open and show OA damper min % setpoint so you can verify the position is as expected. What is the economizer setpoint? It is recommended for the climate zone to use either: OA dry bulb highlimit with a setpoint of 73F or OAT vs RAT. This will enable the economizer when OAT is less than 73F or RAT respectively. Are there economizers on these units? If so recommend verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality. If economizers are not checked regularly add to PMs as besides humidity sensors they are the most common failure.
19	HVAC	Goolsby ES	Boiler plant & Exhaust fan	Fix equipment	OnSite	Site	Boiler 1 & EF-7 is in alarm	Investigate, repair, and release alarm.
20	HVAC	Goolsby ES	FCU2 Storage and restrooms & MZU zone 3	Adjust zone temperature setpoint	BMS	Site	FCU2: Zone temp was 71.9F and calling for 100% heating. Zone temp setpoint is 72H/75C. MZU6 Zn3: always at 100% cooling and zone temp setpoint is 72.5F. Do these serve the same areas?	If these serve the same areas recommend use FCU as back-up so make the zone temperature setpoints wider than the MZU Zn3 setpoint range (71-74F adjustable at tstat), So FCU zone setpoints should be more like 68H/77C (+/-3F of MZU Zn3 range) so ensure systems are not fighting each other or causing to overshoot.
21	HVAC	Hewetson ES	All units	Economizers: Verify min OA, check setpoint, ensure functional.	Onsite	Site	In general, during occupied hours Min OA damper should never be overridden to 0% as ventilation air is required to all occupied spaces. Investigate, repair, and release override. AHU-1 looks to be overridden to 0%, not sure what the issue on AHU-4 is.	**Check AHU-1 & AHU-4:** to verify that these dampers are the main source of ventilation air for the space. If so, investigate why set to 0% for AHU-4 and why overridden for AHU-1. Determine what min OA is required, repair and release override. If another source of ventilation air exists and is expected to be used for these units, add note to BMS screen indicating that 0% is as expected because not main source of ventilation air. **All units:** What is the economizer setpoint? It is recommended for the climate zone to use either: OA dry bulb highlimit with a setpoint of 73F or OAT vs RAT. This will enable the economizer when OAT is less than 73F or RAT respectively. Also verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality. If economizers are not checked regularly add to PMs as besides humidity sensors they are the most common failure.
22	Chiller plant	Hewetson ES	Central plant	Cooling plant enablement		Site	Says Chiller is off, but the CHWST is 42.9F and return is 52.2F	Check trends of chiller status point and temperatures. Replace, repair sensor as needed.

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							(cooling 10F). This is not possible unless the plant is on. Did it just turn off? Investigate.	
23	HVAC	Hewetson ES	Exhaust fans	Fix equipment	Onsite	Site	EF-2, EF-4, EF-7, EF-8, & EF-10 are in alarm.	Investigate, repair, and release alarm.
24	HVAC	Hewetson ES	All units	Investigate night setbacks		Site	What is the unoccupied space temperature setpoints? All units appear to have two sets of night setback setpoints, one based on space temperature (night setback cooling and heating setpoints) and one based on return temperature (night setback cool and heating return). What setpoints are used for control?	If goes into unoccupied mode, adjust space setpoints to =occupied setpoint +/-10F and tighten time-based schedule to match space use schedule. Trial and error to balance un unoccupied occ setpoints with the time schedule to minimize time on.
25	HVAC	Hewetson ES	AHU-1	Fix sensor	Onsite	Site	CHWST varies by unit, is there a separate sensor at each valve? AHU-1 says 32.9F, this is almost freezing, seems wrong as the setpoint is around 42F.	Recommend link to a single global sensor to reduce required maintenance, like the HWST appears to be.
26	HVAC	Hewetson ES	All equipment	Verify equipment turns off during unoccupied hours	BMS	Site	Occupancy schedule is 3am to 1pm Monday through Friday.	Verify all equipment is off outside of these hours by: reviewing trends, going to each unit or reviewing summary screen outside of these hours. Review central plant equipment, AHUs, and exhaust fans. Add equipment to schedule as needed.
27	Chiller plant	McMillan ES	Cooling Plant	Verify cooling plant turns on when needed		Site	CHW valves all at 100% open but cooling plant appears to be off (delta between supply and return is ~0) so cold deck supply setpoints are not being met. Graphic page says CHW plant info may be unreliable.	Is cooling plant off? Should it be? Investigate and correct as needed.
28	HVAC	McMillan ES	All MZ units	Economizers: Verify min OA & add to BMS, check setpoint, ensure functional.	Onsite	Site	OAT=92.9F so OAD should be at minimum for all but OA damper positions vary. MZU-7 min OA is 50% but it is at 100%.	**Check MZU-7 specifically and others**: What is economizer setpoint? It is recommended for the climate zone to use either: OA dry bulb highlimit with a setpoint of 73F or OAT vs RAT. This will enable the economizer when OAT is less than 73F or RAT respectively. Also verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality. If economizers are not checked regularly add to PMs as besides humidity sensors they are the most common failure.
29	HVAC	McMillan ES	All MZ units	Fan speeds		Site	All supply fans at 100% speed.	Are fan speeds supposed to vary? i.e. is there VFDs and do these units serve terminal boxes with dampers? Investigate if supply fan speeds ever vary by looking at trends, compare to design. If supposed to vary, investigate duct static pressure setpoint and possibility of lowering. If not, remove % speed from BMS graphics as this is misleading.
30	Chiller plant	McMillan ES	Cooling Plant	Remove override on CW Pump CWP-1 & Chiller system.		Site	CWP-1 VFD is overridden and operating in hand at 42% speed and chiller system is overridden to enable. At 1:42pm on 6/19/19 all MZUs were off but chiller, CWP and CHWPs were on.	Investigate, repair, and release override so entire cooling plant turns off when there is no call for cooling.
31	Chiller plant	McMillan ES	Cooling Plant	Reduce pumping		Site	CHW-DP setpoint is 150 psi and actual DP is 1.4psi with CHWP-2 operating at 60Hz.	What is design DP setpoint? Review design docs to find, and revise setpoint to this. Then verify CHW pump speed varies as needed to meet setpoint. Typical setpoints are more like 1-15psi.

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32	HVAC	McMillan ES	All units	Schedule off when not needed	BMS	Site	MZUs occupied schedule is 4am-4pm, custodial from 4pm to 11pm (except for MZU-9 which has custodial until 9pm. RTUs occ schedule is 4am to 11pm M-F.	Given discrepancy, suspect there is opportunity to tighten schedule. Review space use schedule and compare to HVAC equipment schedule to minimize on time of each HVAC unit.
33	Boiler plant	Cortez ES	Boiler	Fix equipment	Onsite	Site	BLR-1 is in alarm	Investigate, repair as needed and reset alarm.
34	HVAC	Goolsby ES	FCU 4 Chiller room	Investigate zone conditions & HVAC unit, adjust setpoint		Site	FCU 4 temperature setpoints are 68H/71C and the CHW is always at 100% open, but the actual zone temperature doesn't get below 80F.	Investigate why the zone temperature doesn't get below 80F. Is the tstat is a bad location? Is 80F accurate for the space temperature? Is the CHWV working? If the zone is expected to always be above 80F increase setpoint to reduce the time the FCU is cooling.
35	HVAC	Bracken ES	All AHUs	Adjust global economizer setpoint	BMS	Site	Global econo SP is 65F.	It is recommended for the climate zone to use either: OA dry bulb highlimit with a setpoint of 73F or OAT vs RAT. This will enable the economizer when OAT is less than 73F or RAT respectively.
36	HVAC	Bracken ES	AHU 3-1, AHU 4-7	Adjust Min MA damper SP	BMS	Site	Economizer min damper position setpoint seems inappropriate: 1. AHU 3-1 is 100% min. Is 100% OA required for this unit? 2. AHU 4-7 is 0% min. Is no OA required for this unit?	Verify what min OA is required (check design drawings/space use) and adjust min damper position setpoint. CR can help with determining appropriate setpoint if given square footage, and # of people occupying space per AHU space. Then verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality. If economizers are not checked regularly add to PMs as besides humidity sensors they are the most common failure.
37	HVAC	Bracken ES	AHU 4-12, AHU 2-1, AHU 4-8, AHU 4-9, AHU 8-2, AHU 8-6	Fix economizer operation	Onsite	Site	OAT is 93.4F so all MA dampers (i.e. economizer dampers) should be at min position. The following were found at different positions as noted: AHU 4-12: MA damper was 100% open AHU 2-1, AHU 4-8, AHU 4-9, AHU 8-2, AHU 8-6: MA damper was 0% open, but MA damper min SP is >0.	Verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality.
38	HVAC	Bracken ES	All	Schedule off when not needed	BMS	Site	All HVAC equipment was set to occupied and found on on Sunday 6/30/2019 except Ahu 8-2. Couldn't review schedule - got error when try to view schedule by clicking on blue or black text on screen.	What is the occupied schedule? Does this align with the space use schedule? Could equipment on time be further reduced? Adjust unoccupied setpoints to =occupied setpoint +/-10F and tighten time based schedule to match space use schedule. Trial and error to balance unoccupied setpoints with the time schedule to minimize time on. Reviewing trends of supply fan status, cold and hot deck temperatures vs setpoints on extreme temperature days could help determine if equipment is started too early or comes on too often during the unoccupied periods.
39	HVAC	Bracken ES	AHU 4-6 SF, EF 4-3, EF 1-6, EF 4-4, EF 3-7; FCU 7-1, FCU 7-2;	Fix equipment	Onsite	Site	All this equipment was found in alarm. AHU 4-6 SF in alarm, enable=fan on, fan proof=fan off; EF 4-3, EF 1-6, EF 4-4, EF 3-7; FCU 7-1 & FCU 7-2: fan and night SB alarms;	Investigate, repair as needed and reset alarm.
40	HVAC	Bracken ES	Cooling Plant	Fix equipment	Onsite	Site	Chilled water in alarm. CHW SP is reset between 42F and 57F. Found SP at 42F but actual supply temperature of 47.8F.	Investigate what chilled water alarm means and correct. Also investigate what CHW SP is based on and verify that it is not always stuck at the minimum of 42F.

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41	HVAC	Bracken ES	All AHUs & RTUs	Adjust zone temperature setpoint	BMS	Site	Zone temp setpoints vary. Found 73H/75C, 74H/75C, 71H/75C, 71H/73C.	Standardize across all AHU & widen zone temperature setpoints to at least 4F delta in the occupied period. Recommend reduce heating setpoint to 68F as heating to 73F seems extreme and use cooling setpoint of 75F.
42	HVAC	Bracken ES	AHU 4-1	Fix CW valve	Onsite	Site	AHU 4-1 CHW valve position is 0% and HW valve position is 100%, yet the DAT is 60F, when the MAT is 81F (i.e. DAT is less than MAT even though CHW valve says closed). As a result, the boiler plant is on even though its 93.4F outside.	It appears that the CHWV is leaking by. Investigate and repair valve. Then verify no call for heating and that boiler plant (including pumps) are not turning on at high OATs.
43	HVAC	Bracken ES	Boiler	Reduce boiler enable setpoint	BMS	Site	Boiler pumps and boiler is on but it is 93.4F outside. Boiler enable setpoint is 95F.	Decrease the boiler enable setpoint so the boiler plant doesn't come on when warm outside (adjust lower to perhaps 65F).
44	HVAC	Bracken ES	AHU 4-6	Fix controls	BMS	Site	AHU 4-6 SF is in alarm, fan enable=fan on, fan proof=fan off, and CHW and HW valves are open 100%.	Investigate. When SF is in alarm or fan proof=off, CHW and HW valves both should go to 0% not 100%. Review and update controls.
45	HVAC	Bracken ES	FCU 3-3 & FCU 3-4	Reduce heating setpoint	BMS	Site	Heating setpoint is 75F, cooling setpoint is 76F. Delta T between H/C is only 1F.	Delta T should be at least 4F to minimize simultaneous heating and cooling. Heating setpoint seems really high. What is the minimum setpoint required by this space? Recommend reduce heating setpoint to 68F.
46	HVAC	Bracken ES	MZU 3-1	Fix valves	Onsite	Site	CHW valve @ 0% open but cold deck temperature (50.5F) is ~22F less than MAT (72F). Also the HW valve is at 100% but hot deck temperature (72F) is the same as the mixed air temperature (72F), even though the HW loop temperature is 76F.	It appears that the CHW valve is leaking by. Investigate and repair valve. Also it appears that the HW valve may be stuck closed. Investigate and repair valve.
47	HVAC	Bracken ES	All MZUs	CD reset	BMS	Site	CD reset: For MZU 5-5: CD damper max SP is 95% and max cold deck SP is 75F and min is 55F. Zone damper positions are 50% though and current cold deck temp SP is 75F. For MZU 6-2: CD damper max SP is 75% and max cold deck SP is 65F and min is 50F. Zone damper positions are 50% though and current cold deck temp SP is 65F.	Shouldn't the CD SP vary linearly between the min & the max when the zone damper is less than the damper max SP? What is min zone damper position required for min CD temperature? Verify in controls programming and/or trends that when max zone damper position is 95% or more that the CD temp SP is = min cold deck SP; when max zone damper is at min , CD temp SP is = max cold deck SP; and when it is in between the SP is in between.
48	HVAC	Karl ES	MZU 3	Fix CW valve	Onsite	Site	CHW valve @ 0% open but cold deck temperature (69F) is ~10F less than MAT (79F).	It appears that the CHW valve may be leaking by. Investigate and repair valve.
49	HVAC	Karl ES	All MZU	CD reset	BMS improvement	Site	The cold deck SP changes so I assume it is being reset but there is no way to tell if the SP is appropriate or not because the independent variable isn't indicated.	Check in programming how the CD SP is reset and add all appropriate info to the BMS screens so an operator could verify the resets are working correctly.
50	HVAC	Karl ES	MZU 5 Zone 15 Conference 13	Adjust zone temperature setpoint	BMS	Site	Zone temp setpoint is 78F. All other zones served by MZU 5 are within the global temperature setpoints 72/73F (global setpoints are shown as enabled).	Verify that this zone's temperature setpoint is limited by the global setpoints. If not, change programming to limit it.
51	HVAC	Karl ES	Boiler	Outside air temperature lockout	BMS	Site	Boiler pumps and boiler is on but it is 82.2F outside. The Boiler System Call is on, and there is a red dot next to it, OSA HWS Enabled=OFF, OSA heat on SP is 95F, OSA heat off SP is 100F.	Does the red dot indicate an override? If so, remove override. Enable the OSA lockout feature. Decrease the OSA heat off setpoint so the boiler plant doesn't come on when warm outside (adjust lower to perhaps 65F). Also determine what the OSA heat on setpoint is and adjust so the boiler plant only comes on when colder outside.
52	HVAC	Karl ES	Cooling Plant	Outside air temperature lockout	BMS	Site	CHWS OSA On SP is 60F (under Chiller heading) and CHWS OAT On SP is 52F (under CHW System Enable heading). Also CHWS OA Off SP is 55F (under Chiller heading) and CHWS OAT Off SP is	These points are similarly named so it is not clear which are associated with the chiller and which are associated with the plant. I recommend changing the chiller point names to include the word chiller to make this more obvious.

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							50F (under CHW System Enable). So between 52 and 55F OAT just the plant equipment operates to circulate water. Once the OAT gets above 60F the chiller comes on and once the OAT drops below 55F the chiller turns off, once it drops below 50F the plant turns off.	
53	HVAC	Karl ES	Cooling Plant	Chilled water setpoint	BMS	Site	Current CHWS SP is 54F but CHWS Temp is 43.9F and CHWR Temp is 46.9F.	Why is the chiller supply water temperature 10F less than the setpoint? Investigate. As is you are circulating much colder water than what is called for.
54	HVAC	Karl ES	EF-4	Fix equipment	OnSite	Site	EF-4 is in alarm	Investigate, repair as needed and reset alarm.
55	HVAC	Karl ES	All	Schedule off when not needed	BMS	Site	All HVAC equipment was set to occupied and found on on Sunday 6/30/2019 except the FCUs. Looks like under special events was set to on 24/7 from 6/27/2019 to 7/12/2019. In addition there is another special event entered for the date range 7/1 to 7/19.	Does all equipment really need to be on 24/7 to keep the zone temperature around 72F? Is the space occupied 24/7? What happens when the second special event kicks in? Which will take president? Recommend remove override and use occupancy schedule.
56	HVAC	Karl ES	MZU-6	CD reset & Fix CHW valve	BMS & Onsite	Site	CD Setpoint is 72F when the OSA Temp is 82F but the CD temperature is 48F with the CHW valve at 0%.	The CD setpoint seems really high given the OAT. Investigate that the reset range is inversely related to the demand (e.g. at OAT 55F CD setpoint is 55F and at OAT 65F CD setpoint is 45F). Also it appears that the CHW valve may be leaking by. Investigate and repair valve.
57	HVAC	Karl ES	MZU-4	Fix HW valve	BMS	Site	HW valve position is 0% but the hot deck temperature says 122.7 while the MAT is 84.6F, the HW setpoint is 75F, and the HW temperature is 155F.	It appears that the HW valve may be leaking by. Investigate and repair valve.
58	HVAC	Reedom ES	MZU-2, FC-10, EF-2	Controller offline	BMS	Site	These units are offline. I assume this is a controller issue.	Investigate/reset/replace - do whatever is needed to get back online. As is I assume these are on 24/7 and operating based on onboard controls (if any).
59	Exterior Lights	Bartlett ES	Lighting	Schedule	BMS	Site	The time and date doesn't show up on any of the BMS screens. Also when clicking on schedules an error occurs saying cannot find file. Lastly exterior lighting & pole lighting has a time based, but the schedules are different. Exterior lighting page also shows an astronomical clock. It is not clear how exterior lights are controlled.	Set time and date in BMS. Determine how exterior lighting is controlled if at all and if lights need to be on for safety all hours of the night. If so, recommend use just astronomical clock to keep lights off when sun is up - add if not already in place. If lights do NOT need to be on all dark hours, recommend in addition to astronomical clock add schedule and enable only when needed and dark.
60	HVAC	Bartlett ES	RTU 1, 4, RTU 6,	Change filters	Onsite	Site	Filters are dirty and duct static pressure setpoint is not being met.	Change filters. Add to PM plan to change regularly. Fan motors have to work harder to maintain SP when filters are dirty.
61	HVAC	Bartlett ES	RTU: 2, 3, 5, 8, 9, 9a, 10	Add graphics	BMS improvement	Site	Clicking on any of these RTUs results in showing the database only.	Update system to add graphics for each RTU so users can see associated points and verify operation is as expected.
62	HVAC	Bartlett ES	RTU 4 SF, VAV 4-1 & 4-2, VAV 7-8, VAV: 6-1, 6-5 through 6-9, BP-1 alarm, CP-4 alarm, EF-6	Fix equipment	Onsite	Site	Alarms on all of these units. RTU 4 SF is at 34% and not meeting duct static pressure setpoint. BP-1 alarm might be due to the HW system enable and the boiler enable override to off.	Investigate, repair as needed and reset alarm.
63	HVAC	Bartlett ES	RTU: 4, 9A, 9B, 10	Fix equipment	BMS	Site	On the summary & RTU-4 graphic screens there are multiple points shown in yellow. The other units (RTU-9A, RTU 9B and RTU-10) do not have graphic screens so unable to further investigate. What does yellow mean?	Investigate and correct any issues.
64	HVAC	Bartlett ES	RTU-4	Fix sensor	BMS	Site	Cooling setpoint is reset from 52 to 65F based on return air temperature of 69 to 65F	Check/replace RAT sensor. If it is found that RAT sensor is reading correctly and is in a good position

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							respectively. RTU-4 RAT is 93.1F but the zone temperature range is 73.0F to 80.8F (i.e. RAT>>zones feeding it). The rest of the RTU RATs are within a few degrees of the zone temperatures.	then recommend contact a duct sealing company to investigate. Add to PM it not already included.
65	HVAC	Bartlett ES	RTU-4, RTU 6 & RTU-8	Fix equipment	Onsite	Site	RTU-4 is supplying 82F air but the setpoint is 52F. RTU 6 is supplying 70F air but the setpoint is 50F. Also enable mode is overridden to enable cool but the cooling output says 0%. RTU-8 is supplying 80.1F air but the setpoint is 51.9F.	It is not clear why the cooling output is 0% (RTU 4 & 6, RTU-8 unknown) when the unit is not reaching this setpoint. Verify SA temperature at the unit. Verify DX cooling compressors and condensers are working correctly.
66	HVAC	Bartlett ES	RTU-8	OA flow station and/or damper repair	Onsite	Site	OA damper is at 100% open when OAT is 84.1F and RAT is 81.2F. All other unit OA dampers are <30% open (assuming at minimum required for ventilation.	Verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality. If all RTU economizers are not checked regularly add to PMs as besides humidity sensors they are the most common failure.
67	HVAC	Bartlett ES	All RTUs	Adjust global economizer setpoint	BMS	Site	Econ OA Hi L/O SP is 60F and Econ OA Lo L/O is 50F for all RTUs that have graphic screens.	If integrated economizers (i.e. economizers and mechanical cooling can both operate at same time) It is recommended for the climate zone to use either: OA dry bulb highlimit with a setpoint of 73F or OAT vs RAT. This will enable the economizer when OAT is less than 73F or RAT respectively. As for the low limit it is recommended to lower it to just above freezing to increase economizer hours and keep the cooling coil from freezing.
68	HVAC	Bartlett ES	RTU 2, 4, 6.	OA flow station and/or damper repair	Onsite	Site	OA damper position and flow station cfm do not jive. RTU-2 OA damper position unknown, flow says 0cfm. RTU-4 OA damper position 2%, flow says 0cfm. RTU-6 OA damper position says 15%, flow says 0cfm.	Check OA damper position, and verify flow using calibrated handheld if doesn't match BMS, replace flow station or damper actuator as needed.
69	HVAC	Bartlett ES	RTU-1, RTU-3, RTU-5	Fix sensor	Onsite	Site	CO2 sensors are reading 65,535ppm	Replace CO2 sensor. Especially if this is used for control.
70	HVAC	Bartlett ES	RTU-1, RTU-4, RTU-6	Fix economizer operation	Onsite	Site	OA damper position is less than the min OAD SP.	Verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality.
71	HVAC	Bartlett ES	All units	Schedule	BMS	Site	The time and date doesn't show up on any of the BMS screens. Also when clicking on schedules an error occurs saying cannot find file.	Perform night walk to see if RTUs are on 24/7 (suspect they are). What is the occupied schedule (if there is one)? Does this align with the space use schedule? Could equipment on time be further reduced? Adjust unoccupied setpoints to =occupied setpoint +/-10F and tighten time-based schedule to match space use schedule. Trial and error to balance uno unoccupied cc setpoints with the time schedule to minimize time on. Reviewing trends of supply fan status, cold and hot deck temperatures vs setpoints on extreme temperature days could help determine

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								if equipment is started too early or comes on too often during the unoccupied period
72	HVAC	Chaparral HS Theater	RTU 1	Change filters	Onsite	Site	Filter is dirty.	Change filters. Add to PM plan to change regularly. Fan motors have to work harder to maintain SP when filters are dirty.
73	HVAC	Chaparral HS Theater	AHU-1, FCU 4 through 7	Fix equipment	Onsite	Site	Alarms on all of these units. AHU-1: Zn1 temperature alarm, zn2 temperature alarm, comp1 alarm, RA filter DP. Zone 2 is supplying 83.6F air while zone 1 is supplying 65.2F air and the space temperatures of both zones is ~79F. Space temperature alarms: FCU-4, FCU-5, FCU-6, FCU-7; temperatures range from 96.1F to 103.9F.	Investigate, repair as needed and reset alarm. AHU-1: Based on temperatures it looks like the compressor for zone 2 isn't working, but there is an alarm shown for compressor 1. Recommend: Investigate control point mapping & fix broken compressor. For FCU 4 through 7, serving various mechanical rooms, what are the setpoints? Could you increase the setpoints without negatively affecting equipment in the room so that alarms are not activated?
74	HVAC	Chaparral HS Theater	AHU-1	Fix equipment	Onsite	Site	Return Air Filter DP is 1.07 in wc and is red color. I assume this means it is in alarm because the filter is dirty. Also the cfms don't add up. SA cfm should equal the OA cfm plus the RA cfm.	Change filters. Add to PM plan to change regularly. Fan motors have to work harder to maintain SP when filters are dirty. Calibrate flow sensors.
75	HVAC	Chaparral HS Theater	AHU-1, & all RTUs	Adjust economizer setpoint	BMS	Site	AHU-1 Econo SP is 70F, but the sequence of operations says 75F. RTUs economizer control is at the unit based on the sequence of operations.	It is recommended for the climate zone to use either: OA dry bulb highlimit with a setpoint of 73F or OAT vs RAT. This will enable the economizer when OAT is less than 73F or RAT respectively. If the economizer setpoint is a dial in the RTU units use setpoint "A". This corresponds with a point at approximately 73F dry bulb and 50% RH.
76	HVAC	Chaparral HS Theater	All units	Schedule off when not needed	BMS	Site	All units have the same Occ_Schedule for Sunday 5am-2pm. Monday: all except RTU-1 have the Occ_Schedule 5am-9pm. Tuesday through Friday: all except RTU-2 have the Occ_Schedule 5:30am-9pm. Saturday: AHU-1, RTU-2, and RTU-5 have the same Occ_Schedule 6am-8pm. RTU-1 6:30-7:30pm, RTU-3 & RTU-4 have the same Occ_Schedule 7am-8pm.	Given discrepancy, suspect there is opportunity to tighten schedule. Review space use schedule and compare to HVAC equipment schedule to minimize on time of each HVAC unit.
77	HVAC	Diaz ES	All MZUs	Schedule off when not needed	BMS	Site	MZU 1, 3, 4, 6: Have the same schedule set to unoccupied from 6:30am to 9pm M-F. MZUs 2 & 5 have the same schedule set to unoccupied from 6am to 9pm Monday, and 6:30am to 9pm T-F. All units are on at 8am on Wednesday 7/24/2019. MZU1 though 4 were on Saturday 7/27/2019 at 5am.	MZU 1 through 4 are suspected to be on 24/7. Verify all units turn off outside of occupied hours. If they do not investigate and revise schedule to turn them off outside of space occupied schedule. There may be an opportunity to tighten the schedule. Review space use schedule and compare to HVAC equipment schedule to minimize on time of each HVAC unit.
78	HVAC	Diaz ES	All FCUs	Schedule off when not needed	BMS	Site	All FCUs that can be scheduled have an occupied and a custodial schedule but the schedules vary.	Given discrepancy, suspect there is opportunity to tighten schedule. Review space use schedule and compare to HVAC equipment schedule to minimize on time of each HVAC unit.
79	HVAC	Diaz ES	FCU-10, E EF-2, CT fan	Fix equipment	OnSite	Site	FCU-10 fan serving storage room 50A, EF-2 serving restroom area C, Cooling Tower fan, and boiler 2 are in alarm. Enable=on, but proof=off for FCU-10 and EF-2. Enable=off, but proof=on for the cooling tower fan.	Investigate, repair as needed and reset alarm.
80	HVAC	Diaz ES	All MZUs	CD & HD reset	BMS improvement	Site	There is a min and max cold deck & hot deck SP listed (and setpoints for all MZUs are consistent at CD 50-75 (except MZU-1 with max of 65	Check in programming how the CD & HD SP is reset and add all appropriate info to the BMS screens so an operator could verify the resets are working correctly.

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							(overridden), HD 75-95) so I assume the setpoint it is being reset but there is no way to tell if the SP is appropriate or not because the independent variable isn't indicated.	
81	HVAC	Diaz ES	MZU-1 through MZU-5	HD reset	BMS & Onsite	Site	HD Setpoint is 95F when OSA Temp is 92.0F and the reset range is 75F to 95F.	The HD setpoint seems really high given the OAT. Investigate that the reset range is inversely related to the demand (e.g. at OAT 55F HD setpoint is 95F and at OAT 95F HD setpoint is 75F).
82	HVAC	Diaz ES	Boiler Plant	Boiler enable	BMS	Site	Max HW valve position according the summary screen is 100% but the HW System screens shows the max HW valve position as 0%, yet the HW plant is enabled and HW setpoint is 180F even though the max HW valve SP is 95%.	Review control logic to ensure the HW plant (boilers and pumps) are only enabled when the max HW valve position is greater than the setpoint. Verify the max HW valve position on the HW system screen represents the actual max HW valve position.
83	HVAC	Diaz ES	Boiler Plant	HW temp reset	BMS	Site	The min HWS Setpoint is 140 with a reset range of 40F and a high-OA-T reset SP of 55F and a low-OA-T reset SP of 25F. Yet the actual HWS Setpoint is 180F.	The HW ST SP seems really high given the OAT. Investigate that the reset range is inversely related to the demand (e.g. at OAT 25F HWS Setpoint is 180F and at OAT 55F HWS Setpoint is 140F).
84	HVAC	Diaz ES	Boiler Plant pumps	Fix sensor	Onsite	Site	Pump VFD speed says 100%, but the HW DP is 0.0psi	Are the pumps on? Verify and replace DP sensor if broken. Once replaced verify that the pump speed is not stuck at 100%.
85	HVAC	Diaz ES	Boiler Plant	Revise graphics	BMS	Site	Both boilers seem to be on (fire rate says 100% and boiler enable is on), but the supply temperature is ~78F with a setpoint of 180F and OAT is ~92F.	Are the boilers actually on? If so, they are not working right, if not recommend remove or revise the info shown in the BMS so that it is useful.
86	HVAC	Reedo m ES	All MZUs	Economizers: Check setpoint, ensure functional.	Onsite	Site	economizer - min OA damper=OPEN, It is not clear if there is economizer functionality on these units, what the economizer setpoint is and if economizers are working as no other OA damper related points are shown in the BMS.	Are there airside economizers on these units? If so recommend update BMS screens to: add OAD % open, and show OA damper min % setpoint so you can verify the position is as expected. What is the economizer setpoint? It is recommended for the climate zone to use either: OA dry bulb highlimit with a setpoint of 73F or OAT vs RAT. This will enable the economizer when OAT is less than 73F or RAT respectively. Also verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality. If economizers are not checked regularly add to PMs as besides humidity sensors they are the most common failure.
87	HVAC	Diaz ES	Chiller Plant	Revise graphics	BMS improv ement	Site	The Chiller Data GUI has all zero values. This screen seems quite useless.	Recommend remove this graphic screen so that it doesn't confuse operators.
88	HVAC	Diaz ES	All MZUs	Economizers: Check setpoint, ensure functional.	Onsite	Site	OA damper=100% for all MZU units when OAT ~92F. The OA dampers should be at minimum. It is not clear if: this point represents economizer functionality, what the economizer setpoint is and if economizers are working as no other OA damper related points are shown in the BMS.	Are there airside economizers on these units? If so recommend update BMS screens to: show OA damper min % setpoint so you can verify the position is as expected. What is the economizer setpoint? It is recommended for the climate zone to use either: OA dry bulb highlimit with a setpoint of 73F or OAT vs RAT. This will enable the economizer when OAT is less than 73F or RAT respectively. Also verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit

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								is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality. If economizers are not checked regularly add to PMs as besides humidity sensors they are the most common failure.
89	HVAC	Diaz ES	MZU-4	Fix sensor	Onsite	Site	The RAT sensor reads 82F, when the zones feeding it range from 69.8 to 73.2F and the MAT reads 74.9F while the OAT reads ~92F.	Check/replace RAT sensor. If it is found that RAT sensor is reading correctly and is in a good position then recommend contact a duct sealing company to investigate. Add to PM it not already included.
90	HVAC	Diaz ES	All FCUs	Revise graphics	BMS improv ement	Site	Zone setpoints are less than the occupied heating and cooling setpoints when the units are in occupied mode.	It seems zone setpoint is miss-labelled as this is also a black field which otherwise indicates a feedback/sensor reading. Alternatively these may be controlled via a tstat in which case the occupied cooling and heating fields wouldn't be applicable. Investigate and revise graphics to show useful information so operators can compare the setpoint to the actual zone temp and the
91	HVAC	Goolsb y ES	All MZ units	Schedule off when not needed	BMS	Site	Night setback setpoint is 55F. I assume this is the heating setpoint, not sure what unoccupied cooling setpoint is and how set.	Show night heating and cooling setpoints in BMS. Verify unoccupied setpoints are =occupied setpoint +/-10F and tighten time-based schedule to match space use schedule. Trial and error to balance unoccupied setpoints with the time schedule to minimize time on.
92	HVAC	Karl ES	All MZ units	Economizers: Verify min OA & add to BMS, check setpoint, ensure functional.	BMS	Site	Goolsby OA damper = yes. Carl ES OA damper=enabled. It is not clear what this represents and if economizers exist and are functioning correctly.	Goolsby: What does yes mean? Economizer enabled? If so, recommend rename this economizer enabled. Also recommend update BMS screens to: add OAD % open, and show OA damper min % setpoint so you can verify the position is as expected. What is the economizer setpoint? It is recommended for the climate zone to use either: OA dry bulb highlimit with a setpoint of 73F or OAT vs RAT. This will enable the economizer when OAT is less than 73F or RAT respectively. Are there economizers on these units? If so recommend verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality. If economizers are not checked regularly add to PMs as besides humidity sensors they are the most common failure.
93	HVAC	Dooley ES	All MZU	Occupied temperature setpoint adjustment	BMS	Site	Zone setpoints are shown in black cells with deadband values at right in graphics. Zone setpoints and deadbands vary across MZUs (71-73F setpoint, 0F to 2F deadband). The zone deadband is the range of temperatures as which no heating or cooling would be provided. Trends show cooling damper opening more when this zone setpoint is exceeded so I am quite confident this (setpoint and deadband), not the global setpoints, are controlling the	Verify understanding of how the deadband relates to the zone setpoint: if zone setpoint is 71F and deadband is 2F will the unit open the cold damper at 73F (72+2F) or at 72F (72+2/2F)? Verify that unit is NOT controlling to the global setpoints as expected. Change zone deadbands such that there is at least a 4F delta between the temperature at which the unit calls for more hot air and calls for more cool air as this feedback from the zones can drive the heating/ and cooling at the MZU.

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							damper position. We recommend a 4F deadband between the heating and the cooling setpoint.	
94	HVAC	Dooley ES	All MZU	Unoccupied temperature setpoint adjustment	BMS	Site	Unoccupied setpoints appear to be set as high and low setpoints on the MZU graphic screens (white cells). These setpoints only have a 4F deadband between the heating and the cooling setpoint. The low limit is also higher than the custodial setpoint, so during the custodial period the zone can be anywhere between 68F and 76F for example before a damper opens more, then when the unoccupied period hits the range is 72F to 76F. This higher low limit setpoint (72F vs 68F) could cause heating at the unit.	We recommend widening the unoccupied setpoints to encompass the custodial setpoints and have at least a 10F delta T. This will save energy by allowing the MZUs to remain off more often. A recommended range is 55-60F low limit and 80-85F highlimit.
95	HVAC	Dooley ES	All MZU	CD reset	BMS	Site	The cold deck SP changes for MZU-3 but not for the rest. So I assume it is being reset for MZU-3 at least but there is no way to tell if the SP is appropriate or not because the independent variable isn't indicated. Other MZUs have a CD setpoint of 52F.	Check in programming how the CD SP is reset and add all appropriate info to the BMS screens so an operator could verify the resets are working correctly (independent variable(s) and setpoint range). If MZU 1, 2, 4, 5 are not being reset considering adding a reset. All MZU units should have similar setpoints and ranges.
96	HVAC	Dooley ES	All MZU	Schedule off when not needed	BMS	Site	MZU-1 and MZU-5 are scheduled: M&W occupied: 5:30am to 9pm; T, R, F: occupied: 5:30am to 4pm, custodial: 4pm-9pm. MZU-2, 3, 4 are scheduled: M-F occupied: 5:30am to 4pm, custodial: 4pm-9pm.	Does MZU-1 and MZU-5 need to be on until 9pm M & W? Does this align with the space use schedule? Could equipment on time be further reduced? Tighten time-based schedule to match space use schedule such that equipment is only in occupied mode (tightest zone temperature setpoints) the minimal amount of time.
97	HVAC	Dooley ES	All MZ units	Fix economizer operation	Onsite	Site	MZU-1 OSA min damper position says open and there is a min economizer damper position of 38F, yet the mixed air temperature very closely matches the return air temperature. All other units show similar MAT much closer to the RAT than the OSAT.	Why is there a economizer min position if there is a separate min OSA damper? Only one of these is needed to provide ventilation air during the occupied period. Check at unit that min OSA damper is open, if so set economizer min position to 0%. Check that the economizer damper position matches what the BMS says. The temperature values found make it seem like there is little to no outside air coming into the unit. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality. If economizers are not checked regularly add to PMs as besides humidity sensors they are the most common failure.
98	HVAC	Dooley ES	All MZ units	HD reset	BMS & Onsite	Site	All MZUs have a HD setpoint of 75F on a ~81F OSAT day except MZU-1 which has a HD setpoint of 95F. What is the HD setpoint based on?	MSU-1: The HD setpoint seems really high given the OAT. Investigate that the reset range is inversely related to the demand (e.g. at OAT 55F HD setpoint is 95F and at OAT 95F HD setpoint is 75F). Check in programming how the HD SP is reset and add all appropriate info to the BMS screens so an operator could verify the resets are working correctly (independent variable(s) and setpoint range). All MZU units should have similar setpoints and ranges.
99	HVAC	Dooley ES	Cooling Plant	Fix equipment	Onsite	Site	CHWP-1 and system is in alarm. Chilled water supply temp seems way off at 97.5F when the return temp says 47F. Is 47F the supply temp or is the temperature sensor bad? Compressors say off but also show currents and	Investigate alarms and supply temperature and correct. Also investigate what CHW SP is based on and verify that it is not always stuck at the minimum of 42F.

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							pressures so suspect they are not actually off.	
100	HVAC	Dooley ES	MZU-1 zone 4	Fix equipment	Onsite	Site	Zone 4 kit,gen,elec has a temperature setpoint of 72.1F a 100% damper position and a zone temperature above setpoint. Reviewing the trends the setpoint never seems to be met.	Investigate and repair. What temperature air is being discharged? Check with calibrated handheld and verify matches cold deck temp of MZU-1.. Does the damper modulate fully? If not, repair. Where is the temperature sensor, is it behind something hot? If so, move or widen deadband to avoid a constant call for cooling.
101	HVAC	Foothill HS	AHU-1	Fix equipment	Onsite	Site	EFS associated with AHU-1 is in alarm (EF-1, EF-2, EF-4)	Investigate and repair.
102	HVAC	Foothill HS	HW plant	Fix equipment	Onsite	Site	HW Supply Temp =-40.7F. Separator 1 in alarm and boilers are enabled (overridden?) when it is 63F outside.	Investigate and repair all alarms.
103	HVAC	Foothill HS	AHU-3	Fix equipment	Onsite	Site	EFS associated with AHU-3 is in alarm (EF-6, EF-8)	Investigate and repair.
104	HVAC	Foothill HS	AHU-4	Fix equipment	Onsite	Site	EFS associated with AHU-4 is in alarm (EF-5, EF-7)	Investigate and repair.
105	HVAC	Foothill HS	AHU-5	Fix equipment	Onsite	Site	EFS associated with AHU-5 is in alarm (EF-8)	Investigate and repair.
106	HVAC	Foothill HS	AHU-7	Change filters	OnSite	Site	Filter is dirty.	Change filters. Add to PM plan to change regularly. Fan motors have to work harder to maintain SP when filters are dirty.
107	HVAC	Foothill HS	AHU-7	Fix equipment	Onsite	Site	RFS associated with AHU-7 is in alarm (RF-5)	Investigate and repair.
108	HVAC	Foothill HS	AHU-8	Fix equipment	Onsite	Site	Supply fan in alarm	Investigate and repair.
109	HVAC	Foothill HS	AHU-9	Fix equipment	Onsite	Site	EFS associated with AHU-8 is in alarm (EF-11)	Investigate and repair.
110	HVAC	Foothill HS	AHU-10	Fix equipment	Onsite	Site	EFS associated with AHU-10 is in alarm (EF-17, EF-18)	Investigate and repair.
111	HVAC	Foothill HS	All AHUs and MZUs	Economizers: Verify min OA & add to BMS, check setpoint, ensure functional.	BMS	Site	OA damper enable=open for most units. For AHU12/14 OA damper=30% (not fully open). It is not clear what these values represents. All units should have the same position yet two are at 30% and the rest are at 100% (assuming open=100% open). Also the MAT for some units is higher than both RAT & OAT or lower than both RAT & OAT. This is not physically possible. Therefore, it seems that if economizers exist they may not be functioning correctly.	What does OA damper enabled mean? Economizer is enabled? If so, recommend rename this economizer enabled. Also recommend update BMS screens to: add OAD % open, and show OA damper min % setpoint so you can verify the position is as expected. What is the economizer setpoint? It is recommended for the climate zone to use either: OA dry bulb highlimit with a setpoint of 73F or OAT vs RAT. This will enable the economizer when OAT is less than 73F or RAT respectively. Recommend add setpoint to the graphics too so you can verify working as expected. Are there economizers on these units? If so recommend verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality. If economizers are not checked regularly add to PMs as besides humidity sensors they are the most common failure.
112	HVAC	Foothill HS	All AHUs and MZUs	Request for info	BMS	Site	It is not clear how the CD and HD are reset and the sequence of operation document link is not working. Cold Deck Setpoint: It appears based on what is shown on the graphics that if the high zone pressure (Hi Zone Pressure) is 7.5 or less (CD reset SP @7.5#) then the Cold Deck Setpt should	Please provide the SOO (or describe here) and setpoint ranges so I can further investigate if the CD and HD resets are working . All units should have the same general strategy, as is it appears some are operating one way and the others another, so I there may be opportunity for improvement.

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							match that shown in grey (CD reset SP @7.5#). If it is higher than that the Cold Deck Setpt should decrease. Hot Deck Setpoint: It appears based on what is shown on the graphics that if the low zone pressure (LO Zone Pressure) is 7.5 or more (HD reset SP @7.5#) then the Hot Deck Setpt should match that shown in grey. If it is lower than that the Hot Deck Setpt should increase. What is the minimum cold deck setpoint? What is the maximum hot deck setpoint?	
113	HVAC	Foothill HS	All AHUs	Request for info	Onsite	Site	It is not clear if there is leakage across the CHW and HW valve. Does the % associated with the point 'CHW Valve (NC)' represent the % the valve is open? Does the % associated with the point 'HW Valve (NO)' represent the % the valve is closed? If one represents % open and the other represents % closed this is a bit confusing.	Please provide the SOO or explain how this works so I can further investigate whether valves are leaking or not. Also recommend update names to better describe the value and/or make them consistent.
114	HVAC	Reedom ES	FC-2, EF-3, EF-6, EF-8, Condenser water pump, CS pump alarm	Fix equipment	Onsite	Site	Fan alarms on all of these units	Investigate, repair as needed and reset alarm.
115	HVAC	Foothill HS	AHU-1, 2, 4	Fix temperature sensor	Onsite	Site	The MAT is lower than both the RAT and the OAT. This is not physically possible.	It seems the MAT is bad, investigate by comparing to a calibrated handheld.
116	HVAC	Reedom ES	Boiler Plant	Reduce boiler enable setpoint & correct override	BMS	Site	HW system enabled if less than 95F OAT and button next to HW system enable point is red. Its 94F and the pumps and boiler are on even though there is no HWVs open.	Does the red button indicate its overridden? If so investigate and put back under automatic controls. Also recommend reduce boiler enable setpoint to something more in line with when there would be a call for heating (maybe something like 75F) to keep the boiler plant (boilers & pumps) off more often.
117	HVAC	Foothill HS	AHU-7, 8	Fix temperature sensor	Onsite	Site	The MAT is higher than both the RAT and the OAT. This is not physically possible.	It seems the MAT is bad, investigate by comparing to a calibrated handheld.
118	HVAC	Foothill HS	All AHU & MZUs	Schedule off when not needed	BMS	Site	AHUs 2 through 8 and MZUs 1 & 2 are scheduled as occupied from 4am to 10pm M-F, AHUs 9-15 are scheduled as occupied from 4:30am to 10pm M-F and AHU 1 is scheduled as occupied from 3:45am to 10pm M-F. All also have custodial schedules but these are overridden by the occupied schedule because the time range is within it (e.g. 1:30pm-9pm). Review of trends confirmed fans turn off at end of occupied period as expected.	Does each of these schedules align with the space use schedule? Could equipment on time be further reduced? Tighten time-based schedule to match space use schedule such that equipment is only in occupied mode (tightest zone temperature setpoints) the minimal amount of time. If custodial settings are needed align with
119	HVAC	Reedom ES	All units	Schedule off when not needed	BMS	Site	On the schedule summary page the default output set to occupied and all equipment was found on on Sunday 6/30/2019. However there is an occupied schedule entered M-F 6am-9pm. Also the date/time listed in the upper left corner is wrong. It says 12:04am 7/3/2019 and its 1:12pm 7/3/2019.	I assume this default output setting and the incorrect date time is what is causing the equipment to be overridden to on 24/7. Correct issue and verify following schedule by checking equipment is off after hours.
120	HVAC	Foothill HS	MZU-1, MZU-2	Unoccupied temperature setpoint adjustment	BMS	Site	Unoccupied setpoints appear to be set as high and low setpoints on the MZU graphic screens (grey cells). These setpoints only have	We recommend widening the unoccupied setpoints to encompass the custodial setpoints (if plan to set a cleaning schedule) and have at least a 10F delta T. This will save energy by allowing the MZUs to remain

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							a 4F deadband between the heating and the cooling setpoint. The low limit is also higher than the custodial setpoint, so during the custodial period the zone can be anywhere between 68F and 76F for example before a damper opens more, then when the unoccupied period hits the range is 72F to 76F. This higher low limit setpoint (72F vs 68F) could cause heating at the unit.	off more often. A recommended range is 55-60F low limit and 80-85F highlimit.
121	HVAC	Reedom ES	All MZUs	Remove overrides	BMS	Site	The Max and Min Cold Deck SPs are in purple colored boxes. The Occ CLSP for FC-5 is orange.	Does this mean they are overridden? If so investigate if the override is still needed, and if not remove override.
122	HVAC	Bracken ES	All AHUs, MZU, RTUs	Fix valves	BMS	Site	AHU 3-3: Both cooling and heating valve at 100%.	AHU 3-3: Investigate if both valves are open and correct issue. ALL Units: What does 100% mean? Both open? Investigate whether this means 100% open or 100% closed. Have Tim add label to state which.
123	HVAC	Reedom ES	All MZU	CD & HD reset	BMS improvement	Site	There is a min and max cold deck & hot deck SP listed (and setpoints for all MZUs are consistent at CD 50-65, HD 75-95) so I assume the setpoint it is being reset but there is no way to tell if the SP is appropriate or not because the independent variable isn't indicated.	Check in programming how the CD & HD SP is reset and add all appropriate info to the BMS screens so an operator could verify the resets are working correctly.
124	HVAC	Faiss MS	Units: MZU: 1, 2, 5, 9, 10, 12 and AHU 14	Investigate HW valve function	Onsite	Site	Its 92F outside and all of these units have HW valves at 100% open. Seems these are stuck and not modulating.	
125	HVAC	Faiss MS	MZU-1	Fix CW valve			CW valve says 0% open but CD setpoint is being overshot by ~20F.	Valve may be stuck at 100% open or leaking, investigate & repair: Look at trends to see if temperature setpoint always overshoots. May need to verify temp/valve function at unit.
126	HVAC	McMillan ES	Cooling Plant	Outside air temperature lockout	BMS	Site	under CHW System Enable heading "CP Enable OA SP" and at top "OAD Lockout SP (low end)" is 52F indicating the all cooling (CHW plant and economizer functionality) is only enabled over 52F.	The OA dampers lock out of 52F seems way to high. Usually a low end OAD lockout is to protect the cooling coil from freezing. By locking the OAD out at a much higher temperature you are using more cooling energy than necessary at lower OATs. If OAD functionality is maintained and these setpoints are updated you could use the economizer function to provide free cooling instead at lower temperatures and limit the mechanical cooling to when the units are not in economizer mode (i.e. above ~65F). See guide section 2.1 for more info on appropriate lockouts and section 2.3 for more info on economizers.
127	HVAC	McMillan ES	All MZUs	Investigate Alarms & Overrides	Onsite	Site	MZU-1, 2, 3, 6, 8, : Filter status in alarm (3.0 in/wc) MZU-2: In occupied override MZU-5: SF in alarm Zn-1 classroom 41 zone temp alarm (>76F MZU-9: OA damper overridden to 15% EFs: 5,6,7, 9, 11, 12 in alarm and fans are off	Change filters. Add to PM plan to change regularly. Fan motors have to work harder to maintain SP when filters are dirty. Investigate and correct other listed overrides and alarms. See guide section 2.0 for more info.
128	HVAC	McMillan ES	All MZUs	HD reset	BMS & Onsite	Site	MZU-6 & MZU-7: OAT Heat Enable SP is 70F, its 71.6F OAT and heat is enabled. Something seems wrong here.	Investigate why MZU-6 & MZU-7 had heat enabled when it was warmer than 70F OAT.
129	HVAC	McMillan ES	BAS	Time in BAS is off	BMS	Site	The time is listed as 15 minutes early in the BAS. While likely to not reduce energy usage, comfort might be affected.	Adjust time in BAS.
130	HVAC	McMillan ES	All MZUs	Setpoints vary	BMS	Site	Setpoints vary across units. See workbook 'McMillan Setpoints' for questions and more info.	Can we review this workbook together so we can get a better understanding of in general what we should flag as an issue?

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131	HVAC	McMillan ES	MZU-2, MZU-3, MZU-5, MZU-9	Fix economizer operation	OnSite	Site	Check economizer strategy. See workbook 'McMillan Setpoints' column C for status found by MZU.	Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality.
132	HVAC	Reedom ES	All units	Fix equipment	BMS	Site	Lots of points are highlighted yellow (looks like this might mean a failure in connection?) & orange (looks like this might mean overridden).	Correct connection issues and review if overrides are appropriate.
133	HVAC	Reedom ES	All MZUs	Setpoints vary	BMS	Site	Zone setpoint ranges at tstats (high & low), and deadbands vary across units. See workbook 'Reedom ES Setpoints' for more info on setpoint variation across units and zones.	Recommend standardize the DB to 4F (i.e. the deadband between heating and cooling setpoints) for all zones.
134	HVAC	McMillan ES	MZU-6	Fix valves	OnSite	Site	CHWV=0% but delta T is 13F, valve likely leaking. See workbook 'McMillan Setpoints' column D.	It appears that the CHW valve may be leaking by. Investigate and repair valve.
135	HVAC	McMillan ES	MZU-7	Fix temperature sensor	Onsite	Site	RAT is more than 3F higher than the highest zone temperatures. See workbook 'McMillan Setpoints' column E.	It seems the RAT sensor is bad, investigate by comparing to a calibrated handheld.
136	HVAC	Reedom ES	Chiller Plant & MZU 5	Turn off pumps when not needed & CD reset	BMS	Site	MZU-5 CHWV at 100% but CD temperature setpoint higher than MAT and not even close to setpoint. The cold deck setpoint is 52F while all other MZU are >72F. Seems odd this one is different. Also the chillers are off but pumps are circulating the warm water so this MZU is adding heat when not requested. See workbook 'Reedom ES Setpoints' column E.	Recommend update controls programing to turn off pumps when chillers are off & investigate why MZU CD reset seems backwards compared to other MZUs.
137	HVAC	Bracken ES	All	Fix equipment	Onsite	Site	There is lots of equipment with points highlighted various colors: orange (meaning fan on and in fault), purple (fan off -down) indicating equipment issues. See file 'Bracken ES Setpoints' for AHU list.	investigate and repair
138	HVAC	Bracken ES	AHU 2-1	Fix equipment	Onsite	Site	AHU 2-1 fan is overridden on.	investigate, repair & release override
139	HVAC	Bracken ES	Boiler Plant	Fix equpiment	Onsite	Site	Boiler points 'System enable', 'HWP-1 enable' and 'HWP-1VFD signal' are in fault and defaulted on yet the delta T (supply - return) =0F providing no heat to loop. So you are pumping water that isn't providing any benefit.	If heating equipment is off, turn off pumps too. investigate and repair.
140	Lighting	Bracken ES	lighting	Fix equipment	Onsite	Site	At ~6am all lighting on, at ~8:30am building 1 & 4 exterior lighting still on, at 1:30pm building 1 exterior lighting still on (fault). There are also faults on Building 2&3 & building 9.	Investigate lighting issues. All exterior lighting should be off during the day.
141	HVAC	Bracken ES	exhaust fans	Fix equipment	Onsite	Site	Lots of alarms and faults on the exhaust fan page	Investigate, repair as needed and reset alarm.
142	HVAC	Bracken ES	All AHUs, MZU	Fix economizer operation	Onsite	Site	See file 'Bracken ES Setpoints' column C for spot check results per AHU/MZU.	Verify at unit that: If unit is on: OA damper is at minimum when above setpoint, OA damper is open more than minimum when less than setpoint, and that RA and OA damper are inversely related. If unit is off: OA dampers are closed. Adjust, repair, and lube damper and actuators as needed to ensure when on that OA damper goes min when greater than setpoint and opens further when below setpoint and is closed when off. Stroke dampers as needed to verify functionality.

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143	HVAC	Bracken ES	All AHU, RTU, MZU, FCU	Adjust zone temperature setpoint	BMS	Site	Zone temp setpoints vary. See file 'Bracken ES Setpoints' column under heading 'zone setpoints' for spot check results per AHU/MZU/FCU/RTU	Standardize across all AHU & widen zone temperature setpoints to at least 4F delta in the occupied period. Recommend reduce heating setpoint to 68F as heating to 73F seems extreme and use cooling setpoint of 75F.
144	HVAC	Bracken ES	AHU: 4-8, 8-3, 8-5	Fix valves	BMS	Site	AHU 4-8 in fault, but both CHW & HW valves were open 100%. AHU 8-3 & 8-5: Both CHW & HW valves were open 100% @~6am. See file 'Bracken ES Setpoints' column E for spot check results per AHU.	Possible simultaneous heating and cooling. Correct programming such that never are both valves allowed to be open at the same time.
145	HVAC	Bracken ES	MZU 6-3	Check sensor	Onsite	Site	suspect MAT sensor is off (higher than RAT and OAT). See file 'Bracken ES Setpoints' column D&E for spot check results per MZU.	Calibrate sensor.
146	HVAC	Bracken ES	MZUs	CD reset	BMS	Site	There is a min and max cold deck & hot deck SP listed so suspect it is being reset, setpoints for all MZUs are NOT consistent at. Also there is no way to tell if the SP is appropriate or not because the independent variable isn't indicated. See file 'Bracken ES Setpoints' column H&I for spot check results per MZU.	Suspect variation with CD setpoints is warranted, but if can increase this use less energy. Recommend review setpoints and verify appropriate. Also recommend check in programming how the CD & HD SP is reset and add all appropriate info to the BMS screens so an operator could verify the resets are working correctly.
147	HVAC	Karl ES	All MZU & FCUs	Adjust zone temperature setpoint	BMS	Site	See workbook 'Karl Setpoints' MZU worksheet columns I through R and FCU worksheet. Highlighted cells indicate units with differing setpoints.	Standardize and widen setpoints as described in row 2.
148	HVAC	Karl ES	MZU-3	Fix CW valve	OnSite	Site	CW valve position is 0% but the MAT is 66.1F, the Cold deck setpoint is 65F, and the cold deck temperature is 62.7F (valve is overcooling).	It appears that the HW valve may be leaking by. Investigate and repair valve.
149	HVAC	Diaz ES	Boiler Plant	HW temp reset	BMS	Site	The min HWS Setpoint is 140 with a reset range of +40F and a high-OA-T reset SP of 55F and a low-OA-T reset SP of 25F. Yet the actual HWS Setpoint is 180F and OAT=~42.4F. The calc setpoint should be 156.8F. (same as #83, which was complete).	The HW ST SP seems really high given the OAT. Investigate that the reset range is inversely related to the demand (e.g. at OAT 25F HWS Setpoint is 180F and at OAT 55F HWS Setpoint is 140F) and that the calculation is correct.
150	HVAC	Diaz ES	MZU-3, MZU-4, MZU-6	Check valves & sensors	BMS	Site	MZU-3: HWV appears to be stuck closed. RAT is lower than all zones. MZU-4 RAT is lower than all zones. MZU-6 CHWV appears to be stuck open. See file 'Diaz Setpoints' for more info, highlighted cells under heading 'spot checks' indicate potential issue.	MZU-3 & MZU-6: Investigate valve functionality. MZU-3 & MZU-4: check RAT sensors, calibrate or repair as needed.
151	HVAC	Diaz ES	All MZUs	Standardize setpoints	BMS	Site	MZU-1 zone deadbands vary 0-2F. CD bias varies across MZUs.See file 'Diaz Setpoints' for more info, highlighted cells under 'setpoints' indicate potential issue.	Standardize setpoints across zones and MZUs.
152	HVAC	Twitchell ES	FCU-3	Standardize setpoints	BMS	Site	FCU: Unocc cool setpoint on FCU-3 is diff than rest (95F vs 90F). Occ setpoints are all C/H=73/71.	Standardize setpoints across FCUs. Can they all be increased to 95F?
153	HVAC	Twitchell ES	All MZUs	Time in BAS is off	BMS	Site	Schedule shows: MZUs: M: 5-10, T-F: 5:30-10; FCU M-F: 5-10. From 5:57am-6:12am all MZUs were found off, units started turning on around 6:15am. Under occupancy schedule says next value is occupied@ some time before time it was.	Is BAS time/clock wrong? I can't find it on the Twitchell BAS.

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154	HVAC	Twitchell ES	Central plant	Fix equipment	OnSite	Site	Alarms: Hi Chilled Water Supply Temp, Refrigerant Leak. Override on HW System=on.	Investigate, repair as needed and reset alarm & override
155	HVAC	Twitchell ES	All MZUs	Check valves & sensors	OnSite	Site	Many MZUs have MAT that don't make sense given the OAT and RAT and the CHW valve may be leaking. See file 'Twitchell Setpoints' for more info, highlighted cells under 'spot check' indicate potential issue.	Check sensors, valve for leaky, and OAD position.
156	HVAC	Twitchell ES	All MZUs	BAS alarm adjustment	BMS	Site	MZU-1, MZU-2 have HD low limit alarm when less than 90F even if HD setpoint is less than 90F.	Check all MZU HD low limit alarm setpoints and HD reset range and verify low limit is less than min HD temperature to reduce nuisance alarms.
157	HVAC	Twitchell ES	All MZUs	HD & CD reset	BMS	Site	HD setpoint appears to reset, it is not clear if CD does or what resests are based on.	If you provide the HD and CD reset range and independent variable (e.g. OAT?) I can check the setpoints are calc correctly. Also suggest add this to BAS screens so can verify working correctly in future.
158	HVAC	Bob Miller MS	All Gym units	Temperature setpoints	BMS	Site	Gym appeared to be cooler than expected, setpoints seemed to be low.	Consider raising temperature setpoints in gym after hours.
159	Lighting	Bob Miller MS	lighting	Occupancy Sensors	OnSite	Site	Certain restrooms and classrooms had lights on, could take advantage of occ sensors	Consider occupancy sensors in hallways/restrooms.
160	Lighting	Bob Miller MS	lighting	Daylight sensor	OnSite	Site	Several outside lights on during day	Timer/sensor calibration for outside lighting.
161	HVAC	Bob Miller MS	All equipment	Building Envelope	OnSite	Site	Several outer doors left open	Consider education/awareness campaign around affect of outside doors being open during hot summer weather and effects on building envelope.

FOOD SERVICE FACILITY OPPORTUNITY REGISTER

#	Opportunity Area	Site	Equipment #	Recommended Project	Type	Apply	Existing condition	Project Details
OR-1	Other	FSF	N/A	Begin using notched V-belts rather than smooth V-belts for garden-variety motor-driven applications.	Change belt types	Site	Some notched belts were observed during treasure hunt, but not all areas were screened. Mix of belt types, largely smooth V.	Order notched equivalents when restocking belts. Notched belts can be installed on the regular belt replacement schedule without pulley/sheave changes. Savings are typically 2-3%. For more information: https://www.nrel.gov/docs/fy13osti/56012.pdf
OR-2	HVAC	FSF	N/A	Schedule a remote BAS review with an SEM HVAC specialist. (No charge!)	Remote BAS review	Site	A BAS is present, though isolated from the main district BAS system. This could use a second set of eyes.	Work with your energy coach to determine if this is a good fit for your site, and if so, to schedule a review. You will screenshare your BAS interface with an SEM HVAC specialist who will identify problems and areas for improvement in real time. If you are unable to screenshare your BAS, saving screenshots is an option, too.
OR-3	Boiler plant	FSF	N/A	Perform boiler tune-up (particularly for linkage controls). Schedule this as a regular maintenance activity.	Boiler tune-up	Site	Not discussed during the treasure hunt. This is typically a good fit if: Boiler tune-up has not been recently completed.	Obtain a vendor cost quotation. Work with your energy coach to understand what non-CEI incentives may be available.
OR-4	Boiler plant	FSF	N/A	Survey and repair steam traps. Set this up as a recurring maintenance activity.	Steam trap maintenance	Site	Not discussed during the treasure hunt. This is typically a good fit if: Steam trap survey has not recently (in last 6-12 months) been completed.	Contact a vendor to schedule the survey. (Your boiler service vendor likely offers this service.) Allocate staff and resources to promptly repair all failed steam traps, starting with the highest-pressure traps and moving to the lowest-pressure traps. If you have not recently surveyed, you may see failure rates >15%. Work with your SEM energy coach to understand what non-SEM incentives may be available for this project. A steam trap survey cost analysis tool and trap log sheet are available from your energy coach.
OR-5	Boiler plant	FSF	N/A	Improve boiler sequencing by	Improve	Site	Two boilers are present but no longer are able to communicate	Work with your operators, district BMS programmers, and potentially vendors to review

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				connecting the boiler plant to the existing BMS system. (A boiler that cycles off and on at low load suffers an additional 20-30% efficiency reduction versus its typical low fire performance! Minimize the amount of boiler capacity left on hot standby.)	boiler sequencing		with the BMS. Site utilizes a daily manual check and touch up procedure. An extensive BMS is available in the building, with district programmers available.	boiler sequencing and determine whether existing boilers are capable of communicating with the BMS, and what the economic feasibility of the project would be. When sequencing, consider efficiency across your full range of total system steam flow rates. Before beginning, be sure to collect part-load performance curves for your boilers, understand the rated turndown range for each burner set, and estimate the "base load" of standby losses and additional pumps and fans required to bring each boiler online. As you try sequencing revisions, review available data such as steam meter reads and daily natural gas consumption to determine what sequences perform best under what conditions.
OR-6	Plug loads	FSF	N/A	Eliminate computer screensavers and program monitors and computers to automatically power down	Enable IT sleep modes	Site	IT equipment doesn't seem to shut off completely as required, particularly over weekend. Individual users may have altered their power saving settings for convenience.	Engage IT staff in the Energy Team and work cooperatively with them to implement these changes.
OR-7	Plug loads	FSF	N/A	Install smart power strips	Install smart power strips	Site	Extensive plug loads are present, and many draw power but are not continuously in use. Multiple space heaters and fans were seen at desks during the treasure hunt.	Investigate smart power strip options and purchase several to test in the office areas. These can use timers (e.g., provide 8 hrs of power before needing to be switched on again) or can turn off a subset of plugs based on the status of a master load. Some also come with remote switches to make it easier to turn off the strip at the end of the day. When you've chosen the type you like, purchase additional units and install widely in the office areas.
OR-8	Plug loads	FSF	N/A	Put a space heater policy in place to reduce the number of space heaters in use. Optimize HVAC setpoints to reduce the need for them.	Eliminate space heaters	Site	Space heaters are in use in significant numbers. They may be interfering with proper HVAC system operation through "tricked" thermostats.	Inventory existing space heaters. Work with staff to understand why they have been put into service and attempt to troubleshoot these issues on a space by space basis. If a space remains too cold and some space heating is needed, consider less energy intensive alternatives to traditional space heaters, such as branded jackets/sweatshirts, Cozy Toes or seat warmers. Draft a space heater policy within facilities and work with senior management to develop buy-in, announce the policy AND enforce it. Assign staff to the enforcement effort and set a regular schedule or process for inspections.
OR-9	Kitchen/ Refrigeration / Laundry	FSF	N/A	Install automatic hood controls in kitchen and cooking areas	Kitchen hood controls	Site	Not discussed during the treasure hunt. This is typically a good fit if: Kitchen hoods are controlled manually, and tend to be left on when not cooking, or after hours.	Work with your energy coach and site staff to determine if this is a good fit for your site. If so, obtain vendor cost quotations.
OR-10	Kitchen/ Refrigeration / Laundry	FSF	N/A	Keep preheat times minimal for ovens and fryers. Turn off unused equipment.	Minimize idle kitchen equipment run time	Site	Not discussed during the treasure hunt, but this is a common institutional kitchen efficiency measure.	Work with your energy coach and site staff to determine if this is a good fit for your site.
OR-11	Kitchen/ Refrigeration / Laundry	FSF	N/A	Keep ovens and fryers clean to improve their heating efficiency	Clear kitchen equipment	Site	Not discussed during the treasure hunt, but this is a common institutional kitchen efficiency measure.	Work with your energy coach and site staff to determine if this is a good fit for your site.
OR-12	Kitchen/ Refrigeration / Laundry	FSF	N/A	Make sure door seals and gaskets are in good shape for ovens, steamers, and reach-in coolers	Kitchen equipment weatherization	Site	Not discussed during the treasure hunt, but this is a common institutional kitchen efficiency measure.	Work with your energy coach and site staff to determine if this is a good fit for your site.

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OR-13	Kitchen/ Refrigeration / Laundry	FSF	N/A	Install low-flow pre-wash sprayer valves in dishwashing areas	Low-flow pre-sprayer valves	Site	Not discussed during the treasure hunt, but this is a common institutional kitchen efficiency measure.	Work with your energy coach and site staff to determine if this is a good fit for your site.
OR-14	Lighting	FSF	N/A	Manually turn off lighting that's not needed	Shut off lighting	Site	The offices and admin areas tend to have lighting left on.	Work with your CEI Energy Coach to plan a "light on!" campaign to engage employees. Ensure this includes critical elements that change behavior: building motivation, addressing any barriers (such as hidden light switches), recognizing good behaviors, etc.
OR-15	Lighting	FSF	N/A	Install lighting occupancy sensors where appropriate	Lighting occupancy sensors	Site	No occupancy sensors were observed during the treasure hunt.	Add occupancy sensors in the areas with variable occupancy (e.g., offices, lunch room etc.) and where lighting tends to be left on. For areas with multiple entries, install sensors at each entryway. For areas in which workers may be sedentary, consider dual-technology ceiling-mounted passive infrared and ultrasonic sensors.
OR-16	Lighting	FSF	N/A	Delamp fluorescent lighting fixtures in areas with excessive light	Delamp lighting	Site	3- to 4-lamp troffers with T8 32W lamps in most non-high bay spaces.	Borrow a light meter through the CEI team and systematically check lighting levels against IESNA standards (available from your energy coach), removing lamps in a symmetrical way across the space to ensure best aesthetics.
OR-17	Lighting	FSF	N/A	Replace or relamp non-LED lighting fixtures with LED equivalents	Upgrade lighting to LED	Site	HID lighting dominates the refrigerated spaces, where its heat output is an extra burden on the ammonia system. 3-4 lamp T8 fluorescent is present in most other spaces. Poor light quality is a common complaint despite overlighting. Vendor quote has been received for a comprehensive lighting upgrade.	Work with your CEI and Energy Smart Schools team to understand available incentives and financial case. Be sure to integrate lighting controls with your fixture upgrades for maximum cost effectiveness! Install ASAP.
OR-18	Refrigeration	FSF	N/A	Update maintenance interval for strip curtains in doorways between spaces at different temperatures	Install strip curtains	Site	A lot of door curtains are old/tired/sticking together. These curtains are primarily between conditioned dry storage space and other areas.	Plan within your facilities team: should any of these be replaced with speed doors? Air curtains? New strip curtains, but on a more frequent replacement schedule? Set up work orders to address the chosen strategy.
OR-19	Refrigeration	FSF	N/A	Install electronically commutated (EC) motors on evaporators. Specify these as the standard for replacement when evaporator motors fail.	Install ECM motors on evaporators	Site	Not discussed during the treasure hunt, but this is a common industrial refrigeration efficiency measure.	Work with your energy coach and site staff to determine if this is a good fit for your site.
OR-20	Refrigeration	FSF	N/A	Review air circulation in the medium temp (cooler) area and determine if the air circulation system is needed to reduce hot spots.	Install ECM motors on evaporators	Site	Circulation fans (separate from evap. fans) are present to boost air flow around the cooler, but these are not used.	Check with the system operators to identify any known hot spots or obstructions to flow (e.g., blocked evaps.). When you borrow a thermal imaging camera from the CEI team, use this to check for any areas of the cooler that tend to stay warmer than the rest. If warm spots are present, test out running the fans and seeing if the cooler setpoint can be increased and still meet the same temperatures.
OR-21	Refrigeration	FSF	N/A	Ensure evaporator defrost is appropriately controlled and evaporators are regularly cleaned and not blocked by racking	Service evaporators	Site	Not discussed during the treasure hunt, but this is a common industrial refrigeration efficiency measure.	Work with your energy coach and site staff to determine if this is a good fit for your site.

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OR-22	Refrigeration	FSF	N/A	Repair damaged loading dock seals.	Reduce dock door cold air losses	Site	Great door closing habits (doors closed when no trailer pulled up and no active loading/unloading), but awnings and seals around doors not in great shape, actively looking to replace.	If seals need repair, issue work orders for maintenance. If replacement is needed, collect vendor quotations. If an energy savings estimate is needed to make a cost case to management, your CEI team can assist.
OR-23	Refrigeration	FSF	N/A	Schedule a controls system deep dive with an SEM refrigeration specialist. (No charge!)	Remote refrig. system review	Site	A refrigeration control system is present and well kept could use a second set of eyes.	Work with your energy coach to schedule a review. You will screenshare or provide screenshots/photos of your controls interface with an SEM refrigeration specialist who will identify problems and areas for improvement in real time.
OR-24	Envelope	FSF	N/A	Perform a thermographic scan of the building envelope (interior and exterior!) to reveal areas of significant radiant loss and air infiltration. Weatherize or insulate the affected parts of the building.	Thermographic scan	Site	Major wall between ammonia-cooled cooler section and dry goods storage (approx. 30' x 100') has a fair amount of temperature leakage likely occurring. Mario stated in the morning time if standing far enough away could see mirage effect!	Borrow a thermal imaging camera from the CEI team and use it to identify the most significant areas of energy loss. Your CEI team can help estimate the energy cost associated with specific areas so that you can prioritize for repair.
OR-25	HVAC	FSF	N/A	Troubleshoot IT department humidity problems	Optimize data center return air	Site	RTU on the ground provides cooling for IT department via an open plenum above the space – 10 foot ceiling in rooms, with another 20+ of open plenum space above. Very high humidity, hard to control space temps, causing a number of issues with ceiling tiles as well with moisture	Work with your CEI team to plan next steps. While a vendor quote for system modifications may be in order, technical assistance is available from the CEI team.
OR-26	Other	FSF	N/A	Promote awareness on energy efficiency (e.g., guidelines on turning off lights, managing plug loads)	Employee awareness	Site	There is not a consistent energy efficient culture at the site, though some individuals do a great job with energy.	Educate staff on how their actions can lead to significant energy savings. Take an example of turning off a light or how to use thermostats and create awareness campaign. Provide success stories from your own or similar organizations. Collaborate with HR to design the campaign and run it across all the sites within your organization. Use an eNewsletter, web email, etc. to share relevant information. Work with your energy coach on how to create engagement campaign using ADKAR methodology. Recognize and celebrate achievements.
OR-27	Other	FSF	N/A	Troubleshoot HVAC system serving the data room.	HVAC	Site	Comfort complaints are common in the zones (Purchasing) on the same air handler as the server room. These may be being overcooled as a result of the high heat gain of the data room.	Work with your HVAC team (both district staff and preferred vendors) to troubleshoot. Is the server room setpoint too cold (ASHRAE recommends 80.6 F server intake temp.)? Should it be provided with dedicated cooling? Should branch dampers be adjusted? Work with the IT team to build buy-in on any setpoint adjustments.
OR-28	Refrigeration	FSF	N/A	Manage condenser water chemistry and surface cleanliness so that condensers are at peak efficiency	Service condensers	Site	Condenser treatment program is not very effective as the tubes have been calcified and filled with blisters. This was discussed in detail with the maintenance supervisor	It is recommended to get cost/performance quotes from possible vendors for 1) condenser cleaning to mitigate existing buildup; and 2) a chemical/blowdown management program to balance water usage against scale buildup sustainably over time. Water softening can often be used to support higher cycles of concentration. Cleaning the evaporative condenser will reduce head pressures and thus the refrigeration system energy usage.
OR-29	Refrigeration	FSF	N/A	Reduce minimum head pressure to the lowest possible value	Reduce head pressure	Site	Minimum head pressure currently is 135 psig	Consider reducing this minimum head pressure in steps of 5 psig if possible. Investigate options to reduce the minimum head pressure as the energy savings can be achieved quickly by reducing it.

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OR-30	Refrigeration	FSF	N/A	Install floating head pressure controls	Floating head pressure	Site	Head pressure and/or condenser water temperature is constant. The condenser fans operate based on fan pressure switches.	Floating head pressure controls (also known as wet bulb sensing) allow the condensing temperature to float down to lower condensing temperatures as outside air temperature (wet-bulb) permits. Obtain vendor cost quotation and estimate project simple payback. Proceed if economical, or integrate into next major system upgrade (e.g., condenser replacement or overhaul).
OR-31	Refrigeration	FSF	N/A	Optimize fan and pump staging. (Use surface area first to reduce head pressure, then start moving more air. When in doubt, cooler compressors are better.)	Optimize fan and pump staging	Site	Condenser fans have VFDs	Work with your energy coach to determine whether high-level support from the SEM program or more detailed support from a vendor would be the best fit for you. Data logging and/or trend data may be needed to support an analysis of the existing sequencing and potential improvements to it.

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Appendix B: Model Summary

Non-Alumni Models

Elementary_No Food Electricity Model

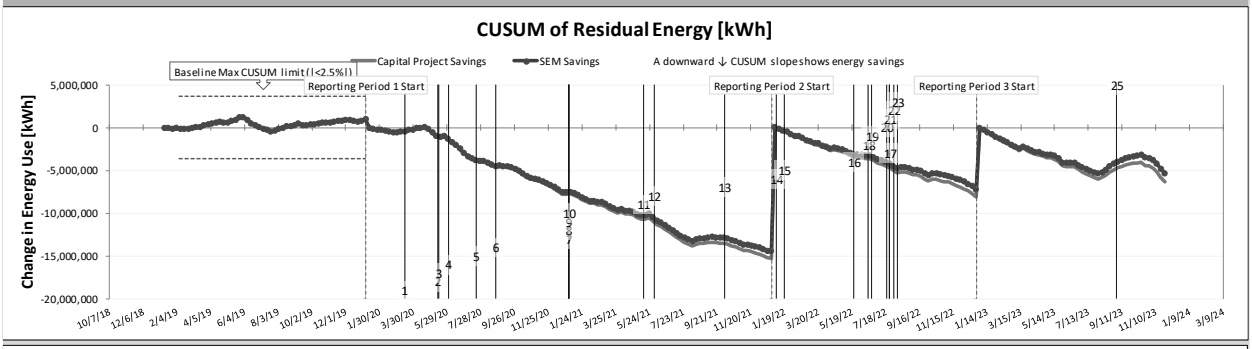
Type of Fuel Electricity - kWh

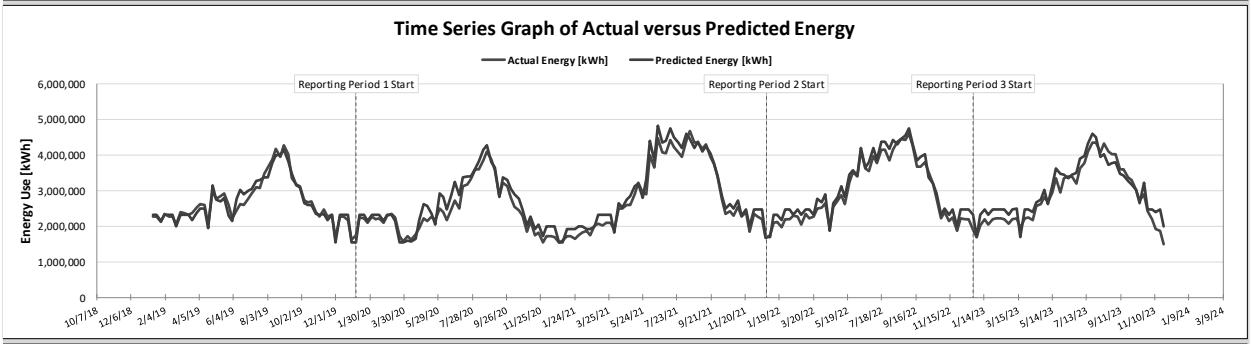
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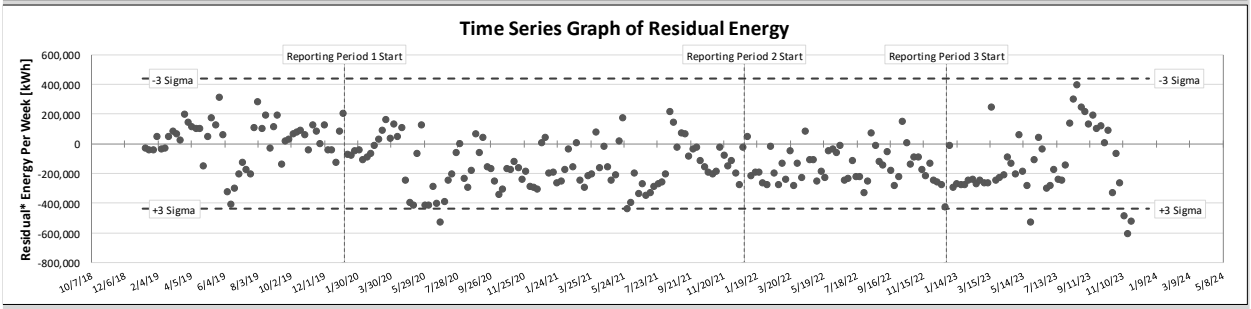
Regression Statistics		
Model Interval	Weekly	
RSquare	0.972	(>0.75)
RSquare Adj	0.970	(>0.75)
Root Mean Square Error	147,787.88	kWh
Mean of Response	2,803,934.20	kWh
Observations (or Sum Wgts)	193	N/A
Autocorrelation	0.43	(<0.5|
F-test Overall P-Value	1.89E-136	(<0.10)
Coefficient of Variance	5.3%	(<10%)
Net Determination Bias	9.98E+05	(<0.005%)
Annual Baseline Energy Use	145,804,578	kWh
5% annual use	7,290,229	kWh
Max Baseline CUSUM %	0.9%	(<2.5%|
Last Measurement Date	11/26/2023	
Excluded Points	-	

Parameter Estimates	Coefficients	Standard Error	t-Stat	p-Value	Baseline Min	Baseline Max
Intercept	1,541,480.91	29,611.24	52.06	<.0001		
CDD (65°F)	8,375.97	148.11	56.55	<.0001	0.00	220.00
School Day [1/0]	152,813.66	6,344.93	24.08	<.0001	0.00	5.00
Event ind - (8/5/2019) Week before first school week wher	593,486.09	84,598.32	7.02	<.0001	0.00	1.00
24/7 Operation Year 2	438,444.09	56,431.25	7.77	<.0001		
24/7 Operation Year 3	456,396.92	58,439.49	7.81	<.0001		
Model Adjustment - (10/4/21) Operational Change [1/0]	155,639.55	57,239.61	2.72	0.0070		

Program Dates	Start	End	Excluded Days	Total Energy Use (kWh) Actual	Predicted	Measured Savings
Baseline	01/07/19	01/05/20	-			
Reporting Period 1	01/06/20	12/26/21	-	272,652,352	287,915,897	15,263,545
Reporting Period 2	12/27/21	12/25/22	-	153,496,011	161,622,174	8,126,163
Reporting Period 3	12/26/22	12/24/23	-	137,953,631	144,313,221	5,698,929







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Middle_No Food Electricity Model

Type of Fuel Electricity - kWh

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Regression Statistics

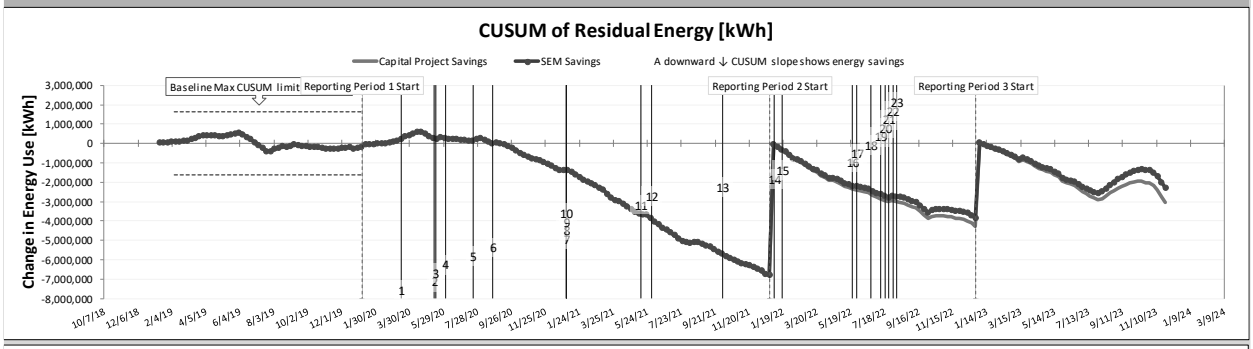
Model Interval	Weekly	
RSquare	0.968	(>0.75)
RSquare Adj	0.966	(>0.75)
Root Mean Square Error	58,837.72	kWh
Mean of Response	1,258,887.29	kWh
Observations (or Sum Wgts)	193	N/A
Autocorrelation	0.48	(<0.5)
F-test Overall P-Value	1.22E-131	(<0.10)
Coefficient of Variance	4.7%	(<10%)
Net Determination Bias	-1.57E+05	(<0.005%)
Annual Baseline Energy Use	65,462,139	kWh
5% annual use	3,273,107	kWh
Max Baseline CUSUM %	0.9%	(<2.5%)
Last Measurement Date	11/26/2023	
Excluded Points	-	

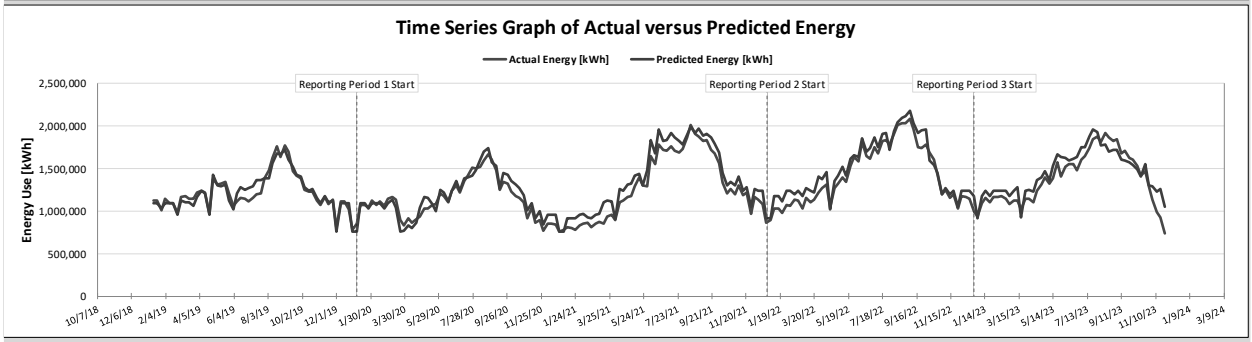
Parameter Estimates

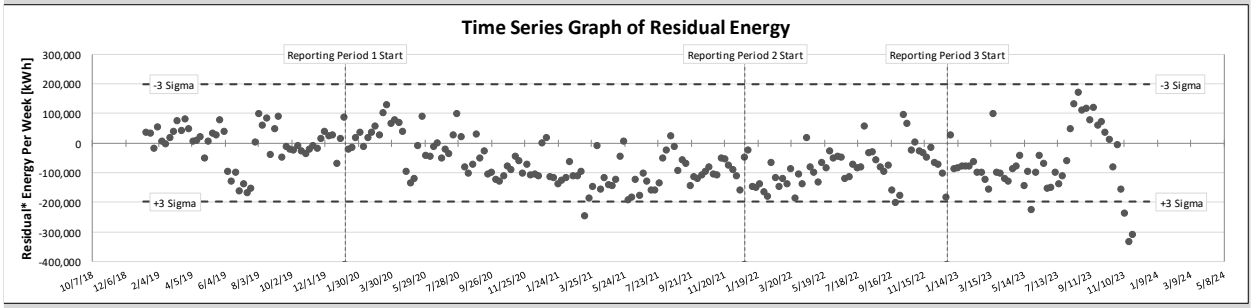
	Coefficients	Standard Error	t-Stat	p-Value	Baseline Min	Baseline Max
Intercept	760,162.36	12,896.11	58.95	<.0001		
CDD (60°F)	2,467.71	60.23	40.97	<.0001	0.00	255.00
School Day [1/0]	65,593.85	2,772.61	23.66	<.0001	0.00	5.00
Event ind - (8/5/2019) Week before first school week when	235,243.85	38,666.87	6.08	<.0001	0.00	1.00
Model Adjustment - 24/7 Operation before School Year [1/0	172,016.91	25,746.82	6.68	<.0001		
Model Adjustment - 24/7 Operation during School Year [1/0	309,709.07	22,656.80	13.67	<.0001		
Model Adjustment - (10/4/21) Operational Change [1/0]	152,744.32	21,921.76	6.97	<.0001		

Program Dates

	Start	End	Excluded Days	Total Energy Use (kWh) Actual	Predicted	Measured Savings
Baseline	01/07/19	01/05/20	-			
Reporting Period 1	01/06/20	12/26/21	-	124,747,338	131,559,614	6,812,276
Reporting Period 2	12/27/21	12/25/22	-	73,787,591	78,077,842	4,290,252
Reporting Period 3	12/26/22	12/24/23	-	66,378,775	69,445,170	2,822,202







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High_No Food Electricity Model

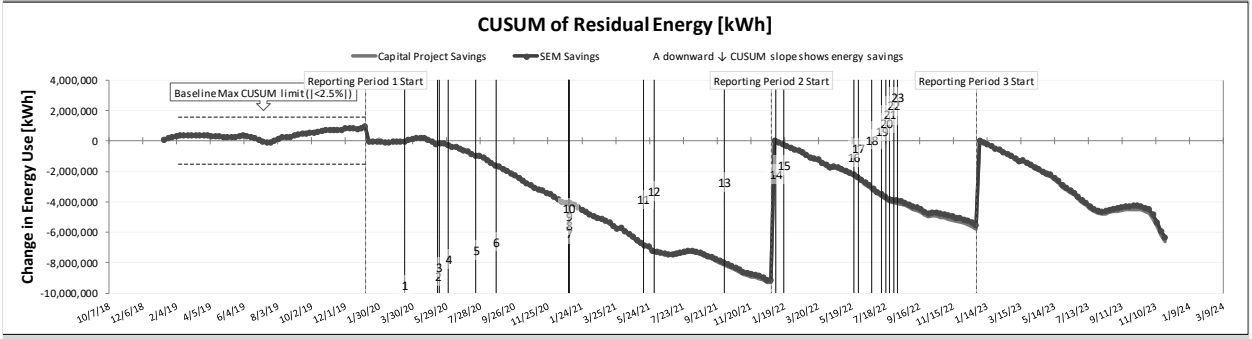
Type of Fuel Electricity - kWh

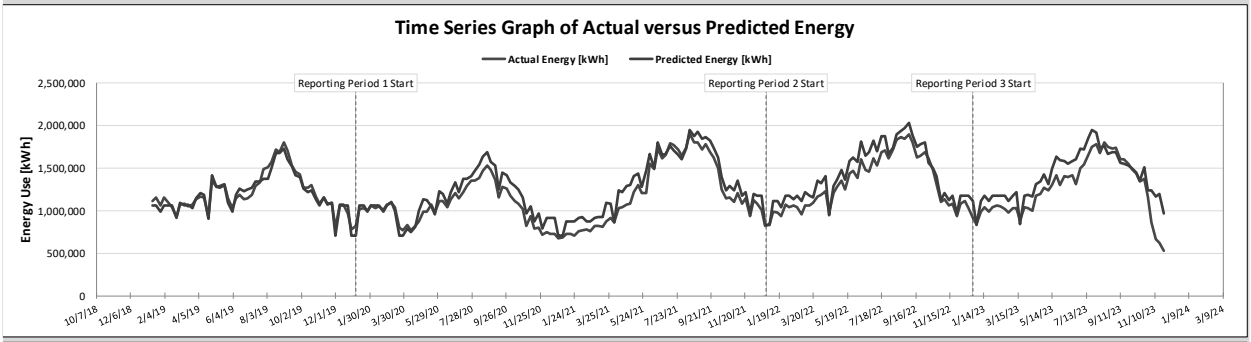
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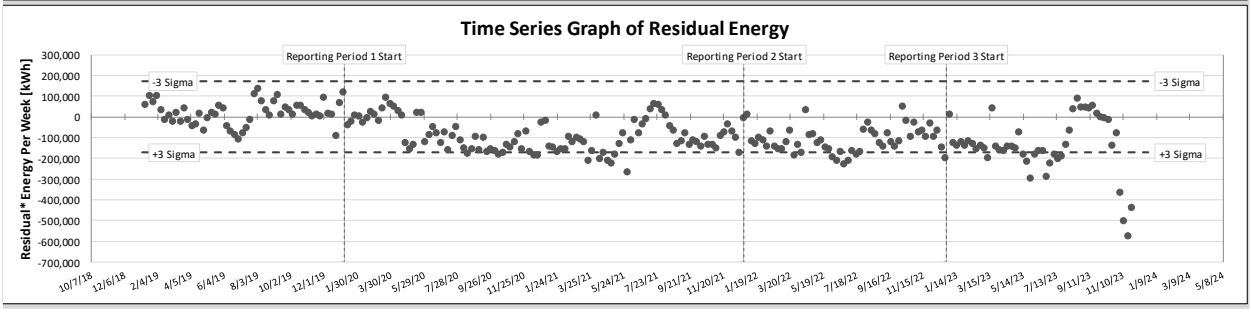
Regression Statistics		
Model Interval	Weekly	
RSquare	0.956	(>0.75)
RSquare Adj	0.954	(>0.75)
Root Mean Square Error	65,938.40	kWh
Mean of Response	1,196,602.06	kWh
Observations (or Sum Wgts)	193	N/A
Autocorrelation	0.53	(<0.5)
F-test Overall P-Value	2.78E-119	(<0.10)
Coefficient of Variance	5.5%	(<10%)
Net Determination Bias	9.51E+05	(<0.005%)
Annual Baseline Energy Use	62,223,307	kWh
5% annual use	3,111,165	kWh
Max Baseline CUSUM %	1.5%	(<2.5%)
Last Measurement Date	11/26/2023	
Excluded Points	-	

Parameter Estimates	Coefficients	Standard Error	*t*-Stat	p-Value	Baseline Min	Baseline Max
Intercept	704,322.12	13,645.56	51.62	<.0001		
CDD (60°F)	2,634.86	57.89	45.51	<.0001	0.00	255.00
School Day [1/0]	70,260.80	3,057.75	22.98	<.0001	0.00	5.00
Event ind - (8/5/2019) Week before first school week when	189,600.65	43,474.53	4.36	<.0001	0.00	1.00
24/7 Operations During School Year - Year 2	265,209.20	32,385.46	8.19	<.0001		
24/7 Operations During School Year - Year 3	186,433.19	31,706.56	5.88	<.0001		
Model Adjustment - (10/4/21) Operational Change [1/0]	122,368.76	27,563.93	4.44	<.0001		

Program Dates	Start	End	Excluded Days	Total Energy Use (kWh) Actual	Predicted	Measured Savings
Baseline	01/07/19	01/05/20	-			
Reporting Period 1	01/06/20	12/26/21	-	116,993,535	126,311,646	9,318,111
Reporting Period 2	12/27/21	12/25/22	-	68,380,198	74,197,025	5,816,827
Reporting Period 3	12/26/22	12/24/23	-	60,481,368	67,090,698	6,401,959







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Other_No Food Electricity Model

Type of Fuel Electricity - kWh

These graphs and tables update

Regression Statistics

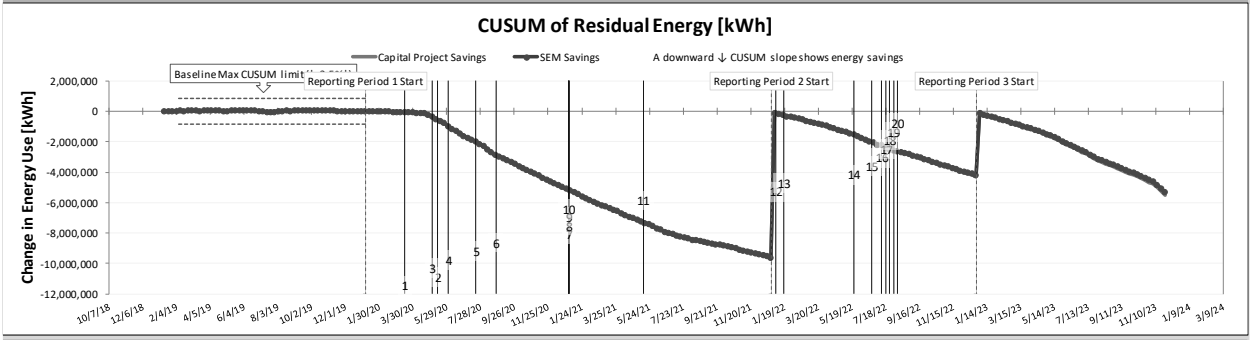
Model Interval	Weekly	
RSquare	0.976	(>0.75)
RSquare Adj	0.974	(>0.75)
Root Mean Square Error	17,331.41	kWh
Mean of Response	633,794.98	kWh
Observations (or Sum Wgts)	52	N/A
Autocorrelation	0.20	(<0.5)
F-test Overall P-Value	1.63E-37	(<0.10)
Coefficient of Variance	2.7%	(<10%)
Net Determination Bias	4.95E-09	(<0.005%)
Annual Baseline Energy Use	32,957,339	kWh
5% annual use	1,647,867	kWh
Max Baseline CUSUM %	0.3%	(<2.5%)
Last Measurement Date	11/26/2023	
Excluded Points	-	

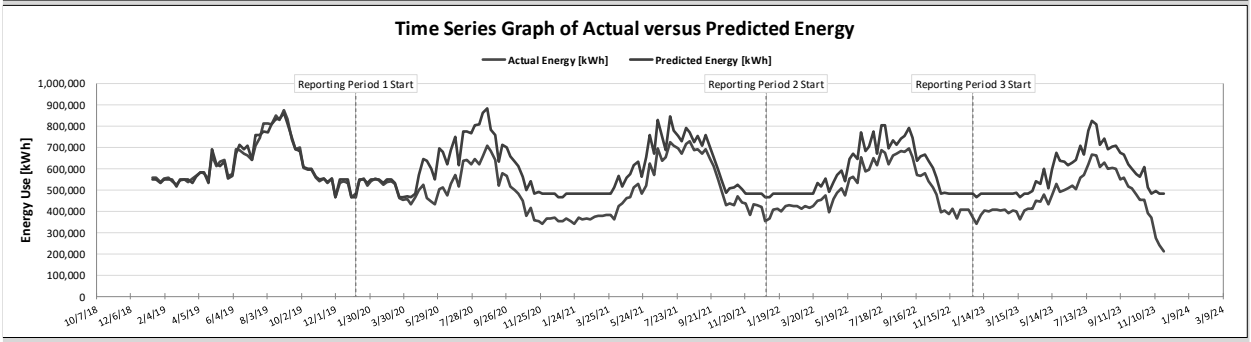
Parameter Estimates

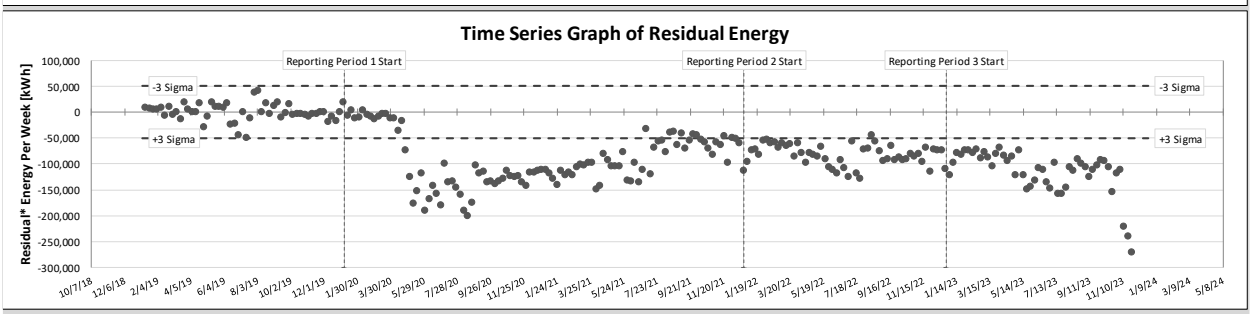
	Coefficients	Standard Error	*t*-Stat	p-Value	Baseline Min	Baseline Max
Intercept	463,708.24	6,350.93	73.01	<.0001		
CDD (65°F)	1,412.80	34.42	41.05	<.0001	0.00	220.00
Holiday Indicator - Independence Day	-75,008.55	18,253.66	-4.11	0.0002	0.00	1.00
Office Days [1/0]	17,035.83	1,281.16	13.3	<.0001	0.00	5.00
Event ind - (8/5/2019) Week before first school week when	67,907.10	18,320.84	3.71	0.0006	0.00	1.00

Program Dates

	Start	End	Excluded Days	Total Energy Use (kWh) Actual	Predicted	Measured Savings
Baseline	01/07/19	01/05/20	-			
Reporting Period 1	01/06/20	12/26/21	-	51,887,227	61,522,412	9,635,185
Reporting Period 2	12/27/21	12/25/22	-	26,206,624	30,489,931	4,283,307
Reporting Period 3	12/26/22	12/24/23	-	22,351,214	27,864,597	5,513,383







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Elementary_Food Service Electricity Model

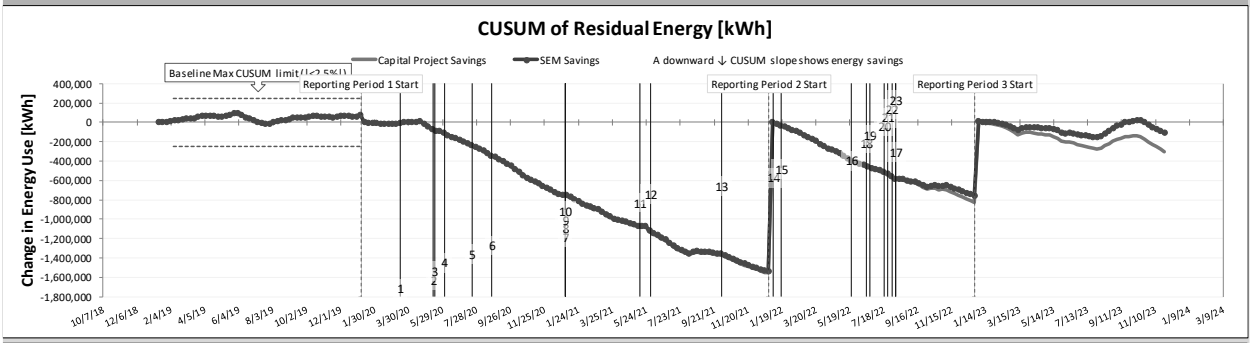
Type of Fuel Electricity - kWh

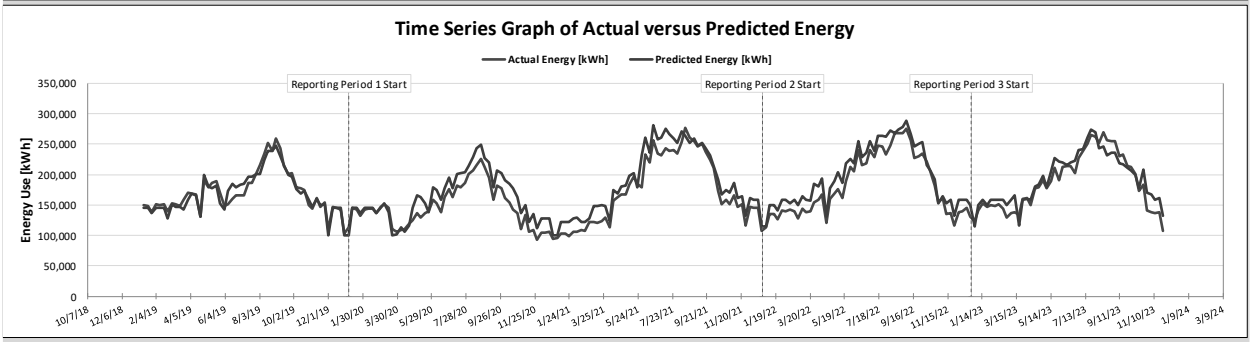
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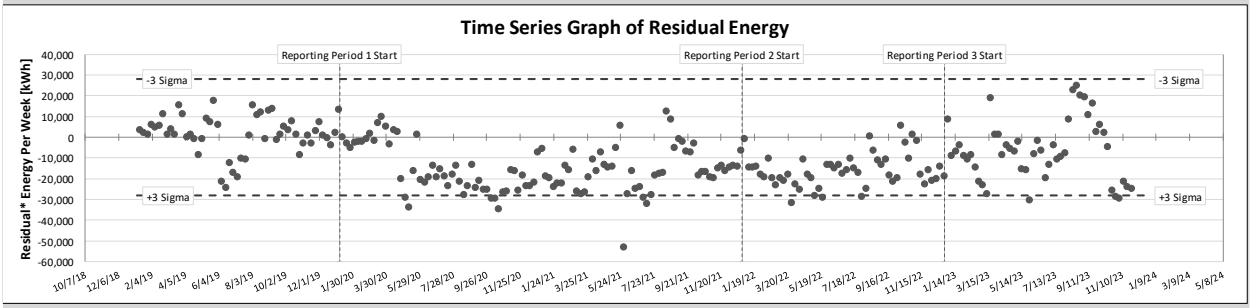
Regression Statistics		
Model Interval	Weekly	
RSquare	0.958	(>0.75)
RSquare Adj	0.956	(>0.75)
Root Mean Square Error	11,415.65	kWh
Mean of Response	191,540.62	kWh
Observations (or Sum Wgts)	193	N/A
Autocorrelation	0.46	(<0.5)
F-test Overall P-Value	2.11E-121	(<0.10)
Coefficient of Variance	6.0%	(<10%)
Net Determination Bias	7.45E+04	(<0.005%)
Annual Baseline Energy Use	9,960,112	kWh
5% annual use	498,006	kWh
Max Baseline CUSUM %	1.0%	(<2.5%)
Last Measurement Date	11/26/2023	
Excluded Points	-	

Parameter Estimates	Coefficients	Standard Error	*t*-Stat	p-Value	Baseline Min	Baseline Max
Intercept	100,669.53	2,010.35	50.08	<.0001		
CDD (60°F)	396.65	8.54	46.47	<.0001	0.00	255.00
School Day [1/0]	9,004.48	425.43	21.17	<.0001	0.00	5.00
Event ind - (8/5/2019) Week before first school week when	31,869.45	5,657.60	5.63	<.0001	0.00	1.00
24/7 Operations Year 2	23,313.20	3,763.43	6.19	<.0001		
24/7 Operations Year 3	29,063.81	3,914.49	7.42	<.0001		
Model Adjustment Changepoint Indicator-(10/4/21) Operat	13,385.60	3,866.97	3.46	0.0006		

Program Dates	Start	End	Excluded Days	Total Energy Use (kWh) Actual	Predicted	Measured Savings
Baseline	01/07/19	01/05/20	-			
Reporting Period 1	01/06/20	12/26/21	-	16,528,241	18,081,719	1,553,478
Reporting Period 2	12/27/21	12/25/22	-	9,503,180	10,328,767	825,587
Reporting Period 3	12/26/22	12/24/23	-	8,953,761	9,253,751	269,300







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Middle_Food Service Electricity Model

Type of Fuel: Electricity - kWh

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Regression Statistics

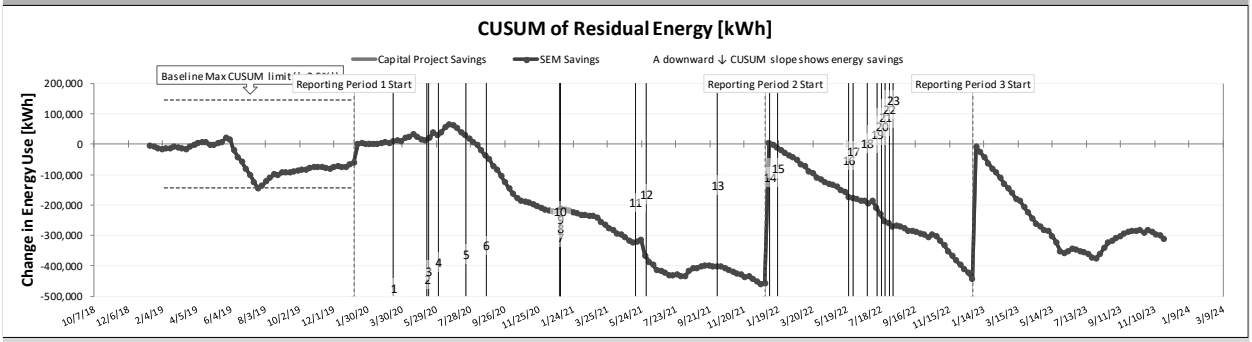
Model Interval	Weekly	
RSquare	0.954	(>0.75)
RSquare Adj	0.952	(>0.75)
Root Mean Square Error	8,584.22	kWh
Mean of Response	110,682.74	kWh
Observations (or Sum Wgts)	193	N/A
Autocorrelation	0.41	(<0.5)
F-test Overall P-Value	1.61E-117	(<0.10)
Coefficient of Variance	7.8%	(<10%)
Net Determination Bias	-6.08E+04	(<0.005%)
Annual Baseline Energy Use	5,755,503	kWh
5% annual use	287,775	kWh
Max Baseline CUSUM %	2.5%	(<2.5%)
Last Measurement Date	11/26/2023	
Excluded Points	-	

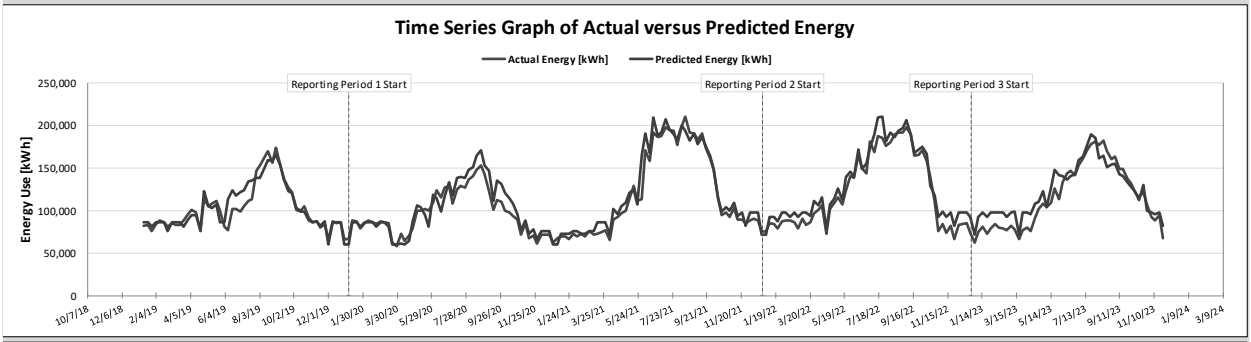
Parameter Estimates

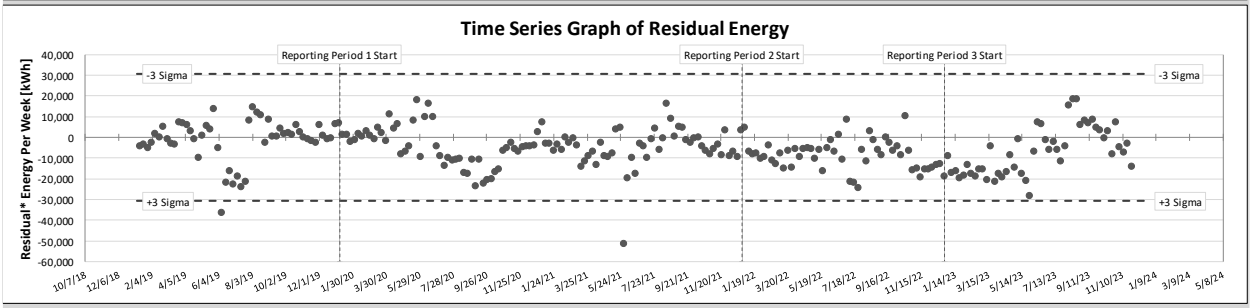
	Coefficients	Standard Error	t-Stat	p-Value	Baseline Min	Baseline Max
Intercept	59,641.49	1,676.39	35.58	<.0001		
CDD (65°F)	361.13	9.01	40.07	<.0001	0.00	220.00
School Day [1/0]	5,303.85	368.10	14.41	<.0001	0.00	5.00
Event ind - (8/5/2019) Week before first school week when	19,769.77	5,061.61	3.91	0.0001	0.00	1.00
24/7 Operations Year 2	33,765.35	3,369.93	10.02	<.0001		
24/7 Operations Year 3	29,578.25	3,179.43	9.3	<.0001		
Model Adjustment Changepoint Indicator-(10/4/21) Operat	11,334.36	3,412.94	3.32	0.0010		

Program Dates

	Start	End	Excluded Days	Total Energy Use (kWh) Actual	Predicted	Measured Savings
Baseline	01/07/19	01/05/20	-			
Reporting Period 1	01/06/20	12/26/21	-	11,177,172	11,634,048	456,876
Reporting Period 2	12/27/21	12/25/22	-	6,330,144	6,772,141	441,996
Reporting Period 3	12/26/22	12/24/23	-	5,533,280	5,847,042	284,120







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High_Food Service Electricity Model

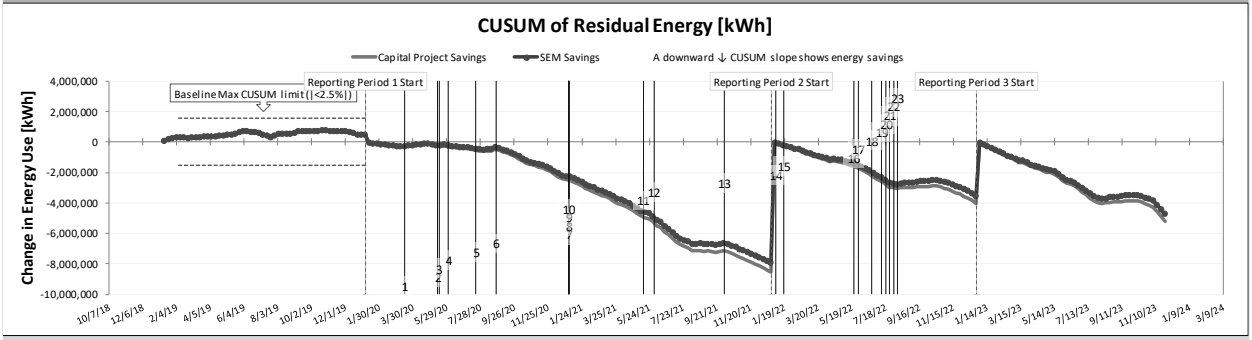
Type of Fuel Electricity - kWh

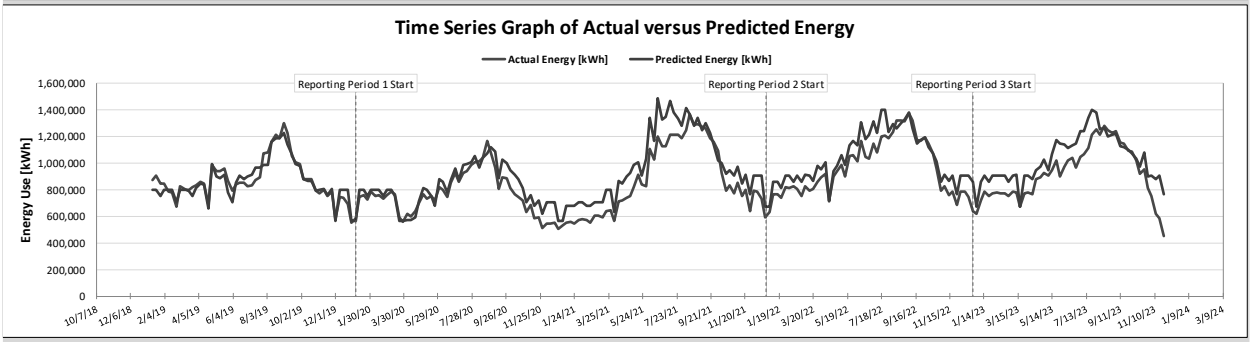
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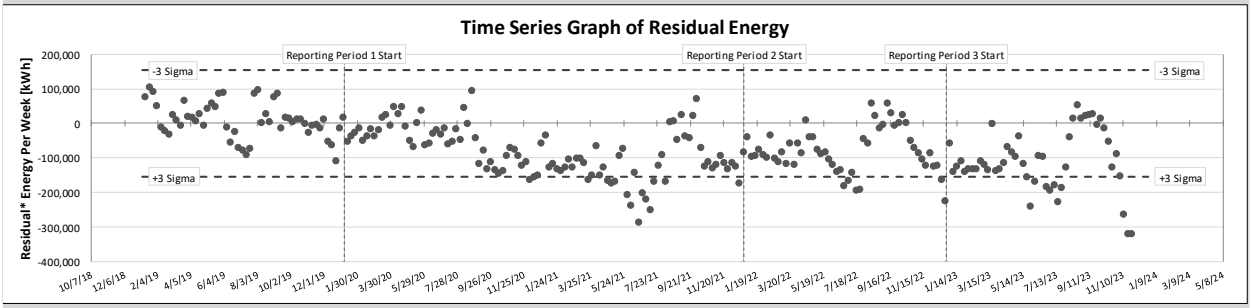
Regression Statistics		
Model Interval	Weekly	
RSquare	0.956	(>0.75)
RSquare Adj	0.954	(>0.75)
Root Mean Square Error	65,938.40	kWh
Mean of Response	1,196,602.06	kWh
Observations (or Sum Wgts)	193	N/A
Autocorrelation	0.53	(<0.5|
F-test Overall P-Value	2.78E-119	(<0.10)
Coefficient of Variance	5.5%	(<10%)
Net Determination Bias	4.85E+05	(<0.005%)
Annual Baseline Energy Use	62,223,307	kWh
5% annual use	3,111,165	kWh
Max Baseline CUSUM %	1.2%	(<2.5%|
Last Measurement Date	11/26/2023	
Excluded Points	-	

Parameter Estimates	Coefficients	Standard Error	t-Stat	p-Value	Baseline Min	Baseline Max
Intercept	563,906.41	10,836.51	52.04	<.0001		
CDD (65°F)	1,935.89	56.48	34.28	<.0001	0.00	220.00
School Day [1/0]	46,665.24	2,413.44	19.34	<.0001	0.00	5.00
Event ind - (8/5/2019) Week before first school week when	217,180.53	63,558.36	3.42	0.0007	0.00	1.00
10/4/2021 Operational Change	110,071.82	22,276.00	4.94	<.0001		
CDD (65°F)*24/7 Operations	844.91	117.68	7.18	<.0001		

Program Dates	Start	End	Excluded Days	Total Energy Use (kWh) Actual	Predicted	Measured Savings
Baseline	01/07/19	01/05/20	-			
Reporting Period 1	01/06/20	12/26/21	-	84,243,975	92,766,765	8,522,790
Reporting Period 2	12/27/21	12/25/22	-	49,976,430	54,036,153	4,059,723
Reporting Period 3	12/26/22	12/24/23	-	44,146,050	49,352,219	5,019,839







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Elementary_No Food Electricity Model		
Baseline Discussion	The baseline was shortened to one year due to data availability. By shortening the baseline, the model focuses on current operations. Weather and site data was available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.	
Variable Descriptions	CDD (65°F)	(Cooling Degree Days with a reference of 65°F) This variable represents the cooling load put on an HVAC system. As temperature increases above 65°F, your energy usage increases.
	School Day [1/0]	This metric represents the energy consumption that scales with School Day [Days]. As school days increase, energy usage increases.
	Event ind - (8/5/2019) Week before first school week when staff start working [0/1]	This binary variable represents the energy consumption that occurs during the week starting 8/5/2019, when all the staff begin work year. The energy usage increases due to increase in occupancy after the summer break.

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Middle_No Food Electricity Model		
Baseline Discussion	The baseline was shortened to one year due to data availability. By shortening the baseline, the model focuses on current operations. Weather and site data was available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.	
Variable Descriptions	CDD (60°F)	(Cooling Degree Days with a reference of 60°F) This variable represents the cooling load put on an HVAC system. As temperature increases above 60°F, your energy usage increases.
	School Day [1/0]	This metric represents the energy consumption that scales with School Day [Days]. As school days increase, energy usage increases.
	Event ind - (8/5/2019) Week before first school week when staffs start working [0/1]	This binary variable represents the energy consumption that occurs during the week starting 8/5/2019, when all the staff begin work year. The energy usage increases due to increase in occupancy after the summer break.

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High_No Food Electricity Model		
Baseline Discussion	The baseline was shortened to one year due to data availability. By shortening the baseline, the model focuses on current operations. Weather and site data was available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.	
Variable Descriptions	CDD (60°F)	(Cooling Degree Days with a reference of 60°F) This variable represents the cooling load put on an HVAC system. As temperature increases above 60°F, your energy usage increases.
	School Day [1/0]	This metric represents the energy consumption that scales with School Day [Days]. As school days increase, energy usage increases.
	Event ind - (8/5/2019) Week before first school week when staff start working [0/1]	This binary variable represents the energy consumption that occurs during the week starting 8/5/2019, when all the staff begin work year. The energy usage increases due to increase in occupancy after the summer break.

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Other_No Food Electricity Model		
Baseline Discussion	The baseline was shortened to one year due to data availability. By shortening the baseline, the model focuses on current operations. Weather and site data was available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.	
Variable Descriptions	CDD (65°F)	(Cooling Degree Days with a reference of 65°F) This variable represents the cooling load put on an HVAC system. As temperature increases above 65°F, your energy usage increases.
	Holiday Indicator - Independence Day	This metric represents the energy consumption that scales with School Day [Days]. As school days increase, energy usage increases.
	School Day [1/0]	This metric represents the energy consumption decrease for the Independence Day holiday due to decreased staffing.
	Event ind - (8/5/2019) Week before first school week when staff start working [0/1]	This binary variable represents the energy consumption that occurs during the week starting 8/5/2019, when all the staff begin work year. The energy usage increases due to increase in occupancy after the summer break.

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Elementary_Food Service Electricity Model		
Baseline Discussion	The baseline was shortened to one year due to data availability. By shortening the baseline, the model focuses on current operations. Weather and site data was available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.	
Variable Descriptions	CDD (60°F)	(Cooling Degree Days with a reference of 60°F) This variable represents the cooling load put on an HVAC system. As temperature increases above 60°F, your energy usage increases.
	School Day [1/0]	This metric represents the energy consumption that scales with School Day [Days]. As school days increase, energy usage increases.
	Event ind - (8/5/2019) Week before first school week when staff start working [0/1]	This binary variable represents the energy consumption that occurs during the week starting 8/5/2019, when all the staff begin work year. The energy usage increases due to increase in occupancy after the summer break.

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Middle_Food Service Electricity Model		
Baseline Discussion	The baseline was shortened to one year due to data availability. By shortening the baseline, the model focuses on current operations. Weather and site data was available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.	
Variable Descriptions	CDD (65°F)	(Cooling Degree Days with a reference of 65°F) This variable represents the cooling load put on an HVAC system. As temperature increases above 65°F, your energy usage increases.
	School Day [1/0]	This metric represents the energy consumption that scales with School Day [Days]. As school days increase, energy usage increases.
	Event ind - (8/5/2019) Week before first school week when staff start working [0/1]	This binary variable represents the energy consumption that occurs during the week starting 8/5/2019, when all the staff begin work year. The energy usage increases due to increase in occupancy after the summer break.

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High Food Service Electricity Model		
Baseline Discussion	The baseline was shortened to one year due to data availability. By shortening the baseline, the model focuses on current operations. Weather and site data was available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section. Autocorrelation for this model is slightly out of the specified range (0.54 instead of <0.5) due to the seasonal operational nature of the schools. While this is slightly outside of the specified range, it does not appear to have a significant impact on the modeled data. To ensure savings are not impacted by the increased autocorrelation, a fractional savings uncertainty (FSU) test will be applied.	
Variable Descriptions	CDD (65°F)	(Cooling Degree Days with a reference of 65°F) This variable represents the cooling load put on an HVAC system. As temperature increases above 65°F, your energy usage increases.
	School Day [1/0]	This metric represents the energy consumption that scales with School Day [Days]. As school days increase, energy usage increases.
	Event ind - (8/5/2019) Week before first school week when staff start working [0/1]	This binary variable represents the energy consumption that occurs during the week starting 8/5/2019, when all the staff begin work year. The energy usage increases due to increase in occupancy after the summer break.

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Alumni Models

Elementary_No Food Electricity Model

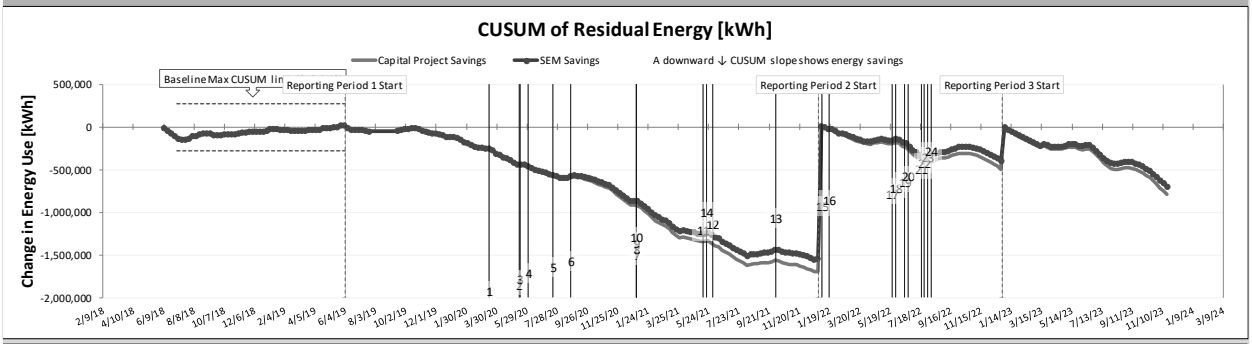
Type of Fuel Electricity - kWh

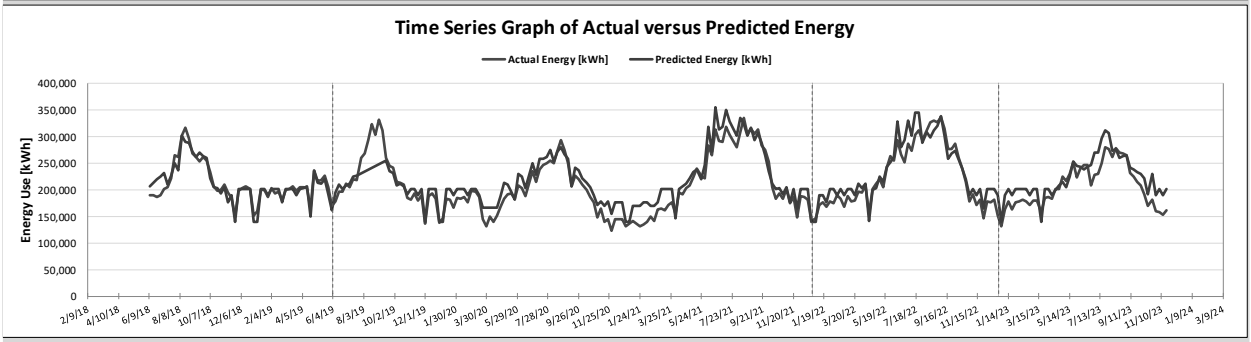
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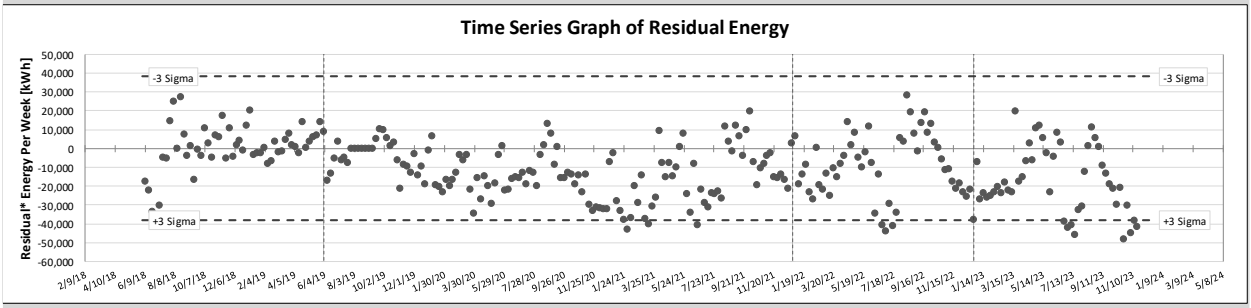
Regression Statistics		
Model Interval	Weekly	
RSquare	0.927	(>0.75)
RSquare Adj	0.924	(>0.75)
Root Mean Square Error	14,097.43	kWh
Mean of Response	211,302.30	kWh
Observations (or Sum Wgts)	219	N/A
Autocorrelation	0.55	(<0.5|
F-test Overall P-Value	1.21E-113	(<0.10)
Coefficient of Variance	6.7%	(<10%)
Net Determination Bias	2.16E+04	(<0.005%)
Annual Baseline Energy Use	10,987,720	kWh
5% annual use	549,386	kWh
Max Baseline CUSUM %	1.4%	(<2.5%|
Last Measurement Date	11/19/2023	
Excluded Points	7	

Parameter Estimates	Coefficients	Standard Error	*t*-Stat	p-Value	Baseline Min	Baseline Max
Intercept	138,801.39	3,032.28	45.77	<.0001		
CDD (70°F)	500.72	17.37	28.83	<.0001	0.00	221.00
School Day- Elementary [0/1]	12,616.00	602.64	20.93	<.0001	0.00	5.00
All Other Licensed Employees Begin Work Year [0/1]	72,082.38	15,034.71	4.79	<.0001	0.00	1.00
Model Adjustment - (3/16/2020-8/23/2020) COVID Operatic	26,888.01	4,400.76	6.11	<.0001		
Model Adjustment - CDD (70°F)*24/7 HVAC Operations Yea	217.78	32.40	6.72	<.0001		
Model Adjustment - CDD (70°F)*24/7 HVAC Operations Yea	237.79	34.36	6.92	<.0001		

Program Dates	Start	End	Excluded Days	Total Energy Use (kWh) Actual	Predicted	Measured Savings
Baseline	06/04/18	06/02/19	-			
Reporting Period 1	06/03/19	12/26/21	49	25,763,904	27,459,352	1,695,449
Reporting Period 2	12/27/21	12/25/22	-	11,767,732	12,266,616	498,884
Reporting Period 3	12/26/22	12/24/23	-	9,729,523	10,522,910	803,379







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Middle_No Food Electricity Model

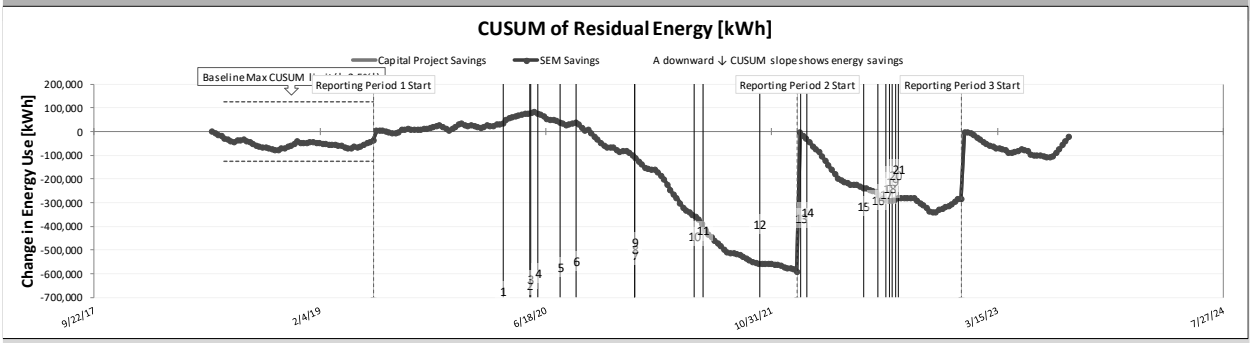
Type of Fuel Electricity - kWh

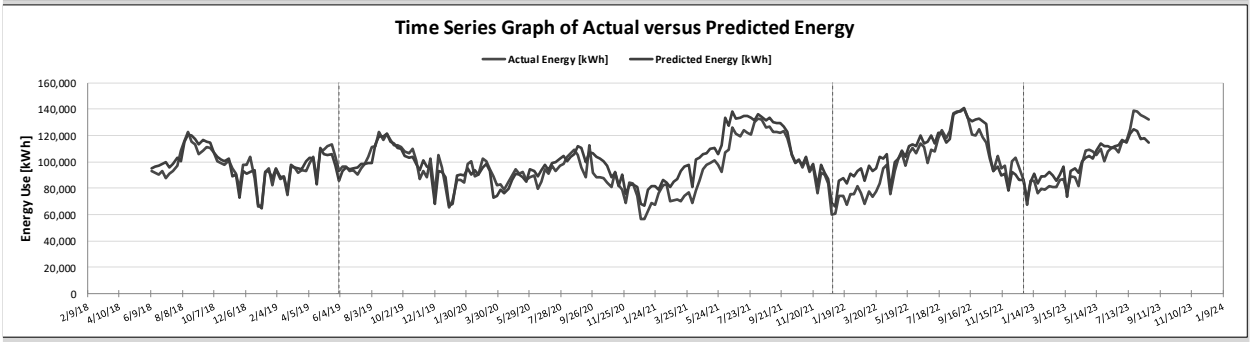
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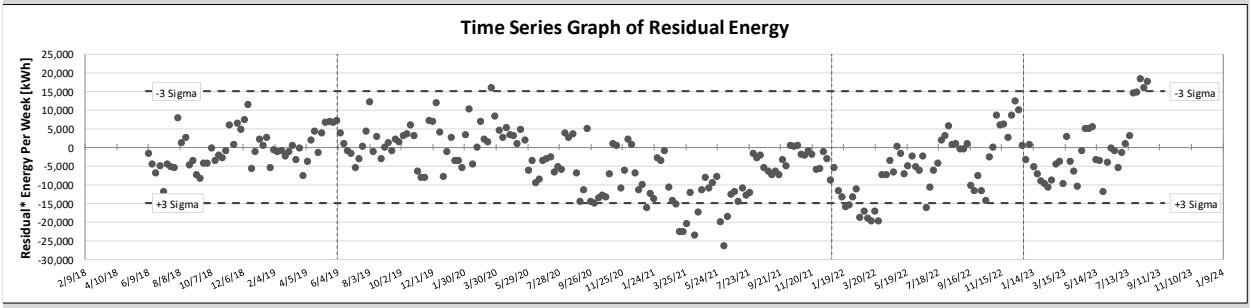
Regression Statistics		
Model Interval	Weekly	
RSquare	0.820	(>0.75)
RSquare Adj	0.814	(>0.75)
Root Mean Square Error	7,454.75	kWh
Mean of Response	96,517.35	kWh
Observations (or Sum Wgts)	226	N/A
Autocorrelation	0.71	(<0.5)
F-test Overall P-Value	1.63E-77	(<0.10)
Coefficient of Variance	7.7%	(<10%)
Net Determination Bias	-3.63E+04	(<0.005%)
Annual Baseline Energy Use	5,018,902	kWh
5% annual use	250,945	kWh
Max Baseline CUSUM %	1.6%	(<2.5%)
Last Measurement Date	8/20/2023	
Excluded Points	-	

Parameter Estimates	Coefficients	Standard Error	*t*-Stat	p-Value	Baseline Min	Baseline Max
Intercept	62,859.15	1,342.18	46.83	<.0001		
CDD (40°F)	93.11	3.83	24.31	<.0001	18.00	431.00
School Day- Middle [0/1]	4,356.94	242.28	17.98	<.0001	0.00	5.00
All Other Licensed Employees Begin Work Year [0/1]	15,986.95	4,984.32	3.21	0.0015	0.00	1.00
Period Indicator - 24/7 HVAC Operations Year 2	14,482.94	2,196.68	6.59	<.0001		
Period Indicator - 24/7 HVAC Operations Year 3	19,625.65	2,489.08	7.88	<.0001		

Program Dates	Start	End	Excluded Days	Total Energy Use (kWh) Actual	Predicted	Measured Savings
Baseline	06/04/18	06/02/19	-			
Reporting Period 1	06/03/19	12/26/21	-	12,721,465	13,313,054	591,589
Reporting Period 2	12/27/21	12/25/22	-	5,229,043	5,514,920	285,877
Reporting Period 3	12/26/22	12/24/23	-	3,437,619	3,460,991	20,556







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High_No Food Electricity Model

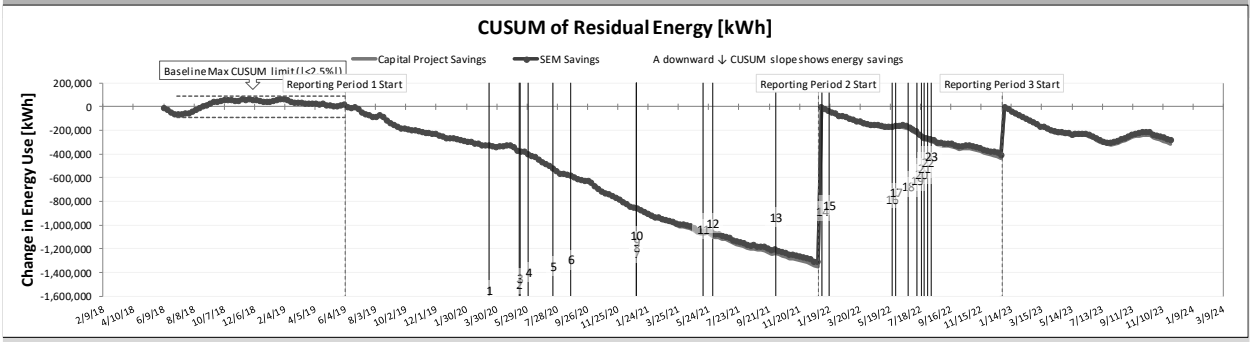
Type of Fuel Electricity - kWh

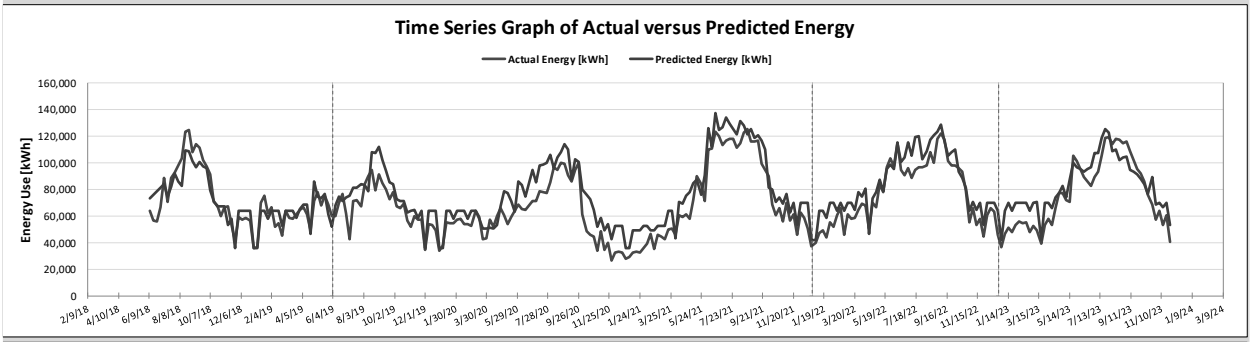
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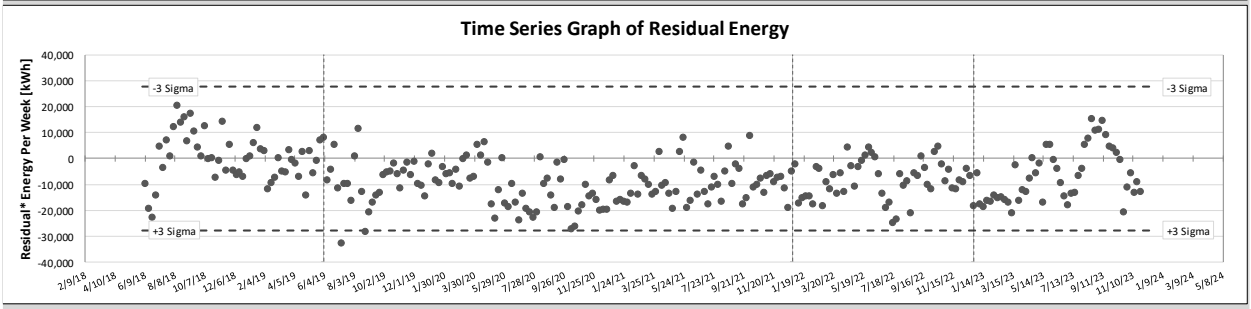
Regression Statistics		
Model Interval	Weekly	
RSquare	0.892	(>0.75)
RSquare Adj	0.888	(>0.75)
Root Mean Square Error	8,178.57	kWh
Mean of Response	70,320.35	kWh
Observations (or Sum Wgts)	226	N/A
Autocorrelation	0.46	(<0.5)
F-test Overall P-Value	2.87E-99	(<0.10)
Coefficient of Variance	11.6%	(<10%)
Net Determination Bias	1.90E+04	(<0.005%)
Annual Baseline Energy Use	3,656,658	kWh
5% annual use	182,833	kWh
Max Baseline CUSUM %	1.8%	(<2.5%)
Last Measurement Date	11/26/2023	
Excluded Points	-	

Parameter Estimates	Coefficients	Standard Error	*t*-Stat	p-Value	Baseline Min	Baseline Max
Intercept	35,845.81	1,690.55	21.2	<.0001		
CDD (65°F)	218.77	7.08	30.88	<.0001	0.00	256.00
School Day- High [0/1]	5,527.89	326.55	16.93	<.0001	0.00	5.00
Model Adjustment - (3/16/2020-9/21/2020) COVID Operatic	14,441.04	2,249.46	6.42	<.0001		
24/7 HVAC Operations Year 2	19,636.50	3,034.89	6.47	<.0001		
24/7 HVAC Operations Year 3	11,227.40	3,402.79	3.3	0.0011		
Model Adjustment - (10/4/2021) Operational Change [0/1]	6,122.97	3,079.61	1.99	0.0478		

Program Dates	Start	End	Excluded Days	Total Energy Use (kWh) Actual	Predicted	Measured Savings
Baseline	06/04/18	06/02/19	-			
Reporting Period 1	06/03/19	12/26/21	-	8,971,774	10,324,251	1,352,477
Reporting Period 2	12/27/21	12/25/22	-	3,989,852	4,427,415	437,562
Reporting Period 3	12/26/22	12/24/23	-	3,677,919	3,990,475	313,385







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Other_No Food Electricity Model

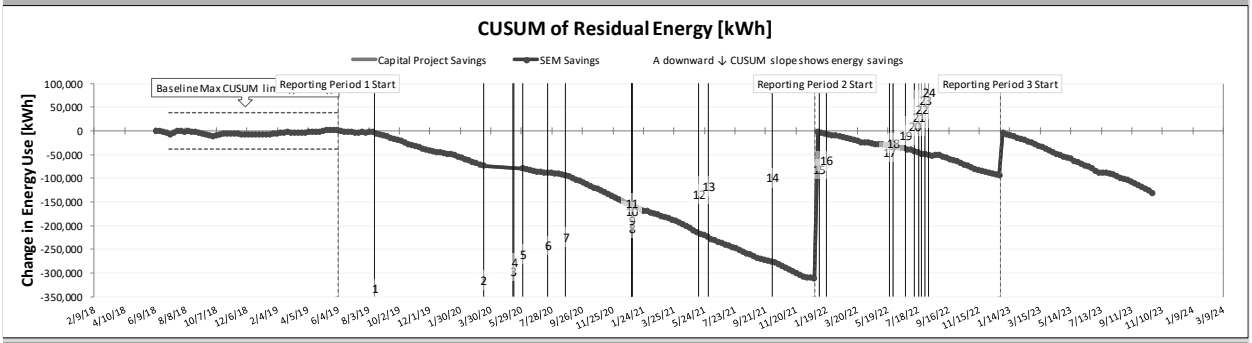
Type of Fuel Electricity - kWh

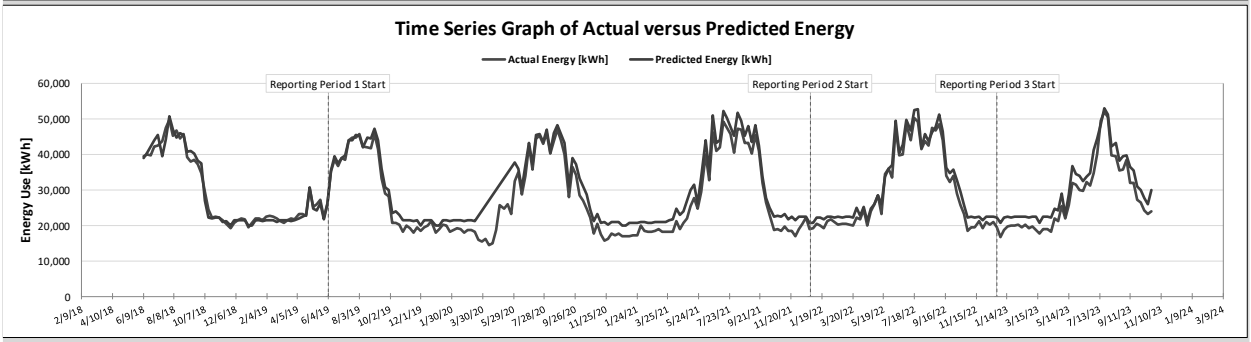
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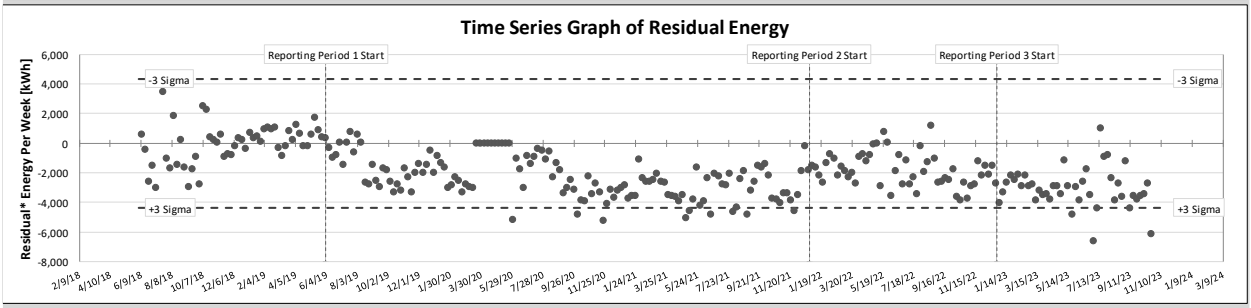
Regression Statistics		
Model Interval	Weekly	
RSquare	0.988	(>0.75)
RSquare Adj	0.988	(>0.75)
Root Mean Square Error	1,189.51	kWh
Mean of Response	29,122.97	kWh
Observations (or Sum Wgts)	216	N/A
Autocorrelation	0.30	(<0.5|
F-test Overall P-Value	4.29E-195	(<0.10)
Coefficient of Variance	4.1%	(<10%)
Net Determination Bias	2.67E+03	(<0.005%)
Annual Baseline Energy Use	1,514,395	kWh
5% annual use	75,720	kWh
Max Baseline CUSUM %	0.8%	(<2.5%|
Last Measurement Date	10/22/2023	
Excluded Points	10	

Parameter Estimates	Coefficients	Standard Error	*t*-Stat	p-Value	Baseline Min	Baseline Max
Intercept	19,883.80	234.92	84.64	<.0001		
CDD (70°F)	139.04	1.24	112.51	<.0001	0.00	221.00
School Day- Other [0/1]	325.80	45.77	7.12	<.0001	0.00	5.00
24/7 Operations Year 2	4,357.44	470.96	9.25	<.0001		
24/7 Operations Year 3	3,329.40	401.89	8.28	<.0001		
ChangePoint 10/4/21 Operational Change	864.44	421.56	2.05	0.0413		

Program Dates	Start	End	Excluded Days	Total Energy Use (kWh) Actual	Predicted	Measured Savings
Baseline	06/04/18	06/02/19	-			
Reporting Period 1	06/03/19	12/26/21	70	3,512,976	3,824,584	311,608
Reporting Period 2	12/27/21	12/25/22	-	1,526,259	1,620,336	94,077
Reporting Period 3	12/26/22	12/24/23	-	1,192,295	1,323,250	129,968







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High_Food Service Electricity Model

Type of Fuel Electricity - kWh

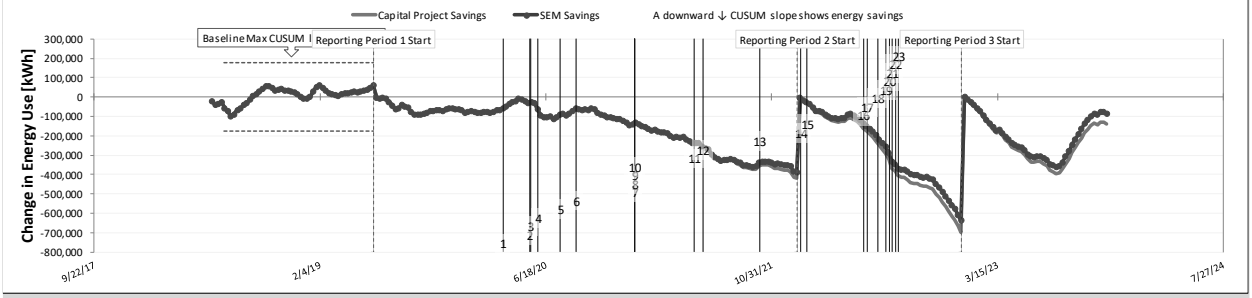
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Regression Statistics		
Model Interval	Weekly	
RSquare	0.898	(>0.75)
RSquare Adj	0.894	(>0.75)
Root Mean Square Error	10,793.61	kWh
Mean of Response	134,757.06	kWh
Observations (or Sum Wgts)	226	N/A
Autocorrelation	0.48	(<0.5)
F-test Overall P-Value	6.68E-101	(<0.10)
Coefficient of Variance	8.0%	(<10%)
Net Determination Bias	6.02E+04	(<0.005%)
Annual Baseline Energy Use	7,007,367	kWh
5% annual use	350,368	kWh
Max Baseline CUSUM %	1.4%	(<2.5%)
Last Measurement Date	11/12/2023	
Excluded Points	-	

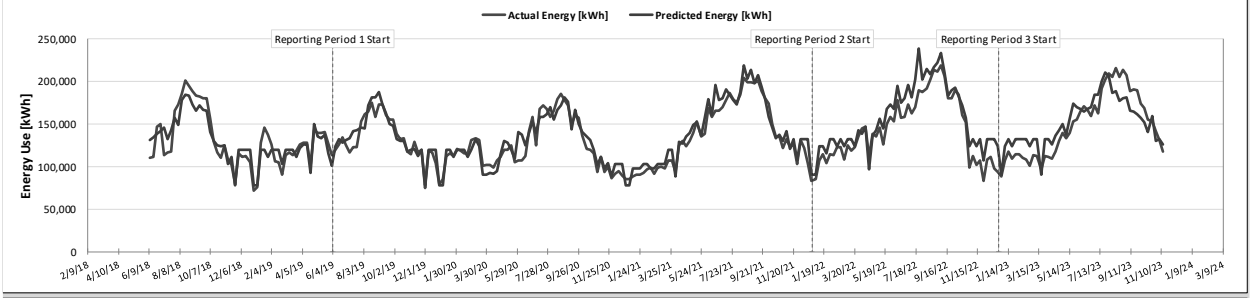
Parameter Estimates	Coefficients	Standard Error	*t*-Stat	p-Value	Baseline Min	Baseline Max
Intercept	77,768.00	2,182.04	35.64	<.0001		
CDD (65°F)	308.41	9.55	32.28	<.0001	0.00	256.00
School Day- High [0/1]	8,240.01	457.48	18.01	<.0001	0.00	5.00
All Other Licensed Employees Begin Work Year [0/1]	34,034.03	8,826.92	3.86	0.0001	0.00	1.00
Model Adjustment - (3/2/2020 - 9/27/2020) COVID operatio	12,745.06	2,836.51	4.49	<.0001		
CDD (65°F)*24/7 Operations Year 2	178.12	29.26	6.09	<.0001		
CDD (65°F)*24/7 Operations Year 3	157.96	24.41	6.47	<.0001		
10/4/21 New Operations	12,495.51	4,130.68	3.03	0.0027		

Program Dates	Start	End	Excluded Days	Total Energy Use (kWh) Actual	Predicted	Measured Savings
Baseline	06/04/18	06/02/19	-			
Reporting Period 1	06/03/19	12/26/21	-	17,599,185	18,020,222	421,037
Reporting Period 2	12/27/21	12/25/22	-	7,471,730	8,170,401	698,670
Reporting Period 3	12/26/22	12/24/23	-	6,836,234	6,976,166	141,156

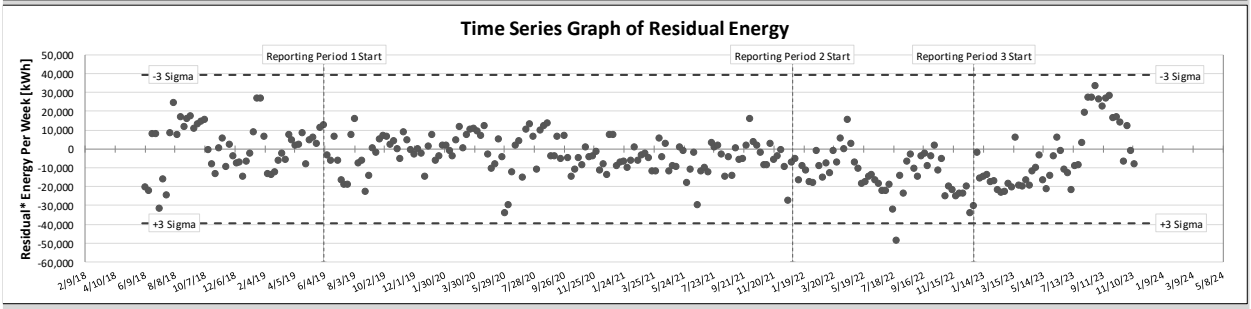
CUSUM of Residual Energy [kWh]



Time Series Graph of Actual versus Predicted Energy



Time Series Graph of Residual Energy



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Elementary_Food Service Electricity Model

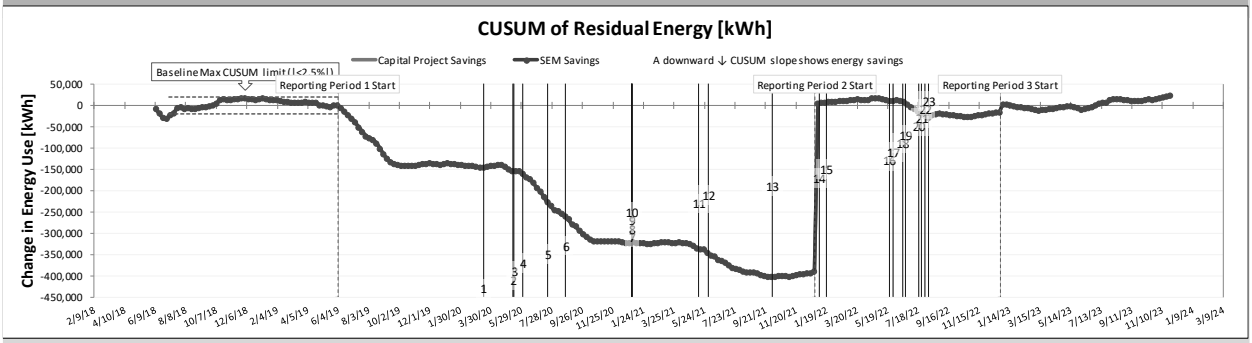
Type of Fuel Electricity - kWh

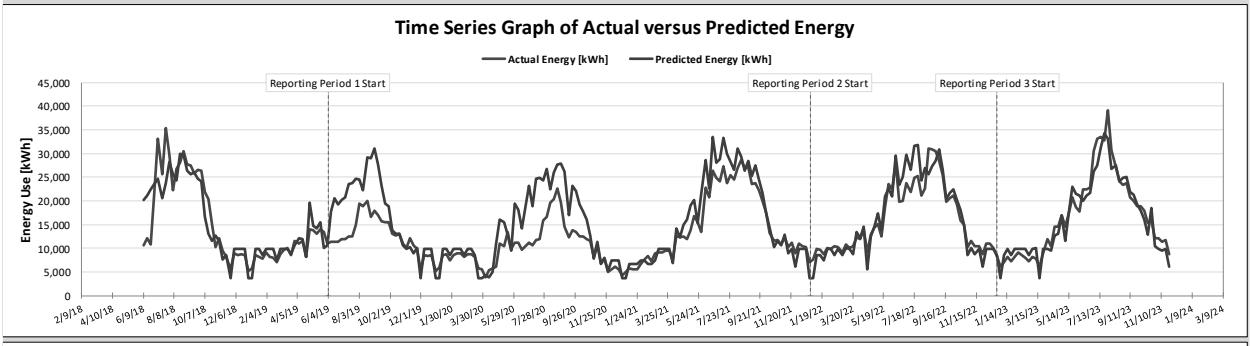
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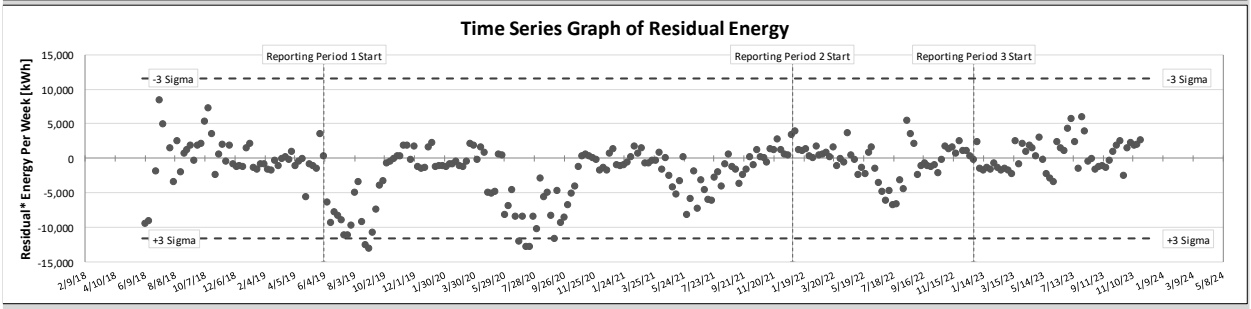
Regression Statistics		
Model Interval	Weekly	
RSquare	0.791	(>0.75)
RSquare Adj	0.783	(>0.75)
Root Mean Square Error	3,945.07	kWh
Mean of Response	15,078.60	kWh
Observations (or Sum Wgts)	52	N/A
Autocorrelation	0.50	(<0.5|
F-test Overall P-Value	2.19E-17	(<0.10)
Coefficient of Variance	26.2%	(<10%)
Net Determination Bias	-1.64E-11	(<0.005%)
Annual Baseline Energy Use	784,087	kWh
5% annual use	39,204	kWh
Max Baseline CUSUM %	4.1%	(<2.5%|
Last Measurement Date	11/26/2023	
Excluded Points	-	

Parameter Estimates	Coefficients	Standard Error	*t*-Stat	p-Value	Baseline Min	Baseline Max
Intercept	3,667.58	1,412.92	2.59575471	0.0124		
CDD (65°F)	96.18	7.17	13.41971633	<0.0001*	0.00	256.00
School Day [Days]	1,231.80	283.71	4.341782258	<0.0001*	0.00	5.00

	Start	End	Excluded Days	Total Energy Use (kWh) Actual	Predicted	Measured Savings
Baseline	06/04/18	06/02/19	-			
Reporting Period 1	06/03/19	12/26/21	-	1,697,405	2,088,827	391,422
Reporting Period 2	12/27/21	12/25/22	-	840,751	858,994	18,243
Reporting Period 3	12/26/22	12/24/23	-	807,590	785,861	(21,730)







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Elementary_No Food Electricity Model		
Baseline Discussion	The baseline was shortened to one year due to data availability. By shortening the baseline, the model focuses on current operations. Weather and site data was available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.	
Variable Descriptions	CDD (70°F)	(Cooling Degree Days with a reference of 70°F) This variable represents the cooling load put on an HVAC system. As temperature increases above 70°F, your energy usage increases.
	School Day [Days]	This metric represents the energy consumption that scales with School Day [Days]. As school days increase, energy usage increases.
	All Other Licensed Employees Begin Work Year [0/1]	This binary variable represents the energy consumption that varies with the event of All Other Licensed Employees Begin Work Year. When this happens, energy usage increases.

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Middle_No Food Electricity Model		
Baseline Discussion	The baseline was shortened to one year due to data availability. By shortening the baseline, the model focuses on current operations. Weather and site data was available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.	
Variable Descriptions	CDD (40°F)	(Cooling Degree Days with a reference of 40°F) This variable represents the cooling load put on an HVAC system. As temperature increases above 40°F, your energy usage increases.
	School Day [Days]	This metric represents the energy consumption that scales with School Day [Days]. As school days increase, energy usage increases.
	All Other Licensed Employees Begin Work Year [0/1]	This binary variable represents the energy consumption that varies with the event of All Other Licensed Employees Begin Work Year. When this happens, energy usage increases.

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High No Food Electricity Model		
Baseline Discussion	The baseline was shortened to one year due to data availability. By shortening the baseline, the model focuses on current operations. Weather and site data was available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section. The Coefficient of Variance is above the designated threshold for the baseline period. This descriptive statistic measures the noise in the baseline period and therefore the expected level of noise in the measurement period. Any savings would need to pass a fractional savings uncertainty analysis to be accepted.	
Variable Descriptions	CDD (65°F)	(Cooling Degree Days with a reference of 65°F) This variable represents the cooling load put on an HVAC system. As temperature increases above 65°F, your energy usage increases.
	School Day [Days]	This metric represents the energy consumption that scales with School Day [Days]. As school days increase, energy usage increases.

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Other_No Food Electricity Model		
Baseline Discussion	The baseline was shortened to one year due to data availability. By shortening the baseline, the model focuses on current operations. Weather and site data was available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.	
Variable Descriptions	CDD (70°F)	(Cooling Degree Days with a reference of 70°F) This variable represents the cooling load put on an HVAC system. As temperature increases above 70°F, your energy usage increases.
	School Day [Days]	This metric represents the energy consumption that scales with School Day [Days]. As school days increase, energy usage increases.

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High_Food Service Electricity Model		
Baseline Discussion	The baseline was shortened to one year due to data availability. By shortening the baseline, the model focuses on current operations. Weather and site data was available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.	
Variable Descriptions	CDD (65°F)	(Cooling Degree Days with a reference of 65°F) This variable represents the cooling load put on an HVAC system. As temperature increases above 65°F, your energy usage increases.
	School Day [Days]	This metric represents the energy consumption that scales with School Day [Days]. As school days increase, energy usage increases.
	All Other Licensed Employees Begin Work Year [0/1]	This binary variable represents the energy consumption that varies with the event of All Other Licensed Employees Begin Work Year. When this happens, energy usage increases.

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Elementary Food Service Electricity Model		
Baseline Discussion	The baseline was shortened to one year due to data availability. By shortening the baseline, the model focuses on current operations. Weather and site data was available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section. The Coefficient of Variance, autocorrelation, and Max CUSUM % are above the designated thresholds for the baseline period. These descriptive statistics measure the noise in the baseline period and potential issues with seasonality and trends which may have implications on the measurement period if savings are not substantial enough to mitigate these risks. Any savings would need to pass a fractional savings uncertainty analysis to be accepted.	
Variable Descriptions	CDD (65°F)	(Cooling Degree Days with a reference of 65°F) This variable represents the cooling load put on an HVAC system. As temperature increases above 65°F, your energy usage increases.
	School Day [Days]	This metric represents the energy consumption that scales with School Day [Days]. As school days increase, energy usage increases.

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9 APPENDIX D: "MEASUREMENT AND VERIFICATION REPORT CONTINUOUS ENERGY IMPROVEMENT (CEI)" PREPARED BY CLEARESULT FOR WASHOE COUNTY SCHOOL DISTRICT

The following report, which was created by the 2023 Energy Smart Schools Program's implementation contractor, was prepared for Washoe County School District (**28** pages including the title page).

CLEAResult

Measurement and Verification Report Continuous Energy Improvement (CEI)

DECEMBER 2023

PREPARED BY

CLEAResult

PREPARED FOR

Washoe County School District

SPONSORED BY

NVEnergy

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1.0 Executive Summary

In late 2020 NV Energy's Energy Smart Schools program, implemented by NV Energy, engaged with Washoe County School District (WCSD) to enroll in a Continuous Energy Improvement (CEI) program that had demonstrated energy savings potential through low to no cost maintenance and operations activities guided by comprehensive strategic energy management practices in other school districts in Nevada.

With successful demonstration for saving energy in 2021, NV Energy approved funding for continued sponsorship of CEI, at no cost to WCSD, with the intention of continuing savings and serving as a complement to WCSD's in-house energy management systems (EnMS) and their work with McKinstry's powerED program.

For 2023, the CLEAResult schools program team updated their plan to support WCSD and McKinstry in their efforts to reduce their energy use and achieve a target minimum of 1,500,000 kWh energy savings in 2023, district wide. The schools program team compiled a list of 108 schools to achieve these savings through energy conservation measures and engagement activities carried out by WCSD and McKinstry, with additional monitoring for trouble areas, collaboration on projects, and verification of savings carried out by CLEAResult. The list of schools was developed based on data availability, year built, construction activities, and other factors.

Building on the successful collaboration of previous years, WCSD and the schools program team continued to see solid savings through the dedicated efforts of WCSD's Energy & Sustainability Manager, the McKinstry powerED team, and CEI and schools program team initiatives. Table 1 summarizes the program savings for 2023 and Table 2 outlines the 2023 CEI parameters.

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Table 1. 2023 CEI Program Savings Summary

Number of Participating Schools	108
Measurement Period	1/02/2023 – 1/1/2024
Predicted Electricity Usage (kWh)	22,304,033 kWh
Actual Electricity Usage (kWh)	20,340,641 kWh
Projects Incentivized Outside of CEI (kWh)	760,976 kWh
Annualized Electricity Savings (kWh)	1,676,568 kWh

Table 2. 2023 CEI Program Parameters

Sponsoring Utility	**NV Energy**
Program Name	Continuous Energy Improvement (CEI)
Implementation Contractor	CLEAResult Consulting Inc.
Energy Type(s)	Electricity (kWh)
Program Engagement	January 2, 2023 – January 1, 2024
Customer	Washoe County School District
Location	Administration, Main Office: 425 East Ninth Street, Reno, NV 89520
Classification	K-12 Schools, Public Education
Executive Sponsor - Energy & Sustainability Manager	
CEI Program Manager	
CEI Energy Coach	
Program Manager	
Energy Engineer	
Energy Model Specialist	
Senior Building Energy Engineer, (McKinstry)	

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2.0 CEI Scope of Work

2023 program engagement between the CEI schools program team and WCSD included:

- Jason , WCSD's Energy and Sustainability Manager
- Mike , McKinstry's powerED advisor for WCSD
- Members of the WCSD facilities team
- McKinstry powerED program team
- CLEAResult and NV Energy Energy Smart School team

Building on successes from 2022, all organizations worked together to continue to dive into energy use around WCSD and implement projects, strategies, and behavioral changes to influence energy savings. All activities and projects were carried out by WCSD and McKinstry, while the CLEAResult schools program team provides ideas, data analysis and backup for the WCSD and McKinstry teams.

The schools program team continued to the trend of attending pre-established check-ins with WCSD and McKinstry every three weeks, developing and maintaining regression models for schools, using these models to verify energy usage trends (increases and decreases) to help WCSD and McKinstry troubleshoot, and collaborate on additional energy savings activities. These activities carried on throughout the year and enabled the schools program team to offer pertinent data through models and feedback on potential issues with buildings to help correct negative savings trends.

3.0 Engagement and Energy Saving Actions

The highlight of the 2023 program year has been the continuation of the strong relationship between the schools' program team and Jason and Mike who are the key players for WCSD and McKinstry, respectively. McKinstry's work through the powerED program bolsters WCSD's energy management program and it is evident the partnership between the two organizations continues to have a very positive impact. The CEI program team provided WCSD critical information and support throughout the year and was always ready to collaborate and help solve problems. Patrick and Allan attended standing meetings with the WCSD and McKinstry team every three weeks. In addition to these meetings, coaches, WCSD and McKinstry staff held separate meetings on an as needed basis throughout the year to collaborate and discuss activities across the district.

Program team support included:

- Helping review and refine WCSD projects (historical, current, and future)
- Brainstorming options and strategies to further reduce energy use in WCSD buildings
- Reviewing models on a bi-weekly basis with an eye towards significant changes in energy use

Given the work McKinstry continues to carry out with WCSD facilities, the greatest benefit the CEI program offered the District was the regression models. By conducting analyses of model changes, the CEI team was able to monitor all enrolled sites and spot changes in energy consumption, specifically sites that were experiencing significant energy usage different than the baseline and previous trends. These discoveries were passed along and discussed with Jason and Mike, which were then further investigated by the WCSD and McKinstry teams. In multiple cases, past and ongoing, significant issues with building schedules, equipment issues, and occupancy were discovered and addressed in a timeline that was a month or more faster than the previous troubleshooting. This eye towards teamwork and collaboration has led to significant benefit for WCSD and has enabled McKinstry and the schools program team to increase their support for the District. Building on the 2022 program year, the program team continued to use the

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model trends log. This document allowed coaches to capture models that had irregular use, document ideas, and share with the McKinstry and WCSD teams. Mike, Jason, and other members were then able to provide comments and identify schools that needed further investigation to determine energy use issues. This increased tempo of communication provided additional value for all parties and subsequently improved savings trends significantly.

4.0 MT&R Baseline Model and Measured Savings

Introduction

CEI savings are determined using statistical energy models. The energy model compares baseline energy consumption, using a best fit linear regression equation, with actual energy use over the measurement period. Energy savings occur when the actual energy consumed is less than the predicted energy usage. CEI program savings are the total observed model savings summed up over the program measurement period minus any savings from incentivized projects reported under different programs.

The baselines for the energy models are developed in JMP statistical software. The baseline information is then transferred to an Excel file, consisting of multiple tabs, that contains the CEI energy model. The Excel model file is the primary information source and documentation for energy savings for this report. The various aspects of the Excel energy model are explained in the sections below. The reader should refer directly to the Excel CEI Model Tracking file, which contains the detailed and specific information for each model. In addition, the following sections contain a high-level summary of the model plus explanations for any unique or special factors to be considered in interpreting the models and savings.

Preliminary modeling employed stepwise regression. This was followed by successive manual changes to the model's specification to identify a model with good predictive performance and a reasonable number of predictors given the sample size. The distribution of each variable in the model was examined for suitability in regression modeling. A time series plot of each variable was analyzed. Outliers were investigated on a univariate basis (through examination of standardized Z-scores) and on a multivariate basis (through analysis of Cook's Distances and leverage plots to identify excessively influential cases or points). The strength of association between variables was evaluated using bivariate correlations as well as partial correlations and associated scatter plots.

The performance of the model was assessed through a variety of statistical measures including overall fit (R2), coefficient of variance, autocorrelation of the regression residuals, X-Y plot of actual vs. predicted values, and a time series plot of actual vs. predicted values superimposed.

The residuals (prediction errors) were examined for normality (via an omnibus normality test) and to identify outlier predictions. The residuals were also examined graphically for statistical homoscedasticity (equal variance) across the range of predicted energy values. The cumulative sum of the differences between actual and predicted energy use over time is defined as the CUSUM. As such, CUSUM was plotted as a time series to evaluate the model's predictive consistency.

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Baseline Energy Model Discussion

The baseline energy model development discussion and rationale can be found on the Model Validation tabs of each of the model files and Appendix B of this report. Parameters used to define the model specifications are shown on the Electricity Model tabs in the "Parameter Estimates" table that lists the energy consumption predictors and their accompanying coefficients. All parameters meet the standard criteria for statistical significance, unless explained otherwise.

Measurement Period Discussion

Completed projects in the measurement period can also be found on the SEM Project List tab in the model files. Several sites were removed from the measurement period due to maintenance issues or failing equipment beyond the control of the school district. These sites are identified in the SEM Savings Summary tab of the model file.

Raw Data

Raw data is contained in two separate Data tabs in the model file. The Raw Energy Data tab contains the daily interval electricity data obtained from the supplying utility for each site. The Raw Weather and Site Data tab contains weather data from RNO weather station and specific occupancy, and site information used in the model.

Baseline Period and Model Interval

The Parameters tab indicates the baseline period as well as the model interval (I.e., weekly) for this district.

Model Parameters and Validity

The model parameters are shown in the Regression Stats tab that lists the energy consumption predictors and their accompanying coefficients. All parameters met the standard criteria for statistical significance.

Cumulative Sum (CUSUM) Table

The CUSUM table is shown for each site in the tabs labeled Modeled Data (1-10), etc. It contains the formulas and quantities for calculating actual energy, predicted energy, the difference between actual and predicted energy, and the cumulative sum of the energy usage differential for each model interval period.

Excluded Points

Excluded points are indicated via the 'Include in Model' column within the CUSUM Table in the Modeled Data tabs. The rationale for excluded points is given in the SEM Project List tab of the model file. Points may be excluded during both the baseline and measurement periods.

CUSUM Graph

The CUSUM graph is shown in the SEM Graphs tab. It graphically depicts the CUSUM value from the CUSUM table, for both the workbook as a whole and each individual site.

Energy Savings Summary

The energy savings summary is contained in the SEM Savings Summary tab. It shows a summary of the measurement period and the savings achieved.

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Incentivized Projects Table

The incentivized projects table is contained in the Capital Projects tab. The table lists incentivized projects conducted during the measurement period and calculates the prorated energy savings to be deducted from the CUSUM savings, ensuring that no incentivized projects outside of the CEI program are incentivized twice.

5.0 Conclusions and Future for CEI

WCSD was able to capture significant energy savings by implementing simple, no- and low-cost measures across their repertoire of buildings. The primary support for WCSD built on the strong relationship and expertise of McKinstry and their powerED program and the efforts being carried out at the District, proving that with some additional support, dedicated time, and the right data, a lot of impact can be made. CEI engineers and coaches worked with WCSD and McKinstry staff to further improve efficiency of the buildings through modeling and communications around projects and opportunities that identified trouble areas, as well as successes. These aspects allowed WCSD to realize significant savings, reduce wear on their buildings, and demonstrate the value of a three-way partnership between the District, energy services contractor, and schools program team. Looking toward the future, the schools program team will continue to support WCSD through the robust regression models and collaborative efforts to improve efficiencies in their energy management system that increase savings and decrease costs of operating and maintaining their District. See Appendix A: 2023 Opportunity Register for a list of energy saving actions WCSD took during the 2023 program year.

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Appendix A: 2023 Opportunity Register

ELEMENTARY SCHOOL SEM PROJECT LIST

ID#	PROJECT ID	PROJECT DESCRIPTION	DATE COMPLETED	NOTES
30		Silver Lake ES: 12/8/21: BCS programmed in automatic override reset.	12/8/2021	Unit C-5 was in override mode and operating 2 4/7 until global overrides were initiated. Automatic override reset removed override.
31		Gomes and Gomm ES running chillers overnight to prevent them tripping during day.	8/15/2022	
32	357	9/2/21 Gym AHU is operating 24/7. No override, but fan is operating well past scheduled time.	10/27/2021	Palmer ES
33	363	CWPs are operating 24/7. It appears that the "call from HP" button is overridden to YES. Recommend resetting this function to "auto" if pumps are not necessary to operate 24/7. 2/10/22: Call for HP set to Auto. All TUX units are communicating. Pumps are back to following schedule.	2/10/2022	Hall ES
34	364	Pump dP setpoint was reset from 10 to 25 psi. This has caused pump speed to increase from roughly 85-90% up to 100%. Recommend resetting value back to previous value or having TAB conducted to determine flow requirements. 2/10/22: dP lowered to 18psig, having a minimal impact on pump speed.	2/10/2022	Hall ES
35	365	Both CHWP1 and CHWP2 are operating during occupied hours. Recommend reviewing pump performance to determine if both pumps are required to operate. 2/10/22: Pumps were in alarm. It was found that trending	2/10/2022	Bennett ES

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		data was command, not status. Both pumps were being commanded to run, but no evidence to support both pumps actually operating. Alarm was cleared - no savings.		
36	366	Multipurpose room south unit control mode is overridden to occupied (See screenshot). Recommend removing override and allowing unit to follow schedule. Override was causing unit to operate 24/7 and maintain occupied setpoints. 2/10/22: Override removed, unit following schedule. Override was placed on 6/21/21.	2/10/2022	Greenbrae ES
37	375	School is in manual override mode. School was place in manual override for freeze protection on 2/22 and override was not removed as of 4/12. Most other schools had freeze protection removed 3/2.	4/13/2022	Sepulveda ES
38	366	Tower Pump in Alarm	12/15/2021	Westergard ES
39	367	Replace OSA Temp Sensor	5/31/2022	Beck ES
40	376	Enable Trends / Investigate High Usage	4/29/2022	Silver Lake ES
41	377	Remove Manual Override	4/13/2022	Warner ES
42	398	Caughlin Ranch ES - On During UnOcc and Excessive Run Time - whole school	3/2/2022	Caughlin Ranch ES
43	26	Add cooling and heating OA lockouts	6/14/2022	Brown ES
44	31	Add VFDs to pump motors	6/14/2022	Donner Springs ES
45	34	Add heating and cooling OA lockouts	2/9/2022	Dodson ES
46	40	Add VFDs to pump motors	6/14/2022	Double Diamond ES
47	46	Add DCV to multipurpose room and stage	6/14/2022	Hidden Valley ES
48	56	Add DCV to various areas	6/14/2022	Huffaker ES
49	58	Add heating and cooling OA lockouts	2/9/2022	Huffaker ES
50	61	Add DCV to various areas	6/14/2022	Hunsberger ES
51	69	Add heating and cooling OA lockouts	2/9/2022	Mathews ES
52	70	Add DCV to various areas	6/14/2022	Mathews ES
53	73	Add kitchen hood exhaust control	2/9/2022	Mathews ES
54	80	Add DCV to various areas	6/14/2022	Moss ES
55	83	Optimize heating and cooling OA lockout setpoints	6/14/2022	Moss ES
56	84	Add DCV to various areas	6/14/2022	Picollo ES
57	152	Chilled Water System Control Improvements	6/14/2022	Double Diamond ES

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58	153	Chilled Water System Control Improvements	6/14/2022	Donner Springs ES
59	212	Trouble shoot loss of control communication	9/27/2022	Hidden Valley ES
60	214	Use Heating Setback Temperatures	12/15/2021	Smithridge ES
61	218	BAS Network Communication	9/1/2022	Moss ES
62	226	Remove Manual Overrides	4/13/2022	Elmcrest ES
63	000371	Alice Smith ES - D-10 Office - High Supply Temp Issue	7/14/2023	Alice Smith ES
64	000403	Remove Manual Override	1/31/2023	Gomm ES
65		Winter break starts	12/23/2022	
66		winter break ends	1/9/2023	
67		spring break week	3/18/2023	
68		Multiple schools went into "arctic mode" - heat pump schools that had to be manually turned off, extra load on sites	1/9/2023	
69		The 2nd half of '22 is higher than previous years. Not real sure what is causing this increased usage across the district.	1/31/2023	Lemon Valley ES
70		Another heat pump school with failing controllers. Oscillations in savings are due to controllers coming in and out of communication.	1/31/2023	Huffaker ES
71		Units have been <NR> periodically. CWPs are currently running 24/7, unsure why. On list to discuss with district.	5/1/2023	Huffaker ES
72		This site has a lot of modular and portable classroom units. These units were taken off the network last summer and only put back on in Jan/Feb of 2023. During that time, they were typically not running per schedule. Should continue to monitor this site.	5/15/2023	Lemon Valley ES
73		In manual override from 4/28 to 7/19.	4/28/2023	Lemon Valley ES

MIDDLE SCHOOL SEM PROJECT LIST

ID#	PROJECT ID	PROJECT DESCRIPTION	DATE COMPLETED	NOTES
19		Billinghurst MS: Simultaneous Heating/Cooling of CW Loop	10/5/2021	The boilers and cooling tower are currently operating simultaneously. This is causing the building loop to be cooled by the cooling tower then reheated

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				by the boiler prior to being supplied to the building. See attachment.
20		Clayton MS: 10/13/21: Manual overrides were removed from equipment.	10/13/2021	Several operational issues were observed in the chilled water plant including: 1) Chiller command manually set to "Day" mode 2) Chiller running longer than expected (running until ~10PM) 3) CHWPs appear to be running 24/7. It is recommended that the manual day override be reset to allow the chiller to follow a schedule and only operate during occupied hours. Additionally, it is recommended that the CHWPs only run during occupied hours. 10/13/21: CHWP overrides were removed and

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				chiller schedule override was removed. Chiller and pumps will now only operate when OSA temperature is above 50F.
21	202	Depoali MS: Zac removed manual overrides and reset equipment to follow schedule	10/14/2021	Most HPs in the school started operating 24/7 on July 13th and continue to do so as of 9/2/21. Units are mostly in manual override (see screenshot). Override done in the priority array and were removed.
22	207	Herz MS: ERVs Operating 24/7	10/27/2021	10/20/21: ERV fans running 24/7. It is recommended that the control sequences be reviewed to determine what is causing ERVs B1, C1, C2, D2 to run 24/7. 10/27/21: Zac removed overrides.
23	359	Sparks MS: HP running constantly corrected	10/27/2021	HP N-11 appears to be running 24/7 based on space temperature trends from 10/26/21. Recommend investigating

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				cause of HP running excessively. Savings from HP, plus CWP having to operate as well. 10/27/21: Unit was forced on in priority array. Zac corrected.
24	365	Many older Heat Pump schools do not have control valves on the heat pumps, leading to the CWPs running at full speed. Most pumps are 25 hp. It is recommended that control valves be installed at the heat pumps and VFDs be installed on the main CWPs. See individual school BIM items for savings calcs. Applies to: A Smith, Caughlin Ranch, Westergard, Silver Lake, Glenn Hare	1/13/2022	Multiple Sites
25	219	Many older Heat Pump schools do not have control valves on the heat pumps, leading to the CWPs running at full speed. Most pumps are 25 hp. It is recommended that control valves be installed at the heat pumps and VFDs be installed on the main CWPs. Applies to: Brown, Huffaker, Hidden Valley, Moss,	1/13/2022	Multiple Sites
26	239	RCx Study - EUI is highest among all Middle Schools. Recommend an RCx study to determine cause of high usage and recommend improvements. Included in FY23 CIP	5/10/2022	Vaughn MS
27	28	Add heating and cooling OA lockouts	2/9/2022	Depoali MS
28	75	Add DCV to various areas	6/14/2022	Mendive MS
29	77	Optimize heating and cooling OA lockout setpoints	2/9/2022	Mendive MS
30	96	Add DCV to various areas	6/14/2022	Vaughn MS
31	151	Chilled Water System Control Improvements	6/14/2022	Mendive MS
32	154	Chilled Water System Control Improvements	6/14/2022	Vaughn MS

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33	215	MDF Room Schedules	12/15/2021	Herz MS
34	387	Entire school has been in manual override, causing 24/7 operation from August 2022 through January 2023.	2/28/2023	Sparks MS
35		Winter break starts	12/23/2022	
36		winter break ends	1/9/2023	
37		spring break week	3/18/2023	
38		Multiple schools went into "arctic mode" - heat pump schools that had to be manually turned off, extra load on sites	1/9/2023	
39		AHUs have been forced on since January with manual override from 3/27-5/17	5/15/2023	Traner MS
40		This is one of the sites that had wet bulb control added to the chilled water plant. This allows changeover from mechanical cooling to free cooling based on wetbulb temp instead of dry bulb. This extends the free cooling hours. It also had a VFD installed on the chilled water pumps.	2/1/2023	Mendive MS

HIGH SCHOOL SEM PROJECT LIST

ID#	PROJECT ID	PROJECT DESCRIPTION	DATE COMPLETED	NOTES
30	000361	Many older Heat Pump schools do not have control valves on the heat pumps, leading to the CWPs running at full speed. Most pumps are 25 hp. It is recommended that control valves be installed at the heat pumps and VFDs be installed on the main CWPs. Applies to: Allen, Taylor, Shaw, Sparks MS, Risley.	1/13/2022	All Sites
31	000220	Both CWP 3 and 4 are operating at 100% with a "Lag override" alarm on. This alarm is due to the lead pump not being able to maintain dP. Recommend investigating cause of alarm.	1/20/2022	AACT HS (Edison Admin, Warehouse)
32	000222	Elementary schools schedule is 0700-1900 M-F, longer hours than the typical 0800-1600 for the rest of the district. Recommend reviewing spaces assigned to this extended schedule to determine if all spaces are necessary. Extended schedules are due to community library and afterschool program. Item closed.	1/25/2022	Gerlach HS (K-12)
33	000367	Chilled water plant is operating 24/7. Central plant has been operating 24/7 starting in August 2021, with a short period September when the plant went back to operating per schedule. See attached plot for whole building kW and CHWP status to see when plant was operating excessively. Enable CHW Plant is commanded to ON in Compass.	2/15/2022	Spanish Springs HS

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		Recommend changing this to NULL to allow plant to follow schedule.		
34	000368	It is recommended that the plate and frame heat exchanger in the central chilled water plant be cleaned and inspected. The approach temperatures are higher than they should be, indicating this heat exchanger is fouled, impacting performance. This reduces the number of hours available for free cooling. On 2/15/22 @ 9:32AM, CW EWT = 47, CHW LWT = 53.2F, 6.2F approach. For comparison, same time '@ NVHS: CW EWT = 52.4, CHW LWT = 54.9F, 2.5F approach. (CT VFD alarm) '@ DRHS: CW EWT = 45.6, CHW LWT = 48F, 2.4F approach.	2/15/2022	Spanish Springs HS
35	000369	HW Valve at AHU-8 is failed open, overheating supply air temperature. Recommend replacing/repairing valve.	2/16/2022	McQueen HS
36	000370	AC-7 possible leaking HWV. With valve commanded closed, SAT was higher than MAT, causing overheating of the space and forcing mechanical cooling to be enabled. See attached.	2/17/2022	McQueen HS
37	000371	Failed supply air temperature sensor in kitchen AC unit. Supply temp of 17F on 2/17/22.	2/17/2022	McQueen HS
38	000372	AC-4 heating and cooling setpoints are not per district standards. Unit has a 1F heating offset and a 0F cooling offset which will cause cycling between heating and cooling. Recommend adjusting setpoints to within district standards.	2/17/2022	McQueen HS
39	000391	Raise IDF room setpoints. Current cooling setpoints are below recommended levels for IDF and electrical rooms. It is recommended that these be increased to 80F. See EBCx report for more information.	3/15/2022	North Valleys HS/Completed
40	000376	Recommend RCx/TAB study to identify potential energy savings and comfort issues.	5/2/2022	Spanish Springs HS
41	000229	RCx Study. Recommend that an RCx study be completed to identify further energy savings opportunities.	5/2/2022	AACT HS (Edison Admin, Warehouse)
42	000230	AC-1 (Theater) unit OSA appears to have a failed osa damper actuator. With OSA temp of 49F, and economizer open to 80%, return and supply air temperatures are the same at 68.7F. Recommend repair/replacement of damper actuator.	5/3/2022	Galena HS
43	000396	Add VFDs to large spaces with varying loads (Theater 7.5 hp, GYM 2x20hp, and small gym 20hp). Use VFD to vary flowrate depending on heating/cooling demands. Fan	5/3/2022	Spanish Springs HS

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		ramps to full speed as heating or cooling is required and slows down during ventilation only mode.		
44	000378	Theater AHU performance: Investigate performance of little theater unit (see attachment). OSA damper and CHWV both commanded to 100% open, but SAT is at 89F. Indicating potentially failed actuators and/or leaking HWV. Space temperatures are outside of typical district settings. Heating setpoint of 60F, cooling of 65F. Recommend leaving heating setpoint at 60F unless space will be occupied and increasing cooling setpoint to 74F.	5/3/2022	Wooster HS
45	000379	Implement Duct Static Pressure Reset Schedule for VAV units. DSP reset should increase DSP setpoint during high load periods and reduce DSP setpoint during low load periods. Development of this will likely require verification and fine tuning of setpoint ranges based on VAV damper positions.	5/9/2022	McQueen HS
46	000237	Implement Duct Static Pressure Reset Schedule for VAV units. DSP reset should increase DSP setpoint during high load periods and reduce DSP setpoint during low load periods. Development of this will likely require verification and fine tuning of setpoint ranges based on VAV damper positions.	5/9/2022	Galena HS
47		Spanish Springs HS: rental chiller running 24/7 due to no connection to controls	5/30/2022	Spanish Springs HS
48	000378	Both chilled water and heating hot water dP sensors in the 2006 addition are reading 0 psi, causing secondary pumps to operate at 100% speed. Recommend repair/replacement of the sensor to allow pumps to modulate. dP sensors repaired in June 2022.	6/10/2022	North Valleys HS/Completed
49		Spanish Springs HS: Rental chiller offline, new permanent chiller online, went from 90 ton to 110 ton	9/16/2022	Spanish Springs HS
50	000385	MAU-1, MAU-2 (Locker Rooms), and Big Gym AH-1/2 are all forced into manual occupied mode, causing units to run 24/7.	11/14/2022	Spanish Springs HS
51	000231	AC-2 Duct static pressure sensor reading negative pressure causing fan speed to remain at 100%.	5/3/2022	Galena HS
52	000232	Conduct an RCx/TAB study. Based on reviews of AHUs and VAV performance, it is recommended that an RCx/TAB study be conducted for the school. Included in FY23 list.	5/3/2022	Galena HS
53	000233	AHUs are allowing simultaneous heating and cooling to occur. When cooling stages on and SAT decreases to below setpoint, the heating water valve opens at the same time. It is recommended that the heating valve be disabled if cooling stages are enabled.	5/3/2022	Galena HS
54	000234	OSA/RA damper calibration: Several AC units are operating with 100% OSA, but SAT is 10F or more higher than OSA.	5/3/2022	Galena HS

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		Recommend investigating OSA/RA damper positions to ensure economizers are operating properly.		
55	000235	Add VFDs to Theater and Gym AHUs. Use VFDs to stage fan based on heating/cooling calls. As heating or cooling call increases, fan speed increases. When no heating/cooling call is present, fan slows down to minimum ventilation only speed. Included in FY23 CIP list	5/3/2022	Galena HS
56	000236	Replace controller for HP 3-1. Unit is regularly <NR>, causing CWP to run 24/7. All other controllers do not have communication issues. Recommend replacement of this controller. In FY23 CIP list	5/3/2022	AACT HS (Edison Admin, Warehouse)
57	000364	Entire site has lost communication with BAS network. This loss of communication has disabled analytics and prevents identification of energy efficiency opportunities. Recommend having BCS troubleshoot and get system back online ASAP. This has also prevented updating schedules, causing equipment to operate excessively.	1/7/2022	Hug HS
58	000365	Many older Heat Pump schools do not have control valves on the heat pumps, leading to the CWPs running at full speed. Most pumps are 25 hp. It is recommended that control valves be installed at the heat pumps and VFDs be installed on the main CWPs. See individual school BIM items for savings calcs. Applies to: A Smith, Caughlin Ranch, Westergard, Silver Lake, Glenn Hare	1/13/2022	Multiple Sites
59	000369	North Valley HS - Excessive Runtime Fault for Agriculture Lab. Cannot find Agriculture lab in control system - need to locate unit. Excessive runtime is limited to winter months - may be greenhouse.	2/4/2022	North Valleys HS
60	000373	Add demand-controlled ventilation to Auditorium (AC-2) and Commons Areas (FC-20,21,22,23,24,25,26).	2/23/2022	North Valleys HS
61	000379	Existing heating hot water system requires two pumps to run 24/7 due to excessive water flow being bypassed in 3-way valves throughout the building. It is recommended that this system be converted to a variable primary system with reduced flow through 3-way bypass valves and VFDs on the HW pumps.	4/29/2022	North Valleys HS
62	000380	The existing chilled water plant in the main building requires two pumps to operate during occupied hours due to excessive bypass through the system 3-way valves. It is recommended that the amount of bypass be reduced, and the system be converted to a variable primary system.	4/29/2022	North Valleys HS

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63	000381	See EBCx report for details. Recommend control programming to keep OSA dampers to remain closed during morning warmup per original design control sequence. Dampers should only open when school is occupied. Additionally, it is recommended that dampers be closed and fans cycle on heating/cooling calls during morning warmup periods.	4/29/2022	North Valleys HS
64	000383	Shutdown new addition primary and secondary pumps during unoccupied hours. Currently, the primary pump is commanded to run 24/7 and the secondary pump runs during many unoccupied hours. See EBCx report for details.	4/29/2022	North Valleys HS
65	000384	Recalibrate or replace failed actuators on heating and chilled water valves. See EBCx report for additional details.	4/29/2022	North Valleys HS
66	000385	Recalibrate CO2 sensors in both gymnasiums. See EBCx report for additional details.	4/29/2022	North Valleys HS
67	000386	Stage CW pumps and program CW reset temperature during free cooling mode. See EBCx report for additional information.	4/29/2022	North Valleys HS
68	000387	The current control programming allows both HW and CHW valves to be open simultaneously. It is recommended that programming be updated to prevent the valves from opening simultaneously. Heating and cooling setpoints should be sufficiently spaced to prevent valve operation from overlapping. See EBCx report for more details.	4/29/2022	North Valleys HS
69	000389	Implement a chilled water reset schedule on the addition air cooled chiller. See EBCx report for additional details.	4/29/2022	North Valleys HS
70	000393	RCx/TAB Study It is recommended that an RCx study be conducted to identify equipment deficiencies and potential additional energy savings.	5/2/2022	Damonte Ranch HS
71	000394	Add VFDs to large spaces with varying loads (Theater 7.5 hp, GYM 2x20hp, and small gym 20hp). Use VFD to vary flowrate depending on heating/cooling demands. Fan ramps to full speed as heating or cooling is required and slows down during ventilation only mode. Added to FY23 CIP list	5/2/2022	Damonte Ranch HS
72	000395	Add VFDs to large spaces with varying loads (Theater 7.5 hp, GYM 2x20hp, and small gym 20hp). Use VFD to vary flowrate depending on heating/cooling demands. Fan ramps to full speed as heating or cooling is required and slows down during ventilation only mode. Recommended for FY23 CIP list	5/3/2022	North Valleys HS
73	000222	Elementary schools schedule is 0700-1900 M-F, longer hours than the typical 0800-1600 for the rest of the district. Recommend reviewing spaces assigned to this extended schedule to determine if all spaces are necessary.	1/25/2022	Gerlach HS (K-12)

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		Extended schedules are due to community library and afterschool program. Item closed.		
74	297	Programming Change Required	2/1/2023	Wooster HS
75	000220	Both CWP 3 and 4 are operating at 100% with a "Lag override" alarm on. This alarm is due to the lead pump not being able to maintain dP. Recommend investigating cause of alarm.	7/14/2023	AACT HS (Edison Admin, Warehouse)
76	000244	School was placed in manual override on 8/12/22 and remained in override through January 2023. Override removed.	1/31/2023	Galena HS
77		Winter break starts	12/23/2022	
78		winter break ends	1/9/2023	
79		spring break week	3/18/2023	
80		Multiple schools went into "arctic mode" - heat pump schools that had to be manually turned off, extra load on sites	1/9/2023	
81		Corrected a sharp manual override trend	1/31/2023	Gomm ES

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Appendix B: Model Summary

Washoe County SD - Elementary Schools Model

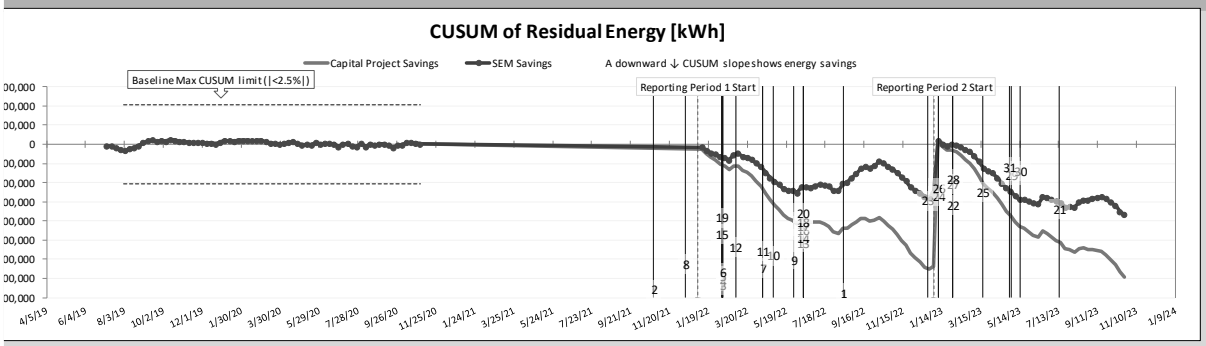
Type of Fuel Electrici kWh

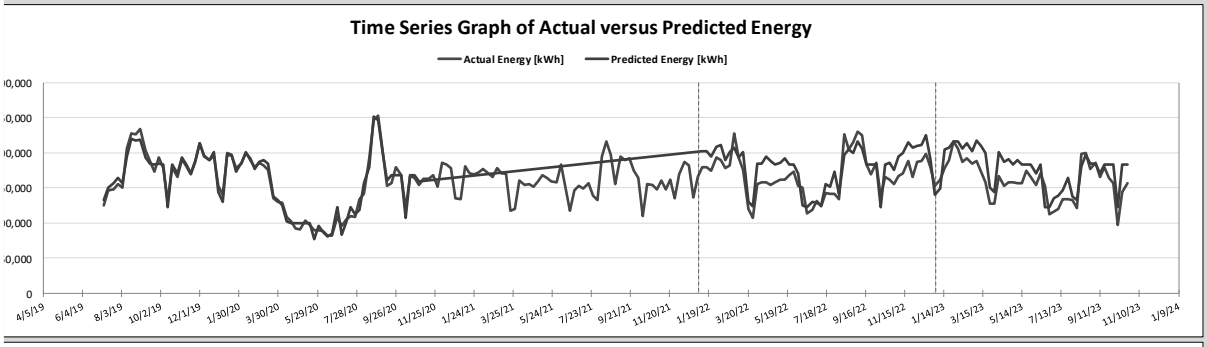
These graphs and tables update automatically

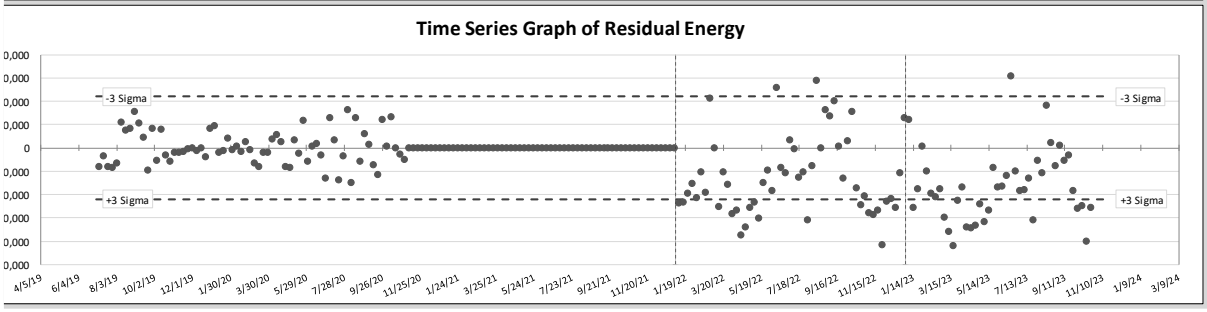
Regression Statistics		
Model Interval	Weekly	
RSquare	0.956	(>0.75)
RSquare Adj	0.951	(>0.75)
Root Mean Square Error	9,619.11	kWh
Mean of Response	158,612.52	kWh
Observations (or Sum Wgts)	70	N/A
Autocorrelation	0.35	(<0.5)
F-test Overall P-Value	1.68E-39	(<0.10)
Coefficient of Variance	6.1%	(<10%)
Net Determination Bias	1.12E-09	(<0.005%)
Annual Baseline Energy Use	8,247,851	kWh
5% annual use	412,393	kWh
Max Baseline CUSUM %	0.4%	(<2.5%)
Last Measurement Date	10/22/2023	
Excluded Points	61	

Parameter Estimates	Coefficients	Standard Error	*t*-Stat	p-Value	Baseline Min	Baseline Max
Intercept	122,586.37	2,291.06	53.50647964	<0.0001*		
HDD (45°F)	270.95	54.97	4.929120636	<0.0001*	0.00	94.00
CDD (70°F)	624.18	43.88	14.22340573	<0.0001*	0.00	73.00
School/Professional Days- COVID Adj	12,068.67	476.11	25.34854919	<0.0001*	0.00	5.00
ES - Period Ind - (5/18/2020 - 8/16/2020) COVID Shutdown [(	-44,883.64	3,054.06	-14.69638471	<0.0001*	0.00	1.00
ES - Period Indicator-(8/17/20-8/30/20) More activities in th	31,538.40	5,980.15	5.27384388	<0.0001*	0.00	1.00
ES - Period Ind - (8/31/2020 - 5/31/2021) only 50% of the stu	-15,212.76	3,043.42	-4.998576163	<0.0001*	0.00	1.00
Holiday Indicator - Thanksgiving	41,504.76	8,856.88	4.686160979	<0.0001*	0.00	1.00

Program Dates	Start	End	Excluded Days	Total Energy Use (kWh) Actual*	Predicted	Measured Savings
Baseline	07/01/19	11/01/20	-			
Reporting Period 1	01/03/22	01/01/23	-	8,764,457	9,402,862	638,405
Reporting Period 2	01/02/23	12/31/23	-	6,757,192	7,450,325	693,133
Reporting Period 3			-	-	-	-







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Baseline Discussion

The baseline period was shortened from two years to 70 weeks to avoid an undefined changepoint in the first part of the baseline. The changepoint was investigated, but a root cause could not be determined. By shortening the baseline, the model focuses on current operations. Weather, energy, and site data were available in good quality for the selected baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant, the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.

Variable Descriptions

HDD (45°F)	(Heating Degree Days with a reference of 45°F) Portable electric heaters serve the heating load at Washoe CSD All ES. As outdoor air temperature decreases below 45°F, energy usage increases linearly.
CDD (70°F)	(Cooling Degree Days with a reference of 70°F) Chillers, RTUs, and heat pumps serve the cooling load at Washoe CSD All ES. As temperature increases above 70°F, your energy usage increases.
School/Professional Days- COVID Adj	This metric represents the energy consumption that scales with actual school/professional days. The Covid 19 shutdown has been removed from the standard School/Professional Days calendar. As school/professional days increase, energy usage increases.
ES - Period Ind - (5/18/2020 - 8/16/2020) COVID Shutdown [0/0.5/1]	This binary indicator variable represents the sustained reduction in baseload energy consumption due to the complete Covid19 shutdown that took effect starting from 4/13/20 to 8/16/20.
ES - Period Indicator-(8/17/20-8/30/20) More activities in the first weeks of new term after Cov19 shutdown[0/1]	This binary indicator variable represents the increase in baseload energy consumption due to more activities in the fisrt weeks of new term after Covid19 shutdown that took effect starting from 8/17/20 to 8/30/20.
ES - Period Ind - (8/31/2020 - 5/31/2021) only 50% of the students on alternating days [0/1]	This binary indicator variable represents the sustained reduction in baseload energy consumption due to reduced occupancy after the COVID shutdown that took effect during the 2020-2021 school year.
Holiday Indicator - Thanksgiving	This binary indicator variable represents the increase in baseload energy consumption during the week of Thanksgiving. Despite fewer school days that week, the school remains otherwise operational.

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Washoe County SD - High Schools Model

Type of Fuel Ele kW

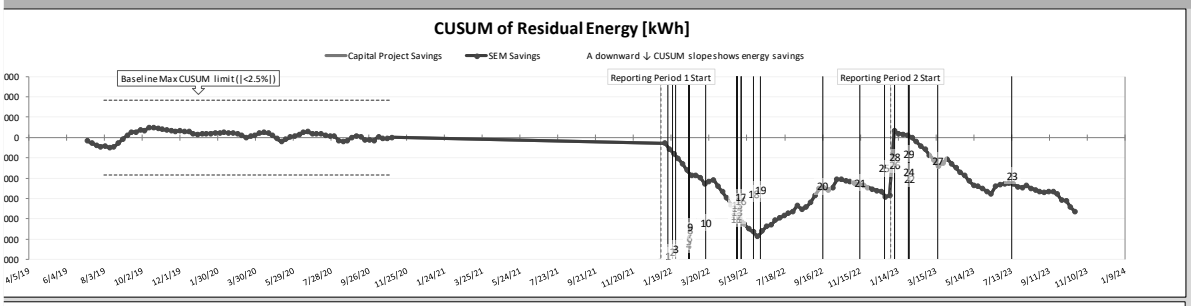
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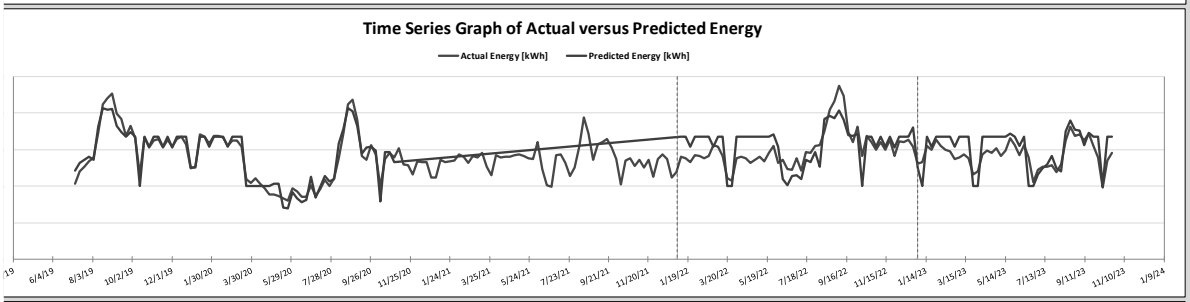
Regression Statistics		
Model Interval	Weekly	
RSquare	0.940	(>0.75)
RSquare Adj	0.936	(>0.75)
Root Mean Square Error	9,686.29	kWh
Mean of Response	141,515.52	kWh
Observations (or Sum Wgts)	70	N/A
Autocorrelation	0.33	|<0.5|
F-test Overall P-Value	9.07E-38	(<0.10)
Coefficient of Variance	6.8%	(<10%)
Net Determination Bias	1.89E-10	(<0.005%)
Annual Baseline Energy Use	7,358,807	kWh
5% annual use	367,940	kWh
Max Baseline CUSUM %	0.7%	|<2.5%|
Last Measurement Date	10/22/2023	
Excluded Points	61	

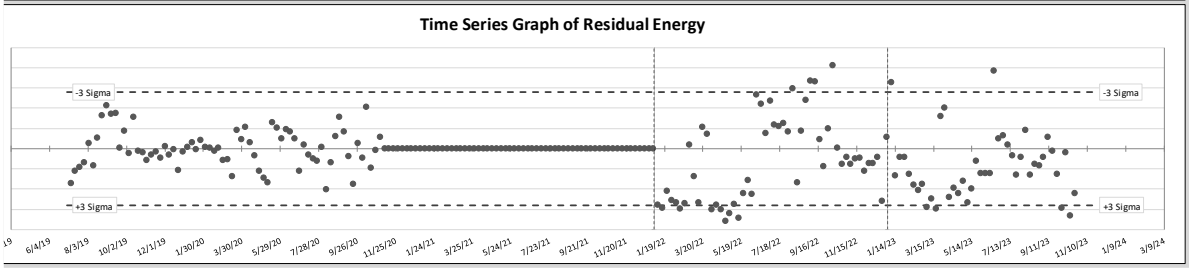
Parameter Estimates	Coefficients	Standard Error	*t*-Stat	p-Value	Baseline Min	Baseline Max
Intercept	99,995.56	2,510.27	39.83461317	<0.0001*		
CDD (65°F)	400.85	32.38	12.37773467	<0.0001*	0.00	108.00
Holiday Indicator - (T,C,N) [0/1]	25,640.59	6,022.94	4.257154651	<0.0001*	0.00	1.00
School/Professional Days- COVID Adj	13,580.94	574.64	23.63377569	<0.0001*	0.00	5.00
HS - Period Ind - (5/11/2020 - 8/16/2020) COVID Shutdown [0/1]	-30,018.33	3,522.32	-8.522328441	<0.0001*	0.00	1.00
HS - Period Ind - (8/31/2020 - 5/31/2021) only 50% of the students on alternating days [0/1]	-21,147.03	3,591.45	-5.888156484	<0.0001*	0.00	1.00

Program Dates

	Start	End	Excluded Days	Total Energy Use (kWh) Actual*	Predicted	Measured Savings
Baseline	07/01/19	11/01/20	-			
Reporting Period 1	01/03/22	01/01/23	-	7,850,082	8,135,737	285,655
Reporting Period 2	01/02/23	12/31/23	-	6,029,394	6,395,420	366,026
Reporting Period 3			-	-	-	-







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Baseline Discussion

The baseline period was shortened from two years to 70 weeks to avoid an undefined changepoint in the first part of the baseline. The changepoint was investigated, but a root cause could not be determined. By shortening the baseline, the model focuses on current operations. Weather, energy, and site data were available in good quality for the selected baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant, the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.

Variable Descriptions

CDD (65°F)	(Cooling Degree Days with a reference of 65°F) A mix of chillers (both air and water-cooled), DX RTUs, and heat pumps serve the cooling load at Washoe CSD All HS. As temperature increases above 65°F, your energy usage increases.
Holiday Indicator - (T,C,N) [0/1]	This binary indicator variable represents the increase in baseload energy consumption during the holiday weeks of Thanksgiving, Christmas, and New Years. Despite fewer school days those weeks, the school remains otherwise operational.
School/Professional Days- COVID Adj	This metric represents the energy consumption that scales with actual school/professional days. The Covid 19 shutdown has been removed from the standard School/Professional Days calendar. As school/professional days increase, energy usage increases.
HS - Period Ind - (5/11/2020 - 8/16/2020) COVID Shutdown [0/1]	This binary indicator variable represents the sustained reduction in baseload energy consumption due to the COVID shutdown that occurred during the initial COVID wave. Students were out of the school around 3/16 which is reflected in the school/professional days varaible, but additional operations were shutdown starting in May. This lasted for the remainder of the summer.
HS - Period Ind - (8/31/2020 - 5/31/2021) only 50% of the students on alternating days [0/1]	This binary indicator variable represents the sustained reduction in baseload energy consumption due to reduced occupancy after the COVID shutdown that took effect during the 2020-2021 school year.

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Washoe County SD - Middle Schools Model

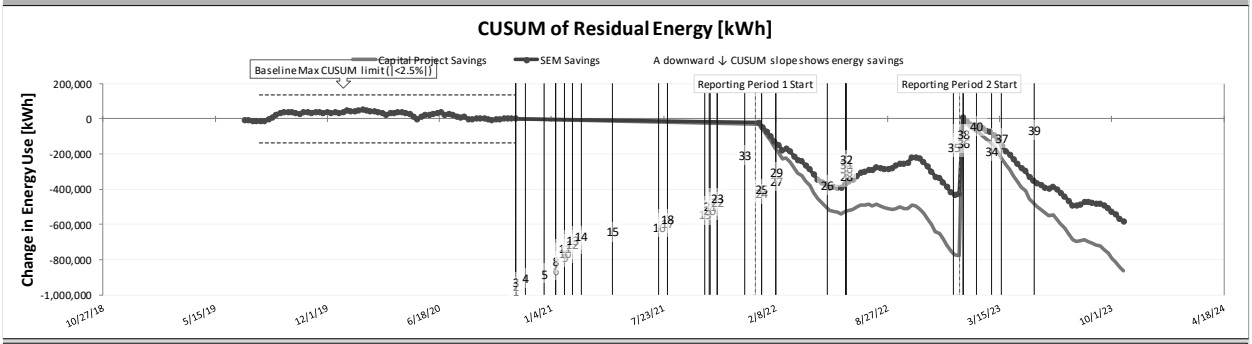
Type of Fuel Electricity - kWh

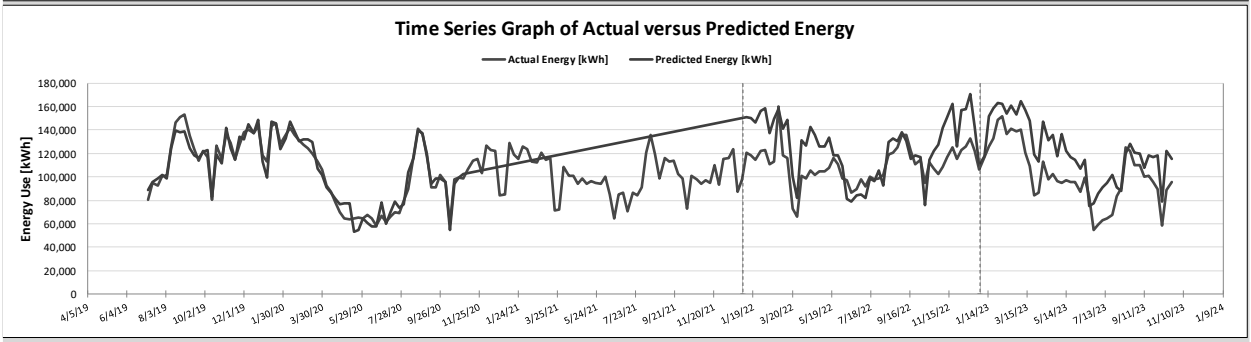
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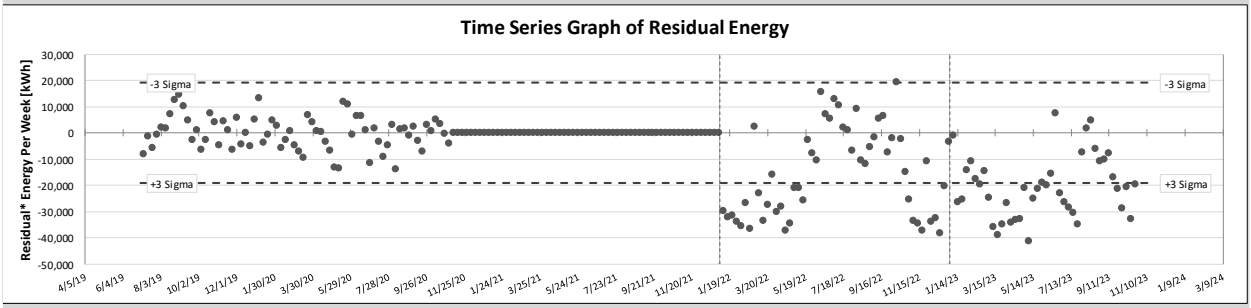
Regression Statistics		
Model Interval	Weekly	
RSquare	0.950	(>0.75)
RSquare Adj	0.946	(>0.75)
Root Mean Square Error	6,622.96	kWh
Mean of Response	106,061.11	kWh
Observations (or Sum Wgts)	70	N/A
Autocorrelation	0.26	(<0.5|
F-test Overall P-Value	3.78E-40	(<0.10)
Coefficient of Variance	6.2%	(<10%)
Net Determination Bias	5.09E-10	(<0.005%)
Annual Baseline Energy Use	5,515,178	kWh
5% annual use	275,759	kWh
Max Baseline CUSUM %	0.9%	(<2.5%|
Last Measurement Date	10/22/2023	
Excluded Points	61	

Parameter Estimates	Coefficients	Standard Error	*t*-Stat	p-Value	Baseline Min	Baseline Max
Intercept	75,221.60	2,060.81	36.50093574	<0.0001*		
HDD (55°F)	251.98	22.27	11.31438688	<0.0001*	0.00	164.00
CDD (65°F)	260.08	26.07	9.975993772	<0.0001*	0.00	108.00
MS - Period Ind - (8/31/2020 - 5/31/2021) only 50% of the st	-20,268.87	2,671.12	-7.588165794	<0.0001*	0.00	1.00
School/Professional Days- COVID Adj	7,860.66	383.64	20.48965098	<0.0001*	0.00	5.00
MS - Period Ind - (5/11/2020 - 8/16/2020) COVID Shutdown	-24,681.61	2,415.66	-10.21734591	<0.0001*	0.00	1.00

Program Dates	Start	End	Excluded Days	Total Energy Use (kWh) Actual*	Predicted	Measured Savings
Baseline	07/01/19	11/01/20	-			
Reporting Period 1	01/03/22	01/01/23	-	5,743,603	6,521,193	777,590
Reporting Period 2	01/02/23	12/31/23	-	4,274,053	5,137,543	863,490
Reporting Period 3			-	-	-	-







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Baseline Discussion

The baseline period was shortened from two years to 70 weeks to avoid an undefined changepoint in the first part of the baseline. The changepoint was investigated, but a root cause could not be determined. By shortening the baseline, the model focuses on current operations. Weather, energy, and site data were available in good quality for the selected baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant, the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.

Variable Descriptions

HDD (55°F)	(Heating Degree Days with a reference of 55°F) Portable electric heaters serve the heating load at Washoe CSD All MS. As outdoor air temperature decreases below 55°F, energy usage increases linearly.
CDD (65°F)	(Cooling Degree Days with a reference of 65°F) Chillers serve the cooling load at Washoe CSD All MS. As temperature increases above 65°F, your energy usage increases.
MS - Period Ind - (8/31/2020 - 5/31/2021) only 50% of the students on alternating days [0/1]	This binary indicator variable represents the sustained reduction in baseload energy consumption due to reduced occupancy after the COVID shutdown that took effect during the 2020-2021 school year.
School/Professional Days- COVID Adj	This metric represents the energy consumption that scales with actual school/professional days. The COVD shutdown has been removed from the standard School/Professional Days calendar. As school/professional days increase, energy usage increases.
MS - Period Ind - (5/11/2020 - 8/16/2020) COVID Shutdown [0/1]	This binary indicator variable represents the sustained reduction in baseload energy consumption due to the COVID shutdown that occurred during the initial COVID wave. Students were out of the school around 3/16 which is reflected in the school/professional days varaible, but additional operations were shutdown starting in May. This lasted for the remainder of the summer.

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Washoe County SD - All Admin

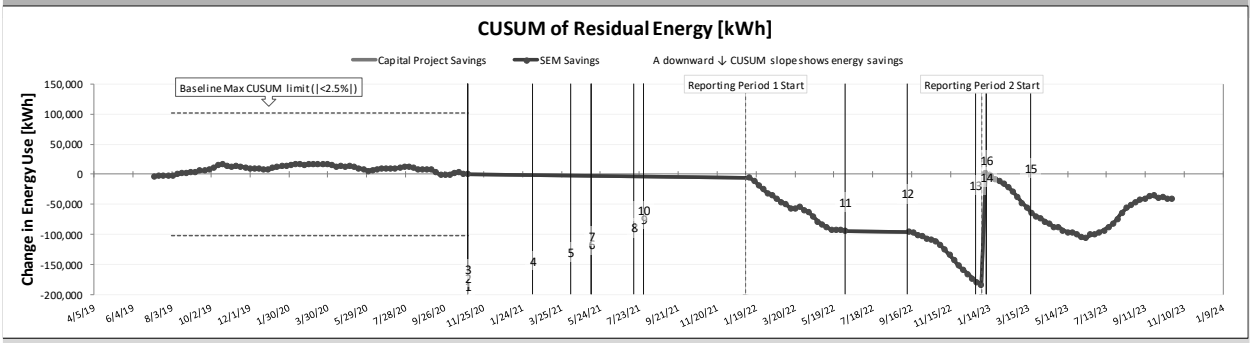
Type of Fuel Electricity - kWh

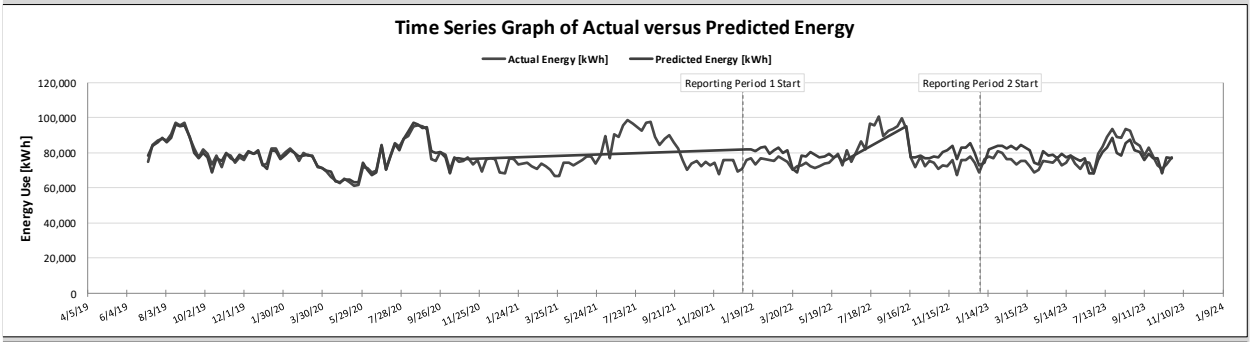
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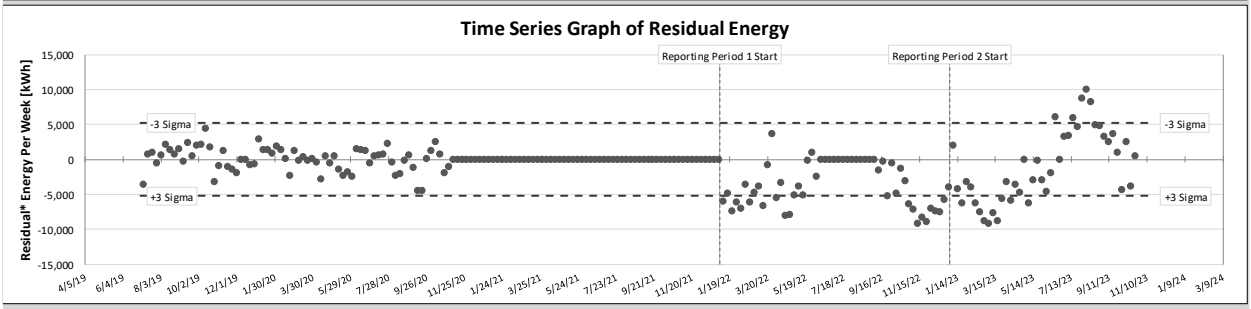
Regression Statistics		
Model Interval	Weekly	
RSquare	0.961	(>0.75)
RSquare Adj	0.958	(>0.75)
Root Mean Square Error	1,796.92	kWh
Mean of Response	78,726.09	kWh
Observations (or Sum Wgts)	70	N/A
Autocorrelation	0.37	(<0.5|
F-test Overall P-Value	6.45E-45	(<0.10)
Coefficient of Variance	2.3%	(<10%)
Net Determination Bias	-2.11E-10	(<0.005%)
Annual Baseline Energy Use	4,093,756	kWh
5% annual use	204,688	kWh
Max Baseline CUSUM %	0.4%	(<2.5%|
Last Measurement Date	10/22/2023	
Excluded Points	74	

Parameter Estimates	Coefficients	Standard Error	*t*-Stat	p-Value	Baseline Min	Baseline Max
Intercept	68,071.57	617.31	110.2720135	<0.0001*		
HDD (50°F)	46.52	7.57	6.142846347	<0.0001*	0.00	129.00
CDD (65°F)	201.00	6.35	31.63659271	<0.0001*	0.00	108.00
School/Professional Days- COVID Adj	1,737.34	116.40	14.92504064	<0.0001*	0.00	5.00
Period Indicator-(4/13/20-7/26/20)Complete Covid19 shutd	-4,849.26	698.21	-6.945310462	<0.0001*	0.00	1.00

Program Dates	Start	End	Excluded Days	Total Energy Use (kWh) Actual*	Predicted	Measured Savings
Baseline	07/01/19	11/01/20	-			
Reporting Period 1	01/03/22	01/01/23	91	2,916,257	3,099,346	183,089
Reporting Period 2	01/02/23	12/31/23	-	3,280,002	3,320,745	40,743
Reporting Period 3			-	-	-	-







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Baseline Discussion

The baseline period was shortened from two years to 70 weeks due to data availability. By shortening the baseline, the model focuses on current operations. Weather, energy, and site data were available in good quality for the entire baseline period. A variety of weather and site provided metrics were tested for correlation with energy to find which variables best represented the energy drivers at the site. Through multiple discussions with the participant, the selected variables both meet statistical qualifications and participant expectations for representing the energy consumed at the site. The selected variables are described in the next section.

Variable Descriptions

HDD (50°F)	(Heating Degree Days with a reference of 50°F) Portable electric heaters serve the heating load at the participant name. As outdoor air temperature decreases below 50°F, energy usage increases linearly.
CDD (65°F)	(Cooling Degree Days with a reference of 65°F) Four large VAV AHUs as well as many DX RTUs and central air cooled chillers serve the cooling load at Washoe CSD All Admin. As temperature increases above 65°F, your energy usage increases.
School/Professional Days- COVID Adj	This metric represents the energy consumption that scales with actual school/professional days. The Covid 19 shutdown has been removed from the standard School/Professional Days calendar. As school/professional days increase, energy usage increases.
Period Indicator-(4/13/20-7/26/20)Complete Covid19 shutdown [0/1]	This binary indicator variable represents the sustained reduction in baseload energy consumption due to the complete Covid19 shutdown that took effect starting from 4/13/20 to 7/26/20.

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DSM-22

2023 Business Energy Services M&V

Business Energy Services
NV Energy
Program Year 2023

Measurement & Verification Report

April 1, 2024

Prepared for:

NVEnergy

Prepared by:

ADM
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1. EXECUTIVE SUMMARY

This Measurement and Verification ("M&V") report provides verified ex-post energy and demand impacts achieved by the Business Energy Services ("BES") program that NV Energy offered to Sierra Pacific Power Company and Nevada Power Company ("SPPC" and, collectively with "NPC," "NV Energy") customers during 2023. This M&V report is provided by ADM Associates, Inc. ("ADM"), an independent, third-party contractor that provides evaluation and M&V services and reports for numerous electric and gas utility clients.

The Program included retrofit, new construction, non-profit agency grants, midstream lighting, and direct install projects. Table 1-1 below summarizes the Program results.

Table 1-1 Summary of Energy (kWh) and Peak Demand (kW) Savings

Territory	Ex-Post First-Year (2023) kWh Savings	Ex-Ante Annual kWh Savings	Ex-Post Annual kWh Savings	Realization Rate	Ex-Post Summer Critical Peak kW Savings	Effective Useful Life (Years)	Program Lifetime kWh Savings
NPC	41,694,662	122,757,423	121,726,064	99.2%	29,998	12.5	1,527,222,307
SPPC	13,314,918	32,165,389	32,197,714	100.1%	4,074	13.8	445,203,445

ADM Associates, Inc. ("ADM"), an independent, third-party evaluation contractor, took the following steps to perform M&V analyses to determine Program energy (kilowatt-hours, ("kWh")) savings and peak demand (kilowatts, ("kW")) reductions.

- Reviewed NV Energy's program tracking database which includes final, certified, Program data for 446 NPC projects and 167 SPPC projects. A project is a unique set of energy efficiency measures installed at a customer's facility. The Program assigns each project a unique Application ID in NV Energy's program tracking database. Measures are unique types of energy efficiency technologies such as heating, ventilation, and air conditioning ("HVAC"), lighting, motors, kitchen and refrigeration equipment, and custom measure types. In addition to program tracking data, ADM reviewed data from Program materials, on-site inspections, customer interviews, and end-use metering.
- Developed a stratified sampling plan to select a sample of projects ("M&V sample sites") for which ADM analyzed Program data to determine ex-post verified savings. The sampling plan achieved ±10 percent precision at the 90 percent confidence interval for each service territory (NPC and SPPC).[1] ADM selected 62 M&V sample sites for NPC and 45 M&V sample sites for SPPC. Savings associated with M&V sample sites represent 48.2 percent of NPC program-level ex-ante savings and 74.4 percent of SPPC program-level ex-ante savings.

[1] Ex-post sampling precision is ±7.61 at the 90 percent confidence level for NPC and ±6.40 at the 90 percent confidence level for SPPC.

- Verified measure installation by reviewing project documents including invoices, specification sheets, applications, photos, and customer energy model calculations for sample sites. ADM conducted phone interviews and site visits, as necessary.
- Calculated ex-post annual energy (kWh) savings and critical peak demand (kW) reduction. For a subset of measures, ADM calculated savings using deemed savings algorithms and values that were determined from historical Program data. Appendix C includes discussion and report of deemed savings algorithms and values.

The program-level realization rate, the quotient of ex-post verified kWh savings and ex-ante claimed kWh savings, is 99.2 percent for NPC and 100.1 percent for SPPC. Main causes of realization rate variances from 100 percent include the following findings.

- Lighting annual Hours of Use (HOU) and heating and cooling interaction factors (HCIF):

  Lighting project realization rate differences are usually caused by the ex-ante and ex-post savings calculations using different HOU and HCIF. ADM used prescriptive HOU and HCIF when a customer's actual HOU are within 35 percent of the prescriptive HOU for the customer's assumed building type. ADM used custom HOU when a customer's actual HOU were outside of the threshold of ±35 percent of the prescriptive HOU for the customer's assumed building type. ADM used supporting documentation and site contacts interviews to verify a facility's actual HOU.

  Furthermore, when custom HOU are used, a custom HCIF is calculated. Custom HCIF are region specific and estimate the lighting project's impact on the facility's HVAC equipment. The Program's implementation contractor does not calculate custom HCIF and only uses prescriptive HCIF.
- Whole-building energy modeling:

  For new construction whole building energy models, savings typically come from lighting and HVAC measures. When determining ex-post verified savings, ADM used the applicable energy building codes to identify baseline efficiency inputs and ADM verified as-built model inputs from site visits and/or supporting documentation. Realization rates that differed from 100 percent were caused by using different baselines and/or model inputs in the ex-ante and ex-post savings calculations.
- Large motors and machines:

  Large projects typically have energy monitoring data from the pre- and post- installation periods. Often production during the measurement period needs to increase or decrease over time to meet the annual production goals. This means the loading of the motor or machine will change over time, and therefore its efficiency will change over time.

With the goal of mitigating future evaluation risks, i.e., reducing uncertainties related to realization rates from M&V analyses, ADM provides the following recommendations developed from M&V analyses from the PY2023 Program.

ADM's overarching recommendation is to continue to review and update the established pre-construction review process,[2] which enables ADM and the Program implementation contractor to compare baseline assumptions and savings calculations with the goal of developing optimal and similar methodologies for large projects. In the spirit of continual improvement for the pre-construction review process, ADM provides the following recommendations:

- At the start of each calendar year, ADM should continue to collaborate with the Program to assess the effectiveness of pre-construction review procedures and update this process as needed. The Program should reassess the thresholds (i.e., ex-ante kWh savings) for determining which future projects require a pre-construction review checklist;
- For projects requiring pre-construction review checklists, the Program's implementation contractor should share the checklists with the M&V contractor before projects are implemented; this is especially important for projects that need baseline data collection.
- The M&V contractor needs all available preliminary project documentation to better inform M&V approaches and plans. Therefore, when sharing pre-construction review checklists, the implementation contractor should share all available preliminary project documentation, including pre-project inspection reports, methodology, calculations for preliminary ex-ante savings estimates, and models developed by outside contractors.

ADM also recommends continuing to have the implementation contractor notify customers whose projects ADM has selected for M&V. NV Energy's customers appreciated this approach. ADM has also found that the M&V work can be conducted more smoothly and expediently when the implementation contractor notifies customers whose projects have been selected for M&V.

ADM also recommends continuing to use deemed savings algorithms and values calculated from historical program data. See Chapter 5 for a more detailed discussion of recommendations resulting from PY2023 M&V analyses.

[2] In 2013, the Program initiated a pre-construction review process to enable the Program and ADM to review large projects before implementation, provide ADM insights regarding ex-ante claimed energy savings, and facilitate ongoing coordination between implementation and M&V activities.

2. PROGRAM BACKGROUND

This chapter provides background information on NV Energy's BES program offered to non-residential customers. It also provides an overview of the M&V methods ADM used to determine ex-post savings values for the program.

2.1. Description of the Business Energy Services Program

The BES program includes three components referred to as pathways: Core, Direct Install, and Midstream Lighting ("MID"). BES offers financial rebates for energy efficiency measures to qualifying non-residential retrofit projects and new construction projects.

2.1.1. *Core Pathway*

The Core pathway includes both retrofit and new construction projects primarily for larger companies. Rebates are available for prescriptive and custom measures. Prescriptive measures include qualified lighting, HVAC, and commercial kitchen equipment installed in retrofit and new construction projects. For new construction projects, the Program provides incentives for equipment with efficiencies that exceed minimum code requirements.

Core also offers rebates for custom measures, i.e., measures for which the Program does not offer prescriptive incentives. Examples of custom measures include chilled water plant control optimization, economizers, light fixture improvements not covered as a prescriptive measure, and large motor variable frequency drives ("VFD"). Program incentives for custom measures depend on the ex-ante claimed energy savings.

The Core pathway also includes Non-Profit Agency Grants ("NPAG") designed to help non-profit organizations[3] reduce their energy consumption and related operating costs by funding weatherization and energy efficiency retrofit projects. The Program offers incentives of up to $7,500 per NPAG project. Table 2-1 below summarizes program participation by organization type.

Table 2-1 NPAG Summary of Participation by Organization Type

Organization Type	NPC		SPPC	
	Number of Grantees	Number of Grants	Number of Grantees	Number of Grants
Community Services	0	0	5	5
Religious	1	1	1	1
Total	1	1	6	6

[3] As defined under section 501(c)(3) of the Internal Revenue Code.

2.1.2. *Direct Install Pathway*

The Direct Install pathway includes retrofit projects for businesses with an annual electricity use of 400,000 kWh or less. Most Direct Install projects are prescriptive lighting projects.

2.1.3. *Midstream ("MID") Pathway*

The MID pathway includes projects in which NV Energy pays incentives to distributors for sales of efficient lighting equipment. Distributors collect end use installation information as a program requirement.

2.1.4. *Savings by Measure Type*

The evaluation of savings installed through the various pathways was based on data contained in NV Energy's program tracking database. It included 446 NPC projects and 167 SPPC projects in the Core, Direct Install, and MID pathways, totaling ex-ante savings of 122,757,423 for NPC and 32,165,389 kWh for SPPC.

Figure 2-1 below shows the distribution of reported ex-ante savings by measure type across all pathways for NPC. The Custom category accounts for the largest percentage of program ex-ante savings. This measure category includes projects that received non-prescriptive incentives and used custom algorithms for calculating ex-ante savings. This category includes a wide range of measures, including improvements to manufacturing or processing equipment (air compressors, injection molding machines, and mixers), retro-commissioning projects, above-code new construction, improvements to control systems, and the installation and optimization of large VFDs.

Figure 2-1. Program Ex-Ante Savings (kWh) by Measure Category: NPC

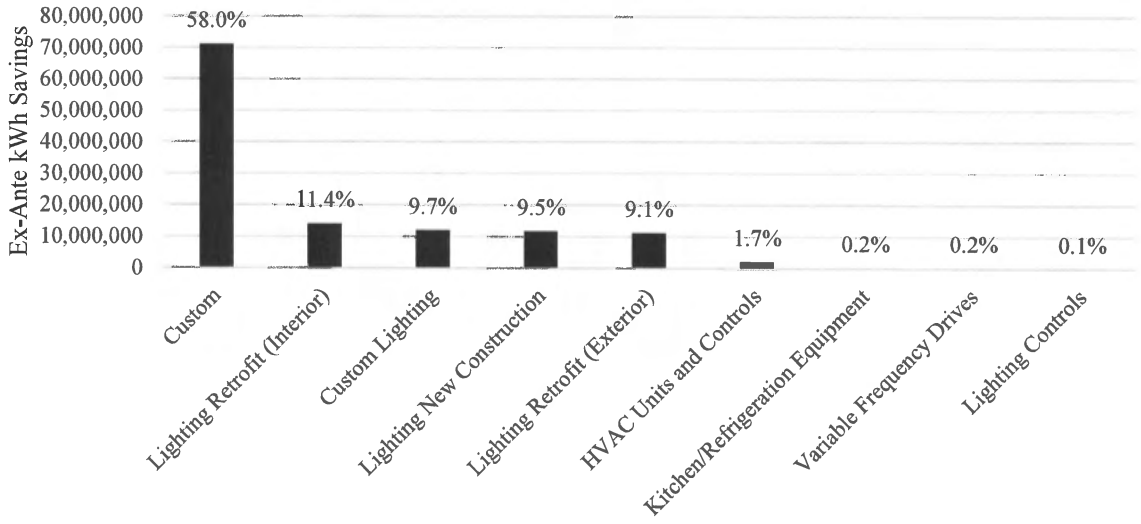
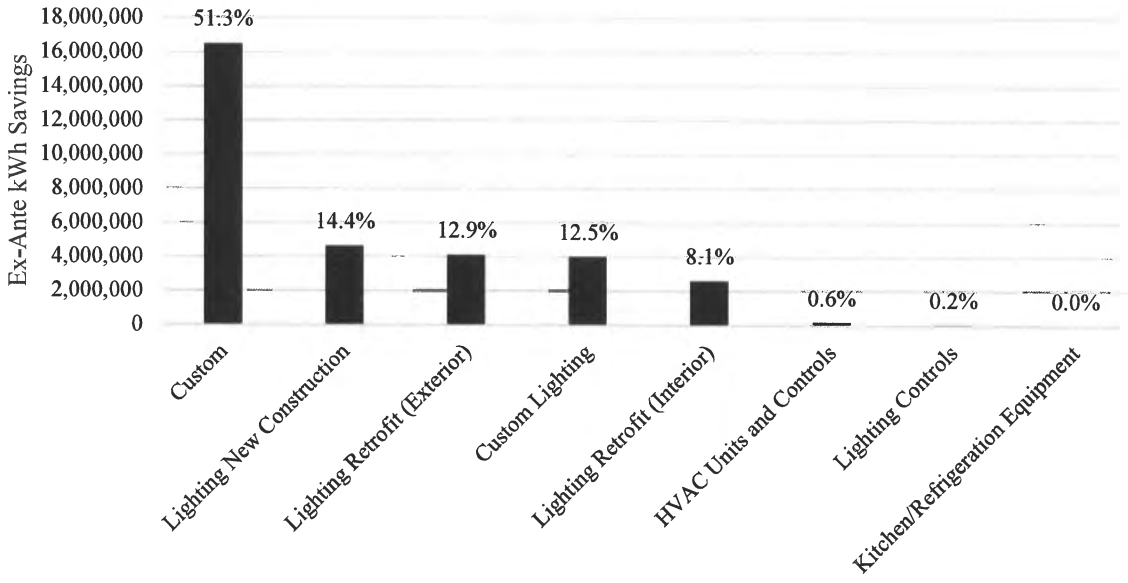


Figure 2-2 below shows the distribution of reported ex-ante savings across all pathways by measure type for SPPC.

Figure 2-2. Program Ex-Ante Savings (kWh) by Measure Category: SPPC



2.2. Outreach Activities

NV Energy and the implementation contractor provided commercial outreach events for non-residential customers. Table 2-2 below shows a summary of the activity, the number of events, and the number of commercial customers impacted.[4]

Table 2-2 Summary of Classes and Outreach Activities

Non-Residential Customer Education Activities	NPC		SPPC	
	Count of Events	Count of Customers Educated	Count of Events	Count of Customers Educated
Webinar (online seminar)	7	1,648	6	1,623
Non-Residential Energy Efficiency Presentation Events	20	11,060	3	6,211
Total	**27**	**12,708**	**9**	**7,834**

2.3. Overview of Evaluation Approach

M&V objectives for this program evaluation included determining energy (kWh) and peak demand (kW) savings resulting from energy efficiency measures ("EEMs") installed through the program.

ADM completed the following activities for its M&V work:

- Reviewed NV Energy's program tracking database, which includes final, certified, program data for 446 NPC projects and 167 SPPC projects. In addition to program tracking

[4] A full description of energy education programs and events is available in the separate M&V report for the PY2023 Energy Education Program.

data, ADM reviewed data from program materials, on-site inspections, customer interviews, and end-use metering.

- Developed a stratified sampling plan to select a sample of projects for which ADM analyzed program data to determine verified savings. The sample design allowed for the M&V of ex-post energy (kWh) savings to achieve ±10 percent precision at the 90 percent confidence interval for each NPC and SPPC. The selected sample included 62 projects for NPC and 45 for SPPC. Savings associated with sampled projects represented 48 percent of NPC ex-ante savings and 74 percent of SPPC ex-ante savings.
- ADM verified measure installation by reviewing project documents including invoices, specification sheets, applications, customer submitted photos, customer energy model calculations for each sampled project, conducted phone interviews, or site visits.
- Calculated ex-post annual energy (kWh) savings and critical peak demand (kW) reduction. For a subset of measures, ADM calculated savings using deemed savings algorithms and values that ADM determined from historical program data.

2.4. Contents of this M&V Report

This report documents ADM's efforts in performing the M&V activities for the BES program. This report includes the following chapters.

- Chapter 3 presents and discusses the M&V methods used for this program.
- Chapter 4 presents findings from M&V data collection and analyses.
- Chapter 5 provides recommendations.
- Appendix A Savings per Month by Rate Class provides program savings per month, by rate class for 2023 through 2026.
- Appendix B Procedures for Updated Verified Energy Savings provides the methodology for reviewing past projects.
- Appendix C Recommendations for Deemed Savings Algorithms and Values provides a detailed discussion of deemed savings algorithms.
- Appendix D Project Specific Realization Rate Variances provides a description of project-specific findings and causes for variances.

3. M&V METHODOLOGY

This chapter discusses ADM's approach and methods to verify and calculate ex-post annual kWh savings and summer critical peak demand kW reductions that resulted from measures installed through the program.

3.1. Sampling Plan

ADM verified savings from a random sample of completed projects to achieve the required sampling precision of ±10 percent at the 90 percent confidence interval. ADM used the verified savings from these projects to determine annual kWh savings achieved through the Program.

Program-level ex-ante kWh savings were positively skewed, i.e., a small number of projects accounted for a high percentage of savings. ADM developed a stratified random sampling plan to account for the positive skew.

Table 3-1 and Table 3-2 below illustrate the project population statistics that ADM used to develop the sample plan for NPC and SPPC, respectively. These tables include the number of projects and ex-ante energy savings of the sample by stratum. ADM assigned all projects to sampling strata that are based on each project's pathway (e.g., Core, Direct Install, or MID) and quantity of ex-ante energy savings.

Table 3-1 Population Statistics Used for Sample Design: NPC

Strata	Number of Projects	Average Ex-Ante Savings per Project	Standard Deviation of Ex-Ante Savings	CV	Sum of Ex-Ante Savings	Number of M&V Sampled Projects	Contribution to Variance
Core South 1	291	70,518	67,705	0.96	20,520,618	22	1.63E+13
Core South 2	45	451,793	134,529	0.30	20,330,666	6	5.29E+12
Core South 3	15	1,450,954	414,245	0.29	21,764,314	4	7.08E+12
Core South 4	8	2,760,994	589,324	0.21	22,087,954	5	1.67E+12
Core South 5	4	8,340,998	6,636,773	0.80	33,363,991	4	0.00E+00
Direct Install South 1	17	30,356	21,693	0.71	516,057	5	1.92E+10
MID South 1	66	63,240	108,087	1.71	4,173,822	16	2.41E+12
Totals	**446**				**122,757,423**	**62**	**3.28E+13**
					Relative Precision at 90 percent Confidence →		**7.65%**

Combined, the sampled projects account for 59,202,573 kWh of ex-ante savings, approximately 48 percent of the total ex-ante savings for NPC. ADM collected project data for the sampled projects as projects completed throughout the program year.

Table 3-2 Population Statistics Used for Sample Design: SPPC

Strata	Number of Projects	Average Ex-Ante Savings per Project	Standard Deviation of Ex-Ante Savings	CV	Sum of Ex-Ante Savings	Number of M&V Sampled Projects	Contribution to Variance
Core North 1	99	39,067	38,824	0.99	3,867,615	14	9.06E+11
Core North 2	12	345,013	88,152	0.26	4,140,160	4	1.86E+11
Core North 3	6	635,708	142,537	0.22	3,814,246	4	6.10E+10
Core North 4	7	2,694,082	2,602,420	0.97	18,858,577	7	0.00E+00
Direct Install North 1	1	25,459	-	-	25,459	1	0.00E+00
MID North 1	42	34,746	77,433	2.23	1,459,331	15	4.53E+11
Totals	**167**				**32,165,389**	**45**	**1.61E+12**
					Relative Precision at 90 percent Confidence →		**6.46%**

Combined, the sampled projects account for 23,930,674 kWh of ex-ante savings, approximately 74 percent of the total ex-ante savings for SPPC. ADM collected project data for the sampled projects as projects completed throughout the program year.

3.2. Review of Documentation

The first step in the evaluation effort was to review project documentation and other relevant program materials that ADM obtained from the program implementation contractor. For each project in the sample, ADM reviewed the available documentation (e.g., audit reports, savings calculation work papers, program forms, databases, reports, billing system data, and weather data) for each rebated measure, with careful attention to the ex-ante savings calculation. ADM reviewed each application to determine whether it included the following information:

- Documentation for the new or retrofitted equipment, including descriptions, schematics, performance data, and other supporting information.
- Methods used to calculate savings, including descriptions of methods used, specifications of assumptions and sources for these specifications, and correctness of calculations.

When project documentation was unclear or incomplete, ADM requested additional clarifying data from the implementation contractor.

3.3. Verification Procedures

ADM contacted customers via phone, email, or video conference to discuss project specifics and, when necessary, to collect primary data required to verify and calculate ex-post savings. Before conducting verifications, ADM notified NV Energy, providing a list of projects for which ADM planned to schedule M&V activities. Notification to NV Energy staff also served as a request to the implementation contractor for any documentation relating to the projects. This list included the company name, the Application ID, and the site address or other premise identification. ADM also

included contact information for the customer representative that ADM intended to contact to schedule an appointment. The implementation contractor verified that ADM had the correct contact information for each project, and notified both the customer and the NV Energy Major Account Executives ("MAEs") that ADM had selected the project for M&V.

3.4. Calculating Energy (kWh) Savings

For each measure included in sample projects, ADM completed an ex-ante review to verify that claimed savings values provided reasonable estimation of savings. Table 3-3 and Table 3-4 below show the distributions of ex-ante savings by measure category for sampled projects.

Table 3-3 Ex-Ante Energy Savings for Sample Projects: NPC

Measure Category	Ex-Ante kWh Savings for Projects in M&V Sample	Ex-Ante kWh Program Savings	Sample Savings as Percent of Program Ex-Ante kWh Savings
Custom	41,515,454	71,196,926	58.3%
Lighting Retrofit (Interior)	5,545,647	14,031,087	39.5%
Custom Lighting	3,743,420	11,922,872	31.4%
Lighting New Construction	6,727,843	11,657,672	57.7%
Lighting Retrofit (Exterior)	1,267,821	11,148,833	11.4%
HVAC Units and Controls	351,624	2,146,463	16.4%
Kitchen/Refrigeration Equipment	50,071	287,281	17.4%
Variable Frequency Drives	0	265,656	0.0%
Lighting Controls	693	100,633	0.7%
Total	**59,202,573**	**122,757,423**	**48.2%**

Table 3-4 Ex-Ante Energy Savings for Sample Projects: SPPC

Measure Category	Ex-Ante kWh Savings for Projects in M&V Sample	Ex-Ante kWh Program Savings	Sample Savings as Percent of Program Ex-Ante kWh Savings
Custom	14,421,275	16,508,816	87.4%
Lighting New Construction	3,485,866	4,645,953	75.0%
Lighting Retrofit (Exterior)	2,973,989	4,134,211	71.9%
Custom Lighting	2,037,440	4,020,293	50.7%
Lighting Retrofit (Interior)	939,607	2,609,151	36.0%
HVAC Units and Controls	3,820	177,564	2.2%
Lighting Controls	57,179	57,903	98.7%
Kitchen/Refrigeration Equipment	11,497	11,497	100.0%
Total	**23,930,674**	**32,165,389**	**74.4%**

ADM used the following data sources to calculate program savings.

- Project documentation including aggregate energy use at a site, disaggregated energy usage data for certain targeted processes (if available), before (actual) and after (projected) data on production, and final reports (which include process improvement recommendations, analyses, conclusions, and performance targets).
- NV Energy billing data.
- Data collected through verification efforts.
- Equipment operating schedules and load (i.e., power draw) data collected through monitoring equipment.

ADM completed additional analysis for projects with high or low realization rates (ex-post savings divided by ex-ante savings) to determine the reasons for the difference between ex-ante and ex-post energy savings.

In past program years, the primary differences between ex-ante and ex-post energy savings were due to differing analysis methodologies for those projects that are eligible for prescriptive measures. ADM used project specific data to inform ex-post savings estimates and these project-specific data often vary from the data used to develop prescriptive ex-ante estimates. The continued differences between custom and prescriptive analyses resulted in ADM recommending the use of deemed savings algorithms for common measures. Appendix C provides deemed savings algorithms for common measures typically incentivized through the prescriptive program pathway.

For those sampled projects that had custom measures, Table 3-5 below provides a summary of the methods used to calculate savings for various custom measures.

Table 3-5 Typical Methods to Determine Savings for Custom Measures

Measure Type	Method to Determine Savings
Lighting	ADM's custom-designed Lighting Evaluation Model, which uses data on wattages before and after installation of measures and hours-of-use data from either site contact interviews, field monitoring, or prescriptive hours.
HVAC (including packaged units, chillers, cooling towers, controls/Energy Management Systems)	M&V methods include: (1) Equivalent full load hour ("EFLH") method to calculate savings resulting from HVAC measures; ADM determined EFLH using DOE-2[5] models developed for each territory using corresponding weather files; (2) Simulations with DOE-2 engineering analysis model, with monitored data; and (3) Billing history econometric analysis.
Large Machine, Motors, VFDs	Common equipment in this measure type are: crushers, air compressors, injection molding machines, VFDs on fans, and mixers. Monitored pre and post data with annual production estimates and/or weather data. Savings are calculated as the difference between the total energy consumption of the normalized pre and post calculations.
Whole Building New Construction	ADM uses International Performance Measurement and Verification Protocol's (IPMVP) option D: Calibrated Simulation to calculate energy savings for these sites. Generally, two energy models are created with the first being a baseline model that uses the IECC 2018 energy code as the requirements for all input parameters. A second model is created using the same building zones and schedules and is then updated with the as-built equipment. The two models are ran using the local TMY3 weather file and savings are calculated as the difference between the total energy consumption of each simulation.
Retro commissioning	ADM's preferred method for evaluating Retro commissioning is IPMVP option C: Whole Facility. The facility billing data will be analyzed from before and after the retro commissioning process. This data will be utilized in creating a pre and post implementation regression curve using one or more of the following variables: CDD, HDD, Dry bulb temp, Enthalpy, number of days, and production. The regression curves will then be normalized to the TMY3 weather data and/or production schedule and savings are the difference in annual energy consumption between the normalized pre and post regressions.

For the measures listed above, the following sections provide more detailed discussion regarding M&V approaches, methodologies, and procedures for determining ex-post verified savings.

3.4.1. *Methods for Analyzing Savings from Lighting Measures*

ADM examined lighting measures including retrofits of existing lamps or fixtures and installations of new high efficiency lamps and fixtures. Retrofit projects include the replacement of existing fixtures, lamps and/or ballasts with energy efficient fixtures, lamps and/or ballasts. New construction projects included installation of high efficiency lighting during construction; for these projects, lighting power densities ("LPD") are less than levels allowed by energy efficiency codes. These types of measures reduce demand, while not affecting operating hours. ADM also examined lighting control strategies including the addition of energy conserving control technologies such

[5] DOE-2, which is funded by the United States Department of Energy, is a widely accepted building energy analysis program that is utilized by evaluators to model the energy consumption and energy savings opportunities for all types of buildings.

as motion sensors, daylighting, and/or dimming controls. These measures typically involve a reduction in hours of operation and/or reduced fixture wattage during a subset of operating hours.

Analyzing the savings achieved by retrofit lighting measures requires data for the fixtures on (1) wattages before and after the retrofit and (2) hours of operation before and after the retrofit. To determine savings for new construction lighting measures, ADM requires data for (1) allowable code LPD requirements for the space, (2) total installed fixture wattage in the space, and (3) hours of operation of the fixtures. When appropriate, to improve calculations, hours of operation are determined from metered data collected after measure installation for a sample of fixtures. For projects that included prescriptive measures, ADM assessed the reasonableness of using prescriptive HOU. When appropriate, ADM applied the prescriptive HOU provided in Appendix C when calculating ex-post energy savings. Generally, ADM determined that using prescriptive HOU is appropriate if the hours documented through an interview with facility staff fall within ±35 percent of prescriptive HOU. This threshold represents approximately one standard deviation from the mean HOU for each facility type, as described in Appendix C.

To determine baseline and post-retrofit demand values for the lighting efficiency measures, ADM used in-house data on standard wattages of lighting fixtures and ballasts developed from lighting industry sources. This lighting data provides information on wattages for common lamp and ballast combinations.

Where appropriate, ADM collects data to determine average operating hours for retrofitted fixtures by using Time-of-Use ("TOU") data loggers. The data loggers monitor a sample of "last points of control" for unique usage areas in sites where Program participants installed lighting efficiency measures. ADM defines usage areas as those areas in a facility that have comparable average operating hours. For commercial customers, expected usage areas include such areas as office space, hallways/stairways, and storage areas.

ADM uses pre-fixture baseline demand, retrofit demand, and appropriate post-retrofit operating hours to calculate peak capacity savings and annual energy savings for sampled fixtures of each usage type. ADM uses the on-off profile and fixture wattages to determine post-retrofit kWh usage. ADM calculates annual energy savings for each sampled fixture per the following formula:

$$Annual\ kWh\ Savings = kWh_{pre} - kWh_{post}$$

Equation 3-1: Annual Lighting kWh Savings

Where:

kWh_{pre} = *amount of kWh used by pre-existing fixtures*

kWh_{post} = *amount of kWh used by post-installation fixtures*

The values for insertion in this formula are determined through the following steps:

- ADM uses results from the monitored sample to calculate the average operating hours of the metered lights for every unique building type or usage area.

- ADM applies these average operating hours to the baseline and post-installation average demand for each usage area to calculate the respective energy usage and peak period demand for each usage area.
- The annual baseline energy usage is the sum of the baseline kWh for each pre-existing lighting fixture. ADM determines post-retrofit energy by summing the post kWh for each post lighting fixture. ADM calculates the energy savings as the difference between baseline and post-installation energy usage.
- When determining savings from lighting measures in conditioned spaces, ADM uses the region-specific, building type-specific HCIF to calculate total savings attributable to lighting measures. The HCIF estimate the project's impact on the energy use of the facility's HVAC equipment. For the Program's projects that receive incentives determined from prescriptive ex-ante methodologies, ADM uses the prescriptive HCIF described in Appendix C. For custom lighting projects, ADM uses appropriate energy savings curves, estimated HVAC system efficiency, and weather data to determine custom HCIF for each usage area in a facility.

3.4.2. *Methods for Analyzing Savings from Custom HVAC Measures*

For custom HVAC measures, ADM used the energy consumption values developed through DOE-2 simulations and engineering calculations to determine energy savings. Each simulation produces HVAC energy and demand usage values based on the assumptions about equipment and/or construction conditions.

Before running the post-installation models to determine savings from HVAC measures, ADM completed baseline simulations to ensure that models accurately calculate building energy use. Baseline simulations include equipment type and specifications, operating profiles, and schedules, and the National Oceanic and Atmospheric Administration ("NOAA") weather data covering the study period. The model calibration output is created using actual weather data for a period corresponding to the available billing data for the site.

The goal of the model calibration effort is to have the results of the DOE-2 simulation come within approximately ten percent of the energy use patterns in the billing data history. After calibrating the DOE-2 model for a facility, ADM determines energy savings from the difference between pre-measure installation energy consumption and post-measure installation energy consumption.

If a DOE-2 simulation model could not be calibrated, which could result from a lack of site data or unique characteristics of a given site (e.g., multiple buildings, discontinuous occupancy patterns, or manufacturing lines with variable loads) that prevented model calibration, ADM used an engineering analysis to determine energy savings.

3.4.3. *Methods for Analyzing Savings from Large Machines, Motors and VFDs*

This category encompasses all large motors that are not covered by prescriptive savings applications. Common equipment that would fall into this category would be: crushers, air compressors, injection molding machines, VFDs on fans, and mixers.

The preferred method for evaluating these sites is to obtain monitoring data of the equipment from before and after the retrofit was implemented and then normalizing the pre and post data based on the parameters that have a strong correlation to energy consumption. For these sites, pre implementation energy monitoring on the retrofit equipment is highly recommended for accurate results.

After monitoring data is collected, this data will be analyzed to estimate an efficiency curve based on various factors such as: CDD, HDD, outside air temperature, outside air enthalpy, and production data. These pre and post efficiency curves are then normalized to a typical year of operation for the equipment. In the case of outside weather being used, then the pre and post curves will be normalized to the closest TMY3 weather data. In the case of production data being used, then as much production data as possible is collected to determine the most likely annual production estimates for a typical year based on past data.

Savings for this equipment is the difference in the pre and post annual energy consumption that has been normalized to the same typical conditions.

3.4.4. *Methods for Analyzing Savings from Whole Building New Construction*

For whole building new construction projects, ADM used IPMVP option D to determine energy savings. For this method, generally two energy simulation models are created, Baseline and Proposed. The baseline energy simulation is modeled with input parameters that match the minimum requirements from IECC 2018 building energy code. The proposed energy simulation is created using the baseline model and updating all specific energy parameters to match the as built design drawings. These updates are generally regarding the following parameters: wall insulation, window insulation, interior lighting power density, exterior lighting power density, cooling efficiency, heat pump heating efficiency, and control strategies.

The baseline and proposed energy simulations are ran using the closest TMY3 weather file and savings are the difference in annual energy consumption between the two models.

3.4.5. *Methods for Analyzing Savings from Retro Commissioning*

For retro commissioning projects, the method ADM uses is IPMVP option C: Whole Facility evaluation. Retro commissioning projects can involve many changes to a facility that may or may not affect the energy usage and generally have a high interactive effect with other systems in the facility. For that reason, a whole building utility bill regression approach is preferred to capture the actual savings associated with the retro commissioning process.

ADM creates pre and post energy consumption regression models using the utility billing data, weather, and production. All statistically relevant correction variables are used in the regression model, such as: CDD, HDD, outside air temperature, outside air enthalpy, and production data.

After the regression models are created, they are then normalized to a standard year of data using the closest TMY3 weather data and all available production information available. Savings are calculated as the difference in the normalized energy consumption of the pre and post regressions.

3.5. Procedures for Determining Energy Savings Curves

ADM develops energy savings curves to allocate energy savings per month, per rate class, and kW demand reduction per month, per rate class, which are specific to each of the sampled M&V projects. These project-level energy savings curves are determined from the project-specific operating schedules and other data gathered at each of the individual projects (as described above).

For each project in the M&V sample, a unique daily operating schedule is identified. Some projects have daily operating schedules that are year-round or non-seasonal (i.e., there is no summer versus winter season), while other projects have daily operating schedules that vary by month or season.

For each hour per day, ADM assigns the measure-specific schedule a fraction that corresponds to the average usage rate during the specific hour. For example, ADM assigns: a value of unity (1.0) for any hour in which the equipment operated 100 percent of the hour; a null value (0.0) if the equipment is not on at all during the hour; or a value of 0.5 for any hour in which the equipment operated an average of 50 percent of the hour.

ADM develops measure-specific schedules from primary data. For projects with fixed operating hours (24 hours, 7 days a week operation, for example), schedules were determined through site contact interviews.

ADM maintains and continuously refines a library of energy savings curves for use in cost effectiveness calculations, potential studies (especially regarding peak demand reduction potentials) and avoided sales calculations. The first set of energy savings curves, developed in 2010, were heavily reliant on secondary sources. For example, ADM normalized end-use load shapes from the California Commercial End Use Survey ("CEUS")[6] to characterize impacts of the BES Program. In past program years, ADM has used primary data to supplement CEUS-derived shapes. ADM generated project specific load shapes at all sampled projects using primary data from supporting documentation. This lessens the dependence on CEUS-derived load shapes.

For lighting projects, ADM developed a spreadsheet-based tool that calculates and develops:

- Primary energy impacts from lighting and lighting controls upgrades in accordance with a project-specific operating schedule.
- Secondary energy impacts from heating and cooling interactions in accordance with site-specific factors such as HVAC system efficiency, heating and cooling energy balance points, and fractions of energy radiated by interior lighting that "promptly" escape the building. These secondary impacts also include potential increases in natural gas or heating energy usage due to more efficient lighting.
- Project specific energy savings curves.

[6] The CEUS study is a comprehensive end-use energy study for the commercial sector. As described on the CEUS web site hosted by the California Energy Commission, the CEUS survey "is a comprehensive study of commercial sector energy use, primarily designed to support the state's energy demand forecasting activities." More information regarding the CEUS survey is available on the CA Energy Commission's web site: http://www.energy.ca.gov/ceus.

The lighting calculator improves the specificity of HCIF calculations and increases M&V transparency.

ADM's sampling approach ensures that primary data are available for the most significant projects.[7] ADM samples all projects above a certain threshold in annual kWh savings with certainty. Because of this sampling approach, primary data are available to inform the energy savings curves that have the largest contributions to the overall program savings.

The assignment of energy savings curves to specific measures, projects, or groups of projects for nonresidential programs is a complex process that ADM conducts in conjunction with the annual M&V effort. The availability of primary data and the applicability of secondary data are important considerations in the assignment of energy savings curves to groups of projects. ADM has constructed energy savings curves that use, to the greatest extent that is possible and appropriate, primary data gathered from M&V visits. For all the sampled projects, both retrofit and new construction, ADM has used primary data collected during the M&V process to develop energy savings curves.

3.6. Calculating First-Year Energy (kWh) Savings

ADM calculated first-year kWh savings by determining the percentage of the year remaining when Program participants installed each measure. ADM extracted measure start-up data from Program tracking data and used those data to calculate the quantity of days remaining in the year as of the measure startup date. For each measure, ADM used the number of days remaining in the year, together with the normalized energy savings curve described above, to determine the share of annualized kWh savings realized during the calendar year. ADM summed first-year kWh savings by month across each customer rate class in the program population to determine first-year kWh savings per month per rate class. Appendix A provides the first-year kWh savings table.

3.7. Calculating Critical Peak Demand Savings

Critical peak demand period per month, provided below in Table 3-6 below, is the hourly period per month during which NV Energy has historically experienced maximum system-level demand. For each service territory, there are nine or ten months in which NV Energy's historical system-level peak demand is near identical for two consecutive hours. Thus, for those months, the consecutive hours appear in the following table.

[7] Significance in this context is the relative share of annual program kWh savings.

Table 3-6 Critical Peak Demand Period per Month

Month	NPC Peak Hour(s)	SPPC Peak Hour(s)
January	18-20	18-19
February	19-20	19-20
March	20	20-21
April	20	21
May	17-18	21
June	17-18	17-18
July (annual peak)	16-18	17-18
August	16-17	17-18
September	17	17-18
October	18-19	19-20
November	18-19	18-19
December	18-19	18-19

ADM calculated critical peak demand (kW) savings per month and per rate class utilizing ex-post program savings determinations and appropriate measure-level 8,760-hour energy savings curves.

For each participant in this Program, ex-post annualized energy savings per measure were allocated to the participant's rate class, and to the specific energy savings curve for that measure. The result is a two-dimensional matrix providing per-rate-class savings per hour for all 8,760 hours of a typical calendar year (a typical year is a non-Leap Year). ADM then inspected the results for each month to identify the maximum average hourly demand (kW) savings during each month's designated peak demand hour.

Summer critical peak demand (kW) savings is the maximum kW reduction that is expected in a typical year during the July peak demand hours indicated in Table 3-6 above.

Appendix A provides the ex-post critical peak demand savings per month and per rate class. For a detailed discussion of ADM's analytical steps for determining critical peak demand (kW) savings, please refer to "ADM's M&V Technical Appendix 1."

3.8. Determining Effective Useful Life and Lifetime Savings

ADM analyzed various data to determine the EUL for each category of measure installed through the program. ADM subsequently employed its EUL determinations to calculate lifetime energy (kWh) savings for each M&V sampled project. ADM determined strata-level EUL that were then assigned to all non-sampled projects.

ADM utilized the DEER to determine EUL values for all measures.[8] Note the following measure-specific issues related to the EUL values provided in this M&V report:

- For the HVAC Retrofits category, all measures installed through the program have the same EUL value in the DEER (15 years).

[8] See, http://deeresources.com/files/deerchangelog/Updated-EULrecords_02-07-2014.xls.

- For the various lighting measures installed, the DEER provides a methodology for calculating EUL using the lamp or fixture rated life divided by HOU. Rated life is typically available on submitted specification sheets, but in the case that rated life is not available, ADM defaults to the DEER assumptions for lamp or fixture rated life: 50,000 for LED fixtures and 70,000 for ballasted fixtures.

For a given energy efficiency program, the program-level EUL is calculated as the quotient of lifetime kWh savings (numerator) and annual kWh savings (denominator). If a program achieves lifetime kWh savings of 1,500 GWh and annual kWh savings of 100 GWh, the program-level EUL would be the quotient of 1,500 and 100, or 15 years.

4. FINDINGS FROM M&V DATA COLLECTION AND ANALYSIS

ADM calculated annual kWh savings, critical peak kW reductions, and energy realization rates for a stratified sample of projects in the program, as described in Chapter 3. ADM then calculated the energy realization rate for each stratum, based on the sample projects, which it applied to all projects within each stratum.

4.1. Ex-Post Energy (kWh) Savings: NPC

Table 4-1 below summarizes the Program results for NPC.

Table 4-1 Annual Energy (kWh) and Critical Peak Demand (kW) Savings: NPC

Program Pathway	Ex-Post First-Year kWh Savings	Ex-Ante Annual kWh Savings	Ex-Post Annual kWh Savings	Realization Rate	Ex-Post Summer Critical Peak kW Savings
Core	39,114,062	118,067,543	117,014,235	99%	29,149
MID	2,254,834	4,173,822	4,178,076	100%	784
Direct Install	325,767	516,057	533,752	103%	65
Totals	**41,694,663**	**122,757,423**	**121,726,064**	**99%**	**29,998**

Program total ex-ante annual kWh savings were determined by summing individual project reported kWh savings found in the program tracking database. Table 4-2 below presents the estimated ex-ante savings, verified ex-post savings and realization rates for each of the M&V sample projects for NPC.

Table 4-2 Ex-Ante and Ex-Post kWh Savings by Project: NPC

Application ID	Strata	Ex-Ante kWh Savings	Ex-Post kWh Savings	Realization Rate
SB-23-11672	Core South 1	35,029	34,448	98%
SB-23-12329	Core South 5	6,388,355	7,024,864	110%
SB-23-12875	Core South 1	110,725	111,055	100%
SB-23-12949	Core South 1	112,036	111,415	99%
SB-23-12980	Core South 1	253,241	253,241	100%
SB-23-12990	Core South 1	46,346	47,658	103%
SB-23-12992	Core South 1	13,467	13,464	100%
SB-23-13150	Core South 4	2,243,286	2,049,373	91%
SB-23-13179	Core South 1	101,403	101,399	100%
SB-23-13205	Core South 1	56,518	56,515	100%
SB-23-13207	Core South 1	28,233	28,233	100%
SB-23-13219	Core South 1	147,490	124,699	85%
SB-23-13229	Core South 1	267,573	263,636	99%
SB-23-13233	Core South 1	956	956	100%

Application ID	Strata	Ex-Ante kWh Savings	Ex-Post kWh Savings	Realization Rate
SB-23-13235	Core South 1	956	956	100%
SB-23-13242	Core South 2	463,216	463,197	100%
SB-23-13259	Core South 1	23,182	23,181	100%
SB-23-13271	Core South 2	444,671	444,671	100%
SB-23-13272	Core South 1	30,573	29,895	98%
SB-23-13274	Core South 1	9,691	9,691	100%
SB-23-13286	Core South 2	367,123	367,107	100%
SB-23-13287	Core South 2	598,227	476,664	80%
SB-23-13289	Core South 1	207,349	205,124	99%
SB-23-13294	Core South 1	1,874	1,300	69%
SB-23-13297	Core South 1	139,818	139,818	100%
SB-23-13321	Core South 3	819,675	819,670	100%
SB-23-13322	Core South 1	9,493	9,493	100%
SB-23-13325	Core South 3	1,578,620	1,578,620	100%
SB-23-13337	Core South 5	18,192,873	18,192,873	100%
SB-23-13383	Core South 1	9,972	9,971	100%
SB-23-13409	Core South 5	4,205,571	4,209,735	100%
SB-23-13456	Core South 1	63,211	63,209	100%
SB-23-13577	Core South 3	2,149,206	2,155,407	100%
SB-23-13608	Core South 5	4,577,191	4,371,231	96%
SB-23-13645	Core South 4	2,337,370	2,337,370	100%
SB-23-13787	Core South 3	1,642,786	1,642,786	100%
SB-23-13788	Core South 2	654,824	654,824	100%
SB-23-13789	Core South 4	2,465,745	2,465,745	100%
SB-23-13791	Core South 4	3,475,660	3,445,660	99%
SB-23-13792	Core South 2	611,600	611,600	100%
SB-23-13809	Core South 4	3,359,158	3,359,158	100%
SD-23-7064	Direct Install South 1	7,688	7,970	104%
SD-23-7066	Direct Install South 1	56,909	58,611	103%
SD-23-7067	Direct Install South 1	25,293	26,222	104%
SD-23-7071	Direct Install South 1	59,055	61,225	104%
SD-23-7074	Direct Install South 1	9,776	10,135	104%
MID-23-06148	MID South 1	4,001	4,025	101%
MID-23-06157	MID South 1	6,037	6,085	101%
MID-23-06158	MID South 1	19,422	19,517	100%
MID-23-06161	MID South 1	132,521	132,521	100%
MID-23-06162	MID South 1	121,778	121,811	100%
MID-23-06172	MID South 1	31,196	31,196	100%
MID-23-06177	MID South 1	27,333	27,333	100%
MID-23-06178	MID South 1	10,250	10,250	100%
MID-23-06181	MID South 1	13,424	13,690	102%
MID-23-06185	MID South 1	314,801	314,801	100%
MID-23-06190	MID South 1	17,158	17,158	100%

Application ID	Strata	Ex-Ante kWh Savings	Ex-Post kWh Savings	Realization Rate
MID-23-06191	MID South 1	2,255	2,255	100%
MID-23-06192	MID South 1	39,774	40,104	101%
MID-23-06195	MID South 1	25,252	25,271	100%
MID-23-06203	MID South 1	31,059	31,059	100%
MID-23-06208	MID South 1	3,298	3,298	100%
Sampled Projects Subtotal		59,202,573	59,274,449	100%
Non-Sampled Projects Subtotal		63,554,849	62,451,614	98%
Total		**122,757,423**	**121,726,064**	**99%**

Table 4-3 below show the realization rate by strata.

Table 4-3 Summary of Stratum-level Energy (kWh) Savings and Realization Rates: NPC

Project Pathway	Sampling Stratum	Sum of Ex-Ante kWh Savings	Sum of Ex-Post kWh Savings	Realization Rate
Core Smallest	Core South 1	20,520,618	20,154,501	98%
Core Medium	Core South 2	20,330,666	19,543,271	96%
	Core South 3	21,764,314	21,786,099	100%
	Core South 4	22,087,954	21,731,661	98%
Core Largest	Core South 5	33,363,991	33,798,703	101%
Direct Install	Direct Install South 1	516,057	533,752	103%
MID	MID South 1	4,173,822	4,178,076	100%
Totals		**122,757,423**	**121,726,064**	**99%**

ADM applied stratum-level realization rates to each of the non-sampled projects, so that each project in the population has a project-level verified savings kWh value. ADM then summed the project-level verified savings values to determine program-level verified annual kWh savings.

4.2. Ex-Post Energy (kWh) Savings: SPPC

Table 4-4 below summarizes the Program results for SPPC.

Table 4-4 Annual Energy (kWh) and Critical Peak Demand (kW) Savings: SPPC

Program Pathway	Ex-Post First-Year kWh Savings	Ex-Ante Annual kWh Savings	Ex-Post Annual kWh Savings	Realization Rate	Ex-Post Summer Critical Peak kW Savings
Core	12,448,129	30,680,598	30,711,804	100%	3,854
MID	851,464	1,459,331	1,459,544	100%	220
Direct Install	15,325	25,459	26,367	104%	0
Totals	**13,314,918**	**32,165,389**	**32,197,714**	**100%**	**4,074**

Program total ex-ante annual kWh savings were determined by summing individual project reported kWh savings found in the program tracking database. Table 4-5 below presents the estimated ex-ante savings, verified ex-post savings and realization rates for each of the M&V sampled project for SPPC.

Table 4-5 Ex-Ante and Ex-Post kWh Savings by Project: SPPC

Application ID	Strata	Ex-Ante kWh Savings	Ex-Post kWh Savings	Realization Rate
SB-23-12888	Core North 1	74,473	75,192	101%
SB-23-12903	Core North 1	19,977	19,976	100%
SB-23-12954	Core North 3	617,492	617,530	100%
SB-23-13054	Core North 3	867,851	867,849	100%
SB-23-13134	Core North 1	34,059	33,001	97%
SB-23-13142	Core North 1	25,164	25,212	100%
SB-23-13176	Core North 1	72,856	73,560	101%
SB-23-13195	Core North 1	74,613	72,507	97%
SB-23-13224	Core North 1	5,880	5,881	100%
SB-23-13234	Core North 1	6,720	6,721	100%
SB-23-13240	Core North 1	14,604	14,605	100%
SB-23-13267	Core North 1	137,757	137,766	100%
SB-23-13279	Core North 2	389,121	388,856	100%
SB-23-13280	Core North 3	544,437	565,194	104%
SB-23-13284	Core North 2	208,335	208,348	100%
SB-23-13300	Core North 1	3,024	2,970	98%
SB-23-13324	Core North 1	26,025	25,274	97%
SB-23-13332	Core North 1	78,052	78,057	100%
SB-23-13334	Core North 2	358,992	358,992	100%
SB-23-13392	Core North 4	1,351,797	1,248,177	92%
SB-23-13404	Core North 3	498,465	495,641	99%
SB-23-13406	Core North 1	24,749	24,751	100%
SB-23-13442	Core North 2	474,179	438,978	93%
SB-23-13596	Core North 4	2,650,272	2,650,048	100%
SB-23-13612	Core North 4	1,885,745	1,885,862	100%
SB-23-13632	Core North 4	1,367,159	1,340,352	98%
SB-23-13728	Core North 4	8,506,699	8,506,700	100%
SB-23-13731	Core North 4	1,492,318	1,495,348	100%
SB-23-13812	Core North 4	1,604,588	1,854,837	116%
SD-23-7069	Direct Install North 1	25,459	26,367	104%
MID-23-06146	MID North 1	1,723	1,723	100%
MID-23-06147	MID North 1	52,646	52,646	100%
MID-23-06150	MID North 1	108,560	108,560	100%
MID-23-06151	MID North 1	17,232	17,232	100%
MID-23-06152	MID North 1	51,695	51,695	100%
MID-23-06155	MID North 1	909	909	100%
MID-23-06156	MID North 1	103,391	103,391	100%
MID-23-06160	MID North 1	7,065	7,065	100%
MID-23-06163	MID North 1	24,965	24,965	100%

Application ID	Strata	Ex-Ante kWh Savings	Ex-Post kWh Savings	Realization Rate
MID-23-06169	MID North 1	8,788	8,860	101%
MID-23-06173	MID North 1	11,804	11,804	100%
MID-23-06176	MID North 1	51,695	51,695	100%
MID-23-06182	MID North 1	39,514	39,514	100%
MID-23-06189	MID North 1	3,619	3,619	100%
MID-23-06209	MID North 1	6,203	6,203	100%
Sampled Projects Subtotal		23,930,674	24,034,434	100%
Non-Sampled Projects Subtotal		8,234,715	8,163,280	99%
Total		**32,165,389**	**32,197,714**	**100%**

Table 4-6 below shows realization rate for each stratum.

Table 4-6 Summary of Stratum-level Energy (kWh) Savings and Realization Rates: SPPC

Project Size	Sampling Strata	Sum of Ex-Ante kWh Savings	Sum of Ex-Post kWh Savings	Realization Rate
Core Smallest	Core North 1	3,867,615	3,851,564	100%
Core Medium	Core North 2	4,140,160	4,037,561	98%
	Core North 3	3,814,246	3,841,355	101%
Core Largest	Core North 4	18,858,577	18,981,324	101%
Direct Install	Direct Install North 1	25,459	26,367	104%
MID	MID North 1	1,459,331	1,459,544	100%
Totals		**32,165,389**	**32,197,714**	**100%**

ADM applied stratum-level realization rates to each of the non-sampled projects. ADM summed the per project verified savings to determine program-level verified annual kWh savings.

4.3. Main Causes of Realization Rate Variances

The main causes of realization rate variances from 100 percent include the following findings. Appendix D provides details regarding realization rate variances for specific projects.

- Lighting HOU:

  Some lighting projects differed from 100 percent realization rate because of differences with HOU. ADM used prescriptive HOU when a project's actual HOU are within 35 percent of the prescriptive HOU for its building type. ADM used custom HOU when a project's actual HOU are outside 35 percent of prescriptive HOU threshold. ADM used supporting documentation and interview with project contacts to identify a project's actual HOU.

- Lighting HCIF:

  Some lighting projects differed from 100 percent realization rate because of HCIF variances. ADM used prescriptive HCIF when a project's actual HOU are within 35

percent of the prescriptive HOU for its building type. ADM used custom HCIF when a project's actual HOU are outside 35 percent of prescriptive HOU threshold. The implementation contractor uses prescriptive HCIF for all lighting projects.

- Whole-building energy modeling:

  For new construction whole building energy models, for which savings typically come from lighting, fans, cooling, and heating measures, ADM verified baseline and as-built model inputs. ADM determined appropriate baseline efficiency inputs from applicable energy building codes. ADM determined as-built model inputs from site visits and/or supporting documentation. Realization rate differences occurred when ex-ante and ex-post savings calculations used different baseline and as-built model inputs.

4.4. Ex-Post Precision Calculation

ADM stratified all projects based on ex-post savings using strata boundaries to calculate statistical precision. ADM provides the results of these calculations in Table 4-7 and Table 4-8 below.

Table 4-7 Ex-Post Precision Calculation Results: NPC

Stratum	Number of Projects	Average Ex-Post Savings / Project	Standard Deviation of Ex-Post Savings	CV	Sum of Ex-Post Savings	Number of M&V Sampled Projects	Contribution to Variance
Core South 1	291	69,259	66,503	0.96	20,154,501	22	1.57E+13
Core South 2	45	434,295	129,234	0.30	19,543,271	6	4.89E+12
Core South 3	15	1,452,407	415,150	0.29	21,786,099	4	7.11E+12
Core South 4	8	2,716,458	608,440	0.22	21,731,661	5	1.78E+12
Core South 5	4	8,449,676	6,622,457	0.78	33,798,703	4	0.00E+00
Direct Install South 1	17	31,397	22,427	0.71	533,752	5	2.05E+10
MID South 1	66	63,304	108,197	1.71	4,178,076	16	2.41E+12
Totals	**446**				**121,726,064**	**62**	3.19E+13
					Relative Precision at 90 percent Confidence →		**7.61%**

Table 4-8 Ex-Post Precision Calculation Results: SPPC

Stratum	Number of Projects	Average Ex-Post Savings / Project	Standard Deviation of Ex-Post Savings	CV	Sum of Ex-Post Savings	Number of M&V Sampled Projects	Contribution to Variance
Core North 1	99	38,905	38,685	0.99	3,851,564	14	9.00E+11
Core North 2	12	336,463	83,011	0.25	4,037,561	4	1.65E+11
Core North 3	6	640,226	140,958	0.22	3,841,355	4	5.96E+10
Core North 4	7	2,711,618	2,598,206	0.96	18,981,324	7	0.00E+00
Direct Install North 1	1	26,367	-	-	26,367	1	0.00E+00
MID North 1	42	34,751	77,443	2.23	1,459,544	15	4.53E+11
Totals	167				32,197,714	45	1.58E+12
					Relative Precision at 90 percent Confidence →		**6.40%**

4.5. Effective Useful Life & Lifetime Energy (kWh) Savings

ADM determined the EUL for each sampled project from a weighted average of measures installed through the program. ADM used EUL determinations to calculate lifetime energy (kWh) savings per sampled project, as shown below in Table 4-9 for NPC and Table 4-10 for SPPC.

Table 4-9 EUL & Lifetime Savings – M&V Sampled Projects: NPC

Application ID	Stratum	Verified Ex-Post Savings (kWh)	EUL (Years)	Lifetime Savings (kWh)
SB-23-11672	Core South 1	34,448	9.8	337,935
SB-23-12329	Core South 5	7,024,864	15.0	105,372,960
SB-23-12875	Core South 1	111,055	15.0	1,665,825
SB-23-12949	Core South 1	111,415	15.0	1,671,225
SB-23-12980	Core South 1	253,241	7.0	1,762,557
SB-23-12990	Core South 1	47,658	11.8	563,794
SB-23-12992	Core South 1	13,464	14.1	189,708
SB-23-13150	Core South 4	2,049,373	15.0	30,740,595
SB-23-13179	Core South 1	101,399	14.4	1,459,132
SB-23-13205	Core South 1	56,515	15.0	847,725
SB-23-13207	Core South 1	28,233	9.4	266,520
SB-23-13219	Core South 1	124,699	13.6	1,690,942
SB-23-13229	Core South 1	263,636	14.5	3,833,267
SB-23-13233	Core South 1	956	15.0	14,340
SB-23-13235	Core South 1	956	15.0	14,340
SB-23-13242	Core South 2	463,197	11.5	5,336,029
SB-23-13259	Core South 1	23,181	11.6	268,668
SB-23-13271	Core South 2	444,671	8.3	3,677,429
SB-23-13272	Core South 1	29,895	8.6	256,034

Application ID	Stratum	Verified Ex-Post Savings (kWh)	EUL (Years)	Lifetime Savings (kWh)
SB-23-13274	Core South 1	9,691	10.0	97,104
SB-23-13286	Core South 2	367,107	11.6	4,254,770
SB-23-13287	Core South 2	476,664	11.9	5,666,655
SB-23-13289	Core South 1	205,124	10.6	2,176,366
SB-23-13294	Core South 1	1,300	15.0	19,500
SB-23-13297	Core South 1	139,818	11.0	1,537,998
SB-23-13321	Core South 3	819,670	10.1	8,295,060
SB-23-13322	Core South 1	9,493	11.6	110,024
SB-23-13325	Core South 3	1,578,620	7.0	11,097,699
SB-23-13337	Core South 5	18,192,873	15.0	272,893,095
SB-23-13383	Core South 1	9,971	15.0	149,565
SB-23-13409	Core South 5	4,209,735	12.4	51,990,227
SB-23-13456	Core South 1	63,209	11.3	712,365
SB-23-13577	Core South 3	2,155,407	15.0	32,331,105
SB-23-13608	Core South 5	4,371,231	15.0	65,568,465
SB-23-13645	Core South 4	2,337,370	15.0	35,060,550
SB-23-13787	Core South 3	1,642,786	10.0	16,427,860
SB-23-13788	Core South 2	654,824	10.0	6,548,240
SB-23-13789	Core South 4	2,465,745	15.0	36,986,175
SB-23-13791	Core South 4	3,445,660	15.0	51,684,900
SB-23-13792	Core South 2	611,600	15.0	9,174,000
SB-23-13809	Core South 4	3,359,158	6.0	20,020,582
SD-23-7064	Direct Install South 1	7,970	10.2	80,975
SD-23-7066	Direct Install South 1	58,611	11.6	679,301
SD-23-7067	Direct Install South 1	26,222	11.6	303,913
SD-23-7071	Direct Install South 1	61,225	10.2	622,046
SD-23-7074	Direct Install South 1	10,135	11.6	117,465
MID-23-06148	MID South 1	4,025	8.4	33,870
MID-23-06157	MID South 1	6,085	8.4	51,200
MID-23-06158	MID South 1	19,517	8.4	164,230
MID-23-06161	MID South 1	132,521	15.0	1,987,822
MID-23-06162	MID South 1	121,811	8.4	1,025,000
MID-23-06172	MID South 1	31,196	8.4	262,500
MID-23-06177	MID South 1	27,333	8.4	230,000
MID-23-06178	MID South 1	10,250	8.4	86,250
MID-23-06181	MID South 1	13,690	8.4	115,200
MID-23-06185	MID South 1	314,801	10.1	3,178,740
MID-23-06190	MID South 1	17,158	8.4	144,375
MID-23-06191	MID South 1	2,255	8.4	18,975
MID-23-06192	MID South 1	40,104	7.9	316,179
MID-23-06195	MID South 1	25,271	8.4	212,650
MID-23-06203	MID South 1	31,059	8.2	253,656
MID-23-06208	MID South 1	3,298	8.4	27,750
Sampled Projects Subtotal		**59,274,449**	**13.5**	**802,683,427**

Table 4-10 EUL & Lifetime Savings – M&V Sampled Projects: SPPC

Application ID	Stratum	Verified Ex-Post Savings (kWh)	EUL (Years)	Lifetime Savings (kWh)
SB-23-12888	Core North 1	75,192	15.0	1,127,883
SB-23-12903	Core North 1	19,976	10.0	199,760
SB-23-12954	Core North 3	617,530	15.0	9,262,950
SB-23-13054	Core North 3	867,849	15.0	13,017,735
SB-23-13134	Core North 1	33,001	15.0	495,015
SB-23-13142	Core North 1	25,212	15.0	378,180
SB-23-13176	Core North 1	73,560	14.3	1,048,966
SB-23-13195	Core North 1	72,507	15.0	1,087,605
SB-23-13224	Core North 1	5,881	15.0	88,215
SB-23-13234	Core North 1	6,721	15.0	100,815
SB-23-13240	Core North 1	14,605	13.2	192,348
SB-23-13267	Core North 1	137,766	11.8	1,628,394
SB-23-13279	Core North 2	388,856	15.0	5,832,840
SB-23-13280	Core North 3	565,194	5.7	3,227,255
SB-23-13284	Core North 2	208,348	15.0	3,125,220
SB-23-13300	Core North 1	2,970	10.0	29,700
SB-23-13324	Core North 1	25,274	10.3	259,564
SB-23-13332	Core North 1	78,057	11.6	906,242
SB-23-13334	Core North 2	358,992	15.0	5,384,880
SB-23-13392	Core North 4	1,248,177	5.7	7,127,091
SB-23-13404	Core North 3	495,641	15.0	7,434,615
SB-23-13406	Core North 1	24,751	14.3	354,929
SB-23-13442	Core North 2	438,978	15.0	6,584,670
SB-23-13596	Core North 4	2,650,048	15.0	39,750,720
SB-23-13612	Core North 4	1,885,862	15.0	28,287,930
SB-23-13632	Core North 4	1,340,352	13.7	18,376,226
SB-23-13728	Core North 4	8,506,700	15.0	127,302,492
SB-23-13731	Core North 4	1,495,348	15.0	22,430,222
SB-23-13812	Core North 4	1,854,837	15.0	27,822,555
SD-23-7069	Direct Install North 1	26,367	11.6	306,121
MID-23-06146	MID North 1	1,723	8.4	14,500
MID-23-06147	MID North 1	52,646	8.4	443,000
MID-23-06150	MID North 1	108,560	8.4	913,500
MID-23-06151	MID North 1	17,232	8.4	145,000
MID-23-06152	MID North 1	51,695	8.4	435,000
MID-23-06155	MID North 1	909	8.4	7,650
MID-23-06156	MID North 1	103,391	8.4	870,000
MID-23-06160	MID North 1	7,065	8.4	59,450
MID-23-06163	MID North 1	24,965	8.4	210,075
MID-23-06169	MID North 1	8,860	15.0	132,893
MID-23-06173	MID North 1	11,804	8.4	99,325
MID-23-06176	MID North 1	51,695	8.4	435,000
MID-23-06182	MID North 1	39,514	8.4	332,500

Application ID	Stratum	Verified Ex-Post Savings (kWh)	EUL (Years)	Lifetime Savings (kWh)
MID-23-06189	MID North 1	3,619	8.4	30,450
MID-23-06209	MID North 1	6,203	8.4	52,200
Sampled Projects Subtotal		**24,034,434**	**14.0**	**337,351,680**

ADM calculated strata-level EUL for M&V sampled projects by dividing total lifetime savings (kWh) per stratum by total verified ex-post (kWh) savings per stratum. Table 4-11 below provides strata-level EUL for NPC; Table 4-12 below provides strata-level EUL for SPPC. ADM applied strata level EUL to non-sampled projects.

Table 4-11 EUL and Lifetime Savings for M&V Sample – NPC

Strata	Verified Ex-Post Savings (kWh)	EUL (Years)	Lifetime Savings (kWh)
Core South 1	1,639,357	12.0	19,644,933
Core South 2	3,018,063	11.5	34,657,124
Core South 3	6,196,483	11.0	68,151,724
Core South 4	13,657,306	12.8	174,492,802
Core South 5	33,798,703	14.7	495,824,747
Direct Install South 1	164,163	11.0	1,803,700
MID South 1	800,374	10.1	8,108,397
All Sampled Projects	**59,274,449**	**13.5**	**802,683,427**

Table 4-12 EUL and Lifetime Savings for M&V Sample – SPPC

Strata	Verified Ex-Post Savings (kWh)	EUL (Years)	Lifetime Savings (kWh)
Core North 1	595,473	13.3	7,897,616
Core North 2	1,395,174	15.0	20,927,610
Core North 3	2,546,214	12.9	32,942,555
Core North 4	18,981,324	14.3	271,097,236
Direct Install North 1	26,367	11.6	306,121
MID North 1	489,882	8.5	4,180,543
All Sampled Projects	**24,034,434**	**14.0**	**337,351,680**

Table 4-13 below shows program-level lifetime savings. Program-level EUL was then calculated as lifetime kWh savings divided by annual verified savings.

Table 4-13 Program Level EUL & Lifetime Savings

Region		Verified Ex-Post Savings (kWh)	EUL (Years)	Lifetime Savings (kWh)
NPC	M&V Sampled Projects	59,274,449	13.5	802,683,427
	Non-sampled Projects	62,451,614	11.6	724,538,879
	Totals	**121,726,064**	**12.5**	**1,527,222,307**

Region		Verified Ex-Post Savings (kWh)	EUL (Years)	Lifetime Savings (kWh)
SPPC	M&V Sampled Projects	24,034,434	14.0	337,351,680
	Non-sampled Projects	8,163,280	13.2	107,851,765
	Totals	**32,197,714**	**13.8**	**445,203,445**

5. RECOMMENDATIONS

ADM presents the following recommendations for future program years.

1) Continue to review and update the established pre-construction checklist review process.

   A pre-construction checklist review process that was instituted in program year 2013 has been used since to review large projects at the beginning of the implementation process, providing an early review of ex-ante claimed energy savings and enabling greater coordination between the Program implementation contractor and ADM. The pre-construction checklist review process has been improved in successive years, enabling ADM and the Program's implementation contractor to compare baseline assumptions and savings calculations with the goal of developing optimal and similar M&V methodologies.

   ADM provides the following recommendations in the spirit of continual improvement for the pre-construction checklist review process:

   - At the start of each program year, continue to collaboratively review these procedures with all stakeholders, working together to adjust and improve this valuable process.
   - The Program implementation contractor should continue to provide ADM the pre-construction checklist review before project implementation.
   - Early in 2024, the Program should review the thresholds which require a project to participate in a checklist review process. It is suggested that a checklist should be completed on custom projects with over 750,000 kWh in the south or 500,000 kWh in the north. This will make sure that a checklist is completed on the largest and most complicated projects. Projects which receive a checklist review usually include custom engineering, new construction whole building models, and custom lighting projects.
   - The implementation contractor should provide ADM all available preliminary project documentation, e.g., pre-project inspection report, and methodology and calculations for preliminary ex-ante savings estimates, including models built by outside contractors. ADM needs the mentioned documentation in addition to the preliminary Project Application and Pre-Construction Checklist document. ADM would use the additional preliminary project documentation to better inform decisions regarding M&V activities; ADM would not use the preliminary data for ex-post analyses.
   - Outside contractors should be invited to participate in the pre-construction review process. Doing so would improve transparency between project implementation and M&V activities and would allow all parties to reach a mutual understanding regarding key activities – such as data collection, project timelines, and baseline requirements – before completing projects.

2) In addition to the pre-construction checklist review process, perform a thorough pre-review on the largest projects in the program before the projects are considered final in DSMC.

It is recommended, for the largest projects in the program, that ADM perform a thorough pre-review before these projects are considered final. Every program year, there are a handful of projects that have significant savings contribution to the program totals. Calculation alignment and accuracy is more important on these large projects. The largest projects could mean projects greater than 6,000,000 kWh for NPC and 3,000,000 kWh for SPPC. Adding this process would help ensure that the implementation contractor and ADM are in alignment with savings calculations.

3) Spread out program production throughout the whole program year.

   Most of the program projects were finalized in the last couple months of the year. Spreading projects out across the year will help avoid evaluation risk. Spreading projects out across the whole year will allow ADM to complete more pre-reviews and checklists. Mid-year sampling plans and program projections will likely be more accurate when production is spread out throughout the year. ADM found realization rate differences in several whole building new construction projects that were submitted late in the program year; it is likely that these differences could have been avoided if there was enough time for in depth pre-reviews.

4) Continue program management meetings and engineering meetings.

   NV Energy, the Program implementation contractor, and ADM have met to collaborate and to discuss program progress and goals, M&V tasks and requirements, and new technologies. Recurring meetings include a weekly program management meeting and a bi-weekly engineering/technical meeting. Ad hoc meetings, usually about specific projects, are scheduled throughout the yar. Recurring meeting frequency should be addressed to make sure an appropriate number of meetings are had.

5) For new construction exterior lighting projects, add a baseline lighting power allowance for building exteriors validation check into ex-ante calculator.

   It is recommended that the Program implementation contractor add a validation check to its new construction exterior lighting calculator. The current calculator allows the baseline lighting power allowance for building exteriors to be added multiple times per project. IECC 2018 states that the lighting power allowance for building exteriors shall only be added once. The realization rate difference for the project SB-23-13219 would have likely been avoided if the implementation contractor had a validation check for the lighting power allowance for building exteriors.

6) Determining HOU for lighting projects that don't fit the prescriptive facility type list and cannot be easily monitored.

   It is recommended that the Program implementation contractor and ADM collaborate to determine appropriate and defensible HOU for lighting projects that don't fit the prescriptive facility type list and that cannot be easily verified or monitored. These facilities spaces could

include residential living spaces in commercial buildings (retirement homes, nursing homes, prisons) and other unique spaces.

7) Review of the Direct Install pathway.

   It is recommended that the Direct Install pathway be combined with the Core pathway in the Program's sampling plan, much like the NPAG projects. The Direct Install pathway is the smallest pathway. It is also implemented similarly and installs similar measures to the Core pathway.

   Also, it is recommended that the Direct Install pathway use the agree upon prescriptive HOU for exterior fixtures. Many of these projects have realization rate differences because the prescriptive exterior HOU are not being used.

8) Continue to have the implementation contractor notify customers whose projects ADM has selected for M&V:

   In recent years, the implementation contractor and ADM coordinated the notification of customers whose projects ADM selected for M&V. First, ADM selects a sample of projects, for which it requests project documentation from the implementation contractor The implementation contractor then verifies customer contact information provided to ADM is correct and notifies the customer that ADM may contacting them. The step of informing customers of potential ADM contact has improved ADM's efficiency of M&V activities. ADM recommends continuing this customer-sensitive approach.

9) Continue to use deemed savings algorithms and values calculated from historical program data.

   The Program relies heavily on prescriptive measures for incentivizing projects. As discussed previously in this M&V report, the most prevalent cause of differences between ex-ante and ex-post savings is due to ex-ante estimates using prescriptive algorithms, while the ex-post analyses use custom algorithms. The variation in savings from project to project can be significant, while overall the Program typically results in gross realization rates near 100 percent. Due to the mature nature of this Program, and the extensive data available from past ex-ante and ex-post analyses, ADM has developed deemed savings algorithms and values for select projects using historical program specific data. Appendix C provides the recommended deemed savings algorithms and values. ADM has used these deemed savings algorithms and values since 2019. ADM recommends continued use of these values in future program years.

APPENDIX A: SAVINGS PER MONTH BY RATE CLASS

A.1 NPC Savings per Month by Rate Class

Table A-1. Calendar Year 2023 (CY2023) Capital Projects Savings/Month/Rate Class (kWh)

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
GS	43,342	63,619	102,562	104,512	159,022	179,603	218,900	478,311	707,750	679,191	563,662	860,470	4,160,944
LGS1	76,651	159,155	269,459	389,316	538,835	917,551	1,381,465	1,877,523	2,016,632	2,137,406	1,963,384	2,096,049	13,823,426
LGS2	135,517	257,130	413,742	590,204	752,591	877,838	1,044,618	1,194,638	1,349,929	1,987,160	2,103,141	1,906,445	12,612,953
LGS3	35,406	56,077	91,373	93,227	105,581	118,622	138,028	367,535	973,418	2,265,075	2,922,750	3,930,248	11,097,340
Total	290,916	535,982	877,137	1,177,258	1,556,030	2,093,614	2,783,012	3,918,006	5,047,728	7,068,832	7,552,936	8,793,212	41,694,663

Table A-2. CY2024-CY2026 Capital Projects Savings/Month/Rate Class (kWh)

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
GS	972,074	882,801	986,109	975,964	1,180,187	1,412,394	1,785,979	1,950,813	1,612,276	1,284,396	1,020,917	971,492	15,035,402
LGS1	2,089,270	1,897,160	2,148,083	2,245,621	2,658,012	2,956,303	3,591,849	3,791,717	3,346,902	2,786,940	2,199,713	2,103,551	31,815,119
LGS2	2,120,560	1,783,298	2,043,454	2,320,338	2,749,651	3,540,140	4,019,768	4,355,058	3,477,099	2,719,384	2,157,480	1,900,387	33,186,617
LGS3	3,932,585	3,478,026	3,471,441	3,285,494	3,415,586	3,187,578	3,316,395	3,405,308	3,348,917	3,511,757	3,397,229	3,938,608	41,688,925
Total	9,114,490	8,041,286	8,649,087	8,827,417	10,003,435	11,096,416	12,713,991	13,502,896	11,785,194	10,302,477	8,775,339	8,914,036	121,726,064

Table A-3. Critical Peak Demand Savings (kW) per Month by Rate Class, NPC

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GS	2,345	1,829	2,053	1,846	2,616	3,817	5,705	5,982	4,185	2,420	2,848	2,080
LGS1	4,721	3,785	4,031	3,667	6,165	7,013	9,305	9,715	7,345	5,111	5,392	4,427
LGS2	4,129	3,057	3,363	4,394	6,447	7,858	9,485	9,846	8,185	4,388	4,801	3,810
LGS3	5,411	6,517	5,238	4,825	4,374	4,033	5,502	5,320	3,670	4,944	4,978	5,819
Total	16,606	15,188	14,684	14,732	19,602	22,721	29,998	30,863	23,386	16,863	18,019	16,136

A.2 SPPC Savings per Month by Rate Class

Table A-4. Calendar Year 2023 (CY2023) Capital Projects Savings/Month/Rate Class (kWh)

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
D1	16,789	27,980	43,175	47,090	85,616	143,044	187,801	209,243	240,435	399,654	423,138	484,140	2,308,105
GS1	7,795	129,654	226,430	306,975	373,926	450,200	572,911	630,962	758,562	816,220	1,569,211	1,760,745	7,603,590
GS2	3,994	76,816	159,693	170,677	192,462	190,463	195,743	202,968	199,569	392,608	636,797	654,416	3,076,207
GS3	-	-	-	33,744	38,573	33,430	38,489	34,865	37,073	38,781	37,456	34,605	327,016
Total	28,578	234,451	429,298	558,486	690,576	817,137	994,945	1,078,037	1,235,639	1,647,263	2,666,601	2,933,906	13,314,918

Table A-5. CY2024-CY2026 Capital Projects Savings/Month/Rate Class (kWh)

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
D1	484,166	414,124	428,728	391,705	401,957	410,323	462,906	486,351	479,897	483,021	467,230	491,531	5,401,940
GS1	1,814,807	1,606,574	1,755,965	1,715,410	1,791,538	1,780,955	1,901,392	1,883,736	1,757,205	1,813,852	1,715,253	1,770,911	21,307,598
GS2	661,305	345,461	198,533	194,017	206,342	201,336	210,375	430,404	647,526	658,259	634,972	660,668	5,049,199
GS3	39,641	32,509	37,786	36,857	38,439	34,014	37,590	35,359	36,853	38,039	36,669	35,220	438,978
Total	2,999,920	2,398,667	2,421,012	2,337,989	2,438,277	2,426,629	2,612,264	2,835,850	2,921,483	2,993,171	2,854,124	2,958,329	32,197,714

Table A-6. Critical Peak Demand Savings (kW) per Month by Rate Class, SPPC

Rate Class	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
D1	1,047	1,019	1,011	998	990	730	771	649	467	1,051	1,075	1,047
GS1	2,843	2,698	2,655	2,545	2,468	2,771	2,941	2,901	2,896	2,746	2,846	2,838
GS2	920	916	279	264	257	314	315	879	974	811	902	919
GS3	52	53	51	60	60	47	47	47	56	44	46	52
Total	4,861	4,687	3,996	3,866	3,774	3,862	4,074	4,476	4,393	4,652	4,869	4,857

APPENDIX B: PROCEDURES FOR UPDATING VERIFIED ENERGY SAVINGS

This chapter provides a description of M&V procedures for updating verified energy (kWh) savings for past projects. ADM developed M&V procedures for reviewing past projects that had either 1) potential uncertainties when ADM completed the original analysis or 2) uncertainties due to specific measure types. An example of measures that may require updated energy savings include: VFD projects, projects with less than one month of billing data, and projects with less than 100 percent occupancy. ADM did not identify any projects in the PY2023 that will require additional M&V in PY2024.

B.1 Procedures to Identify and Review Projects

ADM has developed procedures for providing a review and potentially updating verified energy savings for certain projects that participated in the Program in past years. These prior-year projects are reviewed to verify the persistence of savings for projects with potential uncertainty that were in prior-year M&V samples. Following is a brief description of specific measures that may contribute to high uncertainty in the verified savings analysis:

- VFD Projects: VFD projects can have higher uncertainty in the verified savings due to the changing nature of the VFDs and the systems that they serve. VFD projects may be implemented in HVAC systems, causing VFD operation and verified savings to be highly weather dependent. VFDs in this application typically have a low level of uncertainty due to ADM's ability to normalize for weather impacts. ADM typically accounts for weather impacts by installing monitoring equipment or by using calibrated DOE-2 energy simulation models that result in verified savings with low uncertainty. However, in projects in which VFDs are installed for process control, irrigation, or mining, the uncertainty of verified savings can increase due to external factors other than weather. Energy savings may depend on a facility's production rate, or the equipment controlled by a VFD may move to other locations within the process. (For example, this may occur at mining sites.) In these cases, the uncertainty in the verified savings increases; therefore, a review of these savings in subsequent years is appropriate.
- Projects with minimal billing data: ADM used calibrated DOE-2 energy simulation models to analyze many projects in the M&V samples for previous program years. The evaluation of these projects uses electrical energy billing data to determine the total energy usage of the facility either prior to or after an energy efficiency measure is implemented. ADM used billing data to calibrate DOE-2 energy simulation models to ensure the models accurately represent the energy usage patterns in the buildings. It is standard practice to use 12-months of billing data when calibrating an energy model to ensure the model represents all seasons appropriately. However, fewer months of billing data can still provide verified savings with low uncertainty, especially if the implemented measures are season specific (i.e., cooling system energy savings that occur in summer months). In rare cases, ADM calibrated energy simulation models using three or fewer months of billing

data – typically for new construction projects that were completed at the end of a program year. The timing of such projects prevented ADM from obtaining the usual quantity of billing data from NV Energy prior to having to complete M&V analyses. Such projects may have increased uncertainty regarding verified savings and may receive subsequent review.

- Low occupancy projects: The Program occasionally includes projects for which full occupancy cannot be verified within the normal M&V time constraints. For such projects, ADM has typically determined the ex-post verified savings by estimating the energy usage at full or expected occupancy. However, to reduce uncertainty for low occupancy projects, ADM performs additional M&V to investigate occupancy levels in subsequent years.
- Non-measure specific sites: ADM selects these projects on a case-by-case basis. These are projects that, in ADM's judgment, have high uncertainty due to limited availability of data, uncertainty in process or manufacturing loads, or high variability in operations. This Appendix identifies projects for which ADM recommends additional M&V activities.

APPENDIX C: RECOMMENDATIONS FOR DEEMED SAVINGS ALGORITHMS AND VALUES

C.1 Introduction

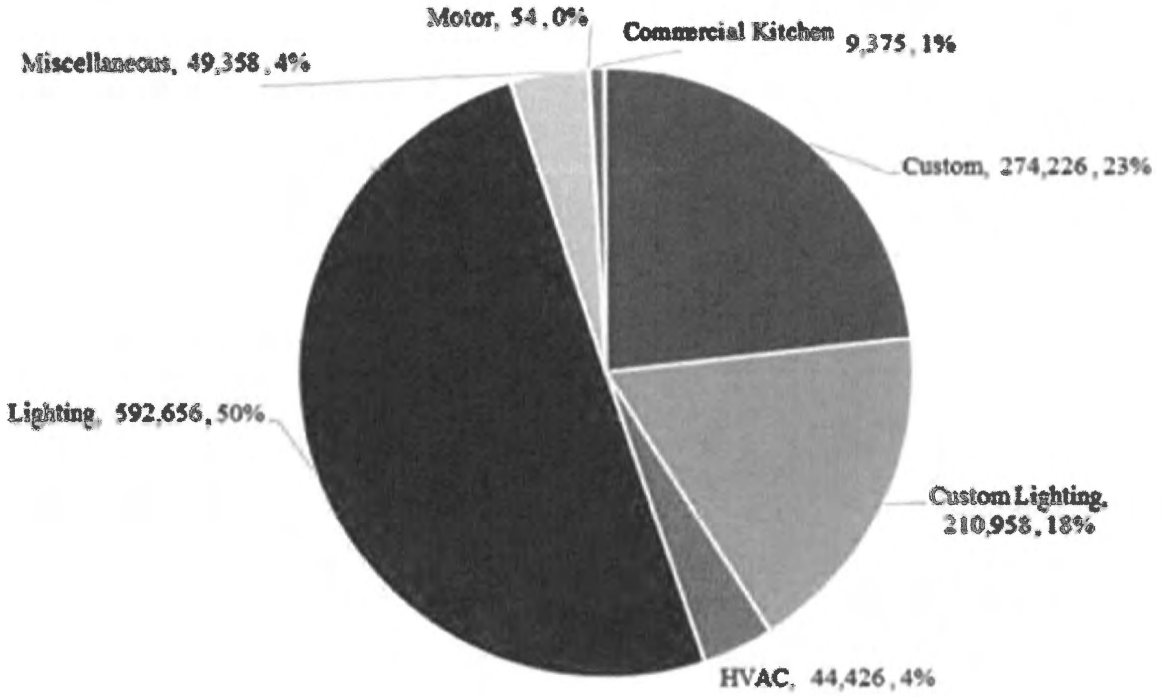
During an annual M&V meeting with the Program on April 18, 2018, ADM discussed the topic of developing deemed savings algorithms and values for the program. The primary interest in developing deemed savings algorithms and values is to reduce the uncertainty associated with realization rates for standard (non-complex) projects. Subsequently, during the 2018 program year, ADM used historical program and M&V data to develop deemed savings algorithms and values that are appropriate for both ex-ante and ex-post savings. These algorithms were first implemented in 2019. They are presented again in the following sections to allow for continued use in future years.

C.2 Historical Project Data

To determine measure types that could most benefit from the development of deemed savings algorithms and values, ADM first reviewed historical ex-ante project data from 2010-2018[9] program years. ADM used the Measure Summary report from the implementation contractor's database to review all paid projects, by measure type. Ex-ante data for 20,845 projects was available, accounting for a total ex-ante savings of 1,181,053 MWh. Figure C-1 below depicts ADM's characterization of all completed projects in the database (as of May 2018) by measure type.

[9] Data for 2018 included data up to May 1, 2018.

Figure C-1. Contribution to Ex-Ante Savings (MWh) per Measure Category



In reviewing historical program data, ADM was interested in identifying High Impact Measures ("HIMs") accounting for more than five percent of program ex-ante savings, as well as measures that commonly use standardized savings calculations. ADM identified three HIMs: prescriptive lighting, custom lighting, and specific non-lighting measures.

Prescriptive lighting projects account for 50 percent of the overall historical ex-ante savings, while custom lighting projects contribute another 18 percent. Prescriptive lighting projects are candidates for the use of deemed savings algorithms and values for calculating ex-post savings. These projects are typically implemented in small or medium sized non-residential facilities and when categorized by facility type, have similar operating hours and HVAC equipment type. The implementer uses partially deemed annual HOU and HVAC interactive factor (HCIF) values when calculating ex-ante savings for prescriptive lighting projects. Custom lighting projects may or may not use partially deemed HOU values. Custom lighting projects often use HOU and HCIF values determined through data collection.

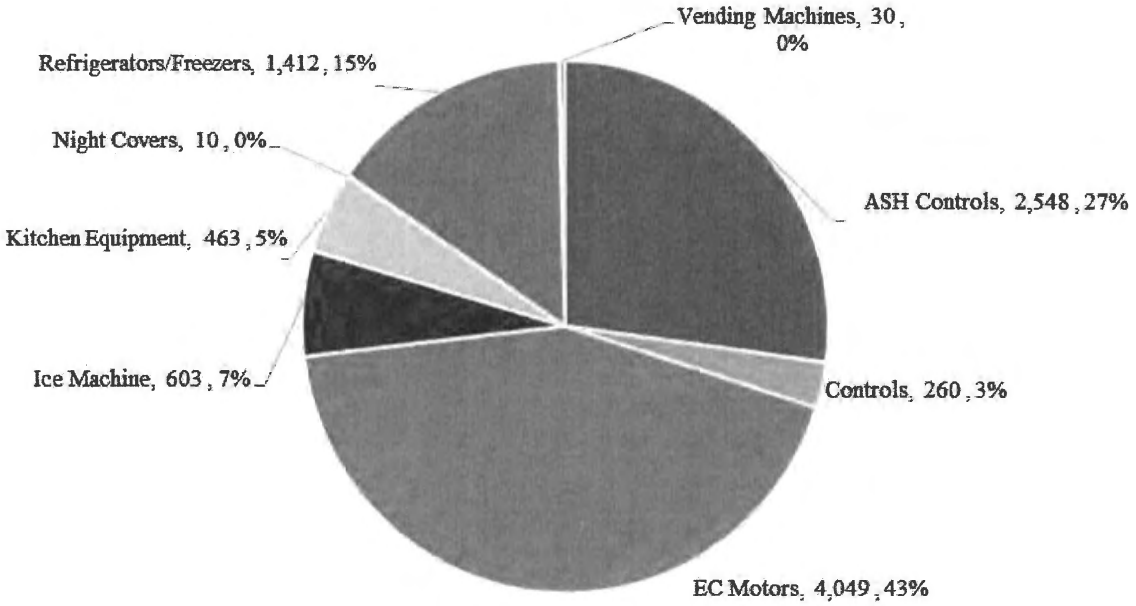
Custom lighting projects may qualify for deemed savings algorithms, depending on the project specific conditions that caused the custom lighting projects to be eligible for Program incentives. Currently, the implementation contractor categorizes large projects (>750,000 kWh) as custom, even if they use deemed savings algorithms when estimating ex-ante savings. To ensure accurate ex-ante savings estimates, the implementation contractor classifies these as "custom" projects and conducts an additional review of project documentation to ensure any deemed savings algorithms are reasonable. Deemed savings algorithms could be appropriate for such projects.

However, custom lighting projects may include lighting controls (e.g., daylighting, occupancy sensors) or atypical occupancy schedules (e.g., an office that is open 24 hours, seven days a week) that cause the operating hours to be significantly different than what would be expected for that facility type and the partially deemed HOU. For these types of projects, which are not good candidates for deemed savings algorithms and values, ex-post verified savings should be determined using a custom approach.[10]

The custom measure is a broad category that includes any non-lighting project that uses a calculation approach and data specific to that project. Non-lighting categories that could benefit from deemed savings algorithms and values include commercial kitchen and select HVAC measures. These measures typically provide small kWh savings, with ex-post savings calculated using deemed savings algorithms and values from various industry workpapers, calculators, or other reference materials.

Commercial kitchen measures that provide an opportunity to use deemed savings algorithms and values include commercial ovens, vat fryers, refrigerators, freezers, anti-sweat heater ("ASH") controls for reach-in coolers and freezers, high-efficiency EC motors for walk-in freezer and cooler evaporator fans, and refrigeration system controls (e.g., evaporator fan controls, floating head pressure controls). In Figure C-2 below, ADM provides a depiction of the contributions per commercial kitchen measure type.

Figure C-2. Commercial Kitchen Measures Contributions to Ex-Ante Savings (MWh)



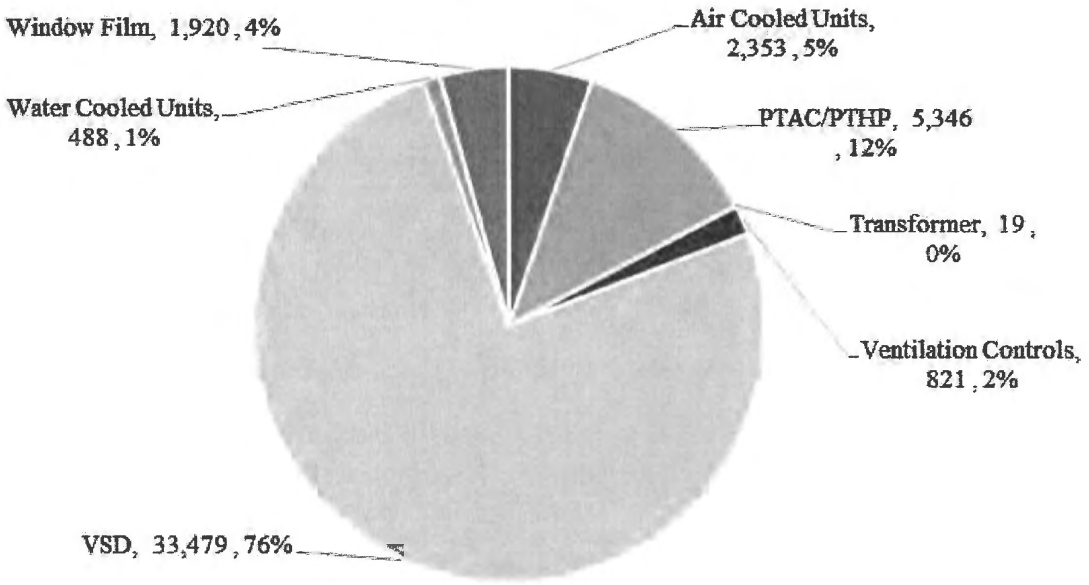
Like the commercial kitchen category, the HVAC category includes measures appropriate for deemed savings algorithms and values. Figure C-3 below provides a visual depiction of the

[10] Regarding deemed savings algorithms and values: ADM recommends that facilities with known hours of operation that differ from the recommended values by more than ±35 percent should be considered custom sites. This threshold represents one standard deviation from the mean determined through the historical program data review.

contribution to historical ex-ante energy savings by measure for the HVAC category. VSDs on HVAC equipment contribute the largest amount of savings to the HVAC category, accounting for 76 percent of historical ex-ante savings. Considering the variability in savings due to project-specific conditions, ADM recommends excluding these projects from the deemed savings approach.

However, ADM recommends including specific measures in this category in the deemed savings algorithms and values. Air Cooled Units, Packaged Terminal Air Conditioners ("PTAC"), Package Terminal Heat Pumps ("PTHP") measures are typically small savings projects with low uncertainty. These measures account for 17 percent of the HVAC measure category savings and are good candidates for deemed savings algorithms and values.

Figure C-3. HVAC Category Measure Contributions to Ex-Ante Savings (MWh)



C.3 Recommended Measures

Table C-1below provides a summary of the measures that ADM recommends including in the deemed savings algorithms and values. The table also includes brief descriptions of suggested deemed savings algorithms and values as well as project specific data requirements for each measure category. Subsequent sections in this appendix provide detailed descriptions of methodologies used to determine deemed savings algorithms and values.

Table C-1 Recommended Deemed Savings Measure Types)

Measure Type	Recommended Deemed Savings Values	Project Specific Inputs Required
Lighting		
Prescriptive Lighting	HOU, HCIF	Quantities, baseline wattage, as-built wattage
Custom Lighting	HOU, HCIF	Quantities, baseline wattage, as-built wattage
HVAC		
HVAC	EFLH by facility type and location	Unit size (tons), facility type, unit type (PTAC, PTHP), unit Coefficient of Performance ("COP")
Commercial Kitchen		
Refrigerators and Freezers	Savings per unit (by Size)	Quantity, unit size (cu. Ft.), unit type (refrigerator/freezer)
EC Motors	Savings per motor	Quantities, motor sizes to inform future revisions to savings
ASH Controls	Savings per linear foot	Quantity of doors, door dimensions, reach in type (cooler/freezer)
Ice Machines	Savings per unit (by size)	Quantity of units, unit capacity (lb. of ice per 24 hr.)
Steam Cookers	Savings per unit	Unit make/model, number of units
Combination Ovens	Savings per unit	Unit make/model, number of units
Convection Ovens	Savings per unit	Unit make/model, number of units
Fryers	Savings per unit	Unit make/model, number of units
Hot Food Holding Cabinets	Savings per unit	Unit make/model, number of units, unit size

C.4 Methodology and Recommended Deemed Savings Algorithms and Values

Lighting Measures

Lighting projects represent the largest opportunity for reducing realization rate uncertainty and streamlining M&V requirements for the Program. ADM uses the following equations to calculate ex-post savings from lighting projects:

Retrofit:

$$\mathrm{kWh_{Savings}} = (\mathrm{N_{base}} \times \mathrm{kW_{base}} - \mathrm{N_{as-built}} \times \mathrm{kW_{as-built}}) \times \mathrm{HOU} \times \mathrm{HCIF}$$

New Construction:

$$\mathrm{kWh_{Savings}} = ft^2_{\mathrm{TotalBuilding}} \times \frac{\left[\left(\frac{W}{ft^2}\right)_{\mathrm{LPDBase}} - \left(\frac{W}{ft^2}\right)_{\mathrm{LPDInstalled}}\right]}{1000} \times \mathrm{HOU} \times \mathrm{HCIF}$$

Where:

$kWh_{savings}$	= *Annual energy savings*
N	= *Number of fixtures*
kW	= *kW of each fixture*
HCIF	= *HVAC interactive factor*
HOU	= *Hours of Use*
base	= *denotes pre-installation state*
as built	= *denotes post-installation state*

$ft^2_{TotalBuilding}$ = *Total building area (sq. ft.)*
W/ft^2 = *Lighting Power Density*

HOU and HCIF are required to calculate lighting energy savings for all project types. To determine partially deemed values for these parameters, ADM reviewed data collected for M&V sampled projects from program years 2010-2017[11]. Because ex-post savings were verified using primary data collected during the M&V process, the past sampled projects include operating hours and HCIF data specific to NV Energy's service territories.

ADM analyzed primary data collected during the M&V process for 611 NV Energy lighting projects. ADM classified the projects by building or facility type. When reasonable, ADM categorized the facilities according to the facility types used in the implementation contractor's deemed savings algorithms.

ADM identified a subset of projects that did not fit within the established categories. For these projects, ADM created additional categories that better described the facilities. ADM also established a "miscellaneous" category for unique projects. In Table C-2 below, ADM provides the count of projects by facility type and service territory.

After categorizing the facilities, ADM verified the HOU and HCIF for each project. For projects that included multiple measures, ADM used the following equation to determine the weighted average HOU and HCIF:

$$\bar{x} = \frac{\sum_{i=1}^{n}(x_i \times kWh_i)}{\sum_{i=1}^{n} kWh_i}$$

Where:

$\bar{x}$ = *Weighted average*
x = *Parameter (HOU or HCIF) for measure i*
kWh = *kWh reduction associated with measure i*

When calculating the weighted average HOU and HCIF for each project, ADM excluded lighting measures that did not follow typical operating schedules. For example, for projects including interior and exterior lighting, ADM excluded the exterior lighting measures from the weighted average calculations. ADM also excluded lighting measures such as exit signs, parking garages, and other lighting measures with operating schedules that were atypical or varied from the expected facility operating schedule. The results offer an average HOU and HCIF suitable for use when calculating energy savings on a whole building basis.

[11] ADM used ex-ante data through May 2018 to determine HIMs. However, in May 2018, ADM had not yet completed M&V for program year 2018. Therefore, ADM used completed M&V sample projects from 2010-2017 to develop deemed parameters.

Table C-2. Lighting Project Counts – by Facility Type and Territory

Facility Type	Project Count, NPC	Project Count, SPPC
Casino	91	23
Exterior	77	43
Retail/Service	69	50
Miscellaneous	34	23
Warehouse	20	47
Parking Garage	17	5
Office	11	14
Grocery	11	5
Restaurant	9	3
Hotel Room Lighting	9	0
Medical	8	5
Process Industrial	6	23
Indoor Agriculture	3	1
Hotel/Motel	2	2
Totals	**367**	**244**

Table C-3 shows the recommended facility categories and ADM's recommended HOU and HCIF. HCIF values vary by territory because the two territories have different heating and cooling loads. ADM calculated the miscellaneous category by taking the average of all other facility types (excluding casino) as well as those M&V projects that did not fit within any of the other established categories.

Table C-3 does not include exterior lighting and parking garage categories because those HOU are typically based on dusk-to-dawn control and range depending on location within the state. The dusk-to-dawn hours were used extensively in both ex-ante and ex-post analyses in previous program years.

The HOU provided in Table C-3 below are applicable to whole facility lighting retrofits for projects incentivized through the prescriptive pathway. ADM considers a given site to be a custom project if its actual HOU differs from the values provided in Table C-3 by greater than ± 35 percent. For these projects, ADM will use the actual HOU determined through primary data collection. This threshold represents approximately one standard deviation from the mean determined for each facility type.

Table C-3. Deemed Savings Values for HOU and HCIF by Facility Type

Facility Type	Implementation Contractor's Workpapers (HOU)	HOU	HCIF (NPC)	HCIF (SPPC)
Casino	8,760	8,760	1.13	1.06
Retail/Service	4,210	5,108	1.13	1.05
Miscellaneous	5,005	5,299	1.11	1.06
Warehouse	4,142	4,371	1.13	1.02
Office	2,808	3,045	1.13	1.06
Grocery	5,824	6,505	1.12	1.11
Restaurant	5,278	6,308	1.13	1.05
Hotel Room Lighting	1,145	1,145	1.11	1.04
Medical	6,474	5,234	1.12	1.06
Process Industrial	4,142	6,665	1.13	1.08
Indoor Agriculture	N/A	4,584	1.09	1.05
Hotel/Motel	8,736	5,336	1.13	1.04

Refrigeration Measures

Electronically commutated ("EC") Motors Methodology

EC motors are direct current motors used in commercial refrigeration applications such as evaporator fan motors in refrigerated display cases or fan coils in walk-in refrigeration units. EC motors replace shaded pole or permanent split capacitor motors.

As observed in Figure C-2 above, EC motor projects represent 43 percent of the ex-ante refrigeration savings, presenting an opportunity for reducing uncertainty and streamlining M&V requirements within the program. EC motor energy savings are dependent on application (walk-in versus reach-in) and temperature type (freezer versus cooler). To establish deemed savings algorithms for EC motors, ADM reviewed multiple state Technical Reference Manuals ("TRMs"), as this is a well-established measure that appears in many non-residential EE programs. The previous savings algorithms used by the implementation contractor for deemed ex-ante savings were reasonable and within the range of savings outlined in various TRMs. Table C-4 below contains TRMs reviewed and their deemed savings ranges.

Table C-4. EC Motors Deemed Savings

Application	Temperature Type	Previous ex-ante Savings (kWh/Motor)	Pennsylvania TRM (kWh/Motor)	Arkansas TRM (kWh/Motor)	Illinois TRM (kWh/Motor)
Walk-in	Coolers	374	377-1,216	392-1,128	392-411
	Freezers	622	452-1,455	466-1,340	392-411
	Average	436	866	831	401
Reach-in	Coolers	337	404-958	392-1,128	392-411
	Freezers	432	483-1,146	466-1,340	392-411
	Average	361	755	831	401

ADM provides the recommended deemed savings algorithm for EC motors in Table C-5 below. The previously used savings algorithm for EC motors were reasonable and within the range of savings outlined in various TRMs.

Table C-5. Recommended Deemed Savings Algorithm, EC Motors

Application	Temperature Type	kWh/Motor
Walk-in	Coolers	374
	Freezers	622
	Average	436
Reach-in	Coolers	337
	Freezers	432
	Average	361

ASH Controls Methodology

ASH controls sense the humidity outside of a reach-in, glass door refrigerated case and turn off the ASH during periods of low humidity. Prior to ASH controls retrofit, the ASH run continuously. Savings result from reduced runtime of the ASH and reduced cooling load on the refrigeration unit when the ASH are off.

ASH control projects represent 27 percent of the ex-ante refrigeration savings, offering a good opportunity for reducing uncertainty and streamlining M&V requirements within the Program. The only input required for determining ASH control energy savings is the number of doors controlled. To establish deemed savings value for ASH controls, ADM reviewed various state TRMs as this is also a well-established measure. The most recent implementation contractor's values utilized for ASH controls were reasonable and within the range of savings outlined in various TRMs. ADM used the implementation contractor's workpapers to develop deemed ex-ante savings for ASH controls projects. Shown in Table C-6 below are the ASH controls savings currently used in the program as well those from various TRMs.

Table C-6. ASH Control Savings

Measure	Ex-ante Savings (kWh/Door)	Pennsylvania TRM (kWh/Door)	Ohio TRM (kWh/Door)	Arkansas TRM (kWh/Door)	Illinois TRM (kWh/Door)
Anti-Sweat Heater Controller	976	1,297	510-1,627	1,270	510-1,627

ADM recommends the deemed savings value for ASH controls shown in Table C-7 below. The previous values utilized for ASH controls were reasonable and within the range of savings outlined in various TRMs.

Table C-7. Recommended Deemed Savings Value, ASH Controls

Measure	kWh/Door
ASH Controller	976

Ice Machines Methodology

This measure pertains to the replacement of an existing unit at the end of its useful life or the installation of a new unit in a new or existing building. The new unit must be an ENERGY STAR® qualified commercial ice machine. This can include ENERGY STAR labeled air cooled ice machines, ice making heads, self-contained, and remote condensing units. Savings from ice machine projects are dependent on the ice harvest rate and ice machine type.

ADM sourced previously used ex-ante savings from the implementation contractor's workpapers, which referenced Pacific Gas and Electric 2005 food service equipment workpapers.[12] Ice machine baseline and efficient standards have changed since 2005. For developing deemed savings algorithm, the proposed baseline equipment is a commercial ice machine that meets federal equipment standards. The efficient machine must conform to the minimum ENERGY STAR efficiency requirements. ADM calculated proposed savings from ice machine projects using the following equation, depending on the project type:

$$\text{kWh}_{\text{Savings}} = \left(\frac{kWh_{base} - kWh_{eff}}{100}\right) \times \text{H} \times 365 \times \text{D}$$

Where:

$kWh_{savings}$ = *Annual energy savings*

kWh_{base} = *Baseline ice machine energy usage per 100lbs. of ice; Table C-8*

kWheff = *Efficient ice machine energy usage per 100lbs of ice, Table C-9*

[12] Food Service Equipment Workpapers; Ice Machine –Commercial Air Cooled," Pacific Gas and Electric. 2005

100 = *Conversion to obtain energy per pound of ice*

H = *Ice harvest rate per 24 hours (pounds/day)*

D = *Duty cycle of ice machine[13]; 0.40*

Table C-8 and Table C-9 below include the baseline and efficient ice machine energy usage per 100 pounds of ice. Ice harvest rate and ice machine type will be project specific.

Table C-8. Ice Machine Baseline Efficiencies[14]

Type	Ice Machine Type	Ice Harvest Rate (H) (lbs./day)	Baseline Energy Use per 100 lbs. of ice (kWh_{base})
Batch Type	Ice Making Head	<300	10 – 0.01233*H
		≥300 and <800	7.05 – 0.0025*H
		≥800 and <1,500	5.55 – 0.00063*H
		≥1,500 and <4,000	4.61
	Remote Condensing without Remote Compressor	≥50 and <1,000	7.97 – 0.00342*H
		≥1,000 and <4,000	4.55
	Remote Condensing with Remote Compressor	<942	7.97 – 0.00342*H
		≥942 and <4,000	4.75
	Self-Contained	<110	14.79 – 0.0469*H
		≥110 and <200	12.42 – 0.02533*H
		≥200 and <4,000	7.35
Continuous Type	Ice Making Head	<310	9.19 – 0.00629*H
		≥310 and <820	8.23 – 0.0032*H
		≥820 and <4,000	5.61
	Remote Condensing w/out Remote Compressor	<800	9.7 – 0.0058*H
		≥800 and <4,000	5.06
	Remote Condensing with Remote Compressor	<800	9.9 – 0.0058*H
		≥800 and <4,000	5.26
	Self-Contained	<200	14.22 – 0.03*H
		≥200 and <700	9.47 – 0.00624*H
		≥700 and <4,000	5.1

[13] Duty cycle varies from one installation to the next; 40 percent is the conservative value assumption from Ohio and Pennsylvania TRMs.

[14] Energy Conservation Program: Energy Conservation Standards for Automatic Commercial Ice Makers; Final Rule. Federal Register/Vol. 80, No. January 28, 2015.

Table C-9. Ice Machine ENERGY STAR Efficiencies[15]

Type	Ice Machine Type	Ice Harvest Rate (H) (lbs./day)	Energy Use Per 100 lbs. of ice (kWh_{base})
Batch Type	Ice Making Head	<300	9.20 – 0.01134*H
		≥300 and <800	6.49 – 0.0023*H
		≥800 and <1,500	5.11 – 0.00058*H
		≥1,500 and <4,000	4.24
	Remote Condensing Unit	<988	7.17 – 0.00308*H
		≥ 988 and ≤4,000	4.13
	Self-Contained	<110	12.57 – 0.0399*H
		≥110 and <200	10.56 – 0.0215*H
		≥200 and <4,000	6.25
Continuous Type	Ice Making Head	<300	7.90 – 0.005409*H
		≥310 and <820	7.08 – 0.002752*H
		≥820 and <4,000	4.82
	Remote Condensing Unit	<800	7.76 – 0.00464*H
		≥800 and <4,000	4.05
	Self-Contained	<200	12.37 – 0.0261*H
		≥200 and <700	8.24 – 0.005429*H
		≥700 and <4,000	4.44

The proposed methodology for ice machine savings reflects the most up to date baseline and efficient ice machine requirements. The savings realized utilizing this methodology will ensure the savings are relevant to projects in the next program year. ADM provides recommended deemed savings algorithms for ice machines in Table C-10 below. ADM determined savings by using the middle ice harvest range for each ice machine type.

[15] ENERGY STAR Commercial Ice Maker Key Product Criteria. Version 3.0. Effective January 28, 2018.

Table C-10. Recommended Deemed Savings Algorithm, Ice Machines

Type	Ice Machine Type	Ice Harvest Rate (H) (lbs./day)	kWh/Unit
Batch Type	Ice Making Head	<300	143
		≥300 and <800	361
		≥800 and <1,500	642
		≥1,500 and <4,000	1,486
	Remote Condensing w/out Remote Compressor	≥50 and <1,000	476
		≥1,000 and <4,000	1,533
	Remote Condensing with Remote Compressor	<942	440
		≥942 and <4,000	2,237
	Self-Contained	<110	147
		≥110 and <200	287
		≥200 and <4,000	3,373
Continuous Type	Ice Making Head	<310	261
		≥310 and <820	740
		≥820 and <4,000	2,780
	Remote Condensing w/out Remote Compressor	<800	862
		≥800 and <4,000	3,318
	Remote Condensing with Remote Compressor	<800	979
		≥800 and <4,000	3,975
	Self-Contained	<200	213
		≥200 and <700	568
		≥700 and <4,000	2,264

Kitchen Equipment

ENERGY STAR Steam Cookers

Kitchen equipment measures are a small portion (five percent) of the refrigeration ex-ante savings. Since ENERGY STAR steam cookers are not a common measure it would be beneficial to streamline the M&V requirements within the program for this measure to reduce the M&V effort required when these projects do come into the M&V sample. This measure applies to the installation of electric ENERGY STAR steam cookers as a new unit or as a replacement for a non-ENERGY STAR qualified unit.

ADM used the implementation contractor's workpapers to determine deemed ex-ante savings for ENERGY STAR steam cookers. ADM also reviewed various state TRMs as this is a well-established measure. The previously used ex-ante values were reasonable and within the range of savings outlined in various TRMs. Shown in Table C-11 and Table C-12 are the ENERGY STAR steam cooker savings from various TRMs as well as the previously used ex-ante values. The savings assume a three-pan steam cooker, operating 12-hours a day, 365-days per year, with one preheat daily.

Table C-11. ENERGY STAR Steam Cooker Savings

Measure	Ex-ante Savings (kWh/Cooker)	Pennsylvania TRM (kWh/Cooker)	Ohio TRM (kWh/Cooker)	Arkansas TRM (kWh/Cooker)	Illinois TRM (kWh/Cooker)
ENERGY STAR Steam Cooker	11,166	2,813	7,497	28,214	13,649

ADM recommends the deemed savings value for ENERGY STAR steam cookers shown in Table C-12 below. The previously used values for ENERGY STAR steam cookers were reasonable and within the range of savings outlined in various TRMs.

Table C-12. Deemed Savings Value, ENERGY STAR Steam Cooker

Measure	kWh/Cooker
ENERGY STAR Steam Cooker	11,166

ENERGY STAR Combination Oven

ENERGY STAR combination ovens are also not a common measure within the program. However, it would be beneficial to streamline the M&V requirements for this measure. This measure applies to efficient combination ovens qualified for ENERGY STAR labeling. Combination ovens combine the function of hot-air convection, steam heating, and combination convection/steam mode for moist heating, steaming, baking, roasting, thermalizing, and proofing of various food products.

ADM used workpapers to determine previous deemed ex-ante savings for ENERGY STAR combination oven projects. To establish a deemed savings value, ADM reviewed various state TRMs as this is a well-established measure. The ex-ante values were reasonable and within the range of savings outlined in various TRMs. Shown in Table C-13 below are the ENERGY STAR combination oven savings from various TRMs as well as the previously used ex-ante values. The savings assume a 10-pan oven, operating 12 hours per day, 365 days per year, with one preheat daily.

Table C-13. ENERGY STAR Combination Oven Savings

Measure	Ex-ante Savings (kWh/Oven)	Ohio TRM (kWh/Oven)	Arkansas TRM (kWh/Oven)	Illinois TRM (kWh/Oven)
ENERGY STAR Combination Oven	18,432	18,432	16,322	6,368

The recommended deemed savings value for ENERGY STAR combination ovens, as shown in Table C-14 below, represents an average of the savings outlined in various TRMs.

Table C-14. Deemed Savings Value, ENERGY STAR Combination Oven

Measure	kWh/Oven
ENERGY STAR Combination Oven	13,707

ENERGY STAR Convection Oven

ENERGY STAR convection ovens are also not a common measure within the Program. However, like other small commercial kitchen equipment measures, it would be beneficial to streamline the M&V requirements within the Program for this measure. ENERGY STAR convection ovens have lower idle energy rates and higher heavy load cooking efficiencies than standard models.

ADM used Program workpapers to determine previous deemed ex-ante savings for ENERGY STAR convection oven projects. To establish a deemed savings value, ADM reviewed other state TRMs containing this measure. The previous values were reasonable and within the range of savings outlined in the Ohio and Arkansas TRMs. Shown in Table C-15 below are the ENERGY STAR convection oven savings as presented in both the Ohio and Arkansas TRMs as well as the previously used ex-ante savings value. The savings assume an oven operating 12 hours a day, 365 days per year, with one preheat daily.

Table C-15. ENERGY STAR Convection Oven Savings

Measure	Ex-ante Savings (kWh/Oven)	Ohio TRM (kWh/Oven)	Arkansas TRM (kWh/Oven)
ENERGY STAR Convection Oven	2,262	3,235	2,485 to 2,787

ADM recommends the deemed savings value for an ENERGY STAR convection oven shown Table C-16 below.

Table C-16. Deemed Savings Value, ENERGY STAR Convection Oven

Measure	kWh/Oven
ENERGY STAR Convection Oven	2,262

ENERGY STAR Fryer

ENERGY STAR fryers have advanced burner and heat exchanger designs, resulting in shorter cook times and higher production rates. Fry pot insulation also reduces idle energy rates.

ADM used Program workpapers and reviewed state TRMs to determine deemed ex-ante savings for ENERGY STAR fryer projects. The values utilized were reasonable and within the range of savings outlined in the Ohio and Arkansas TRMs. Shown in Table C-17 below are the ENERGY STAR fryer savings, the savings assume a fryer operating 16 hours a day, 365 days per year, with one preheat daily.

Table C-17. ENERGY STAR Fryer Savings

Measure	Ex-ante Savings (kWh/Fryer)	Ohio TRM (kWh/Fryer)	Arkansas TRM (kWh/Fryer)
ENERGY STAR Fryer	1,166	982	2,055

ADM recommends the deemed savings value for ENERGY STAR Fryers shown in Table C-18 below. The values utilized were reasonable and within the range of savings reviewed in the Ohio and Arkansas TRMs.

Table C-18. Recommended Deemed Savings Value, ENERGY STAR Fryer

Measure	kWh/Fryer
ENERGY STAR Fryer	1,166

ENERGY STAR Hot Food Holding Cabinet ("HFHC")

ADM used the implementations contractor's workpapers to review previous deemed ex-ante savings for ENERGY STAR HFHC projects. HFHC savings are dependent on the HFHC size. To establish a deemed savings algorithm, ADM reviewed other state TRMs containing this measure. The algorithms utilized for ENERGY STAR HFHC were reasonable and within the range of savings outlined in Ohio and Illinois TRMs. Shown in Table C-19 below are the ENERGY STAR HFHC savings.

Table C-19. ENERGY STAR HFHC Savings

Cabinet Size	Ex-ante Savings (kWh/HFHC)	Ohio TRM (kWh/HFHC)	Illinois TRM (kWh/HFHC)
Full Size HFHC	9,308	5,256	9,308
¾ Size HFHC	3,942	3,847	3,942
½ Size HFHC	2,628	1,862	2,628

Table C-20 below shows the recommended deemed savings algorithm for an ENERGY STAR HFHC. The previous ex-ante algorithm utilized were reasonable and within the range of savings reviewed in the Ohio and Arkansas TRMs.

Table C-20. Recommended Deemed Savings Algorithm, ENERGY STAR HFHC

Measure	kWh/HFHC
Full-Size HFHC	9,308
¾ Size HFHC	3,942
½ Size HFHC	2,628

ENERGY STAR Refrigerators or Freezers

This measure pertains to the replacement of a standard refrigerator or freezer with an ENERGY STAR qualified unit. The unit in question must have a built-in refrigeration system; units with remote refrigeration systems do not qualify. ENERGY STAR labeled units are more energy efficient because they incorporate components such as ECM evaporators, condenser fan motors, ASH controls, or high-efficiency compressors, which reduce energy consumption.

As observed in Figure C-2 above, ENERGY STAR refrigerator or freezer projects represent 15 percent of historical ex-ante refrigeration savings, providing a significant opportunity for reducing uncertainty and streamlining M&V requirements within the program. ENERGY STAR refrigerator or freezer energy savings are dependent on door type (solid door or glass door), temperature type (freezer or cooler), and chilled/frozen compartment volume.

To establish deemed savings algorithm for ENERGY STAR refrigerator or freezer, a well-established measure, ADM reviewed various TRM documents. Previously used algorithms were reasonable and within the range of savings outlined in various TRMs. However, the previous ex-ante savings for glass door refrigerators in the size categories larger than 15 cubic feet are abnormally high. These high values shaded in Table C-21 below are the ENERGY STAR refrigerator or freezer savings from various TRMs as well as previously used ex-ante savings values.

Table C-21. ENERGY STAR Refrigerator/Freezer Savings

Door Type	Temperature Type	Chilled/frozen compartment volume (V, cu. Ft.)	Ex-ante Savings (kWh/unit)	Pennsylvania TRM Savings (kWh/unit)	Ohio TRM Savings (kWh/unit)	Arkansas TRM Savings (kWh/unit)	Illinois TRM Savings (kWh/unit)
Solid Door	Refrigerator	0< V <15	262	268	260	296	260
		15≤ V <30	470	424	459	208	459
		30≤ V <50	822	838	790	281	790
		V≥ 50	1,104	1,205	958	471	958
	Freezer	0< V <15	485	814	458	230	458
		15≤ V <30	869	869	869	778	869
		30≤ V <50	1,901	1,988	1,728	304	1,728
		V≥ 50	3,492	3,405	2,609	874	2,609
Glass Door	Refrigerator	0< V <15	721	722	720	N/A	720
		15≤ V <30	6,234	683	672		672
		30≤ V <50	10,687	763	728		728
		V≥ 50	14,965	927	854		854
	Freezer	0< V <15	1,588	1,901	1,562		1,562
		15≤ V <30	2,004	1,992	2,001		2,001
		30≤ V <50	4,234	4,417	3,869		3,869
		V≥ 50	6,789	6,680	5,694		5,694

For ENERGY STAR refrigerators and freezers, Table C-22 below depicts recommended deemed savings algorithms that represent average savings available from various TRMs. In the table below, ADM highlighted the recommended values that differ from previous ex-ante values.

Table C-22. Deemed Savings Algorithm, ENERGY STAR Refrigerator/Freezer

Door Type	Temperature Type	Chilled/frozen Compartment Volume (V, cu. Ft.)	kWh/Unit
Solid Door	Refrigerator	0< V <15	262
		15≤ V <30	470
		30≤ V <50	870
		V≥ 50	1,104
	Freezer	0< V <15	485
		15≤ V <30	869
		30≤ V <50	1,901
		V≥ 50	3,492
Glass Door	Refrigerator	0< V <15	721
		15≤ V <30	**676**
		30≤ V <50	**740**
		V≥ 50	**878**
	Freezer	0< V <15	1,588
		15≤ V <30	2,004
		30≤ V <50	4,234
		V≥ 50	6,789

HVAC Measures

HVAC measures make up a small fraction of the overall historical program savings. However, there are two HVAC measures that still provide good opportunities for deemed savings algorithm: PTAC[16] and Air-Cooled Units. These measures consist of the replacement or new installation of high efficiency air conditioning ("AC") equipment. The PTAC measure includes the replacement or new installation of small wall mounted room AC and/or heat pump units. The PTAC units provide cooling only, while the PTHP units provide both heating and cooling.

The Air-Cooled Unit measure includes the replacement or new installation of high efficiency roof top AC units. Air cooled units are packaged units that include a blower fan, AC compressor, and air-cooled condenser in a single, roof or ground mounted unit. These units are larger than PTACs and typically range in cooling capacity from three to twenty tons.

Both the PTAC and Air-cooled unit measures use the following algorithm for determining ex-post cooling energy savings:

$$kWh_{Savings_c} = CAP_C \times \frac{1kW}{1{,}000W} \times EFLH_C \times \left(\frac{1}{EER_{base}} - \frac{1}{EER_{post}}\right)$$

[16] This measure typically includes both PTAC and PTHP units. However, the current ex-ante deemed savings does not differentiate between PTAC and PTHP. To be consistent with current practice, ADM only reviewed deemed savings algorithms for PTAC units. PTHP units will continue to receive custom M&V analyses as appropriate.

Where:

CAP_C = *Rated equipment cooling capacity of the new unit (BTU/hr.)*

$EFLH_C$ = *Equivalent full-load hours for cooling*

EER_{base} = *Full Load baseline energy efficiency rating of the baseline cooling equipment*

EER_{post} = *Full Load nameplate energy efficiency rating of the installed cooling equipment*

While most parameters used in this algorithm are project specific, ADM can estimate the $EFLH_C$ based on facility type, providing an opportunity for deemed savings algorithm. To determine $EFLH_C$, ADM reviewed prototypical energy models for different building types. The California Public Utilities Commission developed these prototypical models, which are contained in the DEER.[17] The energy models were developed to represent typical conditions within each facility type, including facility size, exterior wall and glazing construction, lighting systems, HVAC systems, operating hours, and individual space types within the building.

To determine $EFLH_C$ ADM reviewed the energy models for eight of the most common participating facility types. ADM executed the energy models using the DOE-2 energy simulation software with Typical Meteorological Year, version 3 ("TMY3") weather data for three regional climates in the NV Energy service territories: Las Vegas, Reno, and Elko.

ADM executed the energy models with and without airside economizers on the HVAC equipment. Airside economizers allow a cooling system to supply outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather. The economizers reduce the runtime on the AC compressors and thus decrease the $EFLH_C$. Additionally, building codes require economizers on certain types and sizes of equipment. ADM evaluated the models with and without economizers to provide a more comprehensive list of appropriate $EFLH_C$ values.

Using the results of the energy simulations, ADM calculated the $EFLH_C$ as:

$$EFLH_C = \frac{kWh_{usage}}{Cap_{tot} \times EIR_{cooling} \times 0.2931 \frac{kW}{kBTUhr}}$$

Where:

$EFLH_C$ = *EFLH (cooling)*

kWh_{usage} = *Total annual energy usage of all equipment (cooling)*

Cap_{tot} = *Full Load capacity (kBTU/hr) of all equipment (cooling)*

$EIR_{cooling}$ = *Electric Input Ratio (BTU/BTU) from DOE-2 model. Defined as 1/COP for the cooling unit at ARI rated conditions.*

For either PTAC or Air-Cooled Units, Table C-23 below provides a list of the recommended $EFLH_c$ by facility type.

[17] Chapter 6 of the 2004-2005 DEER Update Study provides detailed energy model descriptions. See, http://deeresources.com/files/deer2005/downloads/DEER2005UpdateFinalReport_ItronVersion.pdf.

Table C-23. Recommended Deemed Savings Algorithm, EFLHc by Facility Type

Building Type	With Economizer			Without Economizer		
	Reno	Las Vegas	Elko	Reno	Las Vegas	Elko
Grocery	627	1,611	477	634	1,618	483
Hotel	916	2,062	739	1,158	2,323	921
Hotel Room Units[18]	586	1,258	462	586	1,258	462
Medical Clinic	1,037	1,768	855	1,493	1,963	1,397
Office	624	1,262	518	881	1,513	745
Process Industrial	549	1,407	407	576	1,439	430
Restaurant	767	1,588	624	953	1,798	771
Retail	766	1,737	605	796	1,777	631
Warehouse	282	898	204	282	898	204

C.5 Conclusion and Recommended Next Steps

Using a combination of ex-ante and ex-post data specific to NV Energy's Program, as well as a review of currently utilized TRMs, ADM has provided a list of recommended deemed savings algorithms and values for a range of measures. ADM believes the measures included in this Appendix provide the best opportunity for reducing risk associated with projects and reducing M&V efforts for simple projects while allowing ADM to maintain the overall rigor of M&V activities for the Program. In PY2023, the Program used these values for ex-ante savings calculations and ADM used these values for ex-ante savings calculations. ADM recommends their continued use in PY2024.

[18] EFLH for hotel room units use an average of the DEER prototypical models and calibrated model results for projects incentivized through the Program.

APPENDIX D: PROJECT SPECIFIC REALIZATION RATE VARIANCES

D.1 Project Specific Realization Rate Variances

This chapter provides a description of project-specific findings and causes for realization rate variances. Table D-1 and Table D-2, below, show project level explanation.

Table D-1. Description of NPC Project Specific Realization Rate Variances

Application ID	Ex-Ante Savings (kWh)	Ex-Post Savings (kWh)	Realization Rate	Realization Rate Explanation
SB-23-11672	35,029	34,448	98%	Differences in calculation of savings from the occupancy sensors
SB-23-12329	6,388,355	7,024,864	110%	See site level report in Appendix D
SB-23-12875	110,725	111,055	100%	No difference
SB-23-12949	112,036	111,415	99%	Differences in HVAC capacities and efficiencies
SB-23-12980	253,241	253,241	100%	No difference
SB-23-12990	46,346	47,658	103%	Differences in baseline wattages
SB-23-12992	13,467	13,464	100%	No difference
SB-23-13150	2,243,286	2,049,373	91%	See site level report in Appendix D
SB-23-13179	101,403	101,399	100%	No difference
SB-23-13205	56,518	56,515	100%	No difference
SB-23-13207	28,233	28,233	100%	No difference
SB-23-13219	147,490	124,699	85%	See site level report in Appendix D
SB-23-13229	267,573	263,636	99%	Difference in assumed HOU reduction from daylight dimming
SB-23-13233	956	956	100%	No difference
SB-23-13235	956	956	100%	No difference
SB-23-13242	463,216	463,197	100%	No difference
SB-23-13259	23,182	23,181	100%	No difference
SB-23-13271	444,671	444,671	100%	No difference
SB-23-13272	30,573	29,895	98%	Differences in claimed savings from ice machine
SB-23-13274	9,691	9,691	100%	No difference
SB-23-13286	367,123	367,107	100%	No difference
SB-23-13287	598,227	476,664	80%	See site level report in Appendix D
SB-23-13289	207,349	205,124	99%	Difference in savings calculations from the refrigerator and freezer case lighting
SB-23-13294	1,874	1,300	69%	See site level report in Appendix D
SB-23-13297	139,818	139,818	100%	No difference
SB-23-13321	819,675	819,670	100%	No difference
SB-23-13322	9,493	9,493	100%	No difference
SB-23-13325	1,578,620	1,578,620	100%	No difference
SB-23-13337	18,192,873	18,192,873	100%	See site level report in Appendix D
SB-23-13383	9,972	9,971	100%	No difference
SB-23-13409	4,205,571	4,209,735	100%	See site level report in Appendix D
SB-23-13456	63,211	63,209	100%	No difference
SB-23-13577	2,149,206	2,155,407	100%	No difference
SB-23-13608	4,577,191	4,371,231	96%	See site level report in Appendix D
SB-23-13645	2,337,370	2,337,370	100%	See site level report in Appendix D
SB-23-13787	1,642,786	1,642,786	100%	No difference

Application ID	Ex-Ante Savings (kWh)	Ex-Post Savings (kWh)	Realization Rate	Realization Rate Explanation
SB-23-13788	654,824	654,824	100%	No difference
SB-23-13789	2,465,745	2,465,745	100%	See site level report in Appendix D
SB-23-13791	3,475,660	3,445,660	99%	See site level report in Appendix D
SB-23-13792	611,600	611,600	100%	No difference
SB-23-13809	3,359,158	3,359,158	100%	See site level report in Appendix D
SD-23-7064	7,688	7,970	104%	Differences in prescriptive HOUs
SD-23-7066	56,909	58,611	103%	Differences in prescriptive HOUs
SD-23-7067	25,293	26,222	104%	Differences in prescriptive HOUs
SD-23-7071	59,055	61,225	104%	Differences in prescriptive HOUs
SD-23-7074	9,776	10,135	104%	Differences in prescriptive HOUs
MID-23-06148	4,001	4,025	101%	Differences in baseline wattages
MID-23-06157	6,037	6,085	101%	Differences in baseline wattages
MID-23-06158	19,422	19,517	100%	No difference
MID-23-06161	132,521	132,521	100%	No difference
MID-23-06162	121,778	121,811	100%	No difference
MID-23-06172	31,196	31,196	100%	No difference
MID-23-06177	27,333	27,333	100%	No difference
MID-23-06178	10,250	10,250	100%	No difference
MID-23-06181	13,424	13,690	102%	Differences in baseline wattages
MID-23-06185	314,801	314,801	100%	No difference
MID-23-06190	17,158	17,158	100%	No difference
MID-23-06191	2,255	2,255	100%	No difference
MID-23-06192	39,774	40,104	101%	Differences in baseline wattages
MID-23-06195	25,252	25,271	100%	No difference
MID-23-06203	31,059	31,059	100%	No difference
MID-23-06208	3,298	3,298	100%	No difference

Table D-2. Description of SPPC Project Specific Realization Rate Variances

Application ID	Ex-Ante Savings (kWh)	Ex-Post Savings (kWh)	Realization Rate	Realization Rate Explanation
SB-23-12888	74,473	75,192	101%	Differences in post wattages
SB-23-12903	19,977	19,976	100%	No difference
SB-23-12954	617,492	617,530	100%	See site level report in Appendix D
SB-23-13054	867,851	867,849	100%	See site level report in Appendix D
SB-23-13134	34,059	33,001	97%	Differences in HCIF
SB-23-13142	25,164	25,212	100%	No difference
SB-23-13176	72,856	73,560	101%	Differences in post wattages
SB-23-13195	74,613	72,507	97%	Differences in HCIF
SB-23-13224	5,880	5,881	100%	No difference
SB-23-13234	6,720	6,721	100%	No difference
SB-23-13240	14,604	14,605	100%	No difference
SB-23-13267	137,757	137,766	100%	No difference
SB-23-13279	389,121	388,856	100%	No difference
SB-23-13280	544,437	565,194	104%	See site level report in Appendix D
SB-23-13284	208,335	208,348	100%	No difference
SB-23-13300	3,024	2,970	98%	Differences in prescriptive HOUs
SB-23-13324	26,025	25,274	97%	Differences in prescriptive HOUs
SB-23-13332	78,052	78,057	100%	No difference

Application ID	Ex-Ante Savings (kWh)	Ex-Post Savings (kWh)	Realization Rate	Realization Rate Explanation
SB-23-13334	358,992	358,992	100%	No difference
SB-23-13392	1,351,797	1,248,177	92%	See site level report in Appendix D
SB-23-13404	498,465	495,641	99%	See site level report in Appendix D
SB-23-13406	24,749	24,751	100%	No difference
SB-23-13442	474,179	438,978	93%	Trimmed monitored data to remove unusual readings, found average savings for each hour of a given week
SB-23-13596	2,650,272	2,650,048	100%	See site level report in Appendix D
SB-23-13612	1,885,745	1,885,862	100%	See site level report in Appendix D
SB-23-13632	1,367,159	1,340,352	98%	See site level report in Appendix D
SB-23-13728	8,506,699	8,506,700	100%	See site level report in Appendix D
SB-23-13731	1,492,318	1,495,348	100%	See site level report in Appendix D
SB-23-13812	1,604,588	1,854,837	116%	See site level report in Appendix D
SD-23-7069	25,459	26,367	104%	Differences in prescriptive HOUs
MID-23-06146	1,723	1,723	100%	No difference
MID-23-06147	52,646	52,646	100%	No difference
MID-23-06150	108,560	108,560	100%	No difference
MID-23-06151	17,232	17,232	100%	No difference
MID-23-06152	51,695	51,695	100%	No difference
MID-23-06155	909	909	100%	No difference
MID-23-06156	103,391	103,391	100%	No difference
MID-23-06160	7,065	7,065	100%	No difference
MID-23-06163	24,965	24,965	100%	No difference
MID-23-06169	8,788	8,860	101%	Differences in baseline wattages
MID-23-06173	11,804	11,804	100%	No difference
MID-23-06176	51,695	51,695	100%	No difference
MID-23-06182	39,514	39,514	100%	No difference
MID-23-06189	3,619	3,619	100%	No difference
MID-23-06209	6,203	6,203	100%	No difference

Application ID: SB-23-12329

Project Summary

The customer received incentives for a newly constructed warehouse building that exceeds the following IECC 2018 building code. The warehouse has warehouse spaces (601,600 sq. ft.), offices (44,722 sq. ft.), breakrooms (3,250 sq. ft.), and electrical/mechanical rooms (1,998 sq. ft.).The building exceeded the IECC 2018 building code with its:

- Interior Lighting Power Density
- Exterior Lighting Power Density
- Efficient Envelope Insulation
- Efficient Windows
- Efficient HVAC Equipment

ADM staff verified energy savings by evaluating the accuracy of the provided energy models and verifying equipment installation. Savings are calculated using two Energy Models: baseline and as-built. The baseline model was compared to the IECC 2018 building code's HVAC equipment, lighting, and envelope input parameters. The as-built model was compared to the site notes, complete design drawings, and submittal documents.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	5,722,618	6,352,847	95,292,705	15.00	111%
Lighting	Option A-: TRM (Or other Deemed) Analysis	665,737	672,017	10,080,255	15.00	101%
Total:		6,388,355	7,024,864	105,372,960	15.00	110%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from new construction energy simulations can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} \left(kW_{h,base} - kW_{h,as-built}\right)$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓			✓
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The ex-ante and ex-post model inputs were different for cooling efficiencies.

When determining ex-post verified savings, ADM reviewed all of the relevant model input values. ADM ensured that the baseline case model matched the IECC 2018 building code requirements. ADM confirmed aspects of the proposed models with the provided as-built design drawings and equipment submittals. Additionally, ADM compared the baseline and proposed energy model with each other to ensure that the only differences between the models were stated energy savings measures that would qualify for utility incentives.

The high realization rate comes from adjusting HVAC equipment code baselines.

Application ID: SB-23-13150

Project Summary

The customer received incentives for a newly constructed warehouse building that exceeds the following IECC 2018 building code. The warehouse includes warehouse spaces (132,776 sq. ft.), offices (5,876 sq. ft.), exterior van canopies (85,323 sq. ft.), and parking and drives areas (1,034,956 sq. ft.).The building exceeded the IECC 2018 building code with its:

- Interior Lighting Power Density
- Exterior Lighting Power Density
- Efficient Envelope Insulation
- Efficient Windows
- Efficient HVAC Equipment

The customer also received (6) GD Refrigerator 31-50 cu. ft., (2) GD Refrigerator 15-30 cu. ft., and (1) GD Freezer 15-30 cu. ft.

ADM staff verified energy savings by evaluating the accuracy of the provided energy models and verifying equipment installation during a site visit. Savings are calculated using two Energy Models: baseline and as-built. The baseline model was compared to the IECC 2018 building code's HVAC equipment, lighting, and envelope input parameters. The as-built model was compared to the site notes, complete design drawings, and submittal documents.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	1,979,286	1,785,253	26,778,795	15.00	90%
Kitchen Equipment	Option A-: TRM (Or other Deemed) Analysis	6,661	6,661	99,915	15.00	100%
Lighting	Option A-: TRM (Or other Deemed) Analysis	257,339	257,459	3,861,885	15.00	100%
Total:		2,243,286	2,049,373	30,740,595	15.00	91%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from new construction energy simulations can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{h,base} - kW_{h,as-built})$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Kitchen Equipment: Energy savings for commercial kitchen equipment come from the BES M&V Report Appendix C Methodology and Recommended Deemed Savings Algorithms and Values.

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓			✓
Kitchen Equipment			✓			
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The ex-ante and ex-post model inputs were different for cooling efficiencies, heating efficiencies, wall insulation thickness, window shading, and lighting power density.

When determining ex-post verified savings, ADM reviewed all of the relevant model input values. ADM

ensured that the baseline case model matched the IECC 2018 building code requirements. ADM confirmed aspects of the proposed models with the provided as-built design drawings and equipment submittals. Additionally, ADM compared the baseline and proposed energy model with each other to ensure that the only differences between the models were stated energy savings measures that would qualify for utility incentives.

The main reason for the low realization rate comes from the difference in the interior light baseline. The ex-post calculation used the IECC 2018 interior light baseline for the space-by-space method, for a warehouse with medium to bulky palletized items.

Application ID: SB-23-13219

Project Summary

The customer received incentives for a new construction project which included: HVAC measures, interior lighting, and exterior lighting.

The customer installed 26 HVAC units. The efficiency and size of the HVAC units were verified by reviewing the equipments model number. The baseline efficiency of the HVAC were determined by using the IECC 2018 building code. Below is a list of the installed HVAC units:

- (6)Daikin REYQ120XAYD 114,000 BTU/hr 13.20 EER
- (8) Daikin REYQ96XAYD 92,000 BTU/hr 14.6 EER
- (4) Daikin REYQ144XAYD 138,000 BTU/hr 11.9 EER
- (2) Daikin RX18RMVJU9A 17,400 BTU/hr 19.3 SEER
- (3) Daikin RXS24LVJU 21,400 BTU/hr 20 SEER
- (1) Daikin RK24AXVJU 21,200 BTU/hr 20.00 SEER
- (2) Daikin DPS020AHMY4DW-4 341,200 BTU/hr 11.3 IEER

For the lighting measures, the lighting HOU were based on the provided documentation. Specification sheets were used to verify ex-post fixture wattages. Building plans, invoices, and post installation inspection notes were used to verify lighting counts and as-built lighting power density. The baseline lighting power density was determined by the IECC 2018 building code. The table below shows specifications for the lighting measures.

Location	Area (sq. ft.)	Baseline Lighting Power Density (W/sq. ft.)	As-Built Lighting Power Density (W/sq. ft.)	Pre HOU (hr)	Post HOU (hr)	HCIF
Office	12,553	0.79	0.61	2,132	2,132	1.13
Garage 1st and 2nd Floor	70,803	0.14	0.04	4,313	4,313	1.00
Surface Parking Lot	61,050	0.08	0.05	4,313	4,313	1.00
Walkways	1,160	0.07	0.21	4,313	4,313	1.00
Office Building Uplighting	42,605	0.15	0.1	4,313	4,313	1.00
Trees Uplighting	1,495	0.04	0.15	4,313	4,313	1.00
Top Level Parking Garage	35,418	0.08	0.05	4,313	4,313	1.00

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
HVAC	Option A-: TRM (Or other Deemed) Analysis	66,854	66,593	998,895	15.00	100%
Lighting	Option A-: TRM (Or other Deemed) Analysis	80,636	58,106	692,047	11.91	72%
Total:		147,490	124,699	1,690,942	13.56	85%

Table 1: Measure Details

M&V Methodology

HVAC: Energy savings from HVAC measures can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = CAP_c * EFLH_c \left(\frac{1}{EER_{base}} - \frac{1}{EER_{post}}\right)$$

Definition of Variables

CAP_c = Rated equipment cooling capacity of the new unit (BTU/hr)

$EFLH_c$ = Equivalent full-load hour for cooling (hr)

EER_{base} = Full Load baseline energy efficiency rating of the baseline cooling equipment

EER_{post} = Full Load nameplate energy efficiency rating of the installed cooling equipment

Lighting: Energy savings from new construction lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = ft^2_{lightingproject} * \left(\frac{kW}{ft^2}_{LPDbase} - \frac{kW}{ft^2}_{LPDas-built}\right) * HOU * HCIF$$

Definition of Variables

$ft^2_{lightingproject}$ = area of lighting project

$\frac{kW}{ft^2}_{LPDbase}$ = kilowatts per square foot of lighting project in base case

$\frac{kW}{ft^2}_{LPDas-built}$ = kilowatts per square foot of lighting project in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
HVAC	✓	✓	✓			
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

HVAC unit size and efficiency specifications were verified with a model number lookup. HVAC EFLH were verified based on the facility's location and type.

Pre lighting power densities were verified with 2018 IECC baseline code and the areas of each facility location. Post lighting power densities were verified with lighting fixture quantities, specification sheets, and areas of facility location.

For the exterior fixtures, the prescriptive HOU (4,313 hr) for exterior light were used. For the interior fixtures, the prescriptive HOUs for offices with occupancy sensors reductions (3,045 hr * (1-0.3)= 2,132 hr) were used.

Ex-ante calculations added the IECC 2018 Lighting Power Allowances for Building Exteriors in Zone 4 to every exterior lighting line item in the ex-ante calculator (5 times). Lighting power allowances should only be applied once to the whole exterior lighting project.

The project's differences come from the differences in the ex-ante and ex-post lighting calculations, specifically from the incorporation of Lighting Power Allowances for Building Exteriors.

Application ID: SB-23-13287

Project Summary

The customer received incentives for a new construction project at a retirement home which included: HVAC measures, kitchen equipment, interior lighting, and exterior lighting.

The customer installed 42 HVAC units. The efficiency and size of the HVAC units were verified by reviewing the equipments model number. The baseline efficiency of the HVAC units were determined by using the IECC 2018 building code. Below is a list of the installed HVAC units:

- (15) Friedrich PDE12K3SG 11,760 BTU/hr 11.60 EER
- (5) Trane 4TWR5030H 27,240 BTU/hr 15.25 EER
- (8) Trane 4TWR5024H 24,240 BTU/hr 15.00 EER
- (1) Captive Air CASRTU3-I,200-18-12.5T 153,960 BTU/hr 14.90 EER
- (4) Captive Air CASRTU3-I,200-18-6T 84,000 BTU/hr 13.64 EER
- (5) Trane 4TWR5036H 34,800 BTU/hr 15.00 EER
- (2) Trane 4TWR5048H 48,000 BTU/hr 15.00 EER
- (1) CaptiveAire CASRTU2-I.200-18-10T 120,000 BTU/hr 13.01 EER
- (1) Daikin RXB18AXVJU 18,000 BTU/hr 17 EER

The customer installed the commercial kitchen equipment listed below. Each of these kitchen equipment measures use agreed upon deemed energy savings values shown in Appendix C Methodology and Recommended Deemed Savings Algorithms and Values.

- (6) Kitchen Ventilation Hold Controllers
- (1) Cres Cor H137WSUA12D15A Hot Food Holding Cabinet
- (1) Scotsman Ice Systems N0933A-32E Ice Machine
- (3) Delfield 406P Vertical Solid Door Refrigerator

The new construction lighting project included interior and exterior light fixtures. The baseline lighting power density was determined with the IECC 2018 building code. Building plans, invoices, and post-installation inspection notes were used to verify fixture counts and as-built lighting power density. Specification sheets were used to verify ex-post fixture wattages. The table below shows the lighting calculation key variables.

Location	Area (sq. ft.)	Baseline Lighting Power Density (W/sq. ft.)	As-Built Lighting Power Density (W/sq. ft.)	Pre HOU (hr)	Post HOU (hr)	HCIF
Elec Mech	1,456	0.43	-	-	-	-
Fitness	1,237	0.62	0.45	5,256	5,256	1.13
Food Prep	1,928	1.06	0.34	8,760	8,760	1.13
Audience Seating Area	3,526	2.03	0.26	6,132	6,132	1.13
Sales Area	11,521	1.22	0.32	5,782	5,782	1.13
Dining Area	6,323	0.71	0.40	5,256	5,256	1.13
Living Quarters	134,783	0.54	0.20	2,187	2,187	1.13
Corridor	17,124	0.66	0.41	8,760	8,760	1.13
Uncovered Parking Lot and Drives	124,000	0.04	0.00	4,313	4,313	1.00
Sidewalks	3,565	0.50	0.06	4,313	4,313	1.00
Wide walks	1,250	0.10	0.32	4,313	4,313	1.00
Entrances	140	14.00	2.60	4,313	4,313	1.00
Building Facade	138,600	0.10	0.00	4,313	4,313	1.00
Carport	18,250	0.25	0.02	4,313	4,313	1.00
Main Entry	1,455	0.25	0.14	4,313	4,313	1.00
Pool Plaza	10,844	0.10	0.03	4,313	4,313	1.00

The lighting HOU were based on the provided documentation and the assumed location. The exterior lights use the prescriptive HOU(4,313 hr). The interior lights in the facility's common areas run continuously throughout the year (8,760 hr) The interior lights in the resident's living quarters have an HOU from the 2016 DEER Commercial Indoor Lighting Profile for a patient room at a nursing home (2,187 hr).

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
HVAC	Option A-: TRM (Or other Deemed) Analysis	31,003	32,458	476,483	14.68	105%
Kitchen Equipment	Option A-: TRM (Or other Deemed) Analysis	31,551	38,872	549,098	14.13	123%
Lighting	Option A-: TRM (Or other Deemed) Analysis	535,672	405,334	4,641,074	11.45	76%
Total:		598,226	476,664	5,666,655	11.89	80%

Table 1: Measure Details

M&V Methodology

HVAC: Energy savings from HVAC measures can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = CAP_c * EFLH_c \left(\frac{1}{EER_{base}} - \frac{1}{EER_{post}}\right)$$

Definition of Variables

CAP_c = Rated equipment cooling capacity of the new unit (BTU/hr)

$EFLH_c$ = Equivalent full-load hour for cooling (hr)

EER_{base} = Full Load baseline energy efficiency rating of the baseline cooling equipment

EER_{post} = Full Load nameplate energy efficiency rating of the installed cooling equipment

Kitchen Equipment: Energy savings for commercial kitchen equipment come from the BES M&V Report Appendix C Methodology and Recommended Deemed Savings Algorithms and Values.

Lighting: Energy savings from new construction lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = ft^2_{lightingproject} * \left(\frac{kW}{ft^2}_{LPDbase} - \frac{kW}{ft^2}_{LPDas-built}\right) * HOU * HCIF$$

Definition of Variables

$ft^2_{lightingproject}$ = area of lighting project

$\frac{kW}{ft^2}_{LPDbase}$ = kilowatts per square foot of lighting project in base case

$\frac{kW}{ft^2}_{LPDas-built}$ = kilowatts per square foot of lighting project in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
HVAC		✓	✓			
Kitchen Equipment			✓			
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

HVAC size and efficiency specifications were verified with a model number lookup. HVAC EFLH was verified based on the facility's location and facility type.

The kitchen equipment measure deemed savings were verified with a model number lookup.

Pre lighting power densities were verified with 2018 IECC baseline code and area of each facility location. Post lighting power densities were verified with lighting fixture quantities, specification sheets, and the area of each facility location.

Prescriptive and custom HOU were used. For the exterior fixtures, the prescriptive HOU (4,313 hr) for exterior lights were used. For the interior fixtures, custom HOU were used. Common area light fixtures were verified to always be on (8,760 hr). Facility locations with occupancy sensors or daylight dimming controls had the appropriate prescriptive HOU reductions applied based on the facility location's control type. The interior lights in the residents' living quarters are assumed to be on 2,187 hr per year.

Ex-ante calculations assumed the lights in the residents' living quarters to be on 12 hours per day or 4,380 hours per year. The HOU from the 2016 DEER Commercial Indoor Lighting Profile for a patient room at a nursing home (2,187 hr) provided a reasonable and defensible HOU for the resident's living quarters.

The main difference for the project comes from differences in the lighting measures calculation specifically the HOU assumption in the residential living quarters.

Application ID: SB-23-13294

Project Summary

The customer received incentives for an interior lighting project at a retail/service facility. The lighting project removed (20) 109W lighting fixtures and installed (20) 80W LED fixtures. The lighting baseline was determined to be the wattage of the removed lighting fixtures.

Custom HOU were used because the verified HOU were more than 35% different than the prescriptive HOU for a retail/service facility. The verified HOU were found to be 2,241 hrs per year.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	1,874	1,300	19,500	15.00	69%
Total:		1,874	1,300	19,500	15.00	69%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

Custom HOU and HCIF with verified with an interview with the site contact. The HOU were found to be more than 35% different than the prescriptive HOU for a retail/service facility. The HCIF wasfound to be 1.00 because the facility does not have any heating or cooling equipment present.

The post fixture wattages were confirmed with specific sheets. Baseline fixture wattages were confirmed with the baseline wattage table. Quantities were verified with invoices.

Differences come from the verified HOU and HCIF. Ex-ante calculators use prescriptive HOU (5,108 hrs) and HCIF (1.13). Ex-post calculators use custom HOU (2,241 hrs) and HCIF (1.00).

Application ID: SB-23-13337

Project Summary

The customer received incentives for a newly constructed casino resort that exceeds the following IECC 2018 building code. The casino resort consists of 5,200,000 sq. ft of conditioned space. The building exceeded the IECC 2018 building code with its:

- Interior Lighting Power Density
- Exterior Lighting Power Density
- Efficient Envelope Insulation
- Efficient Windows
- Efficient HVAC Equipment

ADM staff verified energy savings by evaluating the accuracy of the provided energy models and verifying equipment installation during a site visit. Savings are calculated using four energy models: baseline and as built. The baseline model was compared to IECC 2018 building code with regard to the HVAC equipment, lighting, and envelope input parameters. The as-built model was compared to the site visit notes, complete design drawings, and submittal documents.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	18,192,873	18,192,873	272,893,095	15.00	100%
Total:		18,192,873	18,192,873	272,893,095	15.00	100%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from new construction energy simulations can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} \left(kW_{h,base} - kW_{h,as-built}\right)$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓			✓

Table 2: Data Collection Method By Measure

Key Findings

ADM did a concurrent pre-review M&V process for this project because of the high energy savings to ensure the process and calculated energy savings were done correctly by all parties involved. ADM and the implementation contractor did a joint site visit to verify model inputs and submittals

When determining ex-post verified savings, ADM reviewed all of the relevant model input values and ensured that all values matched the IECC 2018 building code requirements for the baseline case and the provided as built design submittal drawings for the proposed model. Additionally, ADM compared the baseline and proposed energy model with each other to ensure that the only differences between the models were stated energy savings measures that would qualify for utility incentives.

No discrepancies were discovered during the concurrent pre-review process or ex-post evaluation.

Application ID: SB-23-13409

Project Summary

The customer received incentives for installing LED lighting fixtures in a newly constructed indoor cannabis growing facility. The lighting project installed (537) 1,000W and (160) 600W LED fixtures. The 1,000W fixtures were installed in the facility's combination room and the 600W fixtures were installed in the vegetation room.

The "New Construction Horticultural LED Lighting Savings Methodology for Cannabis" work paper, written by ADM, was used to establish appropriate new construction lighting baselines. Specific baselines are based on the plant's growing stage and the facility's growing room type. Furthermore, HCIF are based on the plant's growing stage.

The HOU were provided by the customer. The (537) 1,000W LED fixtures in the combination room operate on a 40-week growing cycle. The growing cycle in the combination room has two different growing stages: vegetative and flowering. There are 3 weeks in the vegetative stage and 37 weeks in the flowering stage. The vegetative stage has the lights on for 24 hours per day. The flowering stage has the lights on for 12 hours per day. The combination room lights have an HOU of 2,520 hr in the vegetative stage and an HOU of 3,120 hr in the flowering stage.

The (160) 600W LED fixtures in the vegetative rooms are on continuously throughout the year (8,760 hr) in a vegetative stage.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	4,205,571	4,209,735	51,990,227	12.35	100%
Total:		4,205,571	4,209,735	51,990,227	12.35	100%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from custom lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} HCIF_h * (N_{base} * kW_{base} * f_{dimmed,h,base} - N_{as-built} * kW_{as-built} * f_{dimmed,h,as-built})$$

Definition of Variables

h = hour of year

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$f_{dimmed,h,base}$ = percent dimming of lights at a given hour of the year in base base

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

$f_{dimmed,h,as-built}$ = percent dimming of lights at a given hour of the year in as-built case

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The lighting baselines and HCIF were verified with the "New Construction Horticultural LED Lighting Savings Methodology for Cannabis" work paper based on space types.

The post fixture wattages were confirmed in specification sheets. Fixture quantities were confirmed with supporting documentation. Custom HOU were based on information provided by the customer.

No differences were found.

Application ID: SB-23-13608

Project Summary

The customer received incentives for a newly constructed warehouse building that exceeds the following IECC 2018 building code. The warehouse includes warehouse spaces (638,835 sq. ft.), and offices (17,916 sq. ft.).The building exceeded the IECC 2018 building code with its:

- Interior Lighting Power Density
- Exterior Lighting Power Density
- Efficient Envelope Insulation
- Efficient Windows
- Efficient HVAC Equipment

The customer also received (2) GD Refrigerator 31-50 cu. ft.

ADM staff verified energy savings by evaluating the accuracy of the provided energy models and verifying equipment installation. Savings are calculated using two Energy Models: baseline and as-built. The baseline model was compared to IECC 2018 building code with regard to the HVAC equipment, lighting, and envelope input parameters. The as-built model was compared to the site notes, complete design drawings, and submittal documents.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	4,432,692	4,226,926	63,403,890	15.00	95%
Kitchen Equipment	Option A-: TRM (Or other Deemed) Analysis	1,480	1,480	22,200	15.00	100%
Lighting	Option A-: TRM (Or other Deemed) Analysis	143,019	142,825	2,142,375	15.00	100%
Total:		4,577,191	4,371,231	65,568,465	15.00	96%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from new construction energy simulations can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{h,base} - kW_{h,as-built})$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Kitchen Equipment: Energy savings for commercial kitchen equipment come from the BES M&V Report Appendix C Methodology and Recommended Deemed Savings Algorithms and Values.

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓			
Kitchen Equipment			✓			
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The ex-ante and ex-post model inputs were different for cooling efficiencies for various baseline and proposed HVAC equipment.

When determining ex-post verified savings, ADM reviewed all of the relevant model input values. ADM

ensured that the baseline case model matched the IECC 2018 building code requirements. ADM confirmed aspects of the proposed models with the provided as-built design drawings and equipment submittals. Additionally, ADM compared the baseline and proposed energy model with each other to ensure that the only differences between the models were stated energy savings measures that would qualify for utility incentives.

Differences come from adjusting HVAC equipment code baselines.

Application ID: SB-23-13645

Project Summary

The customer received incentives for a newly constructed casino resort that exceeds the following IECC 2018 building code. The building exceeded the IECC 2018 building code with its:

- Interior Lighting Power Density
- Exterior Lighting Power Density
- Efficient Envelope Insulation
- Efficient Windows
- Efficient HVAC Equipment

ADM staff verified energy savings by evaluating the accuracy of the provided energy models and verifying equipment installation. Savings are calculated using two Energy Models: baseline and as-built. The baseline model was compared to the IECC 2018 building code's HVAC equipment, lighting, and envelope input parameters. The as-built model was compared to the site notes, complete design drawings, and submittal documents.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	2,337,370	2,337,370	35,060,550	15.00	100%
Total:		2,337,370	2,337,370	35,060,550	15.00	100%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from new construction energy simulations can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{h,base} - kW_{h,as-built})$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

ADM completed a concurrent pre-review M&V process for this project because of the high energy savings to ensure the process and calculated energy savings were done correctly by all parties involved.

When determining ex-post verified savings, ADM reviewed all of the relevant model input values and ensured that all values matched the IECC 2018 building code requirements for the baseline case and the provided as built design submittal drawings for the proposed model. Additionally, ADM compared the baseline and proposed energy model with each other to ensure that the only differences between the models were stated energy savings measures that would qualify for utility incentives.

Guest Room Energy Management (GREM) savings were confirmed to not be part of the energy model and instead were added as prescriptive savings (250 kWh per unit) based on the number of guest room energy management systems (243).

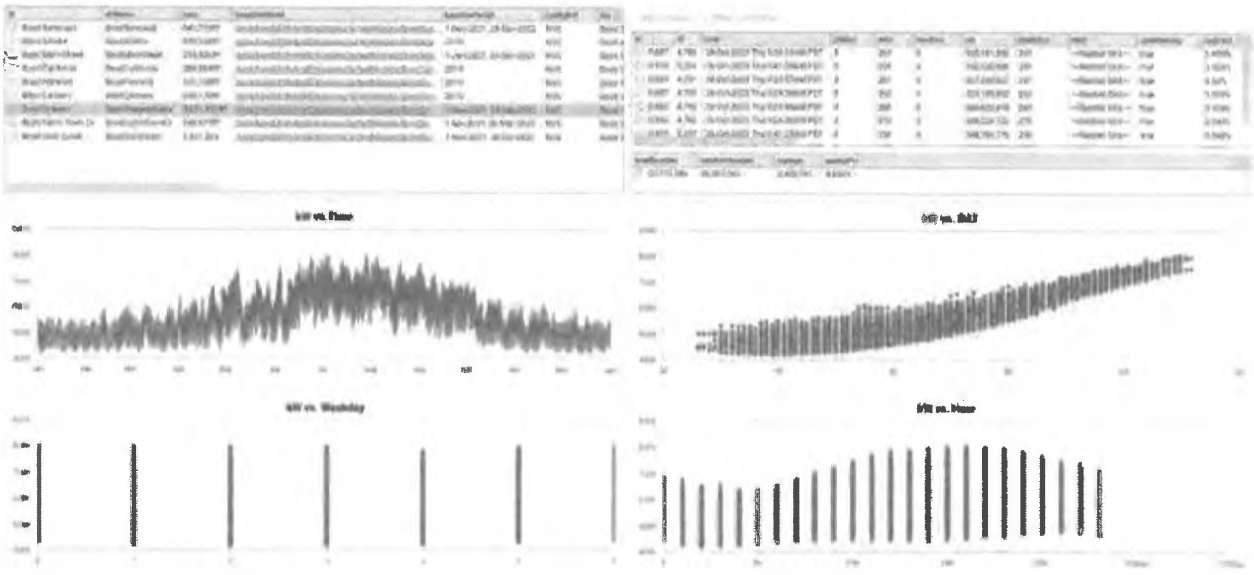
No discrepancies were discovered during the oncurrent pre-review M&V process.

Application ID: SB-23-13789

Project Summary

The customer received incentives for implementing a whole building Monitoring-Based Commissioning (MBCx) project at a casino resort. The implementor installed monitoring equipment throughout the buildings HVAC systems to collect data regarding the status and operations of the equipment. The implementor used this data to provide guidance for building staff to improve the HVAC systems operation and reduce energy consumption.

The image below shows the results from the MBCx regressions.



Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	2,465,745	2,465,745	36,986,175	15.00	100%
Total:		2,465,745	2,465,745	36,986,175	15.00	100%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from MBCx projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{h,base} - kW_{h,as-built})$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓		✓		✓	✓

Table 2: Data Collection Method By Measure

Key Findings

The implementor provided an M&V process to estimate energy savings by looking at the utility billing data before and after the MBCx process. Utility billing data regressions were created using the SkySpark software to estimate energy savings. ADM reviewed the projects reports and regressions for accuracy and validity.

The baseline measurement period was November 2021 to September 2022 and a post-regression period of October 2022 to September 2023. These measurement periods are a full year of data and adequately represent both the heating and cooling weather dependencies.

The regressions used the following variables: hourly billing data, hour of the day, day of the week, outside wet bulb temperature (F), and outside dry bulb temperature (F). The baseline and post regression models were analyzed with actual weather data. Once the models were created, the model variables were applied to TMY3 weather data for typical year savings.

Building occupancy was determined to not be a factor in this regression because the building was almost back to full operation during the post measurement period and occupancy levels do not appear to have an effect on building energy usage. This is evident in the data because there is a strong correlation in the data using weather data. Additionally, ADM knows that this building type can have seasonal building occupancy that can vary by 20% with no measurable difference in energy usage. Therefore, ADM did not include any occupancy variable.

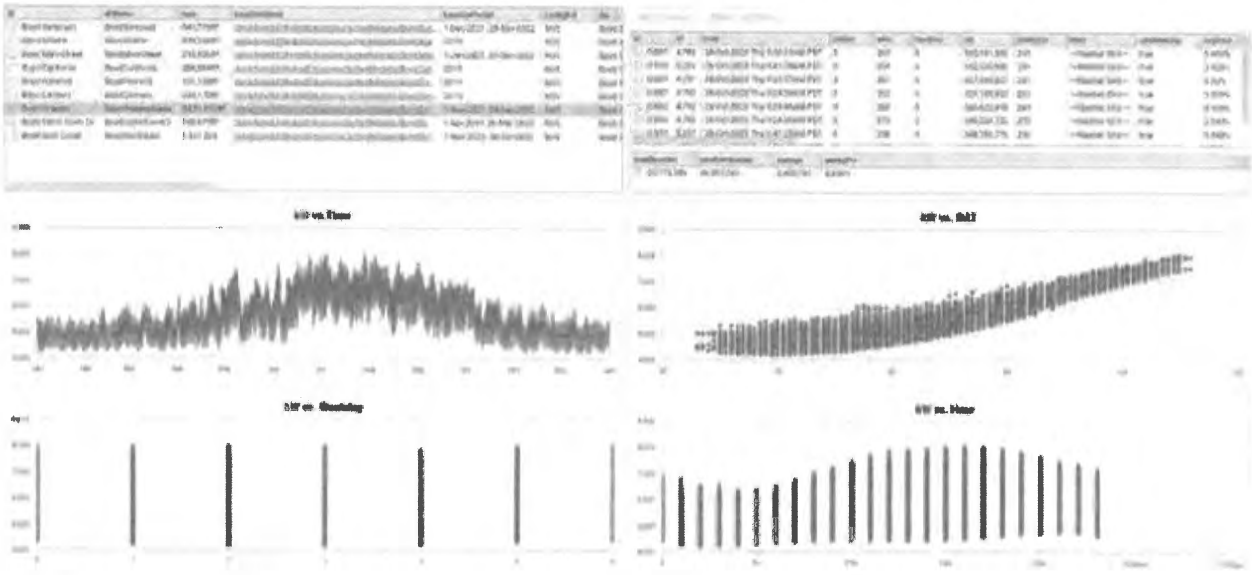
No differences were found.

Application ID: SB-23-13791

Project Summary

The customer received incentives for implementing a whole building Monitoring-Based Commissioning (MBCx) project at a casino resort. The implementor installed monitoring equipment throughout the buildings HVAC systems to collect data regarding the status and operations of the equipment. The implementor used this data to provide guidance for building staff to improve the HVAC systems operation and reduce energy consumption.

The image below shows the results from the MBCx regressions.



Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option A-: TRM (Or other Deemed) Analysis	3,475,660	3,445,660	51,684,900	15.00	99%
Total:		3,475,660	3,445,660	51,684,900	15.00	99%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from MBCx projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{h,base} - kW_{h,as-built})$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓			✓

Table 2: Data Collection Method By Measure

Key Findings

The implementor provided an M&V process to estimate energy savings by looking at the utility billing data before and after the MBCx process. Utility billing data regressions were created using the SkySpark software to estimate energy savings. ADM reviewed the projects reports and regressions for accuracy and validity.

The baseline measurement period was April 2019 to March 2020 and a post-regression period of September 2022 to September 2023. These measurement periods are a full year of data and adequately represent both the heating and cooling weather dependencies.

The regressions used the following variables: hourly billing data, hour of the day, day of the week, outside wet bulb temperature (F), and outside dry bulb temperature (F). The baseline and post regression models were analyzed with actual weather data. Once the models were created, the model variables were applied to TMY3 weather data for typical year savings.

Building occupancy was determined to not be a factor in this regression because the building was almost back to full operation during the post measurement period and occupancy levels do not appear to have an effect on building energy usage. This is evident in the data because there is a strong correlation in the data using weather data. Additionally, ADM knows that this building type can have seasonal building occupancy that can vary by 20% with no measurable difference in energy usage. Therefore, ADM did not include any occupancy variable.

The difference in ex-post savings and ex-ante savings comes from a typo carried through the ex-ante M&V report. The ex-post savings (3,445,660 kWh) are equal to the savings reported by the Skyspark modeling tool. However, the summary of findings section of the ex-ante M&V report states different savings (3,475,660 kWh). The savings stated in the summary of findings section were assumed to be the correct ex-ante savings, not the savings found with Skyspark modeling tool.

Application ID: SB-23-13809

Project Summary

The customer received incentives for a lighting project throughout its casino. The lighting project included:

- replacing (450) 3 Lamp Florescent T-8 lamps with (450) LED BPL 2x4 - 3M50TRI lamps
- replacing (3,450) 35 Watt Cold Cathode lamps with (3,450) FB11 D40 24E 12 SCL 92 lamps
- replacing (1,600) 35 Watt Cold Cathode lamps with (1,600) FT06 03D 2527 E E12 lamps
- replacing (4,800) 32 Watt PAR16 lamps with (4,800) MR16 LED 7.5 W 12V lamps
- replacing (950) Florescent T-8 lamps with (950) 18W 4ft LED T-8 5000k lamps
- replacing (700) Sylvania 60 Watt PAR30 lamps with (700) PAR30SN DIN/927/FL40 lamps

The project uses prescriptive HOU because the verified actual HOU are not more than 35% different than the prescriptive HOU for a casino.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	3,359,158	3,359,158	20,020,582	5.96	100%
Total:		3,359,158	3,359,158	20,020,582	5.96	100%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The baseline fixture wattages were verified to be the removed lighting fixtures' wattages. The installed fixture wattages were confirmed with specification sheets. Lamp quantities were confirmed with supporting documentation. Prescriptive HOU (8,760 hr) and an HCIF (1.13) were used.

No differences were found.

Application ID: SB-23-12954

Project Summary

The customer received incentives for an exterior lighting project at three different correctional centers. The lighting project included:

- replacing (48) 1,000W HPS fixtures with (36) 838W LED fixtures at facility 1
- replacing (104) 1,000W HPS fixtures with (78) 838W LED fixtures at facility 2
- replacing (152) 1,000W HPS fixtures with (114) 838W LED fixtures at facility 3

All installed light fixtures are controlled with photocells. These light fixtures use the prescriptive HOU for exterior fixtures (4,308 hr).

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	617,492	617,530	9,262,950	15.00	100%
Total:		617,492	617,530	9,262,950	15.00	100%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The baseline fixture wattages were verified to be the removed lighting fixtures' wattages. The installed fixture wattages were confirmed with specification sheets. Fixture quantities were confirmed with supporting documentation. Prescriptive HOU (4,308 hrs) and an HCIF (1.00) for exterior fixtures were used.

No differences were found.

Application ID: SB-23-13054

Project Summary

This customer received incentives for replacing (2) 500-ton injection molding machines (IMMs) with (2) new 500-ton IMMs at a manufacturing facility. Post-data monitoring was completed on each machine. For the baseline, IMMs from previous year projects were used to determine accurate baseline efficiencies. Pounds of produced material were also provided during both data monitoring periods. The customer also provided an estimate for annual pounds produced for each new machine.

This project participated in the prereview process. This process helped align calculation methodologies mainly for establishing a proper baseline and accurately estimating annual production.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option A+: Engineering Analysis (Based on Trend or Monitored Data)	867,851	867,849	13,017,735	15.00	100%
Total:		867,851	867,849	13,017,735	15.00	100%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from injection molding machine replacements can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \left(\frac{kW}{lb}_{avg,in-operation,base} - \frac{kW}{lb}_{avg,in-operation,post}\right) * \frac{lb}{yr}$$

Definition of Variables

$\frac{kW}{lb}_{avg,in-operation,base}$ = average kW per pound of material during base case

$\frac{kW}{lb}_{avg,in-operation,post}$ = average kW per pound of material during post case

$\frac{lb}{yr}$ = estimated annual pounds of material produced

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓	✓	✓	✓

Table 2: Data Collection Method By Measure

Key Findings

Both new IMMs (line 32 and line 33) used pre and post monitored data to establish pre and post operating efficiencies.

The baseline operating efficiencies come from a weighted average of two monitored baseline IMMs from PY2018 (SB-18-09874, SB-18-09786). The baseline operating efficiency was found to be 0.89 kWh/lb.

The post operating efficiencies were calculated using data from the post monitoring period. The calculated post efficiencies are: Line 32 0.566 kWh/lb and Line 33 0.425 kWh/lb.

Prereview discussions were had between the customer, implementation contractor, and ADM to establish an accurate annual pounds produced value for each IMM. Initial annual estimates from the customers did not match the pound produced during the monitoring period. The customer was asked to provide more production data to create a more accurate annual production estimate. The annual production estimates are based on the following time periods: Line 32 4/4/2023-4/24/2023 and Line 33 3/8/2023-4/24/2023. Annual production estimates are 1,000,279 lb for Line 32 and 1,173,187 lb for Line 33.

No differences were found.

Application ID: SB-23-13280

Project Summary

The customer received incentives for an interior lighting new construction project at a warehouse.

The lighting project installed (1,280) 39W LED fixtures in 230,400 square feet of warehouse space. These lights operate continuously throughout the year or 8,760 hrs per year.

The lighting baseline was determined to be 10% better than IECC 2018. The appropriate IECC space type was determined to be Warehouse Storage, Smaller, Hand Carried Items. Thus a 0.62 $\frac{kW}{ft^2}_{LPDbase}$ was chosen for the new construction baseline.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	544,437	565,194	3,227,255	5.71	104%
Total:		544,437	565,194	3,227,255	5.71	104%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from new construction lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = ft^2_{lightingproject} * \left(\frac{kW}{ft^2}_{LPDbase} - \frac{kW}{ft^2}_{LPDas-built}\right) * HOU * HCIF$$

Definition of Variables

$ft^2_{lightingproject}$ = area of lighting project

$\frac{kW}{ft^2}_{LPDbase}$ = kilowatts per square foot of lighting project in base case

$\frac{kW}{ft^2}_{LPDas-built}$ = kilowatts per square foot of lighting project in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The lighting baseline was verified to be 10% better than IECC 2018. The post fixture wattages were confirmed in specification sheets. Fixture quantities and the lighting project area were confirmed with supporting documentation. A custom HOU (8,760) and HCIF (1.05) were confirmed with an interview. The warehouse space was confirmed to have heating and cooling space conditioning.

The main differences stem from the determination of the HCIF. The ex-ante calculation used a prescriptive HCIF (1.02) whereas the ex-post calculation used a custom HCIF (1.05).

Application ID: SB-23-13392

Project Summary

The customer received incentives for an interior lighting major renovation project at a process industrial facility. The lighting project installed (326) 199W LED Highbay fixtures in 230,400 square foot production area. These lights operate continuously throughout the year or 8,760 hrs per year.

This project used the prereview process where the implementation and ADM discussed the best way to calculate the project's savings. Discussions led to an agreed upon baseline determination. The implementation contractor noted several changes to the lighting system's design between pre and post cases. Changes included increasing the lighting requirement (lumens per square foot) for the space. It was determined that using the removed lighting fixtures as the baseline was not appropriate and using a new construction baseline (IECC 2018) would be more appropriate. Thus a 0.90 $\frac{kW}{ft^2}_{LPDbase}$ was chosen for the baseline.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	1,351,797	1,248,177	7,127,091	5.71	92%
Total:		1,351,797	1,248,177	7,127,091	5.71	92%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from new construction lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = ft^2_{lightingproject} * \left(\frac{kW}{ft^2}_{LPDbase} - \frac{kW}{ft^2}_{LPDas-built}\right) * HOU * HCIF$$

Definition of Variables

$ft^2_{lightingproject}$ = area of lighting project

$\frac{kW}{ft^2}_{LPDbase}$ = kilowatts per square foot of lighting project in base case

$\frac{kW}{ft^2}_{LPDas-built}$ = kilowatts per square foot of lighting project in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The prereview process established the new construction baseline and savings calculation method. The post fixture wattages were verified with specification sheets. The quantity of fixtures was verified with an inspection of building drawings. The area of the project was verified with the county's property appraiser documentation. The lights were assumed to be on continuously for a HOU of 8,760 hr. The building was found to not have space cooling or heating. No HVAC systems were found in satellite views or interior pictures.

The main differences come from the determination of the HCIF. The ex-ante calculation used a prescriptive HCIF (1.08). The ex-post calculation used a custom HCIF (1.00) for a facility that doesn't have space cooling or heating.

Application ID: SB-23-13404

Project Summary

The customer received incentives for an interior custom lighting project at a grocery warehouse.

The lighting project included:

- replacing (554) 240W LED fixtures with (538) 95W LED High Bay fixtures with daylight dimming controls using interior photocells

These lights were found to use a custom HOU (8,165 hr * (1-0.29)=5,797 hr). The lights were found to be on for 8,165 hr per year with a daylight dimming control reduction of 29%.

The lighting baseline was determined to be the removed lighting fixtures.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	498,465	495,641	7,434,615	15.00	99%
Total:		498,465	495,641	7,434,615	15.00	99%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from custom lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (N_{base} * kW_{base} * f_{dimmed,h,base} - N_{as-built} * kW_{as-built} * f_{dimmed,h,as-built}) * HCIF_h$$

Definition of Variables

h = hour of year

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$f_{dimmed,h,base}$ = percent dimming of lights at a given hour of the year in base base

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

$f_{dimmed,h,as-built}$ = percent dimming of lights at a given hour of the year in as-built case

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The baseline was verified to be the removed lighting fixtures. The post fixture wattages were confirmed in specification sheets. Fixture quantities were confirmed with supporting documentation. A custom HCIF was calculated using the verified HOU with daylight dimming reductions and the known space conditioning types.

The main differences stem from the determination of the HCIFs. The ex-ante calculation used a prescriptive HCIF (1.05) whereas the ex-post calculation used a custom HCIF (1.04).

Application ID: SB-23-13596

Project Summary

The customer received incentives for installing fans with VFDs in two new construction vegetable drying/curing sheds. Each shed has six cells, each cell installed (5) 25hp fans with VFDs. In total, (60) 25hp fans with VFDs were installed.

There is no code requiring VFDs on the fans because drying/curing shed buildings are not regulated under the IECC 2018 building code. The energy savings is the difference between a fan without a VFD and a fan with a VFD.

The baseline energy consumption was found from power monitoring from fans without VFDs. Baseline power monitoring was completed on similar fans at this site in 2016.

For the post case, two fans from three different cells (Cell 68, Cell 71, and Cell 73) were monitored to find the new fans' energy use. The average new fan energy use was found by averaging the six monitored fans together.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option A+: Engineering Analysis (Based on Trend or Monitored Data)	2,650,272	2,650,048	39,750,720	15.00	100%
Total:		2,650,272	2,650,048	39,750,720	15.00	100%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from air compressor leak repair can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{avg,in-operation,base} - kW_{avg,in-operation,post}) * \%_{h,time,in-operation}$$

Definition of Variables

$kW_{avg,in-operation,base}$ = average kW during base case

$kW_{avg,in-operation,post}$ = average kW during post case

$\%_{time,in-operation}$ = percent of time in full operation

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓		✓	✓

Table 2: Data Collection Method By Measure

Key Findings

The pre and post power monitoring data was processed to find the average kWh usage per operating day per fan. The customer noted that the fans run for 180 days per year.

The annual savings are the difference in energy use between the baseline and post cases.

One small difference was found in how the post energy consumption was calculated for cell 73, however, this changes had a very minor effect on the overall savings.

Application ID: SB-23-13612

Project Summary

The customer replaced many street lights in many towns in northern Nevada. The lighting project included:

- replacing (202) 465W HPS fixtures with (202) 123W LED fixtures
- replacing (517) 188W HPS fixtures with (517) 73W LED fixtures
- replacing (2,973) 138W HPS fixtures with (2,973) 34W LED fixtures

All installed light fixtures are controlled with photocells. These light fixtures use the prescriptive HOU for exterior fixtures (4,308 hr).

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	1,885,745	1,885,862	28,287,930	15.00	100%
Total:		1,885,745	1,885,862	28,287,930	15.00	100%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The baseline fixture wattages were verified to be the removed lighting fixtures' wattages. The installed fixture wattages were confirmed with specification sheets. Fixture quantities were confirmed with supporting documentation. Prescriptive HOU (4,308 hrs) and an HCIF (1.00) for exterior fixtures were used.

No differences were found in the project.

Application ID: SB-23-13632

Project Summary

The customer received incentives for upgrading to LED lighting fixtures in a warehouse. The lighting project included:

- replacing (291) 6-lamp T5HO 351W fixtures with (263) 178W LED High Bay fixtures
- replacing (96) 4-lamp T5HO 234W fixtures with (74) 93W LED High Bay fixtures
- replacing (233) 8' 4-Lamp T8 strip 112W fixtures with (233) 37.2W LED light bar kit fixtures
- replacing (4,364) 8' 2-Lamp T8 strip 59W fixtures with (4,382) 24.5W LED light bar kit fixtures

Custom HOU and HCIF were used because the verified HOU of more the 35% different than the prescriptive HOU for a warehouse. The custom HOU include prescriptive HOU reductions from the installed occupancy sensors.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	1,367,159	1,340,352	18,376,226	13.71	98%
Total:		1,367,159	1,340,352	18,376,226	13.71	98%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from custom lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (N_{base} * kW_{base} * f_{dimmed,h,base} - N_{as-built} * kW_{as-built} * f_{dimmed,h,as-built}) * HCIF_h$$

Definition of Variables

h = hour of year

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$f_{dimmed,h,base}$ = percent dimming of lights at a given hour of the year in base base

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

$f_{dimmed,h,as-built}$ = percent dimming of lights at a given hour of the year in as-built case

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The baseline was verified to be the removed fixtures. The post fixture wattages were confirmed in specification sheets. Fixture quantities were confirmed with supporting documentation.

Custom HOU (8,008 hr * (1-0.3) = 5,621 hrs) and HCIFs (1.00) were used. The customer indicated that the light fixtures are on 22 hours per day with occupancy sensors. No space heating and cooling was verified at this facility thus making its HCIF 1.00.

Differences come from the determination of the HCIF factor. Ex-ante calculations used a prescriptive HCIF (1.02) for a warehouse. Ex-post calculations used a custom HCIF (1.00) for an unconditioned space.

Application ID: SB-23-13728

Project Summary

This large manufacturing customer received incentives for retro-commissioning projects. During the retro-commissioning process, the customer discovered and implemented five energy efficiency measures.

Savings for four custom measures were calculated using pre and post energy trending data provided by the customer. Savings the custom measures were as follows: HVAC Fan Coil Unit controls, High Pressure Compressed Air Staging Redesign, High Temperature Heat Recovery Water Piping Improvements, and Heat Recovery Water Pumping Improvement.

The Warehouse High Bay lighting measure used prescriptive lighting savings algorithms to calculate savings.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	8,457,031	8,457,032	126,855,480	15.00	100%
Lighting	Option A-: TRM (Or other Deemed) Analysis	49,668	49,668	447,012	9.00	100%
Total:		8,506,699	8,506,700	127,302,492	14.96	100%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from the custom measures can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{avg,in-operation,base} - kW_{avg,in-operation,post}) * \%_{h,time,in-operation}$$

Definition of Variables

$kW_{avg,in-operation,base}$ = average kW during base case

$kW_{avg,in-operation,post}$ = average kW during post case

$\%_{time,in-operation}$ = percent of time in full operation

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom		✓	✓	✓		✓
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

Energy Savings for the four custom measures were calculated using the provided energy trending data for the various equipment.

HVAC Fan Coil Units Controls: This measure involved reducing the fan operating speed from 75% to 20% overnight and over the weekends. Savings for this measure were calculated as the difference in the fan energy demand when running the fan at 75% speed and 20% speed. Then multiplied by the amount of hours the fans will be operating at the reduced speed.

High Pressure Compressed Air Staging Redesign: This measure involved adjusting the high pressure compressors to operate in a more efficient setpoint. The staging improvement had two out of five compressors operate at full load and the other three units can operate at a more efficient part load operation. Savings for this measure were calculated as the difference in total energy usage of all five air compressors before and after the staging improvement. The average energy usage for each air compressor was calculated per month based on the provided trending data of the equipment. This difference in average energy usage is then applied to 8,760 annual operating hours.

High Temperature Heat Recovery Water Piping Improvement: This measure involved re-piping the equipment bleed line from the heater outlet. This bleed line is necessary for proper operations from the water heater and was being piped into the medium temperature line that had to be cooled to the desired temperature. The new piping design had this bleed line going into the high temperature return line which increases the return temperature and therefore requires less energy to heat this water back up to the desired supply temperature setpoint. Savings for this measure use hourly trending data from the heater and calculate the energy usage based on the water flowrate, inlet temperature, and output setpoint. Energy savings are the

difference in usage between the energy usage before and after implementation. This difference in average energy usage is then applied to 8,760 annual operating hours.

Heat Recovery Water Pumping Improvements: This pumping improvement reduced the flow rate of the heat recovery water. Pumping is reduced both by VFD speed reduction and pump staging. Savings for this measure use hourly trending data from the pumps and then averaged into before and after energy demand. This difference in average energy usage is then applied to 8,760 annual operating hours.

Warehouse High Bay Lighting: The baseline was verified to be the removed lighting fixtures (226W). The post fixtures (180W LED) were confirmed in specification sheets and invoices. Fixture quantities (150) were confirmed with supporting documentation. Prescriptive hours of use (6,665 hrs) and an HCIFS (1.08) were for interior fixtures in a manufacturing facility.

ADM did a concurrent M&V process for this project because of the high energy savings to ensure the process and calculated energy savings were done correctly by all parties involved. No discrepancies were discovered during the concurrent review.

Application ID: SB-23-13731

Project Summary

The customer received incentives for LED light fixtures during a major renovation at their manufacturing facility. The specifics of the project are shown in the table below.

Location	Area (sq. ft.)	Code Lighting Power Density (W/sq. ft.)	Post Lighting Power Density (W/sq. ft.)	Pre HOU (hr)	Post HOU (hr)	HCIF
Manufacturing Facility	462,764	0.90	0.26	4,666	4,666	1.08

Prescriptive HOU were used with reductions from occupancy sensors (6,665 *(1-0.3)=4,666 hr).

This project used the pre-construction review process where the implementation and evaluation contractors discussed the best way to calculate the project's savings. Discussions led to an agreed upon baseline determination. The implementation contractor noted several changes to the lighting system's design between pre and post cases. Changes included increasing the lighting requirement (lumens per square foot) for the space. It was determined that using the removed lighting fixtures as the baseline was not appropriate and using a new construction baseline (IECC 2018) would be more appropriate. Thus a 0.90 $\frac{kW}{ft^2}_{LPDbase}$ was chosen for the baseline.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	1,492,318	1,495,348	22,430,222	15.00	100%
Total:		1,492,318	1,495,348	22,430,222	15.00	**100%**

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from new construction lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = ft^2_{lightingproject} * \left(\frac{kW}{ft^2}_{LPDbase} - \frac{kW}{ft^2}_{LPDas-built}\right) * HOU * HCIF$$

Definition of Variables

$ft^2_{lightingproject}$ = area of lighting project

$\frac{kW}{ft^2}_{LPDbase}$ = kilowatts per square foot of lighting project in base case

$\frac{kW}{ft^2}_{LPDas-built}$ = kilowatts per square foot of lighting project in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The baseline was verified to be the 2018 IECC lighting power density for the manufacturing facility. The post fixture wattages were confirmed in specification sheets. Fixture quantities were confirmed with supporting documentation. Prescriptive HOU with reductions from occupancy sensors HOU reductions (4,666 hr) and prescriptive HCIF (1.08) were used.

No differences were found, mainly due to the collaborative prereview process.

Application ID: SB-23-13812

Project Summary

The customer received incentives for a newly constructed building that exceeds the following IECC 2018 building code. The building exceeded the IECC 2018 building code with its:

o Interior Lighting Power Density
o Exterior Lighting Power Density
o Efficient Envelope Insulation
o Efficient Windows
o Efficient HVAC Equipment

The customer also received incentives for (11) GD Refrigerators 15-30 cu. ft, (2) HE Ice Machine ES Tier 1,500-1,000, and a (1) GD Refrigerator 31-50 cu. ft.

ADM staff verified energy savings by evaluating the accuracy of the provided energy models and verifying equipment installation during a site visit. Savings are calculated using two Energy Models: baseline and as-built. The baseline model was compared to IECC 2018 building code concerning the HVAC equipment, lighting, and envelope input parameters. The as-built model was compared to the site visit notes, complete design drawings, and submittal documents.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	1,550,989	1,802,476	27,037,140	15.00	116%
Kitchen Equipment	Option A-: TRM (Or other Deemed) Analysis	11,497	11,497	172,455	15.00	100%
Lighting	Option A-: TRM (Or other Deemed) Analysis	42,102	40,864	612,960	15.00	97%
Total:		1,604,588	1,854,837	27,822,555	15.00	116%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from new construction energy simulations can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} \left(kW_{h,base} - kW_{h,as-built}\right)$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Kitchen Equipment: Energy savings for commercial kitchen equipment come from the BES M&V Report Appendix C Methodology and Recommended Deemed Savings Algorithms and Values.

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$
Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓			✓
Kitchen Equipment			✓			
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The evaluation contractor did a full review of the energy simulation model input parameters and checked all relevant values to the IECC 2018 code for the baseline and to the provided as-built design drawings for the proposed model.

The ex-ante and ex-post model inputs differed for cooling efficiencies (baseline and proposed) and lighting power density (baseline).

The reason for the high realization rate is mostly unknown because the provided energy model did not match the stated values in the application.

The evaluation contractor reviewed the provided model, made changes as stated above, and used the savings numbers from the reviewed energy model as the ex-post savings number.

Application ID: SB-23-13287

Project Summary

The customer received incentives for a new construction project at a retirement home which included: HVAC measures, kitchen equipment, interior lighting, and exterior lighting.

The customer installed 42 HVAC units. The efficiency and size of the HVAC units were verified by reviewing the equipments model number. The baseline efficiency of the HVAC units were determined by using the IECC 2018 building code. Below is a list of the installed HVAC units:

- (15) Friedrich PDE12K3SG 11,760 BTU/hr 11.60 EER
- (5) Trane 4TWR5030H 27,240 BTU/hr 15.25 EER
- (8) Trane 4TWR5024H 24,240 BTU/hr 15.00 EER
- (1) Captive Air CASRTU3-I,200-18-12.5T 153,960 BTU/hr 14.90 EER
- (4) Captive Air CASRTU3-I,200-18-6T 84,000 BTU/hr 13.64 EER
- (5) Trane 4TWR5036H 34,800 BTU/hr 15.00 EER
- (2) Trane 4TWR5048H 48,000 BTU/hr 15.00 EER
- (1) CaptiveAire CASRTU2-I.200-18-10T 120,000 BTU/hr 13.01 EER
- (1) Daikin RXB18AXVJU 18,000 BTU/hr 17 EER

The customer installed the commercial kitchen equipment listed below. Each of these kitchen equipment measures use agreed upon deemed energy savings values shown in Appendix C Methodology and Recommended Deemed Savings Algorithms and Values.

- (6) Kitchen Ventilation Hold Controllers
- (1) Cres Cor H137WSUA12D15A Hot Food Holding Cabinet
- (1) Scotsman Ice Systems N0933A-32E Ice Machine
- (3) Delfield 406P Vertical Solid Door Refrigerator

The new construction lighting project included interior and exterior light fixtures. The baseline lighting power density was determined with the IECC 2018 building code. Building plans, invoices, and post-installation inspection notes were used to verify fixture counts and as-built lighting power density. Specification sheets were used to verify ex-post fixture wattages. The table below shows the lighting calculation key variables.

Location	Area (sq. ft.)	Baseline Lighting Power Density (W/sq. ft.)	As-Built Lighting Power Density (W/sq. ft.)	Pre HOU (hr)	Post HOU (hr)	HCIF
Elec Mech	1,456	0.43	-	-	-	-
Fitness	1,237	0.62	0.45	5,256	5,256	1.13
Food Prep	1,928	1.06	0.34	8,760	8,760	1.13
Audience Seating Area	3,526	2.03	0.26	6,132	6,132	1.13
Sales Area	11,521	1.22	0.32	5,782	5,782	1.13
Dining Area	6,323	0.71	0.40	5,256	5,256	1.13
Living Quarters	134,783	0.54	0.20	2,187	2,187	1.13
Corridor	17,124	0.66	0.41	8,760	8,760	1.13
Uncovered Parking Lot and Drives	124,000	0.04	0.00	4,313	4,313	1.00
Sidewalks	3,565	0.50	0.06	4,313	4,313	1.00
Wide walks	1,250	0.10	0.32	4,313	4,313	1.00
Entrances	140	14.00	2.60	4,313	4,313	1.00
Building Facade	138,600	0.10	0.00	4,313	4,313	1.00
Carport	18,250	0.25	0.02	4,313	4,313	1.00
Main Entry	1,455	0.25	0.14	4,313	4,313	1.00
Pool Plaza	10,844	0.10	0.03	4,313	4,313	1.00

The lighting HOU were based on the provided documentation and the assumed location. The exterior lights use the prescriptive HOU(4,313 hr). The interior lights in the facility's common areas run continuously throughout the year (8,760 hr) The interior lights in the resident's living quarters have an HOU from the 2016 DEER Commercial Indoor Lighting Profile for a patient room at a nursing home (2,187 hr).

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
HVAC	Option A-: TRM (Or other Deemed) Analysis	31,003	32,458	476,483	14.68	105%
Kitchen Equipment	Option A-: TRM (Or other Deemed) Analysis	31,551	38,872	549,098	14.13	123%
Lighting	Option A-: TRM (Or other Deemed) Analysis	535,672	405,334	4,641,074	11.45	76%
Total:		598,226	476,664	5,666,655	11.89	80%

Table 1: Measure Details

M&V Methodology

HVAC: Energy savings from HVAC measures can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = CAP_c * EFLH_c \left(\frac{1}{EER_{base}} - \frac{1}{EER_{post}}\right)$$

Definition of Variables

CAP_c = Rated equipment cooling capacity of the new unit (BTU/hr)

$EFLH_c$ = Equivalent full-load hour for cooling (hr)

EER_{base} = Full Load baseline energy efficiency rating of the baseline cooling equipment

EER_{post} = Full Load nameplate energy efficiency rating of the installed cooling equipment

Kitchen Equipment: Energy savings for commercial kitchen equipment come from the BES M&V Report Appendix C Methodology and Recommended Deemed Savings Algorithms and Values.

Lighting: Energy savings from new construction lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = ft^2_{lightingproject} * \left(\frac{kW}{ft^2}_{LPDbase} - \frac{kW}{ft^2}_{LPDas-built}\right) * HOU * HCIF$$

Definition of Variables

$ft^2_{lightingproject}$ = area of lighting project

$\frac{kW}{ft^2}_{LPDbase}$ = kilowatts per square foot of lighting project in base case

$\frac{kW}{ft^2}_{LPDas-built}$ = kilowatts per square foot of lighting project in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
HVAC		✓	✓			
Kitchen Equipment			✓			
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

HVAC size and efficiency specifications were verified with a model number lookup. HVAC EFLH was verified based on the facility's location and facility type.

The kitchen equipment measure deemed savings were verified with a model number lookup.

Pre lighting power densities were verified with 2018 IECC baseline code and area of each facility location. Post lighting power densities were verified with lighting fixture quantities, specification sheets, and the area of each facility location.

Prescriptive and custom HOU were used. For the exterior fixtures, the prescriptive HOU (4,313 hr) for exterior lights were used. For the interior fixtures, custom HOU were used. Common area light fixtures were verified to always be on (8,760 hr). Facility locations with occupancy sensors or daylight dimming controls had the appropriate prescriptive HOU reductions applied based on the facility location's control type. The interior lights in the residents' living quarters are assumed to be on 2,187 hr per year.

Ex-ante calculations assumed the lights in the residents' living quarters to be on 12 hours per day or 4,380 hours per year. The HOU from the 2016 DEER Commercial Indoor Lighting Profile for a patient room at a nursing home (2,187 hr) provided a reasonable and defensible HOU for the resident's living quarters.

The main difference for the project comes from differences in the lighting measures calculation specifically the HOU assumption in the residential living quarters.

Application ID: SB-23-13294

Project Summary

The customer received incentives for an interior lighting project at a retail/service facility. The lighting project removed (20) 109W lighting fixtures and installed (20) 80W LED fixtures. The lighting baseline was determined to be the wattage of the removed lighting fixtures.

Custom HOU were used because the verified HOU were more than 35% different than the prescriptive HOU for a retail/service facility. The verified HOU were found to be 2,241 hrs per year.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	1,874	1,300	19,500	15.00	69%
Total:		1,874	1,300	19,500	15.00	**69%**

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

Custom HOU and HCIF with verified with an interview with the site contact. The HOU were found to be more than 35% different than the prescriptive HOU for a retail/service facility. The HCIF wasfound to be 1.00 because the facility does not have any heating or cooling equipment present.

The post fixture wattages were confirmed with specific sheets. Baseline fixture wattages were confirmed with the baseline wattage table. Quantities were verified with invoices.

Differences come from the verified HOU and HCIF. Ex-ante calculators use prescriptive HOU (5,108 hrs) and HCIF (1.13). Ex-post calculators use custom HOU (2,241 hrs) and HCIF (1.00).

Application ID: SB-23-13150

Project Summary

The customer received incentives for a newly constructed warehouse building that exceeds the following IECC 2018 building code. The warehouse includes warehouse spaces (132,776 sq. ft.), offices (5,876 sq. ft.), exterior van canopies (85,323 sq. ft.), and parking and drives areas (1,034,956 sq. ft.).The building exceeded the IECC 2018 building code with its:

- Interior Lighting Power Density
- Exterior Lighting Power Density
- Efficient Envelope Insulation
- Efficient Windows
- Efficient HVAC Equipment

The customer also received (6) GD Refrigerator 31-50 cu. ft., (2) GD Refrigerator 15-30 cu. ft., and (1) GD Freezer 15-30 cu. ft.

ADM staff verified energy savings by evaluating the accuracy of the provided energy models and verifying equipment installation during a site visit. Savings are calculated using two Energy Models: baseline and as-built. The baseline model was compared to the IECC 2018 building code's HVAC equipment, lighting, and envelope input parameters. The as-built model was compared to the site notes, complete design drawings, and submittal documents.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	1,979,286	1,785,253	26,778,795	15.00	90%
Kitchen Equipment	Option A-: TRM (Or other Deemed) Analysis	6,661	6,661	99,915	15.00	100%
Lighting	Option A-: TRM (Or other Deemed) Analysis	257,339	257,459	3,861,885	15.00	100%
Total:		2,243,286	2,049,373	30,740,595	15.00	91%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from new construction energy simulations can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{h,base} - kW_{h,as-built})$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Kitchen Equipment: Energy savings for commercial kitchen equipment come from the BES M&V Report Appendix C Methodology and Recommended Deemed Savings Algorithms and Values.

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓			✓
Kitchen Equipment			✓			
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The ex-ante and ex-post model inputs were different for cooling efficiencies, heating efficiencies, wall insulation thickness, window shading, and lighting power density.

When determining ex-post verified savings, ADM reviewed all of the relevant model input values. ADM

ensured that the baseline case model matched the IECC 2018 building code requirements. ADM confirmed aspects of the proposed models with the provided as-built design drawings and equipment submittals. Additionally, ADM compared the baseline and proposed energy model with each other to ensure that the only differences between the models were stated energy savings measures that would qualify for utility incentives.

The main reason for the low realization rate comes from the difference in the interior light baseline. The ex-post calculation used the IECC 2018 interior light baseline for the space-by-space method, for a warehouse with medium to bulky palletized items.

Application ID: SB-23-13219

Project Summary

The customer received incentives for a new construction project which included: HVAC measures, interior lighting, and exterior lighting.

The customer installed 26 HVAC units. The efficiency and size of the HVAC units were verified by reviewing the equipments model number. The baseline efficiency of the HVAC were determined by using the IECC 2018 building code. Below is a list of the installed HVAC units:

- (6)Daikin REYQ120XAYD 114,000 BTU/hr 13.20 EER
- (8) Daikin REYQ96XAYD 92,000 BTU/hr 14.6 EER
- (4) Daikin REYQ144XAYD 138,000 BTU/hr 11.9 EER
- (2) Daikin RX18RMVJU9A 17,400 BTU/hr 19.3 SEER
- (3) Daikin RXS24LVJU 21,400 BTU/hr 20 SEER
- (1) Daikin RK24AXVJU 21,200 BTU/hr 20.00 SEER
- (2) Daikin DPS020AHMY4DW-4 341,200 BTU/hr 11.3 IEER

For the lighting measures, the lighting HOU were based on the provided documentation. Specification sheets were used to verify ex-post fixture wattages. Building plans, invoices, and post installation inspection notes were used to verify lighting counts and as-built lighting power density. The baseline lighting power density was determined by the IECC 2018 building code. The table below shows specifications for the lighting measures.

Location	Area (sq. ft.)	Baseline Lighting Power Density (W/sq. ft.)	As-Built Lighting Power Density (W/sq. ft.)	Pre HOU (hr)	Post HOU (hr)	HCIF
Office	12,553	0.79	0.61	2,132	2,132	1.13
Garage 1st and 2nd Floor	70,803	0.14	0.04	4,313	4,313	1.00
Surface Parking Lot	61,050	0.08	0.05	4,313	4,313	1.00
Walkways	1,160	0.07	0.21	4,313	4,313	1.00
Office Building Uplighting	42,605	0.15	0.1	4,313	4,313	1.00
Trees Uplighting	1,495	0.04	0.15	4,313	4,313	1.00
Top Level Parking Garage	35,418	0.08	0.05	4,313	4,313	1.00

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
HVAC	Option A-: TRM (Or other Deemed) Analysis	66,854	66,593	998,895	15.00	100%
Lighting	Option A-: TRM (Or other Deemed) Analysis	80,636	58,106	692,047	11.91	72%
Total:		147,490	124,699	1,690,942	13.56	85%

Table 1: Measure Details

M&V Methodology

HVAC: Energy savings from HVAC measures can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = CAP_c * EFLH_c \left(\frac{1}{EER_{base}} - \frac{1}{EER_{post}}\right)$$

Definition of Variables

CAP_c = Rated equipment cooling capacity of the new unit (BTU/hr)

$EFLH_c$ = Equivalent full-load hour for cooling (hr)

EER_{base} = Full Load baseline energy efficiency rating of the baseline cooling equipment

EER_{post} = Full Load nameplate energy efficiency rating of the installed cooling equipment

Lighting: Energy savings from new construction lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = ft^2_{lightingproject} * \left(\frac{kW}{ft^2}_{LPDbase} - \frac{kW}{ft^2}_{LPDas-built}\right) * HOU * HCIF$$

Definition of Variables

$ft^2_{lightingproject}$ = area of lighting project

$\frac{kW}{ft^2}_{LPDbase}$ = kilowatts per square foot of lighting project in base case

$\frac{kW}{ft^2}_{LPDas-built}$ = kilowatts per square foot of lighting project in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
HVAC	✓	✓	✓			
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

HVAC unit size and efficiency specifications were verified with a model number lookup. HVAC EFLH were verified based on the facility's location and type.

Pre lighting power densities were verified with 2018 IECC baseline code and the areas of each facility location. Post lighting power densities were verified with lighting fixture quantities, specification sheets, and areas of facility location.

For the exterior fixtures, the prescriptive HOU (4,313 hr) for exterior light were used. For the interior fixtures, the prescriptive HOUs for offices with occupancy sensors reductions (3,045 hr * (1-0.3)= 2,132 hr) were used.

Ex-ante calculations added the IECC 2018 Lighting Power Allowances for Building Exteriors in Zone 4 to every exterior lighting line item in the ex-ante calculator (5 times). Lighting power allowances should only be applied once to the whole exterior lighting project.

The project's differences come from the differences in the ex-ante and ex-post lighting calculations, specifically from the incorporation of Lighting Power Allowances for Building Exteriors.

Application ID: SB-23-13409

Project Summary

The customer received incentives for installing LED lighting fixtures in a newly constructed indoor cannabis growing facility. The lighting project installed (537) 1,000W and (160) 600W LED fixtures. The 1,000W fixtures were installed in the facility's combination room and the 600W fixtures were installed in the vegetation room.

The "New Construction Horticultural LED Lighting Savings Methodology for Cannabis" work paper, written by ADM, was used to establish appropriate new construction lighting baselines. Specific baselines are based on the plant's growing stage and the facility's growing room type. Furthermore, HCIF are based on the plant's growing stage.

The HOU were provided by the customer. The (537) 1,000W LED fixtures in the combination room operate on a 40-week growing cycle. The growing cycle in the combination room has two different growing stages: vegetative and flowering. There are 3 weeks in the vegetative stage and 37 weeks in the flowering stage. The vegetative stage has the lights on for 24 hours per day. The flowering stage has the lights on for 12 hours per day. The combination room lights have an HOU of 2,520 hr in the vegetative stage and an HOU of 3,120 hr in the flowering stage.

The (160) 600W LED fixtures in the vegetative rooms are on continuously throughout the year (8,760 hr) in a vegetative stage.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	4,205,571	4,209,735	51,990,227	12.35	100%
Total:		4,205,571	4,209,735	51,990,227	12.35	100%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from custom lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} HCIF_h * (N_{base} * kW_{base} * f_{dimmed,h,base} - N_{as-built} * kW_{as-built} * f_{dimmed,h,as-built})$$

Definition of Variables

h = hour of year

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$f_{dimmed,h,base}$ = percent dimming of lights at a given hour of the year in base base

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

$f_{dimmed,h,as-built}$ = percent dimming of lights at a given hour of the year in as-built case

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The lighting baselines and HCIF were verified with the "New Construction Horticultural LED Lighting Savings Methodology for Cannabis" work paper based on space types.

The post fixture wattages were confirmed in specification sheets. Fixture quantities were confirmed with supporting documentation. Custom HOU were based on information provided by the customer.

No differences were found.

Application ID: SB-23-12329

Project Summary

The customer received incentives for a newly constructed warehouse building that exceeds the following IECC 2018 building code. The warehouse has warehouse spaces (601,600 sq. ft.), offices (44,722 sq. ft.), breakrooms (3,250 sq. ft.), and electrical/mechanical rooms (1,998 sq. ft.).The building exceeded the IECC 2018 building code with its:

- Interior Lighting Power Density
- Exterior Lighting Power Density
- Efficient Envelope Insulation
- Efficient Windows
- Efficient HVAC Equipment

ADM staff verified energy savings by evaluating the accuracy of the provided energy models and verifying equipment installation. Savings are calculated using two Energy Models: baseline and as-built. The baseline model was compared to the IECC 2018 building code's HVAC equipment, lighting, and envelope input parameters. The as-built model was compared to the site notes, complete design drawings, and submittal documents.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	5,722,618	6,352,847	95,292,705	15.00	111%
Lighting	Option A-: TRM (Or other Deemed) Analysis	665,737	672,017	10,080,255	15.00	101%
Total:		6,388,355	7,024,864	105,372,960	15.00	110%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from new construction energy simulations can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{h,base} - kW_{h,as-built})$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓			✓
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The ex-ante and ex-post model inputs were different for cooling efficiencies.

When determining ex-post verified savings, ADM reviewed all of the relevant model input values. ADM ensured that the baseline case model matched the IECC 2018 building code requirements. ADM confirmed aspects of the proposed models with the provided as-built design drawings and equipment submittals. Additionally, ADM compared the baseline and proposed energy model with each other to ensure that the only differences between the models were stated energy savings measures that would qualify for utility incentives.

The high realization rate comes from adjusting HVAC equipment code baselines.

Application ID: SB-23-13337

Project Summary

The customer received incentives for a newly constructed casino resort that exceeds the following IECC 2018 building code. The casino resort consists of 5,200,000 sq. ft of conditioned space. The building exceeded the IECC 2018 building code with its:

- Interior Lighting Power Density
- Exterior Lighting Power Density
- Efficient Envelope Insulation
- Efficient Windows
- Efficient HVAC Equipment

ADM staff verified energy savings by evaluating the accuracy of the provided energy models and verifying equipment installation during a site visit. Savings are calculated using four energy models: baseline and as built. The baseline model was compared to IECC 2018 building code with regard to the HVAC equipment, lighting, and envelope input parameters. The as-built model was compared to the site visit notes, complete design drawings, and submittal documents.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	18,192,873	18,192,873	272,893,095	15.00	100%
Total:		18,192,873	18,192,873	272,893,095	15.00	100%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from new construction energy simulations can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{h,base} - kW_{h,as-built})$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓			✓

Table 2: Data Collection Method By Measure

Key Findings

ADM did a concurrent pre-review M&V process for this project because of the high energy savings to ensure the process and calculated energy savings were done correctly by all parties involved. ADM and the implementation contractor did a joint site visit to verify model inputs and submittals

When determining ex-post verified savings, ADM reviewed all of the relevant model input values and ensured that all values matched the IECC 2018 building code requirements for the baseline case and the provided as built design submittal drawings for the proposed model. Additionally, ADM compared the baseline and proposed energy model with each other to ensure that the only differences between the models were stated energy savings measures that would qualify for utility incentives.

No discrepancies were discovered during the concurrent pre-review process or ex-post evaluation.

Application ID: SB-23-13608

Project Summary

The customer received incentives for a newly constructed warehouse building that exceeds the following IECC 2018 building code. The warehouse includes warehouse spaces (638,835 sq. ft.), and offices (17,916 sq. ft.).The building exceeded the IECC 2018 building code with its:

- Interior Lighting Power Density
- Exterior Lighting Power Density
- Efficient Envelope Insulation
- Efficient Windows
- Efficient HVAC Equipment

The customer also received (2) GD Refrigerator 31-50 cu. ft.

ADM staff verified energy savings by evaluating the accuracy of the provided energy models and verifying equipment installation. Savings are calculated using two Energy Models: baseline and as-built. The baseline model was compared to IECC 2018 building code with regard to the HVAC equipment, lighting, and envelope input parameters. The as-built model was compared to the site notes, complete design drawings, and submittal documents.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	4,432,692	4,226,926	63,403,890	15.00	95%
Kitchen Equipment	Option A-: TRM (Or other Deemed) Analysis	1,480	1,480	22,200	15.00	100%
Lighting	Option A-: TRM (Or other Deemed) Analysis	143,019	142,825	2,142,375	15.00	100%
Total:		4,577,191	4,371,231	65,568,465	15.00	96%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from new construction energy simulations can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{h,base} - kW_{h,as-built})$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Kitchen Equipment: Energy savings for commercial kitchen equipment come from the BES M&V Report Appendix C Methodology and Recommended Deemed Savings Algorithms and Values.

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓			
Kitchen Equipment			✓			
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The ex-ante and ex-post model inputs were different for cooling efficiencies for various baseline and proposed HVAC equipment.

When determining ex-post verified savings, ADM reviewed all of the relevant model input values. ADM

ensured that the baseline case model matched the IECC 2018 building code requirements. ADM confirmed aspects of the proposed models with the provided as-built design drawings and equipment submittals. Additionally, ADM compared the baseline and proposed energy model with each other to ensure that the only differences between the models were stated energy savings measures that would qualify for utility incentives.

Differences come from adjusting HVAC equipment code baselines.

Application ID: SB-23-13645

Project Summary

The customer received incentives for a newly constructed casino resort that exceeds the following IECC 2018 building code. The building exceeded the IECC 2018 building code with its:

- Interior Lighting Power Density
- Exterior Lighting Power Density
- Efficient Envelope Insulation
- Efficient Windows
- Efficient HVAC Equipment

ADM staff verified energy savings by evaluating the accuracy of the provided energy models and verifying equipment installation. Savings are calculated using two Energy Models: baseline and as-built. The baseline model was compared to the IECC 2018 building code's HVAC equipment, lighting, and envelope input parameters. The as-built model was compared to the site notes, complete design drawings, and submittal documents.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	2,337,370	2,337,370	35,060,550	15.00	100%
Total:		2,337,370	2,337,370	35,060,550	15.00	100%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from new construction energy simulations can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{h,base} - kW_{h,as-built})$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

ADM completed a concurrent pre-review M&V process for this project because of the high energy savings to ensure the process and calculated energy savings were done correctly by all parties involved.

When determining ex-post verified savings, ADM reviewed all of the relevant model input values and ensured that all values matched the IECC 2018 building code requirements for the baseline case and the provided as built design submittal drawings for the proposed model. Additionally, ADM compared the baseline and proposed energy model with each other to ensure that the only differences between the models were stated energy savings measures that would qualify for utility incentives.

Guest Room Energy Management (GREM) savings were confirmed to not be part of the energy model and instead were added as prescriptive savings (250 kWh per unit) based on the number of guest room energy management systems (243).

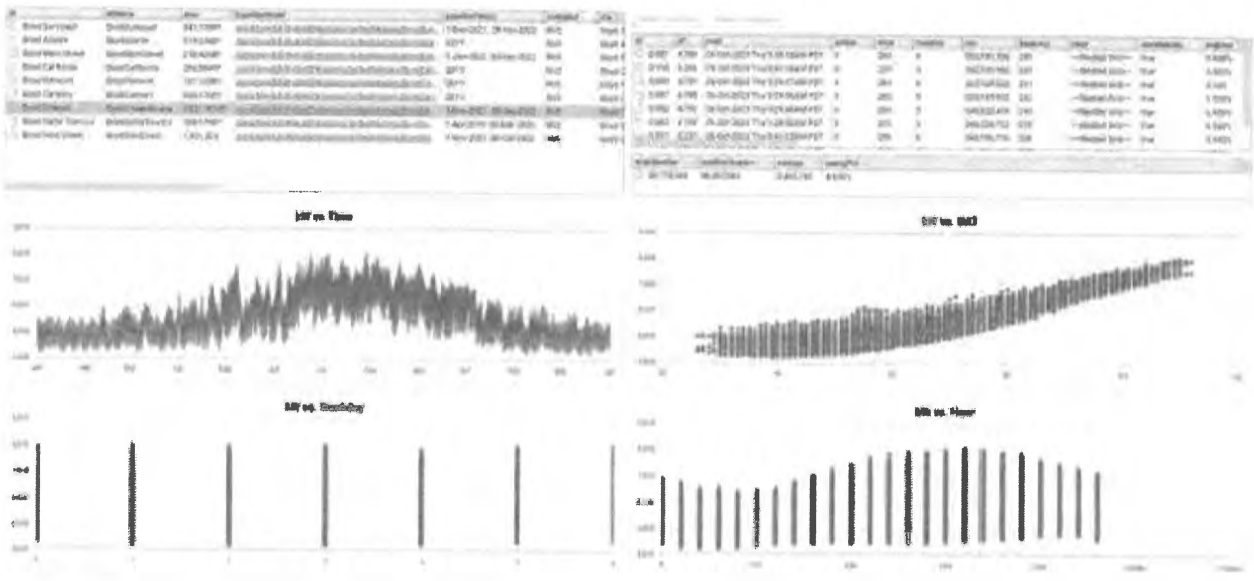
No discrepancies were discovered during the oncurrent pre-review M&V process.

Application ID: SB-23-13789

Project Summary

The customer received incentives for implementing a whole building Monitoring-Based Commissioning (MBCx) project at a casino resort. The implementor installed monitoring equipment throughout the buildings HVAC systems to collect data regarding the status and operations of the equipment. The implementor used this data to provide guidance for building staff to improve the HVAC systems operation and reduce energy consumption.

The image below shows the results from the MBCx regressions.



Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	2,465,745	2,465,745	36,986,175	15.00	100%
Total:		2,465,745	2,465,745	36,986,175	15.00	100%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from MBCx projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} \left(kW_{h,base} - kW_{h,as-built}\right)$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓		✓		✓	✓

Table 2: Data Collection Method By Measure

Key Findings

The implementor provided an M&V process to estimate energy savings by looking at the utility billing data before and after the MBCx process. Utility billing data regressions were created using the SkySpark software to estimate energy savings. ADM reviewed the projects reports and regressions for accuracy and validity.

The baseline measurement period was November 2021 to September 2022 and a post-regression period of October 2022 to September 2023. These measurement periods are a full year of data and adequately represent both the heating and cooling weather dependencies.

The regressions used the following variables: hourly billing data, hour of the day, day of the week, outside wet bulb temperature (F), and outside dry bulb temperature (F). The baseline and post regression models were analyzed with actual weather data. Once the models were created, the model variables were applied to TMY3 weather data for typical year savings.

Building occupancy was determined to not be a factor in this regression because the building was almost back to full operation during the post measurement period and occupancy levels do not appear to have an effect on building energy usage. This is evident in the data because there is a strong correlation in the data using weather data. Additionally, ADM knows that this building type can have seasonal building occupancy that can vary by 20% with no measurable difference in energy usage. Therefore, ADM did not include any occupancy variable.

No differences were found.

Application ID: SB-23-13809

Project Summary

The customer received incentives for a lighting project throughout its casino. The lighting project included:

- replacing (450) 3 Lamp Florescent T-8 lamps with (450) LED BPL 2x4 - 3M50TRI lamps
- replacing (3,450) 35 Watt Cold Cathode lamps with (3,450) FB11 D40 24E 12 SCL 92 lamps
- replacing (1,600) 35 Watt Cold Cathode lamps with (1,600) FT06 03D 2527 E E12 lamps
- replacing (4,800) 32 Watt PAR16 lamps with (4,800) MR16 LED 7.5 W 12V lamps
- replacing (950) Florescent T-8 lamps with (950) 18W 4ft LED T-8 5000k lamps
- replacing (700) Sylvania 60 Watt PAR30 lamps with (700) PAR30SN DIN/927/FL40 lamps

The project uses prescriptive HOU because the verified actual HOU are not more than 35% different than the prescriptive HOU for a casino.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	3,359,158	3,359,158	20,020,582	5.96	100%
Total:		3,359,158	3,359,158	20,020,582	5.96	100%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The baseline fixture wattages were verified to be the removed lighting fixtures' wattages. The installed fixture wattages were confirmed with specification sheets. Lamp quantities were confirmed with supporting documentation. Prescriptive HOU (8,760 hr) and an HCIF (1.13) were used.

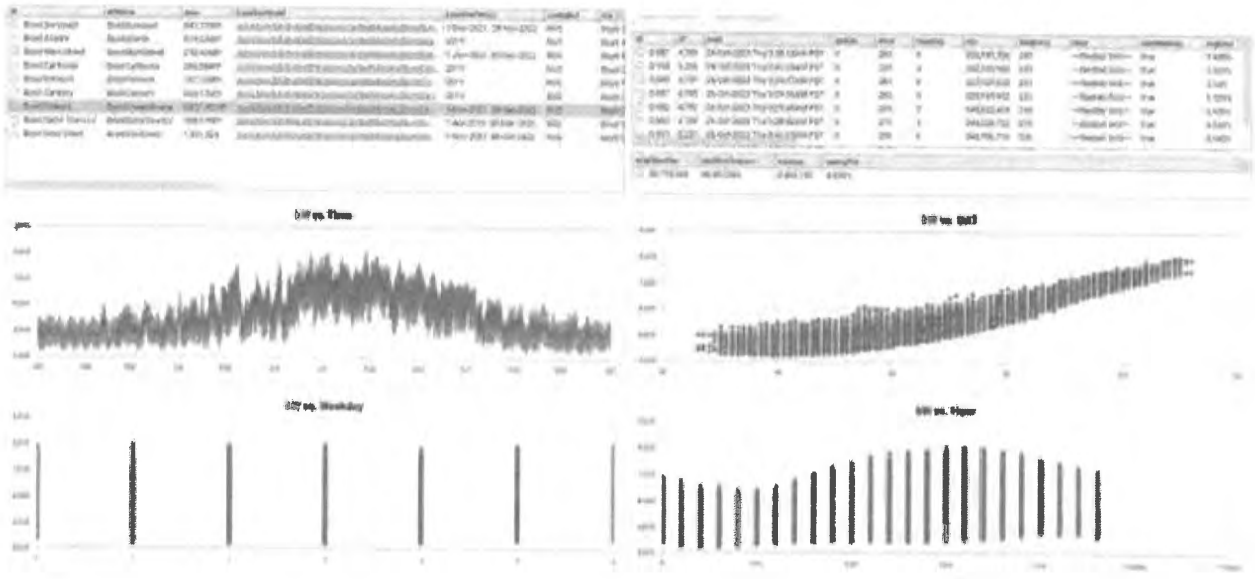
No differences were found.

Application ID: SB-23-13791

Project Summary

The customer received incentives for implementing a whole building Monitoring-Based Commissioning (MBCx) project at a casino resort. The implementor installed monitoring equipment throughout the buildings HVAC systems to collect data regarding the status and operations of the equipment. The implementor used this data to provide guidance for building staff to improve the HVAC systems operation and reduce energy consumption.

The image below shows the results from the MBCx regressions.



Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option A-: TRM (Or other Deemed) Analysis	3,475,660	3,445,660	51,684,900	15.00	99%
Total:		3,475,660	3,445,660	51,684,900	15.00	99%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from MBCx projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{h,base} - kW_{h,as-built})$$

Definition of Variables

$kW_{h,base}$ = kW during a given hour in base case

$kW_{h,as-built}$ = kW during a given hour in as-built case

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓			✓

Table 2: Data Collection Method By Measure

Key Findings

The implementor provided an M&V process to estimate energy savings by looking at the utility billing data before and after the MBCx process. Utility billing data regressions were created using the SkySpark software to estimate energy savings. ADM reviewed the projects reports and regressions for accuracy and validity.

The baseline measurement period was April 2019 to March 2020 and a post-regression period of September 2022 to September 2023. These measurement periods are a full year of data and adequately represent both the heating and cooling weather dependencies.

The regressions used the following variables: hourly billing data, hour of the day, day of the week, outside wet bulb temperature (F), and outside dry bulb temperature (F). The baseline and post regression models were analyzed with actual weather data. Once the models were created, the model variables were applied to TMY3 weather data for typical year savings.

Building occupancy was determined to not be a factor in this regression because the building was almost back to full operation during the post measurement period and occupancy levels do not appear to have an effect on building energy usage. This is evident in the data because there is a strong correlation in the data using weather data. Additionally, ADM knows that this building type can have seasonal building occupancy that can vary by 20% with no measurable difference in energy usage. Therefore, ADM did not include any occupancy variable.

The difference in ex-post savings and ex-ante savings comes from a typo carried through the ex-ante M&V report. The ex-post savings (3,445,660 kWh) are equal to the savings reported by the Skyspark modeling tool. However, the summary of findings section of the ex-ante M&V report states different savings (3,475,660 kWh). The savings stated in the summary of findings section were assumed to be the correct ex-ante savings, not the savings found with Skyspark modeling tool.

Application ID: SB-23-13280

Project Summary

The customer received incentives for an interior lighting new construction project at a warehouse.

The lighting project installed (1,280) 39W LED fixtures in 230,400 square feet of warehouse space. These lights operate continuously throughout the year or 8,760 hrs per year.

The lighting baseline was determined to be 10% better than IECC 2018. The appropriate IECC space type was determined to be Warehouse Storage, Smaller, Hand Carried Items. Thus a 0.62 $\frac{kW}{ft^2}_{LPDbase}$ was chosen for the new construction baseline.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	544,437	565,194	3,227,255	5.71	104%
Total:		544,437	565,194	3,227,255	5.71	104%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from new construction lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = ft^2_{lightingproject} * \left(\frac{kW}{ft^2}_{LPDbase} - \frac{kW}{ft^2}_{LPDas-built}\right) * HOU * HCIF$$

Definition of Variables

$ft^2_{lightingproject}$ = area of lighting project

$\frac{kW}{ft^2}_{LPDbase}$ = kilowatts per square foot of lighting project in base case

$\frac{kW}{ft^2}_{LPDas-built}$ = kilowatts per square foot of lighting project in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The lighting baseline was verified to be 10% better than IECC 2018. The post fixture wattages were confirmed in specification sheets. Fixture quantities and the lighting project area were confirmed with supporting documentation. A custom HOU (8,760) and HCIF (1.05) were confirmed with an interview. The warehouse space was confirmed to have heating and cooling space conditioning.

The main differences stem from the determination of the HCIF. The ex-ante calculation used a prescriptive HCIF (1.02) whereas the ex-post calculation used a custom HCIF (1.05).

Application ID: SB-23-13404

Project Summary

The customer received incentives for an interior custom lighting project at a grocery warehouse.

The lighting project included:

- replacing (554) 240W LED fixtures with (538) 95W LED High Bay fixtures with daylight dimming controls using interior photocells

These lights were found to use a custom HOU (8,165 hr * (1-0.29)=5,797 hr). The lights were found to be on for 8,165 hr per year with a daylight dimming control reduction of 29%.

The lighting baseline was determined to be the removed lighting fixtures.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	498,465	495,641	7,434,615	15.00	99%
Total:		498,465	495,641	7,434,615	15.00	99%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from custom lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (N_{base} * kW_{base} * f_{dimmed,h,base} - N_{as-built} * kW_{as-built} * f_{dimmed,h,as-built}) * HCIF_h$$

Definition of Variables

h = hour of year

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$f_{dimmed,h,base}$ = percent dimming of lights at a given hour of the year in base base

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

$f_{dimmed,h,as-built}$ = percent dimming of lights at a given hour of the year in as-built case

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The baseline was verified to be the removed lighting fixtures. The post fixture wattages were confirmed in specification sheets. Fixture quantities were confirmed with supporting documentation. A custom HCIF was calculated using the verified HOU with daylight dimming reductions and the known space conditioning types.

The main differences stem from the determination of the HCIFs. The ex-ante calculation used a prescriptive HCIF (1.05) whereas the ex-post calculation used a custom HCIF (1.04).

Application ID: SB-23-13392

Project Summary

The customer received incentives for an interior lighting major renovation project at a process industrial facility. The lighting project installed (326) 199W LED Highbay fixtures in 230,400 square foot production area. These lights operate continuously throughout the year or 8,760 hrs per year.

This project used the prereview process where the implementation and ADM discussed the best way to calculate the project's savings. Discussions led to an agreed upon baseline determination. The implementation contractor noted several changes to the lighting system's design between pre and post cases. Changes included increasing the lighting requirement (lumens per square foot) for the space. It was determined that using the removed lighting fixtures as the baseline was not appropriate and using a new construction baseline (IECC 2018) would be more appropriate. Thus a 0.90 $\frac{kW}{ft^2}_{LPDbase}$ was chosen for the baseline.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	1,351,797	1,248,177	7,127,091	5.71	92%
Total:		1,351,797	1,248,177	7,127,091	5.71	92%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from new construction lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = ft^2_{lightingproject} * \left(\frac{kW}{ft^2}_{LPDbase} - \frac{kW}{ft^2}_{LPDas-built}\right) * HOU * HCIF$$

Definition of Variables

$ft^2_{lightingproject}$ = area of lighting project

$\frac{kW}{ft^2}_{LPDbase}$ = kilowatts per square foot of lighting project in base case

$\frac{kW}{ft^2}_{LPDas-built}$ = kilowatts per square foot of lighting project in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The prereview process established the new construction baseline and savings calculation method. The post fixture wattages were verified with specification sheets. The quantity of fixtures was verified with an inspection of building drawings. The area of the project was verified with the county's property appraiser documentation. The lights were assumed to be on continuously for a HOU of 8,760 hr. The building was found to not have space cooling or heating. No HVAC systems were found in satellite views or interior pictures.

The main differences come from the determination of the HCIF. The ex-ante calculation used a prescriptive HCIF (1.08). The ex-post calculation used a custom HCIF (1.00) for a facility that doesn't have space cooling or heating.

Application ID: SB-23-13054

Project Summary

This customer received incentives for replacing (2) 500-ton injection molding machines (IMMs) with (2) new 500-ton IMMs at a manufacturing facility. Post-data monitoring was completed on each machine. For the baseline, IMMs from previous year projects were used to determine accurate baseline efficiencies. Pounds of produced material were also provided during both data monitoring periods. The customer also provided an estimate for annual pounds produced for each new machine.

This project participated in the prereview process. This process helped align calculation methodologies mainly for establishing a proper baseline and accurately estimating annual production.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option A+: Engineering Analysis (Based on Trend or Monitored Data)	867,851	867,849	13,017,735	15.00	100%
Total:		867,851	867,849	13,017,735	15.00	100%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from injection molding machine replacements can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \left(\frac{kW}{lb}_{avg,in-operation,base} - \frac{kW}{lb}_{avg,in-operation,post}\right) * \frac{lb}{yr}$$

Definition of Variables

$\frac{kW}{lb}_{avg,in-operation,base}$ = average kW per pound of material during base case

$\frac{kW}{lb}_{avg,in-operation,post}$ = average kW per pound of material during post case

$\frac{lb}{yr}$ = estimated annual pounds of material produced

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓	✓	✓	✓

Table 2: Data Collection Method By Measure

Key Findings

Both new IMMs (line 32 and line 33) used pre and post monitored data to establish pre and post operating efficiencies.

The baseline operating efficiencies come from a weighted average of two monitored baseline IMMs from PY2018 (SB-18-09874, SB-18-09786). The baseline operating efficiency was found to be 0.89 kWh/lb.

The post operating efficiencies were calculated using data from the post monitoring period. The calculated post efficiencies are: Line 32 0.566 kWh/lb and Line 33 0.425 kWh/lb.

Prereview discussions were had between the customer, implementation contractor, and ADM to establish an accurate annual pounds produced value for each IMM. Initial annual estimates from the customers did not match the pound produced during the monitoring period. The customer was asked to provide more production data to create a more accurate annual production estimate. The annual production estimates are based on the following time periods: Line 32 4/4/2023-4/24/2023 and Line 33 3/8/2023-4/24/2023. Annual production estimates are 1,000,279 lb for Line 32 and 1,173,187 lb for Line 33.

No differences were found.

Application ID: SB-23-13596

Project Summary

The customer received incentives for installing fans with VFDs in two new construction vegetable drying/curing sheds. Each shed has six cells, each cell installed (5) 25hp fans with VFDs. In total, (60) 25hp fans with VFDs were installed.

There is no code requiring VFDs on the fans because drying/curing shed buildings are not regulated under the IECC 2018 building code. The energy savings is the difference between a fan without a VFD and a fan with a VFD.

The baseline energy consumption was found from power monitoring from fans without VFDs. Baseline power monitoring was completed on similar fans at this site in 2016.

For the post case, two fans from three different cells (Cell 68, Cell 71, and Cell 73) were monitored to find the new fans' energy use. The average new fan energy use was found by averaging the six monitored fans together.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option A+: Engineering Analysis (Based on Trend or Monitored Data)	2,650,272	2,650,048	39,750,720	15.00	100%
Total:		2,650,272	2,650,048	39,750,720	15.00	100%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from air compressor leak repair can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{avg,in-operation,base} - kW_{avg,in-operation,post}) * \%_{h,time,in-operation}$$

Definition of Variables

$kW_{avg,in-operation,base}$ = average kW during base case

$kW_{avg,in-operation,post}$ = average kW during post case

$\%_{time,in-operation}$ = percent of time in full operation

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom	✓	✓	✓		✓	✓

Table 2: Data Collection Method By Measure

Key Findings

The pre and post power monitoring data was processed to find the average kWh usage per operating day per fan. The customer noted that the fans run for 180 days per year.

The annual savings are the difference in energy use between the baseline and post cases.

One small difference was found in how the post energy consumption was calculated for cell 73, however, this changes had a very minor effect on the overall savings.

Application ID: SB-23-12954

Project Summary

The customer received incentives for an exterior lighting project at three different correctional centers. The lighting project included:

- replacing (48) 1,000W HPS fixtures with (36) 838W LED fixtures at facility 1
- replacing (104) 1,000W HPS fixtures with (78) 838W LED fixtures at facility 2
- replacing (152) 1,000W HPS fixtures with (114) 838W LED fixtures at facility 3

All installed light fixtures are controlled with photocells. These light fixtures use the prescriptive HOU for exterior fixtures (4,308 hr).

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	617,492	617,530	9,262,950	15.00	100%
Total:		617,492	617,530	9,262,950	15.00	100%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The baseline fixture wattages were verified to be the removed lighting fixtures' wattages. The installed fixture wattages were confirmed with specification sheets. Fixture quantities were confirmed with supporting documentation. Prescriptive HOU (4,308 hrs) and an HCIF (1.00) for exterior fixtures were used.

No differences were found.

Application ID: SB-23-13612

Project Summary

The customer replaced many street lights in many towns in northern Nevada. The lighting project included:

- replacing (202) 465W HPS fixtures with (202) 123W LED fixtures
- replacing (517) 188W HPS fixtures with (517) 73W LED fixtures
- replacing (2,973) 138W HPS fixtures with (2,973) 34W LED fixtures

All installed light fixtures are controlled with photocells. These light fixtures use the prescriptive HOU for exterior fixtures (4,308 hr).

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	1,885,745	1,885,862	28,287,930	15.00	100%
Total:		1,885,745	1,885,862	28,287,930	15.00	100%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The baseline fixture wattages were verified to be the removed lighting fixtures' wattages. The installed fixture wattages were confirmed with specification sheets. Fixture quantities were confirmed with supporting documentation. Prescriptive HOU (4,308 hrs) and an HCIF (1.00) for exterior fixtures were used.

No differences were found in the project.

Application ID: SB-23-13632

Project Summary

The customer received incentives for upgrading to LED lighting fixtures in a warehouse. The lighting project included:

- replacing (291) 6-lamp T5HO 351W fixtures with (263) 178W LED High Bay fixtures
- replacing (96) 4-lamp T5HO 234W fixtures with (74) 93W LED High Bay fixtures
- replacing (233) 8' 4-Lamp T8 strip 112W fixtures with (233) 37.2W LED light bar kit fixtures
- replacing (4,364) 8' 2-Lamp T8 strip 59W fixtures with (4,382) 24.5W LED light bar kit fixtures

Custom HOU and HCIF were used because the verified HOU of more the 35% different than the prescriptive HOU for a warehouse. The custom HOU include prescriptive HOU reductions from the installed occupancy sensors.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	1,367,159	1,340,352	18,376,226	13.71	98%
Total:		1,367,159	1,340,352	18,376,226	13.71	98%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from custom lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (N_{base} * kW_{base} * f_{dimmed,h,base} - N_{as-built} * kW_{as-built} * f_{dimmed,h,as-built}) * HCIF_h$$

Definition of Variables

h = hour of year

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$f_{dimmed,h,base}$ = percent dimming of lights at a given hour of the year in base base

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

$f_{dimmed,h,as-built}$ = percent dimming of lights at a given hour of the year in as-built case

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The baseline was verified to be the removed fixtures. The post fixture wattages were confirmed in specification sheets. Fixture quantities were confirmed with supporting documentation.

Custom HOU (8,008 hr * (1-0.3) = 5,621 hrs) and HCIFs (1.00) were used. The customer indicated that the light fixtures are on 22 hours per day with occupancy sensors. No space heating and cooling was verified at this facility thus making its HCIF 1.00.

Differences come from the determination of the HCIF factor. Ex-ante calculations used a prescriptive HCIF (1.02) for a warehouse. Ex-post calculations used a custom HCIF (1.00) for an unconditioned space.

Application ID: SB-23-13731

Project Summary

The customer received incentives for LED light fixtures during a major renovation at their manufacturing facility. The specifics of the project are shown in the table below.

Location	Area (sq. ft.)	Code Lighting Power Density (W/sq. ft.)	Post Lighting Power Density (W/sq. ft.)	Pre HOU (hr)	Post HOU (hr)	HCIF
Manufacturing Facility	462,764	0.90	0.26	4,666	4,666	1.08

Prescriptive HOU were used with reductions from occupancy sensors (6,665 *(1-0.3)=4,666 hr).

This project used the pre-construction review process where the implementation and evaluation contractors discussed the best way to calculate the project's savings. Discussions led to an agreed upon baseline determination. The implementation contractor noted several changes to the lighting system's design between pre and post cases. Changes included increasing the lighting requirement (lumens per square foot) for the space. It was determined that using the removed lighting fixtures as the baseline was not appropriate and using a new construction baseline (IECC 2018) would be more appropriate. Thus a 0.90 $\frac{kW}{ft^2}_{LPDbase}$ was chosen for the baseline.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Lighting	Option A-: TRM (Or other Deemed) Analysis	1,492,318	1,495,348	22,430,222	15.00	100%
Total:		1,492,318	1,495,348	22,430,222	15.00	100%

Table 1: Measure Details

M&V Methodology

Lighting: Energy savings from new construction lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = ft^2_{lightingproject} * \left(\frac{kW}{ft^2}_{LPDbase} - \frac{kW}{ft^2}_{LPDas-built}\right) * HOU * HCIF$$

Definition of Variables

$ft^2_{lightingproject}$ = area of lighting project

$\frac{kW}{ft^2}_{LPDbase}$ = kilowatts per square foot of lighting project in base case

$\frac{kW}{ft^2}_{LPDas-built}$ = kilowatts per square foot of lighting project in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Lighting	✓	✓	✓			

Table 2: Data Collection Method By Measure

Key Findings

The baseline was verified to be the 2018 IECC lighting power density for the manufacturing facility. The post fixture wattages were confirmed in specification sheets. Fixture quantities were confirmed with supporting documentation. Prescriptive HOU with reductions from occupancy sensors HOU reductions (4,666 hr) and prescriptive HCIF (1.08) were used.

No differences were found, mainly due to the collaborative prereview process.

Application ID: SB-23-13728

Project Summary

This large manufacturing customer received incentives for retro-commissioning projects. During the retro-commissioning process, the customer discovered and implemented five energy efficiency measures.

Savings for four custom measures were calculated using pre and post energy trending data provided by the customer. Savings the custom measures were as follows: HVAC Fan Coil Unit controls, High Pressure Compressed Air Staging Redesign, High Temperature Heat Recovery Water Piping Improvements, and Heat Recovery Water Pumping Improvement.

The Warehouse High Bay lighting measure used prescriptive lighting savings algorithms to calculate savings.

Measure Summary

Measure Type	Analysis Type	Ex-Ante Annual Energy Savings (kWh)	Ex-Post Annual Energy Savings (kWh)	Lifetime Energy Savings (kWh)	EUL (yr)	Energy Realization Rate (%)
Custom	Option D: Calibrated Simulation	8,457,031	8,457,032	126,855,480	15.00	100%
Lighting	Option A-: TRM (Or other Deemed) Analysis	49,668	49,668	447,012	9.00	100%
Total:		8,506,699	8,506,700	127,302,492	14.96	100%

Table 1: Measure Details

M&V Methodology

Custom: Energy savings from the custom measures can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = \sum_{h=1}^{8,760} (kW_{avg,in-operation,base} - kW_{avg,in-operation,post}) * \%_{h,time,in-operation}$$

Definition of Variables

$kW_{avg,in-operation,base}$ = average kW during base case

$kW_{avg,in-operation,post}$ = average kW during post case

$\%_{time,in-operation}$ = percent of time in full operation

Lighting: Energy savings from prescriptive lighting efficiency projects can generally be formulated as follows:

$$Energy\ Savings\ \left(\frac{kWh}{yr}\right) = (N_{base} * kW_{base} - N_{as-built} * kW_{as-built}\ ) * HOU * HCIF$$

Definition of Variables

N_{base} = Number of fixtures in base case

kW_{base} = kilowatts per fixture in base case

$N_{as-built}$ = Number of fixtures in as-built case

$kW_{as-built}$ = kilowatts per fixture in as-built case

HOU = lighting hours of use (hr)

$HCIF$ = heating and cooling interactive factor

Data Collection Method

Measures	Interview Site Personnel	On-Site Observations	Equipment/ Project Documents	Spot Measurements	Short Term Monitoring	Trend Data
Custom Lighting	✓	✓	✓	✓		✓

Table 2: Data Collection Method By Measure

Key Findings

Energy Savings for the four custom measures were calculated using the provided energy trending data for the various equipment.

HVAC Fan Coil Units Controls: This measure involved reducing the fan operating speed from 75% to 20% overnight and over the weekends. Savings for this measure were calculated as the difference in the fan energy demand when running the fan at 75% speed and 20% speed. Then multiplied by the amount of hours the fans will be operating at the reduced speed.

High Pressure Compressed Air Staging Redesign: This measure involved adjusting the high pressure compressors to operate in a more efficient setpoint. The staging improvement had two out of five compressors operate at full load and the other three units can operate at a more efficient part load operation. Savings for this measure were calculated as the difference in total energy usage of all five air compressors before and after the staging improvement. The average energy usage for each air compressor was calculated per month based on the provided trending data of the equipment. This difference in average energy usage is then applied to 8,760 annual operating hours.

High Temperature Heat Recovery Water Piping Improvement: This measure involved re-piping the equipment bleed line from the heater outlet. This bleed line is necessary for proper operations from the water heater and was being piped into the medium temperature line that had to be cooled to the desired temperature. The new piping design had this bleed line going into the high temperature return line which increases the return temperature and therefore requires less energy to heat this water back up to the desired supply temperature setpoint. Savings for this measure use hourly trending data from the heater and calculate the energy usage based on the water flowrate, inlet temperature, and output setpoint. Energy savings are the

difference in usage between the energy usage before and after implementation. This difference in average energy usage is then applied to 8,760 annual operating hours.

Heat Recovery Water Pumping Improvements: This pumping improvement reduced the flow rate of the heat recovery water. Pumping is reduced both by VFD speed reduction and pump staging. Savings for this measure use hourly trending data from the pumps and then averaged into before and after energy demand. This difference in average energy usage is then applied to 8,760 annual operating hours.

Warehouse High Bay Lighting: The baseline was verified to be the removed lighting fixtures (226W). The post fixtures (180W LED) were confirmed in specification sheets and invoices. Fixture quantities (150) were confirmed with supporting documentation. Prescriptive hours of use (6,665 hrs) and an HCIFS (1.08) were for interior fixtures in a manufacturing facility.

ADM did a concurrent M&V process for this project because of the high energy savings to ensure the process and calculated energy savings were done correctly by all parties involved. No discrepancies were discovered during the concurrent review.