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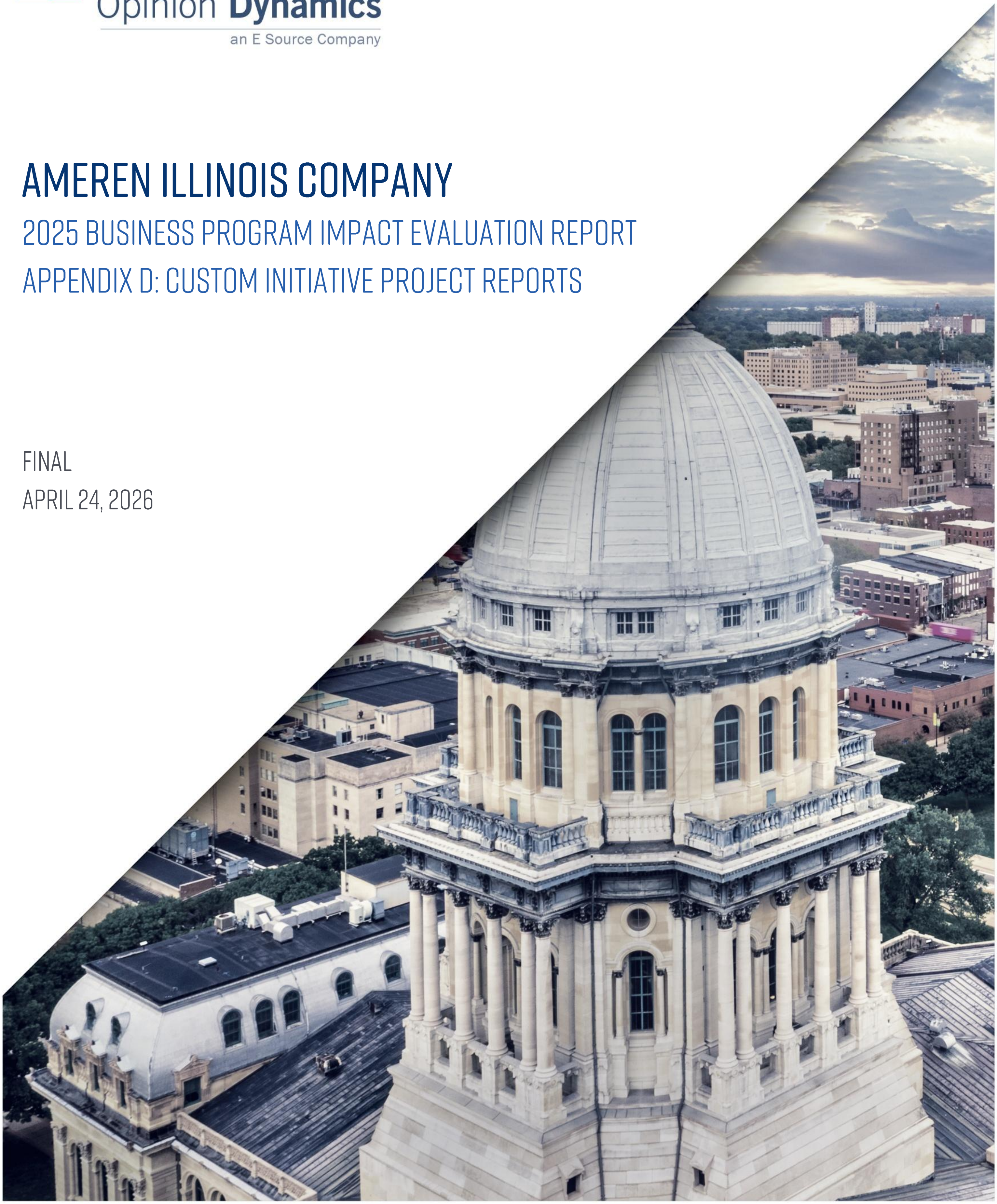
2025 BUSINESS PROGRAM IMPACT EVALUATION REPORT

APPENDIX D: CUSTOM INITIATIVE PROJECT REPORTS

FINAL

APRIL 24, 2026



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TABLES AND FIGURES

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 nine Custom Initiative projects evaluated as part of the 2025 Business Program impact evaluation. The evaluation team selected this subset of projects for additional documentation due to their relative size (i.e., savings) and/or technical complexity.

PROJECT 2300018

Project ID#:	2300018
Measure:	Efficient Envelope, Mechanicals, and Lighting
Ex Ante Savings:	5,305 therms
Facility Type:	Other
End Use:	New Construction
Sampled For:	Gas
Wave:	Wave 1

MEASURE DESCRIPTION

For this project, the energy modeling team verified 58 above-code ECMs across 6 project buildings. Broad measure categories are as follows:

- Wall & roof insulation improvements
- High-performance fenestration (window performance)
- DCV (Demand Control Ventilation) for high occupancy zones
- High-efficiency fuel-burning equipment (furnaces, service water heaters, boilers)
- Low-flow shower heads and kitchen pre-rinse spray valves
- Energy Star kitchen appliances and clothes washers/dryers

KEY FINDINGS

During the evaluation of this project, all claimed ECMs were given a high-level review, and two of the gas-predominant measures within this project were flagged and given a more detailed review with Willdan, the energy modeling consultant, and the customer. These two ECMs (DCV for gym and kitchen spaces) were determined to be prescriptive requirements for minimum energy code compliance with the 2018 International Energy Conservation Code (IECC), applicable to the project. The gas savings from the two measures were removed from the total project savings.

The two ECMs that were removed from the claimed savings totaled 2,136 therms of natural gas savings. The resulting net verified savings for this project are 3,169 therms. The resulting project savings are shown in Table 1.

Table 1. Summary of Project 2300018 Savings

	Therms
Ex Ante	5,305
Verified	3,169
Realization Rate	60%

SUMMARY OF THE EX ANTE CALCULATIONS

Ex Ante Calculation Type: Simulation-based modeling

For software-based building energy modeling projects, the ex ante savings are derived directly from the difference in modeled energy consumption between a baseline building (minimum 2018 IECC) and a proposed building matching the project construction documentation. Both models are developed within the energy modeling software using consistent weather, schedules, loads, and operating assumptions, differing only in the specific measures implemented. Total modeled project ex ante savings were estimated as 5,305 therms per year. New systems and control sequences installed as part of the new construction and renovation project are understood to have been commissioned and functionally verified in accordance with the project specifications. However, documentation of this commissioning and functional performance testing was not made available for review, and the evaluation team was not able to confirm any additional testing/verification by the implementation team.

The NEO modeling software establishes project savings using the energy cost budget method, applying all mandatory and prescriptive requirements of the standard. The NEO software is an online user interface driven by a DOE2 simulation engine, fully compliant with ASHRAE 140 for simulation software requirements. Given the energy cost budget compliance path, individual 2018 IECC code sections may be directly referenced as needed to meet the minimum energy code compliance requirements.

MEASUREMENT AND VERIFICATION PLAN

Review Type: Desk Review

Measurement and verification efforts primarily focused on the validation of modeling software inputs and the reasonableness of simulation outputs. There is no challenge to the underlying computational methodology established in the NEO, DOE2-based software, as it has already been vetted for energy program usage.

The purpose of this evaluation is to verify the accuracy and reasonableness of energy savings claimed through software-based modeling (NEO) for these new construction and major renovation projects. The evaluation team's verification focuses on key modeled measures that drive the majority of project energy savings.

OBJECTIVES

- Validate that the selected ECMs exceed minimum construction/energy code requirements based on the chosen prescriptive compliance path within 2018 IECC, the applicable energy code.
- Confirm that modeled baseline and proposed system inputs and assumptions accurately represent the design intent and installed conditions in accordance with the 100% Construction Documents.
- Ensure that the largest modeled ECMs (> 2% savings) are not mandatory code requirements and are supported by construction documentation and commissioning/direct field observations.

- Remove individual ECM savings determined to be for non-qualifying measures by the standards above, updating project verified savings against the claimed savings.

Baseline Case Questions for Customer

- Occupancy Schedules – confirm occupancy schedules in common spaces, notably in the new multipurpose building (NC) kitchen at 19 hours/day, gymnasium at 18 hours/day, and the administrative building at 16 hours/day.
  - N/A – Customer could not be reached for comment.
- Do these occupancy hours change based on weekdays (e.g., different administration hours on weekends), or are there any seasonal fluctuations in how the multipurpose building is utilized?
  - N/A – Customer could not be reached for comment.

Installed System Verification Questions for Customer

- CO2-based demand control ventilation (DCV) was noted for the gymnasium in the new construction addition. The drawing review indicated that this space may be classified as a "multipurpose room" rather than a fixed-usage gymnasium. Can you please confirm how the space is used and what you would anticipate the maximum occupancy to be? Is there a maximum occupancy sign posted by the fire marshal?
  - N/A – Customer could not be reached for comment.
- A kitchen hood demand control kitchen ventilation (DCKV) system was observed for the type-I kitchen hoods in the multipurpose (NC) addition. The total kitchen exhaust is scheduled to be 5,025 cfm across two hood systems. Can you please confirm the design airflow for each kitchen hood? This should be shown on the kitchen hood nameplate located on the inside of each hood.
  - N/A – Customer could not be reached for comment.
- Can you please confirm the storage tank temperature of the domestic hot water heaters? Typically, this is within the range of 115-140°F but may vary throughout the facility.
  - N/A – Customer could not be reached for comment.

Baseline System Verification Questions for Willdan

For the questions below, refer to the attached Appendix A for Willdan responses.

- How does NEO treat interactive effects within various ECM runs, e.g., are the lighting saving measures run before chiller efficiency measures, or does each measure standalone vs. the baseline?
- Notable area deviation – The multipurpose building (NC) gymnasium is reported to be 9,755 sqft. However, the area take-off shows approximately 4,200 sqft. Please clarify the gymnasium boundary as it relates to the lighting calculations.

Installed System Verification Questions for Willdan

For the questions below, refer to the attached Appendix A for Willdan responses.

- NEO platform: the reviewer could not verify the window area assigned to each exterior wall. How is window area treated within the software, i.e., does the modeler have the capabilities of identifying window walls and assigning window areas vs. an assumed (or user-entered) window-to-wall ratio for each building as a whole?

- Heating hot water - Please clarify that the "aggressive reset" user-entry does not also include savings for IECC required reset control (per IECC C403.4.4, which requires 25% delta-T reset), which would incorrectly count the code compliance portion of the reset as savings.
- Service (domestic) hot water efficiency and savings are often overstated in equipment catalog data where storage temperature does not allow for full condensing operation (e.g., storage at 140°F). Operating temperature or storage tank temperature did not appear to be a modeler-entered value. Is DHW storage temperature accounted for in the underlying savings calculations, and what DHW assumptions are made within the underlying NEO platform?

PRIMARY M&V PLAN

- Review responses to the questions above for the two flagged measures believed to be mandatory requirements under the 2018 IECC, which is the applicable project energy code.
- As run-permissive access to the NEO software was not provided for direct model revisions, the measure-isolated savings reported in the Whole Building Model tabulated output (Appendix B of the "Final Verification Report") will be used to evaluate savings associated with measures determined to be non-qualifying.
- Update the ex ante savings calculation by removing the isolated savings attributed to non-qualifying measures from the total reported project savings.

SUMMARY OF THE VERIFIED CALCULATIONS

Verified Calculation Type: Manual corrections to simulation-based modeling

In discussions with Willdan, the energy modeling consultant, it was determined that the CO2-based DCV for the gymnasium and the kitchen hood DCKV systems were, in fact, mandatory provisions with the 2018 IECC and thus do not qualify as ECMs within the program.

The team relied on the measure-isolated savings results presented in the Whole Building Model tabulated output report included in Appendix B of the Final Verification Report (dated May 30, 2025). These results represent the selected modeling approach in which all project ECMs were simulated concurrently, thereby capturing interactive effects between measures and yielding an integrated estimate of total project savings.

This table is reported on a per-measure basis, isolating the individual measure's contribution to the total modeled savings. DCV for the gymnasium had reported savings of 2,106 therms. The kitchen DCKV had reported savings of 30 therms. These individual measures' savings were manually removed from the reported total project savings to generate the verified savings.

It is anticipated that rerunning the model in the NEO software with these measures removed would yield comparable outputs and projected savings, while potentially providing a more explicit treatment of interactive effects between competing or complementary measures. However, the evaluation team was not granted run-permissive access to the NEO software to perform this analysis.

In support of the manual adjustment methodology, it is expected that any resulting changes in interactive effects associated with the removal of these two measures would be immaterial to total project savings and would fall within the accepted uncertainty and tolerance of simulation-based methodologies when compared to realized savings in operational buildings.

APPENDIX A

Email from Joel Logan, Willdan to Nick Young, Michaels on November 11th 2025.

FLAGGED MEASURES FOR FURTHER DISCUSSION

Evaluator:

CO2-based Demand Control Ventilation (DCV) was noted for the Multipurpose (NC) addition, claiming 2,106 therms of project savings. Drawing review indicated that this space may be classified as a “Multipurpose Room” rather than a fixed-usage gymnasium. Sheet 6-G2.1 Life Safety Plan indicates a design occupancy of 240 people, corresponding to a people density of 37 ppl / 1000 s.f. Given this, DCV is required per 2018 IECC Section C403.7.1 (above 25 ppl / 1000 s.f. and >500 s.f. of space area).

Willdan:

Agree. DCV is required for the Gymnasium space (modeled people density 33sf/person) per the final design. The outside airflow quantities should have been updated by Willdan at verification. Willdan has added a check here to our process.

The Multipurpose building (NC) addition HVAC system served two space asset areas (SAA) – gymnasium and classroom. Based on the floor plans received during the design phase, the modeled Gymnasium SAA included area for the Gymnasium, corridor, storage, classroom, restroom, and M/E spaces in that wing of the new addition.

The floor plans detailed the main space as “Gymnasium”, thus that was used as the basis early in the design process for defining the space.

The Gymnasium SAA had a modeled people density of 33 sf/person (295 people in SAA) - (OA 20cfm/person and 0.18cfm/sf) resulting in 7,668 cfm OA. The Classroom SAA had a modeled people density of 40 sf/person (237 people in SAA) - (OA 10 cfm/per and 0.12 cfm/sf) resulting in 3,515 cfm OA. The total modeled OA was 11,185 cfm for the associated central air handler system.

Per 90.1-2016 Table 6.5.6.1-1, the modeled system included heat recovery as the OA was over 4,500 cfm (and 49.6% OA). As heat recovery was included in baseline and PRONS models, the demand control ventilation strategy was applicable, as the model met 90.1-2016 Exception 6.4.3.8 #1 (Systems with exhaust air energy recovery complying with Section 6.5.6.1).

The final plans show 6-AHU-1 at 26,000 SA and 3,950 OA and no heat recovery, thus demand control ventilation would be required for the Gymnasium.

Figure 1. Ventilation Controls for High-Occupancy Areas

ating, Ventilating, and Air Conditioning

6.4.3.8 Ventilation Controls for High-Occupancy Areas

Demand control ventilation (*DCV*) is required for *spaces* larger than 500 ft^2 and with a design occupancy for *ventilation* of ≥25 people per 1000 ft^2 of *floor* area and served by *systems* with one or more of the following:

a. *Air economizer*.
b. *Automatic* modulating *control* of *outdoor air* damper.
c. Design outdoor airflow greater than 3000 cfm.

Exceptions to 6.4.3.8

1. *Systems* with exhaust air *energy* recovery complying with Section 6.5.6.1.
2. Multiple-zone *systems* without *DDC* of individual zones communicating with a central *control* panel.
3. *Systems* with a design outdoor airflow less than 750 cfm.
4. *Spaces* where >75% of the *space* design outdoor airflow is required for *makeup air* that is exhausted from the *space* or *transfer air* that is required for *makeup air* that is exhausted from other *spaces*.
5. *Spaces* with one of the following occupancy categories as defined in ASHRAE Standard 62.1: correctional cells, daycare sickrooms, science labs, barbers, beauty and nail salons, and bowling alley seating.

Evaluator:

A kitchen hood demand control kitchen ventilation (DCKV) system was observed for the type-I kitchen hoods in the Multipurpose (NC) addition, claiming 6,455 kWh electrical and 30 therms NG project savings. The summation of total kitchen exhaust is scheduled as 5,025 cfm across two hood systems. DCKV is required per 2018 IECC Section C403.7.5, stating that variable airflow systems are required for kitchen exhaust systems with a summation of 5,000 cfm exhaust or higher.

Willdan:

Partially Agree. During the early design phase, the exact kitchen exhaust was not known and based on the size of the space, the exhaust airflow was assumed to be below 5,000 cfm, thus the DCKV strategy was applicable and included in the pre-approved incentive. This is the basis for including the strategy in the verified savings.

Based on the scheduled cfm of exhaust air for the kitchen hoods, the exhaust airflow is less than 1% above the threshold for code requirement of a variable airflow system is required for the system. The exhaust airflow quantities should have been updated by Willdan at verification. Willdan has added a check here to our process.

BASELINE SYSTEM VERIFICATION QUESTIONS

Evaluator:

Occupancy Schedules – confirm occupancy schedules, notably Multipurpose Bldg. (NC) kitchen at 19 hours/day, Gymnasium at 18 hours/day, and the Administrative Building at 16 hours/day (two admin shifts?).

Willdan:

NEO uses schedules from Building Envelope Trade-off Schedules (Addendum an). The hours detailed above are associated with the fans (mechanical schedules) for these spaces. The fan schedule hours are based on the Infiltration schedules defined in the Trade-off Schedules.

The occupancy schedule and other load schedules (lighting, equip, etc.) have fractional values per hour per the Trade-off Schedules.

For occupancy, the Kitchen has 11 hours of core use per day (number of hours where occupancy or use is higher than 50% of the max occupancy/usage). The Gym has 9 hours of core use per day. During and outside of these hours, there is additional fractional occupancy.

Below are defined schedules detailed in the Simulation file LV-G report:

Figure 2. Defined Schedules in Simulation File LVG 1

```
SCHEDULE  KTC1C1OccSch

    THROUGH 31 12

        FOR DAYS  SUN MON TUE WED THU FRI SAT HOL

    HOUR  1    2    3    4    5    6    7    8    9    10   11   12   13   14   15   16   17   18   19   20   21   22   23   24

       0.00 0.00 0.00 0.00 0.00 0.05 0.10 0.40 0.40 0.40 0.20 0.50 0.80 0.70 0.40 0.20 0.25 0.50 0.80 0.80 0.80 0.50 0.35 0.20
```

Figure 3. Defined Schedules in Simulation File LV-G Report 2

```
SCHEDULE  GYM1N1OccSch

    THROUGH 31 12

        FOR DAYS  SUN SAT HOL

    HOUR  1    2    3    4    5    6    7    8    9    10   11   12   13   14   15   16   17   18   19   20   21   22   23   24

       0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.14 0.20 0.20 0.20 0.50 0.50 0.50 0.20 0.20 0.20 0.20 0.19 0.10 0.02 0.00 0.00 0.00

        FOR DAYS  MON TUE WED THU FRI

    HOUR  1    2    3    4    5    6    7    8    9    10   11   12   13   14   15   16   17   18   19   20   21   22   23   24

       0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.20 0.20 0.20 0.80 0.80 0.80 0.80 0.80 0.80 0.80 0.20 0.20 0.20 0.20 0.10 0.00
```

Evaluator:

Notable area deviation, Multipurpose Building (NC) Gymnasium is reported as 9,755 s.f. But the area take-off was approximately 4,200 s.f. Please clarify the Gymnasium boundary as it relates to the lighting calculations.

Willdan:

The Multipurpose Building (NC) - Gymnasium Space Asset Area (SAA) in the model represented more than just the Gymnasium space. A Building Type definition is used when defining area in the model. This SAA was larger than just the Gymnasium as it included the classroom, corridor, storage, restroom, and mechanical/electrical spaces in this wing of the project.

Figure 4. Gymnasium Space Asset Area Model

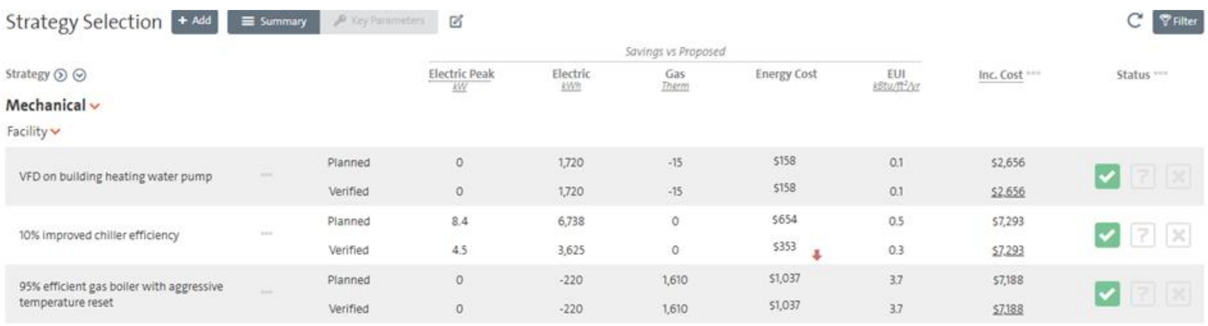
Evaluator:

How does NEO treat interactive effects within various ECM runs, e.g., are the lighting saving measures run before chiller efficiency measures, or does each measure standalone vs. the baseline?

Willdan:

Each strategy is run in isolation, and results shown in NEO are compared to the Proposed model (PRONS -proposed system at code minimums and no strategies). Results represent a change in the key parameter for the respective strategy. As each strategy is a whole building model simulation, any interactive effects from the measure are accounted for. Lighting strategy results are thus independent of mechanical (chiller) strategy results.

Figure 5. Strategy Selection

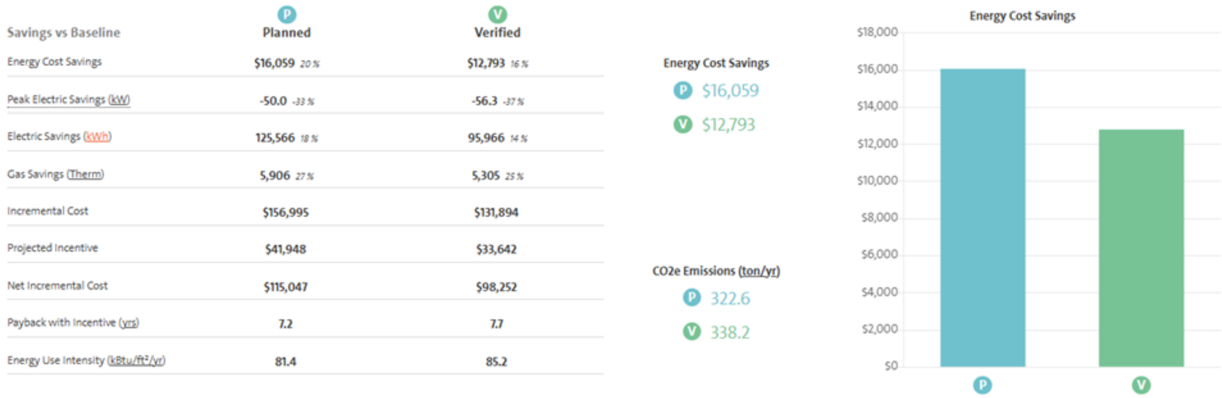


Strategy Selection

Strategy		Electric Peak kW	Electric kWh	Gas Therm	Energy Cost	EUI kBtu/ft²/yr	Inc. Cost	Status
Mechanical								
Facility								
VFD on building heating water pump	Planned	0	1,720	-15	$158	0.1	$2,656	
	Verified	0	1,720	-15	$158	0.1	$2,656	
10% improved chiller efficiency	Planned	8.4	6,738	0	$654	0.5	$7,293	
	Verified	4.5	3,625	0	$353	0.3	$7,293	
95% efficient gas boiler with aggressive temperature reset	Planned	0	-220	1,610	$1,037	3.7	$7,188	
	Verified	0	-220	1,610	$1,037	3.7	$7,188	

The overall bundle results are compared to the baseline system at code minimum. These results account for all interactive effects of all included strategies within the whole building simulation. Bundle results would account for combined effects of improved lighting power and improved chiller efficiency, as well as all other included strategies.

Figure 6. Savings versus Baseline



Savings vs Baseline	Planned	Verified
Energy Cost Savings	$16,059 20 %	$12,793 16 %
Peak Electric Savings (kW)	-50.0 -33 %	-56.3 -37 %
Electric Savings (kWh)	125,566 18 %	95,966 14 %
Gas Savings (Therm)	5,906 27 %	5,305 25 %
Incremental Cost	$156,995	$131,894
Projected Incentive	$41,948	$33,642
Net Incremental Cost	$115,047	$98,252
Payback with Incentive (yrs)	7.2	7.7
Energy Use Intensity (kBtu/ft²/yr)	81.4	85.2

INSTALLED SYSTEM VERIFICATION QUESTIONS:

Evaluator:

NEO platform: the reviewer could not verify the window area assigned to each exterior wall. How is window area treated within the software, i.e., does the modeler have the capabilities of identifying window walls and assigning window areas vs. an assumed (or user-entered) window-to-wall ratio for each building?

Willdan:

In NEO, for this project the window area is defined by a default window to wall area ratio (WWR) that is assigned to each Space Asset Type. Default values follow 90.1 Appendix G definitions.

The modeled window and wall area values are not visible with the NEO user interface, but can be viewed in the Simulation File, LV-D report. This report details window and wall area for each exterior surface and provides an overall summation as well. In this project, the WWR breakdown was as follows:

Apartment SAT- 24% WWR

Office SAT- 40% WWR

Gymnasium SAT- 22% WWR

Garage SAT- 0% WWR

Classroom SAT- 22% WWR

Kitchen SAT- 9% WWR

Overall modeled building had WWR of 8%, (7,802 sf window area, 95,345 sf window+wall area). The same WWR is used in the baseline, PRONS, strategy and bundle simulations.

Window to wall area ratios could be addressed in a modeling protocol.

Figure 7. Appendix G Definitions

Normative Appendix G

Table G3.1.1-1 Baseline *Building Vertical Fenestration* Percentage of Gross *Above-Grade-Wall* Area

Building Area Types[a]	Baseline *Building* Gross *Above-Grade-Wall* Area
Grocery store	7%
Healthcare (outpatient)	21%
Hospital	27%
Hotel/motel (≤75 rooms)	24%
Hotel/motel (>75 rooms)	34%
Office (≤5000 ft^2)	19%
Office (5000 to 50,000 ft^2)	31%
Office (>50,000 ft^2)	40%
Restaurant (quick *service*)	34%
Restaurant (full *service*)	24%
Retail (stand alone)	11%
Retail (strip mall)	20%
School (primary)	22%
School (secondary and university)	22%
Warehouse (nonrefrigerated)	6%

a. In cases where both a general *building* area type and a specific *building* area type are listed, the specific *building* area type shall apply.

Evaluator:

Heating Hot Water - Please clarify that the “aggressive reset” user-entry does not also include savings for IECC required reset control (per IECC C403.4.4 requires 25% delta-T reset), double-counting the code compliance portion of the reset.

Willdan:

The aggressive reset strategy represents a condensing gas boiler with 95% peak efficiency and an aggressive temperature reset schedule with return water temperatures ranging from 140°F (60°C) at peak winter conditions to 90°F (32.2°C) at mild conditions. The baseline model accounts for the code required reset and the strategy reset is beyond code requirements.

The sequence of operations notes that boilers have initial sequence of 130F supply temp at 0F outside air temp and 110F at 65F outside air temp. Boiler Schedule notes a delta T of 20F (130F Supply and 110F return). Based on this the return temps for this reset operation would be 110F and 90F, meeting the strategy intent.

Figure 8. Hot Water Boilers

HOT WATER BOILERS - 2 BOILERS

A. GENERAL:
1. CONTROL ELECTRONICALLY WITH DEDICATED STAND-ALONE HVAC NODE (HN).
2. TOTALIZE RUN TIME OF THE BOILERS AND ALTERNATE LEAD BOILER EVERY 168 HOURS OF OPERATION (ADJ.).

B. SYSTEM OFF: BOILER AND ASSOCIATED PUMP SHALL BE OFF.

C. SYSTEM START:
1. WHEN THE OUTDOOR AIR TEMPERATURE FALLS BELOW THE HEATING SYSTEM ENABLE SET POINT (65°F, ADJ.) THE LEAD BOILER (OPERATOR SELECTABLE) SHALL BE INDEXED TO OPERATE:
   a. ASSOCIATED PUMP SHALL START.
   b. BOILER SHALL ENABLE TO START WHEN PROOF OF FLOW HAS BEEN ESTABLISHED.
   c. BOILER SHALL OPERATE FOR A MINIMUM OF 15 MINUTES (ADJ).

D. SYSTEM RUN:
1. RESET SCHEDULE SHALL BE ADJUSTABLE, WITH THE INITIAL SCHEDULE OF 130°F PRIMARY HOT WATER SUPPLY TEMPERATURE SETPOINT AT 0°F OUTSIDE AIR. SUPPLY TEMPERATURE SHALL BE 110°F SETPOINT AT 65°F OUTSIDE AIR TEMPERATURE. COORDINATE MINIMUM HOT WATER TEMPERATURE WITH BOILER MANUFACTURER'S RECOMMENDATIONS.
2. LAG BOILER SHALL BE PREVENTED FROM OPERATING UNTIL 30 MINUTES (ADJ.) AFTER INITIAL SYSTEM START-UP.
3. LAG BOILER SHALL BE INDEXED TO OPERATE WHENEVER LEAD BOILER CANNOT MAINTAIN THE PRIMARY LOOP SUPPLY TEMPERATURE SETPOINT FOR MORE THAN 5 MINUTES (ADJ.).
4. WHEN BOILERS ARE OPERATING THEIR FIRE RATES SHALL BE MODULATED IN UNISON. LAG BOILER SHALL CONTINUE TO OPERATE UNTIL BOILER FIRE RATE FALLS BELOW 50% (ADJ.) AT WHICH TIME THE LAG BOILER SHALL BE DISABLED. REFER TO "SYSTEM STOP" FOR LAG BOILER SHUTDOWN SEQUENCE.

Evaluator:

Service (Domestic) Hot Water efficiency and savings are often overstated in equipment catalog data where storage temperature does not allow for full condensing operation (e.g., storage at 140°F). Operating or storage tank temperature did not appear to be a modeler-entered value. Is DHW storage temperature accounted for in the underlying savings calculations, and what DHW assumptions are made within the underlying NEO platform?

Willdan:

In NEO water heaters are assumed to have storage tanks. DOE2.1 simulation does account for energy needed to maintain service water heating setpoints and meet demand based on heat losses. NEO defaults to a supply 120F water temp for service water heating, this is not a user entry.

PROJECT 2400051

Project ID#:	2400051
Measure:	Installation of new CHP and steam generator system to completely offset electricity usage and supply steam
Ex Ante Savings:	58,873,723 kWh; 7,632.6 kW (Peak Summer); 669,553 therms
Facility Type:	Manufacturing/Industrial
End Use:	CHP
Sampled For:	Electric and Gas
Wave:	Wave 3

MEASURE DESCRIPTION

The customer installed a 14.43 MW-rated combined heat and power (CHP) system to generate all their own electricity and supply steam to process loads through a heat recovery steam generator (HRSG) with its own duct burners on the exhaust from the CHP's gas turbine. The combined heat from the duct burners and the turbine is then used in the HRSG (an economizer/HX) to generate steam.

This system reduces their electric usage from Ameren to 0 kWh per month. It supplies 163,693 lb/hr of 150 psi steam at 367°F for process use. The CHP system generates an average of 9,965 kW of power. The CHP system has data trending capabilities for steam mass flow, turbine power output, turbine gas input (in kSCFH), heat recovery steam generator gas input (in kSCFH), and feedwater pressure. The customer provided steam production and heat recovery steam generator data for the period of May 27, 2025, to August 26, 2025, feedwater pressure for June 4, 2025, through August 26, 2025, ethanol production data for May 27, 2025, through August 25, 2025, and turbine input gas flow and output power for August 1, 2025, to August 26, 2025. The ethanol production data showed that production volumes remained within 1% of the volumes before the project and during the same time of year in 2023 (1.0102% increase).

During the evaluation, the customer provided updated trend data for all relevant values for the months of September through November. This data showed a lower power output but higher steam generation compared to the previous data.

KEY FINDINGS

The ex ante analysis misapplied the TRM methodology by including gas input and steam output for the HRSG in addition to the CHP system. Using Rentech design documents for system operation both with and without the HRSG in operation, the evaluation team used the trended steam output values and the design steam output value to determine the percent of design steam output (81.8%). We then applied this value to the design steam output with no HRSG burner operation to get the estimated steam output if the turbine were running by itself (52,101 lb/h). We also removed duct burner gas consumption from the FtotalCHP value. The annual hours were increased slightly to 8,568 hours. Finally, after discussion with Ameren and its implementer, we reduced the parasitic losses from an assumed 3% of power generation to only the energy estimated to be consumed by a pneumatic controls compressor (115,051 kWh/year). The net result of all these changes was an increase in CHPeff to 70.9% from 70.3%. This increased the electric and gas savings.

The largest increase in savings on the gas side was due to the inclusion during evaluation of a second measure. This measure covers the increased steam generation efficiency of the HRSG compared to a baseline boiler (82.6% efficiency, taken from a previous Ameren project at the same site). The HRSG has a calculated thermal efficiency of 91.2%. This measure added 1,131,544 therms to the total verified savings.

Demand savings increased significantly, primarily due to the removal of the unsourced 0.75 factor in the ex ante demand savings calculation.

The resulting project savings are shown in Table 2.

Table 2. Summary of Project 2400051 Savings

	kWh	kW	Therms
Ex Ante	58,873,723	7,632.6	669,553
Verified	59,688,544	9747.1	1,926,765
Realization Rate	101%	128%	228%

SUMMARY OF THE EX ANTE CALCULATIONS

Ex Ante Calculation Type: Technical Reference Manual calculations

The implementer used the Illinois TRM version 13, Section 4.4.32, method for the analysis. The central governing equation is:

$$CHP_{efficiency} = \frac{CHP_{thermal} + E_{CHP} * 3.412}{F_{totalCHP}}$$

Where:

$CHP_{efficiency}$ = overall efficiency of CHP system (unitless) using the higher heating value of natural gas,

$CHP_{thermal}$ = useful annual thermal energy output from CHP system actually recovered and used in facility (typically in kBTU/hr, but the ex ante analysis uses therms for all thermal loads),

E_{CHP}= useful annual electricity output produced by CHP system actually used to replace purchased electricity (accounting for parasitic loads), and

$F_{totalCHP}$= total annual fuel (natural gas) consumed by the CHP system.

In the Illinois TRM method, the $CHP_{efficiency}$ value determines how much savings can be claimed. In this project, the ex ante $CHP_{efficiency}$ value was 70.6%, which put it in the >65% $CHP_{efficiency}$ row of the first table on page 454 of the TRM. This means that 70% of E_{CHP} can be claimed as electric savings.

To calculate gas savings, the TRM requires us to calculate $F_{thermal}$, the annual fuel that would have been used on-site by a boiler or furnace to provide the useful thermal energy output the CHP system now provides, using the following formula:

$$F_{thermal} = \frac{CHP_{thermal}}{Boiler\_or\_Furnace_{efficiency}}$$

Where:

$Boiler\_or\_Furnace_{efficiency}$ = efficiency of the boiler or furnace that was providing the heat the CHP system is now providing.

Using the same table on page 454 of the TRM, 2.5% of $F_{thermal}$ can be claimed for every percentage point increase in $CHP_{thermal}$ above 65%. Based on the ex ante CHP system efficiency, that means 2.5% * 5.6, or 14% of $F_{thermal}$ can be claimed as gas savings.

Note that, in this analysis, the implementer did not simply take $CHP_{thermal}$ and divide by the baseline $Boiler_{efficiency}$ to calculate $F_{thermal}$. Instead, they took the rated steam output of the turbine at full load (listed in the calculation as 14 MW, but 14.43 MW on the application) and multiplied that steam production in lb/hr by the ratio of the metered power output of the turbine (9.898 MW) to the rated output (14 MW). This results in a steam flow of 45,006 lb/h from the turbine to downstream ethanol processes in the facility. The implementer then multiplied this value by 8,760 annual operating hours and the difference in enthalpy of the steam leaving the turbine (at 150 psig, 367°F) and the boiler feedwater (20.16 psig, estimated temperature of 228°F). Once converted to MMBTU, this leads to a new value of $CHP_{thermal}$ than used before, which is much smaller (about 3,900 MMBTU vs. 12,100 MMBTU). This value is then divided by the baseline $Boiler_{efficiency}$ taken from a previous Ameren Custom project to calculate the $F_{thermal}$ value. Note that the value of $CHP_{thermal}$ used in this calculation appears to be for when the heat recovery steam generator portion of the CHP system is not in operation, only the main gas turbine.

The original $CHP_{thermal}$ value (used in the $CHP_{efficiency}$ calculation and based on when the heat recovery steam generator is firing) was calculated by taking the metered average steam production from the turbine (137,698 lb/h), multiplying it by 8,760 operating hours, and by the difference in enthalpy of the discharge steam and the feedwater, just as before (using the same enthalpy values). When converted to therms, this value is 12,058,717. Note that the only difference between this $CHP_{thermal}$ calculation and the one used to find $F_{thermal}$ is that the steam production in lb/h here is about three times higher.

E_{CHP} is computed in a few steps. First, the average turbine power output from metered data is multiplied by the ratio of 8,520 hours to 8,760 hours, presumably to account for downtime; however, this is not clear, and no downtime is assumed in any other part of the analysis. This calculation results in 9,898 kW. The parasitic power draw in kW is then calculated by multiplying the turbine power output by 3%. This 3% value is based on an assumption from an NREL Uniform Methods Project paper on CHP project evaluation. This assumes 3% of the power generated is consumed by the CHP system itself to operate its equipment (fans, pumps, motors, etc.). E_{CHP} is computed by taking the turbine output, subtracting the parasitic load (296.9 kW), and multiplying the result by 8,760 hours. E_{CHP} is 84,105,319 kWh or 2,870,489 therms.

$F_{totalCHP}$ was calculated by taking the average metered turbine input gas flow in kSCFH, multiplying it by 8,760 hours, and the higher heating value of natural gas (1.032 MMBTU/kft3, taken from a DOE paper after some unit conversions), and adding in the metered heat recovery steam generator gas use (in kSCFH, converted to MMBTU just like turbine input gas). By including the heat recovery steam generator usage, the calculation is consistent with including it in the $CHP_{thermal}$ calculation in the numerator of the $CHP_{efficiency}$ formula. However, the TRM does say that only the energy output of the CHP system that is actually recovered and utilized in the process should be included in $CHP_{thermal}$. The ex ante analysis included this because the HRSG system runs whenever the turbine does, and the steam output data include steam flow from both. There is no way to separate the steam/heat energy production of the turbine and the HRSG in the current data, so the HRSG fuel use had to be included in the efficiency calculation. Otherwise, the efficiency comes back as 135% (if the HRSG gas use is removed), indicating that the steam output data must include steam generated by the HRSG and the turbine.

Because the system is a combined system involving both the duct burners and the turbine, the ex ante analysis combined their gas input for the $F_{totalCHP}$ and their steam output for the $CHP_{thermal}$. However, when it came time to calculate the $F_{thermal}$ that the CHP system displaces/saves, they used an estimate of the amount of heat that the turbine alone can supply to turn into steam.

The existing TO already needed to take 59°F OA and heat it to 2,000-3,000°F, which may explain why there isn't a significant increase in gas use with the new system installed. It is only adding in the mechanical losses in the turbine. It isn't raising the pressure/temperature of the system just to generate power, like in typical CHP systems. Additionally, the old thermal oxidizer was replaced with a regenerative thermal oxidizer (RTO), which improved system efficiency by reducing gas usage for oxidation.

Claimed gas savings (669,553 therms) are 14% of the $F_{thermal}$ value. Claimed electric savings (58,873,723 kWh) are 70% of E_{CHP}. Demand savings are 75% of the 9.898 MW average power generated by the turbine (adjusted for coincidence). It is unclear why 75% was used in this calculation, as it is not specified in the TRM.

MEASUREMENT AND VERIFICATION PLAN

Review Type: In-Person Site Visit

BASELINE CASE QUESTIONS FOR CUSTOMER

- Can you confirm the old steam boiler efficiency of 82.6%?
- Is there historical (pre-project) data available for the gas usage of the boiler(s) that the CHP system is replacing or at least steam flow rates (with pressure and temperature)?
- Can you share the daily ethanol production data for the 12 months preceding the CHP installation (March 1, 2024, through February 28, 2025)?

PROPOSED CASE QUESTIONS FOR CUSTOMER

- Is the CHP system still operating?
- How many hours per year is the CHP system shut down?
- Has production remained similar to how it was this summer (pre-project)?
- Does the FIT-1 Steam Production in KPPH include steam produced by the HRSG and the gas turbine?
- Is the KSCFH value in the FIT-1 Steam Production data for the gas consumption of the duct heaters?
- Is there trend data available for the gas turbine leaving temperature and airflow?
- What is the 4,000 lb/h of steam that leaves the steam generator and doesn't go to the rest of the facility used for?

QUESTIONS FOR IMPLEMENTER

- Why were 8,520 hours used in E_{CHP} calculation, but 8,760 hours everywhere else?
- Why was 14 MW full turbine capacity used in the $F_{thermal}$ process gas usage calculation, but 14.43 MW listed on the application and 14.125 MW listed on Solar Turbine Specs.pdf at 59°F?

PRIMARY M&V PLAN

- Update steam mass flow (kpph) from FIT-1 Steam Production
- Update turbine output power from operator logs
- Update turbine input gas KSCFH from operator logs

- Update HRSG Duct use from FIT-1 steam production logs
- Confirm feedwater pressure and temperature
- Get baseline efficiency from the previous application
- Get info (nameplates, spot checks of amps/kW) for all parasitic loads
- Confirm full load rated MW
- Get answers to the questions above to address the issue of HRSG gas use and steam output currently being included in the efficiency calculation, and to see if we can find the gas consumption of the previous boiler.
- Get updated gas and electric bills and ethanol production data
- Then, update all the ex ante calculations with more recent values

SECONDARY M&V PLAN

Build a regression model (against production, corn moisture content, weather, season) of pre-implementation to compute project savings by comparing the modeled baseline usage to actual usage post-implementation. Initial tests indicate that a model based only on production versus gas use is not viable due to poor fit.

EARLY REVIEW NOTES

The following questions and comments highlight the evaluation team's observations:

- The basis for the claimed savings comes from values specified in the customer application, and none of the analysis included in the provided spreadsheet ultimately gets used in the reported project savings. No background information was provided regarding the source of the gas usage values in the customer application, so the evaluation team could not verify any reported usage values. It is concerning that the project claims that the CHP system will use natural gas to produce all needed electricity for the facility and meet the facility's steam needs; yet, the annual estimated gas consumption for steam generation is expected to decrease.
  - Observation only.
- The baseline boiler efficiency is 80%, which appears to be new construction efficiency. If the CHP replaces the existing boilers' function, the current boiler efficiency, which we expect to be better than 80%, should be used as the baseline efficiency value in estimating savings. We would expect that the efficiency of the existing boilers has been recorded as part of an annual inspection.
  - Recommendation implemented.
- The claimed steam production efficiency of 94.6% for the HRSG is higher than the evaluation team has seen for any gas-fired steam-producing equipment. It raises concerns that efficiency values are not accurately reported or used in the savings analysis. Use of a more typical estimate in the range of 85 to 90% for a steam boiler with an economizer will help to avoid overestimation of savings and reduce evaluation risk.
  - Recommendation implemented.
- The application states that the savings will be equal to total plant grid usage, and we assume this is to account for 260 hours of CHP downtime or plant shutdowns for maintenance and repair. This should be confirmed during measurement and verification.
  - Recommendation implemented.

- The evaluation team recommends using conservative assumptions wherever possible to avoid overestimating the potential savings and incentives.
  - Recommendation implemented.
- The evaluation team recommends that the implementation team collect metered data from the existing pre-implementation plant, including billed gas and electrical energy usage, plus production data for the year prior to CHP being brought online. Further, this information should be used in a regression analysis to establish a correlation, if one exists, between production and weather conditions and the facility's gas and electricity consumption. The pre-implementation correlation should be used to establish baseline energy usage at typical production levels and TMY3 weather conditions.
  - Data collected, but no regression created.
- Post-implementation billed electrical and gas usage, as well as production data, should be collected, along with CHP output power. A regression analysis should be conducted, like what is recommended for the pre-implementation correlation. Assuming post-installation production is typical, the correlations can be used with post-case production and TMY3 data to compare baseline and proposed energy usage. Algorithms and deemed values from the latest Illinois Technical Reference Manual (IL TRM) may be used to supplement data gaps in establishing gas and electric savings. However, the IL TRM assumptions are generalized and may not be representative of this project's design and operation. Apply the IL TRM judiciously.
  - Data collected, no regression created, TRM calculations used.
- Steam production, feedwater temperature, CHP natural gas flow, and steam pressure should be collected to establish total CHP energy efficiency and ensure TRM compliance.
  - Implemented.
- Post-implementation data should be collected for a wide range of weather conditions to capture seasonal variations in CHP operation. A year of data collection is ideal but may not meet the customer's needs. Due to uncertainty in ex ante analysis, consider calculating and dispersing incentives quarterly, or in other intervals, to allow CHP plant operating conditions and usage to normalize to day-to-day schedules, which will support a more precise estimate of realized energy savings.
  - Data collected. Incentives not disbursed quarterly.
- If energy efficiency measures that are not part of this project (e.g., lighting, VFDs, efficient boilers, etc.) are completed during the pre-and post-installation periods, the claimed savings for those measures should be accounted for in the billed usage analysis to avoid double-counting of savings. Also, process changes that affect plant energy usage should be accounted for in the normalizing process.
  - Not applicable.

SUMMARY OF THE VERIFIED CALCULATIONS

Verified Calculation Type: Technical Reference Manual calculations

The evaluation team reused the ex ante analysis but modified several formulae. Most notably, the team changed the $CHP_{thermal}$ calculation's steam mass flow rate from the ex ante metered value of 137,698 lb/h to a calculated value of 52,101 lb/h. We calculated this value using design documentation from the HRSG manufacturer about the steam production when the HRSG burners are not firing (63,657 lb/h), design steam flow when both the HRSG and turbine are firing (200,000 lb/h), and the actual steam flow when both are firing (163,693 lb/h). The ratio of actual steam production from metered data and the design flow in those conditions was 0.818. We applied this ratio to the 63,657 lb/h value to determine that 52,101 lb/h of steam is generated when only the gas turbine is operating. The customer does not run the system in this mode at any time, so no metered data is available to confirm this value.

The team used this new steam production flow rate in the same way as before to calculate the $CHP_{thermal}$ value. The change in steam flow rate, along with the removal of gas input energy from the HRSG duct burners, had the most significant impact on the verified savings. These changes resulted in the $CHP_{efficiency}$ value increasing to 70.9%, which then results in an increase in claimed gas savings because the percent of $F_{thermal}$ that can be claimed increases to 14.7%.

Some other more minor changes we made to the ex ante analysis include: reducing the parasitic electric loads from an assumed 3% (equivalent to 294.8 kW or 2,582,056 kWh annually) to an estimated 115,051 kWh per year because the gas turbine only has some small air compressor energy consumption, applying the shutdown hours to the annual operating hours in all calculations instead of to the turbine output power calculation only, and adjusting annual operating hours from 8,520 to 8,568 to match the customer's statement of eight shutdown days per year. The result of all these changes was an increase in electric savings, resulting in a 101% realization rate for kWh.

On the gas side, savings for the CHP measure increased to 795,221 therms with all the above changes, most notably the increase in CHP_{eff}. However, during the evaluation process, the evaluation team met with the implementation team and discovered that there should be additional savings in this project for installing a high-efficiency heat recovery steam generator (HRSG) instead of a standard-efficiency steam boiler. These savings were not included in the ex ante analysis. To compute this, the implementor and evaluator agreed upon a thermodynamic energy balance of the HRSG, using temperatures and flow rates from trend data and design information (Rentech boiler documents). The team then used steam tables and combustion analysis tables to determine appropriate enthalpy values. The energy balance includes all the mass flow rates in and out of the system, all the enthalpies of those flows, and the heat added by the duct burner (using trend data).

The equation for the HRSG efficiency is:

$$\eta_{HRSG} = \frac{\dot{m}_{steam}\left(h_{steam} - h_{feedwater}\right) + \dot{m}_{blowdown}\left(h_{blowdown} - h_{feedwater}\right)}{\dot{m}_{gas}\left(h_{gas,in} - h_{exhaust,out}\right) + Q_{ductburner}}$$

This accounts for the mass flow of steam leaving the HRSG, the feedwater entering the HRSG, the steam leaving the HRSG for blowdown, the gas entering the HRSG from the turbine, the combustion gas leaving the exhaust of the HRSG, and the duct burner heat output. Using this efficiency value, the team calculated the HRSG burner steam output in MMBTU/yr and then back-calculated the baseline equivalent value using the baseline steam boiler efficiency of 82.6% from a previous project at this site (2200412). The difference between these two values is the gas savings for the HRSG measure. These savings, 1,131,544 therms, are added to the total verified savings for the project and increase the realization rate substantially.

For electric demand savings, we removed the 0.75 multiplicative factor from the calculation, only multiplying the average turbine power output by the ratio of actual operating hours to 8,760. This was the main driver of the increase in demand savings and a 128% realization rate.

PROJECT 2400072

Project ID#:	2400072
Measure:	Plastic film production process (for plastic bags) changed to eliminate blowers
Ex Ante Savings:	2,244,232 kWh; 256.2 kW (Peak Summer); 169,720 therms
Facility Type:	Heavy Industrial
End Use:	Process Efficiency
Sampled For:	Electric and Gas
Wave:	Wave 1

MEASURE DESCRIPTION

A scented plastics production facility has optimized its scent application process for waste bags by transitioning from scented pellets to applied oil. Previously, scented pellets were blended with plastic pellets before extrusion, creating a strong odor throughout the facility and requiring 20 blowers to continuously exhaust the air. The new process uses 23 pumps to apply scented oil directly during bag manufacturing, significantly reducing ambient odor. As a result, the exhaust fans are no longer needed.

KEY FINDINGS

The evaluation team discovered that an amperage value had a minor typo, and the proposed electric annual hours were overestimated. Together, these findings led to a slight increase in electric energy savings.

The gas savings were reduced slightly because the original space heating equipment efficiency was found to be underestimated.

The resulting project savings are shown in Table 3.

Table 3. Summary of Project 2400072 Savings

	kWh	kW	Therms
Ex Ante	2,244,232	256.2	169,720
Verified	2,268,424	257.3	163,829
Realization Rate	101%	100%	97%

SUMMARY OF THE EX ANTE CALCULATIONS

Ex Ante Calculation Type: Engineering calculations; Calculations based on metered data

The ex ante baseline blower motor power calculations are based on amperage readings collected by the customer, power factor taken from motor specifications, and an assumed 460 Volts. The plant operates 24 hours per day, seven days per week, and 8,760 hours per year. The total baseline power is 267.4 kW, and the annual baseline energy usage is 2,342,856 kWh. The ex ante proposed motor power for the pump system is estimated to be nominal, 0.5 HP, operating at 100% load, 76.2% efficiency with pumps operating 85% of the year. The total proposed power is 11.3 kW, and the energy usage is 83,797 kWh.

The implementation team also considered gas therm savings from reduced ventilation. They assumed that the balance point of the building is 55°F, resulting in 3,281 HDD, corresponding to a 37°F average outdoor temperature during the heating season. The total airflow for the blowers was estimated to be 163,000 CFM, which, when combined with the other assumptions, results in an average heating load of 3,168,720 BTUH. Using 82% efficiency for gas-fired unit heaters and the estimated HDD results in 169,720 therms of savings.

Total claimed savings are 2,244,232 kWh, 256.2 kW, and 169,720 therms.

MEASUREMENT AND VERIFICATION PLAN

Review Type: Virtual Site Visit

PRIMARY M&V APPROACH

Calculate the baseline and proposed energy consumption using the same approach as the ex ante calculations after confirming the equipment and operation information of the fans. To calculate the gas savings, the evaluation team will use the same approach as the ex ante calculations, ensuring that the correct heating equipment and efficiency are utilized. If there is a significant change in production, the team will normalize the baseline and proposed cases based on the quantity of products produced.

SECONDARY M&V APPROACH

If unable to connect with the site contact to confirm the baseline and proposed systems information, the team plans to do a regression analysis using utility data and production data.

INTERVIEW QUESTIONS, RESPONSES AND DATA GATHERED

Can you please confirm:

- The quantity and horsepower of the original fan motors?
  - Customer Response: 20: (18) 30 hp and (2) 15 hp
- The continuous operation of all fans? No control mechanisms? No redundancy/fan rotation? Did fans ever go out? Perhaps there are maintenance records available to verify continuous operation.
  - Customer Response: All running always. Will follow up with maintenance records.
- Did the factory run all year long? If not, were the fans shut off when production was off? Or were they off during any other times?
  - Customer Response: The factory operates year-round, including holidays such as Thanksgiving and Christmas.
- Has any other equipment or control system been impacted by the new system? (Besides less ventilation, subsequently less infiltration, subsequently less heating)
  - Customer Response: No.
- When did the new pumps begin operating? Are the old fans still used in any capacity, or have they been fully decommissioned? Or, removed from the facility altogether?
  - Customer Response: Right around this time last year.

- The make/model information of the equipment serving the manufacturing zone? Did the heating equipment remain consistent before and after new pumps?
  - Customer Response: Boiler serves the space.
- How is the heating controlled?
  - Customer Response: The West Plant is partially heated with a Cleaver-Brooks natural gas-fired boiler that, in turn, runs localized steam heaters. The boiler is a 20,300,000 BTU unit installed in 2002. We run 50 PSI on the steam side.
- Are the 23 pumps all in parallel?
  - Customer Response: The 23 new pumps are standalone paired to each production line. Therefore, they are separate from one another. One pump will be running pine scent, one lemon, one watermelon, and so on.
- Continuous operation of the new pumps? Although the old ventilation fans may have run 24/7, these new pumps should only run during production.
  - Customer Response: Only run when the conversion line runs; 85% of the time scented products are produced
- Are all pumps running simultaneously, or do the pumps vary throughout the year?
  - Customer Response: Only run when the conversion line runs; 85% of the time scented products are produced
- Did the new pumps lead to an increase in production?
  - Customer Response: No.
- Does this time overlap the 1PM-5PM window on weekdays during the summer (June-September)?
  - Customer Response: Yes. It does overlap the window. The pumps shut off when the lines are not running. Our historical measurements demonstrate approximately 85% uptime on the equipment. The old blower did run 24/7.

Can you please provide:

- The quantity, horsepower, and efficiency of the new pumps?
  - Customer Response: 23 new pumps, 1/2 hp.
- The amperage data collected by the old fan motors?
  - Customer response: 23.5 Amps
- Any additional data from the new pumps?
  - Customer response: Customer Response: Only run when the conversion line runs; 85% of the time (2/3) are scented products.
- Any production data?
  - No increase in production, therefore no production data requested.

EARLY REVIEW NOTES

The ex ante savings calculations use a simple spreadsheet approach based on fan motor amperage readings provided by the customer. The evaluation team supports the implementation team’s use of conservative values for baseline voltage (460 V instead of 480 V) and the proposed motor load factor (100%). If better accuracy is desired, the implementer can take or request voltage and power factor meter readings.

The following questions and comments highlight the evaluation team's observations and recommendations:

- The ex ante calculations use 365 days of annual operation, but the customer reports 355 days per year in the application operating conditions. We recommend that ex ante calculations account for plant shutdowns and holidays to establish days of operation operating days instead of 365 days per year.
  - Initial inspection interview with customer and implementer indicated that the operation runs 365 days per year. Evaluation team confirmed continuous operation with site contact.
- We recommend collecting customer maintenance records of blower operation to verify continuous operation of all blowers.
  - The implementer noted that this could be confirmed prior to post installation inspection. The evaluation team received maintenance records and verified continuous operation.
- We recommend that the implementation team verify that all blowers are decommissioned as part of project completion. If any of the blowers are not decommissioned, the implementation team should document which blowers and to what degree they are still operating, if at all.
  - The implementation team noted that this would be done. The evaluation team confirmed the blowers were decommissioned.
- There is no description of the existing heating and makeup air (MUA) systems provided. Systems in similar facilities typically consist of direct-fired MUA units with 92% efficiency or higher. Pre-install inspection/interview between the customer and the implementer confirmed that there are no MUA units, only unit heaters.
- The implementation team did not address the potential effect of lower MUA unit fan use due to reduced exhaust airflow. Decommissioning the blowers will result in reduced airflow of the MUA system. The amount of reduction depends on how airflow in the MUA is controlled (dampers vs VFD). The implementation team should document MUA controls.
  - Implementer responded, "Air flow into the facility is dependent only on the internal building pressure created by the exhaust blowers, offset by infiltration of raw, outside air."
- The evaluation team questions converting gas savings to electrical savings for this project. If the customer is purchasing transport gas, they are not paying into the incentive system, and those savings should not be claimed as project savings. Gas savings should be considered a separate fuel and not assumed to yield electrical energy savings. An exception to this might be if the facility has on-site electrical generation, and the gas savings would also reduce grid demand. The team notes that the customer application only included electrical savings from converting the scent oil application process.
  - Implementer responded, "This is based on G2E conversion policy for non-Ameren gas customers."
- If the implementation team determines that conversion of therm savings to electrical energy savings is appropriate for this project, the justification should be carefully documented to ensure compliance with the program and State of Illinois regulations. If it is acceptable, then the actual effect on the electrical grid must be considered. This would include the appropriate power generation and transmission efficiency for the company location. If gas savings are considered only to estimate ROI, the evaluation team recommends using a lower facility balance point (e.g., 45°F) due to high internal heat gains from the extrusion equipment.
  - Implementer responded, "Conversion based on Ameren G2E policy. Balance point is taken from TRM for industrial buildings. With the high exhaust flow being drawn immediately from the area around the extruder discharge, it is questionable whether a significant amount of the warmed air is discharged before it can be effectively circulated to other areas of the facility that require heating."

SUMMARY OF THE VERIFIED CALCULATIONS

Verified Calculation Type: Engineering calculations

The verified calculations largely followed the ex ante calculations with minor adjustments.

The baseline electric case found power by taking $P = \sqrt{3} \times V \times i \times PF]$. This value was multiplied by 8,760 to convert it to kWh. The proposed electric case was designed to utilize the motor's nameplate power and efficiency. This value was multiplied by 5,840 hours to convert it to kWh.

The gas savings considered the air flow that used to be conditioned and found the energy associated with that flow using the equation:

$$Q = \frac{1.08 \times CFM \times \Delta T}{\eta}$$

The verified savings utilized a slightly higher efficiency to better align with the existing system. Further explanations for each adjustment and result are described below.

For the electric savings, minor adjustments were made that ultimately increased savings. First, the baseline system calculations had a minor typo where 23.4 amps were used, but the correct number was 23.5. This tenth of an amp slightly increased savings. For the proposed system, the hours were reduced from 8,760 to 7,446 (scented products are produced 85% of the time) based on information provided by the site contact. This adjustment also increased the savings.

For the demand savings, the implementor rounded at each step, which compounded, leading to a minor discrepancy.

For gas savings, the implementor modeled the heating system as a unit furnace with an efficiency of 82%. However, the evaluation team confirmed that a boiler system is used, in consultation with the facilities manager, and concluded that an 85% efficiency rating was more appropriate. This reduced the gas savings.

PROJECT 2400097

Project ID#:	2400097
Measure:	Installation of new DDC controls with resets and scheduling
Ex Ante Savings:	90,514 therms
Facility Type:	Medical
End Use:	HVAC Controls
Sampled For:	Gas
Wave:	Wave 1

MEASURE DESCRIPTION

A supply air temperature reset (55°F-65°F) was implemented on all 13 air-handlers. The controls for four of the air-handlers serving VAV boxes were programmed to reduce the minimum damper position to 30% instead of the original 50%. Lastly, one of the units had an occupancy schedule implemented. The system is fully DDC controlled.

KEY FINDINGS

A regression model was used to analyze the savings, using 2023 data for the baseline and 2025 data for the treatment periods, yielding higher savings. The evaluation team found that 2024 energy consumption was highly irregular and not correlated with weather, whereas both 2023 and 2025 were well correlated with weather (heating degree days). The results of the regression analysis showed higher gas savings than the ex ante calculations. However, because the evaluator was unable to reach the customer to confirm key project details, the team concludes that there is too much uncertainty to increase the gas savings beyond the ex ante claim.

The resulting project savings are shown in Table 4.

Table 4. Summary of Project 2400097 Savings

	Therms
Ex Ante	90,514
Verified	90,514
Realization Rate	100%

SUMMARY OF THE EX ANTE CALCULATIONS

Ex Ante Calculation Type: Engineering calculations

The savings from each control measure are hard to describe individually, since a lot of them are interconnected. Instead, the reduction in gas usage is split into three categories: AHU reheat, AHU preheat, and VAV reheat savings.

The reheat savings for each AHU are calculated for hours during which the supply air temperature (SAT) exceeds the discharge air temperature (DAT) and the incoming air needs to be reheated. The savings come from the SAT being reset in the proposed case, reducing the energy required to reheat the supply air to meet the required DAT. The SAT for the baseline case for each unit is based on two weeks of metered data measured in 5-minute increments. The hourly gas usage for cases where this condition is met is obtained using the following formula:

$$Reheat\_Btu = 1.08 * CFM * (SAT - DAT)$$

The cubic feet per minute (CFM) values are tied to the baseline and proposed VAV box damper positions and are lower in the proposed case (see number 3). The reheat amounts are then converted to therms by dividing the Btus by 100,000 and dividing by the AFUE of the boiler (85-86%). The savings from the reduction in the amount of air to be reheated equate to 72,837 therms/year.

The savings from preheating the air come mainly from reducing the flow (CFM) of air required, which lowers the required amount of outdoor air. The following equation is used to assess the amount of gas used in Btus:

$$Preheat\_Btu = 1.08 * CFM * (40F - OAT)$$

The resulting value is then converted to therms, following the approach above. The annual savings from the reduction in preheating total 1,048 therms.

The amount of energy spent on reheating the incoming air by VAV boxes is calculated for cases when the zone supply air setpoint exceeds the temperature of the incoming air:

$$Reheat\_Btus = 1.08\ x\ (CFM\ x\ Box\%)\ x\ (SAT\_zone - T\_after\_fan)$$

The savings from this measure mainly come from changes in the minimum VAV box damper position (Box%) and the general flow (CFM) reduction for each AHU. The supply air temperature for each zone (SAT_zone) remains the same in both cases, while the incoming air temperature (T_after_fan) is lower in the proposed case, but this does not outweigh the savings from the reduction in airflow (CFM). The resulting reduction in gas usage is converted to therms, following the approach above. The savings from reducing reheat at VAV boxes amount to 16,629 therms/year.

The total annual savings from the SAT reset, the reduction of the minimum VAV box damper position, and the occupancy schedule change (on one unit) add up to 90,514 therms.

Measurement and Verification Plan

Review Type: Desk Review

The evaluation team will focus on verifying the information in greater detail for AHUs 10.101 and 10.100, as they account for 72% of the total gas savings and are affected by all listed measures. Information on another AHU, representative of an average unit among the remaining ones, is to be requested as well. It is also not clear if TMY data were used for OAT and OA enthalpy values. It is to be pulled for the closest weather station for the analysis.

Questions for Customer or to Confirm from Documentation

- Need to confirm that all of the units are in place and operational to this day
- Need to check if any of the listed measures were adjusted or removed
- Confirm that the baseline conditions listed in the baseline system description are accurate
- The unit schedule (12 operating 24/7 and one 50% unoccupied) is to be confirmed
- Number of AHUs serving VAV boxes
- Screenshots showing the minimum VAV box damper positions set to 30% are to be requested for units 10.101 and 10.100.

- If trended data is available (mainly the SAT, DAT [temp leaving the AHU], OAT, OA damper position, CFM/supply fan speed%), it is to be requested for the units listed above.
- If there is no trended data, the SAT reset can still be confirmed via screenshots.

The evaluation team has not been able to reach the customer to confirm any of the specifics on the completed controls measure.

SUMMARY OF THE VERIFIED CALCULATIONS

Verified Calculation Type: Regression analysis

The evaluation team conducted a regression analysis to verify the project's savings using the provided monthly site gas usage.

Initial attempts to use the most recent baseline data were unsuccessful because some data are unavailable (10/23-1/24). Replacing the missing months with the data from previous years did not yield better results either. Instead, the closest full continuous year of pre-implementation data was used for the baseline model (10/22-9/23). A year of gas usage data after the project implementation month (11/24) was used for the treatment model (12/24-11/25). All gas usage values were normalized to typical meteorological year (TMY3) data.

The heating degree-day (HDD) variable with an assumed 70°F balance point was most successful. No other variable was found to be statistically significant in either model. The baseline and proposed models have R^2 values of 88% and 89%, respectively. The annual gas savings from the regression analysis equate to 122,413 therms. However, because of the earlier baseline period, and the fact that the evaluator was unable to reach the customer to confirm measure details and possible out of scope projects affecting gas usage, the evaluation team believes there is too much uncertainty to increase the verified saving beyond the ex ante claim.

PROJECT 2400130

Project ID#:	2400130
Measure:	Acoustic emission sensing for optimizing material grinding
Ex Ante Savings:	685,194 kWh; 0 kW
Facility Type:	Heavy Industrial
End Use:	Process Improvement
Sampled For:	Electric
Wave:	Wave 1

MEASURE DESCRIPTION

The customer installed 30 acoustic emission (AE) sensors on grinders to reduce cycle grinding times. These sensors monitor air grinding time and speed up the feed speed until the grinding wheel contacts the part being processed. At that point, the feed speed slows down, and the actual grind cycle begins. A 10% improvement in cycle times was expected at the time of pre-approval, and a 7.7% improvement was calculated by the implementer post-implementation.

KEY FINDINGS

The evaluation team first conducted an on-site visit to verify the installation and operation of the acoustic emission (AE) sensors and to assess the validity of the implementer's assumptions regarding reductions in grinder cycle times. The on-site engineer confirmed that the AE sensors had been properly installed on the BJC line grinders and were functioning as intended. Discussions with facility staff and visual observations of the grinding process indicated that the AE sensors effectively reduced air grinding time, allowing the grinders to transition more efficiently into the loaded grinding phase. These observations supported the implementer's claim of reduced cycle times and validated the reasonableness of the reported average 7.7%-time savings. In fact, one grinder was observed to be cycling through parts in 46.8 seconds with the AE sensors and 55.5 seconds when the sensors were disabled. This is well within the expected range of the implementer's calculations. Amperage, voltage, and power factor values were also measured on-site and found to be within the range the implementer had estimated. The on-site evaluator also confirmed with the site contact that no other major projects have been undertaken at this facility since the implementation of these sensors, and none were completed in the couple of years leading up to this installation.

Following the site visit, the evaluation team conducted a whole-facility regression analysis to further verify the project's energy savings. The analysis was done in many iterations, and the best fit used facility electricity consumption data and the following independent variables:

- Cooling Degree Days (CDD)
- Heating Degree Days (HDD)
- BJC production output

The regression model produced estimated savings of 672,925 kWh, which is within 2% of the 685,194 kWh estimated by the implementer's ex ante calculations. The model satisfied all required statistical criteria, including Adjusted R^2, Coefficient of Variation (CV-RMSE), Autocorrelation Coefficient, Net Determination Bias, and pre-case t-statistics for variables. The only exception was for the post-case t-statistic, which was close but did not meet its threshold for two variables. The other iterations of variables yielded savings ranging from 10% lower to 20% higher than the ex ante savings, but none of them matched all targets for regression statistics. Despite this minor deviation, the best-fit regression results showed a strong and logical correlation between energy use and the selected independent variables, reinforcing confidence that the observed energy reductions were consistent with expectations based on the AE sensor installation.

While the regression results strongly corroborate the magnitude of savings, review of the implementer's engineering workbook indicates that the ex ante calculations appear to double-count the energy reduction from idle days, that is, the savings attributed to ancillary equipment idling were added to the baseline and subtracted from the proposed case, effectively inflating total savings. Additionally, the ex ante approach assumes that all ancillary equipment is fully shut down when the BJC line is idle, which may not reflect actual plant operations, given that some equipment also supports other production lines.

For these reasons, the evaluation team determined that the regression-based estimate of 672,925 kWh represents the more accurate and defensible value for verified annual savings. This approach corrects for potential double-counting in the ex ante analysis while still aligning closely with measured production and weather-normalized energy use.

The resulting project savings are shown in Table 5.

Table 5. Summary of Project 2400130 Savings

	kWh	kW
Ex Ante	685,194	0
Verified	672,925	0
Realization Rate	98%	N/A

SUMMARY OF THE EX ANTE CALCULATIONS

Ex Ante Calculation Type: Engineering calculations; Calculations based on metered data

The ex ante savings calculations employ a straightforward spreadsheet approach, utilizing information provided, presumably, by the customer. Reduced cycle times during the grinding process were expected to result in a 10% increase in total plant output from 38,250 to 42,075 pieces per day. The actual resulting increase in production was 41,194 pieces a day, or 7.7%. CT measurements of grind cycle time before and after the retrofit confirm this 7.7% improvement. The increase in production per day results in a decrease in the annual number of days required to produce the same number of parts. The reduction in production days is 17.94 days, from 250.98 to 233.04 days. The plant will idle the affected production lines during these 17.94 days. The daily energy usage for production is expected to remain the same. Project energy savings result from increasing the number of days per year when the line is idle.

The daily energy usage for production was calculated using spot measurements of amperage, voltage, and power factor for a sample of each type of machine on the production line, such as grinders, mills, and tumblers, in each of three states: loaded, unloaded, and stopped. These measurements were used to calculate the power input in kW for each type of machine in each state. It was assumed that these results are representative of normal production, and they were multiplied by the number of identical machines in the production line to establish a total production equipment power draw of 626.8 kW when loaded. The total equipment power draw is multiplied by 24 hr/day to establish 15,044 kWh of daily production energy usage, which remains the same in the baseline and proposed cases.

The average daily energy usage for the plant was reported to be 42,517 kWh, presumably based on a sample of production days in December 2021 and January 2022 (a screenshot of these values and the 42,517 daily average is included in the calculation workbook). This daily energy usage is comparable to the daily energy usage that the evaluation team can calculate from the interval data provided in the calculation workbook.

Daily energy consumption data was analyzed to estimate energy usage when the plant is shut down. The energy consumed during the Christmas holiday plant shutdowns of 2022 and 2023 was used to calculate an average plant usage of 18,054 kWh per day during plant shutdown.

Equipment in a separate department, not affected by the project, consumes 12,883 kWh per day during production. It is not clear to the evaluation team how this number was derived.

The reduction in ancillary equipment energy consumption that occurs on idle days was calculated by subtracting the energy usage from the unaffected department (12,883 kWh/day) and the average energy consumed per day during plant shutdowns (18,054 kWh/day) from total daily usage (42,517 kWh/day), resulting in energy savings from ancillary equipment of 11,579 kWh for every day the plant can idle. This number was multiplied by the number of days the plant now idles due to the project (17.94), resulting in annual ancillary equipment savings of 207,683 kWh.

To calculate the total baseline annual project affected-plant/line production energy, the implementation team multiplied the production energy (15,044 kWh/day) by the number of production days in the baseline case (250.98), resulting in 3,775,838.30 kWh.

To calculate the total proposed case annual project affected-plant/line production energy, the implementation team multiplied the production energy (15,044 kWh/day) by the number of production days in the proposed case (233.04), resulting in 3,298,327.07 kWh.

The implementation team added the ancillary equipment energy consumption that occurs on idle days (called "idle utility gain" in the calculation workbook) to the baseline energy consumption calculated above for a sum total baseline energy usage of 3,983,521.17 kWh.

The implementation team subtracted the ancillary equipment energy consumption that occurs on idle days (called "idle utility gain" in the calculation workbook) from the proposed case energy consumption calculated above for a total proposed case energy usage of 3,298,327.07 kWh.

The difference between these two numbers is the savings for the project: 685,194.09 kWh.

MEASUREMENT AND VERIFICATION PLAN

Review Type: In-Person Site Visit

QUESTIONS FOR THE IMPLEMENTER (LEIDOS)

"Utilities" tab

- For how long was metering equipment installed in the equipment to get the data on the "Utilities" tab (amps, volts, & PF for each piece of equipment in the BJC line in loaded, unloaded, and stopped modes)?
  - Was metering equipment installed on all 339 pieces of equipment?
  - Can metering be done at the panel level to obtain this same data (or an approximation of it)?
  - How were the voltage, amps (in each stage), and power factor calculated using the metered data (averages?)?

- Can we get access to the raw metered data that was used to calculate the single amperage, power factor, and voltages for each type of equipment in the production line?
- Do all pieces of equipment run simultaneously?

Baseline

- Do you know if there is a production line similar to BJC that doesn't have AE sensors installed on its grinders?
  - Would we be able to determine grind time for those grinders in some way (even if we're watching and using a stopwatch)?
  - Are there production logs for this line that show grind cycle time and average number of parts produced per day?
  - If there isn't a production line similar to BJC, do you know if all the AE sensors have been installed, or are there still some grinders (on the BJC line(s)) without AE sensors?

Idling & "Idle utility gain"

- Did the customer plan to idle the plant at a specific time of year? All at once? Specific days?
  - When the customer idles the plant, are they just idling the BJC line(s)?
  - When the customer idles the BJC line(s) for those ~18 days, are they able to turn off or put into an idle mode all or only some of the ancillary equipment shown in the "From Footprint Tool" table in the "Measure 1" tab of the calc workbook? Or do they still need to run any of the equipment to support the PTJ line(s)?

Figure 9. From Footprint Tool

FROM FOOTPRINT TOOL	
DAILY AVG kW.	**42,517.00**
BJC kWh	19,884.00
PTJ kWh	12,883.20
Office kWh	108.00
Compressors kW	4,130.40
HVAC kWh	3,052.80
Lighting kWh	2,140.80
Filters kWh	2,570.40

  - Can you explain why all the energy in the "From Footprint Tool" table in the "Measure 1" tab of the calc workbook doesn't add up to the total plant use shown in the table (total in table as shown above is 42,517 kWh/day, but when all the loads beneath that number are added together we get 44,769.9 kWh?
  - Is the ancillary equipment that is needed to support both BJC and PTJ everything in the "From Footprint Tool" table in the "Measure 1" tab of the calc workbook (above)? Or are there any other ancillary pieces of equipment we should be aware of?
  - If only the BJC line(s) are idled and the PTJ line(s) are still running, would you expect that the energy savings from the idled/shut down ancillary equipment to be proportional to the % of the plant's energy consumption that the idled line(s) represent?
  - The 11,578 kWh that is calculated in the "Measure 1" tab of the calc workbook is calculated by subtracting the daily energy consumed on a "down day" and the energy consumed by PTJ per day from the average daily consumption of the entire plant. In the workbook, this energy is referred to as "idle utility gain." Would it be correct to call this the "ancillary equipment energy consumption" as an alternative? Our understanding is that this is the energy that is saved by idling the plant. Is that a correct understanding?

    - Can you explain why the "idle utility gain" is added to the baseline and subtracted from the proposed?

Questions for the Customer

- Is the metered data (amps, volts, and PF) from the equipment on the BJC line(s) representative of typical operation?
    - When did the metering occur?
    - For how long was the equipment metered?
    - How was the equipment metered (what metering equipment, setup, etc.)?
    - Was each piece of equipment metered or just a sample of each identical type of equipment?
    - Can we do spot measurements or measurements at the associated electric panels to verify the power draw?
- What is the expected number of down (off) days?
    - Has that changed since before the project?
- Have you been able to idle the BJ Cassette line(s) already?
    - If so, how many idle days?
    - When did they occur?
- Have you increased production due to this project?
- Do you have energy consumption (or voltage, amps & PF data over a specific timeframe) for when only the PTJ line(s) were/are running, including any necessary ancillary equipment?
- What ancillary equipment are you able to shut down or idle when you idle the BJC line(s)?
    - What ancillary equipment must you keep running if you're only idling BJC but running PTJ?
- Are you able to provide us with AE signal data, including cycle timestamps, AE contact events, and part counts?
- Are you able to provide us with cycle times and part counts or production logs from before the project?
- Is there a production line similar to BJC that doesn't have AE sensors installed on its grinders?
    - If not, are there any lines of BJC without AE sensors or where they haven't been installed yet?

Baseline Verification

Plan A: If possible, the evaluation team will attempt to recreate the baseline by inspecting and reviewing production logs for either any BJC line(s) that do not have AE sensors or for production lines very similar to BJC that also do not have AE sensors.

Plan B: If production logs are not available, we may attempt to take video footage (pending client permission) or use a stopwatch to determine grind time.

Plan C: If neither plan A nor plan B are allowed or feasible, our onsite engineer will observe the equipment that is observable and collect any available production logs from before the project to determine if a 7.7% increase in throughput is reasonable. Our onsite engineer may call our office for other ideas, but the 7.7% increase in throughput does not seem unreasonable to us.

The evaluation team will use the data and information gathered in this step to determine if the 7.7% increase in throughput is reasonable.

POST RETROFIT METERING

Plan A: If possible, the evaluation team will attempt to take spot measurements (amps, volts, & PF) on at least two of each type of equipment on the BJC line to confirm the power draws in the calculation workbook.

Plan B: If we are unable to take spot measurements or believe they won't be reliable, we may attempt to measure power at the relevant electric panels.

Plan C: If neither plan A nor plan B are allowed or feasible, the evaluation team will rely on the customer's and Leidos's answers to our questions to determine if the power draws in the "Utilities" tab are reasonable and if they should all be added together. Our onsite engineer may call our office for other ideas if it seems that the power draw or whether all equipment runs simultaneously is questionable.

The evaluation team will use this data to attempt to recreate the "Utilities" tab or at least verify that its data on power draw during production is reasonable.

IDLING ENERGY

Plan A: The evaluation team will collect energy consumption data (or voltage, amps & PF data over a specific timeframe) for when only the PTJ line(s) were/are running, including any necessary ancillary equipment.

Plan B: The evaluation team will rely on the customer's answers to our questions about the ancillary equipment they are able to shut down or idle when they idle the BJC line(s) and what ancillary equipment they must keep running if they're only idling BJC but running PTJ.

Plan C: If the evaluation team is unable to gather the data or information from plan A or plan B, we will inspect utility data for the days that the BJC line(s) were idled to determine if there is a discernable and repeated decrease in energy usage on those days and if it is similar to the "idle utility gain" from the calculation workbook.

Plan D: If the evaluation team is unable to gather the data or information from plan A, B or C, we will rely on the answer provided by Leidos regarding the % of ancillary equipment consumption that they would expect would be needed to run only PJT.

The evaluation team will use the data and information collected to determine if the "idle utility gain" (our understanding is that this is the savings from the ancillary equipment that can be shut off or idled during BJC idle days is reasonable, or should be scaled down to account for the equipment that will still be running to support PTJ.

ALTERNATIVE PLANS AND SCENARIOS

If none of the data or information requested above is either made available to the evaluation team, or is inconclusive, we may attempt to perform a whole plant regression with production of parts from BJC and any other lines (PTJ?) being major variables for consideration. To follow this plan, the evaluation team would need production data from BJC and PTJ from both before and after the project.

If the customer has increased production due to the project, we will determine savings by creating a regression to determine the energy use per part before and after the project. We'd then normalize to the pre-project production level. To follow this plan, the evaluation team would need production data from BJC and PTJ from both before and after the project.

If the onsite engineer encounters any unexpected scenarios (e.g., the AE-equipped grinders are used for BJC and PTJ), they will call our office to determine the best path forward.

EARLY REVIEW NOTES

The following questions and comments highlight the evaluation team's observations and recommendations:

- In the opinion of the implementation team, installing acoustic emission (AE) sensing equipment will yield energy savings. However, the approach used to determine measure savings does not accurately capture the overall effect of adding AE. Therefore, the claimed measure savings represent a substantial evaluation risk.
  - No applicable changes, just observations.
- The customer used an online Amps to kW calculator to establish input power to each machine using spot measurements of amps and an assumed 480 volts and 0.85 PF. The evaluation team recommends using actual power measurements on a sample of machines to get more accurate voltage and PF values.
  - Change made.
- The customer applied a load factor to the calculated machine power, including 85% for the grinders and 75% for the tumblers. If the measured amps were taken at the power input to each machine while the machine was loaded, then the load factor would be accounted for in the measurement. The evaluation team recommends not including the load factor if the amperage measurements included all input power to each machine.
  - Change made.
- The evaluation team also recommends that amperage and PF measurements be taken in the unloaded state for a sample of machines. The PF on the motors is a function of the load factor and will be much lower during unloaded conditions. If the 60% duty factor is accurate, the PF for the remaining 40% of operating hours could significantly impact average equipment power input.
  - Change made.
- Peak demand savings are not expected to occur during peak hours; therefore, it is recommended to ensure that the zero-kW savings shown on the Peak Demand Savings tab are correct and adjust the value on the summary tabs accordingly.
  - Change made.
- The evaluation team questions the application of the idle utility gain in the calculations for the total baseline and proposed measure of energy usage. The idle utility gain is calculated from a five-day sample over Christmas for two years where the plant is closed, but that appears only to represent times when the entire plant is shut down. During the rest of the year, plant usage is relatively consistent, even though the affected department is currently idle for about 114 days per year, about two days per week. Two years of interval data provided by the plant doesn't show significant differences for different hours of the week. If the department equipment represents 828.5 kW of equipment input, the evaluation team would expect to see evidence in the interval data. Still, there is no apparent correlation between production and non-production days. It is recommended to validate savings by comparing the days and hours the department is in production to days when it isn't.
  - Not done.
- The evaluation team also looked at the demand kW distribution of the interval data over the two years from December 1, 2021, through November 30, 2023, and found that nearly 80% of utility demand kW fell between 1,600 kW and 2,200 kW. If turning off all the machines associated with this measure during non-production days is expected to result in a demand reduction of over 800 kW, we would expect to see this level of reduction

represented in the utility data. However, most of the data shows that the difference between days of production and non-production is likely to be much lower than 600 kW.

- No applicable changes, just observations.

SUMMARY OF THE VERIFIED CALCULATIONS

Verified Calculation Type: Engineering calculations; Regression-based modeling

The project savings were verified using a combination of engineering review and regression analysis.

EX ANTE CALCULATION REVIEW

The implementer's calculation method relied on measured equipment power draws and a detailed accounting of daily production and idle energy consumption. The baseline scenario reflected 250.98 production days per year, while the post-retrofit scenario reduced production days to 233.04 due to faster grind cycle times.

Production energy: 15,044 kWh/day (constant in both cases)

Ancillary equipment savings on idle days: 11,579 kWh/day

Reduction in production days: 17.94 days per year

These values resulted in total annual savings of 685,194 kWh, derived primarily from the additional idle days when production lines and ancillary equipment could be powered down.

However, a review of the implementer's engineering workbook indicates that the ex ante calculations appear to double-count some energy savings as the savings attributed to ancillary equipment idling were both added to the baseline and subtracted from the proposed case, thereby doubling those savings and inflating the total savings. Additionally, the ex ante approach assumes that all ancillary equipment is fully shut down when the BJC line is idle, which may not reflect actual plant operations, given that some equipment also supports other production lines. However, from the on-site visit, the customer stated that the original estimated number of days for downtime (17-19) is approximately what is happening. Demand fluctuates slightly, so it is difficult to determine precisely.

REGRESSION VERIFICATION

After visiting the site to verify the installation and operation of the sensors, the evaluation team decided to verify these savings by developing a weather-normalized (TMY3 data) energy-use model using monthly utility data, BJC production data (as well as production data from other production lines), and degree-day variables. The model produced savings of 672,925 kWh, validating the order of magnitude of the implementer's estimate. The slight difference (approximately 1.8%) between the model and ex ante results was well within expected analytical uncertainty, particularly given the limitations of available data. For more information, see the detailed description in the key findings section above.

The statistics for this model were as follows:

Table 6. Model Accuracy Criteria

	Baseline	Test	Target
Adjusted R Squared	0.82	Pass	>0.75
Coefficient of Variation (RSME)	0.03	Pass	<0.2

	Baseline	Test	Target
Autocorrelation Coefficient	0.08	Pass	<0.5
Net Determination Bias	2.66E-17	Pass	<0.005
Pre case t-values outside target	0	pass	<-2 and >2

Recognizing the close alignment between the regression-based verification and the implementer’s engineering-based estimate, the errors made in the implementer's calculation described above in the key findings section, and the fact that almost all model statistics met standard thresholds, the evaluation team accepted the regression savings of 672,925 kWh as verified.

PROJECT 2400140

Project ID#:	2400140
Measure:	Removal of one-pass oil heater to connect all presses to triple-pass oil heater at higher efficiency
Ex Ante Savings:	106,961 therms
Facility Type:	Manufacturing/Industrial
End Use:	Process Improvement
Sampled For:	Gas
Wave:	Wave 2

MEASURE DESCRIPTION

The customer is a commercial casework manufacturer with two production plants in Illinois, Plant A and Plant B. Plant B operates three laminating machines, while Plant A has a single laminating machine. The customer proposes moving the single machine from Plant A to Plant B to consolidate this production phase. After implementation, Plant B will host four laminators connected to a relocated triple-pass oil heater (the single-pass unit from Plant A will be retained as emergency backup and will normally be idle). Plant A will cease active oil heating for laminators. The new system reduces the number of active process heaters from two to one, thereby eliminating duplicated idle losses and reallocating process thermal loads to a higher-efficiency heater.

KEY FINDINGS

The evaluation team followed the secondary approach described in the M&V Plan section, which involved confirming the major ex ante assumptions and adjusting the implementer's calculations as needed. The evaluation team determined that, while there were assumptions that could not be independently verified, they were reasonable, so no changes were made to the savings.

There is a minor discrepancy in the claimed savings of record (106,691 therms) and the savings in the ex ante calculations workbook (106,601 therms). The verified savings are equal to the ex ante calculated savings.

The resulting project savings are shown in Table 7.

Table 7. Summary of Project 2400140 Savings

	Therms
Ex Ante	106,961
Verified	106,961
Realization Rate	100%

SUMMARY OF THE EX ANTE CALCULATIONS

Ex Ante Calculation Type: Engineering calculations

The ex ante calculation used a hybrid approach. Baseline fuel use was estimated in a multi-step calculation. First, the monthly average fuel use from non-heating months (April through October), i.e., average monthly production gas usage, was subtracted from the total gas usage during heating months for both plants. This first step established the heating-related gas usage for the heating months. Then the total annual heating usage was subtracted from the total annual gas usage for each plant. This second step establishes the production-related gas usage for the entire year for each plant, assuming that the oil heaters represent all process gas demand.

Then, an engineering heat-duty computation was performed for the new heater using customer-supplied design heat demand, assumed load factors, and a simple ratio method to estimate idle losses (380°F/500°F = 76%). The team used the billed production period gas to estimate the non-heating process load and then used heater efficiency assumptions to estimate the proposed post-installation fuel consumption. This hybrid approach mixes billed monthly data with engineering assumptions.

Steps performed by implementers are as follows:

- Collected monthly billed gas for each plant and averaged April through October usage as production months.
- November through March were considered to be heating months.
- Estimated process gas usage by subtracting the seasonal heating component from total billed usage, and attributing all process gas to the oil heaters.
- Summed process gas for both plants to establish baseline gas consumption (therms).
- For the proposed system, they used vendor design heat duty (5,000,000 BTU/hr), assumed production load factor (80% for 6,000 hrs/year), and assumed idle output (60% of full load) for 2,760 hrs/year at a reduced oil temperature (380°F).
- The implementer converted heat duty to fuel input using a rated efficiency of 75% for the triple-pass heater (no adjustment to an operating efficiency), computed the annual fuel input by multiplying by the hours of operation in idle and production modes (BTU/efficiency * hours), and converted to the value to therms (100,000 BTU/therm).
- Finally, they calculated savings as baseline therms minus proposed therms.

It appears that the ex ante estimate is conservative based on some of the implementer's choices for creating estimates, which included using the 380°F/500°F ratio for idle demand. However, using rated instead of measured operating efficiencies for the triple-pass heater could bias the savings upward, so we agreed with this approach upon early review.

MEASUREMENT AND VERIFICATION PLAN

Review Type: Virtual Site Visit

PRIMARY M&V METHOD

Monthly gas regression. The estimated completion date is 12/31/2024; therefore, there is approximately one year of post-installation data available. This approach involves a performing a regression analysis of monthly gas usage versus production (combining locations) and ambient temperature data (assumed to impact gas usage).

CUSTOMER INTERVIEW QUESTIONS FOR PRIMARY METHOD

- Can we get production data for one year before the move of equipment (all of 2024, or more, for both plants) and post-installation (to now, same, both plants)?
  - Response: Prior to the project, the combined panel output from both plants in 2024 (January 1-Nov 17th, 2024) was close to 971,303 panels. Following the project, output from just Plant B year-to-date (January 1-

November 17, 2025), was 1,087,432 panels. The customer provided monthly production data for 2024 and 2025.

SECONDARY (BACKUP) M&V METHOD

Accept the ex ante calculation methodologies and attempt to verify any assumptions or data used to update calculations, if needed.

CUSTOMER INTERVIEW QUESTIONS FOR SECONDARY METHOD

- Can you identify other gas uses? Are the oil heaters the only significant process gas load?
  - Response: The oil heaters are the only significant process load in the facility. There are some forced air heaters for climate control, but that is it.
- Can we obtain any data from the post-installation temporary gas meters on the triple-pass heater (and the single-pass backup)? This data could include any of the following: fuel flow, oil temperature, and/or heater run hours.
  - Response: “I have no real way to test the fuel flow, and I do not believe the controls have an hour meter either. The oil runs around 500°F during the week and occasionally on Saturday, and around 420°F on Sunday. The heater never really shuts off, it just runs a little cooler when we are not running the presses. If we let the oil cool too much, it draws moisture and causes all kinds of issues.”
- For the implementer, if needed: A 54.8% heater efficiency was given in the early review and in the red text of the calculation. It was used on a side calculation, which showed the post-installation gas usage would be 412,669.97 therms. Why was this not used in the final savings calculation?
  - Response: "A formal document was not produced. The TR (technical reviewer) performed a simplified analysis of year-over-year usage."

EARLY REVIEW NOTES

The evaluation team made the following comments and recommendations as part of the project’s Early Review.

- Estimated gas savings are great enough to show up in billed gas usage. The evaluation team recommends verifying savings by combining gas usage for both plants to capture the interactive effects of heating.
  - The ex ante calculations used monthly gas usage to calibrate the baseline energy usage, but did not verify the savings with a billing analysis.
- The evaluation team recommends confirming that there are no other heating demands beyond the oil heaters to ensure that billed usage accurately represents oil heater gas demand.
  - The ex ante calculations accounted for gas space heating.
- The implementation team should collect pre- and post-implementation production data for the four laminators to normalize baseline and proposed gas usage to typical production hours and units of production.
  - The ex ante calculations did not incorporate production data.
- The implementation team estimated gas usage during hold periods using a ratio of 380°F/500°F = 76%. This ratio does not accurately estimate actual heat loss or account for the reduction in process demand during hold periods. This is a conservative approach that likely overestimates proposed gas usage and underestimates savings, and the evaluation team does not recommend changes to this approach at this time.

- The implementation team used a different method to account for hold period energy in the ex ante calculations, instead estimating the idle thermal output as 60% of full load. While the hold temperature was still noted as 380°F, the ratio 380°F/500°F = 76% was not used. The basis for the assumed load percentages during active production (80%) and hold periods (60%) is unclear.

- The evaluation team notes that the relocation costs do not include electrical and mechanical work, e.g., piping.
  - This observation does not affect the impact analysis.
- The evaluation team notes that the single-pass unit has a rated efficiency of 64.2%, but based on the billed usage of the facility, the actual operating efficiency was calculated to be 54.8% - a difference of nearly 10%. For the proposed 3-pass oil heater, the rated efficiency is used at face value, with no calculation to determine an estimated operating efficiency. This could lead to inflated savings for the project. The evaluation team is skeptical that the 3-pass oil heater could achieve the rated efficiency heating to 500ºF, given how high the stack temperatures would need to be to maintain working fluid temperatures. The team would expect the operating efficiency to maintain an oil temperature of 500ºF to be more in the 75% range.
  - The ex ante calculations used 75% for the 3-pass unit.

SUMMARY OF THE VERIFIED CALCULATIONS

Verified Calculation Type: Engineering calculations

The evaluation team attempted a normalized billing regression using monthly natural gas usage, monthly production data for both facilities (provided by the customer), and heating degree days (HDD). Multiple regression structures were evaluated; however, none satisfied all the statistical criteria for verification (examples of tested statistics included Adjusted R^2, CV(RMSE), autocorrelation, net determination bias, and t-statistics). These results suggest that key drivers of gas consumption were either not captured in the available data or exhibit variability inconsistent with the assumptions of the normalized billing approach. In addition, the team is unsure if all the relevant gas meters were captured in both the data provided in the implementer's calculations and the data provided up to October 2025.

Given these challenges, the the evaluation team shifted to the secondary approach of leveraging the ex ante calculations with verified inputs. Interviews with the customer and implementer verified several aspects of the original engineering calculation:

- Oil heaters are the only significant process gas load.
- Other gas usage is limited to a few forced-air heaters for building climate control.
- Heater operation profile matches ex ante assumptions.
- The heater runs continuously at 500°F on production days and 420°F on Sundays or low-production periods. It rarely shuts off due to moisture and operational constraints, supporting the assumption of a continuous “hold” load.
- No additional submetering or metered performance data is available.
- The temporary post-installation gas meters did not provide usable data. No hour meters, flow meters, or temperature-based performance logs exist, eliminating the possibility of a metered performance-based model.
- Load distribution during production vs. standby appears reasonable but unverifiable.
- The implementer assumed 80% load during production and 60% load during hold periods. While this general relationship aligns with customer-reported operating temperatures and the continuous nature of the system, it cannot be independently validated without detailed flow and temperature data from the process loops.

The evaluation team was unable to find better rules of thumb or other methodologies to improve the accuracy of the ex ante savings, and concluded that no changes were warranted to the claimed savings.

PROJECT 2400879

Project ID#:	2400879
Measure:	Replacement of two compressors and a dryer with a fixed speed baseload and a VFD unit, and a heated regenerative dryer
Ex Ante Savings:	278,932 kWh; 32.5 kW (Peak Summer)
Facility Type:	Heavy Industrial
End Use:	Compressed Air
Sampled For:	Electric
Wave:	Wave 1

MEASURE DESCRIPTION

The customer installed a 75HP fixed-speed compressor, a 125HP variable-speed compressor, and a heated regenerative air dryer to improve the energy efficiency of their compressed air system. The baseline equipment includes two new 100HP fixed-speed compressors with load/no-load controls and one 1,250 CFM heatless regenerative air dryer. Energy savings are generated through the higher part-load efficiency of the variable speed compressor compared to a fixed speed compressor with load/unload controls. Heated regenerative dryers are more efficient than heatless regenerative dryers because the former applies heat to regenerate (dry) the dessicant, reducing the volume of purge air required.

KEY FINDINGS

The ex ante and verified analyses both considered the project as composed of two measures: one related to the compressor savings and the other related to the dryer savings. The evaluation team determined the ex ante savings calculations and baseline assumptions for each measure were reasonable. A binning error in the ex ante calculations resulted in a slight decrease in peak kW savings.

The resulting project savings are shown in Table 8.

Table 8. Summary of Project 2400879 Savings

	kWh	kW
Ex Ante	278,932	32.5
Verified	278,932	32.0
Realization Rate	100%	99%

SUMMARY OF THE EX ANTE CALCULATIONS

Ex Ante Calculation Type: Engineering calculations based on metered data

The implementation team collected one week of flow data and grouped the measurements into CFM bins. All recorded values were grouped within the 1,160-1,200 CFM range, and the representative flow rate was set to the midpoint of this range (1,180 CFM). For both the baseline and proposed cases, the team calculated the percentage loading and power required by each compressor to meet the flow requirement using compressor part-load curves (percent of full load kW versus percent of full load CFM).

The ex ante calculations for the heated regenerative dryer savings consider the reduced compressor energy needed to produce the lower purge airflow and include the additional energy needed in the proposed condition for heating the dessicant. The input sources for this calculation include dryer performance data, engineering estimates for purge air flow, and average compressor efficiency (CFM per kW) derived from the compressor calculations described above.

To determine annual savings, the ex ante calculations determined the average kW savings over the metering period for each measure and extrapolated to 8592 hours of operation per year.

Measurement and Verification Plan

Review Type: Virtual Site Visit

Customer Interview and Responses

- We can see flow data for one week in October 2023 where rates varied between 1,086 and 1,341 CFM. Is this a typical range year-round?
  - Customer response: We don't collect flow data on the compressors themselves, so I can't say for sure, but that behavior is typical year-round. The compressors run 24/7 and flows might vary with the material being combusted.
- If not, can you estimate how many hours different flows are needed?
  - Customer response: We don't collect flow data.
- Would you happen to have any data or production logs to support these estimates?
  - Customer response: Yes, we have maintenance records that I can send over.
- It looks as though the compressors are off on weekends and holidays. Is that true? Are there any other times when the compressors aren't running?
  - Customer response: No, they run constantly.

Primary M&V Approach

Verify the flow data is representative of typical operation with the customer, requesting production logs from the customer as supporting documentation. Confirm operating hours with customer.

Secondary M&V Approach

If primary method will not work: If the one week of data is not typical year-round, use any additional information the customer has on typical loading. If the customer is unable to provide reliable loading information, TRM assumptions may be used as a last resort.

Summary of the Verified Calculations

Verified Calculation Type: Engineering calculations based on metered data

The evaluation team applied the ex ante calculation approach, but discovered that some flow readings in the ex ante calculations were outside the 1,160 CFM – 1,200 CFM range and thus grouped incorrectly in this range. The team distributed these reads to the correct bins, which resulted in a small decrease in kW and kWh savings. The kWh decrease was offset by adjusting the operating hours to 8760 per the customer's statement that there is no planned downtime for the compressed air system.

The evaluation team did not adjust the dryer savings calculation except for increasing the operating hours to 8760.

PROJECT 2500071

Project ID#:	2500071
Measure:	Installation of new VSD compressor, high-efficiency dryer
Ex Ante Savings:	953,826 kWh; 112.8 kW (Peak Summer)
Facility Type:	Manufacturing/Industrial
End Use:	Compressed Air
Sampled For:	Electric
Wave:	Wave 2

MEASURE DESCRIPTION

After conducting a compressed air system audit, facility management decided to install a new 422 HP oil-flooded, rotary screw, VSD compressor, which would allow for the decommissioning of two older, single-stage, variable displacement units that had exceeded their useful life (one manufactured in 1988 and one in 1995). The combined horsepower of these old units is 350 HP. Moreover, additional ductwork was installed on the new unit to recover and provide heat to one area of the facility. Lastly, a new cycling refrigerated dryer, rated at 2,400 cfm, was installed to supplement the new compressor, along with 1,060-gallon receiver tank. The application was submitted in October of 2024, and the incentive was paid in June of 2025.

KEY FINDINGS

The ex ante and verified savings analyses used notably different approaches (the evaluation team used their compressed air and dryer engineering calculation templates, instead of TRM algorithms). A comprehensive analysis of Plant 1 was conducted in the evaluation, which is the biggest difference between the analyses.

Some notable discrepancies between the ex ante and verified savings analyses include:

- Operating hours for half of the plant which includes the newly installed equipment were updated to be lower in the verified savings analysis due to reduced weekend operation.
- The effect of decommissioning the old compressors and dryers was accounted for by removing the units from the post-case analysis, rather than using the factors from the TRM.

The resulted project savings are shown in Table 9.

Table 9. Summary of Project 2500071 Savings

	kWh	kW
Ex Ante	953,826	112.8
Verified	1,022,321	84.2
Realization Rate	107%	75%

SUMMARY OF THE EX ANTE CALCULATIONS

Ex Ante Calculation Type: Engineering calculations

The implementer utilized version 13 of the Illinois Technical Reference Manual (TRM) to estimate the savings for all three measures (VSD compressor, heat recovery, and dryer). The heat recovery savings methodology is not discussed here since the project was sampled for its electric savings only.

VSD Compressor savings were calculated using the following formula, listed under section 4.7.1:

$$kWh\ Savings = 0.9\ x\ HPcompressor\ x\ Hours\ x\ (CFb - CFe)$$

Where:

> 0.9 = Compressor motor nominal HP to full load kW conversion factor
>
> $HPcompressor$= Compressor motor nominal HP (422 HP)
>
> $Hours$ = Compressor total hours of operation (8,320 Hours)
>
> CFb = Baseline compressor factor, load/unload controls at 50% loading (0.7386)
>
> CFe = New compressor factor, single-stage VSD controls at 50% loading (0.5313)

The deemed operating hours were taken from the TRM, assuming a 4-shift (24/7) operation, while the compressor factors for the baseline and proposed cases were taken from the stored CAGI sheet database. The energy usage in the baseline case equates to 2,333,929 kWh, while the new unit consumes 1,678,874 kWh. The difference between the values yields 655,055 kWh in annual energy savings.

The demand for both cases is obtained by dividing the energy savings by the operating hours (without using the coincidence factor as recommended in the TRM), yielding 79.0 kW in demand savings. The baseline unit would use 280.5 kW, while the new compressor was calculated to pull 202.0 kW on average.

The savings associated with the installation of a new dryer were estimated by using the equation in section 4.7.5:

$$kWh\ Savings = P_s\ x\ (EC50_b -\ EC50_e)\ x\ Hours\ x\ CFM$$

Where:

> P_s = Full flow specific power of the dryer (0.1370)
>
> $EC50_b$ = Energy consumption ratio of baseline dryer at 50% inlet load capacity as compared to fully loaded operating conditions (0.843)
>
> $EC50_e$ = Energy consumption ratio of efficient dryer at 50% inlet load capacity as compared to fully loaded operating conditions (0.729)
>
> $Hours$ = Compressor total hours of operation (8,320 Hours)
>
> CFM = Cubic feet per minute, rated capacity of refrigerated dryer (2,300 cfm)

The full flow specific power was calculated by dividing 315 kW (from an unknown source that does not match the specification sheet) by the rated airflow (cfm). TRM values were used for energy consumption ratios and operating hours. Inserting the values into the equation yields 298,771 kWh in energy savings. The demand savings are obtained by dividing the energy savings by the operating hours and multiplying the resulting value by the coincidence factor of 0.95 (for a 4-shift schedule from the TRM), yielding 34.1 kW in demand savings.

Combining the savings from both measures yields 953,826 kWh in energy savings and 112.8 kW in demand savings.

MEASUREMENT AND VERIFICATION PLAN

Review Type: Virtual Site Visit

A virtual site visit will be conducted to verify the information for the completed projects. It is important to note that the location of the new compressor in the compressed air audit report provided is shown as Plant 2, though other documentation states that the heat recovery will benefit Plant 1. The two decommissioned compressors are also located at Plant 1, and the report stated that each building had its own compressed air system; therefore, some of the details (likely changed over time) do not add up. The evaluation team is treating the measure to affect strictly Plant 1 and will confirm the exact project details via an interview.

The evaluation team's compressed air engineering calculation template is to be used to evaluate the two electric measures, since it allows the evaluation team to analyze the compressed air system as a whole, which is a more appropriate approach to estimating the energy savings for these measures, as noted in the early review. To assess the savings, we need the following information:

- Confirmation of installation and operation of the new VSD compressor, along with the new dryer unit (including the model numbers)
  - Confirmed
- Confirmation of the decommissioning of two variable displacement units that were listed in the documentation
  - Confirmed, along with the associated dryers shown on the provided diagram.
- Confirmation of the current configuration of operating compressors (by model number provided in the study), associated dryers, and storage tanks. A baseline diagram is provided and will be used to assist the process.
  - Confirmed via email.
- If available, getting the CAGI sheets for each unit would be ideal.
  - Not provided. Found online.
- Information on how the compressors are sequenced.
  - No real sequencing, since each unit is operated separately, though they are installing a BAS for the plant. Most units operate as baseload compressors, with various trim units throughout the plant. The units with higher-than-average HPs are shut off on weekends, including the new unit.
- If the current compressors are controlled individually, as stated in the report, or if they are connected to the building automation system (BAS) as was stated in the early review.
  - No BAS on plant as of right now.
- If they are controlled via a BAS, we would request trends for up to a year.
  - NA
- Confirmation of the system operating pressure (ideally via trended data, if available)
  - 95 PSI
- Confirmation of the operating acfm is for each compressor, if available.
  - Confirmed via email and pictures from site.
- Confirmation of the operating hours per compressor (and dryer).
  - Confirmed via phone call.

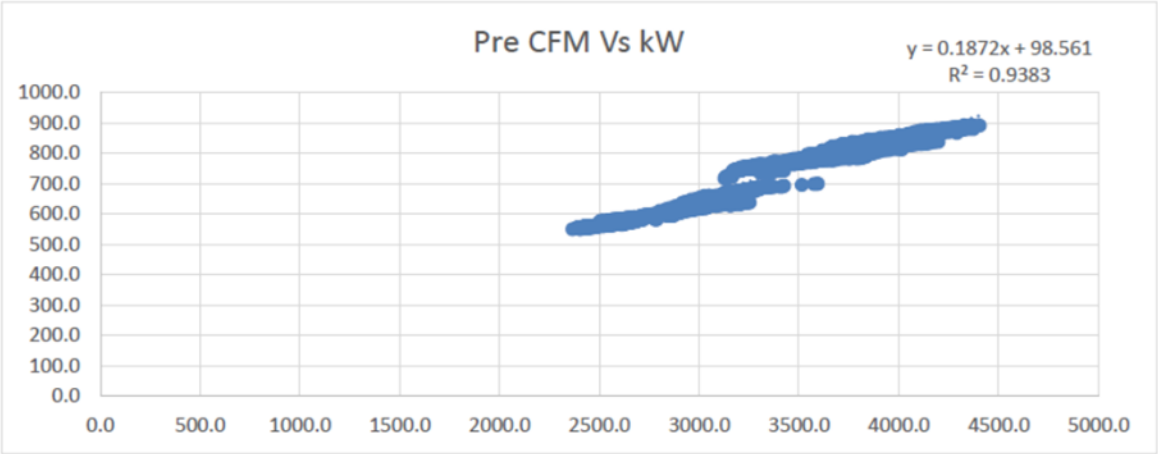
- Alternatively, confirmation of the facility's schedule.
  - NA
- Estimated downtime per unit, if available.
  - No real downtime provided, except for weekend operation stoppages.
- The amount of air storage (number of tanks and volume).
  - Confirmed via phone call.
- Confirmation of the number of air dryers on site, along with design types.
  - Confirmed via email.
- The unit amps and power factor for the facility (voltage and phase are provided per unit).
  - Power factor unknown. Due to the high volume of requests from the evaluation team, we used power draw for similar dryer models found online.
- The average and peak flow through the dryers (or an estimate) would be ideal (have some baseline info from the diagrams).
  - Confirmed via email and pictures from site.
- The dew point temperature need to be confirmed.
  - Confirmed via pictures from the site.

Some of this information will likely be requested via email in a table format to make the process easier for the site contact.

EARLY REVIEW NOTES

- The evaluation team recommends establishing project savings by analyzing the compressed air system as a whole rather than estimating the effect of a single compressor. This is the only approach that will accurately determine the effect of a compressor change and added controls on the energy usage of the compressed air system. While this approach may require significant metering to establish system characteristics, the savings expected from these measures appear large enough to warrant the added effort. The new central controls might include provisions for trending system data, including compressor power, pressure, and airflow.
  - Customer was unwilling to incur the cost of a full-system study. Implementation team used available past study data as possible to validate TRM savings approach.
- The evaluation team recommends collecting operating data to establish a correlation between total system compressor power and air production. We suggest collecting pre- and post-implementation data from the vendor in CSV format to make analysis easier. A sample correlation is shown in Figure 1. If strong correlations can be established for pre- and post-operation, they can be used with typical operating CFM to determine baseline and new system demand power kW and energy usage kWh. This will also allow for determining power savings during peak demand periods. Typical operation should be confirmed by the customer, as it could be pre-implementation or post-implementation, or an average of the two conditions.
  - . Customer was unwilling to incur the cost of a full-system study. Implementation team used available past study data as possible to validate TRM savings approach.

Figure 10. Sample CFM vs kW Correlation



The evaluation team has the following additional comments and recommendations regarding the electrical savings for this project.

- As noted above, the evaluation team recommends analyzing the overall effect on the compressed air system due to the installation of the new compressor and controls. This is particularly important for this project because the compressed air system includes many different compressors in different areas. Also, the existing compressors have a variety of control systems, so the assumption that the new VSD compressor will always function as the trim compressor may not be appropriate.
  - Customer was unwilling to incur the cost of a full-system study. Implementation team used available past study data as possible to validate TRM savings approach.
- The evaluation team notes that the vendor includes potential savings for leak repairs. If this work is completed, the implementation team should ensure this demand reduction is accounted for in the final verification. They should ensure that leak-repair savings are accounted for in compliance with Ameren's incentive requirements. We recommend using the correlations described above to model the effect of demand reductions along with equipment and control changes.
  - NA

SUMMARY OF THE VERIFIED CALCULATIONS

Verified Calculation Type: Engineering calculations

The evaluation team's compressed air engineering calculation template was used to holistically evaluate the measures as was recommended in the Early Review.

During the interview, the customer clarified that two of the existing air compressors and their associated air dryers at Plant 1 were decommissioned as part of the project. Plant 2 remained unaffected.

- VSD Compressor savings:
  - All Plant 1 compressors were included in the analysis of this measure. The calculation template takes various inputs for each unit (control type, motor HP, rated pressure & airflow capacity, operating pressure, average and peak airflow) and uses the expected power curves for each compressor type to calculate power consumption for each case. Most of the inputs used in the calculation were taken from a study provided by the implementer. The

operating pressure (95 psi), updated operating hours per compressor (some operating 6,240 hours/year due to reduced weekend operation), and the inputs for the new unit were confirmed by the site contact. Some airflow (cfm) values for the air compressors differ from those shown in the study. These need to match the airflow (cfm) of the dryers (including the purge air flow). The remaining difference of 190 cfm accounts for the removal of a heated desiccant dryer, which lowered the average flow through the compressors (by 40 cfm) and eliminated the need to purge 150 cfm of compressed air.

  - The analysis described above yields 1,024,255 kWh and 84.6 kW in annual energy and demand savings.

- New compressed air dryer savings:
  - The evaluation team's engineering calculation template determines power consumption for both the baseline and installed cases, using estimated plant air conditions, the rated unit input power, and intake air temperatures. The air dryer analysis also heavily relies on the values shown in the implementer's study. The air dryers' rated, average, and peak air flows were taken from said study, while the operating hours of the dryers were set to match the corresponding compressors. The rated input power values for the air dryers were estimated based on information for similar units found online. The dew point temperature was set to -40°F, since most units at the plant are desiccant. For heated desiccant dryers, the electric heater wattage was used, as no additional information was available. The new dryers' operating flows were set to match the new air compressor's values, while the input power was taken from the specification sheet. The dryers associated with decommissioned compressors were excluded from the installed case.
  - The analysis described above results in slight negative savings of -1,935 kWh and -0.4 kW for the year.

Combining all the savings results in a total of 1,022,321 kWh and 84.2 kW in energy and demand savings.

PROJECT 2500323

Project ID#:	2500323
Measure:	Installation of a high efficiency boiler for process steam generation with new controls
Ex Ante Savings:	128,363 therms
Facility Type:	Manufacturing/Industrial
End Use:	Process Efficiency
Sampled For:	Gas
Wave:	Wave 3

MEASURE DESCRIPTION

In the existing condition, the customer was running two boilers, a newer Miura boiler and an older, less efficient Hurst boiler to provide steam for a commercial cooking process. An additional Miura boiler of the same capacity was installed to provide steam for the added third production line, along with controls for the two new Miura boilers to allow them to turn off completely during off-production times. The Hurst boiler was left in place but only to serve off-production cleaning.

Savings are realized from the higher efficiency of the new Miura boiler compared to a standard efficiency boiler of the same capacity, and from the new controls shutting down the boilers during non-production hours, when they previously cycled to maintain steam header pressure.

KEY FINDINGS

- The ex ante savings from installing a higher efficiency boiler were calculated relative to a baseline of the existing Hurst boiler and existing Miura boiler. The evaluation team believes a new standard-efficiency boiler is a more appropriate baseline for this savings component because the Hurst boiler now serves a different end use: off-production cleaning. Since the Hurst boiler was repurposed, the customer's choice was to install the selected Miura boiler or a less efficient boiler of the same capacity.
- The ex ante savings for the boiler efficiency improvement are based in part on the customer's existing gas usage data, assuming a baseline of the existing Miura and Hurst boilers. The verified savings for this component were calculated per the IL-TRM V13 algorithm for process boilers and assumed a new standard efficiency boiler for the baseline, resulting in slightly lower savings: 24,168 therms versus 26,671 therms in ex ante.
- The ex ante control savings calculations are equal to the sum of two Miura boilers running at low fire plus the Hurst boiler running at lower fire during non-production hours, split between winter and summer months, less additional gas usage for daily startups in the efficient condition. The evaluation team believes only two boilers should be considered for this calculation: one Miura and one Hurst, as only two boilers were operating in the existing condition. Using the customer-provided duty cycle data for the Miura and Hurst boilers during non-production hours, the evaluation team calculated total controls savings of 73,618 therms versus 96,888 therms in ex ante.
- The ex ante savings included an HVAC savings component resulting from increased boiler efficiency. The verified calculations removed this component because the customer confirmed during M&V that these production boilers do not and have never provided HVAC support.

The resulting project savings are shown in Table 10.

Table 10. Summary of Project 2500323 Savings

	Therms
Ex Ante	128,363
Verified	97,785
Realization Rate	76%

SUMMARY OF THE EX ANTE CALCULATIONS

Ex Ante Calculation Type: Engineering calculations

The implementation team established savings using owner-supplied operating information for the existing boilers: total production hours, boiler gas consumption rates during both production and non-production hours, and warm-up times from idle conditions. Baseline gas usage was estimated using billed usage, consumption rates for the two existing boilers, and production and non-production hours. Gas usage during on-demand production hours is 85.5 and 78.8 therms per hour for the Hurst and Miura boilers, respectively, according to their manufacturers, to provide the same 200 hp of steam output.

For the boiler efficiency improvement measure, the implementation team estimated the total possible production gas usage in the baseline and proposed conditions using the provided boiler gas consumption rates for the existing Hurst and Miura boilers. A load factor of 0.85 was included to account for metered gas consumption relative to theoretical consumption if the boilers ran at full capacity continuously during production hours. Production hours were estimated as 4,040 per year, equivalent to 80 hours per week, less 120 hours to account for holidays and scheduled shutdowns. The result of these calculations was 26,671 therms of savings per year during production.

Boiler Efficiency Savings:

$$Baseline\ (Therms/yr) = ((Input\ Therms/hr)Miura + (Input\ Therms/hr)Hurst) * EFLHprod * LF = 567{,}782$$

$$Proposed\ (Therms/yr) = 2 * (Input\ Therms/Hr)Miura * EFLHprod * LF = 541{,}068$$

$$Savings\ (Therms/yr) = 567{,}782 - 541{,}068 = 26{,}671$$

For the controls savings, the implementation team estimated the baseline off-production gas usage assuming two Miura boilers and one Hurst boiler were operating with the duty cycle information provided by the customer. The Miura boilers' baseline usage was split into summer and winter operation, and the additional gas consumption resulting from more frequent warm-ups in the efficient condition was subtracted. This resulted in savings of 57,400 therms over the summer months and 24,896 therms over the winter months.

$$Summer\ Control\ Savings\ (Therms) = 2 * (Low\ Input\ Therms/hr)Miura * 41\ hr/week * 28\ weeks = 57{,}400$$

$$\begin{aligned} Winter\ Control\ Operation\ (Therms) & \\ &= 2 * (Low\ Input\ Therms/hr)Miura * 41\ hr/week * 20\ weeks \\ &* (Ave\ Summer\ Therms/Month\ /\ Ave\ Winter\ Therms/Month) - 2 * (StartUp\ Therms/yr) \\ &= 28{,}224 - 2 * 1664 = 24{,}896 \end{aligned}$$

$$Hurst\ Control\ Savings = (Ave\ Therms/hr\ in\ Low\ Fire)Hurst * 80\ hrs/week * 48\ weeks = 14{,}592$$

$$Total\ Control\ Savings\ (Therms/yr) = 57{,}400 + 24{,}4896 + 14{,}592 = 96{,}888$$

Additionally, the ex ante savings calculations estimated the gas savings for reduced space heating energy due to increased boiler efficiency.

$$HVAC\ Savings\ (Therms/yr)\ =\ Baseline\ HVAC\ Usage/yr\ -\ Proposed\ HVAC\ Usage/yr$$

$$Baseline\ HVAC\ Usage\ (Therms/yr)\ =\ (Ave\ Winter\ Usage/Mo\ -\ Summer\ Usage/Mo)\ *\ 5\ months\ /\ 2\ =\ 53{,}540$$

$$Proposed\ HVAC\ Usage =\ (Input\ Therms/hr)Miura\ *\ HoursHVAC\ =\ 48{,}736$$

$$Hours_{HVAC} = Baseline\ HVAC\ Usage\ /\ (Input\ Therms/hr)_{Hurst} = 618.7$$

$$HVAC\ Savings\ (Therms/yr)\ =\ 53{,}540\ -\ 48{,}736\ =\ 4{,}805$$

The total ex ante savings (128,336 therms) are equal to the sum of the three components above.

Measurement and Verification Plan

Review Type: Desk Review

Customer Interview Questions

- How often does the Hurst boiler run to support the two Miura boilers?
  - The Hurst boiler only runs to keep its internal pressure between 60 – 80 psi. It does not run to support the Miura boilers. The Miura boilers maintain the steam header at 110 psi.
- Do the boilers cycle off at all in the winter, or do they run consistently to supply HVAC space heat?
  - These boilers are not for HVAC. Only the production cooking process.
- Do the two Miura boilers turn completely off during off-production times when no space heat load is present?
  - Yes, the Miura boilers on/off are controlled by the cooking process.
- Has there been a major change in production levels over the past two years?
  - Yes, in approximately May 2025, we started our second production line, with a third line being commissioned later this calendar year.
- What other machines on site use natural gas?
  - A Lochinvar boiler for the production area HVAC, 6 make-up air units for heating in cold weather, 5 HVAC units for the office area, 4 hanging heaters in the warehouse, 2 small hanging units – 1 in the boiler room and 1 in the wastewater room.
- What is the refiring time from off to the production pressure level each time the boilers come on during the week?
  - The Miura boilers will have the steam header to 110 psi in 5 to 7 minutes after being turned on.
- What pressure do the boilers operate at for regular production?
  - The Miura boilers operate to keep the steam header at 110 psi.
- Does the Hurst actively utilize its steam for anything currently, or does it only maintain internal pressure to be in a "ready" state if it is needed as a redundant boiler? If it only maintains head pressure, does it do so 24/7/365, or does it fire up to maintain 60-80 psi only during production hours?

    - The Hurst maintains head pressure to supply our small heat exchanger, which is used for cleaning, after production hours, daily. During this time, the Mirus are off.
- Will the two Miura boilers have the capacity to serve the upcoming 3rd line as well? Or will the Hurst then be likely needed to support the two Miuras?
    - The two Miuras have the capacity to supply the third line.
- Has the Lochinvar boiler been present since before this project, or was it added due to the removal of the Hurst/Miura from HVAC service?
    - The Lochinvar was installed before any of the other boilers as the sole purpose of HVAC only.

EARLY REVIEW NOTES

- The existing and proposed systems will both use the Miura boiler for meeting winter heating demand, so it is not clear to the evaluation team that there will be any savings for the proposed boiler and controller associated with space heating.
    - N/A – According to the customer, the boilers in question are not used for space heating. The HVAC savings were removed from the verified savings calculations.
- The load factor does not appear to account for non-production gas usage, as it was assumed that all gas usage for process loads was consumed during production hours.
    - The implementer included a comment explaining why there is a load factor for on-production but made no changes to the calculation.
- The calculations consider gas usage for space heating for five months of winter, but the final calculations only account for space heating when developing the load factor. There are entries for off-demand gas usage during winter months, but they assume the usage is only to maintain system pressure during off-demand hours. During the winter months, the off-demand usage will contribute to space heating.
    - The ex ante calculations include a reference to additional on-time for boilers in the winter, estimated as 30% but no changes were made to the original calculation.
- The calculation files provided to the evaluation team do not clearly show how some of the gas input rates for the boilers were determined, but the evaluation team suggests that any instances in which boiler efficiency values are used in the calculations be reviewed for consistency in the efficiency metrics being used. This is noted because the efficiency of the new Miura boiler is expressed in AFUE, whereas the code-minimum efficiency noted elsewhere in the calculation file for a baseline boiler is thermal efficiency. These two efficiency metrics represent different measurements. Further, we recommend using any available literature from the boiler manufacturer to accurately gauge the boiler's operating efficiency at its actual operating conditions rather than at standard conditions.
    - N/A - the ex ante calculations do not directly apply the boiler efficiencies; they use the rated input capacities of the boilers.
- It appears that savings for off-demand gas usage are double-counted. The baseline includes off-demand usage for all boilers, but the proposed calculations subtract it from production usage. The evaluation team recommends setting the proposed off-demand usage to zero, or whatever value the implementation team establishes during post-installation verification.
    - The implementation team addressed this comment by including an explanation and adding calculation steps to more clearly delineate between the HVAC savings and the process-related savings.

- The proposed operation is modeled to let the boilers shut off during off-demand periods. The implementation team should confirm that the customer will allow the system to be turned off to realize the off-demand savings.
  - The “Notes” tab of the ex ante calculation workbook includes a statement, presumably from the customer, implying that the new controls will only provide pressurized steam if needed.
- The final calculations do not include provisions for warm-up energy consumption. If the system pressure is lower during off-demand periods after the retrofit, the warm-up gas usage should be included for both pre- and post-case conditions.
  - The implementer added a re-pressurization penalty to the calculation to account for start-up gas usage.
- The evaluation team recommends that the implementation team consider space heating separately from the off-demand gas usage. During the winter months, space heating will be required during off-demand periods, so steam output will be put to beneficial use.
  - The ex ante savings distinguish between process and HVAC gas usage.

SUMMARY OF THE VERIFIED CALCULATIONS

Verified Calculation Type: Engineering calculations; Technical Reference Manual calculations

The verified calculations use a federal standard-efficiency boiler baseline[1] , along with the process-heating boiler savings calculation from IL TRM V13, to calculate 24,168 annual therms saved, based on the 4,040 annual hours of on-production time stated by the customer and used in the ex ante calculations.

$$Boiler\ Efficiency\ Savings\ (Therms/yr) = (Input\ Btu/h)_{Miura} * (Eff_{Miura} - Eff_{Std}) / Eff_{Std} * EFLH_{prod} / 100{,}000 = 24{,}168$$

Where:

$$(Input\ Btu/h)_{Miura} = 7{,}876{,}471,\ Eff_{Miura} = 0.85,\ Eff_{Std} = 0.79,\ EFLH_{prod} = (80 * 52 - 120) = 4{,}040$$

For the controls savings, the evaluation team only considered the off-production usage of one Miura boiler and the Hurst boiler, since there were only two boilers operating in the existing condition. Using the duty cycle data for the Miura and Hurst boilers during non-production hours and the warmup data provided by the customer, the evaluation team calculated the control savings as follows:

$$Control\ Savings\ (Therms/yr) = (Control\ Savings)_{Miura} + (Control\ Savings)_{Hurst} - 2*(StartUp\ Energy)_{Miura}$$

Where:

$$(Control\ Savings)_{Miura} = (Input\ Btu/h)_{Miura} / TDR_{Miura} * EFLH_{non\text{-}prod} * DC_{Miura} / 100{,}000 = 60{,}662$$

$$TDR_{Miura} = turndown\ ratio = 2.7,\ EFLH_{non\text{-}prod} = 88 * 52 - 120 = 4456,$$

$$DC_{Miura} = duty\ cycle = 28\ min/hour = 28/60 = 0.47$$

$$(Control\ Savings)_{Hurst} = (Average\ Input\ therms/h)_{Hurst} * EFLH_{non\text{-}prod} = 16{,}933$$

$$(Average\ Input\ therms/h)_{Hurst} = 3.8$$ [2]

[1] As defined in 10 CFR § 431.87 (b)

[2] This figure reflects the duty cycle data provided by the customer specific to the Hurst boiler during non-production hours.

$$(Startup\ Energy)Miura = (Input\ Btu/h)_{Miura} * (0.1\ hr/startup) * (5\ startups/week) * (EFLH_{prod}/80\ hrs/week) = 1{,}989$$

$$Total\ Verified\ Savings\ (therms/yr) = 24{,}168 + 60{,}662 + 16{,}933 - 2 * 1{,}989 = 97{,}785$$

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