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Ameren Illinois Company 2021 Business Program Impact Evaluation Report

Appendix D - Custom Initiative Project Reports

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Appendix D. Custom Initiative Project Reports

In this section, we present detailed project-level desk review, remote measurement and verification (M&V), and on-site M&V reports for 18 Custom Initiative projects evaluated as part of the 2021 Business Program impact evaluation.

Project 2100314

Project ID#:	2100314
Measure:	Variable Frequency Drives
Savings:	31,561 kWh, 2.1 kW
Facility Type:	Municipality
End-Use:	Drainage Pumps
Sampled For:	Electric
Wave:	2

Measure Description

This project consisted of installing one 800-horsepower (HP) electric motor with a variable frequency drive (VFD). The 800-HP motor with VFD has a 100,000 gallon per minute (GPM) pumping capacity. The new motor drives an existing pump used to provide municipal drainage. Previously, one 800-HP diesel engine drove the existing pump. The facility also has a 60,000-GPM pump driven by a 600-HP motor and VFD and a 115,000-GPM pump driven by a diesel engine. This project saves electric energy due to the speed controls of the VSD.

Key Findings

The evaluation team observed that the implementer capped savings at 4% of calculated energy and 0.7% of calculated electric demand savings, as a result of evaluation findings for a similar 2020 project (2000193). Following verification, the evaluation team agreed with this approach and made no adjustments to the savings for this project.

Table 1 presents the project savings.

Table 1. Summary of Project 2100314 Savings

	kW	kWh
Ex Ante	2.1	31,561
Verified	2.1	31,561
Realization Rate	100%	100%

Summary of the Ex Ante Calculations

Annual pump energy use varies according to rainfall and river levels and is not consistent from year to year. The implementation team estimated the average yearly gallons of water pumped using pump runtime hours and pump flow curves. The pump ran 1,892 hours per year according to the site contact’s records. Using the pump flow curve, the flow rate at a maximum pump efficiency of 85% was 78,000 GPM. The implementation team estimated annual flow as follows:

Equation 1. Annual Flow in Gallons Pumped

78,000 GPM * 1,892 hrs * 60 min/hr = 8,852,220,000 gallons/year

Since the engine being replaced is diesel-powered, the implementation team assumed a baseline of the new 800-HP electric motor without VFD driving the existing pump. Using pump specifications, the implementation team estimated an 87,000 GPM baseline pumping rate. Applying the baseline GPM pumping rate and annual flow, the implementation team calculated an annual run time of 1,696 hours for the 800-HP electric baseline pump.

The baseline energy and demand calculations are as follows:

Equation 2. Baseline Pump Motor Demand

800 HP * (0.746 kW/HP) / 96.2% motor efficiency = 620 kW

Equation 3. Baseline Pump Motor Annual Energy Consumption

620 kW * 1,696 hours/year = 1,052,048 kWh/year

The new system will run with the same motors as assumed in the baseline calculation but with VFDs installed. The implementation team assumed that the speed, and therefore flow rate, would be set to 50% under normal conditions. At an average 50% flow rate, the pump would run 3,392 hours per year. The implementation team estimated the new motor demand using the standard affinity relationship, with an exponent of three between pump speed and motor power. The proposed energy and demand calculations are as follows:

Equation 4. New Pump Motor Demand

$620\ kW * (0.5)^3 = 78\ kW$

Equation 5. New Pump Motor Annual Energy Consumption

78 kW * 3,392 hours = 263,012 kWh

The calculated energy and demand savings are 739,036 kWh and 302.7 kW, respectively. Due to the project's similarity to 2020 project number 2000193 and to mitigate evaluation risk; however, the realization rates from that project, 4.0% for energy and 0.7% for demand, were applied to the calculated savings. The results are the claimed savings of 31,561 kWh and 2 kW.

Measurement and Verification Plan

The evaluation plan included an in-person on-site verification to confirm the installation and operation of the VFDs and motors. The goal was to record motor and VFD nameplate information and to collect the following information:

- Total hours of operation on the motors equipped with VFDs to date
- Typical weekly or daily flow profiles, or, if not available, the average speed of the VFDs according to trend data or operator logs
- A description or historical flow rate data to support how flow rates/pump speeds were previously controlled

- A description or historical flow rate data to support how flow rates/pump speeds are currently controlled
- Normal pump discharge pressure and flow rates from trend data or logs
- Minimum VFD speed or control static pressure setpoint

In addition, the evaluation team planned to ask the site contact the following questions:

- Do the pumps represent the majority of the billed power and diesel use?
- How often do operators change pump speeds?
- Has the pump been modified since the motor and VFD installation?
- Was the speed of the diesel pump modulated? If not, was its full speed equal to the new motor's full speed?
- Was the diesel pump at the end of its useful life?

Summary of the Verified Calculations

Our on-site verification visit found that the 600-HP pump generally runs more often than the other pumps, but the pump driven by the new 800-HP motor will be used as needed to maintain the water level in the ditch. The diesel pump is the least frequently used of the three pumps and only runs when significant flow rates are needed to keep the water level in the ditch from rising too high. The minimum operating setpoint for the new VFD is 50 Hz, or about 83.3% speed, while the minimum speed of the 600-HP motor is 45 Hz, or 75% speed. At slower speeds, the pumps will not move the water due to static pressure.

The implementer incorrectly assumed that the pump, at reduced speed, would follow the standard affinity factor of 3 without accounting for static head. Zero flow can happen at relatively high speeds in this project, so the control band is very narrow. This incorrect assumption made their power estimate at reduced speeds much too low, as was verified by interval data in the 2020 project that used a nearly identical calculation approach. There was insufficient data available, however, to adjust the ex ante savings. The new motor and VFD have only been in use for one season, and the plant operator reported it was used sparingly—about 12 hours this year due to abnormally low rainfall. Typical operating times and flow rates for the pump with the new motor have not been established, but the plant operator expects its hours of use to be similar to the diesel engine it replaced. Given the lack of new operating data and the fact that the savings were capped at 4% and 0.7% for energy and demand, respectively, we feel that the claimed savings are reasonable for this project.

Project 2001142

Project ID#:	2001142
Measure:	Kitchen Hood Controls
Savings:	18,074 therms
Facility Type:	Educational Facility
End Use:	Kitchen Hood Fans
Sampled For:	Gas
Wave:	2

Measure Description

This project covered several kitchen hood controls upgrades in the kitchen classroom at a college. Prior to this project, the kitchen exhaust fans operated 24/7, with the makeup air unit operating 24/7 as well. The upgrades include temperature sensors and VFDs on the exhaust fan motors that will modulate speed based on exhaust duct temperature. This project is expected to save both gas and electric energy. Only gas savings, however, are evaluated because this project was only selected as a part of the gas sample. The project was completed on January 31, 2021.

Key Findings

The evaluation team made multiple changes to ex ante calculations, with the single largest impact resulting from changing the assumed building temperature balance point of 65°F to the site contact provided makeup air unit (MAU) supply air temperature of 70°F. By increasing this base temperature, the gas usage of the MAU also increases in heating outdoor air to a higher temperature. Because the savings from this project come from allowing the MAU to not operate during unoccupied hours, this increase in base temperature resulted in increased savings. The resulting project savings are shown in Table 2 below.

Table 2. Summary of Project 2001142 Savings

	Therms
Ex Ante	18,074
Verified	20,691
Realization Rate	114%

Summary of the Ex Ante Calculations

The kitchen exhaust hoods are comprised of four fans, each with an airflow of 3,250 cubic feet per minute (CFM). In the baseline, the implementation team assumed that the exhaust fans operated 24/7 year-round for a total of 8,760 hours per year. They also assumed that the MAU operated 24/7 except during June through August for a total of 6,570 hours per year. By using average monthly outdoor air temperatures (OAT), a building balance point of 65°F, operating hours of 6,570 hr/yr, and the full fan capacity of 3,250 CFM, the implementation team estimated the energy required to make up the exhausted air and maintain the space temperature. They also estimated the gas usage required to bring the air in the space up to typical kitchen hood duct temperatures. Summing these energy uses and assuming a boiler thermal efficiency of 93% resulted in a total baseline natural gas usage of 26,952 therms.

In the proposed case, the implementation team assumed that the exhaust fans typically operate four hours per day, five days a week except during the second half of May through the first half of August for a total of 720 hours per year. They also assumed that the MAU operates four hours per day, five days a week except during the second half of May through August for a total of 680 hours per year. The implementation team calculated a time-weighted average fan capacity of 2,958 CFM by estimating VFD duties using typical exhaust duct temperatures. By using average monthly OATs, a building balance point of 65°F, operating hours of 680 hr/year and the average fan capacity of 2,958 CFM, the implementation team used the same algorithm as in the baseline to estimate the energy required to make up the exhausted air and maintain the space temperature. Similarly, they also estimated the gas usage that would be required to bring the air in the space up to typical kitchen hood duct temperatures. The total proposed natural gas usage was 8,878 therms.

The difference between the baseline and the proposed natural gas usages yielded a savings value of 18,074 therms.

Measurement and Verification Plan

This project was verified through a desk review of the documentation and phone call verification to confirm installation and operation of the kitchen hood controls. The evaluation team collected information from the site contact regarding kitchen operating hours (during regular school year and over breaks), operation of the kitchen hood controls (minimum VFD setpoints, minimum duct temperature setpoints), and operation of the MAU (direct or indirect fired, supply air temperature setpoint).

Summary of the Verified Calculations

The site contact verified installation and operation of the kitchen hoods controls and MAU. During the regular school year, the kitchen is usually in use Monday through Friday, 7:30 a.m.–2:00 p.m., except for a week in March for spring break and a week in December for winter break. During the summer break in June and July, the kitchen is on a reduced schedule, operating only Monday through Thursday, 10:00 a.m.–2:00 p.m. The fan motors turn on to 45 Hz at a duct temperature of 80°F and modulate up to 60 Hz at a duct temperature of 120°F. The MAU operates only when the exhaust fans are on and is direct fired with a 70°F supply air temperature setpoint and no cooling.

In the baseline, the evaluation team assumed that the MAU operates 24/7 year-round but that it only uses heating when OATs are greater than 70°F for a total of 6,552 hours per year. By using average monthly OATs from TMY3 data,[1] 6,552 hours per year, and the full fan capacity of 3,250 CFM, the evaluation team estimated the energy required to heat makeup air to a supply air temperature of 70°F. Summing these energy uses and assuming a direct fired efficiency of 92% results in a total baseline natural gas usage of 24,227 therms.

In the proposed case, the evaluation team used the actual operating schedule of the kitchen to determine that it operates 1,486 hours per year. We calculated a time-weighted average fan capacity of 2,884 CFM using the frequency setpoints provided by the site contact and the VFD duties as per the ex ante. By using average OATs only during hours of operation from TMY3 data, operating hours of 1,486 hours per year, and the average fan capacity of 2,884 CFM, the evaluation team used the same algorithm as the baseline to calculate a total proposed natural gas usage of 3,535 therms.

[1] Typical meteorological year (TMY) datasets, including TMY3, are available from the National Solar Radiation Database: https://nsrdb.nrel.gov/

Unlike the ex ante calculations, the evaluation team did not consider the gas usage required to bring the air in the space up to typical kitchen hood duct temperatures. This gas usage is from the kitchen equipment, not the MAU, and was not impacted by the project. Therefore, it was removed from consideration.

As described in the Key Findings section, the increase in savings was mainly due to updating the base temperature from the assumed building balance point of 65°F to the supply air temperature setpoint of 70°F provided by the site contact. This change, along with using average OATs only during hours of operation in the proposed case and the slight decrease in time-weighted average fan capacity, increased savings. These savings increases were partially offset, however, by an increase in the operating hours from ex ante to verified calculations and removing the gas usage from the kitchen equipment. The difference between the baseline and the proposed natural gas usages yielded a savings value of 20,691 therms.

Project 2100091

Project ID#:	2100091
Measure:	Compressed Air
Savings:	719,021 kWh, 82.3 kW
Facility Type:	Industrial Facility
End-Use:	Compressed Air
Sampled For:	Electric
Wave:	2

Measure Description

This project covered compressor replacements and an operating pressure reduction measure at an industrial facility. Two fixed-speed 150-HP compressors were replaced with two variable speed drive (VSD) 150-HP compressors. Additionally, one of the fixed-speed 150-HP compressors was kept as a backup unit, replacing a 75-HP backup compressor. The operating pressure was reduced from 110 pounds per square inch gauge (psig) to 100 psig. All measures decrease power use and save electricity. The project was completed on May 4, 2021.

Key Findings

There is a slight reduction in savings because the evaluation team changed the algorithm used to calculate the savings from the pressure reduction measure. The implementation team assumed a 1% increase in savings for every 2 psig in pressure reduction in the ex ante calculations. Therefore, for a pressure reduction from 110 psig to 100 psig, the savings were increased by 5%.

The evaluation team instead used Compressed Air & Gas Institute (CAGI) compressor data to estimate the power savings that would result from operating the compressors at a lower pressure. The resulting project savings are shown in Table 3 below.

Table 3. Summary of Project 2100091 Savings

	kW	kWh
Ex Ante	82.3	719,021
Verified	79.5	701,551
Realization Rate	97%	98%

Summary of the Ex Ante Calculations

The contractor provided a compressed air audit for the facility. Provided in this audit were metered data for the airflow in cubic feet per minute (CFM) and power (kW) demand of the two fixed-speed compressors and the one backup compressor at the facility over one week. The implementation team used the audit report to calculate electric savings. Assuming the week was representative of typical operations, the estimated baseline energy consumption was 2,096,612 kWh.

The implementation team binned the airflow (CFM) demand data and used CAGI data sheets to calculate the energy consumption for the proposed compressors. They assumed that the proposed compressors would be equally loaded. The estimated proposed energy consumption before pressure reduction was 1,409,830 kWh.

The energy savings before pressure reduction are the difference between the baseline and proposed cases, 684,782 kWh. The implementation team assumed a 1% increase in savings for every two psig in pressure reduction. Therefore, for a pressure reduction from 110 psig to 100 psig, the savings were increased by 5%.

The total energy savings were 719,021 kWh (684,782 kWh * 1.05). Using the hours of operation of 8,736 hours per year provided by the site contact, the peak coincident power demand savings were taken to be the average power demand savings of 82.3 kW (719,021 kWh / 8,736 hours per year).

Measurement and Verification Plan

The evaluation team performed a desk review of the documentation and email verification to confirm installation and operation of the compressed air system. The evaluation team collected information from the site contact regarding installation and operation of the proposed compressors, implementation and operation of the pressure reduction measure, the proposed compressors' make and model numbers, baseline and proposed compressor staging, and any production changes between pre- and post-project.

Summary of the Verified Calculations

The site contact confirmed installation and operation of the VSD compressors, make and model numbers, and compressor sequencing and verified that the pressure reduction measure was still in place. Therefore, the evaluation team's baseline and proposed case energy usage calculation methods were the same as the ex ante calculations.

The evaluation team did change the pressure reduction savings calculations, however. The evaluation team attempted to find CAGI datasheets for the installed VSD compressors at an operating pressure of 100 psig, but only one datasheet for operation at 110 psig was available. Instead, datasheets for a similar VSD compressor from a different manufacturer were found for operation at 102 psig and 138 psig. Using these data sheets, the evaluation team calculated an adjustment factor for the power reduction per psig of pressure reduction. This power reduction adjustment factor was applied to the data for the installed VSD compressors.

The evaluation team also updated the demand reduction to reflect peak coincident power demand savings instead of average power demand savings. In the audit report, the average compressed air demand during shifts one (Monday–Friday, 7:00 a.m.–3:00 p.m.) and two (Monday–Friday 3:00 p.m.–11:00 p.m.) in the baseline case were 907 standard cubic feet per minute (SCFM) and 885 SCFM, respectively. Averaging these values gives an approximated compressed air demand of 896 SCFM during the 1:00 p.m.–5:00 p.m. peak hours. To meet this air demand, the two VSD compressors loaded equally would require a total of 165.3 kW.

The total verified energy and demand savings from the compressor replacements and pressure reduction are 701,551 kWh and 79.5 kW, respectively.

Project 2100014

Project ID#:	2100014
Measure:	HVAC Controls
Savings:	1,489,424 kWh, 0.0 kW, 21,971 Therms
Facility Type:	Healthcare Facility
End Use:	HVAC
Sampled For:	Electric and Gas
Wave:	2

Measure Description

This project covered several HVAC system improvements in two buildings at a medical center. The customer also completed steam trap replacements through the Steam Trap Repair and Replace initiative offered through the Standard Core Channel. Therefore, these improvements are not a part of the Custom project and evaluation.

Improvements in the first building included the addition of VFDs on three 20-HP hot water loop pumps, 15 pressure-independent chilled water control valve installations, and Automated Logic direct digital controls (DDC) installations for two air handling units (AHUs), chilled water heat exchanger energy valves, as well as heating radiant panel heat exchangers.

Improvements in the second building included Automated Logic DDC installations for one AHU, 26 variable air volume (VAV) boxes with hot water reheat, and four exhaust fans.

This project saves both electricity and gas and was completed March 31, 2021.

Key Findings

The evaluation team lowered the overall savings of this project by correcting for the lower reduction in airflows on AHU-5 and AHU-6 based on the trend data provided by the building engineers. Both air handlers are expected to vary flow from 30% to 100%, but site contact-provided trend data indicate these systems consistently run between 85% to 90% speed. This reduced the gas savings, which was entirely based on the air handler reheat. The evaluation team found. however, that the chilled water savings, which represent a majority of the electric savings, were reasonable.

The implementation team applied a cap to electric savings for HVAC control projects as a means of ensuring conservative ex ante claimed savings. The evaluation team analyzed the full scope of savings and did not apply the cap, which is why the realization rate is above 100% for the electric energy savings.

The resulting project savings are shown in Table 4 below.

Table 4. Summary of Project 2100014 Savings

	kW	kWh	Therms
Ex Ante	0.0	1,489,424	21,971
Verified	0.0	1,616,686	8,418
Realization Rate	NA	109%	38%

Summary of the Ex Ante Calculations

The implementation team used EnergyPlus building energy models created by the contractor to determine the electricity and gas savings. Based on a review of the energy model, the evaluation team believes the implementation team was aiming to achieve the following measures in each building:

- First Building
  - Reduce minimum airflows for AHU-5 and AHU-6
    - Baseline: constant volume
    - Proposed: variable volume with 30% minimum flow
  - Increase hot water pumping efficiency
    - Baseline: constant volume
    - Proposed: optimized pump sequencing and variable flow
  - Installation of chilled water energy valves
    - Baseline: 4°F differential temperature
    - Proposed: 12°F differential temperature
- Second Building
  - Reduce minimum air flows for AHU-3200
    - Baseline: 60% minimum air flows
    - Proposed: 30% minimum air flows
  - Supply temperature reset on AHU
    - Baseline: constant discharge air temperature of 57°F
    - Proposed: temperature resets between 55°F and 65°F
  - Widen zone temperature satisfied band
    - Baseline: satisfied between 70°F and 72°F
    - Proposed: satisfied between 68°F and 75°F

Calculated energy savings from the energy models are 1,658,384 kWh and 21,971 therms. The implementation team capped electric and gas savings for HVAC projects, however, to ensure that claimed savings are conservative and low risk. For this project, the modeled electric savings exceeded the cap while the gas savings did not. The final claimed electricity and gas savings were 1,489,424 kWh and 21,971 therms, respectively. The implementation team did not calculate demand savings.

Measurement and Verification Plan

The evaluation plan included verification of this project via a desk review of the documentation and email correspondence to confirm installation and operation of the controls measures and the VFD installations and control valve upgrades. We will also attempt to collect trend data for VFD pump speeds, AHU supply/return fan speeds and discharge air temperatures, VAV box damper positions, chilled water temperatures and flows, and exhaust fan operation. The goal was to compare these data will to the building energy model outputs to assess the ex ante assumptions and savings calculations. The evaluation team planned to ask the site contact questions regarding measures in two buildings.

Regarding the measures in the first building, we planned to ask the site contact:

- Our records show that variable frequency drives were installed on three 20-HP hot water loop pumps, 15 pressure-independent valves were installed, and DDC was installed on AHU-5 and AHU-6 and the radiant panels on the fourth and fifth floors. Is this accurate, and are these measures currently still in place and operational?
- If available, can you provide the following documentation showing implementation of these measures?
  - Trend data for the three VFD pump speeds
  - AHU-5 and AHU-6:
    - Outdoor air (OA) damper, minimum position and economizer strategy
    - Supply/return fan speeds
    - Discharge temp trends
  - Radiant panels:
    - Scheduling, setbacks, occupancy sensors
    - Temperature set points in baseline and proposed case
  - Pressure valves:
    - Chilled water supply and return temperatures
    - Pump speeds

Regarding the measures in the second building, we will ask the site contact:

- Our records show that DDC were installed for AHU-3200, VAV terminals, and exhaust fans. Is this accurate, and are these measures currently still in place and operational?
- Can you provide the following documentation showing implementation of these measures?
  - Trend data for three to four VAV box damper positions.
  - For AHU-3200, trend data for supply/return fan speeds, discharge air temperatures, outside air damper positions, scheduling.
  - For exhaust fans, trend data for on/off monitoring

Summary of the Verified Calculations

The evaluation team reviewed the current operating sequences with the building engineer and compared current trend data from the automation system with the proposed changes made in the energy models. The following observations were made based on the trend data provided:

- Trends for the hot water pumps show the pumps alternating their lead and operating at or below 65% speed as modeled with the optimized sequencing.
- Trends show that there is a greater than 14°F delta between the supply and return temperatures post-implementation on the cooling loop when it is active.

- AHU-5 and AHU-6 run consistently between 85%–90% speed.
- Trends show that the modeled space temperature heating set points of 70°F are accurate.
- AHU-5 and AHU-6 have a reset schedule now that resets supply temperatures between 55°F and 58°F as seen in the trend data, instead of the previous constant set point of 57°F.
- VAV boxes served by AHU-3200 have had their minimum air flows reduced from the assumed baseline of 60%, based on pneumatic controls, to the trends showing minimums of roughly 30% on average.

Based on the building trends supplied by the site contact, it appears that the ex ante calculations overestimated the overall air flow reduction for AHU-5 and AHU-6. The evaluation team used a multizone air handling unit calculation to model the baseline energy use of AHU-5 and AHU-6, which confirmed this fact.

The same calculation was used to model the expected savings by lowering the air flows to 30% of the original design (the implementation team's assumed airflow reduction) and the actual reduction of fan airflows to the range of 85%–90% as seen in the building trends. The uncapped ex ante savings values were then reduced by the difference between the savings from lowering the airflows to 30% and the reduced savings from only lowering the airflows to 85%–90%.

The majority of the electricity savings in this project are from the optimization of the chilled water system where the evaluation team did not make any adjustments. The trend data provided by the site contact shows a significant improvement in differential temperature which impacts the fans' energy consumption by lowering discharge air temperatures to their design conditions and thus reducing total cooling airflow.

The adjustment that the evaluation team made to minimum airflows was made on two of air handlers. All of the gas savings were from the three air handlers, two of which did not achieve the airflow turndown the implementation team proposed. As a result, our adjustments to correct for not effectively lowering the minimum airflows or properly scheduling the fans resulted in a larger impact on the realization rate for gas savings than electric. See Table 5 below for a summary of savings reductions.

Table 5. Energy End Use Breakdown

End-Use	Ex Ante Savings		Verified Savings	
	Electricity (kWh)	Gas (Therms)	Electricity (kWh)	Gas (Therms)
Heating	41	21,971	41	8,418
Cooling	923,682	0	891,796	0
Interior Lighting	0	0	0	0
Exterior Lighting	0	0	0	0
Interior Equipment	0	0	0	0
Exterior Equipment	0	0	0	0
Fans	123,468	0	113,656	0
Pumps	235,112	0	235,112	0
Heat Rejection	372,674	0	372,674	0
Humidification	3,407	0	3,407	0
Total	**1,658,384**	**21,971**	**1,616,686**	**8,418**

The verified electric and gas savings are 1,616,686 kWh and 8,418 therms, respectively. The evaluation team agrees with the implementation team that there were not likely demand savings as measures like VFDs, economizers, chilled water, and air handler temperature resets would not reduce usage during peak times.

Project 2100019

Project ID#:	2100019
Measure:	HVAC Controls
Savings:	94,697 kWh; 27,650 therms
Facility Type:	University
End Use:	HVAC Controls
Evaluated Fuel:	Electric and Gas
Wave:	1

Measure Description

This project consisted of updating HVAC controls in one building at a university campus. The existing automation system in the building was removed and replaced by Automated Logic controllers. The project application was submitted on June 29, 2020. The project was completed on November 18, 2020. This project was completed concurrently with Project 2100018.

Key Findings

The evaluation team found that the energy models used to estimate project savings were somewhat consistent with the project work completed but made several adjustments that substantially impacted gas savings. First, we modified several setpoints to reflect actual building heating setpoints (72°F rather than 68°F during the occupied mode). Second, the evaluation team found a large air handling conversion from constant volume to variable air volume was not part of this project. The equipment had previously had variable volume controls. Third, we modified schedules to reflect actual building operation; we found more run-time during weekdays but less during weekends. Finally, there was a slight change where we reduced the achieved temperature differential based on trended chilled water data

The resulting project savings are shown in Table 6 below.

Table 6. Summary of Project 2100019 Savings

	kW	kWh	Therms
Ex Ante	0.0	94,697	27,650
Verified	0.0	93,373	15,628
Realization Rate	N/A	99%	57%

Summary of the Ex Ante Calculations

The implementation team evaluated project savings using EnergyPlus models for the baseline and proposed cases. The operating hours for the baseline and proposed cases are 8,760 hours.

The following primary changes drove the energy savings in the ex ante models:

- Schedules and temperature setbacks were added to several spaces in the proposed model
  - Baseline equipment ran continuously, 24 hours per day, seven days per week. This was changed in the proposed case to operate during scheduled occupancy hours of 7:00 a.m. to 5:00 p.m., seven days per week.

  - The baseline cooling setpoints were a constant 72°F. In the proposed model, cooling setpoints were set to 75°F during occupied hours and 100°F during unoccupied hours.
  - The baseline heating setpoints were a constant 70°F. In the proposed model, heating setpoints were set to 68°F during occupied hours and 62°F during unoccupied hours.
- In the proposed model, infiltration rates in many spaces were reduced by 20%–25%.
- AHUs 5, 6, & 7 were converted from constant volume in the baseline model to VAV air handlers with 30% minimum fan speeds in the proposed model.
- Chilled water loop sizing changed from 7.2°F in the baseline model to 16°F in the proposed model to represent the improved temperature differential of the chilled water loop.

Measurement and Verification Plan

The evaluation team M&V approach consisted of a review of project documentation and a virtual visit with a site contact. We planned to ask about other energy efficiency projects that may have been completed in the last two years, as well as any effects of the COVID-19 pandemic on campus activity and operation of the HVAC systems.

We planned to request a virtual demonstration and/or screenshots of the new controls to verify the following capabilities and setpoints of the new energy management system (EMS):

- Schedules, control of pressures/temperatures, and reset capabilities of air handling units (AHUs)
- Control of VAV terminal units where applicable

The evaluation team also planned to request trend data to verify operation of the chilled water plant covering pre- and post-retrofit conditions and ensure chilled water system management is consistent with expected operation.

We also planned to inquire about capabilities and condition of the controls being replaced, including scheduling and setpoints, temperature and pressure resets, and monitoring capability.

The evaluation team planned to use the information provided in the documentation and gathered during the virtual verification to update the ex ante EnergyPlus models to establish ex post savings.

Summary of the Verified Calculations

The evaluation team interviewed the site contact by phone on November 24, 2021. The site contact confirmed installation and operation of the new controls and provided screenshots of AHU controls. We also collected graphical trend data from January 6, 2021, through December 21, 2021, of chilled water supply flows for pre- and post-retrofit conditions. We had a follow-up interview with the site contact on December 21, 2021, to collect additional information, including spreadsheet files of chilled water supply and return temperatures and flows covering January 6, 2021, through December 21, 2021. We confirmed operating schedules and VAV operation, where applicable.

The site contact reported that the existing controls were in very poor condition and were not capable of scheduling AHU operation.

The evaluation team verified savings by updating the ex ante EnergyPlus models with information collected from the site contact.

We adjusted several model parameters and inputs based on data collected from the site contact on the actual operation conditions and setpoints:

- Verified setpoint temperatures were set to 74ºF/85ºF (occupied/unoccupied) for cooling and 72ºF/55ºF for heating. The ex ante modeled setpoint temperatures were 75ºF/100ºF for cooling and 68ºF/62ºF for heating. This primarily decreased the gas savings.
- The verified proposed model's temperature difference between the chilled water supply and chilled water return was set to 8.5˚F based on trend data of average chiller plant supply and return temperatures provided by the site contact for the period covering January 6, 2021, through December 21, 2021. The ex ante proposed model assumed a 16˚F temperature difference, compared to the ex ante baseline model's temperature difference of 7.2°F. A smaller temperature differential between the supply and return means less heat exchanged between the chilled water and the AHU, resulting in increased operating hours to condition the space. This decreased the electric savings.
- The proposed building occupancy schedule was changed to 6:30 a.m.–9:00 p.m., Monday through Saturday, and otherwise set to unoccupied mode. In comparison, the ex ante proposed occupancy schedule was 7:00 a.m.–5:00 p.m., seven days per week. The verified model's increase in weekday hours and decrease in Sunday hours largely offset each other.
- The ex ante baseline AHU system was modeled as constant volume. In our verification, however, we found it was a VAV system prior to the controls project implementation, so the verified baseline model was modified to operate as a VAV system. This decreased both gas and electric savings.

Project 2000305

Project ID#:	2000305
Measure:	Compressed Air
Savings:	6,180,973 kWh; 587.4 kW
Facility Type:	Manufacturing/Industrial
End Use:	Compressed Air Dryer
Sampled For:	Electric
Wave:	3

Measure Description

The customer installed a new high-efficiency heat-of-compression (HOC) dryer system with five desiccant dryers, instead of a standard heatless dryer system (requiring six dryers to meet demand) in a compressed air system for a manufacturing facility. The compressed air system is made up of five 1,500-HP compressors outputting 7,000 or more actual cubic feet per minute (ACFM). At least one compressor is operating continuously (8,760 hours per year) serving production, assembly, and painting areas in the facility.

Key Findings

The evaluation team found that the installation and operation of the compressed air system with the five new dryers are as expected. However, the ex ante calculation over-estimated savings. The equipment is not yet capable of providing trends, but runtime data indicate the primary compressors, in both the baseline and efficient cases, run approximately 55% of the time in comparison to 100% operation assumed in ex ante savings. Therefore, the evaluation team adjusted annual energy savings and coincident peak demand based on this reduced runtime.

The resulting project savings are shown in Table 7 below.

Table 7. Summary of Project 2000305 Savings

	kW	kWh
Ex Ante	587.4	6,180,973
Verified	366.1	3,944,136
Realization Rate	62%	64%

Summary of the Ex Ante Calculations

The whole compressed air system is new. As a result, the ex ante savings are based on a new construction baseline. The baseline is six heatless compressed air dryers with an average purge rate of 4,422 CFM. The efficient case is five HOC dryers with minimal purge and heat reclaimed from the air compressors. The baseline case annual purge, heater and controls' energy usage is 7,129,513 kWh, assuming continuous operation. The efficient case assumes continuous operation (8,760 hours), analogous to baseline operation, resulting in annual energy usage of 948,540 kWh.

Measurement and Verification Plan

This was conducted as a virtual onsite evaluation. The evaluation team used the calculations and documentation from implementation as well as an interview with a site contact and runtime data.

The following questions were asked:

- It is assumed that the peak kW draw of the system is reached during Illinois' coincident peak period.
  - Is this likely to be true? Does usage change during different times of the year?
- Can we get trends of the following?
  - Dryer power
  - System CFM
  - Blow-off
  - Hours of operation
- How is the reclaimed heat from the compressed air system ducted?
- Is backup required?
- Are all five new dryers used continuously?

Summary of the Verified Calculations

In an interview with the site contact, they noted all five dryers have been operating with a capacity of approximately 7,000 CFM since the fall of 2020. The heat used by the dryers is recovered from the air compressors. Cycle times are 480 minutes long consisting of 240 minutes on stream, 90 minutes on heating, 90 minutes on stripping, and 60 minutes on cooling. The dryers have a 50 kW heater, which provide the low dew points required. The heater consumes on average 1,730 kWh every 24 hours. Cycle times, dew points, and other settings are controlled manually at this time, because monitoring capabilities are limited. This information aligns well with the ex ante calculations.

The site contact provided an updated table of operating hours and standby hours for each dryer. On average, each dryer is operating 55% of the time with the system as a whole running continuously. This data deviates from the ex ante assumptions.

The ex ante baseline and efficient calculations assume full purge flow throughout the year. This assumption requires that compressed air backflow into dryers at all times. While this may occur in smaller systems, the evaluation team does not believe that a baseline without automatic isolation valves represents industry standard practice for a system of this size. Therefore, the evaluation team adjusted the average purge flow in the baseline and efficient calculations to reflect the duty cycle of the dryers (i.e., dryers only purge when their associated compressor is operating).

The evaluation team cross checked the custom calculated verified savings with a prescriptive-calculated value following the guidance in the IL-TRM V9.0. Our inputs for the TRM algorithm are as follows:

- 35,000CFM dryer (operating at 55% capacity)
- 0.027 baseline kW/CFM
- 0.012 efficient-case kW/CFM
- 0.6 purge reduction factor
- 5,928 hours of use assuming the three-shift value given in the TRM which is conservative based on the actual hours provided

This additional verification resulted in a savings estimate (3,526,664 kWh and 565 kW) very similar to the verified savings.

As the plant compressed-air needs ramp up to the expected capacity, additional savings may be claimed in subsequent years.

Project 2100027

Project ID#:	2100027
Measure:	HVAC Controls
Savings:	134,316 therms
Facility Type:	Medical
End Use:	Controls
Evaluated Fuel:	Gas
Wave:	3

Measure Description

This project consisted of updating HVAC controls at a medical center. The project included new VFDs, control valves, sensors, and damper actuators that were installed on five air handling units (AHUs). New actuators were installed on five zone dampers and three reheat zone controls were updated. The project application was submitted on July 7, 2021. The project was completed on October 29, 2021.

Key Findings

The evaluation team reviewed the implementer's EnergyPlus files and energy usage data to evaluate this project. We concluded that the implementer's ex ante estimate is reasonable.

The resulting project savings are shown in Table 8 below.

Table 8. Summary of Project 2100027 Savings

	Therms
Ex Ante	134,316
Verified	134,316
Realization Rate	100%

Summary of the Ex Ante Calculations

The implementation team evaluated project savings using EnergyPlus models for the baseline and proposed cases.

Measurement and Verification Plan

The evaluation team M&V approach consisted of a review of project documentation and an in-person site visit with a site contact. We planned to ask about other energy efficiency projects that may have been completed in the last two years as well as the effects of the COVID-19 pandemic on facility activity and operation of the HVAC systems.

The evaluation team planned to request a demonstration of the new controls to verify the following capabilities and setpoints of the upgraded EMS:

- Multi-Zone AHU S-8: supply air temperature (SAT) reset programing, occupied/unoccupied schedule, control of new supply and return fan VFDs (one 20-HP and two 3-HP)

- 100% Outside Air AHU S-10: SAT reset programing, occupied/unoccupied schedule, control of new supply fan VFD (15-HP)
- Constant air volume (CAV) AHU S-11: SAT reset programing, occupied/unoccupied schedule, control of new supply and return fan VFDs (one 15-HP and one 5-HP)
- CAV AHU S-14: SAT reset programing, occupied/unoccupied schedule, control of new supply and return fan VFDs (one 30-HP and one 5-HP)
- 100% Outside Air AHU S-13: SAT reset programing, occupied/unoccupied schedule, control of new supply fan VFD (25-HP)
- S-8 zone dampers (five): changes to program logic and damper operation
- S-13 reheat zones (three): changes to program logic and damper operation
- Induction units supply/return loop pump (30-HP): Control of VFD and other changes to program logic
- Screenshots of setpoints, schedules, and other programming

The evaluation plan included a request for trend data to verify operation of the AHUs for pre- and post-retrofit conditions.

The goal was to use information provided in the documentation and gathered during the in-person verification to update the ex ante EnergyPlus models to establish ex post savings.

Summary of the Verified Calculations

The evaluation team reviewed the EnergyPlus models and verified modeling inputs and parameters for this project. We made minor changes to the models based on our verification. These new models showed higher gas savings, but the facility gas usage does not support higher savings.

Because the project was completed in October 2021, we were not able to develop normalized energy savings projections using a regression analysis. We did, however, review gas usage before and after the project. The ex ante savings are approximately an 18% reduction in energy use, while the actual gas savings are in the 5%–10% range based on three months of data available to the evaluation team. The project may generate additional savings during the summer months, however, to make up the difference. With that in mind, the evaluation team believes the ex ante savings are reasonable.

Project 2100034

Project ID#:	2100034
Measure:	HVAC Controls
Savings:	12,161 therms
Facility Type:	Miscellaneous
End Use:	HVAC
Sampled For:	Gas
Wave:	2

Measure Description

This project covered replacement of outdated pneumatic controls and sensors in part of a single-story training and resource facility. The building is 103,400 square feet (sf) and the controls for 18,900 sf were previously converted to DDCs as part of an earlier phase of the project. This phase of the project replaced controls for a total of nine AHUs that serve a total of 47 VAV boxes, and the affected building area is 81,475 sf.

As part of the new controls, each of the AHUs was retrofitted with new heating and cooling control valves, each thermal zone was equipped with a new zone air temperature sensor, and each VAV box was equipped with a new discharge air temperature sensor. With the new controls installed, the customer will be able to implement setback schedules for temperature and airflow for all of the air handling units and thermal zones involved in this project.

The savings for this project amount to approximately 30% of the building's billed annual gas usage. This project was sampled for gas savings. Energy savings associated with electricity are not part of this evaluation.

Key Findings

The verified gas savings for this project are equal to ex ante savings because weather-normalized regression analyses using energy consumption data showed similar savings. While few data were available about the operation of the HVAC equipment prior to the completion of the project, the evaluation team suspects the new controls significantly reduced the amount of outside air being brought into the building as observed during the EMS walkthrough with the site contact. This data supports the billing regression analysis results and ex ante claimed savings.

The resulting project savings are shown in Table 9 below.

Table 9. Summary of Project 2100034 Savings

	Therms
Ex Ante	12,161
Verified	12,161
Realization Rate	100%

Summary of the Ex Ante Calculations

The ex ante savings for this project were determined using Carrier HAP modeling software. The simulation outputs for the modeled building are shown below in Figure 1.

Figure 1. Simulation Outputs

Table 2. Annual Energy Consumption

Component	Existing Building	Proposed Building
HVAC Components		
Electric (kWh)	1,019,395	661,703
Natural Gas (Therm)	32,520	15,478
Fuel Oil (na)	0	0
Propane (na)	0	0
Remote HW (na)	0	0
Remote Steam (na)	0	0
Remote CW (na)	0	0
Non-HVAC Components		
Electric (kWh)	774,003	774,003
Natural Gas (Therm)	0	0
Fuel Oil (na)	0	0
Propane (na)	0	0
Remote HW (na)	0	0
Remote Steam (na)	0	0
Totals		
Electric (kWh)	1,793,398	1,435,706
Natural Gas (Therm)	32,520	15,478
Fuel Oil (na)	0	0
Propane (na)	0	0
Remote HW (na)	0	0
Remote Steam (na)	0	0
Remote CW (na)	0	0

The simulation results show modeled savings of 17,042 therms. A cap was applied to limit gas savings to 30% of the estimated baseline gas use of the affected area of the building, which is 12,160 therms. This capped value is the ex ante savings for the project.

Measurement and Verification Plan

The evaluation team planned to verify this project through a remote site visit that included a conference call with the site contact. We planned to interview the site contact about the operation of the building HVAC system and the new controls system and ask the site contact to do a screen share of the control system, if possible. The goal of the screenshare request was to observe the setpoints and schedules in the new control system, along with any available readouts of system airflow rates, hydronic system control setpoints and readings, and the VAV system controls.

Specific questions the evaluation team planned to ask the site contact included:

- When was the project completed?
- Did the AHUs have any schedules before the project?
- What were the space temperature set points before the project?
- What was the condition of the control system before the project was completed?
- Did the air handlers have an economizing function prior to this project? Did it work?

  - Do the new controls include economizer controls? And if so, are they based on enthalpy or temperature? What is the minimum % of outdoor air?
- What is the nameplate and efficiency information for the chiller? Is there a time of year when the chillers would be disabled?
- What is the nameplate and efficiency information for the boiler?
- What are the current schedule settings (times and temperatures)? Are there any spaces that were not scheduled as intended? What spaces and floor areas?
- Were there any other changes to AHU controls, e.g., supply air temperature reset?
- Were there any changes to VAV minimum settings? If so, what was changed?
- What are the major loads in the space?
- Have operators been trained on the new control system? Who is able to change settings in the new control system?
- Have there been any other projects in the building since the controls upgrade that could significantly impact the building energy use?

The evaluation plan included the following COVID-19 specific questions:

- Has the operation of your facility been affected by COVID-19?
- If so, how has occupancy changed?
- Have the control settings changed due to COVID-19? If so, what changes were made to control settings, e.g., scheduling and setbacks?
- Will control settings return to proposed values when operation becomes “normal”? If not, what is your prediction for set points at that time?

Summary of the Verified Calculations

This project did have some shutdowns in the baseline period due to COVID-19. These shutdowns were primarily during the cooling season of 2020; however, and likely did not have a large impact on the gas consumption of the facility.

Therefore, the evaluation team attempted to verify savings using weather-normalized billed energy consumption regression analyses. The weather-normalized regressions created with monthly gas usage data showed roughly a 32% reduction in annual gas use (12,622 therms) and is consistent with the ex ante savings. The gas model did not meet statistical thresholds and was only based on seven months of post-replacement data, including two months of heating season data. Based on the HVAC system operation verified in the EMS, we suspect the new controls significantly reduced the amount of outside air being brought into the building, which supports the reduction in gas use seen in the ex ante analysis.

As a result, the evaluation team did not adjust the gas savings for this project.

Project 2100054

Project ID#:	2100054
Measure:	Modulation of Makeup Air Units
Savings:	323,590 kWh; 36.9 kW; 43,828 therms
Facility Type:	Manufacturing/Industrial (Food Processing)
End Use:	HVAC
Evaluated Fuels:	Electric and Gas
Wave:	1

Project Description

This project was completed in an approximately 90,000 square foot food processing facility that had recently been purchased and repurposed. Three direct-fired, 40,000 CFM MAUs without fan speed control were installed to provide make-up air to the food processing areas. The facility then upgraded the three MAUs with VFDs and building pressure controls to ensure the food processing areas stay positively pressurized. This project only focused on the installation of the VFDs and building pressurization controls. The MAUs now operate at fan speeds ranging from 60%–100%. The project application was submitted on October 7, 2020. The project was completed on January 8, 2021.

Key Findings

The evaluation team modified both the electric and natural gas savings for several reasons. The first reason is that we believe over-pressurization of the building was not a correct baseline, and therefore made damper modulation the baseline condition. This means that there are no natural gas savings, as the outdoor air volumes are the same in both the baseline and proposed cases. Additionally, we changed the operating hours from five months out of the year to continuous operation, to reflect the actual operating hours of the MAUs, in both the baseline and proposed cases. To calculate the electrical savings, we used a proprietary VFD electrical savings calculator and input the modifications listed above. This resulted overall in a decrease in electrical savings for the project. This is due to there being a larger decrease in electrical savings from modifying the baseline than the increase in electrical savings from increasing the operating hours.

The resulting project savings are shown in Table 10 below.

Table 10. Summary of Project 2100054 Savings

	kW	kWh	Therms
Ex Ante	36.90	323,590	43,828
Verified	10.73	128,007	0
Realization Rate	29%	40%	0%

Summary of the Ex Ante Calculations

The implementation team estimated gas savings by first determining the average heating system input using Equation 6.

Equation 6. Average Heating System Input

$$Average\ Heating\ System\ Input\ \left(\frac{therm}{hr}\right) = \frac{1.08\ \left(\frac{BTU}{hr\ CFM\ °F}\right)\ x\ \Delta T(°F)\ x\ \dot{V}(CFM)}{100{,}000\ \left(\frac{BTU}{therm}\right)\ x\ Eff}$$

The implementation team assumed the heating system would operate continuously from November to March and assumed an input temperature of 36.1°F, which is the average outdoor air temperature during those months. They assumed an outlet temperature from the three MAUs of 85°F and a system efficiency of 95%.

The implementation team used the average heating system inputs to calculate the baseline and new systems' gas energy usage, assuming the baseline system runs continuously at full capacity and the new system follows the schedule in Table 11.

Table 11. Ex Ante Assumed MAUs Operating Schedule in New System

System Operating Capacity	Percent of Annual Operating Hours
100%	20%
90%	20%
80%	30%
70%	20%
60%	10%

The implementation team established electric energy (kWh) savings based on a report from the trade ally (TA). It is unclear to the evaluation team where the data for the existing and proposed systems energy use, and therefore energy savings, are sourced. The electric power (kW) savings is calculated by dividing the energy savings by 8,760 hours.

Measurement and Verification Plan

The evaluation team attempted to get in contact with a member of the site owner's team, but was unsuccessful. We were able to reach the TA and gain some insight into the project. We felt there were still too many unknowns to proceed with a desk review; however, so the evaluation team evaluated and established project savings with an in-person onsite visit.

Prior to the onsite visit, the evaluation team had two remaining areas of uncertainty. First, it was unclear what the typical fan speeds are during ongoing operation and whether the load profile used in the ex ante is appropriate. Regardless, we aimed to gather more insight into how the fans are controlled and how variable the make-up/exhaust needs are in the space. Second, it was unclear whether the assumption that the discharge temperature of the MAUs will be approximately 85°F throughout the winter on average.

To better understand these two issues, the evaluation team conducted the following items during the in-person onsite visit:

- Assess the amount of heat given off by process equipment running in the space. The more heat given off by running equipment, the less heat is required by the MAUs in the winter months.
- Determine the discharge temperature from the make-up air system into the processing area. According to the TA, this temperature is variable and controlled based on a thermostat in the space. The evaluation team planned to take note of the outside air temperature to determine the correlation between the outside air temperature and the discharge temperature

- Take note of the percent capacity that the MAUs are running at during the site visit. Identify how the fan speed is controlled, both while the burners are firing and are not firing.
- Attempt to identify exhaust requirements (both variable and constant exhaust) and how they are controlled and vary throughout the day.
- Collect available trend data on fan speed and discharge temperatures. We will work with operators to get data trending set up if it is not already set up.

Summary of the Verified Calculations

Onsite we found that the MAUs are new and manufacturer documentation indicates the units are available with an optional inlet damper modulation add-on that was not installed in these units. The ex ante calculation assumes that there is no volume control on the units; however, this will lead to over-pressurizing the building. When a building is over-pressurized, notable energy and safety problems arise, such as malfunctioning doors not closing behind people entering or exiting the building or becoming more difficult to open with indoor pressure exceeding outdoor ambient pressure. Such problems are immediately resolved by facility managers through implementation of pressure controls. As a result of these findings, we made proper building pressurization with damper modulation the baseline condition. This means that there are no natural gas savings, as the outdoor air volumes are the same in both the baseline and proposed cases

The evaluation team used damper modulation as the baseline condition to calculate the electric savings with a proprietary VFD savings calculator. We changed the operating hours from five months of the year to continuous operation, to reflect the actual operating hours of the MAUs, in both the baseline and proposed cases. During the in-person site visit, we gathered information about the number of units running throughout the year and the capacities at which they run. We used that information to build a schedule in our in-house VFD savings calculator. The VFD savings calculator allowed us to better model both the baseline and proposed cases and calculate the electrical savings for the project, using the information we gathered during our in-person site visit. These modifications overall resulted in a decrease in electrical savings for the project, as the decrease in savings due to the change in baseline was larger than the increase in savings due to the change in schedule.

Project 2100018

Project ID#:	2100018
Measure:	HVAC Controls
Savings:	825,887 kWh; 0.0 kW; 104,614 therms
Facility Type:	University
End Use:	Controls
Evaluated Fuel:	Electric and Gas
Wave:	1

Measure Description

This project consisted of updating HVAC controls at a university campus. Central plant chiller controls were updated and existing chilled water temperature control valves throughout the campus were replaced with pressure-independent control valves. The existing automation systems in six of the buildings were removed and replaced by Automated Logic controllers. The project application was submitted on June 29, 2020. The project was completed on November 18, 2020. This project was completed concurrently with Project 2100019.

Key Findings

The evaluation team found the energy models used to estimate project savings were largely consistent with the project work completed. The evaluation team adjusted several schedules where the ex ante anticipated weekend operation, while the evaluation team found the equipment was being shut off over the weekends. Additionally, the evaluation team removed several air-handling-unit constant-to-variable air volume conversions after finding that these units had not been converted. Finally, we removed a few ventilation modifications (demand-controlled ventilation and outside air reductions) from the verified models because they had not been implemented.

The resulting project savings are shown in Table 12 below.

Table 12. Summary of Project 2100018 Savings

	kWh	kW	Therms
Ex Ante	825,887	0.0	104,614
Verified	846,644	0.0	64,690
Realization Rate	103%	N/A	62%

Summary of the Ex Ante Calculations

The implementation team evaluated project savings using EnergyPlus models for the baseline and new cases, for all buildings. The operating hours for the baseline electric and gas cases were 8,760 hours. The operating hours for the new electric and gas cases were 8,362 and 8,566 hours, respectively. See the Summary of the Verified Calculations section for details on the changes that were made between the ex ante baseline and efficient models along with the changes our team made to estimate verified savings.

Measurement and Verification Plan

The evaluation team M&V approach consisted of a review of project documentation and a virtual visit with a site contact. We planned to ask about other energy efficiency projects that may have been completed in the last two years. Also, we planned to inquire about the effects of the COVID-19 pandemic on campus activity and operation of the HVAC systems.

The evaluation team planned to request a virtual demonstration and/or screenshots of the new controls to verify the following capabilities and setpoints of the new EMS:

- Schedules, control of pressures/temperatures, and reset capabilities of two AHUs, plus one MAU in building A
- Schedule, control of pressures/temperatures, and reset capabilities of AHU in building B
- Schedules, control of pressures/temperatures, and reset capabilities of two AHUs in building G
- Schedule, control of pressures/temperatures, and reset capabilities of AHU in building H
- Schedules, control of pressures/temperatures, and reset capabilities of two AHUs in building L
- Schedules, control of pressures/temperatures, and reset capabilities of six AHUs in building X
- Control of VAV terminal units where applicable
- Control of central chilled water system
- Verbal confirmation of installation and control of 23 pressure-independent AHU chilled water control valves throughout the campus

The evaluation team also planned to request trend data to verify operation of the chilled water plant covering pre- and post-retrofit conditions to ensure chilled water system management is consistent with expected operation.

We planned to inquire about capabilities and condition of the controls being replaced, including scheduling and setpoints, temperature and pressure resets, and monitoring capability.

The goal was to use information provided in the documentation and during the virtual verification to update the ex ante EnergyPlus models to establish ex post savings.

Summary of the Verified Calculations

The evaluation team interviewed the site contact by phone on November 24, 2021. The site contact confirmed installation and operation of the new controls and provided screenshots of AHU control and a sample of VAV terminal units. We also collected graphical trend data from January 6, 2021, through December 21, 2021, of chilled water supply flows for pre- and post-retrofit conditions. We had a follow-up interview with the site contact on December 21, 2021, to collect additional information, including spreadsheet files of chilled water supply and return temperatures and flows covering January 6, 2021, through December 21, 2021. We also confirmed operating schedules and VAV operation, as applicable.

The site contact reported that the existing controls were in very poor condition and were not capable of scheduling AHU operation.

Initially, the evaluation team reviewed billed electrical and gas usage data as a verification of claimed savings. We determined there were too many variables (e.g., COVID-19 effects) and other efficiency projects occurring in the past several years to develop a valid regression analysis with the data. We believe, however, that compared to actual usage, the verified savings are reasonable.

The evaluation team verified savings by first checking the ex ante baseline EnergyPlus model for the reasonableness of its inputs and to see whether the inputs matched the appropriate baseline condition. For any discrepancies between the most appropriate baseline and the baseline EnergyPlus model, our team created a verified version of the EnergyPlus model with inputs modified.

Our team then compared the ex ante baseline and efficient EnergyPlus models to determine what changes were made between the two models. We verified any changes made between the two models using information collected from the site contact. Based on this information, we create a verified EEM EnergyPlus model and updated the verified baseline EnergyPlus model with inputs modified as needed. Table 13 through Table 20 summarize the verified modeling inputs and parameters for each of the buildings included in this project and note where inputs differ between ex ante and verified models as a result of information collected through participant interviews and virtual inspection of the controls system.

Table 13. Verified Model Inputs and Parameters for Building A

Model	Input/Parameter	Ex Ante Assumption	Verified Assumption
Baseline	Schedules and Setpoints	Heating 70°F and Cooling 72°F	Heating verified and Cooling changed to 74°F
		Continuous operation	Verified
	AHU 1 and 2	Typical and reasonable fan curves on the supply and exhaust/return fans	Verified
	Air infiltration	Typical and reasonable infiltration	Verified
EEM	Schedules and Setpoints	Occupied heating 68°F and cooling 75°F Unoccupied heating 62°F and cooling 100°F	Verified
		5:00 a.m.–7:00 p.m., seven days a week	7:00 a.m.–5:00 p.m., Monday–Friday Off Saturday and Sunday
	AHU 1 and 2	Added a hot water coil	Verified
		Fan curves on the supply and exhaust/return fans were modified	Verified
	Air infiltration	Infiltration reduction of ~50%–75%	Verified

Table 14. Verified Model Inputs and Parameters for Building B

Model	Input/Parameter	Ex Ante Assumption	Verified Assumption
Baseline	Schedule	Continuous operation	Verified
	B AHU	Typical and reasonable fan curves on the supply and exhaust/return fans	Verified
	Air infiltration	Typical and reasonable infiltration	Verified
EEM	Schedule	5:00 a.m.–7:00 p.m., seven days a week	7:00 a.m.–5:00 p.m., Monday–Friday Off Saturday and Sunday
	B AHU	Fan curves on the supply and exhaust/return fans were modified	Verified
	Air infiltration	Infiltration reduction of ~25%–40%	Verified

Table 15. Verified Model Inputs and Parameters for Building C

Model	Input/Parameter	Ex Ante Assumption	Verified Assumption
Baseline	Schedules and Setpoints	For spaces without existing DDC/pneumatic controls, no humidity or CO_2 controls For spaces with existing DDC/pneumatic controls, continuous operation	Verified
	Theater 1–4 (four different AHUs)	CAV air handling equipment	Verified
	Pneumatics AHU	Typical and reasonable fan curves on the supply and exhaust/return fans	Verified
	Air infiltration	Typical and reasonable infiltration	Verified
EEM	Schedules and Setpoints	Humidification/dehumidification setpoints added to 10% & 90% respectively	Verified
		CO_2 controls added; set to 900 ppm max, 600 min	Verified
		5:00 a.m.–7:00 p.m., seven days a week	8:30 a.m.–6:30 a.m., Monday–Saturday; off Sunday
	Pneumatics AHU	AHUs 1-3: changed from constant volume (CV) to VAV with 30% minimum fan speed	Reverted verified EEM model to CV; these changes weren't made
		AHU 4: changed from CV to VAV with 90% minimum fan speed	Reverted verified EEM model to CV; these changes weren't made
		Fan curves on the supply and exhaust/return fans were modified	Verified
	Air infiltration	Infiltration reduction of ~30%–50%	Verified

Table 16. Verified Model Inputs and Parameters for Building G

Model	Input/Parameter	Ex Ante Assumption	Verified Assumption
Baseline	Schedules and Setpoints	Continuous operation, no DCV	Verified
	G AHU	Typical and reasonable fan curves on the supply and exhaust/return fans	Verified
	Baseboard heaters	Reasonable size given hot water temperatures	Verified
	Air infiltration	Typical and reasonable infiltration	Verified
EEM	Schedules and Setpoints	CO_2 controls added; set to 900 ppm max, 600 min	CO_2 controls removed; no DCV was installed
		5:00 a.m.–7:00 p.m., seven days a week	6:30 a.m.–5:30 p.m., Monday–Friday, Off Saturday and Sunday
	G AHU	Fan curves on the supply and exhaust/return fans were modified	Verified

Model	Input/Parameter	Ex Ante Assumption	Verified Assumption
	Baseboard heaters	Resized to handle lower hot water temperatures (180°F to 170°F)	Verified EEM model reverted to size from ex ante baseline model; no evidence that they installed bigger radiant heaters
	Air infiltration	Infiltration reduction of ~30-50%	Verified

Table 17. Verified Model Inputs and Parameters for Building H

Model	Input/Parameter	Ex Ante Assumption	Verified Assumption
Baseline	Schedules and Setpoints	Cooling design day space setpoint of 75°F	Verified
		Vestibules: heating to 68°F and cooling to 73°F during the day, and 62°F and 100°F during the night	Verified
		Typical and reasonable temperature setpoints in other spaces	Verified
	Central AHU	Continuous operation	Verified
	Space Types	Reasonable given project scope	Verified
	Air infiltration	Typical and reasonable infiltration	Verified
EEM	Schedules and Setpoints	Cooling design day space setpoint of 79°F	In the verified EEM model we reverted the design day space setpoint to the baseline condition (75°F) because the higher setpoint resulted in decreased equipment sizes being modeled in the ex ante efficient model due to DesignBuilder's default auto-sizing feature We also ensured equipment sizes were the same in both the verified baseline and verified efficient models. There was no evidence that equipment sizes or design day space setpoints had changed.
		Vestibules: night set back modified as heating to 55°F and cooling to 90°F	Verified
		Several spaces (old janitors' closet, bathroom, clinic EF) had their setpoints relaxed in the efficient model	Reverted to baseline; no evidence that these changes were made in these spaces
	Central AHU	Fan curves on the supply and exhaust/return fans were modified	Verified
		7:00 a.m.–4:00 p.m., Monday–Friday operation, off Saturday and Sunday	6:30 a.m.–9:00 p.m., Monday–Friday, off Saturday and Sunday
	Space Types	Some space types were changed between the baseline and efficient models	All were reverted as no spaces were changed as part of this project
	Air infiltration	Infiltration reduction of ~50%–100%	Verified

Table 18. Verified Model Inputs and Parameters for Building L

Model	Input/Parameter	Ex Ante Assumption	Verified Assumption
Baseline	Schedules and Setpoints	Continuous operation	Verified
	AHU	Outside air set to 20%	Verified
		Typical and reasonable fan curves on the supply and exhaust/return fans	Verified
	Fume hood schedule	Running full speed continuously	Verified
	Chilled water pumps	CV	Changed to variable speed; existing pump had a VFD and operated as variable speed
	Cadaver rooms	CV	Verified
EEM	Schedules and Setpoints	7:00 a.m.–5:00 p.m., Monday–Friday	7:00 a.m.–9:00 p.m., Monday–Friday, off Saturday and Sunday
		Occupied setpoints are 68°F for heating and 75°F for cooling	Occupied setpoint changed to 72°F for heating; Occupied cooling setpoint verified
		Unoccupied setpoints are 62°F for heating and 100°F for cooling	Verified
	AHU	Outside air changed from 20% to 50%	Reverted verified EEM model to baseline condition; no change to outside air dampers was reported
		Fan curves on the supply and exhaust/return fans were modified	Verified
	Fume hood schedule	Ramps the fans down to 53% during unoccupied periods. The fans ramp up to 98% at noon, and back down until 8:00 p.m. on weekdays. On weekends, they ramp up to 65% from 9:00 a.m.–1:00 p.m.	Reverted verified EEM model to baseline condition; there were no reported changes to the fume hood schedules
	Chilled water pumps	Variable speed with a 0% flow	Verified
	Cadaver rooms	VAV	Reverted to baseline condition; these rooms are still manually controlled

Table 19. Verified Model Inputs and Parameters for Building P

Model	Input/Parameter	Ex Ante Assumption	Verified Assumption
Baseline	AHU S1, S3, 2, 3, 4	Constant volume	Verified
	Chilled water design ΔT	7.9°F	Verified
EEM	AHU S1, S3, 2, 3, 4	VAV with a 30% min fan flow	Verified
	Chilled water design ΔT	16°F	Verified

Table 20. Verified Model Inputs and Parameters for Building X

Model	Input/Parameter	Ex Ante Assumption	Verified Assumption
Baseline	AHU 1, 2 & 3	Typical and reasonable fan curves on the supply and exhaust/return fans	Verified

Model	Input/Parameter	Ex Ante Assumption	Verified Assumption
	TV 1,2, and 3	Constant volume	Verified
	Fume hoods	Running full speed continuously	Verified
	Air infiltration	Typical and reasonable infiltration	Verified
EEM	AHU 1, 2 & 3	Fan curves on the supply and exhaust/return fans were modified	Verified
	TV 1, 2 & 3	VAV with a 30% min flow	Verified efficient model was reverted to baseline condition; units are still constant volume
	Fume hoods	Ramps the fans down to 53% during unoccupied periods. The fans ramp up to 98% at noon, and back down until 8:00 p.m. on weekdays. On weekends, they ramp up to 65% from 9:00 a.m. –1:00 p.m.	Verified EEM model was reverted to baseline condition; there is no VFD on the unit
	Air infiltration	Infiltration reduction of ~40%	Verified

Project 2000349

Project ID#:	2000349
Measure:	HVAC controls
Savings:	23,571 therms
Facility Type:	Office
End Use:	HVAC
Evaluated Fuel:	Gas
Wave:	3

Measure Description

This project consists of the installation of four 700-ton centrifugal chillers and four condensing boilers. The evaluation team selected this project as part of the gas sample; therefore, the chiller project is not part of this evaluation. The equipment is installed in an existing office building with 288,598 square feet of floor space that is undergoing a major renovation and remodel. Therefore, the baseline efficiencies for the equipment are the code-required minimums. The project application was submitted on February 20, 2020. The equipment was installed on November 30, 2021, although the ongoing building renovation is not yet complete.

Key Findings

The primary reason for the decrease in savings between the ex ante and verified value is due to a reduced verified effective full load hours value for new construction rather than existing buildings. The resulting project savings are shown in Table 21 below.

Table 21. Summary of Project 2000349 Savings

	Therms
Ex Ante	23,571
Verified	12,907
Realization Rate	55%

Summary of the Ex Ante Calculations

The implementation team estimated project gas savings using a methodology from the IL-TRM V9.0. The values they used for the calculations are shown in Table 22:

Table 22. Calculation Inputs

Input	Value
EFLH	1629
Quantity	3
Capacity (MBH)	2805
AHRI Eff (baseline)	0.82
AHRI Eff (proposed)	0.961

Savings were calculated as follows in Equation 7:

Equation 7. Therm Energy Savings Formula

$$Therm\ Savings = \frac{EFLH\ \times \text{Quantity} \times Capacity \times \frac{Eff_{Prop} - Eff_{Base}}{Eff_{Base}} \times 100}{100{,}000}$$

The equivalent full load hours (EFLH) value assumes the building is an existing mid-rise office building in climate zone 2. The quantity of boilers assumes that one boiler is a redundant backup boiler.

Measurement and Verification Plan

The evaluation team measurement and verification approach consisted of a review of project documentation and an in-person site visit with a site contact. We planned to ask about current and future occupancy and expected hours of operation.

The evaluation plan includes a request for a demonstration of the new equipment to verify the following capabilities and setpoints of the HVAC system:

- Control of boiler water system, including sequence programming and pump control
- What is the building schedule?
- What are the occupied/unoccupied setpoints?
- Is optimal start/stop part of the control sequence?

We also planned to ask the following questions:

- Is one of the boilers a backup?
- Does the hot water system include other measures, e.g., pump, VFDs?

The evaluation team will also request trend data to verify operation of the hot water system. We will review hot water data to ensure hot water system management is consistent with expected operation.

The evaluation team will use information provided in the documentation and during the in-person verification to update the ex ante savings models to establish ex post savings.

Summary of the Verified Calculations

The evaluation team conducted a site visit to ask the above questions and confirm the installation and operation of incentivized equipment and controls. The equipment was installed, operating, and commissioned. The building has been occupied for less than two months and is not yet to full occupancy. Therefore, we didn't have any reliable data to support the savings claim.

The evaluation team also used the IL-TRM V9.0 to estimate savings for this project. The methodology is identical to that used in the ex ante calculation. The primary difference between the ex ante and verified savings value is due to a reduced verified EFLH value when selecting new construction rather than existing buildings. There was a slight increase in the verified EFLH from using climate zone 3 rather than climate zone 2.

To check the reasonableness of this adjustment, the evaluation team reviewed the building's gas usage records. The building previously used approximately 62,000 therms in 2019, approximately 70,000 therms in 2020, and approximately 92,000 therms in 2021. The calculated ex ante baseline usage was approximately 161,000 therms, while the calculated verified baseline was approximately 88,000 therms. As a result, the evaluation team not only believes that the new construction baseline is more appropriate for a major renovation, it also more closely approximates the building's gas usage in previous years.

The verified annual savings are 12,907 therms.

Project 2100117

Project ID#:	2100117
Measure:	Process Improvement
Savings:	85,554 therms
Facility Type:	Industrial
End Use:	Process
Evaluated Fuel	Gas
Wave	3

Measure Description

This project consisted of the installation of infrared heaters to improve the efficiency of an industrial drying process. The infrared heaters were installed as additional equipment and are not a direct replacement for any existing equipment. The infrared heaters will pre-heat the materials before steam cans dry the product to the desired moisture content. Using infrared heaters to heat the material before drying occurs is more efficient than the steam cans doing both the initial heating and the drying.

Key Findings

All of the information collected during the site contact interview is consistent with the information used in the determination of the ex ante savings. The site contact was unable to provide updated production data as they are still getting the production line dialed in with the new infrared heaters. The ex ante savings analysis was reviewed and no necessary adjustments were identified by the evaluation team.

The resulting project savings are shown in Table 23 below.

Table 23. Summary of Project 2100117 Savings

	Therms
Ex Ante	85,554
Verified	85,554
Realization Rate	100%

Summary of the Ex Ante Calculations

The ex ante savings were determined using production data of the various grades of material produced by the facility and a year of natural gas use records. The customer is anticipating that this project will allow them to increase production rates by around 10%, so the savings analysis is based on the gas use per ton of material produced rather than a straight comparison of the gas use before & after the project.

Prior to the completion of the project, the facility had an average specific natural gas use of 52.64 therms per ton of product. With the completion of this project, the specific gas use is expected to decrease to 50.13 therms per ton. It should be noted that this analysis applies to a majority of the material grades produced, but some of the lowest grades of product were not included in the analysis as their gas use per ton is expected to stay the same.

Based on production rates prior to the completion of the project, the annual natural gas savings were determined to be 85,554 therms.

Measurement and Verification Plan

The evaluation team planned to verify this project through a review of documentation and calculations and a call with the site contact to verbally confirm details of the project. We planned to perform an updated analysis with post-installation production and gas use data, if possible.

During the call with the site contact, the evaluation team planned to ask the following questions:

- Is the new infrared heater system operating as anticipated?
- What temperature is the material after the infrared heaters?
- When was this project completed?
- Would you be able to provide production data for the time period since the project was done?
- Have any other changes been made to the production equipment or the building that would have a substantial impact on the gas use of the facility?
- Are the steam cans still run with 50psi steam, or has the pressure been changed at all?

Summary of the Verified Calculations

The evaluation team reviewed the information provided in the project documentation and the ex ante savings analysis and found the ex ante calculations are reasonable. The evaluation team originally planned to true-up the savings calculations using post-implementation production data and billed monthly gas usage, but the customer is still fine-tuning the system with the new infrared heaters. This resulted in no significant length of time of “normal” operation at the facility. Therefore, the savings cannot be trued-up at this time. The site contact confirmed that the production is anticipated to increase by around 10% as a result of this project, and the material is entering the steam cans at around 170°F now rather than 140°F. The evaluation team did not find any necessary adjustments to the savings for this project. The verified savings are equal to ex ante savings.

Project 2100017

Project ID#:	2100017
Measure(s):	HVAC Controls, Efficient Boilers
Savings:	78,559 therms
Facility Type:	School
End Use(s):	HVAC
Evaluated Fuels:	Natural Gas
Wave:	2

Measure Description

This project covers the replacement of HVAC controls, conversion from constant volume (CV) to variable volume (VAV) air handling, and the installation of efficient boilers

Key Findings

The evaluation team determined that the primary gas savings for this project were due to the installation of condensing boilers. Although the HVAC controls measure contributed some gas savings, most of the EMS savings resulted in electrical savings. The resulting project savings are shown in Table 24 below.

Table 24. Summary of Project 2100017 Savings

	Therms
Ex Ante	78,559
Verified	42,690
Realization Rate	54%

Summary of the Ex Ante Calculations

The savings for this project were determined using simulations run with building models in the Department of Energy's EnergyPlus software. The evaluation team did not receive baseline EnergyPlus files in time for this evaluation. Therefore, we were not able to determine the changes made between the baseline and proposed models.

The TA used two sets of EnergyPlus models. They discovered an error in the building floor areas (baseline and proposed models used different areas) in the first set of models, so a new set was created. The implementation team considered the gas savings in the new models unreasonably high; however, so they used the more conservative gas savings from the first set of models, alongside the electric savings from the second set of models. They could not determine all the changes made between the first set of models and the second because the change in building areas alone did not seem to account for the entirety of the change in savings and they were not able to investigate the input files in depth.

The implementation team calculated ex ante demand savings as the ex ante energy savings divided by 8,760 hours.

Measurement and Verification Plan

The evaluation team planned to verify this project through a review of documentation, the energy modeling files, and a virtual site visit to confirm equipment installation and assess its operation.

The virtual site visit was intended to include collection of building automation system screenshots showing implementation of all HVAC controls measures, and confirmation of boiler operation.

Summary of Verified Savings

The evaluation team interviewed the director of buildings and grounds for the school district about the details of the project during a video conference on January 19, 2022. The district shared their screen showing the new controls and was able to provide a virtual walkthrough of the spaces and projects that were completed. They confirmed the installation of the equipment and controls included in this project. During a subsequent email exchange, the site contact reported that the existing equipment was thought to be original to the building, which was built in 1963.

The verification plan called for use of energy modeling in coordination with site visit findings. The implementer was unable to provide the baseline EnergyPlus modeling files (.idf) in time for this evaluation; however, and we could not run the proposed case model files that were provided. Therefore, we evaluated the project using billing regression and engineering analysis.

The evaluation team estimated savings due to the installation of efficient boilers comparing billed usage for 2021 and 2019 calendar years. We assumed the minimum monthly summer usage during 2021 represented average monthly gas usage for domestic hot water (DHW). The gas chiller was replaced after summer of 2020. We estimated gas chiller usage by taking the difference between summer 2019 and summer 2021 usage. The gas usage for DHW and the gas chiller was subtracted from the total actual 2019 usage to estimate annual baseline boiler gas input.

The new boiler system includes condensing and non-condensing boilers that are staged according to OAT to use non-condensing boilers when supply temperatures are greater than 150º F. We estimated the efficiency of the new boiler system using the hot water reset schedule and local typical meteorological year (TMY3) data, resulting in average 92.6% proposed efficiency. We used IL-TRM V9.0, Measure 4.4.10 to establish the efficiency of the baseline steam boilers as 79%. We estimated baseline boiler output using the 79% baseline efficiency and used that value to estimate proposed boiler gas usage at 92.6% efficiency. This method may overestimate first-year gas savings because the steam boilers are still in service, but the site contact reported that the steam boilers are planned for removal later in 2022.

The evaluation team considered energy management system savings for constant volume (CV) to variable volume (VAV) system plus supply air temperature (SAT) and supply air pressure (SAP) reset. We determined that the CV to VAV conversion contributed a small amount of gas savings, which were primarily due to a reduction in estimated outside air (OA) intake. The SAT reset measure contributed minimal heating energy savings and SAP reset contributed only electrical energy savings.

Project 2000261

Project ID#: 2000261	2000261
Measure:	HVAC Controls
Savings:	638,042 kWh; 48.4 kW; 54,061 therms
Facility Type:	University
End Use:	Controls
Evaluated Fuel:	Electric and Gas
Wave:	1

Measure Description

This project consisted of replacing outdated HVAC controls with Automated Logic's WebCTRL temperature control and building automation systems in four buildings of a university campus: communications and fine arts, library, science classrooms and labs, and the visitor's center. The baseline temperature control and building automation system consisted of various versions and brands that were connected by LONworks, a communication network protocol. The new system integrates the baseline building automation system hardware into Automated Logic's WebCTRL front-end. The project application was submitted on January 31, 2020. The project was completed on March 31, 2021.

Key Findings

The evaluation team found that the energy models used to estimate project savings were largely consistent with the project work completed. The evaluation team adjusted the chilled water plant temperature differential based on trend data found on site, and removed several small air handling unit constant to variable air volume conversions after the evaluation team found these units were not converted.

The resulting project savings are shown in Table 25 below.

Table 25. Summary of Project 2000261 Savings

	kW	kWh	Therms
Ex Ante	48.4	638,042	54,061
Verified	47.7	622,177	53,249
Realization Rate	98%	98%	98%

Summary of the Ex Ante Calculations

The implementation team estimated project savings using DesignBuilder models for the baseline and new cases for both buildings. The HVAC operating hours for the baseline electric and gas cases were 8,760 hours. The HVAC operating hours for the new electric and gas cases were 8,362 and 8,566 hours, respectively. Potable water savings are also included in the model.

Measurement and Verification Plan

The evaluation team M&V planned approach consisted of a review of project documentation and a virtual site visit with a site contact. We planned to ask about other energy efficiency projects that may have been completed in the last two years. Also, we planned to inquire about the effects of the COVID-19 pandemic on campus activity and operation of the HVAC systems.

The evaluation plan included a request fora virtual demonstration of the new controls to verify the following capabilities and setpoints of the new EMS:

- Schedules of the two AHUs in the science classrooms and labs building
- Control of pressures/temperatures and reset capabilities plus schedules of two AHUs and terminal units in the science classrooms and labs building
- Control of pressures/temperatures and reset capabilities plus schedules of central plant equipment in the science classrooms and labs building
- Schedules and control of new fan VFDs and demand control ventilation (DCV) in the library
- Control of pressures/temperatures and reset capabilities plus schedules of AHUs and zone terminals in the communications building
- Control of pressures/temperatures and reset capabilities plus schedules of communications building central plant equipment
- Operation of DCV in the visitors' center

The evaluation team also planned to request trend data, if available, for a sample of equipment to review to ensure overall system management is consistent with proposed operation.

We also planned to inquire about the capabilities and condition of the controls being replaced, including scheduling and setpoints, temperature and pressure resets, and monitoring capability. The project included VFDs in the library, so we planned to ascertain whether those were incentivized under the prescriptive program.

Project 2000260 was completed in December 2020 to update controls in two other campus buildings. The evaluation plan included collecting utility or sub-metered consumption data and attempting a regression analysis. If we determined that a regression analysis of energy usage was statistically appropriate, we planned to analyze pre- and post-retrofit periods to include savings from both projects and allocate savings according to claimed savings for each project.

If we determined that there are other factors that invalidate a regression analysis, e.g., other projects affecting energy usage, COVID-19 effects, etc., we planned to use information provided in the documentation and during the virtual verification to update the ex ante EnergyPlus models to establish verified savings. The evaluation plan included a request for a schedule of major equipment to confirm model inputs.

Summary of the Verified Calculations

The evaluation team interviewed the site and vendor contacts during a video conference on January 17, 2022. The site contact confirmed installation and operation of the new controls and provided a demonstration of the controls via screen sharing of AHU controls and a sample of VAV terminal units.

Table 26 through Table 29 summarize the verified modelling inputs and parameters for each of the buildings that were a part of this project and note where inputs differ between ex ante and verified models as a result of information collected through participant interviews and virtual inspection of the controls system. In lieu of adjusting the model for the visitors' center, we used our template to calculate DCV because that was the only measure completed in that building.

Table 26. Verified Model Inputs and Parameters for Communications and Fine Arts Building

Model	Input/ Parameter	Ex Ante Assumption	Verified Assumption
Baseline	Four AHUs	No DCV	Verified
	Infiltration	Typical and reasonable infiltration levels	Verified
	Chilled Water	Typical and reasonable supply and return temperature differential	Verified
	Chilled Water Pump	Constant speed operation	Verified
Efficient	Four AHUs	Added DCV	Verified
	Infiltration	Reduced by ~50%	Verified
	Chilled Water	Increased differential temperature	Reverted the verified efficient model inputs to ex ante baseline model inputs; no modifications to the chilled water system
	Chilled Water Pump	Added pump VFD	Verified

Table 27. Verified Model Inputs and Parameters for the Library

Model	Input/ Parameter	Ex Ante Assumption	Verified Assumption
Baseline	Economizer	Fixed dry bulb switchover	Verified
	Six AHUs	Constant air volume (CAV)	Verified
		No DCV	Verified
Efficient	Economizer	Comparative enthalpy control	Verified
	Six AHUs	All systems are VAV	Reverted the verified efficient model to constant volume conditions; One AHU had no VFD, two AHUs had VFDs set to constant spee
		Added DCV	Verified.

Table 28. Verified Model Inputs and Parameters for the Science Building

Model	Input/ Parameter	Ex Ante Assumption	Verified Assumption
Baseline	Two AHUs	Typical and reasonable fan curves on supply and exhaust/return fans	Verified
		No building pressure controls	Verified
Efficient	Two AHUs	Fan curves on the supply and exhaust/return fans were modified from baseline	Verified
		Add building pressure controls	Verified

Table 29. Verified Parameters for the Visitors Center

Model	Input/ Parameter	Ex Ante Assumption	Verified Assumption
Baseline	AHU	Constant air volume	Changed verified baseline model to be VAV; only modification to unit was addition of DCV
		No DCV	Verified
Efficient	AHU	Variable air volume	Verified
		Added DCV	Verified

The evaluation team notes that, with the exception of the library, all AHUs associated with this project had VFDs prior to implementation. However, the baseline AHUs were generally modeled as constant volume. The site contact reported that, due to the condition of the existing dampers and VAV boxes, they had limited control of AHU flows. Therefore, we did not change the baseline to VAV for those units.

For the visitors' center, the evaluation team removed savings resulting from converting the system from constant volume to variable volume as the AHU was already operating as VAV prior to the project. The remaining measure for that building, DCV, was the only difference between the verified baseline and verified EEM models. The evaluation team found that these models produced identical energy outputs (indicating zero savings). As a result, we modeled the DVC savings using a spreadsheet calculation.

In future projects the evaluation team strongly recommends modeling each measure as individual parametric runs. The details of this recommendation are presented in the annual report chapter.

Project 2000260

Project ID#:	2000260
Measure:	HVAC Controls
Savings:	869,380 kWh; 93.4 kW; 96,042 therms
Facility Type:	University
End Use:	Controls
Evaluated Fuel:	Electric and Gas
Wave:	1

Measure Description

This project consisted of replacing outdated HVAC controls with Automated Logic's WebCTRL temperature control and building automation systems in two buildings of a university campus: (1) an academic building and (2) a multipurpose arena. The baseline temperature control and building automation system consisted of various versions and brands that were connected by LONworks, a communication network protocol. The new system integrates the baseline building automation system hardware into Automated Logic's WebCTRL front-end. The project application was submitted on January 31, 2020. The project was completed on December 24, 2020.

Key Findings

The evaluation team found that the energy models used to estimate project savings were consistent with the project work completed and the savings estimates to be reasonable.

The resulting project savings are shown in Table 30 below.

Table 30. Summary of Project 2000260 Savings

	kW	kWh	Therms
Ex Ante	93.4	869,380	96,042
Verified	93.4	869,380	96,042
Realization Rate	100%	100%	100%

Summary of the Ex Ante Calculations

The implementation team evaluated project savings using EnergyPlus models for the baseline and new cases (i.e., EEM models) for both buildings. The HVAC operating hours for the baseline electric and gas cases were 8,760 hours. The HVAC operating hours for the new electric and gas cases were 8,533 and 8,014 hours, respectively. See the Summary of the Verified Calculations section for details on the changes made between the ex ante baseline and EEM models along with the changes our team made to estimate verified savings.

Measurement and Verification Plan

The evaluation team measurement and verification planned approach consisted of a review of project documentation and a virtual site visit with a site contact. We will planned to about other energy efficiency projects that may have been completed in the last two years and the effects of the COVID-19 pandemic on campus activity and operation of the HVAC systems.

We planned to request a virtual demonstration of the new controls to verify the following capabilities and setpoints of the new EMS:

- Schedules of six AHUs in the arena
- Reset capabilities (pressure/temperature) and schedules of the six AHUs and 104 zone terminals in the arena
- Reset capabilities (pressure/temperature) and schedules of the arena's central plant equipment
- Schedules of the 13 AHUs in the academic building
- Reset capabilities (pressure/temperature) and schedules of the 13 AHUs and 271 zone terminals in the academic building
- Reset capabilities (pressure/temperature) and schedules of the academic building's central plant equipment

The evaluation team will also request trend data, if available, for a sample of equipment to review to ensure overall system management is consistent with proposed operation.

We will also inquire about the capabilities and condition of the controls being replaced, including scheduling and setpoints, temperature and pressure resets, and monitoring capability.

Project 2000261 was completed in March 2021 to update controls in four other campus buildings. We planned to collect utility or sub-metered consumption data and attempt a regression analysis. If we determined that a regression analysis of energy usage is statistically appropriate, we planned to analyze pre- and post-retrofit periods to include savings from both projects and allocate savings according to claimed savings for each project.

If we determined that there are other factors that invalidate a regression analysis, e.g., other projects affecting energy usage, COVID-19 effects, etc., we planned to use information provided in the documentation and during the virtual verification to update the ex ante EnergyPlus models to establish verified savings. The evaluation pan also included a request for a schedule of major equipment to confirm model inputs.

Summary of the Verified Calculations

The evaluation team interviewed the site and vendor contacts during a video conference on January 17, 2022. The site contact confirmed installation and operation of the new controls and provided a demonstration of the controls via screen sharing of AHU control and a sample of VAV terminal units. We also collected trend data for submeters installed for each of the two buildings.

The evaluation team verified savings by first checking the ex ante baseline EnergyPlus model for the reasonableness of its inputs and to see whether the inputs match the appropriate baseline condition. If there were any discrepancies between the most appropriate baseline and the baseline EnergyPlus model, our team created a verified version of the EnergyPlus model with inputs modified as needed.

Our team then compared the ex ante baseline and EEM EnergyPlus models to determine what changes were made between the two models. We verified any changes made between the two models using information collected from the site contact. Based on this information, we create a verified EEM EnergyPlus model and updated the verified baseline EnergyPlus model with inputs modified as needed.

Table 31 and Table 32 summarize the modeling inputs and parameters for each of the buildings that the evaluation team changed as a result of information collected through participant interviews and virtual inspection of the controls system. Where a model input is changed in one model (Baseline or EEM), the corresponding input from the other model is included as a reference point for the impact of the change.

Table 31. Verified Model Inputs and Parameters for Arena Building

Model	Input/ Parameter	Ex Ante Assumption	Verified Assumption
Baseline	Economizer	Fixed dry bulb switchover	Verified
	13 AHUs	No demand control ventilation	Verified
		Typical and reasonable fan curves on the supply and exhaust/return fans	Verified
	Infiltration	Typical and reasonable infiltration	Verified
EEM	Economizer	Comparative enthalpy control	Verified
	13 AHUs	Added demand control ventilation	Verified
	Economizer	Fan curves on the supply and exhaust/return fans were modified	Verified
	Infiltration	Reduced by ~50%	Verified

Table 32. Verified Model Inputs and Parameters for the Academic Building

Model	Input/ Parameter	Ex Ante Assumption	Verified Assumption
Baseline	Economizer	Fixed dry bulb switchover	Verified
	Six AHUs	Typical and reasonable fan curves on the supply and exhaust/return fans	Verified
		No demand control ventilation	Verified
EEM	Economizer	Comparative enthalpy control	Verified
	Six AHUs	Fan curves on the supply and exhaust/return fans were modified	Verified
		Added Demand control Ventilation	Verified

The evaluation team also reviewed the submeter trend data, which covered a post-retrofit period from October 2, 2021, through February 4, 2022. The data does not include any pre-retrofit periods, but the post retrofit data suggest higher actual usage than the ex ante EEM model predicted.

Project 2100313

Project ID#:	2100313
Measure:	HVAC Controls
Savings:	655,240 kWh; 0.0 kW
Facility Type:	Medical
End Use:	Controls
Evaluated Fuel:	Electric
Wave:	3

Measure Description

This project consisted of updating HVAC controls at a medical center. Chilled water plant controls were updated, including central controls to integrate the operation of six chillers, primary and secondary pumps, condenser loop pumps, and cooling tower. VFDs were installed for the cooling tower fans.

Existing chilled water temperature control valves on six air handling units were replaced with pressure-independent control valves. New temperature sensors for chilled water supply and return on the AHUs were installed. The new valves and sensors were interfaced with the existing control system.

The project application was submitted on January 29, 2021. The project was completed on October 29, 2021.

Key Findings

The evaluation team utilized EnergyPlus modeling output data in coordination with the IL-TRM V9.0 and a proprietary spreadsheet model to verify the savings. We calculated savings on measures that could be broken out with the EnergyPlus output using general rules of thumb and the IL-TRM. We determined the model was providing reasonable values and was likely providing a more accurate savings estimate than our calculations.

The only adjustment the evaluation team made to the ex ante savings was to more accurately convert the energy model's kBtu outputs to kWh, which increased savings slightly.

The resulting project savings are shown in Table 33 below.

Table 33. Summary of Project Savings

	kW	kWh
Ex Ante	0	655,240
Verified	0	670,371
Realization Rate	N/A	102%

Summary of the Ex Ante Calculations

The implementation team evaluated project savings using EnergyPlus models for the baseline and proposed cases. Table 34 shows the changes in the energy model affected energy usage in the following end uses (negative numbers mean an increase in energy usage, positive numbers indicate energy savings):

Table 34. Impact of Energy Model Changes on Energy Usage

End-Use	Electricity [kBtu]	Natural Gas [kBtu]
Heating	(2,853)	(935,912)
Cooling	574,737	
Interior Lighting		
Exterior Lighting		
Interior Equipment		
Exterior Equipment		
Fans	12,941	
Pumps	1,713,255	
Heat Rejection	(3,202)	
Humidification	(1,538)	
Heat Recovery		
Water Systems		
Refrigeration		
Generators		
Total End Uses (kBtu)	**2,293,340**	**(935,912)**

Measurement and Verification Plan

The evaluation team measurement and verification planned approach consisted of a review of project documentation and an in-person site visit with a site contact. We planned to ask about other energy efficiency projects that may have been completed in the last two years as well as the effects of the COVID-19 pandemic on facility activity and operation of the HVAC systems. The questions regarding COVID-19 impacts were included to take any impacts into account when reviewing trend and billing data and exclude the impacts of the pandemic on savings.

The evaluation plan included a request of a demonstration of the new controls to verify the following capabilities and setpoints of the upgraded EMS:

- Quantity and cooling capacity of chillers
- Number and HP of chilled and condenser water pumps
- Cooling tower capacity and fan HP
- Capacity control of pre-case pumps and cooling tower
- Control of central chilled water system, including sequence programming, pump VFD operation, and cooling tower fan operation
- Confirmation of installation and control of six pressure-independent AHU chilled water control valves
- Screenshots of setpoints, schedules, temperature and pressure reset programming

The evaluation team also planned to request trend data to verify operation of the chilled water plant covering pre- and post-retrofit conditions and review the data to ensure chilled water system management is consistent with expected operation.

Summary of the Verified Calculations

Due to the short time period between installation and evaluation, we could not do a building regression model using interval data to verify any annual savings. Therefore, we first compared the outputs of the EnergyPlus model to the IL-TRM V9.0 algorithm for VFD installations for hot water pumps, chilled water pumps, and cooling tower fans. We also compared the EnergyPlus model outputs to outputs from our own proprietary calculations to represent the chiller efficiency improvements due to installing a VFD on the chiller and pressure-independent valves on downstream equipment. The EnergyPlus models' savings compared well to these two calculations and savings differences are likely due to better load calculations provided by the energy model. Next, we compared the baseline EnergyPlus model to the monthly usage for the building. We determined the model was well calibrated. For both electric and gas, the model usage predicted 98% and 102% of the actual usage for a single baseline year. We therefore decided the ex ante savings were reasonable.

The only adjustment we made to the savings was to change the conversion factor from kBtu to kWh, adjusting the conversion factor to 3.412 instead of the 3.5 that was used in the calculation. This increased savings by 2%.

For demand savings, the evaluation team did not modify the ex ante savings of 0.0 kW; however, as the majority of savings are from the cooling system, pumps, and fans, coincident peak demand savings could possibly be claimed. We would need the EnergyPlus model to verify savings occurring during the peak period versus off-peak hours. The evaluation team did not have access to the EnergyPlus files; therefore, we left the savings as 0.0 kW.

Project 2001135

Project ID#:	2001135
Measure:	Cooling Tower Replacement
Savings:	426,561 kWh; 64.8 kW
Facility Type:	Manufacturing/Industrial
End-Use:	Compressed Air
Sampled For:	Electric
Wave:	1

Measure Description

This project is part of a larger project to decommission the site's acid recovery equipment in the fall of 2020. The project consisted of right-sizing the cooling tower system for the remaining compressed air system and optimizing controls. Decommissioning of cooling towers D7A and D7B occurred simultaneous to the decommissioning of the acid recovery equipment. The installed new cooling tower serves only the compressor load. Modulating controls added to the towers are designed to maintain a leaving temperature of 75°F. This control strategy saves additional energy through limiting heat injection from the steam system to keep the basin from freezing.

Key Findings

The realization rate of the project was affected by the verified operation of the new cooling tower having to run both the towers and pumps continuously to satisfy the load on the loop and due to the incorrect application of the fan affinity laws by the implementation team when calculating baseline tower fan energy consumption.

Table 35 presents the project savings.

Table 35. Summary of Project 2001135 Savings

	kW	kWh
Ex Ante	64.8	426,561
Verified	40.3	256,438
Realization Rate	62%	60%

Summary of the Ex Ante Calculations

The implementation team established project savings using control data from the old (baseline) system. The implementation team calculated baseline energy use based on continued operation of the smaller of the two old cooling towers with four fans and three pumps running continuously. This was then compared to the operation of the new system.

The implementation team collected runtime and fan speed output data for all original seven pumps and eight tower fans. They used this data to calculate the total energy consumed by the existing cooling tower annually. To calculate the tower fan energy usage, they attributed motor power proportionately to the fan's speed. If the cooling tower fan's speed was at 51%, they equated that to 51% power consumption.

The new cooling tower was designed to run a pump and modulate one fan at a time. For redundancy, a second pump and fan were included in the design—only with the intention of being redundant, running only one set at a time for heat rejection. For their calculation, the implementation team assumed one pump was running continuously throughout the year, and the tower fan speed is similar to the baseline trend data from the existing tower.

Measurement and Verification Plan

The evaluation team conducted a virtual onsite to verify project implementation, equipment specifications, and operational characteristics. We reviewed documentation and ex ante calculations and communicated with the site contact about the system controls data, confirming equipment installation and assessing operational conditions.

Our communications included, where possible, verification of baseline cooling tower pump flows and fan airflow.

The evaluation team asked the site contact about the operation of the new system and the facility in general, including the following questions:

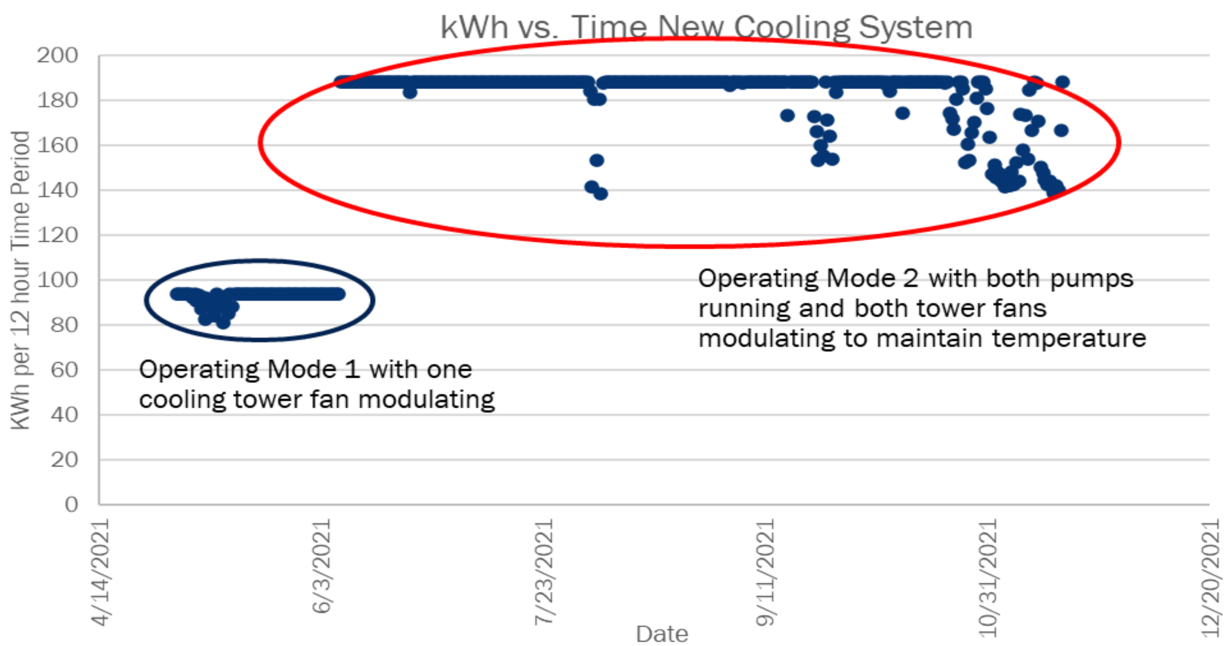
- Is there any information on the existing towers relating to pump curves and design flow?
- Were the new cooling tower fan VFDs programmed to maintain 75°F cooling water?
- Was the new pump balanced to 150 GPM? If so, is there a balance report?
- Has production changed because of the COVID-19 pandemic? If so, how?

Description of Verification

The evaluation team received responses to emailed questions on November 21, 2021. Through email, we interviewed the onsite project engineer to confirm the baseline conditions and the performance of the new compressors. The new cooling tower system has one primary and one redundant 7.5-HP pump, each paired with a 3-HP tower fan. The contact confirmed that the cooling tower system is operating to maintain a cooling tower leaving water temperature of 75°F. While the contact did not know the exact flow of the new system, we confirmed the air compressors on the new system were at the terminal end receiving the proper design flow. The compressor equipment's required flow is approximately 150 GPM.

The site contact indicated that due to some cooling tower water quality issues, one tower fan ran at higher than the expected output at times, and sometimes both pumps and tower fans had to run just to maintain a leaving water temperature that would sustain proper air compressor operation. As shown in Figure 2, the new cooling tower initially only ran one of the two cells, but early in the summer, the second cell was energized, and both fans were still running at high speeds well into the shoulder months. Operating mode 1 was the original design intent of the new cooling tower. However, because the single pump and tower were not keeping up with the loads on the new loop, the owner's representative made an adjustment to the system operation. This new strategy, operating mode 2 as shown below, involves running both tower pumps continuously and only cycling the tower fans to maintain loop temperature. This resulted in a much higher energy consumption in the proposed case than was originally modeled, and reduced the verified savings.

Figure 2. Increased Cooling Tower Usage



As indicated by the trend data, the new cooling system started operating in April 2021. We confirmed they have not seen lower operational use of the process equipment due to the COVID-19 pandemic. The evaluation team considers the trend data typical of annual operation.

Summary of the Verified Calculations

To properly account for baseline tower fan energy consumption, the evaluation team used the same quantity of fans and pumps running to calculate baseline energy consumption. To more accurately account for fan energy at part loads, the evaluation team applied the fan affinity laws to calculate the true power consumed at part loads rather than the assumption that fan energy was proportional to speed. This reduced the baseline energy consumption thereby reducing energy savings. Our calculation resulted in verified baseline energy consumption of 377,929 kWh/year instead of the ex ante value of 485,985 kWh/year and a verified baseline peak demand of 55.95 kW instead of the ex ante value of 78.36 kW.

The evaluation team analyzed the new system's data by looking at the average power for each twelve-hour period. Using data on the pumps' status, we determined if one cell or two cells of the tower were running at a given time. We calculated the tower fan power for each time period using the baseline tower fan motor running at the trended post period fan speed. We extrapolated these data from the 200-day trend period to a full 365-days. This analysis resulted in verified proposed case energy consumption of 121,491 kWh/year instead of the ex ante value of 59,424 kWh/year and a verified proposed case peak power demand of 15.7 kW instead of the ex ante value of 13.6 kW.

Project 2001321

Project ID#:	2001321
Measure:	Condensate Return System Upgrade
Savings:	66,734 therms
Facility Type:	Animal Byproduct Processing Plant
End Use:	Industrial Dry Rendering
Sampled For:	Gas
Wave:	3

Measure Description

This project is an upgrade to an existing steam system at a facility that collects and processes poultry, pork, sheep, and beef offal. Offal is indirectly steam heated in a continuous cooker to drive off moisture. The baseline steam system has low pressure condensate return and an undersized condensate/boiler feed water tank. This system loses condensate due to the undersized tank and flashing when pressure is reduced. The new system includes a high-pressure condensate pump at the discharge of the cooker to return high pressure condensate to a new, larger high-pressure condensate/boiler feed tank, which should essentially eliminate condensate loss. The project was completed between October and December 2020.

Key Findings

The ex ante savings were calculated based on an estimated 20% of condensate being lost to the drain in the baseline case. This estimate was not based on measured data and has a substantial impact on the energy savings. This calculation would have led to a 10% decrease in gas consumption. The implementer capped and claimed savings at 5.5% of the plant's metered natural gas use.

The evaluation team used metered gas and production data to estimate the savings impacts and found that production-related gas usage required per unit of production only dropped by 2.3% as a result of this project. We believe the difference is because the implementation team used baseline data from a similar plant, while we used baseline data from the plant where this project took place.

The resulting project savings are shown in Table 36 below.

Table 36. Summary of Project 2001321 Savings

	Therms
Ex Ante	66,734
Verified	27,236
Realization Rate	41%

Summary of the Ex Ante Calculations

The ex ante calculations were performed by calculating the annual natural gas required to operate the continuous cooker in the baseline case and comparing it against the actual natural gas consumption post upgrade.

The calculations for the baseline include the energy required to run the cooker and the energy required to heat makeup water. Makeup water is necessary due to condensate loss that was estimated as 20% lost to the drain plus 5.5% lost to flash (due to lower pressure return) plus 7.1% due to periodic blowdown. Given the estimated makeup water volume, the energy required to heat this makeup water was then calculated assuming the water is heated from 55°F to 360°F.

The calculations for the new conditions were originally performed by the TA in the same manner as the baseline—assuming 100% of condensate would be returned (except blowdown, which is still necessary). This approach was subsequently abandoned; however, and instead the TA used metered natural gas data. Weekly metered gas data was divided by production from that week to find the efficiency of production in terms of therms/CWT where CWT means 100 lbs. of product. This efficiency was then multiplied by the annual average production volume to estimate natural gas consumption for one year with the new system.

The original calculation assumed savings of approximately 10% of the plant's annual gas use. The implementation team capped the savings at approximately 5.5% of the plant's annual gas use. Using post-installation data, the implementation team then recalculated savings to be 6.5% of the plant's annual gas use, and it appears that because the reduced usage was still above the cap, the implementation team did not modify the savings based on post-installation gas usage data.

Measurement and Verification Plan

The evaluation team planned to verify this project through a review of production records and natural gas metering data. Additionally, we planned to interview the site contact to verify the baseline and new conditions and ensure the natural gas meter data is not affected by factors other than production. This approach is preferable as there is no way to verify the actual amount of condensate loss in the baseline case but metered natural gas data could capture overall system efficiency before and after the upgrade.

The specific questions we asked of the site contact are listed below:

- The savings calculations show that 20% of condensate was lost to the drain before this upgrade. Has the system always dumped this condensate or was that a recent issue? Was 20% an estimate or a measured value?
- Does the system now capture 100% of the condensate?
- How well insulated is the new return system?
- Is there any data on makeup feed water or pump operation?
- How much of the natural gas use at the facility goes towards this steam system? What, if any, other major gas end uses are there in the building?
- Can you provide production data records going back one year before the steam upgrade (back to approximately October 2019)?
- Has there been any impact from the COVID-19 pandemic on your operations? Has it returned to pre-COVID conditions, or do any of those changes appear to be part of the "new normal"?
- Do you have any idea how efficient your steam boilers are (any recent combustion tests?) Do you have any boiler economizers or anything that might lead to a more efficient boiler system? If not, do you have boiler make/model/age?
- Were the old boilers replaced due to poor efficiency or simply due to old age/reliability concerns? Do you have any combustion testing information from the old boilers?

Summary of the Verified Calculations

The verified calculations were performed using weekly gas meter and production data from 15 weeks before and 15 weeks after the project supplied by the site contact. The evaluation team used this data to deriv an overall system efficiency for the baseline and new conditions. Natural gas consumption during each week was divided by the production (in lbs.) to find the production efficiency for that week. We calculated the average gas usage per pound of product before and after the condensate return installation to arrive at a baseline and post-project production efficiency. The production efficiency for the baseline and post-project conditions was then multiplied by the average annual production to estimate natural gas consumption for each case. The difference between the baseline and new annual natural gas consumption is the verified savings.

The implementation team calculated savings for the plant using a production efficiency value based on an average of five years of data prior to the project. However, the evaluation team only received 13 weeks of post energy usage data from the summer period, with a corresponding baseline set of data from 2019. The customer indicated that the COVID-19 pandemic had a large impact on production. Therefore we used the 13 weeks' worth of data from 2019 as it was the most recent non-COVID-impacted data to normalize baseline energy consumption on a therm/lbs of product basis. When we recalculated the production efficiency based on the 2019 13-week baseline data, the savings dropped to 2.3% of annual natural gas use instead of the ex ante value of 5.5%.

The evaluation team notes that the existing steam boilers were replaced, which was not part of the scope of this project. While the site contact indicated that these were replaced due to age and reliability concerns, it is plausible that some of the claimed savings came from the upgraded efficiency of the new boilers. When evaluating a project using metered data, the evaluation team normally attempts to deduct savings from simultaneous efficiency projects that are not a part of the project under evaluation to ensure we are only accounting for the savings from the measures included in the application. The evaluation team did not find evidence that the new boilers had higher efficiencies; however, so we did not adjust the savings for this project due to the boiler replacements.

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