Spring-Ford Area School District

Investment Grade Audit Report

Submitted by:
Johnson Controls, Inc.

August 2022

The power behind **your mission**

Johnson Controls

Table of Contents

Executive Summary

The Spring-Ford Area School District (SFASD) requested that Johnson Controls (JCI) prepare an Investment Grade Audit Report for ten facilities in preparation for a Guaranteed Energy Savings Act (GESA) Performance Contract between the school district and JCI. This report summarizes the results of audits and analysis conducted by JCI between February and July of 2022.

For all ten buildings, JCI completed a detailed analysis: including multiple site audits, detailed utility analysis, development of bid designs for Limerick ES and Royersford ES, energy savings modeling, construction pricing from multiple contractors, bid analysis with descope, and preliminary construction planning. Based on the capital and infrastructure needs of SFASD, JCI applied a special focus to Limerick ES and Royersford ES, developing solutions that holistically upgrade the HVAC infrastructure in these buildings for better comfort, ventilation, and efficiency.

Audit Outcomes

The ten-facility infrastructure upgrade project outlined in this report will result in **$17M** of building infrastructure renewal and address a significant portion of the school district's capital needs. Over the term of the project, these improvements will result in **$4.7M** of guaranteed energy savings, while savings the school district a projected **$2.5M** in operations and maintenance (O&M) costs. The school district is expected to see a net energy cost savings of **13.4%** annually.

Most importantly, this solution substantially impacts the mission of the school district by improving the learning environment and the comfort of the students and staff. This solution will provide high quality lighting and new sources of cooling, heating, and ventilation to learning spaces. These changes will result in a healthier and more comfortable learning environment.

Features of the Solution Components

With this project, JCI along with SFASD staff strive to provide a pragmatic, reliable, and comprehensive approach to designing ECMs at these ten schools. This began with putting the student health and safety first, by ensuring solutions will improve the learning environment. To make these improvements manageable for the school district, JCI designed ECMs that are simple for maintenance staff to service and operate. To ensure the school district does not need to return to these facilities and further invest in infrastructure, our solutions extend beyond simple retrofits and take a holistic design approach (Specifically at Limerick ES and Royersford ES). Our solutions solve core infrastructure needs as opposed to providing temporary fixes that will need further investment later. The heart of the effort includes several core projects:

- **Comprehensive LED Lighting Upgrades** with sensor ready retrofit kits and lamp replacement where applicable. Schools will have a bright, safe, and productive classroom environment, save energy, and reduce O&M costs.
- **Window Replacements** at Limerick ES will upgrade the existing windows to add insulation capabilities and standardize with the other schools in the district.

- **Controls Upgrades** included in this project will provide long-term assurance of consistent operation, accurate temperature control, and easier troubleshooting of equipment.
- **HVAC System Upgrades** provide safe ventilation and improved comfort in classrooms at Limerick ES and Royersford ES. Proper ventilation and temperature control have been shown to improve student performance as well as student and staff health and attendance.

Along with the benefits outlined above, **JCI will provide full construction management support**, ensuring that the project gets procured and installed in **a safe, timely, and cost-effective manner, without interruptions to students, teachers, and community** and without delay to the start of the school year. Our team will functionally test the installations, provide training, and full warranty and documentation turnover to the school district. We expect the majority of work to be completed during the 2023 calendar year.

Investment Grade Audit Activity

In October of 2021, JCI responded to a competitive RFP to develop a Performance Contract for SFASD. The RFP response and selection process took place from October 2021 through January 2022, with JCI ultimately being awarded a contract and given Notice to Proceed (NTP) on February 1, 2022. Between February and August of 2022 JCI worked closely with SFASD staff and SFASD's consultants, ICS and Provident Energy Consulting (PEC), to develop the project outlined in this report.

October 2021 – January 2022	•JCI completes preliminary walkthroughs of facilities & responds to RFP •JCI selected by SFASD to develop Performance Contract Agreement
February 2022	•JCI receives Notice to Proceed to begin developing the project per PDA •JCI begins comprehensive audits of **10 facilities**, totaling over **1.5 million SF** •JCI begins utility data collection and analysis of **17 accounts** and **over 700 utility bills**
March- April 2022	•JCI hires ICS to complete 50% Design Bid Set for Limerick ES & Royersford ES •Drawings are reviewed by JCI and SFASD •First Project Scope reveiw meetings and M&V Workshops completed •JCI installs metering equipment to begin baseline M&V •Utility baseline is finalized and aproved
May 2022	•ICS 100% Bid Design drawing set completed and reviewed by JCI and SFASD •JCI walks contractors to begin pricing effort •Project Scope based on preliminary pricing completed, financial model presented, and JCI Finance team introduced.
June – July 2022	•JCI performs contractor descope and cost negotiation with 20+ sub-contractors and trades. •JCI provides pricing summary and detailed scope of work for ICS and SFASD evaluation •Final project scope and target price provided by ICS and SFASD •JCI finalizes pricing and submits contract to SFASD
August – October 2022	•JCI, ICS/PEC, and SFASD to review and agree to contract terms •SFASD secures financing •JCI, ICS/PEC, & SFASD present project to SFASD KDMs •Board Approval and NTP in October 2022

Overview of Facilities

Summary of Facilities

See Appendix A for detailed descriptions of each facility.

The following table summarizes the facilities owned and operated by SFASD. As part of this project, JCI audited and completed utility analyses for the ten schools owned and operated by the school district. At the request of the school district, Spring City ES was removed from JCI's scope and the Administration Buildings were never considered for the GESA project.

Building	Address	City & State	Zip Code	Sqft	Year Built
Brooke ES	339 North Lewis Road	Royersford, PA	19468	74,110	1991, Add/ Renovations 2006
Evans ES	125 Sunset Road	Limerick, PA	19468	92,872	2007
Limerick ES	81 Limerick Center Road	Limerick, PA	19469	72,555	1959, Add 1966 & 2002
Oaks ES	325 Oaks School Dr	Oaks, PA	19456	76,421	1965, Add 1997, Renovations 2000
Royersford ES	450 Spring St	Royersford, PA	19468	71,222	1957, Add 1992
Upper Providence ES	833 S Lewis Rd Building 3	Royersford, PA	19468	92,872	2003
5-7th Grade Center	834 S Lewis Rd	Royersford, PA	19468	335,036	2004
8th Grade Center	700 Washington St	Royersford, PA	19468	132,330	1930, Add 1966, Renovations 1995, 1996
9th Grade Center	400 S Lewis Road	Royersford, PA	19468	148,055	1996, Add 2005, Renovations 2000, 2005
Spring-Ford Area HS	350 S Lewis Road	Royersford, PA	19468	473,404	1999, Add 1999
Total Area				**1,568,877**	
Buildings Not Included in the GESA Project					
Spring City ES	190 Wall St	Spring, PA	19475	33,914	1959
Admin Building	834 S Lewis Rd	Royersford, PA	19468	13,000	2004
Total Area				**46,914**	

Summary of Findings

JCI completed onsite audits of ten of the district's schools, reviewed building automation system (BAS) software, observed trends, performed baseline M&V, and completed utility analysis. Buildings are well designed, clean, and well maintained (See Appendix A for Facilities Descriptions). JCI's assessment is that most of SFASD schools operate surprisingly efficiently for their age.

General Conditions

SFASD buildings and mechanical infrastructure are well maintained; it is obvious that equipment is serviced regularly, and that staff is very conscientious about keeping systems in proper working order. Equipment is well documented and facility drawings are organized and well maintained. **The greatest challenged faced by SFASD is that while well maintained, much of the school districts infrastructure is at or near the end of its useful life and in need of replacement.** Spring-Ford ASD's schools are on average more than 45 years old; mechanical equipment and lighting infrastructure are well over 20 years old. This project will allow the school district to make sensible and targeted upgrades to equipment that needs immediate or near-term replacement while accounting for the benefits of doing this work under one procurement effort.

Building Envelope

Most of the district's facilities have well maintained brick and block exteriors. Roofs are a mix of metal pitched surfaces and flat EPDM. Windows are well maintained and good condition at most of the schools. 9th Grade Center windows were recently replaced. Some of the schools have wooden framed windows and inoperable. A reoccurring challenge faced by the district is infiltration at roof-wall intersections. In multiple buildings, there are air gaps at the point where the roof and the exterior wall interface. This is a very common problem in facilities old and new, leading to energy loss and potentially contributing to humidity issues. Facilities would benefit from window caulking and weather-striping of doors (See ECM 5), however this measure was not included in the final scope of this project as they took lower priority to more urgent needs. Due to the age and condition of windows, as well as economies of construction with proposed HVAC upgrades, window upgrades at Limerick ES have been included as part of this project (see ECM 6). Roofs are in relatively good condition and not evaluated as part of this projects scope.

Mechanical and HVAC Systems

Mechanical systems at most facilities are original to the construction of the buildings. While well maintained, systems are quickly nearing the end of useful life and should be upgraded in the next few years. As systems age, they require more maintenance, operate less efficiently, and have negative interactive effects with other equipment. Older equipment is less reliable at providing comfort and ensuring occupant health with well managed ventilation.

Schools are generally served by a central plant including boilers, chillers, and hydronic pumps. Classrooms are typically served by unit ventilators. Outside air is provided directly from the outside through unit ventilators or in some cases by dedicated outside air unit (DOAS).

Four schools – 9th Grade Center, 5-7th Grade (Flex) Center, Upper Providence ES, and Evans ES are served by highly efficient ground source heat pump systems that use the earth to recover and reject heat dependent of the season. The installation of these systems speaks to SFASD's commitment to efficient use of resources and economically providing comfort for its schools. In addition to ground source heat pumps, these four schools are equipped with heat recovery units to provide ventilation and humidity control. Heat recovery units at Flex and Upper Providence ES are no longer manufactured and sourcing parts has become a challenge. Repair of these systems is cost prohibitive (See ECM 10).

As part of this project, Royersford ES and Limerick ES were targeted for significant HVAC upgrades. These schools are the among the district's oldest buildings with highest energy usage by area; HVAC systems can be optimized to provide better ventilation and comfort with an efficient HVAC system (See ECMs 14 and 15).

Controls upgrades are proposed across the district as a means of modernizing legacy system panels by upgrading engines and supervisory controls along with the existing front-end. The district shall benefit from advanced control visibility of the controls system, ongoing maintenance reduction, and improved digital security (See ECM 8).

Lighting

Lighting infrastructure throughout the facilities are well maintained; fixtures are clean and lamps are replaced as they fail. The district is using legacy fluorescent technology which requires more maintenance, uses more energy, and generates lower quality light than LED technologies. Most fixtures are either original to the facilities or in excess of 20 years old. Upgrading light fixtures from fluorescent to LED technologies will help to create brighter spaces, reduce the cost of maintenance associated with lamp replacements, and reduce energy consumption. JCI has investigated and recommends doing lighting upgrades across all facilities (ECM 1). Exterior LED upgrades were considered for facility exteriors, but the district has already performed the conversion to high efficiency LED lighting.

Similarly, stadium LED upgrades at the McNelly Stadium and the Rams Field were also evaluated, but ultimately not recommended due to a poor return on investment (ECM 4).

Humidity Concerns

Humidity, especially at Limerick ES and Royersford ES has been a concern raised by the school district. The humidity concerns are a function of preferred comfort levels; we did not witness any significant infrastructure deficiencies resulting from humidity.

Generally, humidity is introduced into the spaces from factors both outside the buildings (rain, humid air, seepage through walls and floors) and inside the buildings (humans, water sources/use.) Humidity is removed by cooling air and condensing water vapor via the HVAC system. Ideal indoor conditions in school buildings to maintain a comfortable learning environment are about 68 - 76°F space temperature with 40% - 60% relative humidity (RH);

dependent on the season. From an energy perspective, in the warmer months the space should be no cooler and no drier than necessary, because additional energy is required to lower space temperature or space RH.

The districts' HVAC systems across all buildings are generally equipped to remove both heat and moderate amounts of humidity from indoor air via air conditioning (cooling) systems. However, there is some variability from one system to another regarding their ability to provide targeted humidity control. Most HVAC systems partially remove humidity from the room air when cooling (those buildings with unit ventilator systems); buildings with heat recovery units are better equipped to manage humidity. Without systems specifically designed to provide dehumidification, it is challenging (if not impossible) and extremely energy intensive to remove humidity by control strategies alone.

SFASD systems have been controlled to actively manage the humidity in the spaces. Humidity has been a concern at both Limerick ES and Royersford ES, as well as Oaks ES. To address the potential downsides of humidity, such as mold growth and uncomfortable space conditions, the district developed strict protocols in attempt to manage humidity. These attempts have made some of the schools the highest energy users in the school district. The existing HVAC systems at some of the buildings, due to both age and design, do not facilitate dehumidification. The proposed HVAC systems at Limerick ES and Royersford ES are designed to allow the mechanical systems to better address humidity issues (See ECM 14 and 15). It is recommended that the school district takes additional precautions in the future to tighten building envelope (see ECM 6).

Utility Analysis

Overview

To accurately assess performance of an ECM, it is necessary to make comparisons of pre-retrofit and post-retrofit conditions of the facility under similar conditions. The pre-retrofit baseline was established by documenting conditions (in terms of unit energy consumption, energy efficiency, or other performance parameters) over a defined period. The baseline will thus provide a benchmark for the pre-retrofit operation of the facility in terms of hours of use on a daily/monthly/yearly basis and the corresponding energy consumption performance for those hours of use. When possible, a baseline may be created from already-established energy consumption information. A baseline may be established by using utility billing data for a utility type and measurements of the various end uses.

JCI evaluated the various utility types (electricity, natural gas, etc.) used at the facilities, whether the various utilities are metered on more than one utility (billing) meter per utility type, and whether the facility in question is a single- or a multi-building facility. Typically, a baseline is established for each utility type and ECM.

A baseline is the set of operating conditions, including hours, load(s), and other related values. The performance measurement is the measured value(s) of the (post-retrofit) operating condition(s) affected by the retrofit implementation. Energy savings estimates are the result of the agreed upon energy savings calculation, which is based on the difference between the performance measurement(s) and its associated baseline value(s). Energy cost savings is determined by applying the appropriate unit cost to the calculated energy savings.

Utilities

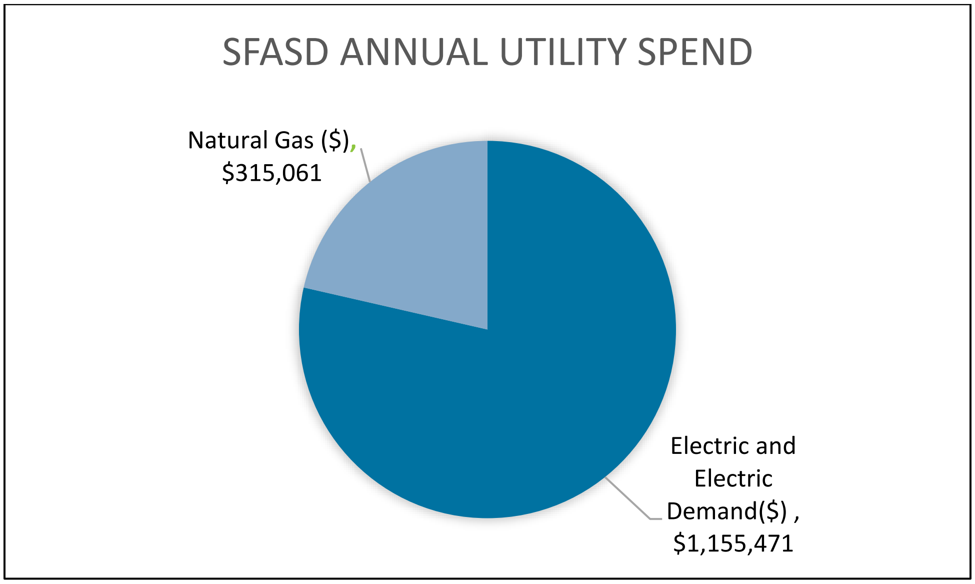
Electricity and natural gas is supplied to SFASD through PECO Utilities. Electricity is generally used for lighting, mechanical HVAC systems, as well as plug loads. Natural gas is primarily used for heating and kitchens. The school district does not have any significant oil or propane use at its facilities.

Utility Electric Rates		Natural Gas				
$/kWh	Average $/kW	Delivery $/ ccf <2000	Delivery $/ ccf >2000	Delivery Service $/ccf	Supply $/DTH	Supply $/ccf
0.0566	$8.06	$0.40	$0.30	$0.04	$3.74	$0.39

Annual Energy Expenditure

Expense by Utility

JCI analyzed utility data from 2019 to 2021. Based on 2021 utility data, SFASD spends just short of $1.5 million annually on the ten schools included in this project.



Electricity constitutes a significant portion of utility spend compared to total energy expenditure because several buildings are conditioned by electric ground source heat pump systems.

Expense by Facility

The table below shows the total energy cost that was summarized from the commodity usage data and rates provided by SFASD. This table captures the 12 month usage period from January 2021 to December 2021. The 8th Grade Center natural gas analysis uses calendar year 2016 due to a meter issue.

Building Name	Total Annual Energy Cost ($)
5-7th Grade Center	$262,659
8th Grade Center	$102,695
9th Grade Center	$181,120
Brooke ES	$70,493
Evans ES	$92,629
Limerick ES	$79,756
Oaks ES	$72,106

Building Name	Total Annual Energy Cost ($)
Royersford ES	$78,540
Spring-Ford Area HS	$461,824
Upper Providence ES	$68,711
TOTAL	**$1,470,531**

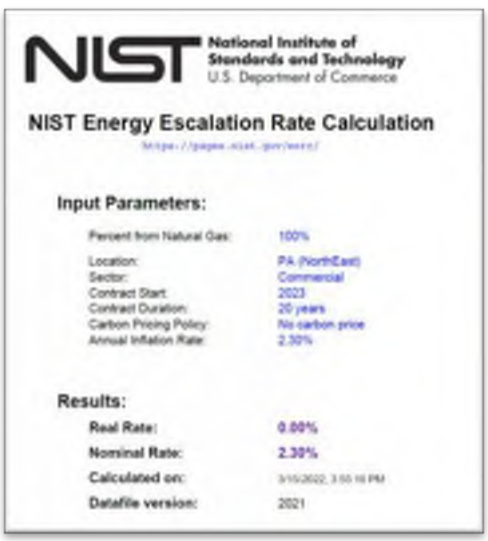
Utility Escalation Rates

Per the direction of SFASD and Provident Energy Consulting the following escalation rates were used for purposes of calculating the extended value of the energy savings of this project. Based on recent influxes in energy cost and inflation, we believe that the 2% escalation is likely conservative.

Electric Consumption		Electric Demand		Natural Gas	
Escalation Rate	Start Year of Escalation	Escalation Rate	Start Year of Escalation	Escalation Rate	Start Year of Escalation
2%	Year 1	2%	Year 1	2%	Year 1

Note: Install period 1 represents first 12 months of construction period.

The escalation rates for electric and natural gas were compared to the National Institute of Standards and Technology Energy Escalation Rate Calculator. Results are shown below.


NIST National Institute of Standards and Technology U.S. Department of Commerce

NIST Energy Escalation Rate Calculation

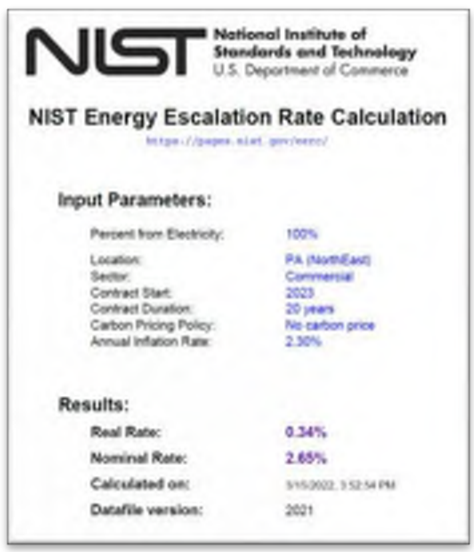
https://pages.nist.gov/eerc/

Input Parameters:

Percent from Natural Gas:	100%
Location:	PA (NorthEast)
Sector:	Commercial
Contract Start:	2023
Contract Duration:	20 years
Carbon Pricing Policy:	No carbon price
Annual Inflation Rate:	2.30%

Results:

Real Rate:	0.00%
Nominal Rate:	2.30%
Calculated on:	3/15/2022, 3:50:16 PM
Datafile version:	2021


NIST National Institute of Standards and Technology U.S. Department of Commerce

NIST Energy Escalation Rate Calculation

https://pages.nist.gov/eerc/

Input Parameters:

Percent from Electricity:	100%
Location:	PA (NorthEast)
Sector:	Commercial
Contract Start:	2023
Contract Duration:	20 years
Carbon Pricing Policy:	No carbon price
Annual Inflation Rate:	2.30%

Results:

Real Rate:	0.34%
Nominal Rate:	2.65%
Calculated on:	3/15/2022, 3:52:54 PM
Datafile version:	2021

Energy Consumption

Electricity

The electric utility measures consumption in kilowatt-hours (kWh) and maximum demand in kilowatts (kW). One kWh usage is equivalent to 1,000 watts running for one-hour. One kW of electric demand is equivalent to 1,000 watts running at any given time. The basic usage charges are shown as generation service and delivery charges along with several non-utility generation charges. The graph below represents the electric consumption and demand for all ten buildings during the 2021 performance year.

A detailed look at the annual usage (kWh), demand (kW) and total electric cost by building is shown in the table below.

Building Name	Utility Electricity		
	Annual Consumption (kWh)	Monthly Average Utility Demand (kW)	Annual Cost ($)
5-7th Grade Center	3,262,788	964	$241,773
8th Grade Center	877,056	433	$79,563
9th Grade Center	2,553,631	656	$177,434
Brooke ES	561,984	216	$48,049
Evans ES	1,064,832	410	$88,872
Limerick ES	586,500	294	$50,965
Oaks ES	545,760	220	$47,239
Royersford ES	580,992	238	$50,132
Spring-Ford Area HS	4,346,261	1,228	$307,911
Upper Providence ES	997,265	136	$63,533
TOTAL	**15,377,069**	**480**	**$1,155,471**

Natural Gas

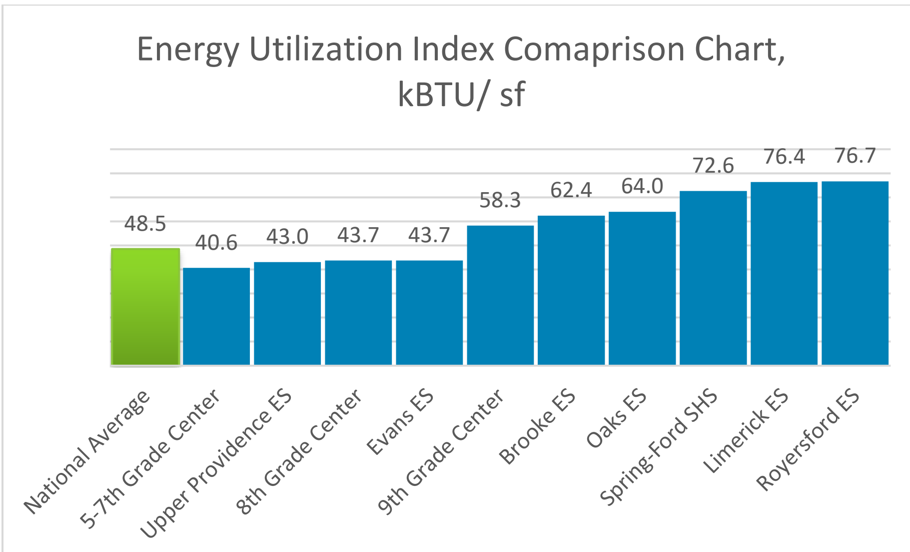
Gas rates are based on measuring consumption in CCF. The graph below represents the natural gas usage for all ten buildings during the 2021 performance year. The table below shows the natural gas consumption and cost for January 2021-December 2021.

Building Name	Natural Gas	
	Annual Consumption (CCF)	Annual Cost ($)
5-7th Grade Center	24,398	$20,887
8th Grade Center	27,410	$23,132
9th Grade Center	4,150	$3,686
Brooke ES	26,530	$22,444
Evans ES	4,229	$3,756
Limerick ES	34,752	$28,790
Oaks ES	29,708	$24,867
Royersford ES	34,121	$28,407
Spring-Ford Area HS	191,680	$153,913
Upper Providence ES	5,829	$5,178
TOTAL	**382,807**	**$315,061**

Energy Performance

EUI is measured in kBtu per square foot, or annual energy use per square foot of building. A lower score is better. The national median site EUI is one of the best metrics for early evaluation of the energy savings potential for a given building type.

SFASD provided over 700 utility bills to JCI for analysis. The bills included electric, natural gas, and water/ sewer consumption and cost data predominantly for the years 2019, 2020, and 2021. JCI analyzed the data and established baseline profiles for each buildings using 2021 data. The national median EUI for a typical K-12 schools is 48.5 kBtu/sf; in schools with ground source heat pumps, the benchmark drops to 25 kBtu/sf.



As seen in the chart above, Limerick ES and Royersford ES are the district's two poorest performers. They are also some of the district's oldest buildings. As a result, these two buildings are targeted for mechanical upgrades as part of this project (ECMs 14 & 15). Sub-optimal performance in other buildings is attributed to equipment (controls, chillers, boilers, unit ventilators, and air-handlers) being at or near end of useful life. Some facilities also have sizeable kitchens that further impact the energy use (See Appendix A for detailed Facility Descriptions).

Energy Footprint and Ground Source Heat Pump Performance

5-7th Grade (Flex) Center, Upper Providence ES and Evans ES are among the districts most efficient buildings. These buildings, along with the 9th Grade Center are served by highly efficient ground source heat pump systems (GSHP). These systems leverage temperature differences between the surface air and subterranean ground as an efficient heat exchanger. The systems at SFASD require minimal fuel to heat, as they rely heavily on ground heat and electricity. The current design has GSHP units distributed across the buildings, typically one unit per space. This allows for the units to heat or cool individual classrooms or areas via zone space conditioning. With the exception to the 9th grade center, which was completed as a retrofit, the existing GSHP units are original to their respective buildings. The district has been maintaining the units with great care by replacing filters, failed values, and damaged compressors.

The 9th grade center is believed to be underperforming relative to other schools due the age of the HVAC equipment. The facility also has a large single-story footprint and underwent several additions and renovations, both of which tend to negatively impact facility performance. While a detailed engineering study was not completed, the refurbishment of heat pumps and heat recovery units along with system recommissioning can further reduce the energy footprint of all four buildings served by heat pumps. Given the overall quantity of 521 units across four buildings a comprehensive approach to refurbishment or replacement should be part of future planning for the district.

Note: a critical driver for replacement of the GSHPs is the rising cost of ongoing maintenance due to failed parts and the phase out of R22 refrigerant. Beginning in 2020, R-22 is no longer produced or imported. Only recovered, recycled, or reclaimed supplies of R-22 will be available. The production (not use) of R-22 is being phased out. While the district is not required to stop using R-22 air conditioners nor to replace existing equipment the cost finding replacement will burden the operational and maintenance budgets of the district.

Project Scope: Energy Conservation Measures

Summary of Investigated ECM

The following table summarizes the scope of ECMs JCI has evaluated:

ECM #	Base Energy Conservation Measures	Brooke ES	Evans ES	Limerick ES	Oaks ES	Royersford ES	Upper Providence ES	5-7th Grade Center	8th Grade Center	9th Grade Center	Spring-Ford Area HS
1	Interior LED Lighting Upgrades	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	Interior Lighting Controls	○	○	○	○	○	○	○	○	○	○
3	Exterior LED Lighting Upgrades	○	○	○	○	○	○	○	○	○	○
4	Stadium Lighting Upgrades								○		○
5	Building Envelope Improvements	○	○	○	○	○	○	○	○	○	○
6	Window Replacements			✓							
7	Water Conservation	○	○	○	○	○	○	○	○	○	○
8	Recommissioning DDC Controls	○	○	○	○	○	○	○	○	○	○
9	Upgrade DDC Systems	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
10	Heat Recovery Unit Refurbishment		○				○	○		○	
11	Kitchen Hood Controls	○	○	○	○	○	○	○	○	○	○
12	Load Shedding / PLC Mgmt / DR / Battery Storage	○	○	○	○	○	○	○	○	○	○
13	Chiller Replacement	○							○		
14	HVAC System Improvements - Limerick ES										
14.1	Classroom Ducted UV Upgrade [LES]			✓							
14.2	Chiller, Pumps & VFD Upgrades [LES]			✓							
14.3	Admin Area VRF System Upgrade [LES]			✓							
14.4	AHU Refurbishment (x3) [LES]			✓							
15	HVAC System Improvements - Royersford ES										
15.1	CR UV & FCU Upgrade [RES]					✓					
15.2	Chiller, Pumps & VFD Upgrades [RES]					✓					
15.3	Boiler, Pumps & VFD Upgrades [RES]					✓					
15.4	AHU Refurbishment (x6) [RES]					✓					
16	UVC Systems	○									○
17	Solar Photovoltaic Systems	○	○	○	○	○	○	○	○	○	○
18	AHU Refurbishment								○	○	○
19	AHU Replacement	○									
20	Unit Ventilator Replacement								○		
21	Motor Replacement	○					○	○	○	○	

✓ ECM Included in the final project   ○ ECM investigated but not included in the final project

Recommended Project

The following project was selected based on many interactive work sessions between SFASD Leadership, ICS and Provident Consulting (SFASD 3rd Party Consultants), and JCI. The project addresses items in the school district's capital plan, improves two of the district's oldest and least energy efficient buildings: Limerick ES and Royersford ES, while also achieving standardization of equipment across the district for ease of O&M. A multitude of projects beyond those selected are possible (several of which are outlined in this report), but the selected measures address the district's most critical needs in a holistic fashion while meeting a target project size.

ECM #	Energy Conservation Measure	Project Cost	Annual Utility Savings	Annual Operational Savings	Rebates
1.0	Interior Lighting LED Upgrade - Kit Replacement*	$3,908,087	$170,414	$59,815	$0
6.0	Window Replacement [LES]	$2,222,097	$1,995	$0	$152
9.0	Upgrade DDC System [10 Bldgs]	$682,959	$0	$51,500	$0
14.1	CR Ducted UV Upgrade [LES]	$4,437,718	$3,771	$8,498	$507
14.2	Chiller, Pumps & VFD Upgrades [LES]	$445,780	$1,343	$1,030	$3,500
14.3	Admin Area VRF System Upgrade [LES]	$317,878	$393	$0	$0
14.4	AHU Refurbishment (x3) [LES]	$114,150	$613	$1,236	$797
15.1	CR UV & FCU Upgrade [RES]	$3,862,612	$2,957	$2,066	$500
15.2	Chiller, Pumps & VFD Upgrades [RES]	$262,297	$1,652	$1,030	$3,900
15.3	Boiler, Pumps & VFD Upgrades [RES]	$518,859	$5,046	$0	$1,300
15.4	AHU Refurbishment (x6) [RES]	$226,647	$787	$0	$600
	Total	**$16,999,085**	**$188,973**	**$125,175**	**$11,256**

Recommended but Not Included in the Project

4.0	Stadium Lighting Upgrades [HS, 9th]	$887,729	$6,476	$16,480	$11,100
5.1	Building Envelope Improvements [10 Bldgs]	$419,672	$20,391	$0	$22,238
5.2	Attic Insulation & Weatherization [RES]	$428,050	$3,042	$0	$539
8.0	Recommission Controls [10 Bldgs]	$677,979	$45,616	$2,575	$63,779

Note: Addition of measures to the base project may vary the individual pricing of other measures.

*Cost reflective of rebate absorption by JCI

Note that pricing is indicative of JCI prepaying lighting rebates to the school district; JCI is expected to recover a portion of this prepayment amount by becoming recipient of all lighting rebates achieved by this project directly from PECO (i.e. JCI is reducing the cost of the project by $592,460 with the expectation of receiving approximately $491,858 in rebates).

Pricing is inclusive of ICS and Provident Energy Consulting Representation and Engineering fees per the RFP released by SFASD.

Indicative Cash Flow

The following cashflow indicates how the project will perform over a 20-year period.

Year	Utlity Costs without Project A	Utility Costs with Project B	Total Utility Savings C = A - B	Annual O&M Savings D	Rebates and Incentives E	Capital Avoidance F	Total Savings G = C+D+E+F	Tentative Annual Payments H	Service Agreement I	Total Payments J = H+I	Net Annual Benefits I=G-H
0	$1,697,320	$1,528,731	$168,589				$168,589				
1	$1,731,266	$1,542,294	$188,973	$125,793	$11,256	$16,316,126	$16,810,736	$12,721,286	$23,323	$12,744,609	$4,066,127
2	$1,765,892	$1,573,139	$192,752	$129,567			$322,319	$297,595	$24,723	$322,318	$1
3	$1,801,210	$1,604,602	$196,607	$133,454			$330,061	$303,854	$26,206	$330,060	$1
4	$1,837,234	$1,636,694	$200,539	$137,457			$337,997	$337,996	$0	$337,996	$1
5	$1,873,978	$1,669,428	$204,550	$141,581			$346,131	$346,130	$0	$346,130	$1
6	$1,911,458	$1,702,817	$208,641	$145,828			$354,470	$354,469	$0	$354,469	$1
7	$1,949,687	$1,736,873	$212,814	$150,203			$363,017	$363,016	$0	$363,016	$1
8	$1,988,681	$1,771,611	$217,070	$154,709			$371,780	$371,779	$0	$371,779	$1
9	$2,028,455	$1,807,043	$221,412	$159,351			$380,762	$380,761	$0	$380,761	$1
10	$2,069,024	$1,843,184	$225,840	$164,131			$389,971	$389,970	$0	$389,970	$1
11	$2,110,404	$1,880,047	$230,357	$99,843			$330,200	$330,199	$0	$330,199	$1
12	$2,152,612	$1,917,648	$234,964	$102,839			$337,803	$337,802	$0	$337,802	$1
13	$2,195,664	$1,956,001	$239,663	$105,924			$345,587	$345,586	$0	$345,586	$1
14	$2,239,578	$1,995,121	$244,456	$109,102			$353,558	$353,557	$0	$353,557	$1
15	$2,284,369	$2,035,024	$249,346	$112,375			$361,720	$361,719	$0	$361,719	$1
16	$2,330,057	$2,075,724	$254,332	$115,746			$370,078	$370,077	$0	$370,077	$1
17	$2,376,658	$2,117,239	$259,419	$119,218			$378,637	$378,636	$0	$378,636	$1
18	$2,424,191	$2,159,583	$264,608	$122,795			$387,402	$380,102	$0	$380,102	$7,300
19	$2,472,675	$2,202,775	$269,900	$126,479			$396,378	$380,102	$0	$380,102	$16,276
20	$2,522,128	$2,246,831	$275,298	$130,273			$405,571	$380,102	$0	$380,102	$25,469
Total	**$43,762,541**	**$39,002,409**	**$4,760,131**	**$2,586,667**	**$11,256**	**$16,316,126**	**$23,842,768**	**$19,484,739**	**$74,252**	**$19,558,991**	**$4,115,188**

Total Project Cost:	**$16,999,085**
Modeled Interest Rate	3%
Loan Term (Years)	20 years
Energy Inflation Rate	2%
O&M/Replacement Cost Inflation Rate	3%

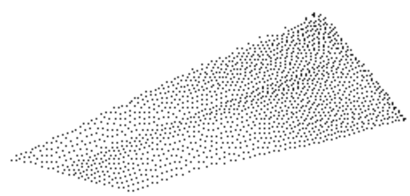
Energy Conservation Measures - At a Glance

Recommended and Included

ECM 1 - Interior Lighting LED Upgrades

All interior fluorescent lighting will be upgraded with LED lamps at all ten schools. Troffer fixtures will receive “door kits” which replace all visible elements of the fixture to provide a “new” fixture, while leveraging the housing of the existing fixture. This measure will save electricity by reducing the amount of energy required to light the spaces. LED lamps and fixtures require less frequent re-lamping, reducing O&M costs. Additionally, standardization of fixtures across all ten buildings will further economize and simplify maintenance. This measure will also create the appearance of a brighter classroom, due to LED’s better light rendering, with a more modern troffer fixture.

The following images are samples of lighting upgrades:


ECM 6 – Window Replacement at Limerick ES

This measure will replace all windows at Limerick ES. Windows at this building are over 30 years old and showing their age. This project will provide new windows that match the school district’s standard specification. New windows will be more energy efficient and should provide a level of aestetic renewal to classroom spaces. There are also advantages to completing this project in concert with proposed HVAC upgrades (i.e. construction can be completed in one summer vs. multiple summers).

Elementary School with window upgrades. Similar materials to be used for Limerick ES upgrades

ECM 9 – Upgrade DDC System

JCI will perform comprehensive upgrades to HVAC controls across the district. New controls will improve the operability and performance of building HVAC systems and standardized the control platform across buildings. The school district has been gradually investing over the past few years to upgrade its BAS by replacing legacy control engines and supervisory controls. This process, while deliberate, is staged and thus acts an ongoing burden to operation budgets and creates a perpetual cycle by which the system is never fully up to-date.

The scope included as part of this project builds on the momentum to upgrade the direct digital control (DDC) units and completes the upgrade process at all ten buildings. Existing NAE control engines are scheduled to be upgraded to the technologically advance SNE and similarly, supervisory controls will be upgraded. The Metasys User Interface (UI) upgrades included in the project will provide a simple location-based navigation approach to finding information for each building, including the ability to search for any location or equipment by name and to bookmark a location or equipment in a web browser. All data displayed in the Metasys UI is organized in a dashboard format that gives the school district an overview of what is happening within a space, equipment, or mechanical plant. The SFASD team will be able to access the Metasys from a multitude of devices.

ECM 14 - HVAC System Improvement – Limerick ES

The majority of Limerick ES HVAC system is original to the building and nearing the end of expected useful life. The design of the existing system may be contributing to issues with humidity and occupant comfort. Replacing the existing system with newer, more efficient units will reduce the energy profile for the building and provide an upgraded ventilation system.

Limerick ES is primarily served by air-handling units (AHUs), fan coil units, and unit ventilators. The AHUs serve large spaces, and the classrooms are conditioned by unit ventilators with constant speed supply fans and outside air dampers. These systems work in conjunction with relief vents and exhaust fans in the building to ensure proper air circulation.

Existing classroom unit ventilators will be replaced with ducted vertical unit ventilators capable of heating and cooling; they also include fresh air ventilation with built-in energy recovery wheels capable (via energy recovery ventilation) of reclaiming nearly 70% of the energy from exhausted air. The new system is a vast improvement over the old ventilation system, which did not recover energy from outgoing air. The existing ventilation method not only created hot and cold spots within the space, but it also significantly increased the load on the chiller and boiler systems. The upgraded system provides even distribution of conditioned air across the classroom and works to eliminate any humidity issues in the classroom. Along with the unit ventilator upgrades, AHUs serving major spaces will be refurbished to improve their longevity and continued service.

By taking on a comprehensive HVAC upgrade for the classrooms, the building heating and cooling requirements will also change. To meet the new reduced cooling demand the existing 190-ton chiller will be right-sized to meet the new cooling demand of the building (new chiller is currently sized to be 160 tons; design to be finalized). This drives additional energy saving potential and critical infrastructure renewal.

The following is depiction of new classroom unit ventilator and downsized chiller to be installed.

ECM 15 - HVAC System Improvement – Royersford ES

Royersford ES is served by a HVAC system consisting of AHUs, fan coil units and unit ventilators. The AHUs serve large spaces, and the classrooms are conditioned by unit ventilators with constant speed supply fans and outside air dampers. These systems work in conjunction with relief vents and exhaust fans in the building to ensure proper air circulation.

The new HVAC system being proposed at Royersford ES will be a combination of installing dedicated rooftop DOAS with cooling, heating and energy recovery ventilation capabilities along with new duct work, piping, and direct gas supply to the units. The DOAS system will provide well managed levels of tempered ventilation to the schools. Along with the DOAS system fan coil units will be installed to meet the heating and cooling needs of the individual spaces.

The new DOAS system is designed with the ability to provide heating and cooling as well as energy recovery, further reducing the overall load on the heating and cooling system. To meet the new reduced cooling demand one of the existing 80-ton chiller will be right-sized to meet the new cooling demand of the building and the boiler system will also be replaced with appropriately sized units to meet the adjusted demand (new chiller is currently sized to be 50 tons and boiler at two 1000 MBH units; design to be finalized).

A chiller and boilers similar to the images below will be installed as part of the scope at Royersford ES.

Investigated but Not Included:

ECM 2 – Interior Occupancy Controls

JCI explored adding advanced controls to interior lighting. Sensors would be capable of controlling light based on occupancy and daylight levels (known as daylight harvesting).

JCI performed baseline measurements of lighting run hours and found them to be considerably lower than average. SFASD teachers and staff do a notably good job of managing light use and keeping lights off when classrooms and spaces are unoccupied.

With these low run hours, occupancy sensors will provide only marginal benefit to the school district and the cost of this hardware cannot be justified by the energy cost savings (the simple payback on this measure was more than 20 years). It is worth noting however, that the new lighting retrofit kit fixtures being installed as part of ECM 1 can have an occupancy sensor easily added via USB connector in the future.

ECM 3 – Exterior Lighting

JCI performed a preliminary survey of existing exterior lighting systems at the buildings within the school district. Majority of exterior lighting including wall packs, flood lights, shoebox, canopy, and pole-mounted fixtures have already been upgraded to low watt LED fixtures that deliver energy savings to the school district. Initially it was considered to incorporate pole lighting repairs into the project, but this scope was removed in early stages due to the lack of energy savings relative to high cost. No further exterior lighting upgrades were necessary as part of the scope.

ECM 4 – Stadium Lighting Upgrades

Stadium Lighting upgrades were investigated at the Coach McNelly Stadium and the Rams Field. These upgrades had simple paybacks in excess of 39 years. Theses upgrades would likely provide a quality of light improvement to the sports facilities; however, energy cost savings is limited due to low hours of operation. Currently Stadium Lighting is managed through a contract with Musco Lighting. The lighting system is not in immediate need of replacement but may be in the coming years. It will be most cost-effective for the school district to work directly with Musco who will provide full-service upgrades for the lighting.

ECM 5 – Building Envelope Improvements

This measure includes weatherization of the ten buildings that will save energy by reducing loads on space conditioning equipment. Weatherization includes window caulking, door seals, sealing roof-wall joints, and the addition of attic insulation. Tighter and better insulated buildings allow mechanical equipment to run less often and still maintain the desired interior environment. The benefits of a successful weatherization project are reduced fuel consumption, reduced utility costs, and improved occupant comfort.

This measure was excluded due to the low impact on the project’s energy savings profile. Several elements of this measure can be and are being performed in-house.

ECM 7 – Water Conservation

As part of this scope, JCI completed a holistic review of the existing plumbing fixtures and water usage at the buildings. JCI determined that the water usage infrastructure is well maintained, and the district makes good use of low flow fixtures and irrigation water management. JCI did identify some specific instances where water conservation projects could be undertaken to save water, however the costs outweighed the benefits.

ECM 8 – Recommission DDC Controls

With this measure, JCI would provide detailed HVAC programming and equipment review across all ten facilities along with adjusting setpoints, system overrides where conducive to equipment performance and overall system efficiency. The general intent of this ECM is to restore peak performance of the HVAC systems. This measure was proposed to save significant energy by optimizing the overall system operation and eliminate losses occurring due to ongoing usage/wear and tear of the systems. However, HVAC controls are already well managed, and the school district can accomplish this non-invasive, non-construction intensive measure outside of this project.

ECM 12 – Load Shedding / PLC Mgmt / DR and Battery Storage System

A portion of SFASD’s PECO electric bill is for peak demand and peak load contribution (PLC). Demand and PLC can be managed using custom programming of the BAS to selectively turn off (shed) equipment (loads), such as HVAC equipment, or adjusts setpoints to limit energy use during periods of the day that are traditionally high-use peak times. The approach could also monitor continuously to maintain a specified energy reduction by shedding non-critical loads. Another approach would be to add a battery storage system to store energy during off peak times and discharge when peak load is approaching.

While investment in these approaches make sense in areas of high electricity demand, where demand is priced accordingly, Spring-Ford’s billing data at a building level does not reflect a significant enough demand penalty to warrant the investment in managing the subcomponents of demand billing. Energy efficiency measures are typically evaluated in the context of *both* improving site conditions *and* saving energy; demand reduction measures do not typically create benefits beyond utility savings and may also require a curtailment in lighting and/or space conditioning.

It is worth noting that the school district is also already participating in a demand management program with EnelX.

ECM 13 – Chiller Replacement

JCI evaluated replacement of the existing nominal efficiency chillers with new high efficiency units at Brooks ES and 8th Grade Center. The proposed chillers improve part-load performance and uses environmentally friendly R-134A refrigerant. Replacing the old chillers will avoid future chiller repair and replacement expenditures for the district. The latest generation of air-cooled chillers also have variable frequency drive compressors, improved DDC and operating sequences to improve efficiency, reliability, and turndown capacity.

This measure is excluded as Brooks ES chiller was replaced by the district due to immediate requirement and the 8th Grade Center units are proposed to be replaced as part of the district's capital plan.

ECM 16 – UV-C Systems

Installation of an Ultraviolet-C (UV-C) solution within AHUs (including large energy recovery ventilators) at SFASD was considered. Air quality of spaces served using this technology will improve by eradication of airborne pathogens. More recent AHU and other equipment offerings come with an option to add this factory installed. Though this measure is proven to provide improved air quality, the measure does not provide any savings, and has an energy penalty. In this regard, JCI recommends keeping fresh air ventilation at levels recommended by ASHRAE Standards. Including UV-C options (or heat wheels) should be considered when evaluating future equipment replacement.

ECM 17 – Solar Photovoltaic Systems

JCI performed a detailed analysis of solar potential at all ten building locations. The goal of the measure was to sustainably reduce utility cost by allowing the school district to generate its own electricity. Options explore included roof mount and ground mount installations as well direct ownership and power purchase agreements (PPA). The measure was also explored as a means of managing peak power demand. Ultimately, the measure was not included because it neither had a reasonable simple payback (>30 years), nor addressed a significant infrastructure need. Low electricity cost from the utility is the greatest inhibitor to the economic viability of this measure. See Appendix F for solar photovoltaic (PV) layouts developed by JCI.

ECM 18 – AHU Refurbishment

Refurbishment of AHUs will extend the life of existing units by cleaning the interiors, replacing failed parts and components including motors and dampers, and through cleaning of the coils where applicable. This ECM was proposed to include 11 AHUs at 8th Grade Center, seven units at 9th Grade Center, and 41 units at Spring-Ford Area HS. Some of the other schools were also considered for this scope. On many units where parts are hard to source and equipment (new motors) requires a crane lift, replacement becomes a more pragmatic option. Though the impact of this measure extends the life of the equipment, the energy savings component is minimum, and the measure is cost prohibitive for the target size of the overall project. AHUs are being refurbished at Limerick ES (ECM 14) and Royersford (ECM 15). It is recommended that for future capital projects, the school district considers replacement instead of refurbishment for some of its oldest units that are no longer supplied with parts.

ECM 19 – AHU Replacement

Five AHUs at Brook ES were considered for replacement as part of this scope. Similar to AHU Refurbishment, the energy savings component was minimum, and the measure was cost prohibitive in the context of payback. The new units would dramatically reduce the O&M associated with these units. Some of these units are in the district's plan for future replacement but are still functional in the short-term.

ECM 20 – Unit Ventilator Replacement

8th Grade Center has a total of 29 Trane unit ventilators serving the classrooms across the building. These units are original to the renovations of the building and are near the end of useful life. With the overall aging infrastructure at 8th Grade Center, the district would be better suited to handle this as comprehensive project inclusive a holistic renovation of the buildings HVAC like proposed at Limerick ES and Royersford ES (ECMs 14 and 15).

ECM 21 – Motor Replacement

During the discovery phase of the IGA a total of 16 motors pump motors in the range of 7.5 HP to 125 HP were considered for replacement at five schools. Replacement of existing pump motors with high efficiency rate motors allows the district to capture energy savings and renews its equipment. This measure has been excluded from the project due to high payback. In many cases, motors can be more cost effectively replaced in-house.

ECM Savings Estimates

The following tables provides a breakdown of energy savings by utility type for the final scope of work included as part of this project:

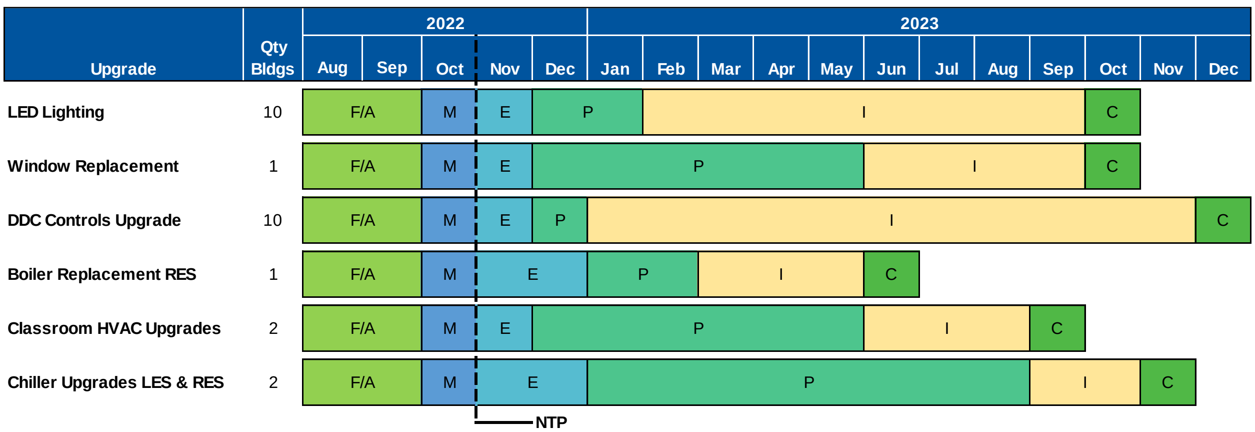
ECM No.	Energy Conservation Measure	Electricity Savings (kWh)	Monthly Demand Savings (kW)	Total Electric Savings $	Natural Gas Savings (CCF)	Natural Gas Savings $	Total Utility Savings
1.0	Interior Lighting LED Upgrade - Kit Replacement	1,768,311	782	$172,838	-	($2,423)	$170,414
6.0	Window Replacement [LES]	24,885	41	$1,437	70,828	$558	$1,995
9.0	Upgrade DDC System [10 Bldgs]	-	-	$0	-	$0	$0
14.1	CR Ducted UV Upgrade [LES]	(1,903)	118	$951	4,025	$2,821	$3,771
14.2	Chiller, Pumps & VFD Upgrades [LES]	14,554	56	$1,343	-	$0	$1,343
14.3	Admin Area VRF System Upgrade [LES]	(1,700)	(1)	($107)	714	$501	$393
14.4	AHU Refurbishment (x3) [LES]	8,130	28	$721	(154)	($108)	$613
15.1	CR UV & FCU Upgrade [RES]	(14,047)	(3)	($838)	5,415	$3,795	$2,957
15.2	Chiller, Pumps & VFD Upgrades [RES]	18,189	67	$1,652	-	$0	$1,652
15.3	Boiler, Pumps & VFD Upgrades [RES]	(910)	(1)	($62)	7,288	$5,107	$5,046
15.4	AHU Refurbishment (x6) [RES]	11,123	38	$984	(280)	($196)	$787
	Total	**1,826,632**	**1,125**	**$178,919**	**87,836**	**$10,054**	**$188,973**

Implementation

As part of the outlined project, JCI will finalize design, procure labor and material, plan, manage, and supervise construction activity, functionally test equipment, train staff, and turn over all equipment and design documentation.

Indicative Project Implementation Schedule

The following table summarizes the target plan for executing construction of this project. Relatively non-invasive construction can be accomplished during second shift in the spring and fall, while heavy construction will take place during the summer. The schedule is contingent upon JCI receiving a NTP in October of 2022. This timing is critical due to the long lead times on equipment.



Financing and Approval	F/A
Mobilization	M
Engineering / Planning	E
Procurement	P
Installation	I
Closeout	C

Material Purchase	Leadtime
Unit Vents, FCUs & VRF	30 weeks
Chillers	42 weeks
Boilers	12 Weeks
Windows	16 weeks
Lighting	8 weeks

Training

By partnering with JCI, SFASD will have the ability to customize training to increase the self-sufficiency of your staff or to develop competencies in specific areas. Training, in conjunction with our other ongoing support offerings, maximizes the efficiency of your building operations.

As the leading technical service provider with 16,000 technicians and 12,500 global service delivery personnel, JCI has more in-house knowledge regarding efficiency than any other company in the world. We have implemented similar energy and process improvements in countless educational facilities. Our training programs are focused on:

- Reducing facility energy costs, operation risks and equipment downtime.
- Increasing equipment reliability/life.
- Increasing workforce productivity and improving job satisfaction with fewer turnovers.

Based on the identified training gaps or to address new equipment or systems, we will work with the school district to determine the best approach to providing training on the new systems and equipment. Topics typically include:

1. Startup and shutdown procedures, operation under all modes of operation, and correct procedures under emergency or abnormal conditions.
2. Procedures necessary for effective operational monitoring and alarming.
3. Analysis of useful information that can come from monitored data, and why the information is important in analyzing the system operation.
4. Inspection, service, and maintenance requirements for each system.

Training of SFASD Personnel

ECM training will be a joint effort between equipment, material vendors, and JCI staff. JCI will conduct initial training for O&M of new systems for facility personnel. ECM training will include aspects of operation for which the SFASD staff will have direct involvement and responsibility. O&M manuals will be presented and reviewed to cover step-by-step maintenance and repair procedures consistent with manufacturers' recommendations.

ECM training programs will be prepared for each Selected ECM. The JCI Construction Project Manager, along with the installation subcontractor, equipment suppliers, and/or factory representatives, will provide this training using equipment O&M manuals and actual equipment installed. ECM training will also include a review of the basis for the savings.

JCI will provide a letter to SFASD listing those individuals who have satisfactorily completed the training.

JCI's training personnel will provide or arrange for instruction on the operation, troubleshooting, maintenance, and repair of equipment and systems modified or installed under each Selected ECM. Training will be conducted onsite using actual Selected ECM equipment wherever possible. For major equipment installed as part of ECM implementation, training may be supplemented with an instructional session by the equipment vendors. The session would include maintenance requirements, emergency and emergency shutdown procedures, technical functions, and warranty provisions for their equipment. For example, EMS vendors offer classroom training using mock-ups and computer simulation of the actual energy management control strategies that JCI installs.

The following table summarizes the amount of training to be provided on an ECM- by-ECM basis:

EC M	ECM Description	Hours for Training Provided in Contract	Training By (Prime/Sub/Rep)	Media	General Training Description
1.0	Lighting LED Upgrades	2	Prime	As-Builts, LxL, and O&M Manuals	Review of As-Builts, O&M, Warranty Procedure
6.0	Window Replacements	2	Subcontractor	As-Builts and O&M Manuals	Review of As-Builts, O&M, Warranty Procedure
9.0	DDC Equipment Upgrades	2	Prime	As-Built Drawings O&M Manuals	Review of As-Builts, O&M, Warranty Procedure
9.0	Metasys Controls	3 Day class - 2 seats (48 total hours)	JCI Institute	Metasys Operator Training Class #388	Workshop held at JCI branch office for two district employees. Training lab environment with other students in classroom. All Metasys workstation operations are taught in 3 - day session.
15.1	HVAC System - DOAS	4	Sub/Rep	Video Recording, As-Builts, O&M Manuals	Operation of Equipment, Review O&M Manuals
14.2 15.2	Chiller Replacement	4	Prime	Video Recording, As-Builts, O&M Manuals	Operation of Equipment, Review O&M Manuals
15.3	Boiler Replacement	4	Prime	Video Recording, As-Builts, O&M Manuals	Operation of Equipment, Review O&M Manuals

Measuring and Guaranteeing Performance

Our Assured Performance Guarantee works in a straightforward manner. If the utility and operational savings are less than the guaranteed amount, we will pay the shortfall. The guarantee is reconciled annually, as described below. The Assured Performance Guarantee is not a third-party insurance policy. We are directly accountable for the financial risk.

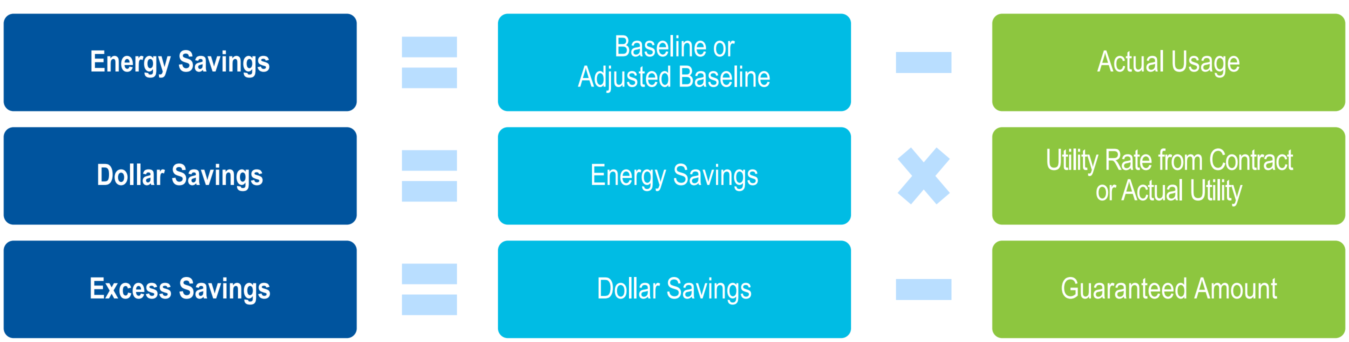
To ensure we are achieving the savings and accurately measuring project performance, we worked with the school district to implement a plan for ongoing services. Specifically, the performance engineer is responsible for:

- Monitoring, evaluating, and adjusting for performance after installation.
- Resolving any problems that may arise.
- Consulting with the school district to ensure customer satisfaction.

The performance engineer is also responsible for monitoring and reporting the savings. The nature of our guarantee is defined in the following development, tracking and reconciliation process:

- JCI guarantees in writing the savings amount in an exhibit included in the contract.
- As the installation of ECMs are completed, JCI will begin monitoring and reporting the savings performance of the program and will continue to do so for the duration of the agreement.
- On an annual basis, we will collate the information and reconcile the guarantee if need be. If there is a shortfall, JCI will pay the difference between the actual and the guaranteed amount to the school district in the form of a check or services in kind.
- The annual tracking and reconciliation process is repeated each year throughout the term of the agreement.

Cost savings are determined as follows:



This figure shows how we calculate energy savings, dollar savings, and excess savings.

JCI has the experience and the assets to provide a true performance guarantee. We employ a proven process for definition, measurement, tracking and reconciliation of such a contract. JCI assumes the risk; we do not “sell” the risk to an outside insurance provider. Therefore, we maintain a stake in the overall performance of the project.

Measurement and Verification Methodologies

The types of Measurement and Verification (M&V) methodologies that JCI will use to guarantee the performance of this project have been developed and defined by widely used guidelines including International Performance Measurement and Verification Protocol (IPMVP) 2016.

There are four guarantee options that may be used to measure and verify the performance of a particular ECM. Each one is described below.

Option A – Retrofit Isolation: Key Parameter Measurement

Energy savings is determined by field measurement of the key parameters affecting the energy use of the system(s) to which an improvement measure was applied separate from the energy use of the rest of the facility. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter, and the length of the reporting period.

Measurement of key parameters means that those parameters not selected for field measurement will be estimated. Estimates can be based on historical data, manufacturer’s specifications, or engineering judgment. Documentation of the source or justification of the estimated parameter will be described in the M&V plan in the contract. Energy savings is determined through engineering calculations of the baseline and post-retrofit energy used based on the combination of measured and estimated parameters, along with any routine adjustments.

Option B – Retrofit Isolation: All Parameter Measurement

Like Option A, energy savings is determined by field measurement of the energy use of the systems to which an improvement measure was applied separate from the energy use of the rest of the facility. However, all the key parameters affecting energy use are measured; there are no estimated parameters used for Option B. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the savings and the length of the reporting period. Energy savings is determined through engineering calculations of the baseline and post-retrofit energy used based on the measured parameters, along with any routine adjustments.

Option C – Whole Building Metering/Utility Bill Comparisons

Option C involves the use of utility meters or whole building sub-meters to assess the energy performance of a total building. Option C assesses the impact of any type of improvement measure, but not individually if more than one is applied to an energy meter. This option determines the collective savings of all improvement measures applied to the part of the facility monitored by the energy meter. Also, since whole building meters are used, savings reported under Option C include the impact of any other change made in facility energy use (positive or negative).

Option C may be used in cases where there is a high degree of interaction between installed improvement measures or between improvement measures and the rest of the building or the isolation and measurement of individual improvement measures is difficult or too costly.

This Option is intended for projects where savings are expected to be large enough to be discernable from the random or unexplained energy variations that are normally found at the level of the whole facility meter. The larger the savings, or the smaller the unexplained variations in the baseline, the easier it will be to identify savings. Also, the longer the period of savings analysis after installing the improvement measure, the less significant is the impact of short-term unexplained variations. Typically, savings should be more than 20% of the baseline energy use if they are to be separated from the noise in the baseline data.

Periodic inspections should be made of all equipment and operations in the facility after the improvement measure installation. These inspections will identify changes from baseline conditions or intended operations. Accounting for changes (other than those caused by the improvement measures) is the major challenge associated with Option C-particularly when savings are to be monitored for long periods.

Savings are calculated through analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis.

Option D – Calibrated Simulation

Option D involves the use of computer simulation software to predict energy use, most often in cases where baseline data does not exist. Such simulation models must be calibrated so that it predicts an energy use and demand pattern that reasonably matches actual utility consumption and demand data from either the base-year or a post-retrofit year.

Option D may be used to assess the performance of all improvement measures in a facility, akin to Option C. However, different from Option C, multiple runs of the simulation in Option D allow estimates of the savings attributable to each improvement measure within a multiple improvement measure project.

Option D may also be used to assess just the performance of individual systems within a facility, akin to Option A and B. In this case, the system's energy use must be isolated from that of the rest of the facility by appropriate meters.

Savings are calculated using energy use simulation models, calibrated with hourly or monthly utility billing data and/or end-use metering.

Selecting M&V Options for a Specific Project

The tailoring of your specific M&V option is based on the level of M&V precision required to obtain the desired accuracy level in the savings determination and is dependent on:

- The complexity of the Facility Improvement Measure
- The potential for changes in performance
- The measured savings value

The challenge of the M&V plan is to balance three related elements:

- The cost of the M&V Plan
- Savings certainty
- The benefit of the particular improvement measure

Savings can also be determined by other/non-measured methods. If savings are non-measured, the savings will be determined by a method other than direct measurement and will be described in the M&V documentation.

Non-measured energy savings are typically limited to a small proportion of the overall project energy savings.

Option C was evaluated as a potential M&V method for the Limerick ES and Royersford ES buildings, which will include comprehensive HVAC system upgrades. Savings calculations show that the combined savings in those buildings comprise only 20% of the value of the total project savings, and half of each buildings' savings is lighting. Because only 10% of project savings is related to non-lighting improvements, in the interest of reduced measurement costs, Option A is recommended for the HVAC upgrades instead of Option C. Window replacement at Limerick ES contributes 1% of the total project savings, therefore it is a non-measured ECM.

JCI has recommended M&V methodologies which are summarized the following table.

Proposed Measurement and Verification IPMVP Options

ECM Description	Adjustment Approach - Summary	Description of Measurements
1. Lighting – Lighting LED Upgrades 2. Lighting – Interior Lighting Occupancy Controls	**Option A:** One-time pre and post-retrofit kW measurement. Burn hours and occupancy hours determined using logger data collected in the field on major space types.	**Pre M&V**: Lighting power readings were taken on a sample of the major savings types of lighting fixtures. Additional power readings will be based on manufacturer data. Lighting burn hours and occupancy were measured using light loggers and usage schedules. **Post M&V**: Lighting power readings will be taken on a sample of major savings types of lighting fixtures. These measurements will occur once at the outset of the agreement. Burn hours logged during the baseline data collection will be used as the post-installation burn hours. **Energy Savings**: Energy savings will be calculated using the difference between pre and post wattage applied to measured burn hours. Occupancy sensor savings will be calculated using the post wattage and occupancy hours.

ECM Description	Adjustment Approach - Summary	Description of Measurements
14,15. HVAC System Upgrades	**Option A:** Building modeling software was calibrated to the baseline usage. Savings is based on modeling software output. **(Limerick ES, Royersford ES)**	**Pre M&V**: Building modeling software (eQUEST) was used to calculate energy consumption baselines. Models were be calibrated to utility bills. **Post M&V**: Control points within the building management system (e.g. occ command, fan status, zone temperature, outdoor temperature, warmup/cooldown command, damper position, minimum damper setpoint) will be trended and/or totalized over the course of system operation. This data will be used to verify that all control strategies are in place and functioning as intended. If differences are found to be due to the fault of JCI, savings will be adjusted accordingly. **Energy Savings**: The savings generated by the building model will be used for calculations. If differences occur between the as-built condition and the original design, the savings will be re-calculated.
6. Window Replacements	**Non-measured:** Savings are from the reduced heating/cooling loss by replacing the windows. **(Limerick ES)**	**Pre M&V:** The type and quantity of the existing windows was determined from a field audit. Savings from window installation was determined by modeling software. **Post M&V:** Once the installation is completed, the type and quantity of windows will be determined from as-builts. **Energy Savings:** If differences occur between the as-built and the original design, the savings will be re-calculated.

Grants, Rebates, and Incentives

Find Money Here: Professional Grant, Rebate & Incentive Services

With tight budgets, many of our customers need creative sources of financing for their projects. Our Alternative Funding Team has one shared goal: to find money for you. The team identifies and helps apply for applicable grants, rebates, and incentives so you can make more improvements to your facilities and infrastructure, reduce total cash outlay, and realize greater savings.

Leverage our grant expertise

Countless customers have turned to our dedicated grant experts. With your permission, we are ready to help you. We can collaborate to identify qualified funding opportunities, facilitate and develop grant applications, and provide support to help manage reporting and compliance requirements.

Sample opportunities include, but are not limited to, energy efficiency improvements; compressed natural gas buses; security equipment and emergency operations planning; renewable energy projects; professional development; environmental education; landscaping; and parks, playgrounds, and recreational facilities.

Drive down the cost of your project

Since 2009, Johnson Controls has helped win more than $433 million in grant funding.

Our team has an 80% win rate compared to an average industry win rate of 17% – 30%.

We win funding from many sources, including the U.S. Department of Energy, the U.S. Department of Justice, and the U.S. Department of Homeland Security.

At your request, we will use the following process to help you identify and secure funding:

1. Conduct customized research and identify organizational and project-specific government and private grants, as well as subsidized loans and bonds.
2. Generate a funding opportunity report that highlights potential sources.
3. Create a project management plan for application development.
4. Manage the grant application process from start to finish.
    a. Implement strategy to develop and gather appropriate information for competitive and responsive proposals.
    b. Coordinate completion of required attachments.
    c. Write, edit, and format response documents.
5. Review final content to ensure compliance with requirements, ensuring project schedules are met.

We work together throughout this process. Your organization will focus on identifying subject matter experts, obtaining application review and approval from executive leadership, contributing key program and organizational information, and submitting a final application. This close collaboration strengthens the final application.

Sampling of Grants Received by Our Customers and Partners

- Nueces County, Texas – $7.9 million to support energy efficiency facility improvements.
- Acadia Parish School Board, Louisiana – $7.3 million in Qualified Zone Academy Bonds. Funding paid for facility renovations that included lighting, an emergency management system, HVAC replacement, and a water well.
- Danbury Housing Authority, Connecticut – $2.5 million to implement energy efficient facility improvements.
- Kalamazoo County, Cheboygan County, and Missaukee County in Michigan – each county received $508,346 through the Energy Efficiency and Conservation Block Grant Program. In total, the three counties received over $1.5 million.
- Case Western Reserve University and JCI, Ohio – $1.4-million research-and-development grant to demonstrate the effectiveness of virtual energy audits in small commercial buildings.
- Santa Fe Trail Board of Cooperative Educational Services, Colorado - $1,240,074 to implement a regional interoperable communications system for six school districts and local law enforcement and first responders.
- Sheridan School District 2, Colorado – $1,102,362 for school security improvements.
- Libby Public Schools, Montana – $1.1 million grant to install a new HVAC system.
- Mississippi State Hospital, Mississippi – $750,000 to support energy efficiency facility improvements.
- Aberdeen Proving Ground, Maryland – $682,000 in grant funding to support energy efficiency facility upgrades.
- Branson 82 School District, Michigan – $625,950 for school security improvements.
- South St. Paul Housing Authority, Minnesota – $529,000 to implement fire safety education, purchase and install kitchen fire prevention equipment, and purchase and install smoke detectors and fire alarms for individuals who are visually and hearing impaired.
- Rose Tree Media School District, Pennsylvania – $500,000 to purchase 15 new compressed natural gas buses.
- Municipal Housing Authority of the City of Utica, New York – $363,672 to implement fire safety prevention education, purchase and install kitchen fire prevention equipment, and purchase and install smoke detectors and fire alarms for individuals who are visually and hearing impaired. A portion of the funds supported the local fire department and local Somali refugee translation services for fire prevention education.
- Rose Tree Media School District, Pennsylvania – $300,000 to convert eight diesel buses to compressed natural gas.
- Rocky Ford School District, Colorado – $258,399 for school security improvements.
- Croswell-Lexington Public Schools, Michigan – $205,448 for security improvements.

- Fort Madison Police Department and Fort Madison Public Schools, Iowa – $174,257 for security funds to evaluate, finalize and implement an enhanced school district safety plan and purchase and install a district-wide card key access system and CCTV system.
- Cheboygan Public Schools, Michigan – $170,000 for school security improvements.
- Warren State Hospital, Pennsylvania – $150,000 to purchase and install a woody biomass boiler.
- Wyandotte Public Schools, Michigan – $148,736 for a more secure front entrance, security equipment, and enhanced security planning.
- Jackson Metropolitan Housing, Ohio – $84,000 to purchase fire prevention equipment focused on individuals and families that have mobility issues and/or hearing or visual impairments. Funds also supported fire prevention education in partnership with the local fire department.
- City of Trinidad, Colorado – $75,000 to install smart water meters.
- Troy Public Schools, Montana – $50,000 to purchase and install a woody biomass boiler.
- Wolverine Public Schools, Michigan – $50,000 for school security improvements.
- Freeland Public Schools, Michigan – $48,074 for school security improvements.
- Clinton County RESA, Michigan – $43,790 for school security improvements.
- West Middlesex Area School District, Pennsylvania – $25,800, to implement a district-wide visitor management system.

Prospective grant funding for SFASD

Based on the potential scope of this project, there are two primary grants we will be targeting for SFASD. Total grant amounts cannot be predicted.

Funding Opportunity	Examples of funded activities	Award information
Grants for Energy Efficiency and Renewable Energy Improvements at Public School Facilities	• Energy efficiency (envelope, HVAC, lighting, controls, etc.), ventilation, renewable energy, alternative vehicles, and alternative fuel vehicle infrastructure improvements.	• Part of the new Infrastructure Bill. • Funding amount: $500,000,000 – available until expended. • Opportunity will open in Fall of 2022. • Infrastructure Bill Guidebook
Alternative and Clean Energy Program (ACE)	• Installation of equipment for use by an eligible applicant to facilitate or improve energy conservation or energy efficiency (including but not limited to heating, lighting, and cooling equipment).	• Program link • 50% match requirement. • Grants for manufacturers of alternative and/or clean energy generation equipment or components shall not exceed $10,000 for every job projected to be created by the business within three years after approval of the grant. • Contact Pennsylvania Department of Community and Economic Development for more information.

Prospective Rebate Funding for SFASD

The following table summarizes rebates that were researched during the IGA. Not all rebates will be achieved as part of this projects and are subject to change based on final project design and rebates available from the utility.

Facility	Associated ECM	Equipment	Qty	Size	Unit	Rebate Type	Rebate/unit	Total
All Facilities	Interior Lighting LED Upgrade	Lamps / Fixt.	16,693*	n/a	Lamps	Prescriptive	Various	$491,858
HS, 9th Cntr	Stadium Lighting Upgrades [HS, 9th]	Lamps / Fixt.	148	n/a	Lamps	Prescriptive	Various	$11,100
All Facilities	Building Envelope Improvements [10 Bldgs]	Envelope	1	222,283	kWh	Custom	$0.10	$22,238
Royersford ES	Attic Insulation & Weatherization [RES]	Envelope	1	5,389	kWh	Custom	$0.10	$539
Limerick ES	Window Replacement [LES]	Envelope	1	1,515	kWh	Custom	$0.10	$152
All	Recommission Controls [10 Bldgs]	RCx	1	637,790	kWh	Custom	$0.10	$63,779
Limerick ES	CR HVAC System Base [LES]	Unit Ventilators	1	5,073	kWh	Custom	$0.10	$507
	Chiller, Pumps & VFD Upgrades [LES]	Chiller	1	190	Tons	Prescriptive	$3,100	$3,500
	AHU Refurbishment (x3) [LES]	Refurbishment	1	7,970	kWh	Custom	$0.10	$797
Royersford ES	CR HVAC System Base [RES]	Unit Ventilators	1	5,000	kWh	Custom	$0.10	$500
	Chiller, Pumps & VFD Upgrades [RES]	Chiller	1	80	Tons	Prescriptive	$3,100	$3,100
	Chiller, Pumps & VFD Upgrades [RES]	CWP Motor	4	15	HP	Prescriptive	$200	$800
	Boiler, Pumps & VFD Upgrades [RES]	HWP Motor	2	5	HP	Prescriptive	$150	$300
	Boiler, Pumps & VFD Upgrades [RES]	HWP VFD	2	5	HP	Prescriptive	$500	$1,000
	AHU Refurbishment (x6) [RES]	AHU	1	6,000	kWh	Custom	$0.10	$600
Multiple	Heat Recovery Unit Refurbishment [4 Bldgs]	HRU	17	11 to 50	HP	Custom	$200	$3,400

*Only lighting fixtures eligible for rebates are indicated in the above quantity for Interior Lighting LED Upgrades

Please note that the above table contains the rebate estimate for projects included and excluded as part of this GESA project.

Appendix

Appendix A: Detailed Facility Descriptions

5th – 7th Grade Center

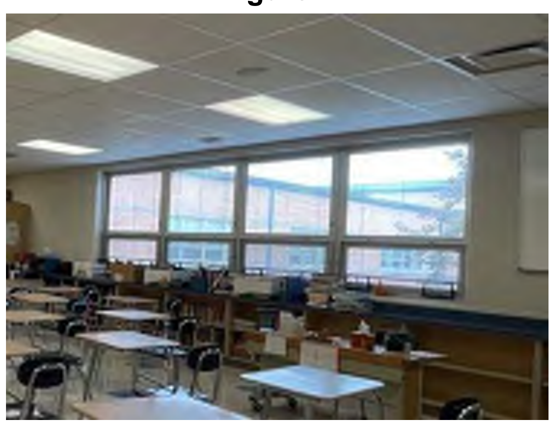
Structure and Envelope

5th – 7th Grade Center is located at 833 S. Lewis Rd, Royersford, PA, and was originally commissioned in 2004 with no other additions/alterations made to-date. The building has a total gross square footage of 335,036. The student body consists of 1,850 students containing grades 5th through 7th grade per enrollment data available from Pennsylvania Department of Education. The two-story building consists of classrooms, a gymnasium/multi-purpose rooms, offices, computer rooms, cafeteria, auditorium and a library. The building edifices are mostly brick veneer and is in good condition. The building's hours of operation are from 6:00 am to 4:00 pm with office areas occupied until 5:00 pm.

The windows that are installed are double-pane, mostly hopper style in aluminum frames. Windows in the building are in good condition and are shown in Figures 1 and 2.

Figure 1

Figure 2



The roof installed is mostly pitched metal with small sections of flat roof for mechanical equipment. From visual inspections, the pitched metal roof appears to be in good condition and the flat sections in fair condition with water pooling observed at the time of the audit. One instance of a roof leak was also found during the audit and are shown in Figures 3 through 7.

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

HVAC Systems

The building's ventilation is primarily through mechanical ventilation. The building is served by heat pumps, heat recovery units, and unit heaters. The units that serve large spaces and can vary the amount of air flow to these spaces for energy efficient operation. These systems work in conjunction with relief vents and exhaust fans in the building to ensure proper air circulation. Figures 8 through 11 show the different type of installed HVAC systems.

Figure 8

Figure 9

Figure 10

Figure 11

Many of the heat pumps in the building are located in the ceiling and are identified by markings on the ceiling tile grids. Larger heat pumps are located in mechanical rooms and is shown in the above pictures.

Many of the equipment are in good condition given their age. A sample of the heat recovery units were opened and inspected. These units will benefit from deep retro-commissioning. Opportunities to restore system performance and increase equipment including verifying motor shaft alignments and cleaning heat wheels inside the unit. Audit observations are shown in Figures 12 through 19.

Figure 12

Figure 13

Figure 14

Figure 15

Figure 16

Figure 17

Figure 18

Figure 19

Air that is introduced into the building is removed using exhaust fans and relief vents. Maintaining proper exhaust fan operation is very important to manage fresh air ventilation and reduce energy usage. The volume of air that is exhausted is drawn into the building by the heat recovery units, operable windows and through any openings that exist around windows, doors, and other building envelope penetrations. The exhaust fans and relief vents are designed to remove air from the corridors, bathrooms, and various other areas.

The HVAC equipment installed is controlled by a DDC JCI Metasys system located in the main mechanical room shown in Figure 20.

Figure 20

Figures 21 through 24 show a sample of thermostats that are installed in the building. The thermostats are mostly of similar vintage. It is recommended the existing thermostats should be considered for upgrade to standardize to smart thermostats. New smart thermostats also have additional built-in features that allow for deeper space setbacks and efficient space comfort management.

Figure 21

Figure 22

Figure 23

Figure 24

The building is served by a geothermal system with a boiler plant for supplemental heating. During the time of the audit, the boiler plant was in the process of being replaced. The overall system is generally in good condition and is shown in Figures 25 through 28. The existing circulation pumps are high efficiency and the volume of water circulating in the loop is varied through the use of variable frequency drives (VFDs). Air conditioning is provided to most spaces of the building by the ceiling installed water source heat pump systems.

Figure 25

Figure 26

Figure 27

Figure 28

Pipe, valve, and impeller insulation opportunities were identified during the audit and shown in Figures 29 and 30. Insulation opportunities were also identified on exterior duct work on which existing insulation had deteriorated, shown in Figure 31.

Figure 29

Figure 30

Figure 31

Building Envelope

There is generally a tight envelope in the building with minimal air gaps observed. Some opportunities were identified during the audit and are shown in Figures 32 and 33. The useful life of weather-strips will vary with usage of the doors they are installed on. The existing door weather-strips were most likely installed when the building was built in 2004. They should be considered for replacement to reduce the air gap between door and frame and thereby reduce energy loss.

Figure 32

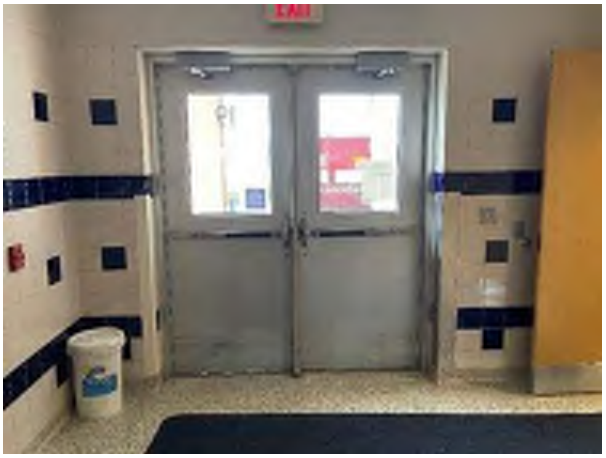


Figure 33

Domestic Hot Water

Domestic hot water is supplied to the kitchen and restrooms by three domestic hot water boilers; one AO Smith boiler rated at 80,000 Btu/hr and two Rheem boilers rated at 500,000 Btu/hr each. All three boilers are located in the main mechanical room and shown in Figure 34.

Figure 34

Kitchen Equipment

The building has a full functioning kitchen including a stove, pot/prep sinks and large refrigeration units. The kitchen exhaust hood is used each day when the school is in session, typically 7am to 2pm.

Figure 35

Figure 36

Figure 37

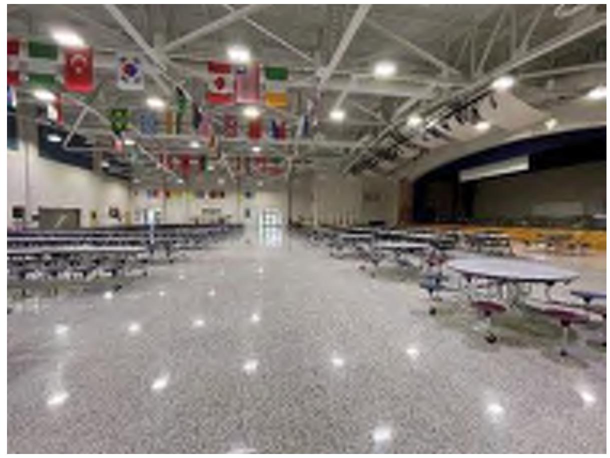
Figure 38

Lighting

A sizeable quantity of fixtures in the building are T-8 fixtures with electronic ballasts. Some spaces such as the cafeteria have been converted to LED. The T-8 fixtures are generally in good condition; nevertheless, upgrades to LED systems should be considered to reduce overall electric energy consumption in the building.

Figure 39

Figure 40



Utilities

On the electric side, the building is provided with secondary, three-phase service by PECO and have a total capacity of 4,000 amps. There are nine step-down transformers located in an electrical closet in the building. The building also has natural gas service for the supplemental boiler and kitchen use.

Figure 41

Figure 42

8th Grade Center

Structure and Envelope

8th Grade Center islocated at 700 Washington Street, Royersford, PA and was originally commissioned in 1930 with additions/alterations made in 1966, 1995 and 2013. The building has a total gross square footage of 130,330. The student body consists of 641 students in 8th grade per enrollment data available from Pennsylvania Department of Education. The three-story building consists of classrooms, gymnasiums, art/music rooms, computer rooms, offices, cafeteria, and a library. The building edifices are mostly brick veneer and is in good condition. The building's hours of operation are from 6:00 am to 4:00 pm with office areas occupied until 5:00 pm.

The windows installed are double-pane, mostly hopper style in aluminum frames with wood finish frames on the interior. Top sections of the windows systems are fixed and inoperable. Windows in the building are in fair to good condition and are shown in Figures 1 and 2.

Figure 1

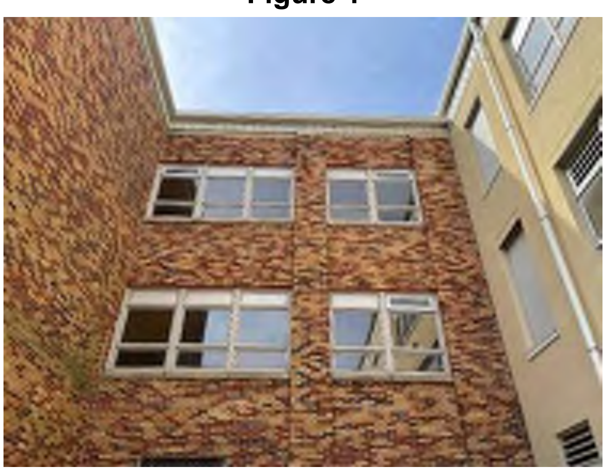


Figure 2

The roof installed on the building has two different types of roof. Some sections have a slightly pitched metal roof and other sections are flat membrane roof.

HVAC Systems

The building's ventilation is primarily through mechanical ventilation. The building is served by unit ventilators for classrooms and AHUs for larger spaces in the buildings. Select spaces in the building also have PTAC and heat pumps. Some AHUs in the building were recently upgraded while the existing unit ventilators are in fair working condition. The units are however being recommended for replacement given their age. The rate of component failure is high towards the end of a HVAC system's lifecycle. Newer systems will also be more energy efficient. Figures 3 through 8 show the different type of installed HVAC systems.

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

Air that is introduced into the building is removed using exhaust fans and relief vents. Maintaining proper exhaust fan operation is very important to manage fresh air ventilation and reduce energy usage. The volume of air that is exhausted is drawn into the building by AHUs, unit ventilators (in select spaces), operable windows and through any openings that exist around windows, doors, and other building envelope penetrations. The exhaust fans and relief vents are designed to remove air from the corridors, bathrooms, and various other areas.

The HVAC equipment installed is controlled by a DDC JCI Metasys system located in the boiler room shown in Figures 9 and 10. Some of the large valves have pneumatic control served by one compressor shown in Figure 11. Additionally, field controllers installed in select mechanical spaces control the large AHUs. One such control panel is shown in
Figure 12.

Figure 9

Figure 10

Figure 11

Figure 12

Figures 13 through 16 show the typical thermostats that are installed in the building. In some instances, the old thermostats were left in place and new thermostats were installed next to the old units. It is recommended the existing thermostats should be considered for upgrade since new smart thermostats provide more data points. New smart thermostats have additional built-in features that allow for deeper space setbacks and efficient space comfort management. It is also recommended the abandoned thermostats be removed and disposed of properly.

Figure 13

Figure 14

Figure 15

Figure 16

Air condition is provided by two air-cooled chillers located on the ground level. One of the Trane chillers is at the end of its useful life and should be considered for replacement. Figure 17 shows the newer chiller and Figures 18 through 21 show the old chiller.

Figure 17

Figure 18

Figure 19

Figure 20

Figure 21

Two boilers are installed to provide hot water for the heating of the building, shown in Figures 22 and 23. The Weil-McLain boilers are dual-fuel, of identical capacity and are in good working condition.

Figure 22

Figure 23

The conditioned water is circulated to unit ventilators and AHUs utilizing pumps located in the boiler room. The overall circulation system is in good condition and is shown in Figures 24 and 25. The existing pump motors are standard efficiency and shall be considered for upgrade to higher efficiency motors.

Figure 24

Figure 25

The chilled water system pumps were observed to be operating on the day of the audit when the building was unoccupied. A VFD based system will allow for scaling back water circulation during unoccupied hours.

Figure 26

The existing unit ventilations are in fair to poor condition and nearing the end of its useful life. It is recommended these units be upgraded to avoid high maintenance expenditure and downtime. Figures 27 through 33 show some of the observations made on the sample unit ventilators inspected during the audit. Damaged fin coils and corrosion on pipes and tubes was consistent in the unit ventilators opened for inspection.

Figure 27

Figure 28

Figure 29

Figure 30

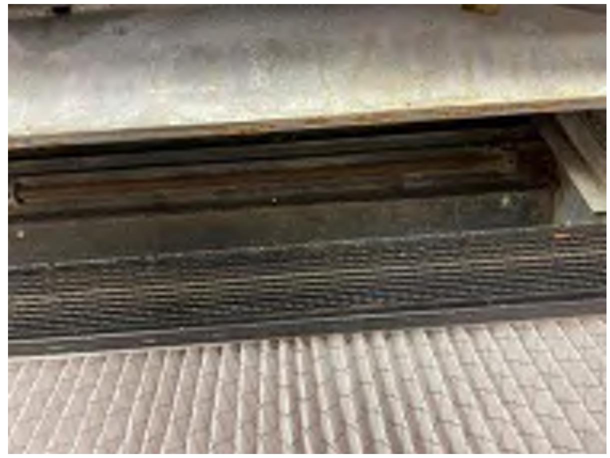


Figure 31

Figure 32

Figure 33

Building Envelope and Insulation

Some building envelope opportunities were identified during the site audit. The conditions observed onsite are shown in Figures 34 and 35. The useful life of weather-strips will vary with usage of the doors they are installed on. The air gap on the door on Figure 34 appears to be minimal while it is clearly visible on the door in Figure 35.

Figure 34

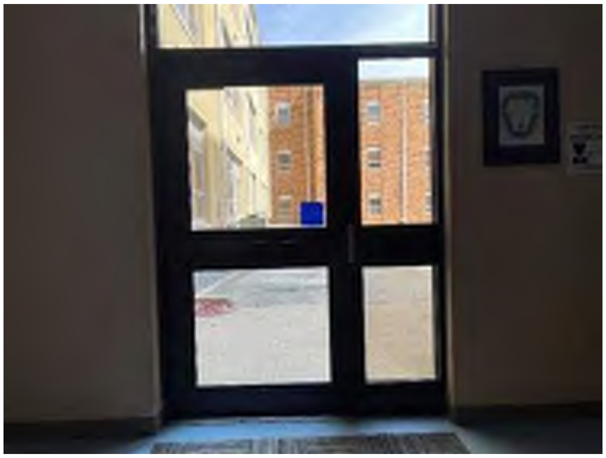


Figure 35

Most heat transfer systems in the building are well insulated and only very minor opportunities for insulation (on domestic hot water piping) were observed during the site audit.

Domestic Hot Water

Domestic hot water is supplied to the kitchen and restrooms by one AO Smith boiler rated at 250,000 Btu/hr located in the boiler room and shown in Figure 36.

Figure 36

Kitchen Equipment

The building has a full functioning kitchen including a stove, pot/prep sinks and large refrigeration units. The kitchen exhaust hood is used each day when the school is in session, typically 7am to 2pm.

Figure 37

Figure 38

Figure 39

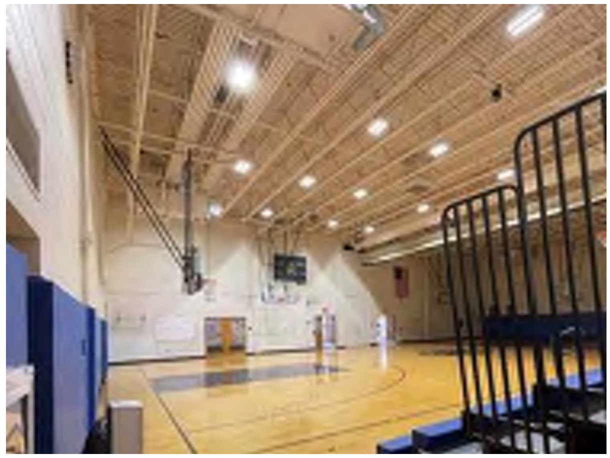
Figure 40

Lighting

A sizeable quantity of fixtures in the building are T-8 fixtures with electronic ballasts. Some spaces such as the Main and Aux Gymnasiums have been converted to LED. The T-8 fixtures are generally in good condition; nevertheless, upgrades to LED systems should be considered to reduce overall electric energy consumption in the building.

Figure 41

Figure 42



The stadium lights next to the 8th Grade Center were evaluated for upgrades. The poles were in good condition and need not be replaced as part of an upgrade to LED.

Figure 43

Figure 44

Utilities

On the electric side, the building is provided with secondary, three-phase service by PECO and have a total capacity of 2,000 amps. There are six step-down transformers located in the electrical closets in the building. The building also has natural gas service for the supplemental boiler and kitchen use. There is also an above ground fuel storage tank located on premises.

Figure 45

Figure 46

Figure 47

9th Grade Center

Structure and Envelope

9th Grade Center is located at 400 S. Lewis Rd, Royersford, PA and was originally commissioned in 1996 with additions/ alterations made in 2005. The building has a total gross square footage of 148,055. The student body consists of 668 students in 9th grade per enrollment data available from Pennsylvania Department of Education. The single-story building consists of basement mechanical room, classrooms, gymnasiums, art/music rooms, computer rooms, offices, cafeteria, and a library. The building edifices are mostly brick veneer and is in good condition. The building's hours of operation are from 6:00 am to 4:00 pm with office areas occupied until 5:00 pm.

The windows that are installed are double-pane, mostly awning style in aluminum frames. Top sections of the windows systems are fixed and inoperable. Windows in the building are in fair to good condition and are shown in Figures 1 and 2.

Figure 1

Figure 2

The roof installed is mostly pitched metal with small sections of flat roof for mechanical equipment. From visual inspections, the roof appears to be in good condition.

HVAC Systems

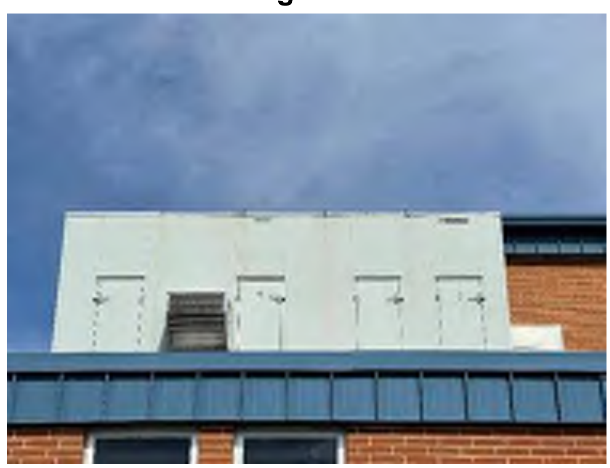
The building's ventilation is primarily through mechanical ventilation. The building is served by heat pumps, heat recovery units, one makeup air unit and unit heaters. These systems work in conjunction with relief vents and exhaust fans in the building to ensure proper air circulation. Many of the equipment are in good to fair condition given their age. Figures 3 through 6 show the different type of installed HVAC systems.

Figure 3

Figure 4

Figure 5

Figure 6



Air that is introduced into the building is removed using exhaust fans and relief vents. Maintaining proper exhaust fan operation is very important to manage fresh air ventilation and reduce energy usage. The volume of air that is exhausted is drawn into the building by the makeup air unit, operable windows and through any openings that exist around windows, doors, and other building envelope penetrations. The exhaust fans and relief vents are designed to remove air from the corridors, bathrooms, and various other areas.

The HVAC equipment installed is controlled by a DDC JCI Metasys system located in the boiler room shown in Figure 7.

Figure 7

Figures 8 through 11 show the typical thermostats that are installed in the building. These thermostats are good working condition, but it is recommended the existing thermostats be considered for upgrade since new smart thermostats provide more data points. New smart thermostats have additional built-in features that allow for deeper space setbacks and more efficient space comfort management.

Figure 8

Figure 8

Figure 10

Figure 11

The building is served by a geothermal system with one boiler for supplemental heating. The overall system is generally in good condition and is shown in Figures 12 and 13. The existing circulation pumps are high efficiency and the volume of water circulating in the loop is varied through the use of VFDs shown in Figure 14. Select storage spaces in the building have dedicated unit heaters.

Figure 12

Figure 13

Figure 14

Air conditioning is provided to most spaces of the building by water source heat pump systems located in the attic and is shown in Figures 15 and 16.

Figure 15

Figure 16

In addition to external observations, one of the heat pumps' paneling was opened to inspect internal conditions. The system appeared to be in good working condition and no leaks were observed.

Figure 17

Figure 18

Building Envelope and Insulation

A sample of the doors observed onsite are shown in Figures 19 and 20. The useful life of weather-strips will vary with usage of the doors they are installed on. Some air gaps were observed onsite, and it is recommended the existing weather-strips be replaced.

Figure 19

Figure 20

Most heat transfer systems in the building are well insulated. The uninsulated pipes on the geothermal side of the system is starting to show signs of corrosion; shown in Figure 21. It is recommended these bare pipes and valves be insulated to prevent leaks in the future. Other minor opportunities for insulation were observed on the domestic hot water piping.

Figure 21

Domestic Hot Water

Domestic hot water is supplied to the kitchen and restrooms by one Bradford White boiler rated at 505,000 Btu/hr located in the boiler room and shown in Figure 22.

Figure 22

Kitchen Equipment

The building has a full functioning kitchen including a stove, pot/prep sinks and large refrigeration units. The kitchen exhaust hood is used each day when the school is in session, typically 7am to 2pm.

Figure 23

Figure 24

Figure 25

Figure 26

Lighting

A sizeable quantity of fixtures in the building are T-8 fixtures with electronic ballasts. Some spaces such as the Main and Aux Gymnasiums have been converted to LED. The T-8 fixtures are generally in good condition; nevertheless, upgrades to LED systems should be considered to reduce overall electric energy consumption in the building.

Figure 27

Figure 28

Utilities

On the electric side, the building is provided with secondary, three-phase service by PECO and have a total capacity of 3,200 amps. There are six step-down transformers located in the electrical closets in the building. The building also has natural gas service for the supplemental boiler and kitchen use.

Figure 29

Figure 30

Brooke Elementary School

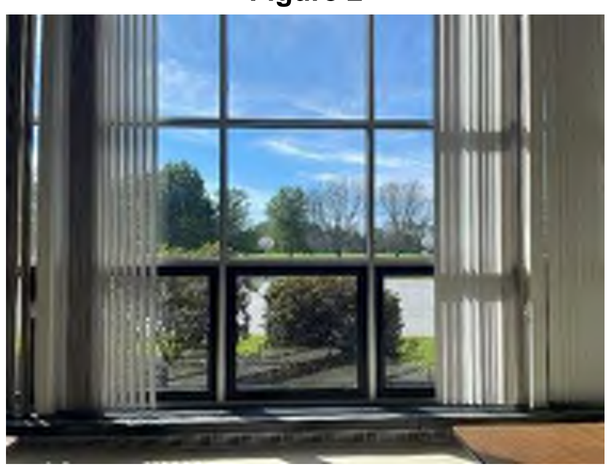
Structure and Envelope

Brooke ES is located at 339 North Lewis Road, Royersford, PA and was originally commissioned in 1991 with no other additions/alterations made to-date. The building has a total gross square footage of 74,109. The student body consists of 441 students containing grades K through 4th grade per enrollment data available from Pennsylvania Department of Education. The two-story building consists of classrooms, a gymnasium/multi-purpose room, offices, cafeteria and a library. The building edifices are mostly brick veneer and is in good condition. The building's hours of operation are from 7:00 am to 4:00 pm with office areas occupied until 5:00 pm.

The windows that are installed are double-pane, mostly awning style in aluminum frames. Top sections of the windows systems are fixed and inoperable. Windows in the building are in fair to good condition and are shown in Figures 1 and 2.

Figure 1

Figure 2



The roof installed is mostly pitched metal with small sections of flat roof for access. Portions of the pitched metal section have mechanical equipment in the space between the metal roof and membrane.

Figure 3

Figure 4

HVAC Systems

The building's ventilation is primarily through mechanical ventilation. The building is served by heat pumps, AHUs and unit heaters in select areas like hallways. The systems are currently in fair working condition. The units are however being recommended for replacement given their age. The rate of component failure is high towards the end of a HVAC system's lifecycle. Newer systems will also be more energy efficient. If replacement is not economical currently, a deep retro-commissioning is recommended to replace aging components, restore equipment performance, and extend the useful life of the equipment. Figures 5 through 8 show the different type of installed HVAC systems.

Figure 5

Figure 6

Figure 7

Figure 8

Air that is introduced into the building is removed using exhaust fans and relief vents. Maintaining proper exhaust fan operation is very important to manage fresh air ventilation and reduce energy usage. The volume of air that is exhausted is drawn into the building by AHUs, unit ventilators (in select spaces), operable windows and through any openings that exist around windows, doors, and other building envelope penetrations. The exhaust fans and relief vents are designed to remove air from the corridors, bathrooms, and various other areas.

The HVAC equipment installed is controlled by a DDC JCI Metasys system located in the boiler room shown in Figures 9 and 10. Some of the large valves have pneumatic control served by one compressor shown in Figure 11. Additionally, field controllers installed in select mechanical spaces control the large AHUs. One such control panel is shown in Figure 12.

Figure 9

Figure 10

Figure 11

Figure 12

Figures 13 through 16 show the typical thermostats that are installed in the building. The thermostats are of varying vintage manufactured by JCI. Figure 14 shows a CO_2 sensor next to thermostat in the cafeteria. It is recommended the existing thermostats should be considered for upgrade since new smart thermostats provide more localized control and also have additional built-in features that allow for deeper space setbacks and efficient space comfort management.

Figure 13

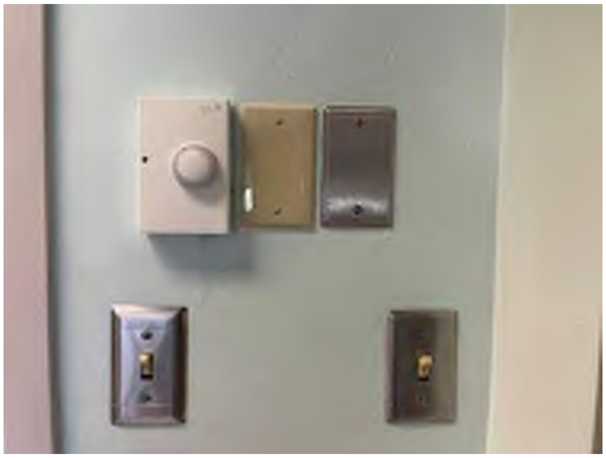


Figure 14

Figure 15

Figure 16

The building is served by two systems; larger spaces are condition by AHUs supported by a boiler plant and a chiller plant and shown in Figures 17 through 22. The chiller plant and boiler plant are in fair condition and should be considered for upgrades.

Figure 17

Figure 18

Figure 19

Figure 20

Figure 21

Figure 22

Certain wings in the building are conditioned by water source heat pumps serviced by a cooling tower which is in fair to poor condition and shown in Figures 23 through 24.

Figure 23

Figure 24

Figure 25

Figure 26

The water source heat pumps and other split units on the roof have R-22 refrigerant and should be considered for upgrade to more environmentally friendly types of systems. The overall systems are in fair to poor condition and is shown in Figures 27 and 28.

Figure 27

Figure 28

Most heat transfer systems in the building are well insulated. Minor opportunities for insulation were observed during the audit and is shown in Figure 29.

Figure 29

Building Envelope

Building envelope opportunities were identified during the site audit and is shown in Figures 30 and 31. The useful life of weather-strips will vary with usage of the doors they are installed on. The existing door weather-strips were most likely installed when the building was built in 1991.

Figure 30

Figure 31

Domestic Hot Water

Domestic hot water is supplied to the kitchen and restrooms by one AO Smith boiler rated at 390,000 Btu/hr located in the boiler room and shown in Figure 32.

Figure 32

Kitchen Equipment

The building has a full functioning kitchen including a stove, pot/prep sinks and large refrigeration units. The kitchen exhaust hood is used each day when the school is in session, typically 7am to 2pm.

Figure 33

Figure 34

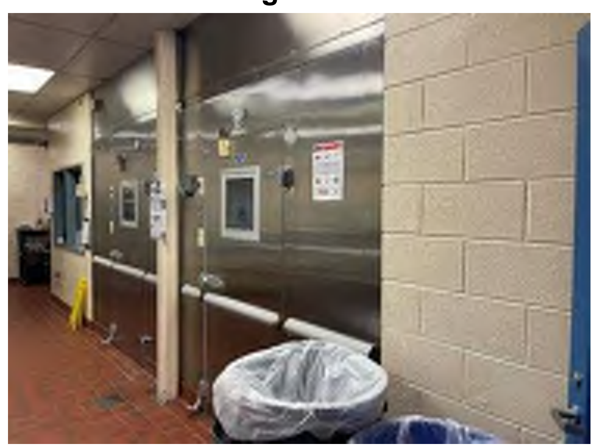


Figure 35

Figure 36

Lighting

A sizeable quantity of fixtures in the building are T-8 fixtures with electronic ballasts. Some spaces such as areas of the library have already been converted to LED. The T-8 fixtures are generally in good condition; nevertheless, upgrades to LED systems should be considered to reduce overall electric energy consumption in the building.

Figure 37

Figure 38

Utilities

On the electric side, the building is provided with secondary, three-phase service by PECO and have a total capacity of 800 amps. There are two step-down transformers located in the boiler room. The building also has natural gas service for the supplemental boiler and kitchen use.

Figure 39

Figure 40

Evans Elementary School

Structure and Envelope

Evans ES is located at 125 Sunset Road, Limerick, PA and was originally commissioned in 2007 with no other additions/alterations made to-date. The building has a total gross square footage of 92,872. The student body consists of 541 students containing grades K through 4th grade per enrollment data available from Pennsylvania Department of Education. The two-story building consists of classrooms, a gymnasium/multi-purpose room, offices, cafeteria and a library. The building edifices are mostly brick veneer and is in good condition. The building's hours of operation are from 7:00 am to 4:00 pm with office areas occupied until 5:00 pm.

The windows that are installed are double-pane, mostly hopper style in aluminum frames. Windows in the building are in good condition and are shown in Figures 1 and 2. Select areas of the building have curtain wall windows.

Figure 1

Figure 2

The roof installed is mostly pitched metal with small sections of flat roof for mechanical equipment. From visual inspections, the roof appears to be in good condition.

HVAC Systems

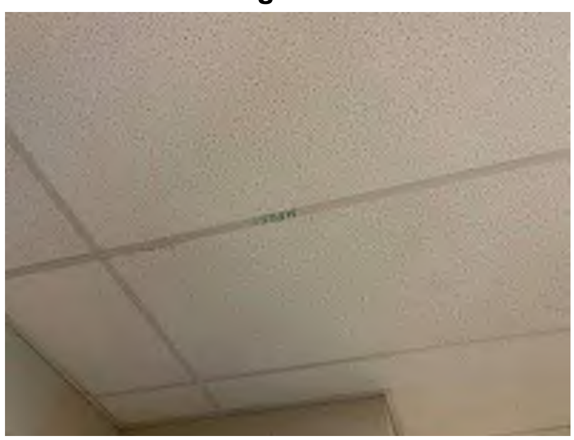
The building's ventilation is primarily through mechanical ventilation. The building is served by heat pumps, heat recovery units, one AHU and unit heaters. The units that serve large spaces and can vary the amount of air flow to these spaces for energy efficient operation. These systems along with the unit ventilators work in conjunction with relief vents and exhaust fans in the building to ensure proper air circulation. Figures 3 and 4 show the different type of installed HVAC systems.

Figure 3

Figure 4

The heat pumps in the building are located in the ceiling and are identified by markings on the ceiling tile grids, as shown in Figure 5.

Figure 5



Many of the equipment are in good condition given their age. One of the heat recovery units was opened and it appeared to be in good condition as shown in Figures 6 and 7. A slight increase in efficiency is expected from retro-commissioning these units.

Figure 6

Figure 7

It is recommended tools and spare parts be stored outside the heat recovery units to prevent accidental damage to the unit during operation.

Figure 8

Figure 9

Air that is introduced into the building is removed using exhaust fans and relief vents. Maintaining proper exhaust fan operation is very important to manage fresh air ventilation and reduce energy usage. The volume of air that is exhausted is drawn into the building by AHUs, unit ventilators, operable windows and through any openings that exist around windows, doors, and other building envelope penetrations. The exhaust fans and relief vents are designed to remove air from the corridors, bathrooms, and various other areas.

The HVAC equipment installed is controlled by a DDC JCI Metasys system located in the boiler room shown in Figures 10 and 11.

Figure 10

Figure 11

Figures 12 through 15 show the typical thermostats that are installed in the building. Most thermostats are of similar vintage and are JCI T600HPP and TE-6700 thermostats. It is recommended these two types of units should be considered for upgrade to new smart thermostats that provide more localized control. New smart thermostats also have additional built-in features that allow for deeper space setbacks and efficient space comfort management.

Figure 12

Figure 13

Figure 14

Figure 15

The building is served by a geothermal system with one boiler for supplemental heating. The overall system is generally in good condition and is shown in Figures 16 and 17. The existing circulation pumps are high efficiency and the volume of water circulating in the loop is varied through the use of VFDs. Select storage spaces in the building have dedicated unit heaters.

Figure 16

Figure 17

The uninsulated pipes on the geothermal side of the system is starting to show signs of corrosion; shown in Figure 18. It is recommended these bare pipes and valves be insulated to prevent leaks in the future.

Figure 18

Air conditioning is provided to most spaces of the building by ceiling mounted water source heat pump systems.

Building Envelope

There is generally good building envelope and is shown in Figures 19 and 20. The useful life of weather-strips will vary with usage of the doors they are installed on. The existing door weather-strips were most likely installed when the building was built in 2007. The next couple of years will be a good time to replace existing weather-strips to continue to maintain a tight building envelope.

Figure 19

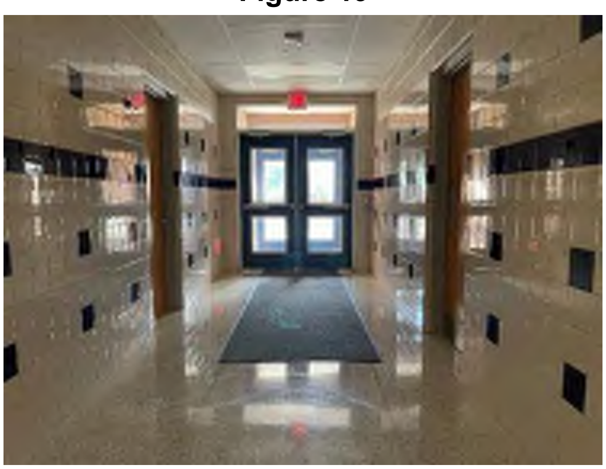
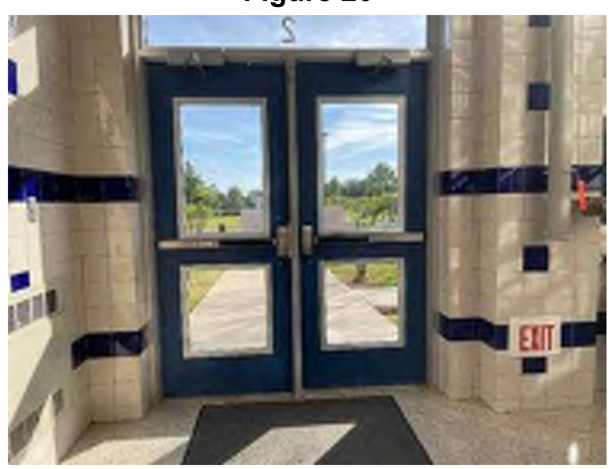


Figure 20



Domestic Hot Water

Domestic hot water is supplied to the kitchen and restrooms by one Bradford White boiler rated at 505,000 Btu/hr located in the boiler room and shown in Figure 21.

Figure 21

Kitchen Equipment

The building has a full functioning kitchen including a stove, pot/prep sinks and large refrigeration units. The kitchen exhaust hood is used each day when the school is in session, typically 7am to 2pm.

Figure 24

Figure 25

Figure 24

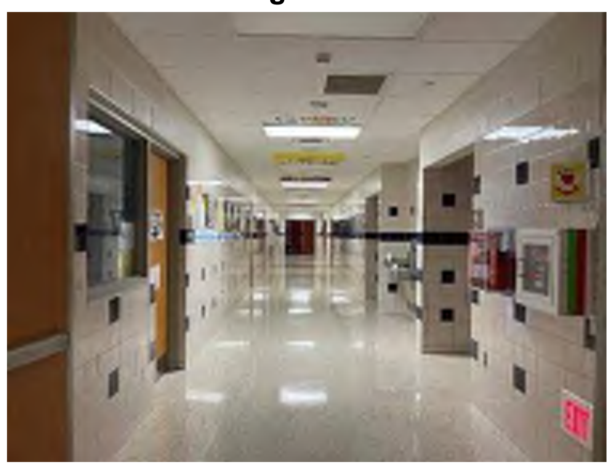
Figure 25

Lighting

A sizeable quantity of fixtures in the building are T-8 fixtures with electronic ballasts. The fixtures are generally in good condition; nevertheless, upgrades to LED systems should be considered to reduce overall electric energy consumption in the building.

Figure 26

Figure 27



Utilities

On the electric side, the building is provided with secondary, three-phase service by PECO and have a total capacity of 3,000 amps. There are ten step-down transformers located in electrical closets in the building. The building also has natural gas service for the supplemental boiler and kitchen use.

Figure 28

Figure 29

Limerick Elementary School

Structure and Envelope

Limerick ES is located at 81 Limerick Center Rd, Royersford, PA and was originally commissioned in the 1959 with additions/alterations made in 1966 and 2002. The building has a total gross square footage of 72,355. The student body consists of 252 students containing grades K through 4th grade per enrollment data available from Pennsylvania Department of Education. The single-story building consists of classrooms, a gymnasium, offices, cafeteria and a library. The building edifices are mostly of masonry and concrete construction and is in good condition. The building's hours of operation are from 7:00am to 4:00pm with office areas occupied until 5:00pm.

The windows that are installed are double-pane, awning style in aluminum exterior frames and interior wood finish that are in fair condition, shown in Figures 1 and 2.

Figure 1

Figure 2

The roof installed is a metal and concrete roof deck and appears to be in good condition from ground level visual inspections.

HVAC Systems

The building's ventilation is primarily through mechanical ventilation. The building is served by AHUs, fan coil units and unit ventilators. The AHUs serve large spaces and can vary the amount of air flow to these spaces for energy efficient operation. These systems along with the unit ventilators work in conjunction with relief vents and exhaust fans in the building to ensure proper air circulation. Figures 3 through 6 show the different type of installed HVAC systems.

Figure 3

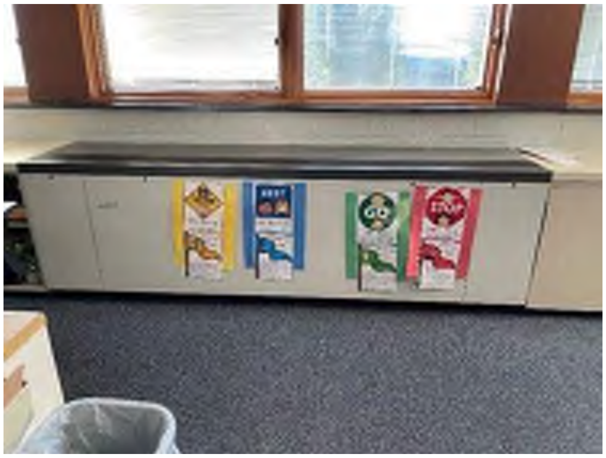


Figure 4

Figure 5

Figure 6

Many of the equipment are in fair to good condition given their age. A sample set of unit ventilators were opened and these appeared to be in good condition as shown in Figures 7 through 10. A slight increase in efficiency is expected from retro-commissioning these units.

Figure 7

Figure 8

Figure 9

Figure 10

The AHUs will benefit more from retro-commissioning thereby increasing overall system performance and extend its useful life. Figures 11 through 14 are of some of retro-commissioning observations made during the site audit.

Figure 11

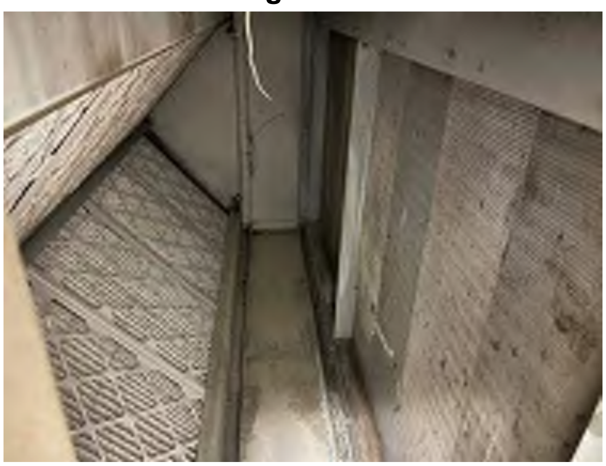


Figure 12

Figure 13

Figure 14

Air that is introduced into the building is removed using exhaust fans and relief vents. Maintaining proper exhaust fan operation is very important to manage fresh air ventilation and reduce energy usage. The volume of air that is exhausted is drawn into the building by AHUs, unit ventilators, operable windows and through any openings that exist around windows, doors, and other building envelope penetrations. The exhaust fans and relief vents are designed to remove air from the corridors, bathrooms, and various other areas.

The HVAC equipment installed is controlled by a DDC JCI system located in the boiler room shown in Figures 15 and 16. Additional field controllers are located within each unit ventilator as shown in Figure 16 and in mechanical spaces in the building as shown in Figure 17 and 18.

Figure 15

Figure 16

Figure 17

Figure 18

Figures 19 through 22 show the typical thermostats that are installed in the building. Most thermostats are of similar vintage and are JCI T-5002 Room Temperature Transmitter. Given the vintage of these units, they should be considered for upgrade to new smart thermostats that provide more data points. This will allow for deployment of deeper space setbacks and more efficient space comfort management.

Figure 19

Figure 20

Figure 21

Figure 22

During JCI's site audit, the boilers serving the building were in the process of being replaced. Only one boiler was installed and connected at the time of the audit. In reviewing the mechanical drawings in the boiler room, it is understood there will be a total of two 2,000 MBH Aerco condensing boilers installed to serve the building. Figure 23 shows the nameplate of the newly installed Aerco boiler.

Figure 23

Figure 24 shows the new hot water pumps installed in the boiler room. These Armstrong pumps are high efficiency and allow for deeper energy saving through highly efficient parallel pump operation. At the time of the audit, these pumps were set to "hand" operation as the boiler plant was in the Installation Phase during the time of the audit.

Figure 24

Figure 25

Figure 26

Air conditioning is provided to most spaces of the building by an air-cooled chiller that appears to be a fair to good condition and is shown in Figure 27. The chiller plant will benefit from minor retro-commissioning including inspection and verification that the condenser fan motors are operating freely and as intended.

Figure 27

Figure 28

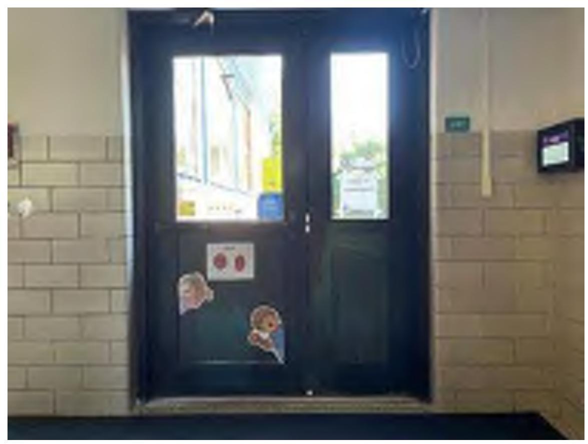
Figure 29

Building Envelope and Insulation

There is generally good building envelope and pipe insulation in the building. Some areas of opportunity were identified during the audit and are shown in Figures 30 and 31. The useful life of weather-strips will vary with usage of the doors they are installed on. Based on JCI's assessment, the existing weather-strips should be replaced to maintain a tight building envelope.

Figure 30

Figure 31



Domestic Hot Water

Domestic hot water is supplied to the kitchen and restrooms by one AO Smith burners rated at 199,000 Btu/hr, located in the boiler room and shown in Figure 32.

Figure 32

Kitchen Equipment

The building has a full functioning kitchen including a stove, pot/prep sinks and large refrigeration units. The kitchen exhaust hood is used each day when the school is in session, typically 7am to 2pm.

Figure 33

Figure 34

Figure 35

Figure 36

Lighting

A sizeable quantity of fixtures in the building are T-8 fixtures with electronic ballasts. Some spaces such as the main gymnasium have been converted to LED. The T-8 fixtures are generally in good condition; nevertheless, upgrades to LED systems should be considered to reduce overall electric energy consumption in the building.

Figure 37

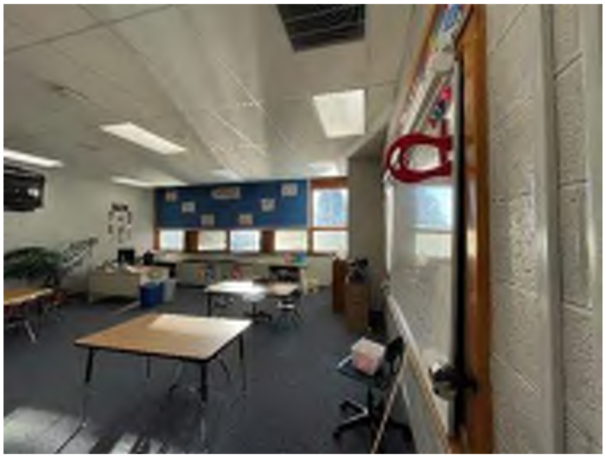
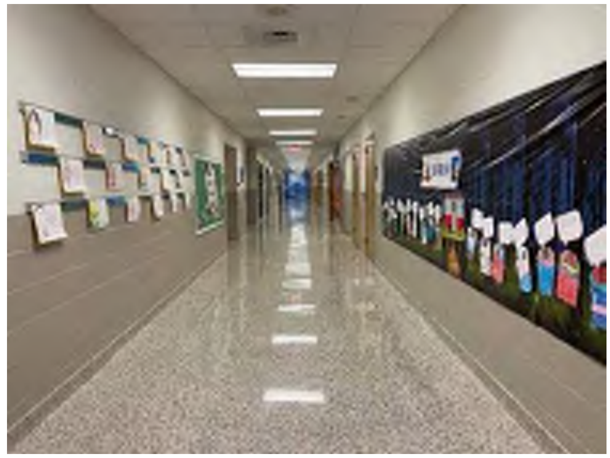


Figure 38



Utilities

On the electric side, the building is provided with secondary, three-phase service by PECO and have a total capacity of 3,000 amps. The building also has natural gas service and a large aboveground fuel storage tank.

Figure 39

Figure 40

Oaks Elementary School

Structure and Envelope

Oaks ES is located at 325 Oaks School Dr, Oaks, PA and was originally commissioned in 1965 with additions/alterations made in 1997 and 2000. The building has a total gross square footage of 76,421. The student body consists of 569 students containing grades K through 4th grade per enrollment data available from Pennsylvania Department of Education. The single-story building consists of classrooms, a gymnasium/multi-purpose room, offices, cafeteria and a library. The building edifices are mostly of brick veneer and is in good condition. The building's hours of operation are from 7:00am to 4:00pm with office areas occupied until 5:00pm.

The windows that are installed are double-pane, mostly awning style in aluminum frames with interior frames in wood. Top sections of the windows systems are fixed and inoperable. Windows in the building are in good condition and are shown in Figures 1 and 2.

Figure 1

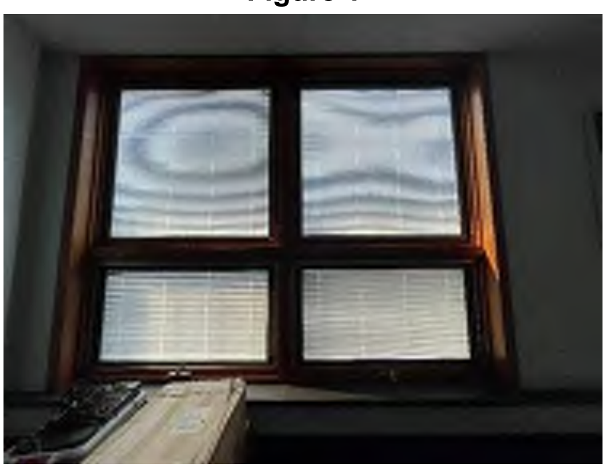


Figure 2

The roof installed is mostly pitched metal and appears to be in good condition. One small section of the flat roof also has metal roof installed over the existing roof.

HVAC Systems

The building's ventilation is primarily through mechanical ventilation. The building is served by AHUs, fan coil units and unit ventilators. The AHUs serve large spaces and can vary the amount of air flow to these spaces for energy efficient operation. These systems along with the unit ventilators work in conjunction with relief vents and exhaust fans in the building to ensure proper air circulation. Figures 5 and 6 show the different type of installed HVAC systems.

Figure 3

Figure 4

A sample set of unit ventilators were opened and these appeared to be in fair to poor condition and are nearing the end of its useful life. It is recommended these units be upgraded to avoid high maintenance expenditure and downtime. Figures 7 through 14 show some of the observations made on the sample unit ventilators inspected during the audit. Damaged fin coils and corrosion on pipes and tubes was consistent in the unit ventilators opened for inspection.

Figure 5

Figure 6

Figure 7

Figure 8

Air that is introduced into the building is removed using exhaust fans and relief vents. Maintaining proper exhaust fan operation is very important to manage fresh air ventilation and reduce energy usage. The volume of air that is exhausted is drawn into the building by AHUs, unit ventilators, operable windows and through any openings that exist around windows, doors, and other building envelope penetrations. The exhaust fans and relief vents are designed to remove air from the corridors, bathrooms, and various other areas. It is understood some of the exhaust fans are inoperable due to access issues to maintain the exhaust fans.

The HVAC equipment installed is controlled by a DDC Siemens Apogee system which appears to be integrated into a JCI supervisory controller, both of which are located in the boiler room and shown in Figures 9 and 10. Additional field pneumatic controllers are located mechanical rooms and within unit ventilators. The compressor providing air to the pneumatic controls and a large valve controller are shown in Figure 11 and 12.

Figure 9

Figure 10

Figure 11 **Figure 12**

During the audit JCI noticed evidence of flooding in the basement of the building shown in Figure 13 and 14. While it is unclear how often flooding happens in the basement, high water levels can contribute to humidity issues. The thermostats in the building should be considered for upgrade (as part of a DDC upgrade) to new smart thermostats that provide humidity monitoring in addition temperature control. This will firstly help identify specific areas in the building that have humidity issues and allow for deployment of localized mitigation strategies including closing outside dampers and localized dehumidification.

Figure 13 **Figure 14**

Two boilers are installed to provide hot water for the heating of the building, shown in Figure 15. The burner system for the boiler is shown in Figure 16. The Weil-McLain boilers have Webster burners, are dual-fuel and are of identical capacity and in good working condition.

Figure 15

Figure 16

Air condition is provided by a ground mounted air-cooled chiller shown in Figure 17. The Trane chiller has a fair amount dust/debris build-up as shown in Figure 18 and will likely see increased efficiency from retro-commissioning.

Figure 17

Figure 18

The conditioned water is circulated to unit ventilators and AHUs using pumps located in the boiler room. The overall circulation system is in fair condition and is shown in Figures 19 and 20. The existing pump motors are standard efficiency and shall be considered for upgrade to higher efficiency motors.

Figure 19

Figure 20

Both existing hot water and chilled water pumps have VFDs to allow for scaled back operation of the water loops during unoccupied and low-demand periods of time. These VFDs for the hot water and chilled water systems are shown in Figure 21 and 22.

Figure 21

Figure 22

Building Envelope and Insulation

A fair amount of building envelope and insulation opportunities were observed during the site audit. In general, all water damaged insulation should be replaced as their integrity has been compromised. A sample of the opportunities identified during the audit and are shown in Figures 23 through 25.

Figure 23

Figure 24

Figure 25

Domestic Hot Water

Domestic hot water is supplied to the kitchen and restrooms by one AO Smith burner rated at 199,000 Btu/hr located in the boiler room and shown in Figure 26.

Figure 26

Kitchen Equipment

The building has a full functioning kitchen including a stove, pot/prep sinks and large refrigeration units. The kitchen exhaust hood is used each day when the school is in session, typically 7am to 2pm.

Figure 27

Figure 28

Figure 29

Figure 30

Lighting

A sizeable quantity of fixtures in the building are T-8 fixtures with electronic ballasts. The fixtures are generally in good condition; nevertheless, upgrades to LED systems should be considered to reduce overall electric energy consumption in the building.

Figure 31

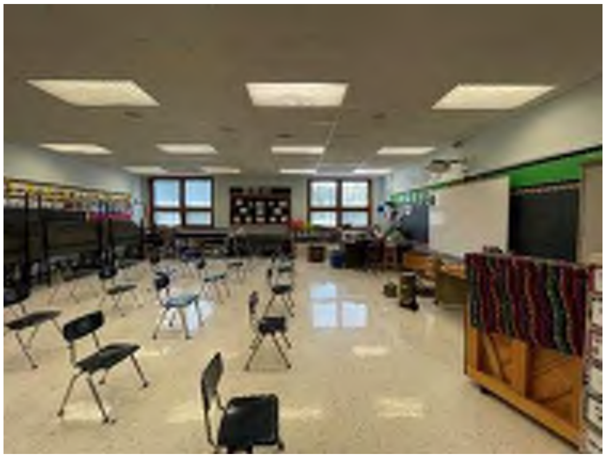
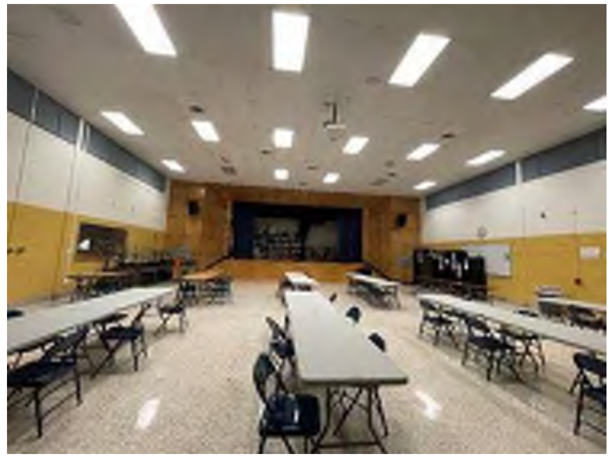


Figure 32



Utilities

On the electric side, the building is provided with secondary, three-phase service by PECO and have a total capacity of 2,000 amps. The building also has natural gas service for the boilers and kitchen use. The building also has a 275-gallon fuel storage tank in the boiler room.

Figure 33

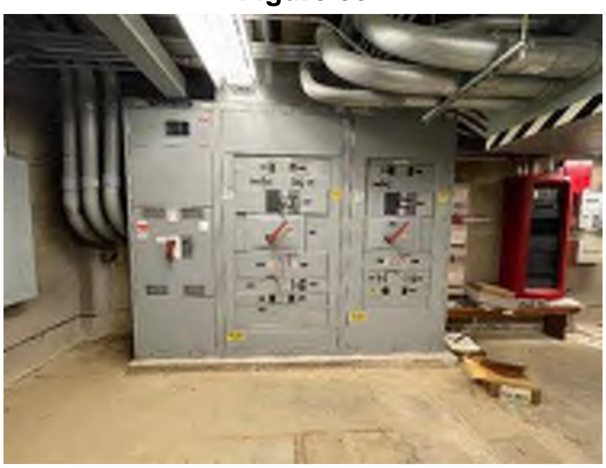


Figure 34

Royersford Elementary School

Structure and Envelope

Royersford ES is located at 450 Spring St, Royersford, PA and was originally commissioned in 1957 with additions/alterations made in 1992. The building has a total gross square footage of 71,222. The student body consists of 385 students containing grades K through 4th grade per enrollment data available from Pennsylvania Department of Education. The single-story building consists of classrooms, a gymnasium, offices, cafeteria and a library. The building edifices are mostly of masonry and concrete construction and is in good condition. The building's hours of operation are from 7:00am to 4:00pm with office areas occupied until 5:00pm.

The windows that are installed are double-pane, single hung style in aluminum frames and are in good condition, shown in Figures 1 and 2.

Figure 1

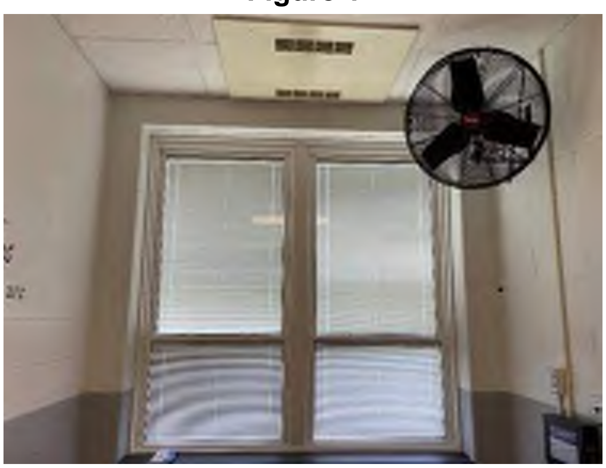


Figure 2

The roof installed is mostly pitched metal and appears to be in good condition. Small sections of the roof with mechanical equipment are flat roof.

Figure 3

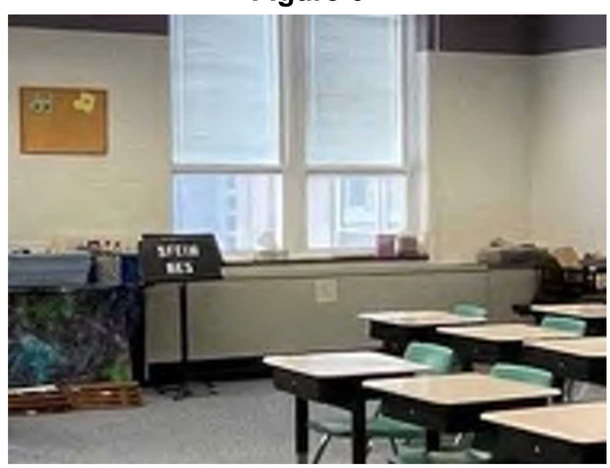
Figure 4

HVAC Systems

The building's ventilation is primarily through mechanical ventilation. The building is served by AHUs, fan coil units and unit ventilators. The AHUs serve large spaces and can vary the amount of air flow to these spaces for energy efficient operation. These systems along with the unit ventilators work in conjunction with relief vents and exhaust fans in the building to ensure proper air circulation. Figures 5 and 6 show the different type of installed HVAC systems.

Figure 5

Figure 6



A sample set of unit ventilators were opened and these appeared to be in fair to poor condition and are nearing the end of its useful life. It is recommended these units be upgraded to avoid high maintenance expenditure and downtime. Figures 7 through 14 show some of the observations made on the sample unit ventilators inspected during the audit. Damaged fin coils and corrosion on pipes and tubes was consistent in the unit ventilators opened for inspection.

Figure 7

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

Figure 13

Figure 14

A sample set of AHUs were opened for inspection. While the AHUs in the building are generally in good condition, these units will also benefit from retro-commissioning.

Figure 15

Figure 16

Air that is introduced into the building is removed using exhaust fans and relief vents. Maintaining proper exhaust fan operation is very important to manage fresh air ventilation and reduce energy usage. The volume of air that is exhausted is drawn into the building by AHUs, unit ventilators, operable windows and through any openings that exist around windows, doors, and other building envelope penetrations. The exhaust fans and relief vents are designed to remove air from the corridors, bathrooms, and various other areas. It is understood some of the exhaust fans are inoperable due to access issues to maintain the exhaust fans.

The HVAC equipment installed is controlled by a DDC JCI system located in the boiler room shown in Figures 17 and 18. Additionally, pneumatic controllers are located in mechanical rooms and within unit ventilators as shown in Figures 19 and 20. A compressor located in the boiler room provides air to the pneumatic controls in the building.

Figure 17

Figure 18

Figure 19

Figure 20

Figures 21 and 22 show the typical thermostats that are installed in the building. Most thermostats are of similar vintage and are Johnson Controls T-5002 Room Temperature Transmitter. While these temperature sensors are a recent install, they should be considered for upgrade (as part of a DDC upgrade) to new smart thermostats that provide more data points. New smart thermostats have additional built-in features that allow for deployment of deeper space setbacks and more efficient space comfort management.

Figure 21

Figure 22

Two boilers are installed to provide hot water for the heating of the building, shown in Figures 23 and 24. The Burnham boilers that have Webster burners are gas-fired and are of identical capacity and in good working condition.

Figure 23

Figure 24

Air condition is provided by two air-cooled split-barrel chillers located on the roof with plate-and-frame heat exchangers located in the boiler room. These units are shown in Figures 25 through 27. The Trane chiller is at the end of its useful life and should be considered for replacement.

Figure 25

Figure 26

Figure 27

The conditioned water is circulated to unit ventilators and AHUs utilizing pumps located in the boiler room. The overall circulation system is in fair condition and is shown in Figures 28 and 29. The existing pump motors are standard efficiency and shall be considered for upgrade to higher efficiency motors.

Figure 28

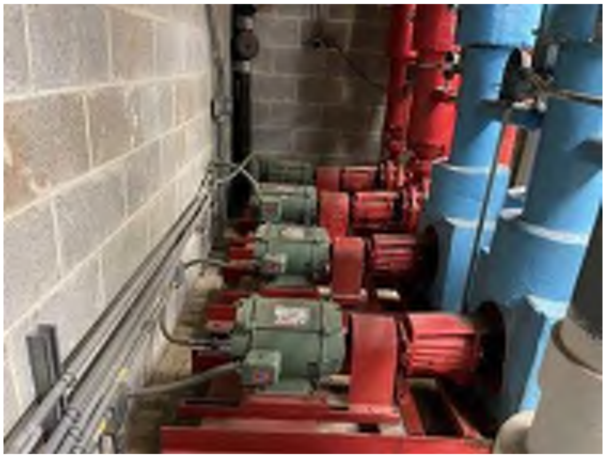


Figure 29

Both existing hot water and chilled water pumps have VFDs to allow for scaled back operation of the water loops during unoccupied and low-demand periods of time. These VFDs are shown in Figure 30 and 31.

Figure 30

Figure 31

Building Envelope and Insulation

There is generally good building envelope and pipe insulation in the building. Some areas of opportunity were identified during the audit and are shown in Figures 32 and 33.

Figure 32

Figure 33

Domestic Hot Water

Domestic hot water is supplied to the kitchen and restrooms by one AO Smith burner rated at 199,000 Btu/hr located in the boiler room and shown in Figure 34.

Figure 34

Kitchen Equipment

The building has a full functioning kitchen including a stove, pot/prep sinks and large refrigeration units. The kitchen exhaust hood is used each day when the school is in session, typically 7am to 2pm.

Figure 35

Figure 36

Figure 37

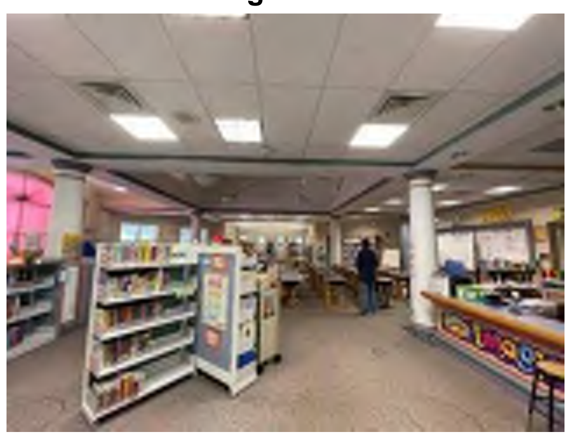
Figure 38

Lighting

A sizeable quantity of fixtures in the building are T-8 fixtures with electronic ballasts. Some spaces such as the lobby and gym area have been converted to LED. The T-8 fixtures are generally in good condition; nevertheless, upgrades to LED systems should be considered to reduce overall electric energy consumption in the building.

Figure 39

Figure 40



Utilities

On the electric side, the building is provided with secondary, three-phase service by PECO and have a total capacity of 1,200 amps. The building also has natural gas service for the boilers and kitchen use.

Figure 41

Figure 42

Spring-Ford Area High School

Structure and Envelope

Spring-Ford Area HS is located at 350 S. Lewis Rd, Royersford, PA and was originally commissioned in 1999 with additions/alterations made in 1999, 2010 and 2020. The building has a total gross square footage of 473,404. The student body consists of 2,584 students containing grades 10th through 12th grade per enrollment data available from Pennsylvania Department of Education. The two-story building consists of classrooms, gymnasiums, offices, computer rooms, cafeteria and a library. The building edifices are mostly of masonry and concrete construction and is in good condition. The building's hours of operation are from 6:00am to 4:00pm with office areas occupied until 5:00pm.

The majority of the windows that are installed are double-pane, awning style in aluminum frames, some with wood interior frames and are in good condition, shown in Figures 1 and 2.

Figure 1

Figure 2

The roof installed is mostly pitched metal and appears to be in good condition. Small sections of the roof with mechanical equipment are flat roof and are in fair condition.

Figure 3

Figure 4

HVAC Systems

The building's ventilation is primarily through mechanical ventilation. The building is served by AHUs, fan coil units, heat pumps, energy recovery units, and unit ventilators. The AHUs serve large spaces and some wings of the building. The AHUs are constant volume and no VFDs were observed on the air-side equipment. These systems along with the unit ventilators work in conjunction with relief vents and exhaust fans in the building to ensure proper air circulation. Figures 5 through 10 show a sample of the installed HVAC systems.

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10

A sample set of air-side equipment were opened and these appeared to be in fair to good condition. It is recommended these units be retro-commissioned to restore system performance and extend its useful life. Figures 11 through 15 show some of the observations made during the audit. Some of the opportunities identified onsite include repairing damaged fin coils and cleaning heat wheels.

Figure 11

Figure 12

Figure 13

Figure 14

Figure 15

Figure 16

Air that is introduced into the building is removed using exhaust fans and relief vents. Maintaining proper exhaust fan operation is very important to manage fresh air ventilation and reduce energy usage. The volume of air that is exhausted is drawn into the building by AHUs, unit ventilators, operable windows and through any openings that exist around windows, doors, and other building envelope penetrations. The exhaust fans and relief vents are designed to remove air from the corridors, bathrooms, and various other areas.

The HVAC equipment installed is controlled by a DDC JCI system located in the boiler room shown in Figures 17 through 20. Additional field pneumatic controls are serviced by a compressor located in the boiler room.

Figure 17

Figure 18

Figure 19

Figure 20

Figures 21 through 24 show the typical thermostats that are installed in the building. Most thermostats are of similar vintage and are Johnson Controls NS Series units. While these temperature sensors are a recent install, they should be considered for upgrade (as part of a DDC upgrade) to new smart thermostats that provide more data points. New smart thermostats have additional built-in features that allow for deployment of deeper space setbacks and efficient space comfort management.

Figure 21

Figure 22

Figure 23

Figure 24

Four boilers are installed to provide hot water for heating the older wings of the building and are shown in Figures 25 and 26. All the Weil-McLain boilers have Powerflame burners that are dual-fuel. are of identical capacity and in fair condition given their age.

Figure 25

Figure 26

The newer wing of the building is served by water source heat pumps located within classrooms and mechanical rooms for both heating and cooling. The equipment that the water source heat pumps reject (or pick up) heat to/from are shown in Figure 27 and Figure 28.

Figure 27

Figure 28

Air condition is provided to the old wing of the building by three air-cooled chillers located on the roof. These units and their operating parameters are shown in Figures 29 through 34. The controls pad on one of the units could not be accessed due to faulty touch sensors. Reviewing entering and leaving water temperatures on the other two Trane units showed inefficient operation. These Trane chillers will benefit from deep retro-commissioning which should help restore system performance and extend its useful life.

Figure 29

Figure 30

Figure 31

Figure 32

Figure 33

Figure 34

The conditioned water is circulated to unit ventilators and AHUs using pumps located various mechanical rooms. The overall circulation system is in fair to good condition and is shown in Figures 35 through 38. The existing pump motors are a mix of standard and premium efficiency.

Figure 35

Figure 36

Figure 37

Figure 38

All existing heat distribution pumps have VFDs to allow for scaled back operation of the water loops during unoccupied and low-demand periods of time. The chilled water pumps are on a Bell&Gossett VFD package system, shown in Figure 39. There is a VFD on the primary hot water loop and is shown in Figure 40. At the time of the audit, it was unclear why this VFD was installed. This VFD was set to bypass mode to have the primary loop pump run constantly.

Figure 39

Figure 40

Figure 41

Figure 42

Building Envelope and Insulation

Pipe and valve insulation opportunities were identified during the audit and shown in Figures 43 and 44. Some weather-stripping opportunities were also identified during the audit; one such example is shown in Figure 45. The useful life of weather-strips will vary with usage of the doors they are installed on. The existing door weather-strips were most likely installed when the building was built in 1999 and 2010. The existing weather-strips should be considered for replacement to continue to maintain a tight building envelope.

Figure 43

Figure 44

Figure 45

Domestic Hot Water

Domestic hot water is supplied to the kitchen and restrooms by one super duty condensing high efficiency natural gas-fired boiler rated at 500,000 Btu/hr and one kW boiler located in two mechanical rooms and shown in Figures 46 and 47.

Figure 46

Figure 47

Kitchen Equipment

The building has a full functioning kitchen including a stove, pot/prep sinks and large refrigeration units. The kitchen exhaust hood is used each day when the school is in session, typically 7am to 2pm.

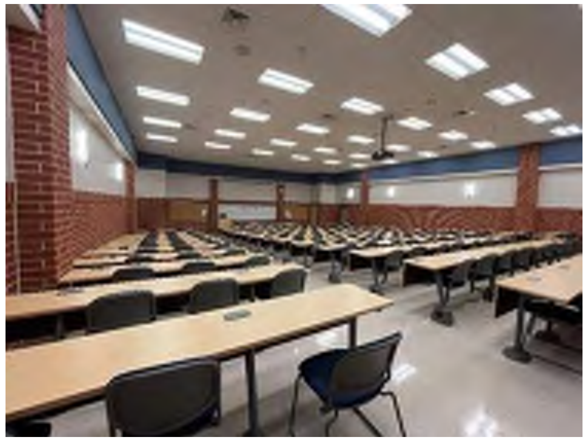
Figure 48

Lighting

A sizeable quantity of fixtures in the building are T-8 fixtures with electronic ballasts. Some spaces such as the lobby area and the main gym have been converted to LED. The T-8 fixtures are generally in good condition; nevertheless, upgrades to LED systems should be considered to reduce overall electric energy consumption in the building.

Figure 49

Figure 50



Utilities

On the electric side, the building is provided with secondary, three-phase service by PECO and have a total capacity of 3,000 amps. The building also has natural gas service for the boilers and kitchen use. There is also an above ground fuel storage tank outside the boiler room.

Figure 51

Figure 52

Figure 53

Upper Providence Elementary School

Structure and Envelope

Upper Providence ES is located at 833 S Lewis Rd Building 3, Royersford, PA and was originally commissioned in 2003 with no other additions/alterations made to-date. The building has a total gross square footage of 92,872. The student body consists of 449 students containing grades K through 4th grade per enrollment data available from Pennsylvania Department of Education. The two-story building consists of classrooms, a gymnasium/multi-purpose room, offices, cafeteria and a library. The building edifices are mostly brick veneer and is in good condition. The building's hours of operation are from 7:00am to 4:00pm with office areas occupied until 5:00pm.

The windows that are installed are double-pane, mostly hopper style in aluminum frames. Windows in the building are in good condition and are shown in Figures 1 and 2. Select areas of the building have curtain wall windows.

Figure 1

Figure 2

The roof installed is mostly pitched metal with small sections of flat roof for mechanical equipment. From visual inspections, the pitched metal roof appears to be in good condition and the flat sections in fair condition.

Figure 3

Figure 4

HVAC Systems

The building's ventilation is primarily through mechanical ventilation. The building is served by heat pumps, heat recovery units, and unit heaters. The units that serve large spaces and can vary the amount of air flow to these spaces for energy efficient operation. These systems work in conjunction with relief vents and exhaust fans in the building to ensure proper air circulation. Figures 5 through 8 show the different type of installed HVAC systems.

Figure 5

Figure 6

Figure 7

Figure 8

The heat pumps in the building are located in the ceiling and are identified by markings on the ceiling tile grids, as shown in Figure 9.

Figure 9

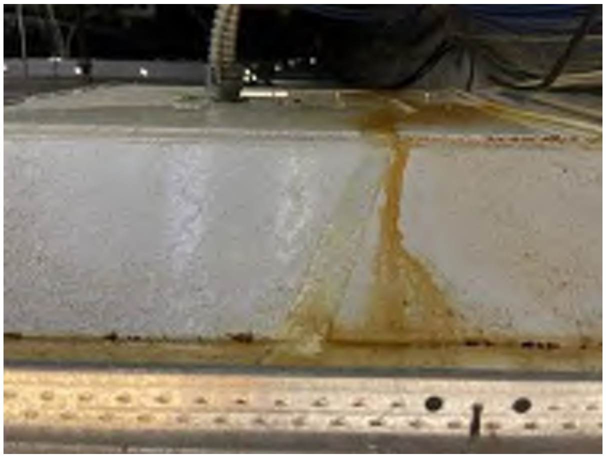
During the audit, leaks from valves connected to the heat pumps were directly observed. A few floor and ceiling stains from the water leaks were observed during the audit. Water stains can be seen on the ceiling grid on Figure 9 and floor stains are shown in Figure 10. These leaks present a slip hazard through wet floors.

Figure 10

The water leaks also present an electric hazard when dripping on ceiling mounted light fixtures. Figure 11 show a leak observed onsite and Figure 12 shows the water settled in the grooves of the light fixture close to the leaky valve.

Figure 11

Figure 12



Other than the leaks from faulty valves, many of the equipment are in good condition given their age. One of the heat recovery units were opened and inspected. These units will benefit from deep retro-commissioning. Opportunities to restore system performance and increase equipment including verifying motor shaft alignments and cleaning heat wheels inside the unit. Audit observations are shown in Figure 13 through 16.

Figure 13

Figure 14

Figure 15

Figure 16

Air that is introduced into the building is removed using exhaust fans and relief vents. Maintaining proper exhaust fan operation is very important to manage fresh air ventilation and reduce energy usage. The volume of air that is exhausted is drawn into the building by the heat recovery units, operable windows and through any openings that exist around windows, doors, and other building envelope penetrations. The exhaust fans and relief vents are designed to remove air from the corridors, bathrooms, and various other areas.

The HVAC equipment installed is controlled by a DDC JCI Metasys system located in the boiler room shown in Figures 17 and 18.

Figure 17

Figure 18

Figures 19 through 22 show the typical thermostats that are installed in the building. The thermostats are of varying vintage. It is recommended the existing thermostats should be considered for upgrade to standardize to smart thermostats. New smart thermostats also have additional built-in features that allow for deeper space setbacks and efficient space comfort management.

Figure 19

Figure 20

Figure 21

Figure 22

The building is served by a geothermal system with one boiler for supplemental heating. The overall system is generally in good condition and is shown in Figures 23 through 26 The existing circulation pumps are high efficiency and the volume of water circulating in the loop is varied through the use of VFDs. Select storage spaces in the building have dedicated unit heaters. Air conditioning is provided to most spaces of the building by the ceiling installed water source heat pump systems.

Figure 23

Figure 24

Figure 25

Figure 26

The water distribution system on the geothermal side have corrosion from condensation on pipes, impellers, and exposed surfaces; shown in Figure 27 and 28. Condensation has also damaged nearby insulation. It is recommended these bare pipes and impellers be insulated to prevent further deterioration and avoid leaks in the future. Valve insulation opportunities were also identified during the audit. Insulation opportunities were also identified on exterior duct work on which existing insulation had deteriorated, shown in Figures 29 and 30.

Figure 27

Figure 28

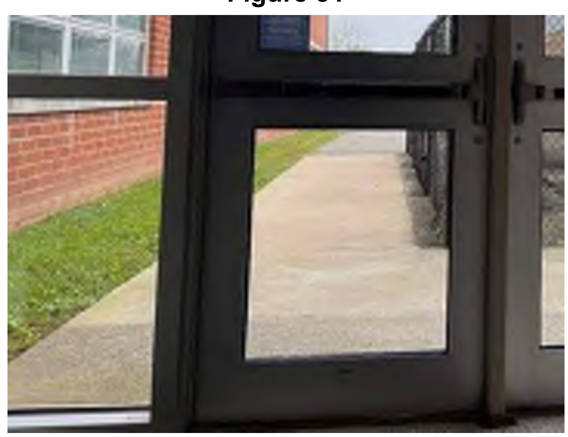
Figure 29

Figure 30

Building Envelope

There is generally tight envelope in the building with minimal air gaps observed. Some opportunities were identified during the audit, one such opportunity is shown in Figure 31. The useful life of weather-strips will vary with usage of the doors they are installed on. The existing door weather-strips were most likely installed when the building was built in 2003. The existing weather-strips should be considered for replacement to continue to maintain a tight building envelope.

Figure 31



Domestic Hot Water

Domestic hot water is supplied to the kitchen and restrooms by one RUDD Xtreme boiler rated at 550,000 Btu/hr located in the main mechanical room and shown in Figure 32.

Figure 32

Kitchen Equipment

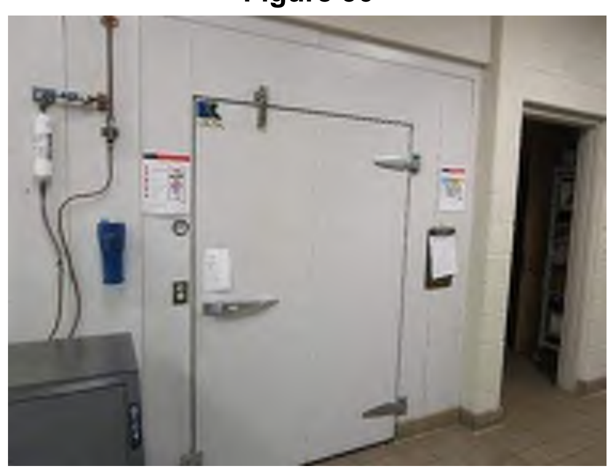
The building has a full functioning kitchen including a stove, pot/prep sinks and large refrigeration units. The kitchen exhaust hood is used each day when the school is in session, typically 7am to 2pm.

Figure 33

Figure 34

Figure 35

Figure 36



Lighting

A sizeable quantity of fixtures in the building are T-8 fixtures with electronic ballasts. Some spaces such as the main gymnasium and areas of the library have been converted to LED. The T-8 fixtures are generally in good condition; nevertheless, upgrades to LED systems should be considered to reduce overall electric energy consumption in the building.

Figure 37

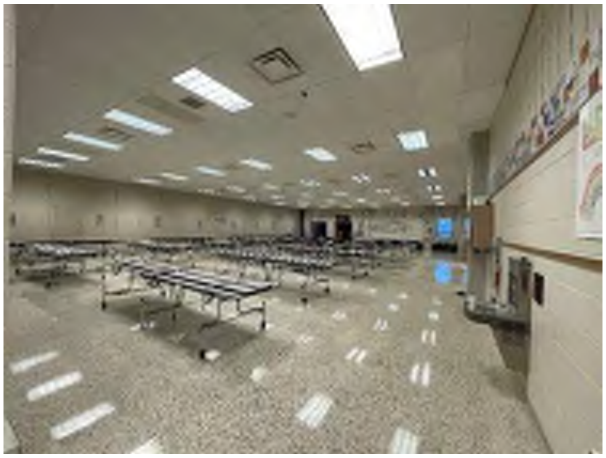
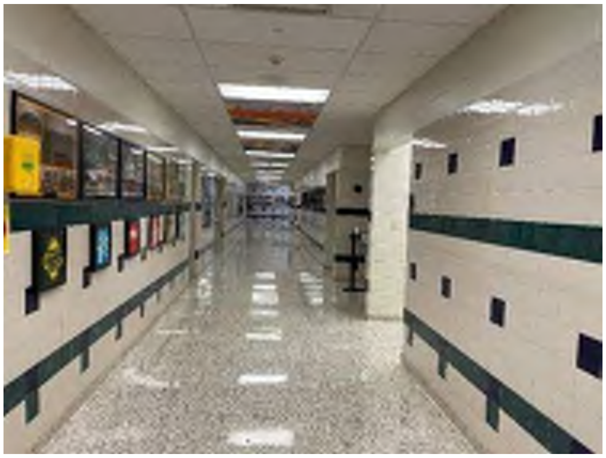


Figure 38



Utilities

On the electric side, the building is provided with secondary, three-phase service by PECO and have a total capacity of 3,000 amps. There are two step-down transformers located in an electrical closet in the building. The building also has natural gas service for the supplemental boiler and kitchen use.

Figure 39

Figure 40

Appendix B: Detailed Utility Summary

Energy Rates

The utility rates identified below were used for purposes of calculating the dollar effect of the energy savings for the schools. These rates were determined based on data from tariff data and information provided by the district and Provident Energy.

Building	Utility Electric Rates		Natural Gas				
	$/kWh	$/kW	Delivery $/ ccf <2000	Delivery $/ ccf >2000	Delivery Service $/ccf	Supply $/DTH	Supply $/ccf
5-7th Grade Center	0.0566	$6.30	$0.40	$0.30	$0.04	$3.74	$0.39
8th Grade Center	0.0566	$8.81	$0.40	$0.30	$0.04	$3.74	$0.39
9th Grade Center	0.0566	$6.30	$0.40	$0.30	$0.04	$3.74	$0.39
Brooke ES	0.0566	$8.81	$0.40	$0.30	$0.04	$3.74	$0.39
Evans ES	0.0566	$8.81	$0.40	$0.30	$0.04	$3.74	$0.39
Limerick ES	0.0566	$8.81	$0.40	$0.30	$0.04	$3.74	$0.39
Oaks ES	0.0566	$8.81	$0.40	$0.30	$0.04	$3.74	$0.39
Royersford ES	0.0566	$8.81	$0.40	$0.30	$0.04	$3.74	$0.39
Spring-Ford Area HS	0.0566	$6.30	$0.40	$0.30	$0.04	$3.74	$0.39
Upper Providence ES	0.0566	$8.81	$0.40	$0.30	$0.04	$3.74	$0.39

Energy Consumption by Building

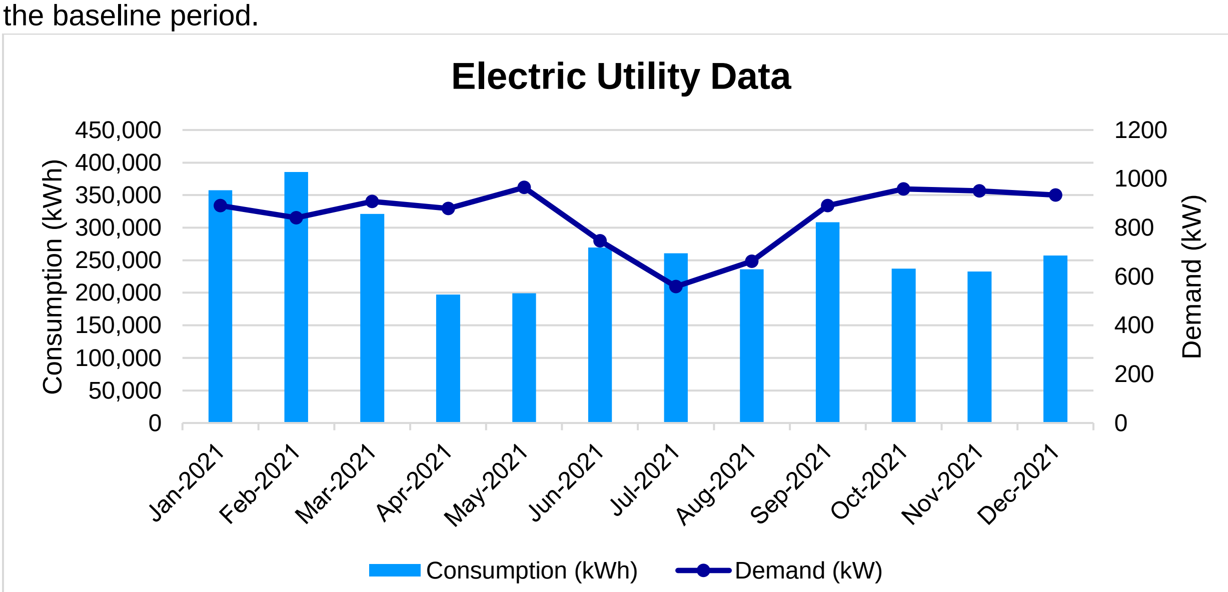
Center

Electric Usage and Demand

A detailed look at the usage (kWh), demand (kW) and total electric cost by month is shown below in table format.

Month	Consumption (kWh)	Demand (kW)	Total Electric Cost
Jan-2021	357,265	889.92	$25,057
Feb-2021	385,741	840.96	$26,299
Mar-2021	321,242	907.2	$23,204
Apr-2021	197,411	878.4	$16,281
May-2021	199,070	964.8	$16,916
Jun-2021	269,586	746	$19,377
Jul-2021	260,872	558.72	$17,722
Aug-2021	236,069	662.4	$17,025
Sep-2021	308,578	889.92	$22,406
Oct-2021	236,964	959.04	$18,943
Nov-2021	232,777	950.4	$18,660
Dec-2021	257,213	933.12	$19,882
Total/Max	3,262,788	10,181	$241,773

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the demand (kW-secondary axis) and electricity usage (kWh-primary axis) over the baseline period.

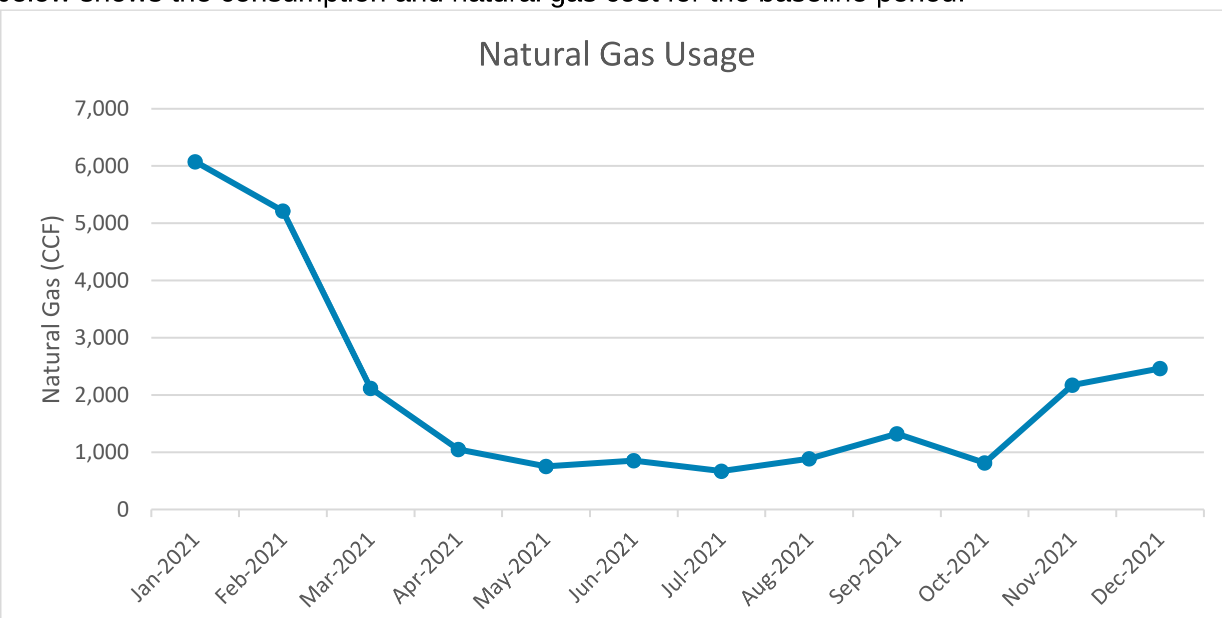


Natural Gas Usage

A detailed look at the monthly consumption (CCF) in a typical year is shown below in table format.

Month	Consumption (CCF)	Natural Gas Cost ($)
Jan-2021	6,077	$5,000
Feb-2021	5,216	$4,320
Mar-2021	2,117	$1,869
Apr-2021	1,051	$934
May-2021	752	$668
Jun-2021	855	$759
Jul-2021	671	$596
Aug-2021	885	$786
Sep-2021	1,321	$1,173
Oct-2021	814	$723
Nov-2021	2,173	$1,913
Dec-2021	2,466	$2,145
Total/Max	24,398	$20,887

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the consumption and natural gas cost for the baseline period.



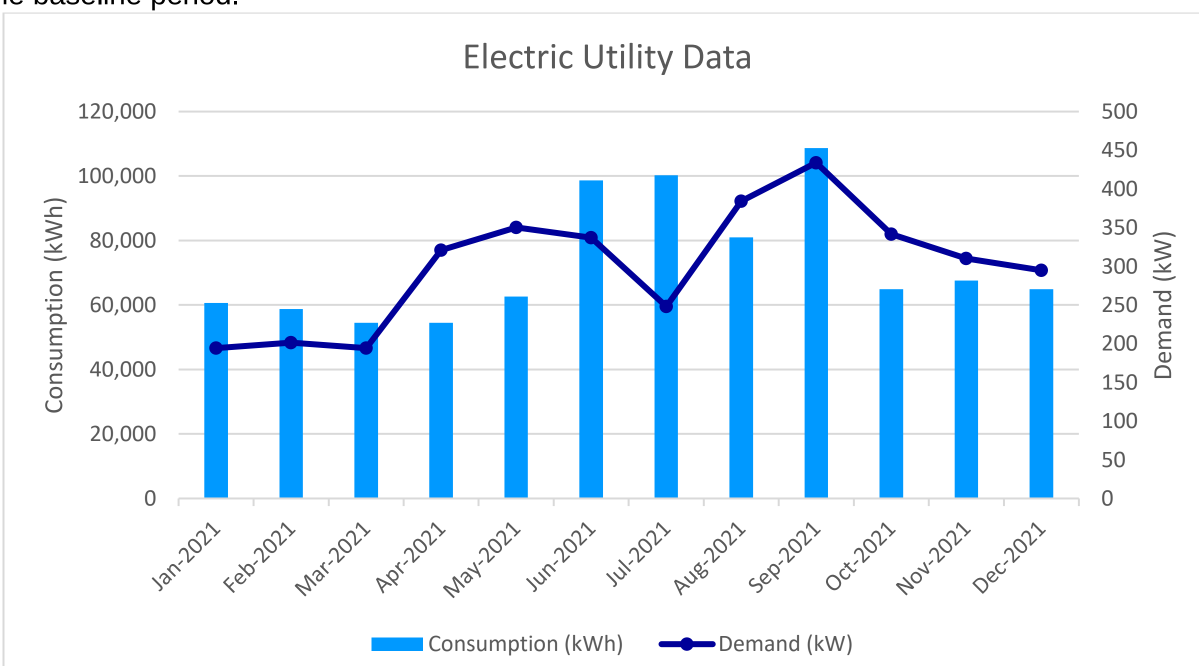
Center

Electric Usage and Demand

A detailed look at the usage (kWh), demand (kW) and total electric cost by month is shown below in table format.

Month	Consumption (kWh)	Demand (kW)	Total Electric Cost
Jan-2021	60,672	194.3	$5,015
Feb-2021	58,752	201.22	$4,971
Mar-2021	54,528	194.3	$4,680
Apr-2021	54,528	321.02	$5,797
May-2021	62,592	350.21	$6,493
Jun-2021	98,688	337.15	$8,343
Jul-2021	100,224	248.06	$7,642
Aug-2021	81,024	384	$7,794
Sep-2021	108,672	433.92	$9,739
Oct-2021	64,896	341.76	$6,544
Nov-2021	67,584	310.27	$6,413
Dec-2021	64,896	294.91	$6,131
Total/Max	**877,056**	**3,611**	**$79,563**

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the demand (kW-secondary axis) and electricity usage (kWh-primary axis) over the baseline period.

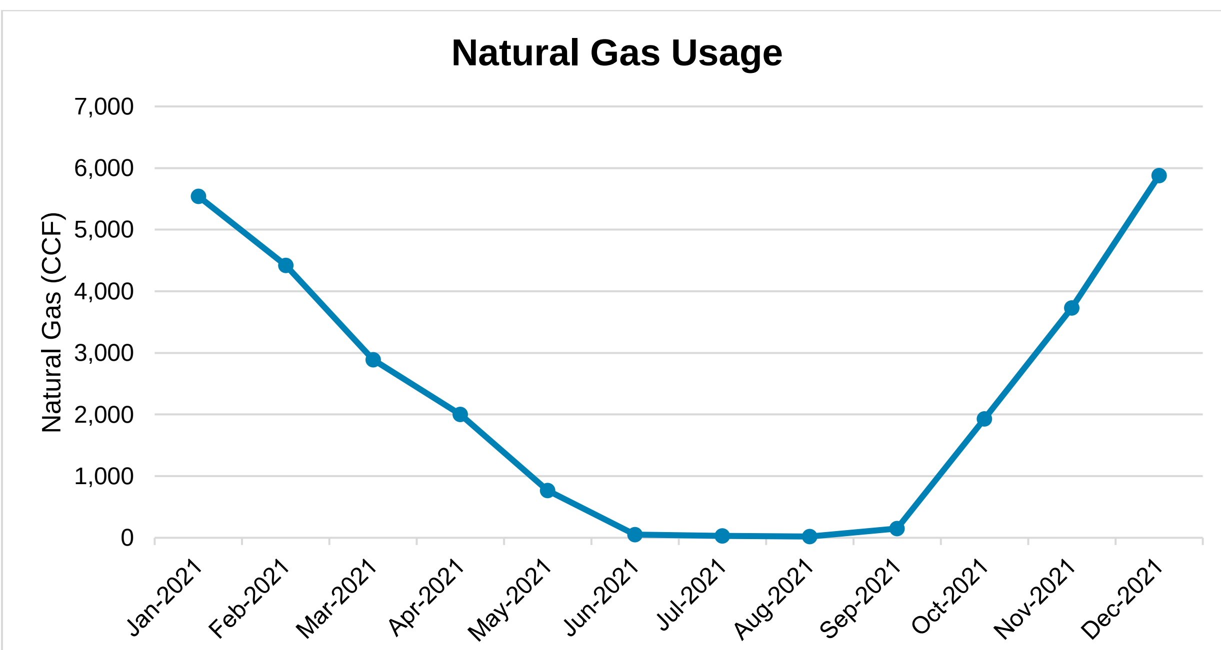


Natural Gas Usage

A detailed look at the monthly consumption (CCF) in a typical year is shown below in table format.

Month	Consumption (CCF)	Natural Gas Cost ($)
Jan-2021	5,540	$4,576
Feb-2021	4,420	$3,690
Mar-2021	2,890	$2,480
Apr-2021	2,000	$1,777
May-2021	770	$684
Jun-2021	50	$44
Jul-2021	30	$27
Aug-2021	20	$18
Sep-2021	150	$133
Oct-2021	1,930	$1,714
Nov-2021	3,730	$3,145
Dec-2021	5,880	$4,845
Total/Max	27,410	$23,132

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the consumption and natural gas cost for the baseline period.



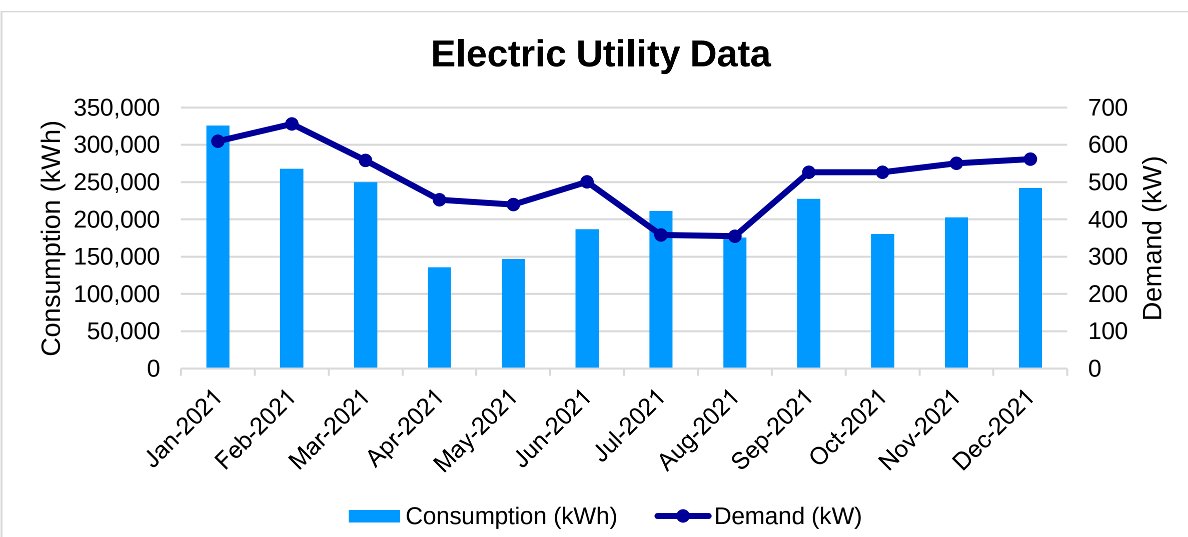
ɔ Center

Electric Usage and Demand

A detailed look at the usage (kWh), demand (kW) and total electric cost by month is shown below in table format.

Month	Consumption (kWh)	Demand (kW)	Total Electric Cost
Jan-2021	325,710	610	$21,575
Feb-2021	268,060	656	$18,727
Mar-2021	250,122	558.4	$17,135
Apr-2021	135,922	453	$10,254
May-2021	146,882	440	$10,769
Jun-2021	186,867	500.8	$13,328
Jul-2021	211,211	358.4	$13,757
Aug-2021	175,738	355.2	$11,805
Sep-2021	227,638	526.4	$15,709
Oct-2021	180,370	526.4	$13,136
Nov-2021	202,936	550.4	$14,516
Dec-2021	242,175	561.6	$16,723
Total/Max	2,553,631	6,097	$177,434

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the demand (kW-secondary axis) and electricity usage (kWh-primary axis) over the baseline period.

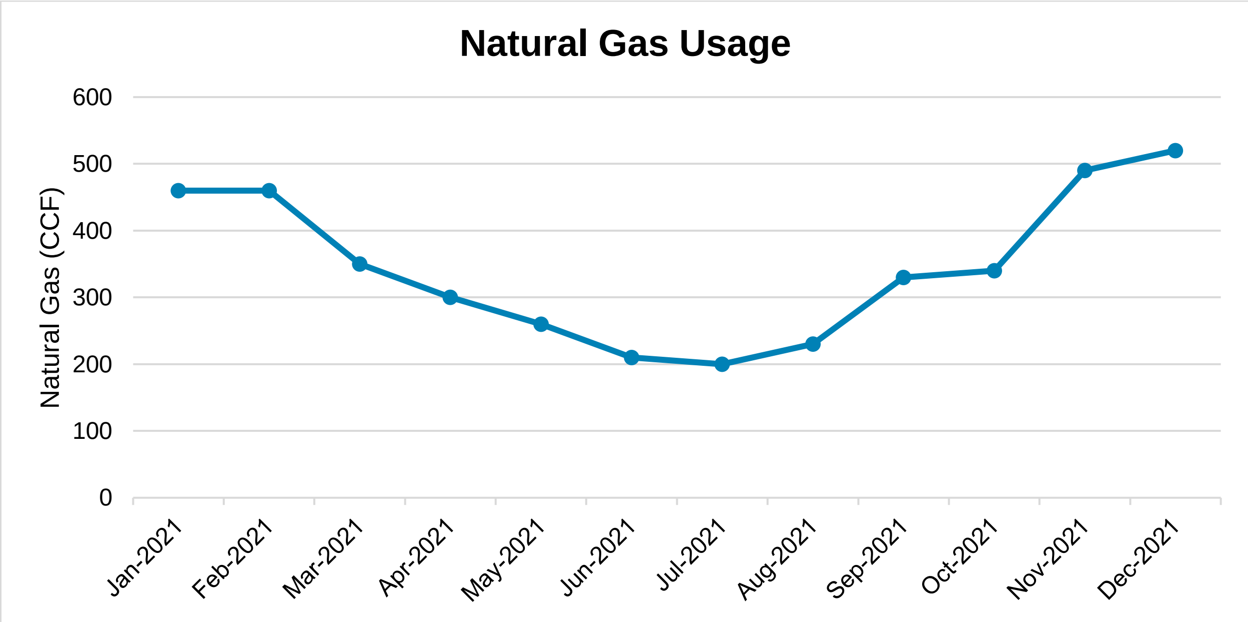


Natural Gas Usage

A detailed look at the monthly consumption (CCF) in a typical year is shown below in table format.

Month	Consumption (CCF)	Natural Gas Cost ($)
Jan-2021	460	$409
Feb-2021	460	$409
Mar-2021	350	$311
Apr-2021	300	$266
May-2021	260	$231
Jun-2021	210	$187
Jul-2021	200	$178
Aug-2021	230	$204
Sep-2021	330	$293
Oct-2021	340	$302
Nov-2021	490	$435
Dec-2021	520	$462
Total/Max	4,150	$3,686

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the consumption and natural gas cost for the baseline period.



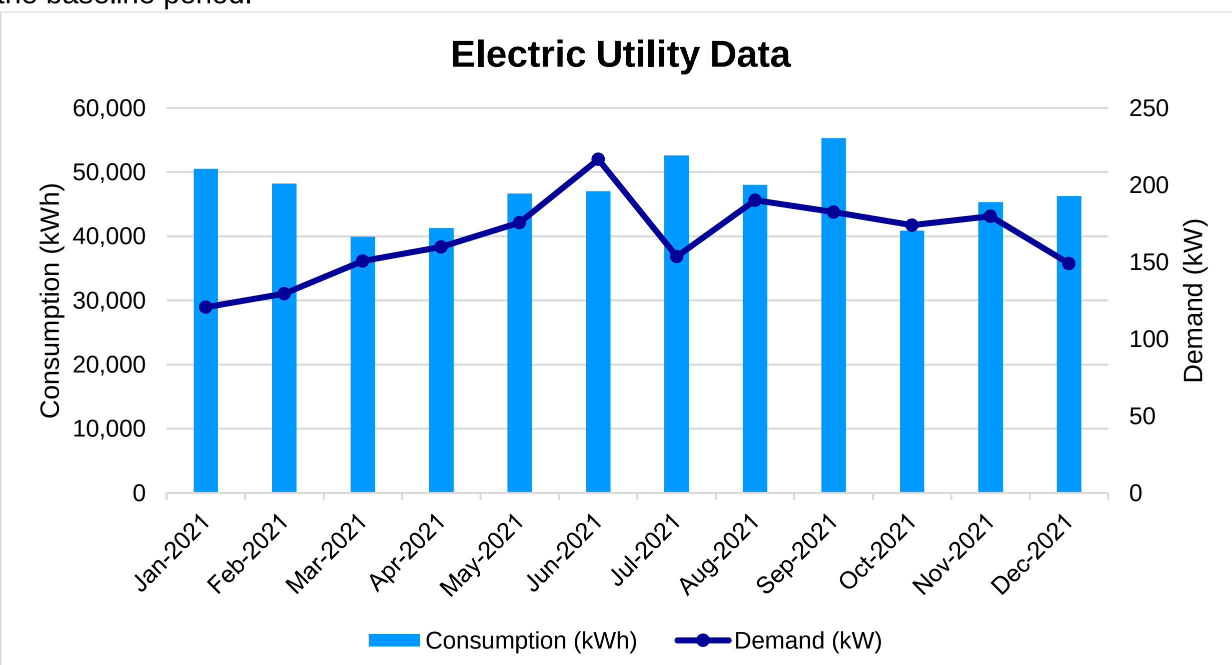
ntary School

Electric Usage and Demand

A detailed look at the usage (kWh), demand (kW) and total electric cost by month is shown below in table format.

Month	Consumption (kWh)	Demand (kW)	Total Electric Cost
Jan-2021	50,496	120.58	$3,811
Feb-2021	48,192	129.41	$3,764
Mar-2021	39,936	150.53	$3,500
Apr-2021	41,280	159.74	$3,655
May-2021	46,656	175.49	$4,086
Jun-2021	47,040	216.58	$4,469
Jul-2021	52,608	153.6	$4,217
Aug-2021	48,000	190.08	$4,288
Sep-2021	55,296	182.4	$4,617
Oct-2021	40,896	173.95	$3,759
Nov-2021	45,312	179.71	$4,050
Dec-2021	46,272	148.99	$3,832
Total/Max	561,984	1981	$48,049

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the demand (kW-secondary axis) and electricity usage (kWh-primary axis) over the baseline period.

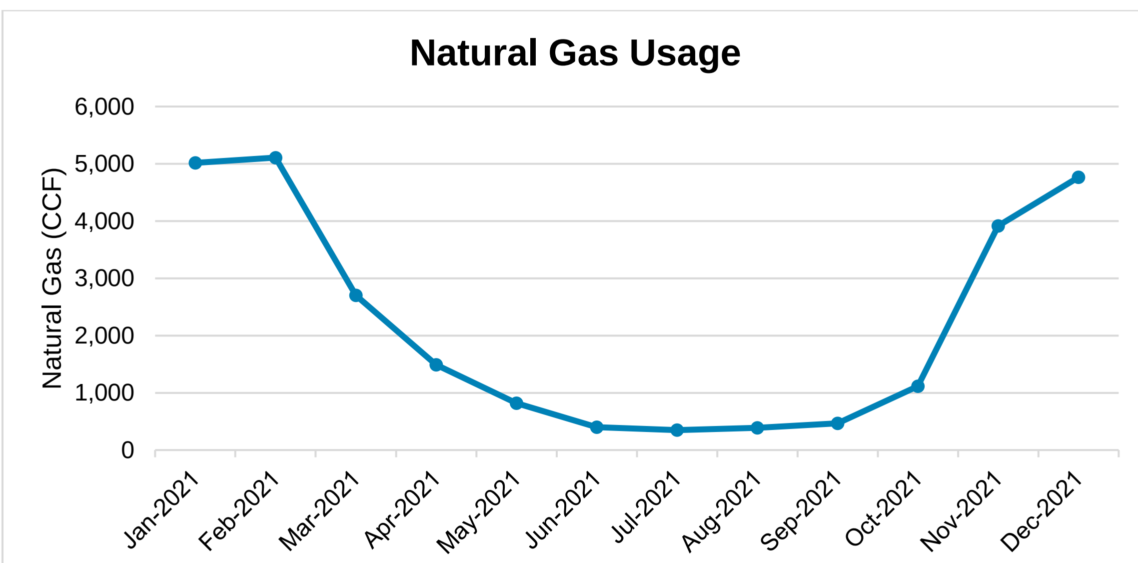


Natural Gas Usage

A detailed look at the monthly consumption (CCF) in a typical year is shown below in table format.

Month	Consumption (CCF)	Natural Gas Cost ($)
Jan-2021	5,016	$4,161
Feb-2021	5,108	$4,234
Mar-2021	2,704	$2,333
Apr-2021	1,492	$1,325
May-2021	820	$728
Jun-2021	400	$355
Jul-2021	348	$309
Aug-2021	387	$344
Sep-2021	466	$414
Oct-2021	1,113	$989
Nov-2021	3,914	$3,290
Dec-2021	4,762	$3,961
Total/Max	26,530	$22,444

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the consumption and natural gas cost for the baseline period.



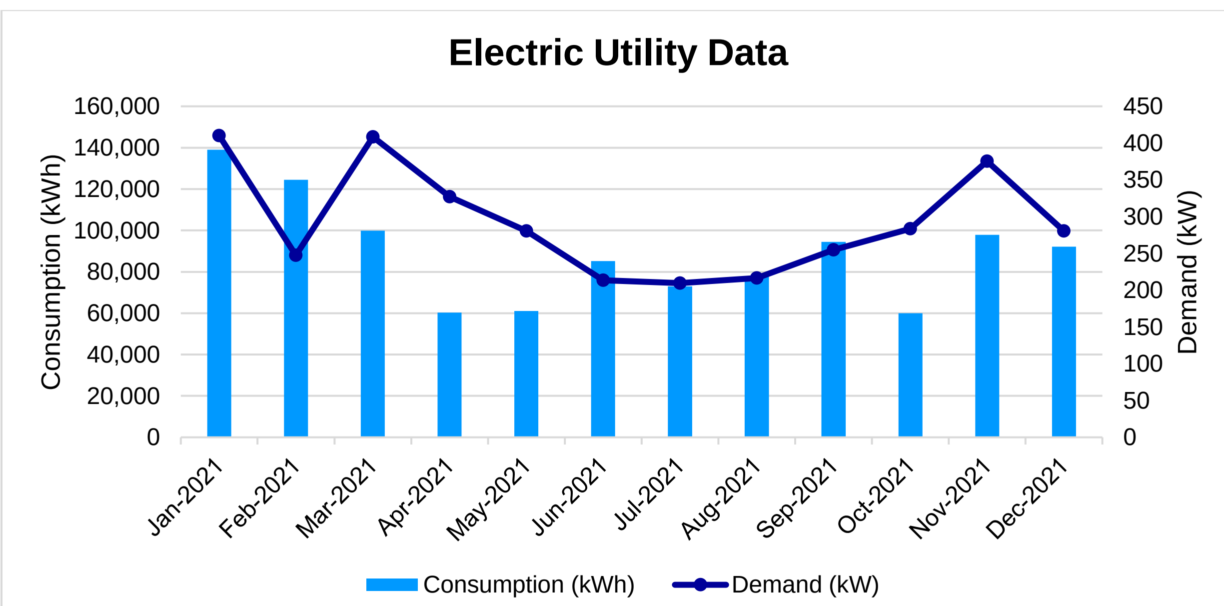
tary School

Electric Usage and Demand

A detailed look at the usage (kWh), demand (kW) and total electric cost by month is shown below in table format.

Month	Consumption (kWh)	Demand (kW)	Total Electric Cost
Jan-2021	139,008	410.11	$11,181
Feb-2021	124,416	247.3	$8,952
Mar-2021	99,840	408.58	$9,035
Apr-2021	60,288	327.17	$6,165
May-2021	61,056	280.32	$5,794
Jun-2021	85,248	213.5	$6,522
Jul-2021	72,960	209.66	$5,819
Aug-2021	77,568	216.58	$6,131
Sep-2021	94,464	254.98	$7,389
Oct-2021	59,904	283.39	$5,758
Nov-2021	97,920	375.55	$8,640
Dec-2021	92,160	280.32	$7,487
Total/Max	1,064,832	3,507	$88,872

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the demand (kW-secondary axis) and electricity usage (kWh-primary axis) over the baseline period.

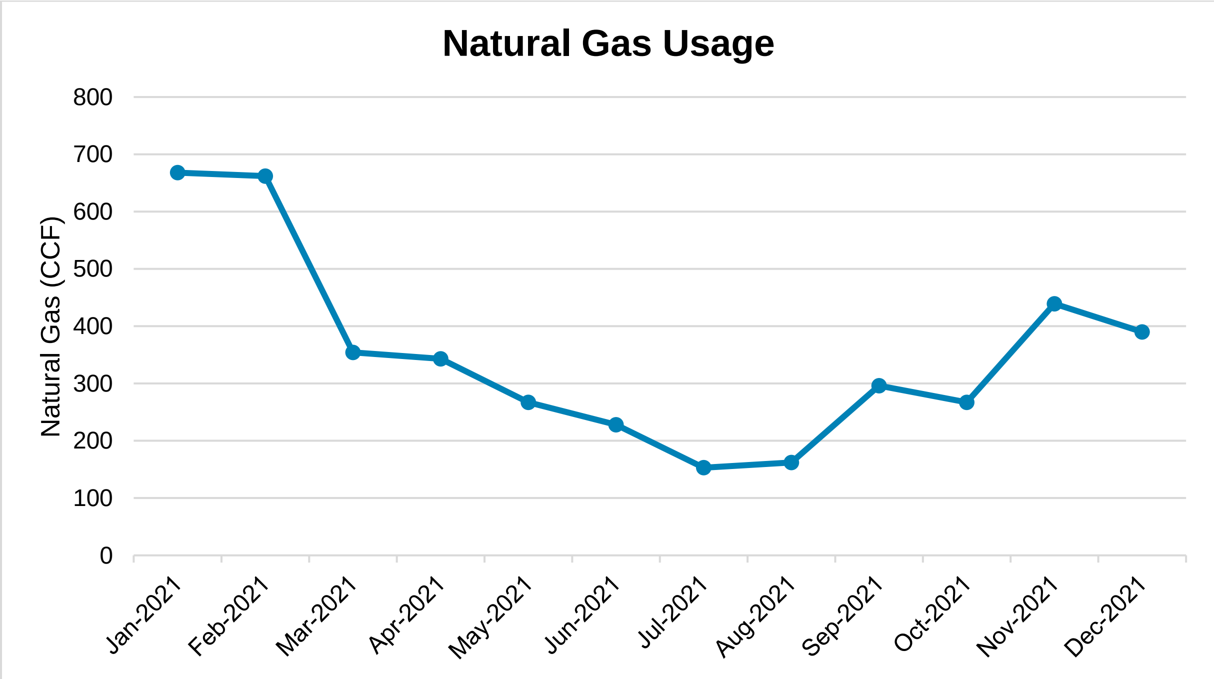


Natural Gas Usage

A detailed look at the monthly consumption (CCF) in a typical year is shown below in table format.

Month	Consumption (CCF)	Natural Gas Cost ($)
Jan-2021	668	$593
Feb-2021	662	$588
Mar-2021	354	$314
Apr-2021	343	$305
May-2021	267	$237
Jun-2021	228	$203
Jul-2021	153	$136
Aug-2021	162	$144
Sep-2021	296	$263
Oct-2021	267	$237
Nov-2021	439	$390
Dec-2021	390	$346
Total/Max	4,229	$3,756

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the consumption and natural gas cost for the baseline period.



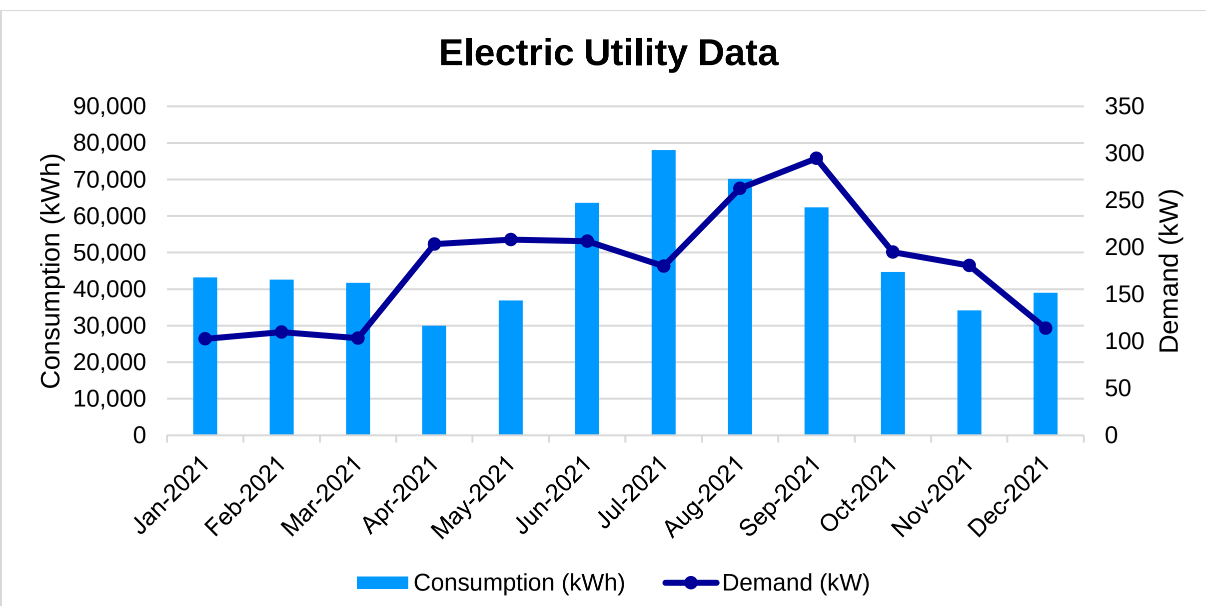
ntary School

Electric Usage and Demand

A detailed look at the usage (kWh), demand (kW) and total electric cost by month is shown below in table format.

Month	Consumption (kWh)	Demand (kW)	Total Electric Cost
Jan-2021	43,200	102.6	$3,256
Feb-2021	42,600	109.8	$3,287
Mar-2021	41,700	103.2	$3,179
Apr-2021	30,000	203.4	$3,425
May-2021	36,900	208.2	$3,843
Jun-2021	63,600	206.4	$5,281
Jul-2021	78,000	180	$5,832
Aug-2021	70,200	262.8	$6,137
Sep-2021	62,400	294.6	$5,993
Oct-2021	44,700	195	$4,152
Nov-2021	34,200	180.6	$3,453
Dec-2021	39,000	114	$3,128
Total/Max	586,500	2,161	$50,965

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the demand (kW-secondary axis) and electricity usage (kWh-primary axis) over the baseline period.

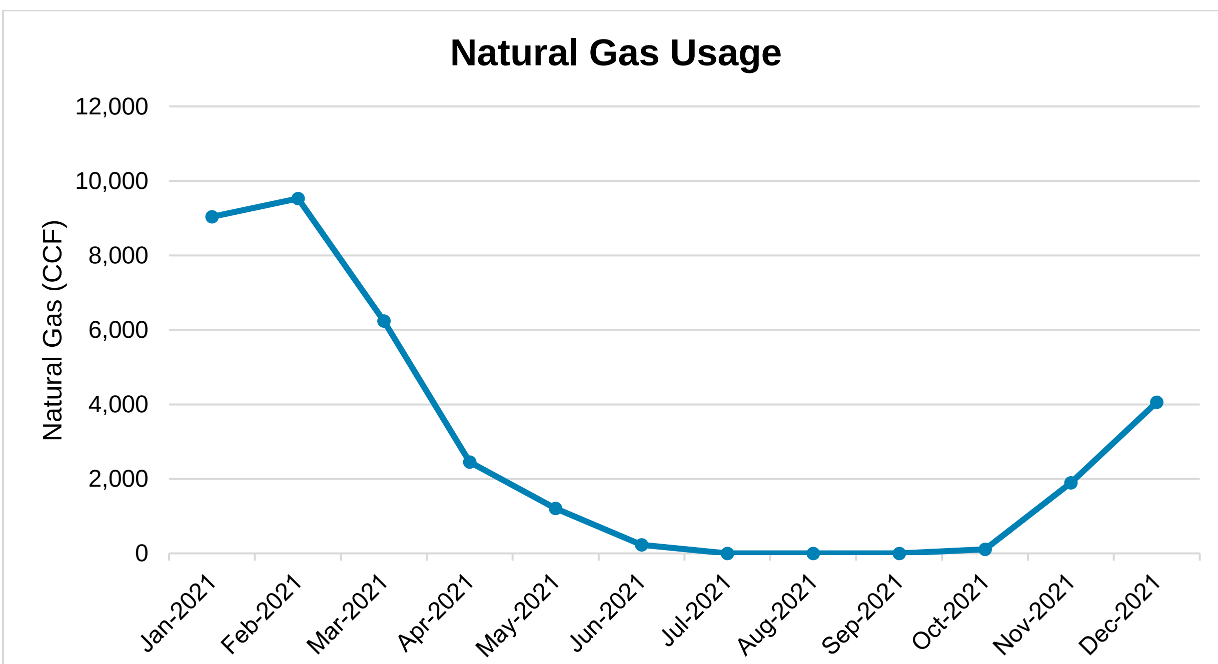


Natural Gas Usage

A detailed look at the monthly consumption (CCF) in a typical year is shown below in table format.

Month	Consumption (CCF)	Natural Gas Cost ($)
Jan-2021	9,039	$7,343
Feb-2021	9,528	$7,729
Mar-2021	6,242	$5,131
Apr-2021	2,453	$2,135
May-2021	1,207	$1,072
Jun-2021	226	$201
Jul-2021	0	$0
Aug-2021	0	$0
Sep-2021	0	$0
Oct-2021	107	$95
Nov-2021	1,896	$1,684
Dec-2021	4,054	$3,401
Total/Max	34,752	$28,790

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the consumption and natural gas cost for the baseline period.



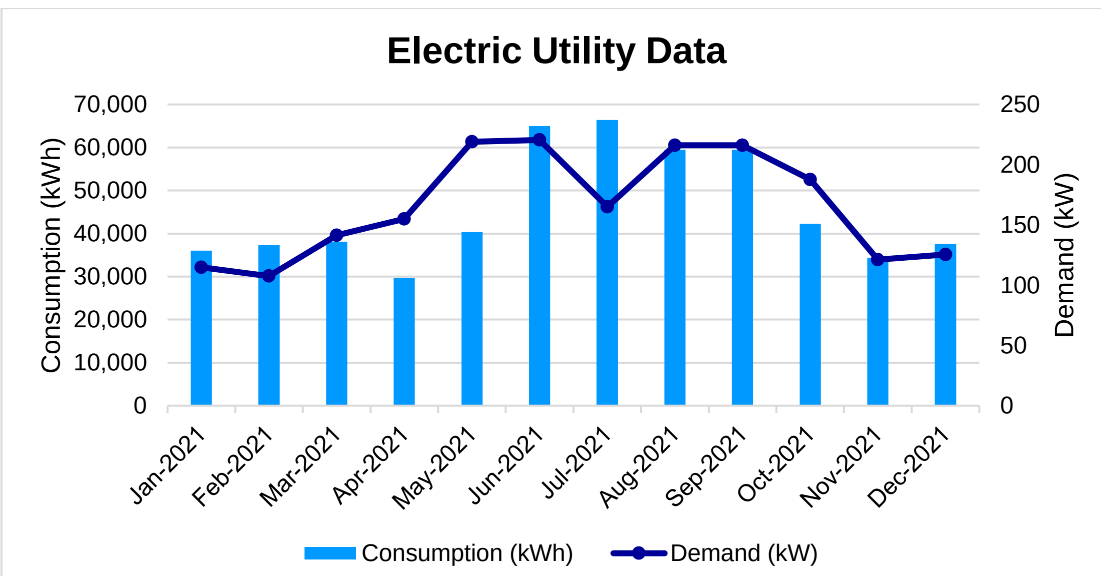
tary School

Electric Usage and Demand

A detailed look at the usage (kWh), demand (kW) and total electric cost by month is shown below in table format.

Month	Consumption (kWh)	Demand (kW)	Total Electric Cost
Jan-2021	36,000	114.88	$2,972
Feb-2021	37,280	107.52	$2,977
Mar-2021	38,080	141.44	$3,319
Apr-2021	29,600	154.88	$2,976
May-2021	40,320	218.88	$4,123
Jun-2021	64,960	220.48	$5,479
Jul-2021	66,400	165.12	$5,070
Aug-2021	59,440	216	$5,139
Sep-2021	59,440	216	$5,139
Oct-2021	42,240	187.52	$3,952
Nov-2021	34,400	121.28	$2,941
Dec-2021	37,600	125.44	$3,152
Total/Max	545,760	1989	$47,239

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the demand (kW-secondary axis) and electricity usage (kWh-primary axis) over the baseline period.

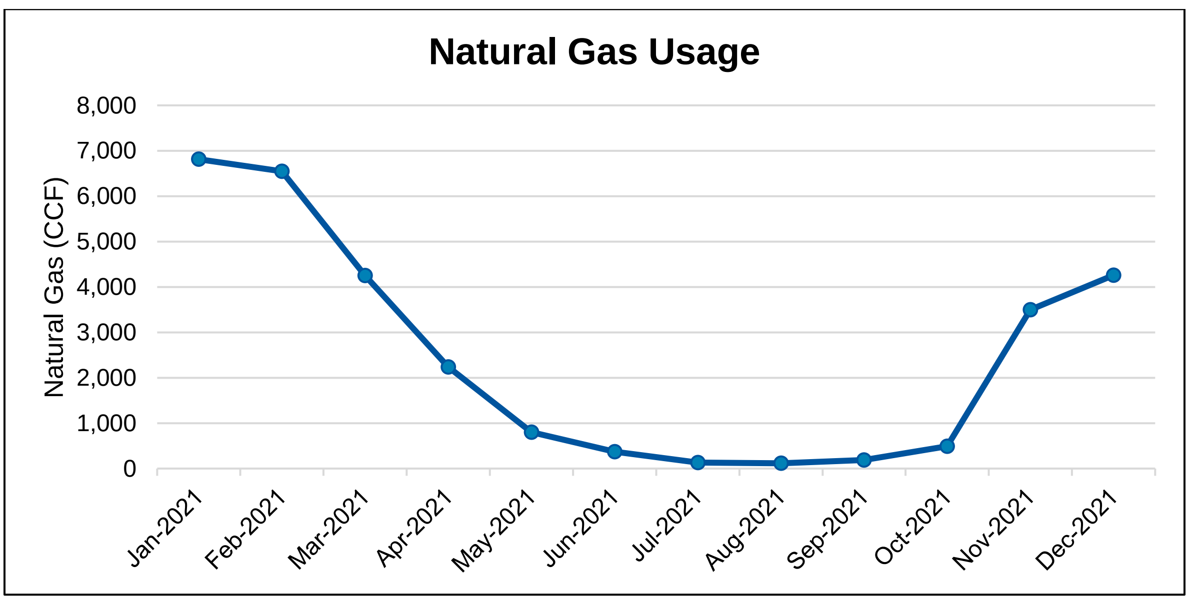


Natural Gas Usage

A detailed look at the monthly consumption (CCF) in a typical year is shown below in table format.

Month	Consumption (CCF)	Natural Gas Cost ($)
Jan-2021	6,812	$5,582
Feb-2021	6,544	$5,370
Mar-2021	4,255	$3,560
Apr-2021	2,238	$1,965
May-2021	799	$710
Jun-2021	373	$331
Jul-2021	135	$120
Aug-2021	116	$103
Sep-2021	186	$165
Oct-2021	492	$437
Nov-2021	3,498	$2,961
Dec-2021	4,260	$3,564
Total/Max	29,708	$24,867

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the consumption and natural gas cost for the baseline period.



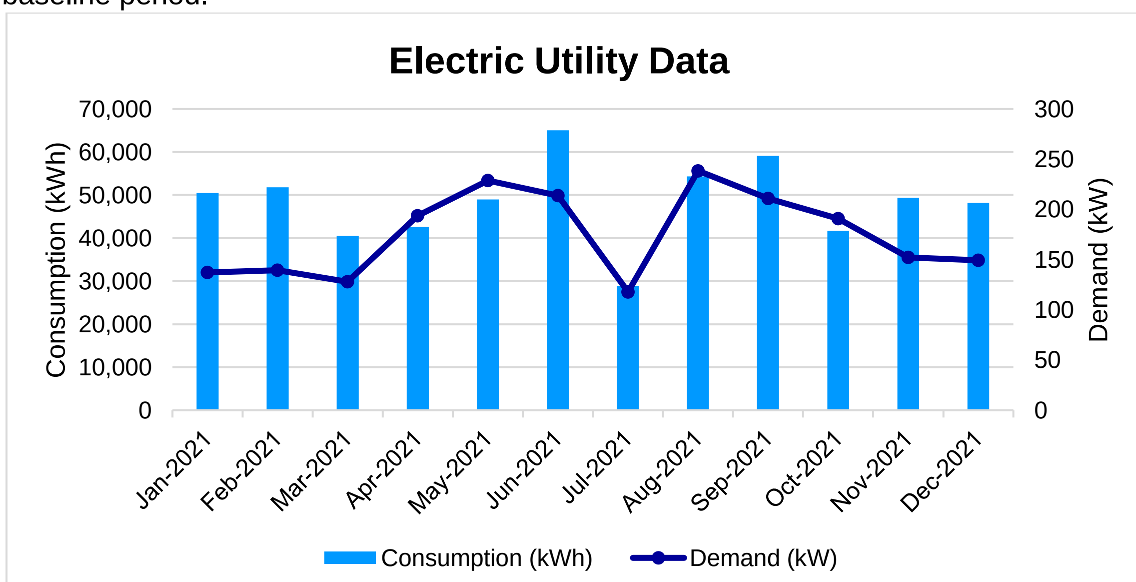
entary School

Electric Usage and Demand

A detailed look at the usage (kWh), demand (kW) and total electric cost by month is shown below in table format.

Month	Consumption (kWh)	Demand (kW)	Total Electric Cost
Jan-2021	50,496	137.09	$3,957
Feb-2021	51,840	139.39	$4,050
Mar-2021	40,512	127.87	$3,332
Apr-2021	42,624	193.54	$4,026
May-2021	48,960	228.86	$4,682
Jun-2021	65,088	213.89	$5,428
Jul-2021	28,800	117.89	$2,607
Aug-2021	54,336	238.46	$5,059
Sep-2021	59,136	210.82	$5,077
Oct-2021	41,664	190.85	$3,950
Nov-2021	49,344	152.06	$4,026
Dec-2021	48,192	149.38	$3,940
Total/Max	580,992	2,100	$50,132

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the demand (kW-secondary axis) and electricity usage (kWh-primary axis) over the baseline period.

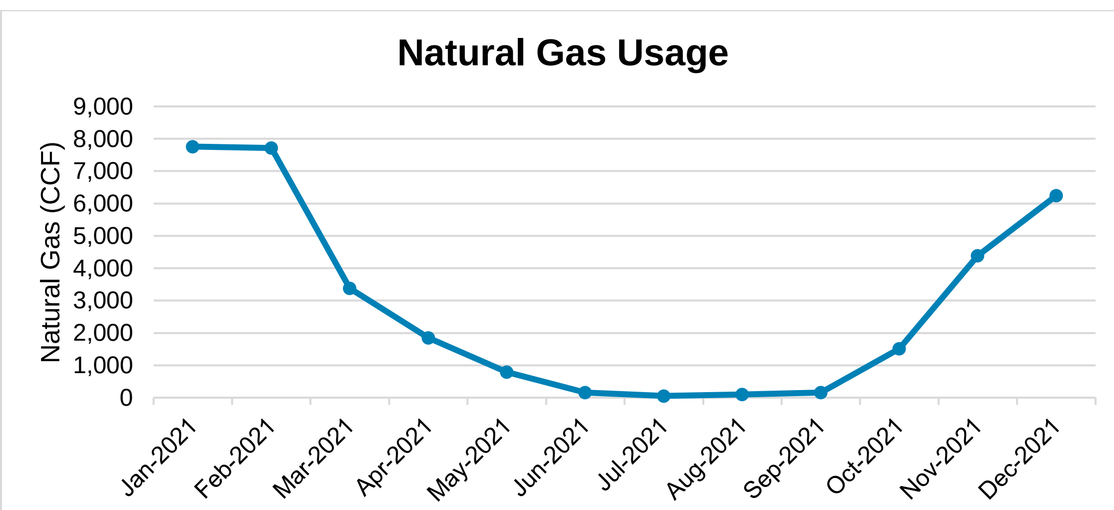


Natural Gas Usage

A detailed look at the monthly consumption (CCF) in a typical year is shown below in table format.

Month	Consumption (CCF)	Natural Gas Cost ($)
Jan-2021	7,759	$6,331
Feb-2021	7,717	$6,297
Mar-2021	3,383	$2,870
Apr-2021	1,846	$1,640
May-2021	793	$704
Jun-2021	156	$139
Jul-2021	54	$48
Aug-2021	101	$90
Sep-2021	162	$144
Oct-2021	1,511	$1,342
Nov-2021	4,391	$3,667
Dec-2021	6,248	$5,136
Total/Max	34,121	$28,407

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the consumption and natural gas cost for the baseline period.

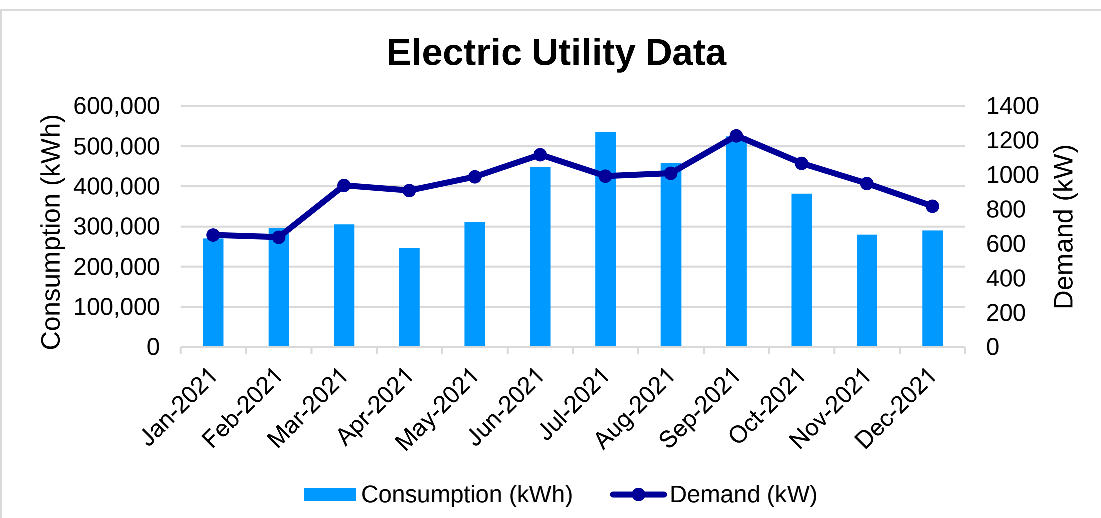


Electric Usage and Demand

A detailed look at the usage (kWh), demand (kW) and total electric cost by month is shown below in table format.

Month	Consumption (kWh)	Demand (kW)	Total Electric Cost
Jan-2021	270,305	652.03	$18,824
Feb-2021	295,530	638.78	$20,114
Mar-2021	305,761	939.55	$22,565
Apr-2021	246,456	909.22	$19,146
May-2021	310,605	990.53	$23,150
Jun-2021	449,154	1,118.02	$31,496
Jul-2021	534,950	994.27	$35,388
Aug-2021	457,201	1,009.63	$31,252
Sep-2021	524,636	1,228.32	$36,301
Oct-2021	381,782	1,067.04	$27,507
Nov-2021	279,804	950.98	$21,224
Dec-2021	290,077	817.73	$20,944
Total/Max	4,346,261	11,316	$307,911

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the demand (kW-secondary axis) and electricity usage (kWh-primary axis) over the baseline period.

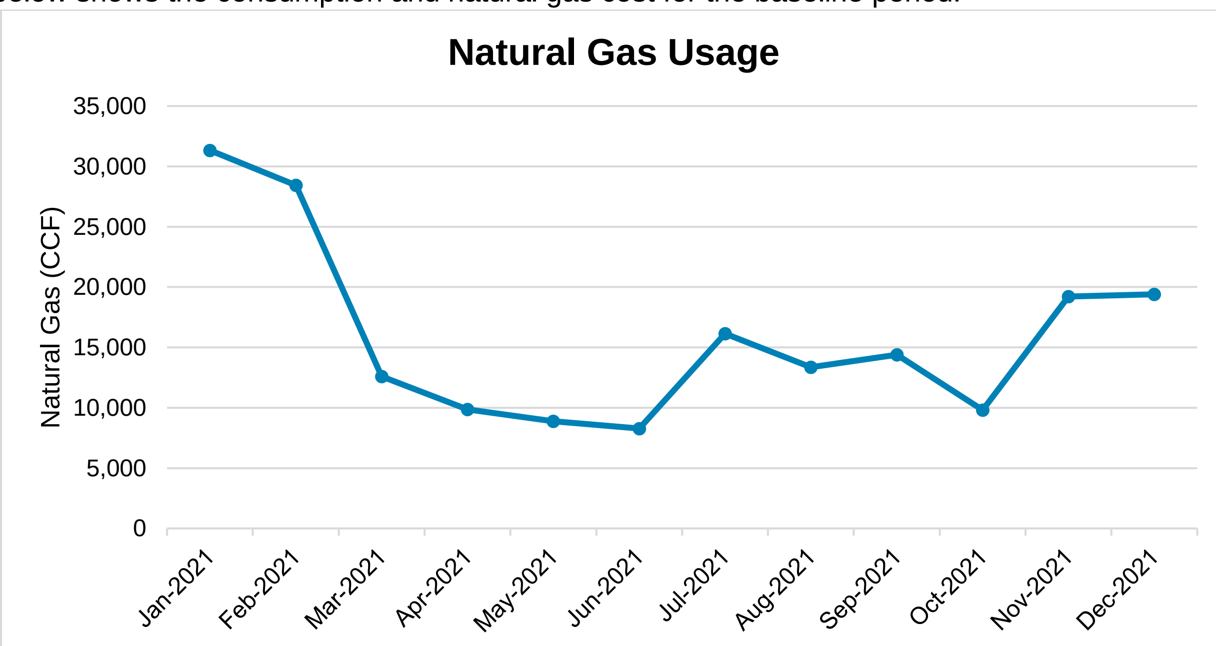


Natural Gas Usage

A detailed look at the monthly consumption (CCF) in a typical year is shown below in table format.

Month	Consumption (CCF)	Natural Gas Cost ($)
Jan-2021	31,330	$24,969
Feb-2021	28,430	$22,676
Mar-2021	12,600	$10,159
Apr-2021	9,850	$7,984
May-2021	8,870	$7,209
Jun-2021	8,280	$6,742
Jul-2021	16,130	$12,950
Aug-2021	13,370	$10,767
Sep-2021	14,400	$11,582
Oct-2021	9,800	$7,944
Nov-2021	19,220	$15,393
Dec-2021	19,400	$15,536
Total/Max	191,680	$153,913

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the consumption and natural gas cost for the baseline period.



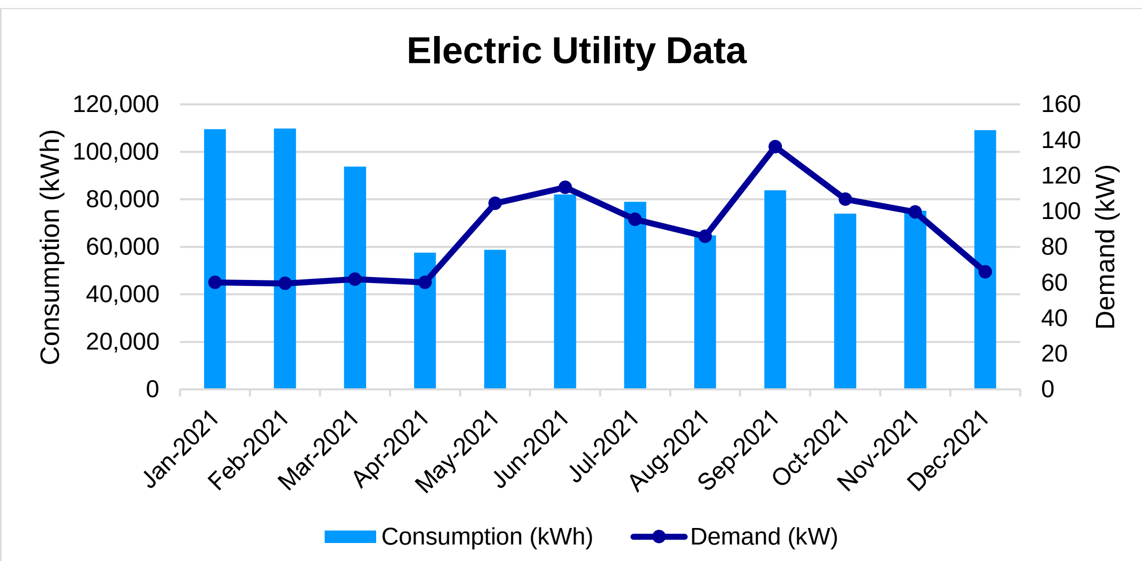
Elementary School

Electric Usage and Demand

A detailed look at the usage (kWh), demand (kW) and total electric cost by month is shown below in table format.

Month	Consumption (kWh)	Demand (kW)	Total Electric Cost
Jan-2021	109,483	60	$6,489
Feb-2021	109,790	59.4	$6,501
Mar-2021	93,742	61.8	$5,648
Apr-2021	57,513	60	$3,660
May-2021	58,799	104.4	$4,121
Jun-2021	82,031	113.4	$5,465
Jul-2021	78,983	95.4	$5,140
Aug-2021	64,792	85.8	$4,283
Sep-2021	83,868	136.2	$5,766
Oct-2021	73,988	106.8	$4,969
Nov-2021	75,149	99.6	$4,969
Dec-2021	109,127	66	$6,523
Total/Max	997,265	1,049	$63,533

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the demand (kW-secondary axis) and electricity usage (kWh-primary axis) over the baseline period.

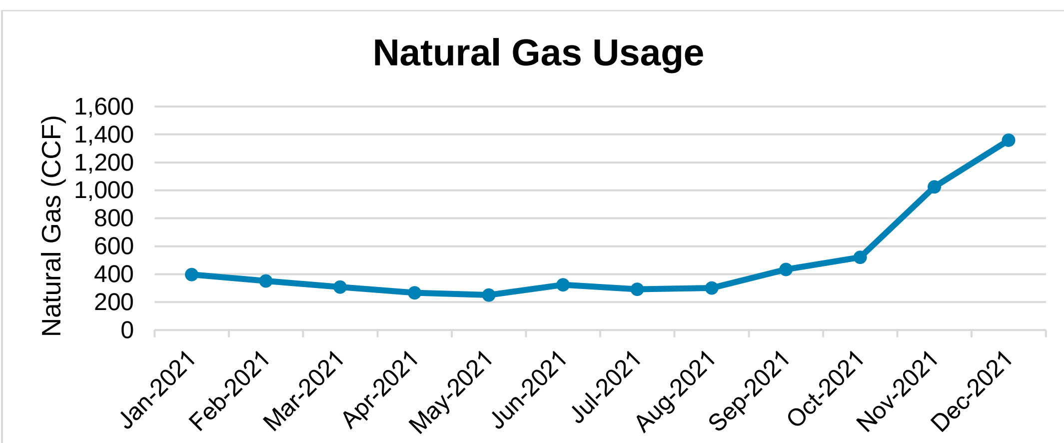


Natural Gas Usage

A detailed look at the monthly consumption (CCF) in a typical year is shown below in table format.

Month	Consumption (CCF)	Natural Gas Cost ($)
Jan-2021	398	$354
Feb-2021	352	$313
Mar-2021	309	$274
Apr-2021	266	$236
May-2021	251	$223
Jun-2021	323	$287
Jul-2021	291	$258
Aug-2021	301	$267
Sep-2021	433	$385
Oct-2021	521	$463
Nov-2021	1,025	$910
Dec-2021	1,359	$1,207
Total/Max	5,829	$5,178

Based on the last year of utility bill information – January 2021 to December 2021, the figure below shows the consumption and natural gas cost for the baseline period.



Appendix C: Detailed ECM Descriptions of Included Measures

ECM 1 – Interior Lighting LED Upgrade with Sensor Ready Kit Replacement

ECM Summary

All locations were surveyed for the application of this measure. Lighting energy efficiency upgrades provide substantial energy benefit and quality of light improvement in each building.

State-of-the-art LED lighting technology is now cost-effective, efficient, and recommended for all light fixtures in the school district.

School Districts realize significant utility savings, reduced maintenance costs, and improved overall lighting systems performance, visual comfort and acuity. In addition to saving energy and reducing costs, the lighting upgrades will:

- Improve lighting quality through designs that meet or exceed current IES recommendations while addressing specific illumination requirements for task/area functions. The scope will provide a quality of light superior to what is currently installed.
- Be economically viable and meet the school district's financial requirements.
- Improve lighting inventory standardization for long-term maintenance improvements.
- Be environmentally sustainable via reduced greenhouse gas emissions and eliminate hazardous materials such as mercury in linear fluorescent and compact fluorescent lamps.

In an effort to reduce cost, we are proposing to retrofit the existing lighting system with newer energy efficient technology. The lighting retrofit design incorporates the replacement of lamps and removal of ballasts.

Existing System

The existing linear fluorescent lighting systems throughout SFASD's facilities utilize T8 lamps operating on early generation electronic ballasts. At most facilities, the luminaires are, generally, still in excellent condition. Maintenance practice appears good with few lamp or ballast burnouts observed. Light levels are generally adequate when compared to current recommended practice.

Much of the exterior lighting at Spring-Ford's facilities has already been upgraded to LED. The exterior lighting appears to be controlled at the circuit level. Many of the high bay fixtures in the gyms have also been upgraded to LED.

There are few occupancy/vacancy sensors installed across the district.

Figure 1

Figure 2

Figure 3

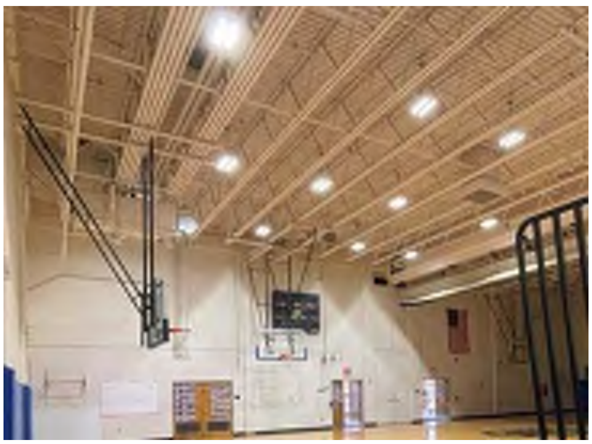


Figure 4

Proposed System

JCI identified opportunities for energy savings through the installation of kit replacement. Kit replacement will be applied to lighting fixtures that would have the most impact on aesthetic. Fixtures where kit replacement is not feasible, new high efficiency LED lighting re-lamping will be performed. The primary upgrade strategies consist of the following categories.

Scope of Work

LED Volumetric Re-Light Kits – Controls Ready

Most classrooms and offices are illuminated by 2'x4' troffers recessed into suspended grid ceilings. 1'x4' and 2'x2' troffers are also found in many of the district's facilities. We suggest removing the original parabolic louvers or prismatic lenses, and installing a volumetric LED re-light kit into the existing fixture body. While the initial installed cost is higher, this solution should maintain more than 70% of its initial lumen output 100,000 hours into the future.

The result will be a refreshed, attractive, modern sense of space with gently illuminated walls, cubicles, and work surfaces. Volumetric lighting provides all of the energy savings and demand reductions of other systems. In addition, it excels at delivering the lighting quality components that have such important impact on comfort and productivity.

Each re-light kit will be equipped with a port that allows for the future integration of daylight/occupancy sensors and/or control modules that will allow for individual control of each fixture. Wireless wall-mounted dimmers can be installed in hard-walled spaces such as offices and classrooms to provide personalized control of light levels within the space. The controls system also provides the ability to task tune the light output of the luminaires to meet the needs of each space, which increases savings by eliminating unneeded lumen output. This may also extend the already long life expectancy of the LEDs, as they will not be driven to their maximum output. This option offers the greatest energy savings and puts SFASD in compliance with most of the current energy codes, as they pertain to lighting systems.

The recessed troffers in areas such as closets, mechanical spaces, storage rooms, and other "back of house" spaces will be retrofit with LED tubes. This was part of a value engineering of the project to reduce the cost of the lighting scope, while maintaining the energy savings.

LED Line Voltage Tubes

All non-recessed linear fluorescent fixtures will be retrofit with LED tubes that are equipped with integrated drivers that were designed to replicate the lumen output of the 32-watt T8 lamps that they replace. The LED tube recommended for the retrofits throughout the district produce 1,750 lumens, while drawing only 11.5 watts. The existing ballasts will be removed from the fixtures and line voltage will be fed directly to the tombstones.

Maintenance personnel will no longer have to worry about diagnosing and replacing failed ballasts, and ballasts will no longer need to be carried as replacement stock.

LED tubes have a number of advantages over today's T8 fluorescent lamps in addition to significant energy savings. They suffer no adverse effects from frequent on/off switching cycles, which makes them a great lamp choice for applications with motion sensors. They also start with full light output in spaces with temperatures down to -4° F. LEDs are also environmentally friendly because they do not contain mercury. This allows for non-hazardous waste disposal.

This light source also has no flicker or buzz, which leads to safer conditions in areas such as mechanical rooms, kitchens, and shop classrooms.

Maintenance is another area where LED lamps offer significant improvement. Standard fluorescent lamps (both T12 and T8) are typically rated at 20,000 hours whereas LED tubes are often rated for 50,000 hours.

	Linear Fluorescent			Compact Fluorescent			
School	Re-Light Kit	LED Tube	LED Downlight	Screw-In LED	Plug-Based LED	Exterior LED	No Upgrade - Existing LED
8th Grade Center	924	387	40	15	0	7	293
9th Grade Center	1,262	224	28	76	2	0	129
Brooke ES	628	158	39	33	6	0	89
Evans ES	878	178	23	0	1	0	43
Spring-Ford Area HS	3,494	742	352	71	0	16	959
5th – 7th Grade Center	3,197	612	23	25	32	0	361
Limerick ES	745	132	0	1	11	0	176
Oakes ES	817	81	29	40	0	0	21
Royersford ES	495	252	26	16	6	0	74
Upper Providence ES	929	115	0	8	0	0	44

Recessed Downlights w/ Plug-In CFLs

Recessed downlight fixtures are found in many of SFASD's facilities. Most recessed cans are equipped with one or two plug-based compact fluorescent lamps (CFL).

The proposed solution is the installation of LED retrofit downlight kits, which replace the existing reflector and socket assembly. These kits fit into the existing downlight housings. This is another solution that reduces energy consumption by over 50%. In addition, these fixtures are often maintenance headaches as the existing lamps are typically rated at 12,000 to 16,000 hours (average life). The recommended LED replacements have an L70 rating of 50,000 hours, which make this a very attractive solution when the school district considers the labor costs and management overhead of maintaining the existing fixtures.

Incandescent & Compact Fluorescent to LED

While incandescent light bulbs have some advantages (e.g. color rendering, dimming performance), they are among the worst choices from an energy point of view. In fact, many incandescent bulbs have been legislated out of the market. Screw-in LED lamps are recommended as replacements for fixtures containing either incandescent or CFL. Where possible, we strive to match the bulb envelope of the existing incandescent lamp. For example, an existing R30 lamp will be replaced with an R30 style LED.

Compared to incandescent sources LED's offer substantial energy savings (roughly 80%), reduced heat output and extended operating life (typically 25,000 hours vs. 1,000-2,500 hours) at reasonable costs. While the savings when compared to compact fluorescents are less, the rated life is still five times greater. This will greatly reduce the time and cost spent replacing burned out lamps.

Note that dimming operation may be affected. Incandescent lamps dim smoothly from full output to "off." Dimmable screw-in LEDs have a broader dimming range than dimmable compact fluorescents but, with typical wall dimmers, they still tend to "drop out" or flicker at the lower end of the dimming range. They may not operate satisfactorily with certain dimmers, requiring replacement of the existing dimmer with a compatible device.

There is an aesthetic issue to consider as well. Traditional incandescent lamps appear warmer in color temperature as they dim whereas the color temperature of many LEDs on the market remains constant throughout the dimming range. This is not necessarily desirable behavior as we are accustomed to color temperature dropping as lighting levels are reduced.

Another concern is "snap-back." Since these LED's simply screw-in, there is always the possibility that the next time a lamp change is required an incandescent lamp will be re-installed. It is important to continue using LED's and not revert back. Replacement of the entire fixture with a new luminaire (with integral LED's) eliminates this possibility but adds expense to the project and was not considered.

Emergency Backups – Generator Fed

In many of the facilities, the emergency egress lighting utilizes an additional fluorescent lamp and ballast in some of the fluorescent fixtures along the egress path that is fed from the generator during a power failure. For the fixtures that are to be upgraded with LED tubes, we are simply including an additional line voltage LED tube in these fixtures that will be connected to the generator feed. Any dual-fed recessed fixtures will be including a transfer switch with the light upgrade that will flip to the generator feed during a power outage.

School	Transfer Switch	Additional Tube	EM BB
8th Grade Center	114	39	0
9th Grade Center	203	14	0
Brooke ES	95	0	0
Evans ES	141	32	4
Spring-Ford Area HS	282	192	0
5-7th Grade Center	381	82	0
Limerick ES	188	24	0
Oakes ES	58	0	7
Royersford ES	339	8	26
Upper Providence ES	25	0	0

Energy Savings Methodology

Our recommendations are based on guidelines established by the Illuminating Engineering Society of North America (IES) and commonly accepted lighting practices. We believe we captured the majority of energy and dollar savings, while maintaining the quality of illumination at all ten facilities.

Fixture Input Watts

Fixture input wattages are based on book values. M&V services are not included in this scope, but can be added.

Operating Hours

Hours of operation are based on a data logging results recorded across a sampling of areas throughout the school district. The data loggers collected data within these spaces over the course of a 27-day period spanning April 5, 2022 to May 2, 2022.

Room Type	Annual Operating Hours
Auditorium	2,453
Bathroom	3,074
Cafeteria	2,453
Classroom	2,144
Storage/Service	1,840
Corridor	3,074
Gym	2,453
Kitchen	2,453
Library	1,913
Locker Room	2,453
Restroom	3,074
Office	1,422
Stairwell	7,392
Exterior	4,368

In general, JCI uses the following approach to determine savings for this specific measure:

Existing kW	= Existing wattage/1,000 per fixture
Cost per kWh	= Average $/kWh
Cost of Existing Lighting	= Existing kW x Cost per kWh x Existing Hours of Operation
Proposed kW	= Proposed wattage/1,000 watts per fixture
Cost per kWh	= Average $/kWh
Cost of Proposed Lighting	= Proposed kW x Cost per kWh x Proposed Hours of Operation
Energy Savings $	= Cost of Existing Lighting – Cost of Proposed Lighting

Detailed line-by-line calculations have been provided to the school district as part of the contract.

O&M Savings

Maintenance savings are based on the avoided cost of replacing spent fluorescent, high intensity discharge, and incandescent lamps. The savings take into account the retail cost of the existing lamp, the expected life of that lamp, and the assumed yearly hours of operation. The cost is then averaged on a yearly basis over the socket life of the lamp. A similar approach is taken to amortize the ballast cost.

There is no labor factor included in the maintenance savings calculations.

Detailed line-by-line calculations have been provided to the school district as part of the contract.

Warranty

All installed equipment and workmanship will be warranted for a period of one year after customer acceptance. All parts, labor and costs will be covered by JCI during this period.

Customer Support and Coordination with Utilities

Coordination of the electrical tie-in will be required. All interruptions will be coordinated and scheduled with the staff in advance.

Training

Training will be provided to enable SFASD staff to successfully operate the equipment installed as part of this project. More details about the training are covered at the end of the Project Implementation Plan section.

ECM 6 – Window Replacement at Limerick ES

ECM Summary

JCI will replace the existing windows at Limerick ES with new high efficiency double-pane windows. The windows at this building are over 30 years old and showing their age. This project will provide new windows that match the school district's standard spcification. New windows will be more energy efficient and should provide a level of aestetic renewal to classroom spaces.

The intent of this ECM is to create energy savings through installation of better insulating windows. Better insulating windows will result in the heating/cooling systems working less to meet and maintain building desired temperatures. Both electric and thermal savings will be achieved through implementation of this work.

All work to be in accordance with prevailing industry practice, state, and local codes.

Existing System

Facility / Location	Description	Sq.ft
Limerick ES	Double-Pane, Awning style in Aluminum Frames (exterior) with wood finish interior frames	1,900

Proposed Scope of Work

- 264 windows in approximately 71 openings
- Dark Bronze Anodized Finish
- Glazing Infills:
  - 1" IGU Vision
    - ¼" Clear Tempered (ext) Solar Ban 60 #2
    - ½" Argon w/black warm edge spacer
    - ¼" Clear Tempered (int)
    - Blind in one of ten standard color offerings by Wausau
    - ¼" Clear Tempered Glass
  - 1" IGU Obscure (Bathroom areas)
    - ¼" Clear Tempered (ext) Solar Ban 60 #2
    - ½" Argon w/black warm edge spacer
    - ¼" Clear Tempered (int) velour #3 by Wausau
  - 1" Insulated Panel
    - .032 Aluminum Skin (Dark Bronze Anod coil to match)
    - 4mm Corrugated Polypropylene Stabilizer
    - 5/8" Insulated Polyisocyanurate Core
    - 4mm Corrugated Polypropylene Stabilizer

- Thermal aluminum window unit by Wausau; 3250i XLT Series
  - 1” Blinds with hinged or lift out glass panels on interior of blind, standard manual operation
- Demolition and Disposal of existing windows included
- Manufacturer Warranties: 2 Years Window; 10 Years Finish; 5 Years Glass
- Windows are tested at 0.30 U-Factor by Wausau

Energy Savings Methodology

Energy savings calculated using eQUEST (Refer Appendix E and eQUEST attachments). Baseline performance was calibrated using existing window conditions. Savings calculated by changing characteristic of 0.30 U-Factor for parametric runs.

Warranty

All installed equipment and workmanship will be warranted for a period of one year after customer acceptance. All parts, labor and costs will be covered by JCI during this period.

Customer Support and Coordination with Utilities

No utility interruptions are expected. All interruptions (if necessary) will be coordinated and scheduled with the staff in advance.

Training

Training will be provided to enable SFASD staff to successfully operate the equipment installed as part of this project. More details about the training are covered at the end of the Project Implementation Plan section.

ECM 9 – Upgrade DDC System

ECM Summary

All school buildings have DDC. A few schools in the district have a DDC overlay system by which terminal units settings are managed through pneumatic controls. The intent of this measure is to have a control system that provides full remote visibility and control of all the equipment's subcomponents. The school district shall have the ability to modify equipment operation based on RH% levels.

Through this work, equipment (including newly upgraded units) in a building shall be visible and controllable through a single web-based platform (Metasys 12.0 release).

Existing System

Facility / Location	Equipment Type	Existing Controls
Brooke ES	CHWS, HWS, AHU-1 Admin, AHU-2 Café, AHU-3 Gym, AHU-4 Stage, AHU-5 Library, 33 Classroom Units, 11 Support Space Room Units, 5 Exhaust Fans	Metasys DDC - SNE, mix of DDC and pneumatic field controllers.
Evans ES	Central Plant, 83 Heat Pumps, 2 HRUs, 1 MUA, 3 VAVs, 3 Exhaust Fan Systems	Metasys DDC - NAE
Limerick ES	CHWS, HWS, AC-1 Office, AC-2 Library, AC-3 Gym Hallway, AC-4 Main Hallway, AC-5 Rom 104, AC-6 200 Corridor, AC-7 300 Corridor, AC-8 LGI Room, AHU-23 Library, AHU-25 Gym, AHU-33 Cafeteria, 9 VAVs, 10 Bathroom Heaters, 7 Vestibule Heaters, 4 Finned Tube, 35 Classroom Units, 12 Exhaust Fans	Metasys DDC - SNE
Oaks ES	19 Classroom Units in the 97 Wing, 2 Exhaust Fans in the 97 Wing, 1 CHWS, 1 HWS, AHU-1 – Multi-Purpose, AHU-2 – Gym, AHU-3 – Library, BC-1 – Nurses Office, 2 VAVs, 7 Classroom Units, 19 Units in the 2001 Wing, 8 Exhaust Fans	Metasys DDC - NAE (Overlay) on Siemens DDC Controls, pneumatic field controllers
Royersford ES	HWS, CHWS, AHU-1 Stage, AHU-2 Cafeteria, AHU-2A Gym, AHU-3 Kitchen, AHU-4 Media Center, AHU-5 Administration, AHU-6 Kitchen, 6 VAVs, 12 Fan Coil Units, 35 Classroom Unit Ventilators, 12 Exhaust Fans, 23 Unit Heaters	Metasys DDC - NAE, mix of DDC and pneumatic field controllers.
Upper Providence ES	CHWS, HWS, 79 Heat Pumps, 2 HRUs, 10 Exhaust Fans, 4 Unit Heaters, 1 MUA, 1 HV-1	Metasys DDC - NAE
5-7th Grade Center	Central Plant, 243 Heat Pumps, 6 HRUs, 1 MUA, 1 HV1, 12 VAVs, 39 Cabinet Unit Heaters, 25 Propeller Unit Heaters, 28 Exhaust Fan Systems	Metasys DDC - SNE
8th Grade Center	CHWS, HWS, 27 Fan Coil Units, 29 Unit Ventilators, 15 AHUs, 32 Baseboard Units, 30 Wall Heaters & Unit Heaters, 11 Exhaust Fans	Metasys DDC - NAE, mix of DDC and pneumatic field controllers.
9th Grade Center	CHWS, HWS, 133 Heat Pumps, 7 ERVs, 1 MAU	Metasys DDC - NAE

Facility / Location	Equipment Type	Existing Controls
Spring-Ford Area HS	CHWS, HWS, 172 VAVs, 22 Unit Heaters, 10 Exhaust Fans, 65 Unit Ventilators, 52 Small to Medium AHUs, 2 Fan Coil Units	Metasys DDC - SNE, mix of DDC and pneumatic field controllers.

Proposed System

All the buildings listed in this scope will be upgraded to the latest controls technology, moving away from the legacy Metasys systems. This enables a consistent mechanical system mapping to a single front-end, allowing the facility management team to schedule, monitor, and control from a single dashboard with remote capabilities. Graphics will be provided for all the new systems included in the building automation and all mechanical equipment to be controlled by the system.

Existing automatic temperature controls in most of the buildings are JCI Metasys controls. Local controllers and sensors should be assessed for refurbishment or replacement. Additionally, updates should be included for the existing network level controls to the current hardware and software version of JCI Metasys. Web-based graphics and historical trending to be added for all existing and new systems on the network upon project completion. Coordinate point trending with SFASD.

Scope of Work

Facility / Location	Add Metasys User Interface	Replace Existing DX9100s to new CGMs / SNCs	Replace Existing NAE with new SNE
Brooke ES	Included		
Evans ES	Included	Geotherm DX	NAE-09; NAE-10
Limerick ES	Included		
Oaks ES	Included		NAE-17; NAE-18
Royersford ES	Included		NAE-13; NAE-15
Upper Providence ES	Included	Boiler Room DX-100	NAE-03; NAE-06
5-7th Grade Center	Included	Boilers & Pumps DX-200	NAE-07
8th Grade Center	Included		NAE-14; NAE-16
9th Grade Center	Included	Boiler Room DX	
Spring-Ford Area HS	Included	Boiler DX; Chiller DX	NAE-08; NCE-24; NCE-25; NCE-26; NCE-27; NCE-28; NCE-29; NCE-30; NCE-31

O&M Savings

The school district has been gradually investing over the past few years to upgrade its BAS by replacing legacy control engines and supervisory controls. O&M savings is expected through eliminating the need for future investments towards upgrades. The savings are derived from estimating the failure rate of engines, controllers and other critical components based on JCI's experience in installing and maintaining similar equipment. O&M activities were reviewed during the investment grade audit to determine savings.

Warranty

All installed equipment and workmanship will be warranted for a period of one year after customer acceptance. All parts, labor and costs will be covered by JCI during this period.

Customer Support and Coordination with Utilities

No utility interruptions are expected. All interruptions (if necessary) will be coordinated and scheduled with the staff in advance.

Training

Training will be provided to enable SFASD staff to successfully operate the equipment installed as part of this project. More details about the training are covered at the end of the Project Implementation Plan section.

ECM 14 – HVAC System Improvement at Limerick ES

ECM Summary

Majority of Limerick ES HVAC system is original to the building and nearing the end of expected useful life. JCI has identified HVAC equipment for replacement, with signs of damage including corrosion or nearing the end of its ASHRAE rated useful life. The design of the existing system may be contributing to issues with humidity and occupant comfort.

The intent of this ECM is to create energy savings and ventilation upgrades by replacing the existing system with newer, more efficient units.

Existing System

The building's ventilation is primarily through mechanical ventilation. The building is served by AHUs, fan coil units, and unit ventilators. The AHUs serve large spaces and can vary the amount of air flow to these spaces for energy efficient operation. These systems along with the unit ventilators work in conjunction with relief vents and exhaust fans in the building to ensure proper air circulation.

AH No.	JCI Tag #	Area Served	Total Airflow CFM	Min. OA CFM
1	236	Library/Computer Rm.	7,003	2,801
2	235	Multi-purpose Room A-121	10,012	9,099
3	234	Cafeteria C-007	8,902	8,576

Figures 1 through 4 show the different type of installed HVAC systems.

Figure 1

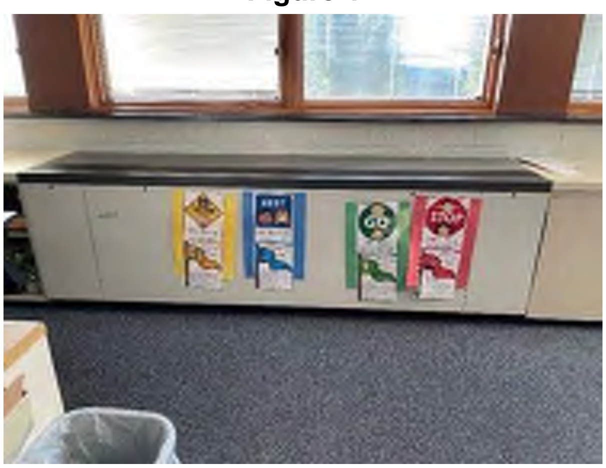


Figure 2

Figure 3

Figure 4

Most of the equipment is in fair to good condition given their age. A sample set of unit ventilators were opened and appeared to be in good condition as shown in Figures 5 through 8.

Limerick ES Classroom Unit Sizes

Room	MBH	Size
A-113 Special Ed	23.9	30
A-116 Special Ed	24.3	30
B-107 Seminar	26.3	30
B-110 Classroom	30.9	30
B-117 Classroom	33.9	40
B-119 Classroom	35.7	40
B-121 Resource	10.0	30
B-123 Classroom	36.3	40
B-126 Kindergarten	35.3	40
B-130 Kindergarten	37.8	40
B-133 Classroom	37.5	40
B-138 Classroom	37.1	40
B-142 Classroom	29.9	30
B-143 Classroom	32.8	40
C-102 Classroom	29.5	30
C-104 Classroom	30.1	30
C-110 Classroom	41.2	50
C-112 Classroom	41.3	50
C-117 Classroom	37.3	40

Room	MBH	Size
D-102 Faculty Rm	17.8	30
D-105 Music Classroom	44.9	50
D-106 Practice Rm	13.4	30
D-108 Guidance	12.2	30
D-111 Art Classroom	28.8	30
D-114 Classroom	33.1	40
D-116 Classroom	33.1	40
D-118 Classroom	33.3	40
D-120 Classroom	24.6	30
D-122 Classroom	36.4	40
D-124 Classroom	34.5	40
D-126 Classroom	28.6	30
D-128 Classroom	34.7	40
D-130 Classroom	34.2	40
D-131 Seminar	18.7	30
D-136 Server	7.8	30

Figure 5

Figure 6

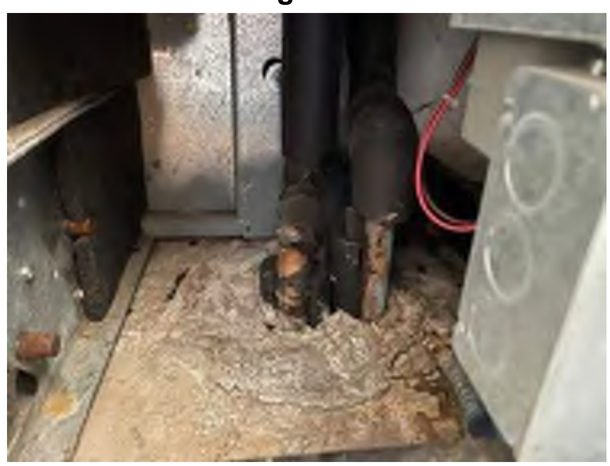


Figure 7

Figure 8

The AHUs will benefit from retro-commissioning thereby increasing overall system performance and extend useful life.

Proposed System

Type of Work

- Replace existing unit ventilators with new ducted unit ventilators with energy recovery wheels. Seal existing unit ventilator outside air openings and modify cabinetry as needed for new unit configuration.
- Modify existing piping throughout the school, and ceilings as required.
- Upgrade Admin area HVAC with variable refrigerant flow.
- Upgrade chiller plant by replacing chiller and associated pumps.
- Integrate new equipment added as part of this scope with existing DDC system.
- Refurbish three existing AHUs serving Gym, Café and Library.

Scope of Work

All scope included as part of this measure is based on the specification and design provided as part of the 30% design drawings by the Engineer of Record. Please refer to the 30% design drawings. Final engineering to be completed post contract signing. The drawings and specifications may change as a result of final engineering.

14.1 Classrooms HVAC System

- Replace classroom unit ventilators with vertical ducted unit ventilators with energy recovery and supply ductwork distribution in ceiling.
- Extend existing 4-pipe distribution piping from crawl space to new unit ventilators.
- Modify ceilings as required for supply ductwork distribution for each unit vent.
- Modify existing wall opening and provide louvered curtain wall portions as required to provide new unit ventilator intake and exhaust louvers.

- New unit ventilator will block a portion of the new window system. Provide insulated metal panel.
- Coordinate with JCI's window replacement scope during installation.
- Cap existing classroom relief system (re-roof/patch at existing gravity relief ventilators may be required)
- Reinstall cabinetry as required.

14.2 Chiller Replacement and System Upgrades

- Reclaim the refrigerant of the existing air-cooled chiller and dispose of properly.
- Demolish and remove the existing chiller – McQuay Model # AGZ190CHHNN-ER10 (JCI Tag# 239).
- Demolish the motor starters and safe off the power circuit.
- Provide and install York air-cooled chiller as per capacity and operation provided in the design drawings.
- Provide the required trucking of the old and new equipment to and from the site.
- Provide the required crane to load the old chiller onto trucks and the new chiller into place.
- Provide and install schedule 40 Steel pipe and fittings to connect the new air-cooled chiller to the chilled water piping connections.
- Provide and install the required drains on the new chilled water piping.
- Provide and install new chilled water isolation valves if existing valves cannot be reused.
- Provide and install rubber isolation spheres at the chiller.
- Provide the required new electrical conduit and cable to connect the new chiller to the existing power connection.
- Provide new fiberglass pipe insulation for the new chilled water piping exterior of the building, Exterior insulation shall be covered in aluminum covering. Insulation shall be 2" thick.
- Fill and test the new piping.
- Factory startup and test the system.
- Clean off the work area.
- Provide freeze protection (bundle heater, heat tracing, and pump operation @ min speed under 35°F preferred by SFASD)
- Provide new chilled water pumps with VFDs.

Inclusions for Chiller Replacement and System Upgrades

- Submittals, including drawings, product data, warranty information, installation instructions, operating instructions, and maintenance instructions.
- Manufacturer's authorized startup and testing, and operator training.
- Engineering drawings.

14.3 Admin Area HVAC System

- Remove DX/hot water PTACs
- Provide new variable refrigerant flow system (approx. 12.5 tons)
- Replace existing fan coil unit with small DOAS/energy recovery ventilation and modify ductwork to provide ventilation and exhaust air to the admin spaces
- Refer to Schedules attachment for existing unit details

14.4 AHU Refurbishment

- Vacuum cleaning of entire AHU cabinet
- Vacuum cleaning of heating and cooling coils (if applicable)
- Replacement of defective motors
- Replacement of damper bearing and edge seals
- Replace up to 50% of seals and 25% of damper bearings
- Repair/replacement of speed switch and fan transformer (as necessary)
- Repair/replacement of fuses and disconnect (as necessary)
- Filter replacement
- Condensing unit (if applicable) cleaning / washing & fin straightening

Exclusions for HVAC System Improvements

- Temporary heating and cooling during transition.
- Repair or replacement of defective mechanical equipment, except the equipment described in the ECM description. JCI will identify the location of defective equipment and notify the SFASD.
- Repair or upgrades required to bring adjacent electrical and mechanical systems up to code.
- Overtime work caused by unforeseen circumstances beyond the control of JCI, such as scheduling changes by SFASD. The cost difference between the overtime work wages and normal time work wages will be the responsibility of SFASD calculated as [(overtime rate – normal rate) x hours]).
- Asbestos abatement and removal for this project is entirely the responsibility of SFASD. If hazardous materials are encountered during the implementation phase, JCI will immediately stop work, take measures to reduce any contamination, and notify the SFASD facility manager of the possible hazardous material condition and location. JCI will then request that SFASD remove and dispose of the hazardous materials prior to any continuation of work. Hazardous materials encountered during the ongoing service phase of the project will remain the property and disposal responsibility of SFASD. JCI will work with SFASD and our subcontractors to sufficiently identify the scope, costs, and project scheduling implications of any required abatement such that SFASD can adequately plan for this requirement.

- The cost of hazardous material abatement or removal, such as asbestos, mold and lead paint that is not currently specified in the engineering scope of work. In the event hazardous materials are uncovered and abatement is beyond the ability of JCI to abate under this contract, the ECM will be evaluated for possible removal from the scope of work or the transfer of this responsibility to SFASD.
- Water balance of additional equipment (air-handlers, condensers, etc.), unless specified in the scope of work.
- Engineering services, studies and analysis associated with any exclusions or work clearly outside of the scope definition.
- Unknown permits, fees or processes required by local or oversight jurisdiction and/or utilities.
- Structural work not specified in drawings.
- Resolution of existing design, service, and or distribution conditions known or unknown.
- Repairs/replacement of insulation, piping, electrical or ductwork found to be corroded or rusted or otherwise unacceptable for installation of components or fittings required for installation other than what is specified in the Scope of Work.

Energy Savings Methodology

Energy savings calculated using eQUEST (Refer Appendix E and eQUEST attachments). Baseline performance was calibrated using existing equipment operation and conditions. Savings calculated by changing characteristic of replacement equipment features and performance for parametric runs.

O&M Savings

O&M savings is expected through reduced maintenance of new equipment.

Warranty

All installed equipment and workmanship will be warranted for a period of one year after customer acceptance. All parts, labor and costs will be covered by JCI during this period.

Customer Support and Coordination with Utilities

Support will be required for the interruption of utilities for brief tie-in periods. All interruptions will be coordinated and scheduled with the staff in advance.

Training

Training will be provided to enable SFASD staff to successfully operate the equipment installed as part of this project. More details about the training are covered at the end of the Project Implementation Plan section.

ECM 15 – HVAC System Improvement at Royersford ES

ECM Summary

Royersford ES is served by a HVAC system consisting of AHUs, fan coil units and unit ventilators. The AHUs serve large spaces, and the classrooms are conditioned by unit ventilators with constant speed supply fans and outside air dampers. These systems work in conjunction with relief vents and exhaust fans in the building to ensure proper air circulation.

JCI has identified HVAC equipment for replacement, with signs of damage including corrosion or nearing the end of its ASHRAE rated useful life. The design of the existing system may be contributing to issues with humidity and occupant comfort. Overall, both electric and thermal savings will be achieved through implementation of this work. A slight increase in energy consumption of some equipment can be expected where currently the equipment does not work or in instances where ventilation to spaces is increased.

Existing System

The building's ventilation is primarily through mechanical ventilation. The building is served by AHUs, fan coil units, and unit ventilators. The AHUs serve large spaces and can vary the amount of air flow to these spaces for energy efficient operation. These systems along with the unit ventilators work in conjunction with relief vents and exhaust fans in the building to ensure proper air circulation. Figures 1 and 2 show the different types of installed HVAC systems.

List of Air-Handling Units

Symbol	CFM	CFM OA
AHU-1	1,250	480
AHU-2	12,000	5,130
AHU-3	3,200	1,000
AHU-4	3,000	750
AHU-5	1,600	480
AHU-6	3,400	3,400

Figure 1

Figure 2

A sample set of unit ventilators were opened. They appeared to be in fair to poor condition but are nearing the end of useful life. It is recommended these units be upgraded to avoid high maintenance expenditure and downtime. Figures 3 through 6 show some of the observations made on the sample unit ventilators inspected during the audit. Damaged fin coils and corrosion on pipes and tubes was consistent in the unit ventilators opened for inspection.

Royersford ES Classroom Unit Sizes and Types

Room	MBH	Unit Size	Type
A036 Faculty	15.2	06	Horizontal Ducted
A037 Kindergarten Cr	34.2	12	Vertical Floor-Mounted
A038 Kindergarten Cr	29.6	10	Vertical Floor-Mounted
A041 1st Grade Cr	33.9	12	Vertical Floor-Mounted
A042 1st Grade Cr	40.4	12	Vertical Floor-Mounted
A043 1st Grade Cr	42.9	12	Vertical Floor-Mounted
A044 1st Grade Cr	38.4	12	Vertical Floor-Mounted
B009 Music Cr	31.1	10	Vertical Floor-Mounted
B017 Art Cr	24.9	08	Horizontal Ducted
B018 2nd Grade Cr	23.2	08	Horizontal Ducted
B019 2nd Grade Cr	23.4	08	Horizontal Ducted
B020 2nd Grade Cr	22.0	06	Vertical Floor-Mounted
B021 2nd Grade Cr	18.4	06	Vertical Floor-Mounted
B022 Special Ed Cr	22.3	06	Horizontal Ducted
B023 Reading Center	11.5	04	Vertical Floor-Mounted
B024 3rd Grade Cr	23.3	08	Horizontal Ducted
B025 3rd Grade Cr	23.1	08	Horizontal Ducted
B026 3rd Grade Cr	22.2	06	Vertical Floor-Mounted
B027 3rd Grade Cr	22.1	06	Vertical Floor-Mounted
B028 Speech/Sgi	11.8	04	Horizontal Ducted
B103 Gifted Support Office	1.7	02	Horizontal Ducted
B104 Large Group Instr	39.1	12	Vertical Floor-Mounted
B109 Computer Cr	33.6	12	Vertical Floor-Mounted
B110 5th Grade Cr	24.9	08	Vertical Floor-Mounted
B111 5th Grade Cr	24.9	08	Vertical Floor-Mounted
B112 5th Grade Cr	23.7	08	Vertical Floor-Mounted
B113 5th Grade Cr	23.4	08	Vertical Floor-Mounted

Room	MBH	Unit Size	Type
B114 Special Ed Cr	23.0	08	Vertical Floor-Mounted
B115a Sgi	10.4	04	Vertical Floor-Mounted
B115b Sgi	10.3	04	Vertical Floor-Mounted
B116 4th Grade Cr	25.0	08	Vertical Floor-Mounted
B117 4th Grade Cr	25.0	08	Vertical Floor-Mounted
B118 4th Grade Br	25.2	08	Vertical Floor-Mounted
B119 4th Grade Cr	25.1	08	Vertical Floor-Mounted
B120 Ipc	8.7	03	Vertical Floor-Mounted

Figure 3

Figure 4

Figure 5

Figure 6

Proposed System

Type of Work

- Replace existing unit ventilators with new fan coil units. Seal existing unit ventilator outside air openings and modify cabinetry as needed for new unit configuration.
- Add a DOAS unit with Energy Recovery Wheel, heating and cooling capabilities to provide ventilation and comfort to the classrooms.
- Modify existing piping throughout the school, and ceilings as required.
- Upgrade boiler plant by replacing boiler and associated pumps.
- Upgrade chiller plant by replacing chiller and associated pumps.
- Integrate new equipment added as part of this scope with existing DDC system.
- Refurbish six existing AHUs serving kitchen, café, library, office, stage, and gym.

Scope of Work

All scope included as part of this measure is based on the specification and design provided as part of the 30% design drawings by the Engineer of Record. Please refer to the 30% design drawings. Final engineering to be completed post contract signing. The drawings and specifications may change as a result of final engineering.

15.1A Classrooms HVAC System

- Provide new 12,000 cfm DOAS, DX, gas-fired, with energy recovery.
- New DOAS unit to be located adjacent to the chillers on the roof.
- Extend ductwork to the two-story classroom wing via the attic.
- Extend ductwork to the single-story K-1 wing via short run of roof-mounted ductwork to get into ceiling space.
- Replace classroom under-window unit ventilators with console fan coil units.
- Replace classroom horizontal ducted unit ventilators with ducted fan coil units.
- Extend existing 4-pipe distribution piping from ceiling space to new unit ventilators.
- Cap existing classroom relief system (re-roof/patch @ existing gravity relief ventilators may be required) and tie relief air into DOAS.
- Cap existing general building exhaust system, approx. 12 exhaust fans (re-roof/patch @ existing gravity relief ventilators may be required), and tie relief air into DOAS.

15.2 Chiller Replacement and System Upgrades

- Reclaim the refrigerant of the existing air-cooled chiller and dispose of properly.
- Demolish and remove the existing chiller –Trane Model # RAUJC804PA1020DF01CS (JCI Tag# 225).
- Demolish the motor starters and safe off the power circuit.
- Provide and install York air-cooled chiller as per capacity and operation provided in the design drawings.

- Provide the required trucking of the old and new equipment to and from the site.
- Provide the required crane to load the old chiller onto trucks and the new chiller into place.
- Provide and install schedule 40 steel pipe and fittings to connect the new air-cooled chiller to the chilled water piping connections.
- Provide and install the required drains on the new chilled water piping.
- Provide and install new chilled water isolation valves, if necessary.
- Provide and install rubber isolation spheres at the chiller.
- Provide the required new electrical conduit and cable to connect the new chiller to the existing power connection over to the new chiller.
- Provide new fiberglass pipe insulation for the new chilled water piping exterior of the building, exterior insulation shall be covered in aluminum covering. Insulation shall be 2" thick.
- Fill and test the new piping.
- Start and test the system.
- Set up the chilled water flow across the chiller.
- Clean off the work area.
- Provide new chilled water pumps with VFDs.

15.3 Boiler Replacement and System Upgrades

- Demolish and remove two existing Burnham boilers (JCI tags #213 & #212) rated at gross output of 2,440 MBH.
- Isolate the heating hot water system from the boilers.
- Provide and install high efficiency condensing hot water heating boilers operating on natural gas.
- Install as per the manufacturer’s recommendations.
- Provide, fabricate, and install the required piping, valves, and fittings to modify the primary and secondary loops.
- Exact location and specifications to be determined in the design drawings.
- Provide and install the required primary and secondary pumps.
- Provide VFDs on any boiler system pump motors greater than 5 HP.

15.4 AHU Refurbishment

- Vacuum cleaning of entire AHU cabinet
- Vacuum cleaning of heating and cooling coils (if applicable)
- Replacement of defective motors
- Replacement of damper bearing and edge seals
- Replace up to 50% of seals and 25% of damper bearings

- Repair/replacement of speed switch and fan transformer (as necessary)
- Repair/replacement of fuses and disconnect (as necessary)
- Filter replacement
- Condensing unit (if applicable) cleaning / washing & fin straightening

Exclusions for HVAC System Improvements

- Temporary heating and cooling during transition.
- Repair or replacement of defective mechanical equipment, except the equipment described in the ECM description. JCI will identify the location of defective equipment and notify the SFASD.
- Repair or upgrades required to bring adjacent electrical and mechanical systems up to code.
- Overtime work caused by unforeseen circumstances beyond the control of JCI, such as scheduling changes by SFASD. The cost difference between the overtime work wages and normal time work wages will be the responsibility of SFASD calculated as [(overtime rate – normal rate) x hours]).
- Asbestos abatement and removal for this project is entirely the responsibility of SFASD. If hazardous materials are encountered during the implementation phase, JCI will immediately stop work, take measures to reduce any contamination, and notify the SFASD facility manager of the possible hazardous material condition and location. JCI will then request that SFASD remove and dispose of the hazardous materials prior to any continuation of work. Hazardous materials encountered during the ongoing service phase of the project will remain the property and disposal responsibility of SFASD. JCI will work with SFASD and our subcontractors to sufficiently identify the scope, costs, and project scheduling implications of any required abatement such that SFASD can adequately plan for this requirement.
- The cost of hazardous material abatement or removal, such as asbestos, mold and lead paint that is not currently specified in the engineering scope of work. In the event hazardous materials are uncovered and abatement is beyond the ability of JCI to abate under this contract, the ECM will be evaluated for possible removal from the scope of work or the transfer of this responsibility to SFASD.
- Water balance of additional equipment (air-handlers, condensers, etc.), unless specified in the scope of work.
- Engineering services, studies and analysis associated with any exclusions or work clearly outside of the scope definition.
- Unknown permits, fees or processes required by local or oversight jurisdiction and/or utilities.
- Structural work not specified in drawings.
- Resolution of existing design, service, and or distribution conditions known or unknown.
- Repairs/replacement of insulation, piping, electrical or ductwork found to be corroded or rusted or otherwise unacceptable for installation of components or fittings required for installation other than what is specified in the Scope of Work.

Energy Savings Methodology

Energy savings calculated using eQUEST (Refer Appendix E and eQUEST attachments). Baseline performance was calibrated using existing equipment operation and conditions. Savings calculated by changing characteristic of replacement equipment features and performance for parametric runs.

O&M Savings

O&M savings is expected through reduced maintenance of new equipment.

Warranty

All installed equipment and workmanship will be warranted for a period of one year after customer acceptance. All parts, labor and costs will be covered by JCI during this period.

Customer Support and Coordination with Utilities

Support will be required for the interruption of utilities for brief tie-in periods. All interruptions will be coordinated and scheduled with the staff in advance.

Training

Training will be provided to enable SFASD staff to successfully operate the equipment installed as part of this project. More details about the training are covered at the end of the Project Implementation Plan section.

Appendix D: ECM Descriptions (Evaluated but Not Included)

Note this section includes descriptions of measures inclusive of information at the time of removal from scope. Summary descriptions of all ECMs can be found in the "Energy Conservation Measures" section of the main document.

ECM 4 – Stadium Lighting Upgrades

Reason for Exclusion

Capital driven project with minimal energy savings and some operational savings. This project can be directly and cost effectively executed with the school district's stadium lighting vendor, Musco, when the existing system fails.

ECM Summary

SFASD's stadiums and sports fields were surveyed for the application of this measure. Stadium lighting energy efficiency upgrades provide a substantial energy benefit and quality of light improvement. Significant operating utility savings, reduced maintenance costs, and improved overall lighting systems performance are achieved through this upgrade.

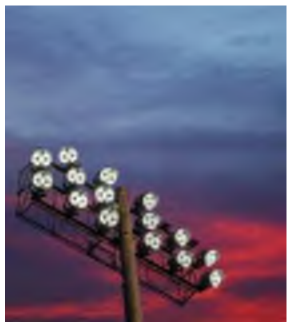
Existing System

Energy savings calculations are based upon hours of operation. These hours were obtained from site personnel.

Proposed System

JCI has identified opportunities for energy savings through the installation of new high efficiency lighting similar to those shown in Figure 1. JCI proposes to replace these fixtures with new LED fixtures that will produce a brighter and sharper light which will enhance player's visibility and safety.

Figure 1: Sample Stadium Light Fixture



Locations & Quantities of Lighting Fixtures Included for Upgrades

Facility/Location	# Light Fixtures Impacted
Coach McNelly Stadium	84
Rams Baseball	64
Total	148

Scope of Work

Retrofit existing Metal Halide pole top fixtures with LED pole top fixtures

New fixtures to incorporate Sports ClusterGreen technology (manufacturer – Musco)

Installation to include:

- Demolition of existing light fixtures, crossarms, and associated lighting components.
- Offloading, assembly, and installation of Sports Cluster Green components and Lighting Contactor Cabinets.
- Reconnection to existing underground wiring, and existing main distribution panels.

ECM 5 – Building Envelope Improvements

Reason for Exclusion

This measure was excluded due to the low impact on the project's energy savings profile. Several elements of this measure can be and are being performed in-house.

ECM Summary

All locations were surveyed for the application of this measure. Energy is lost throughout the buildings due to infiltration. The heat losses and heat gains occur due to gaps and openings that allow the building's conditioned (heated or cooled) air to mix with the outside ambient air. This measure will seal these leaks, resulting in energy savings and improved comfort in the areas and occupied spaces that are subjected to outside air infiltration.

Existing System

Infiltration/exfiltration is the rate of uncontrolled air exchange that occurs through unintentional building openings. Throughout the buildings, some leaks were found that would allow heat to be lost during the winter and heat gained during the summer. These openings range from gaps around doors, and various other gaps allowing air to pass from a region of higher pressure to that of lower pressure. Outside wind conditions also provide increased pressure gradients across the leakage surfaces, which allow for correspondingly increased leakage rates. Temperature gradients also create the "source to sink" flow, therefore the greater the difference between the outside air and the indoor air temperature, the greater the rate of infiltration. Doors, roof-to-wall joint, rooftop ventilator, and defunct relief vents are all major heat loss contributors to the building.

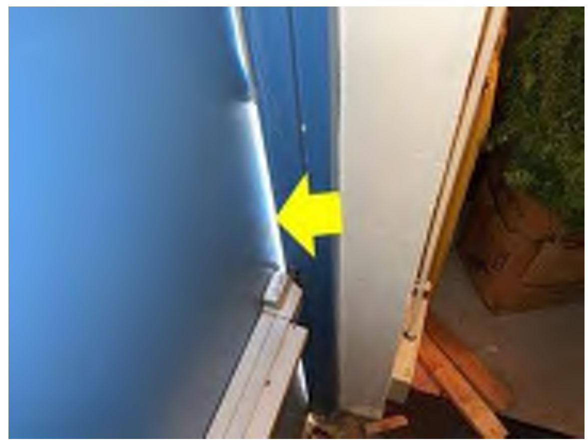
Buck Frame Air Sealing – the buck frame is the rough opening in the structural framing of the building left open for windows or doors to later be installed. This opening is sometimes filled with foam insulation sealants and finished with a variety of casing materials; often the buck frame is not sealed properly with fiberglass or not sealed at all leaving buck frames very susceptible to air leakage. This condition is especially prominent above drop ceilings where finishing air barrier materials such as window casing and caulk are not continued due to builders assuming they were aesthetic finishes only; this misunderstanding allows unnecessary air infiltration and exfiltration at unfinished buck frames.

Caulking – there are unsealed perimeter joints and holes found at the window systems at Limerick ES. These gaps allow air to find its way into the wall and window frame cavities or directly from outside to inside resulting in unwanted energy losses.

Attic Air Barrier Retrofit – chicken wire supporting unfaced fiberglass is a building envelope flaw. Dirt build-up at fiberglass intersections is a clear sign of air permeable fiberglass "filtering" air leaking through the thermal envelope of the building (Royersford ES).

Caulking – missing sealants at the window casing are leading to a clear air leakage pathway as seen by daylight (Limerick ES).

Door Weather-Stripping – weather-stripping was improperly installed at the sides of the door as seen by clear daylight at the perimeter of the door (Spring-Ford Area HS).



Door Weather-Stripping – weather-stripping was improperly installed at the sides of the door as seen by clear daylight at the perimeter of the door (Oaks ES).

Door Weather-Stripping – a missing door sweep next to an existing door sweep needs to be installed to prevent drafts at the bottom of the door assembly (Royersford ES).

Roof Insulation – roof assemblies were connected but insulation is not continuous. It is believed that condensation forms at these intersections and drips onto drop ceiling below; enhancing the thermal barrier (5th-7th Grade Center).

Roof-Wall Intersection Air Sealing – the roof-wall intersection is regularly an area that allows unwanted air leakage through the building shell. This is the primary area of unwanted air leakage throughout the school buildings in the SFASD. Exterior flashing and finish details at this area are not constructed to stop air leakage (exterior flashings are for water control, not air control); unsealed exterior flashing details combine with interior gaps in the framing between the roof and wall assembly to allow infiltration/ exfiltration.

Roof-Wall Intersection Air Sealing – the exterior flashing and finishes at the roof-wall intersection are not constructed to stop air leakage (Upper Providence ES).

Roof-Wall Intersection Air Sealing – air permeable fiberglass installed in the roof-wall intersection is allowing air infiltration and exfiltration (Evans ES).

Proposed System

JCI shall furnish and install weather-stripping around exterior doors. Caulking will be applied around the building to seal structural gaps to prevent air leakage. Cracks and openings within the building envelope will be sealed properly to help prevent air infiltration.

Buck Frame Air Sealing – install new polyurethane sealant between the window header and window frame for an air-tight transition from the top of the aluminum window frame to the header, and to the wall assembly above.

Caulking – caulk the non-operational components of the window jamb, casing or trim that have been identified as pathways for air leakage using siliconized acrylic caulk or elastomeric caulking as necessary.

Door – Install Jamb Spacer **–** install metal spacer at perimeter of door frame as mounting surface to receive door weather-stripping carrier. Caulk behind metal spacer for air-tight seal.

Door Weather-Stripping – ensure the door operates and closes appropriately. Notify prime contractor and/or owner when doors are damaged. Install heavy duty weather-stripping with aluminum carrier and Q-lon insert gasket at door sides and top jamb. Install for 40% - 60% weather-strip compression. Caulk behind weather-strip carrier for air-tight seal. Cut aluminum carrier weather-strip at locks, swing arms or any other hardware where necessary. Install door bottom sweep with aluminum carrier and sweep insert. For double doors install an astragal weather-strip material at both sides of the center meeting.

Overhang Air Sealing – install air barrier materials and sealants to create an air-tight transition at the opening/ soffit at the overhang. For smaller gaps, install spray polyurethane foam sealant to seal the gap. For mid-size or large gaps, install Dow Thermax Sheathing as blocking/ backer, install fasteners with washers as necessary to fasten the Thermax Sheathing in place, install polyurethane sealants at the perimeter and seams of the Thermax Sheathing for an air-tight seal. Install all materials to create an air-tight seal in accordance with the manufacturer's specifications.

Roof-Wall Intersection Air Sealing – install air barrier materials and sealants to create an air-tight transition at the roof-to-wall intersection. For smaller gaps, install spray polyurethane foam sealant to seal the gap. For mid-size or large gaps, install Dow Thermax Sheathing as blocking/ backer, install fasteners with washers as necessary to fasten the Thermax Sheathing in place, install polyurethane sealants at the perimeter and seams of the Thermax Sheathing for an air-tight seal. Install all materials to create an air-tight seal in accordance with the manufacturer's specifications.

Wall Air Sealing – install air barrier materials and sealants to create an air-tight transition at the incomplete areas of wall air barrier and insulation materials. For smaller gaps, install spray polyurethane foam sealant to seal the gap. For mid-size or large gaps, install Dow Thermax Sheathing as blocking/ the primary air barrier material, install fasteners with washers as necessary to fasten the Thermax Sheathing in place, install polyurethane sealants at the perimeter and seams of the Thermax Sheathing for an air-tight seal. Install all materials to create an air-tight seal in accordance with the manufacturer's specifications.

Attic Air Barrier Retrofit – re-locate the existing fiberglass batt insulation as necessary to create open access to attic floor framing (save for re-use); install Thermax rigid insulation secured to the existing framing using screws and screw plates; use sheathing tape to cover all fastener penetrations in rigid insulation material; install polyurethane foam sealant or sheathing tape at perimeter and seams of all rigid insulation boards for an air-tight seal. At the attic floor intersection with gable walls and the intersection of the underside of the roof assembly create an air-tight seal between Thermax rigid insulation and the adjoining wall or roof surface using polyurethane sealants. Reinstall the fiberglass batt insulation on the Thermax air barrier surface.

Attic Flat Insulation – install additional fiberglass batt insulation to attic flat for 100% coverage of attic surface with fiberglass batt material.

Roof Insulation (5th-7th Grade Center) – at roof intersection seams install 2-part spray polyurethane foam at a minimum of 4" thickness. Insulation should overlap the intersections by a minimum of 4 inches on either side of the intersections noted. Foam is to be covered by intumescent coating to meet thermal barrier requirement.

Roof Insulation (Oaks ES) – install continuous air barrier at the underside of the existing fiberglass and strapping assembly utilizing 2 inches of 2-part spray polyurethane foam. Foam is to be covered by intumescent coating to meet thermal barrier requirement.

Wall Air Sealing – install air barrier materials and sealants to create an air-tight transition at the incomplete areas of wall air barrier and insulation materials. Install Dow Thermax Sheathing as blocking/ the primary air barrier material, install fasteners with washers as necessary to fasten the Thermax Sheathing in place, install polyurethane sealants at the perimeter and seams of the Thermax Sheathing for an air-tight seal. Install all materials to create an air-tight seal in accordance with the manufacturer's specifications.

Scope	5-7th Grade Center	8th Grade Center	9th Grade Center	Brooke ES	Evans ES
Caulking (LF)				2,470	
Door - Install Jamb Spacer (Units)					
Door Weather-Striping - Doubles (Units)	14	15	25	8	13
Door Weather-Stripping - Singles (Units)	19	14	12	2	1
Overhang Air Sealing (LF)					
Overhang Air Sealing (SF)					
Overhead Door Weather-Stripping (Units)		16			
Roof-Wall Intersection Air Sealing (LF)	471	2,495	2,278	233	1,062
Roof-Wall Intersection Air Sealing (SF)					
Wall Air Sealing (LF)					
Wall Air Sealing (SF)	918	390	300		
Wall Air Sealing (Units)	34				

Task	Limerick ES	Oaks ES	Royersford ES	Spring-Ford Area HS	Upper Providence ES	Total Quantity
Caulking (LF)	3,040		6,192			11,702
Door - Install Jamb Spacer (Units)		4				4
Door Weather-Striping - Doubles (Units)	16	4	15	27	12	174
Door Weather-Stripping - Singles (Units)	7	2	1	6	11	85
Overhang Air Sealing (LF)				9		9
Overhang Air Sealing (SF)				93		93
Overhead Door Weather-Stripping (Units)						16
Roof-Wall Intersection Air Sealing (LF)	1,956	646		3,089	571	15,871
Roof-Wall Intersection Air Sealing (SF)					215	215
Wall Air Sealing (LF)				1,035		1,035
Wall Air Sealing (SF)		1,292				2,900
Wall Air Sealing (Units)						34

Scope of Work

Door Weather-Stripping

- Ensure door operates and closes appropriately. Notify Customer when doors are damaged.
- Install heavy duty weather-stripping with aluminum carrier at door sides and top jamb. Install for 40% - 60% weather-strip compression.
- Caulk behind weather-strip carrier for air-tight seal.
- Cut aluminum carrier weather-strip at locks, swing arms or any other hardware where necessary.
- Install door bottom sweep with aluminum carrier.
- For double doors install astragal at center meeting.

Caulking

- Seal the non-operational components of the jamb, casing or trim that have been identified as pathways for air leakage.
- Install backer rod as required at large gaps.

Roof-Wall Intersection Air Sealing

- Drape a protective sheet over furnishings and the wall below the drop ceiling.
- Remove ceiling tiles as necessary to access the roof-wall intersection.
- Install an approximately 4 inch – 6 inch wide and 2-inch-deep bead of high-density spray polyurethane foam at the air leakage pathway.
- Replace the drop ceiling tiles and clean the area.

Overhang Air Sealing

- Drape a protective sheet over furnishings and the wall below the drop ceiling.
- Remove ceiling tiles as necessary to access the space.
- Install Dow Thermax polyisocyanurate rigid insulation to block the entire air leakage pathway.
- Seal the perimeter and seams of the rigid insulation board with a foam or tape sealant.

Wall Air Sealing

- Fasten Dow Thermax polyisocyanurate rigid insulation to create air barrier and insulation continuity over the wall system.
- Seal the perimeter and seams of the rigid insulation board with foam sealant or sheathing tape.

ECM 7 – Water Conservation

Reason for Exclusion

High payback and existing low flow fixtures. JCI identified some specific instances where water conservation projects could be undertaken to save water, however the costs outweighed the benefits.

General

The following general requirements are associated with water conservation measures for buildings listed in the table below. The general intent of this ECM is to reduce water usage as well as wastewater production. An additional benefit of this ECM will be reduced heating energy utilized to produce hot water. Water, sewer charges and thermal savings will be achieved through implementation of this work.

All work to be in accordance with prevailing industry practice, state, and local codes.

Water Fixtures Retrofit Quantities

Facility/Building	Toilet	Urinal	Faucet	Faucet (other)	Shower
5-7th Grade Center	-	39	130	87	-
8th Grade Center	22	16	15	1	-
9th Grade Center	1	10	35	13	-
Brooke ES	-	9	25	33	-
Evans ES	-	8	13	43	-
Limerick ES	4	8	21	6	-
Oaks ES	8	10	21	32	-
Royersford ES	5	11	11	29	-
Spring-Ford Area HS	-	34	121	-	24
Upper Providence ES	-	8	34	30	-
Totals	44	155	438	284	24

Demolition, Removal and Onsite Prep Work

- Disconnect, remove, and properly dispose of components no longer necessary for the proper working of the retrofitted equipment.
- Wipe down equipment being worked on.

New Installation Work

Furnish and install new high efficiency retrofits as identified in the table above. Specifically:

- Remove and dispose of 40 existing flushometer type toilet and replace with new 1.28 gpf toilet china and manual diaphragm flush valve; existing top- or side-mount sensors will be reused.
- Remove and dispose of 155 existing flushometer type urinal and replace with new 0.25 gpf urinal china and manual diaphragm flush valve; existing top- or side-mount sensors will be reused.
- Remove and dispose of four existing toilet flush valve diaphragm kit and replace with new 1.6 gpf flush valve diaphragm kit.
- Retrofit 719 existing sink faucet with new aerator (remove and dispose of existing aerator, if applicable):
    - 438 0.5 gpm aerators
    - 281 1.5 gpm aerators
- Remove and dispose of 24 existing showerhead and replace with new 1.5 gpm head.
- Remove and dispose of three existing kitchen pre-rinse nozzle and replace with new 1.5 gpm nozzle.

The existing top and side-mount flush valve sensors were to be reused. JCI proposed to provide touch-up painting, wall repair and all other necessary repair to ensure work area is in a condition equal to or better than original condition.

ECM 8 – Recommission DDC Controls

Reason for Exclusion

HVAC controls are already well managed, and the school district can accomplish this non-invasive, non-construction intensive measure outside of this project.

ECM Summary

The following requirements are associated with the retro-commissioning of existing controls equipment, including software components such as sequences of operation pertaining to chillers, boilers, AHUs, makeup air units, energy recovery ventilators, radiators, unit ventilators, heat pumps, cooling towers, exhaust fans. All sensors and field controllers connected to equipment listed in the table below shall be inspected. The intent of this ECM is to restore peak performance of equipment, upgrade failing/failed components and verify programming continues to work as intended. Both electric and thermal savings will be achieved through the implementation of this work. All work to be in accordance with prevailing industry practice, state, and local codes.

Existing System

Facility / Location	Equipment Type	Existing Controls*
Brooke ES	CHWS, HWS, AHU-1 Admin, AHU-2 Café, AHU-3 Gym, AHU-4 Stage, AHU-5 Library, 33 Classroom Units, 11 Support Space Room Units, 5 Exhaust Fans	Metasys DDC - SNE, mix of DDC and pneumatic field controllers.
Evans ES	Central Plant, 83 Heat Pumps, 2 HRUs, 1 MUA, 3 VAVs, 3 Exhaust Fan Systems	Metasys DDC - NAE
Limerick ES	CHWS, HWS, AC-1 Office, AC-2 Library, AC-3 Gym Hallway, AC-4 Main Hallway, AC-5 Rom 104, AC-6 200 Corridor, AC-7 300 Corridor, AC-8 LGI Room, AHU-23 Library, AHU-25 Gym, AHU-33 Cafeteria, 9 VAVs, 10 Bathroom Heaters, 7 Vestibule Heaters, 4 Finned Tube, 35 Classroom Units, 12 Exhaust Fans	Metasys DDC - SNE
Oaks ES	19 Classroom Units in the 97 Wing, 2 Exhaust Fans in the 97 Wing, 1 CHWS, 1 HWS, AHU-1 – Multi-Purpose, AHU-2 – Gym, AHU-3 – Library, BC-1 – Nurses Office, 2 VAVs, 7 Classroom Units, 19 Units in the 2001 Wing, 8 Exhaust Fans	Metasys DDC - NAE (Overlay) on Siemens DDC Controls, pneumatic field controllers
Royersford ES	HWS, CHWS, AHU-1 Stage, AHU-2 Cafeteria, AHU-2A Gym, AHU-3 Kitchen, AHU-4 Media Center, AHU-5 Administration, AHU-6 Kitchen, 6 VAVs, 12 Fan Coil Units, 35 Classroom Unit Ventilators, 12 Exhaust Fans, 23 Unit Heaters	Metasys DDC - NAE, mix of DDC and pneumatic field controllers.
Upper Providence ES	CHWS, HWS, 79 Heat Pumps, 2 HRUs, 10 Exhaust Fans, 4 Unit Heaters, 1 MUA, 1 HV-1	Metasys DDC - NAE

Facility / Location	Equipment Type	Existing Controls*
5-7th Grade Center	Central Plant, 243 Heat Pumps, 6 HRUs, 1 MUA, 1 HV1, 12 VAVs, 39 Cabinet Unit Heaters, 25 Propeller Unit Heaters, 28 Exhaust Fan Systems	Metasys DDC - SNE
8th Grade Center	CHWS, HWS, 27 Fan Coil Units, 29 Unit Ventilators, 15 AHUs, 32 Baseboard Units, 30 Wall Heaters & Unit Heaters, 11 Exhaust Fans	Metasys DDC - NAE, mix of DDC and pneumatic field controllers.
9th Grade Center	CHWS, HWS, 133 Heat Pumps, 7 ERVs, 1 MAU	Metasys DDC - NAE
Spring-Ford Area HS	CHWS, HWS, 172 VAVs, 22 Unit Heaters, 10 Exhaust Fans, 65 Unit Ventilators, 52 Small to Medium AHUs, 2 Fan Coil Units	Metasys DDC - SNE, mix of DDC and pneumatic field controllers.

* Scope includes only fully DDC components.

Proposed System

Depending on the ECMs included within the final project, consider recommissioning all existing DDC controls that are untouched as part of new work. Recalibrate all inputs and outputs including all dampers and valves. Ensure minimum position outdoor air damper percentages are adjusted per current ASHRAE 62.1 standards and physical position matches DDC percentages displayed in system. Provide air-balancing and ensure duct static pressure sensors and pipe differential pressure sensors are calibrated and set to the proper setpoint for efficient control. For each facility, develop improved control sequences to provide some level of humidity control during summer operation.

Scope of Work

Classroom Units

- Review Sequence of Operation from O&M manual.
- Place fan coil unit in occupied mode.
- Verify unit is on-line and communicating to BAS.
- Verify zone temperature and setpoint are reading correct values.
- Verify control valves stroke full open to full close.
- Verify unit fan is functioning.

Fan Coil Units

- Review Sequence of Operation from O&M manual.
- Place fan coil unit in occupied mode.
- Verify unit is on-line and communicating to BAS.
- Verify zone temperature and setpoint are reading correct values.
- Verify control valves stroke full open to full close.
- Verify unit fan is functioning.

Exhaust Fans

- Review Sequence of Operation from O&M manual.
- Place fan coil unit in occupied mode.
- Verify unit is on-line and communicating to BAS.
- Verify unit fan is functioning.

Chilled Water Supply

- Review Sequence of Operation.
- Place chilled water system in occupied or operational mode.
- Verify temperature sensors are reading a correct value.
- Verify chilled water supply pumps start/stop/status.
- Verify safety circuit and alarms.

Hot Water Supply

- Review Sequence of Operation.
- Place heating hot water system in occupied or operational mode.
- verify hot water supply and hot water return temperature sensors are reading a correct value.
- Verify hot water pumps start/stop/status.
- Verify boiler command, status and modulation values.
- Verify fuel oil pump status.
- Verify safety circuit and alarms.

AHUs

- Review Sequence of Operation.
- Place AHU in occupied mode.
- Verify temperature, CO_2 and humidity sensors are reading correct value.
- Verify control valves stroke to full open and full close.
- Verify coil freeze protection pumps operate.
- Verify any damper actuators modulate from full open to full closed.
- Verify supply and return fan command and status are functioning.
- Verify safety circuit shutdown of unit.
- Verify air filter status is operational.
- Verify associated exhaust fan(s) start on AHU occupied command.

Unit Heaters

- Review Sequence of Operation from O&M manual.
- Place unit in occupied mode.
- Verify unit is on-line and communicating to BAS.
- Verify heating control valve stroke full open to full close.

Central Plant

- Review Sequence of Operation.
- Place chilled water system in occupied or operational mode.
- Verify temperature sensors are reading a correct value.
- Verify chilled water supply pumps start/stop/status.
- Verify safety circuit & alarms.
- Review Sequence of Operation.
- Place heating hot water system in occupied or operational mode.
- Verify hot water supply and hot water return temperature sensors are reading a correct value.
- Verify hot water pumps start/stop/status.
- Verify boiler command, status and modulation values.
- Verify fuel oil pump status.
- Verify safety circuit & alarms.

Heat Pumps

- Review Sequence of Operation from O&M manual.
- Place fan coil unit in Occupied mode.
- Verify unit is on-line and communicating to BAS.
- Verify zone temperature and setpoint are reading correct values.
- Verify control valves stroke full open to full close.
- Verify unit fan is functioning.

Heat Recovery Unit

- Review Sequence of Operation.
- Place AHU in occupied mode.
- Verify temperature, CO_2 and humidity sensors are reading correct value.
- Verify control valves stroke to full open and full close.
- Verify coil freeze protection pumps operate.
- Verify any damper actuators modulate from full open to full closed.

- Verify supply and return fan command and status are functioning.
- Verify safety circuit shutdown of unit.
- Verify air filter status is operational.
- Verify associated exhaust fan(s) start on AHU occupied command.

MUA

- Review Sequence of Operation.
- Place AHU in occupied mode.
- Verify temperature, CO_2 and humidity sensors are reading correct value.
- Verify control valves stroke to full open and full close.
- Verify coil freeze protection pumps operate.
- Verify any damper actuators modulate from full open to full closed.
- Verify supply and return fan command and status are functioning.
- Verify safety circuit shutdown of unit.
- Verify air filter status is operational.
- Verify associated exhaust fan(s) start on AHU occupied command.

HVs

- Review Sequence of Operation.
- Place AHU in occupied mode.
- Verify temperature, CO_2 and humidity sensors are reading correct value.
- Verify control valves stroke to full open and full close.
- Verify coil freeze protection pumps operate.
- Verify any damper actuators modulate from full open to full closed.
- Verify supply and return fan command and status are functioning.
- Verify safety circuit shutdown of unit.
- Verify air filter status is operational.
- Verify associated exhaust fan(s) start on AHU occupied command.

AC

- Review Sequence of Operation.
- Place AHU in occupied mode.
- Verify temperature, CO_2 and humidity sensors are reading correct value.
- Verify control valves stroke to full open and full close.
- Verify coil freeze protection pumps operate.
- Verify any damper actuators modulate from full open to full closed.

- Verify supply and return fan command and status are functioning.
- Verify safety circuit shutdown of unit.
- Verify air filter status is operational.
- Verify associated exhaust fan(s) start on AHU occupied command.

Baseboard Units

- Review Sequence of Operation from O&M manual.
- Place unit in occupied mode.
- Verify unit is on-line and communicating to BAS.
- Verify heating control valve stroke full open to full close.

Wall Heaters & Unit Heaters

- Review Sequence of Operation from O&M manual.
- Place unit in occupied mode.
- Verify unit is on-line and communicating to BAS.
- Verify heating control valve stroke full open to full close.

Energy Recovery Ventilations

- Review Sequence of Operation.
- Place AHU in occupied mode.
- Verify temperature, CO_2 and humidity sensors are reading correct value.
- Verify control valves stroke to full open and full close.
- Verify coil freeze protection pumps operate.
- Verify any damper actuators modulate from full open to full closed.
- Verify supply and return fan command and status are functioning.
- Verify safety circuit shutdown of unit.
- Verify air filter status is operational.
- Verify associated exhaust fan(s) start on AHU occupied command.

ECM 10 – Heat Recovery Unit Refurbishment

Reason for Exclusion

American Air heat recovery units are not being manufactured anymore and the cost of replacement parts is prohibitive. Replacement of units will be a better option for the district.

ECM Summary

The following requirements are associated with the recommissioning of existing heat recovery units at four schools. The units identified for recommissioning are generally in good shape and have more remaining useful life.

The intent of this ECM is to extend the useful life of the listed equipment through refurbishment. To some extent replacing/repairing failed or failing control valves, heat recovery wheels, and other components will address overheating/cooling, improve the heat transfer capabilities, and improve dehumidification functionalities of the units. Both electric and thermal savings will be achieved through implementation of this work.

Existing System

- Upper Providence ES
- 5-7th Grade Center
- Evans ES
- 9th Grade Center

Building	Quantities	Manufacturer
9th Grade Center	7	Annex Air
Evans ES	2	Annex Air
5-7th Grade Center	6	American Air
Upper Providence ES	2	American Air

Proposed System

Building	HRU No.	Area Served	Total CFM	Supply CFM	Air Stream	Outside Air	Exhaust Air
Evans ES	1	Zone 1 (East)	21,010	19,855	Outdoor	-	-
		Gymnasium - Admin.	19,635	18,480	Exhaust	-	-
	2	Zone 2 (West)	37,202	35,880	Outdoor	-	-
		Classrooms	34,582	33,260	Exhaust	-	-
Upper Providence ES	1	Zone 1 (East)	18,282	16,485	Outdoor	-	-
			18,061	16,264	Exhaust	-	-
	2	Zone 2 (West)	22,470	20,389	Outdoor	-	-
			19,916	17,835	Exhaust	-	-
5-7th Grade Center	1	Area A	Not applicable.			10,000	8,000
	2	Area B				6,000	5,000
	3	Area C				6,000	5,000
	4	Area D				6,000	5,000
	5	Area E				6,000	5,000
	6	Area F				6,000	5,000
9th Grade Center	ERV-AB	Area I	Not applicable.			11,150	8,925
	ERV-CD	Area D				6,050	5,985
	ERV-EJ	Area J				11,325	10,140
	ERV-F1	Area F				7,770	7,770
	ERV-F2	Area F				7,620	7,620
	ERV-GH	Area G				13,160	12,645
	ERV-1	Area I				6,750	5,920

Scope of Work

- Vacuum cleaning of entire heat recovery unit cabinet
- Replace motors and belts
- Replacement of damper bearing and edge seals
- Replace enthalpy wheels where applicable
- Repair/replacement of speed switch and fan transformer (as necessary)
- Repair/replacement of fuses and disconnect (as necessary)
- Filter replacement

ECM 11 – Kitchen Hood Controls

Reason for Exclusion

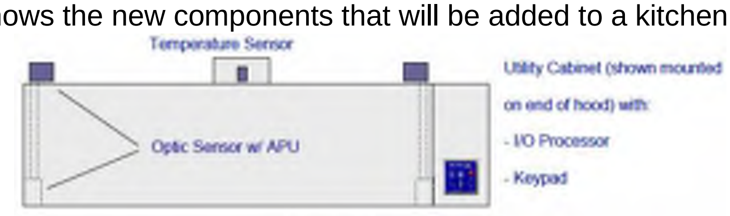
This is a high payback and low priority item for the school district.

General

Kitchen hoods are usually operated from the time the first kitchen employee enters the kitchen to the time the last kitchen employee leaves. Operating the fume hoods at full power all the time wastes electrical fan energy and the fume hood also draws conditioned air out of the space causing the heating and cooling systems to over work. There is significant energy to be saved by controlling the fume hood fans based on the cooking load directly below. The fan will be modulated based on monitoring of the exhaust air temperature and smoke load inside the hood. The kitchens have constant flow exhaust hoods that are operated manually by the kitchen staff. The overall strategy for improving the performance of the kitchen hood systems is to install a MeLink Intelli-Hood control system that determines kitchen hood fan speed based on the cooking load under the hood.

JCI will provide Melink (or equal) kitchen hood system for the kitchens at all school buildings in the RFP. This measure will reduce annual energy costs and maintenance. In addition, time of day scheduling, manual timer controls are added to reduce the operation time of the exhaust fans. The new kitchen hood control system will automatically control the speed of the exhaust and makeup fans to setback when not in use thereby saving energy. Installation to be performed in accordance with mechanical, electrical, fire, local, state, and national installation and operational codes.

The figure below shows the new components that will be added to a kitchen hood system.



Kitchen Hood Controls Diagram

The general intent of this ECM is to create energy savings through reset. Both electric and thermal savings will be achieved through implementation of this work.

Demolition, Removal and Onsite Prep Work

Electrical

- Safely disconnect existing units.
- Properly disconnect and isolate smoke alarms and other life safety devices connected to the unit.

Other Onsite Prep

- Clear debris on areas of new install.
- Inspect support structures (kitchen hood) for continued integrity. Customer will be informed of any concerns.

New Installation Work

Electrical

- Each new Intelli-Hood Processor will be mounted in the ceiling (or wall) of the kitchen in close proximity to the hoods it serves. When available or provided by the hood manufacturer, the processor can be mounted in the hood end cabinet.
- Each processor shall be wired with an input power of 120 VAC. This circuit must lose power when the fire suppression system is activated. If the hoods served by a processor have separate fire suppression systems, the fire system interlocks must be wired in series such that if any hood has a fire condition, the processor loses power.
- Install Intelli-Hood keypad(s) (one for each processor) in two-gang junction box directly under the processor (or other designate area approved by Melink and owner).
- Keypad must be installed within 50’ of the processor.
- Install CAT-5 cable provided by Melink from processor to keypad. Install in conduit where exposed.
- Install VFDs per installation instructions of VFD manufacturer.
- Power the VFDs with three-phase power from existing motor starter circuit.
- The existing motor starters must be left in place as interlocks to the building controls that are connect to these starters must remain intact and functional.
- If there are motor overload devices on the existing motor power circuit, these devices must be removed or bypassed to avoid issues of the VFD causing these devices to trip.
- Connect VFDs to the fans and ensure correct rotation direction.
- Connect three-phase power of VFDs to their respective fans. Existing wiring will be used where possible.
- The output wiring from each VFD shall be installed in separate conduit.
- Install CAT-4 communication cable(s) provided by Melink, from Intelli-Hood Processors to the VFDs.
- One cable from each processor shall be run to the VFD location.
- Install low voltage wiring from the processor to the MUA unit.
- Wire a dedicated 115V circuit to the MUA unit to energize the MUA controls.

ECM 12 – Load Shedding/PLC Management/Demand Response and Battery Storage

Load Shedding/PLC Management/Demand Response

Reason for Exclusion

This ECM was excluded due to the potential negative impact on space conditioning and operation of the schools.

Executive Summary

The following general requirements are associated with all school buildings included in the RFP. Through this work, participation in existing demand response curtailment programs will become more automated. The general intent of this ECM is to generate revenue through increasing (or sustaining) demand response enrollment levels by automating load reduction strategies. All work to be in accordance with prevailing industry practice, state, and local codes.

New Installation Work

Electrical

- Verify existing power meters and data recorders for proper function and communication.
- Inform current Curtailment Services Provider of any updates/upgrades necessary for proper operation.
- Provide labor, conduit, fittings breakers, insulation, etc.

Controls

- Furnish and install automated programming to effectively participate in existing demand response curtailment programs.
- Perform one-time one-hour test to validate committed load reductions.
- Perform one-time test to validate all buildings return to standard occupied mode after completion of above one-hour test event.

Battery Storage

Reason for Exclusion

A high payback made this ECM uneconomical.

General

The following general requirements are associated with the installation of a battery storage system for schools listed in the table below.

Energy storage potentially in conjunction with electricity production from a PV system (at Spring-Ford Area HS) can provide a source of renewable energy, offset peak demand charges, and take advantage of utility incentive programs including demand response by storing electricity and discharging that electricity during required periods.

Through this work, all equipment (including newly upgraded units) in a building shall be visible and controllable through a single web-based platform. The general intent of this ECM is to generate energy-based revenue through participation in utility programs. Batteries have the added capability of providing additional resiliency for identified buildings. Additionally, minor energy savings will be achieved through implementation of this work.

All work to be in accordance with prevailing industry practice, state, and local codes.

Building List for Potential Battery Storage System

Facility/Location	Size/Dispatch	Existing Switchgear Size
Evans ES	770.1 kW/ 4 Hours	3000 Amps
Limerick ES	770.1 kW/ 4 Hours	3000 Amps
Upper Providence ES	770.1 kW/ 4 Hours	3000 Amps
5-7th Grade Center	770.1 kW/ 4 Hours	4000 Amps
9th Grade Center	770.1 kW/ 4 Hours	3200 Amps
Spring-Ford Area HS	770.1 kW/ 4 Hours	3000 Amps

Demolition, Removal and Onsite Prep Work

Other Onsite Prep

- Clear debris in area identified for installation of new pads.
- Inspect ground for continued integrity after installation of equipment.

New Installation Work

Site

- Site engineering and work shall comply with all applicable federal, state, and local codes.
- Concrete pads to be sized for the battery storage system.

Civil

- JCI shall perform analysis to understand/mitigate storm water, grading and erosion issues that may impact the pad site. All work shall comply with all applicable federal, state, and local codes.

Structural Engineering

- JCI shall provide engineering for the pad site.

Electrical

- Furnish and install new battery storage systems sized for 770kW bi-direction power inverter with BACnet interface to be installed in locations identified in the table above.
- Identify an electrical interconnection point for the newly installed battery system. All wiring will be sized appropriately for the proper operation of the installed battery system.
- Furnish and install new 480V/12.47 KV power transformer.
- Furnish and install new sub-sub-switchgear and new electrical disconnect to existing switchgear.
- Furnish and install new power metering.
- At Spring-Ford HS, furnish and install a 2.22 MW system capable of producing 2.765 GWH annually. Total of 5,416 JA Solar JAM72S10-410MR panels will be installed. Refer to Figure 1 for locations.
- Furnish and install 15 SolarEdge SE80KUS and eight SolarEdge SE66.6KUS inverters.
- Provide labor, conduit, fittings breakers, insulation, etc.

ECM 13 – Chiller Replacement

Reason for Exclusion

High payback and capital-intensive project. This measure is excluded as Brooks ES chiller was replaced by the district due to immediate requirement and the 8th Grade Center units are proposed to be replaced as part of the district's capital plan.

General

The following general requirements are associated with the replacement of existing air-cooled chillers with new high efficiency units as listed in the table below. All work to be in accordance with prevailing industry practice, state, and local codes.

Through this work, all new chillers will be visible and controllable through a single web-based platform (upcoming Metasys 12.0 release). The general intent of this ECM is to create energy savings through reset strategies and installation of more efficient units. Electric savings will be achieved through implementation of this work.

ID#	Facility / Location	Description		Qty	Make	Model #	Size
Chiller 1	8th Grade Center	Air-Cooled	Existing>	1	Trane	RTAA1704YM01A1D0BFN	170 tons
			Proposed>	1	TBD		

Demolition, Removal and Onsite Prep Work

Electrical

- Safely disconnect existing units.
- Remove existing electrical disconnect.
- Remove existing thermostat and/or BAS connections.
- Properly disconnect and isolate smoke alarms and other life safety devices connected to the unit.

Mechanical

- Safely recover existing R22 refrigerant and dispose according to state and local codes.
- Remove existing units (exclude heat exchangers at Royersford ES) and dispose of properly.
- Safety disconnect equipment from existing refrigerant lines chilled water piping.
- Temporarily seal or cap all disconnected utilities.

Other Onsite Prep

- Clear debris on newly exposed pads and power wash existing pads. Inspect pads to ensure continued integrity of pads.

- Inspect support structures, beams and pads holding evaporator, condensers, and chilled water pipes for continued integrity. Replace as needed.

New Installation Work

Electrical

- Furnish and install new high efficiency air-cooled chillers (York or equal)
- Reconnect equipment to existing electrical power wiring. Verify integrity of existing power wiring. Replace if damaged.
- Furnish and install new electrical disconnect and equipment starter/VFD (as needed)
- Reconnect equipment to existing BAS.
- Provide labor, conduit, fittings, gauges, insulation, etc.

Mechanical

- Installation to be performed in accordance with mechanical, electrical, fire, local, state, and national installation and operational codes.
- Assemble and install curb adapters as required. All work will be performed in a neat and workmanlike manner.
- New chillers to have screw compressors (as applicable for selection and unit size).
- New chillers to have free-cooling coils (as applicable for selection and unit size).
- New chillers to have VFDs.
- All new chillers to come with hot-gas bypass.
- Reconnect equipment to existing chilled water piping. All new chilled water piping to be insulated.
- New chillers to come with native communication capability for BACnet over IP. Reconnect equipment to existing BAS.
- New chillers to come SC-EQUIP interface card and SC-AP access point.
- Include all required cranes and rigging.
- Obtain all licenses, permits, and required inspections.
- Startup and checkout to be performed by a factory authorized representative and shall follow manufacturer's startup and checkout procedures. Checkout shall include part-load and full load operations. Performance report to be provided by JCI.
- Submit O&M documentation in Adobe Acrobat® format.

Controls

JCI will make all points necessary to successfully operate the equipment available on the building's BAS.

ECM 16 – UV-C Systems

Reason for Exclusion

This measure does not provide any savings. JCI recommends keeping fresh air ventilation at levels recommended by ASHRAE Standards. Including UV-C options (or heat wheels) should be considered when evaluating future equipment replacement.

General

The following general requirements are associated with the installation of a UV-C solution within AHUs (including large energy recovery ventilators) at SFASD. Through this work, there will be an improvement in air quality of spaces served using a technology that is supported by the CDC. The general intent of this ECM is the eradication of airborne pathogens. The proposed UV-C solution has a URV-13 output and provides 99% eradication of airborne pathogens per air exchange. Cleaning the air in theory allows for fresh air entering a space to be reduced. JCI has however not claimed any savings in this regard and recommends keeping fresh air ventilation at levels recommended by ASHRAE Standard 62.1-2019. All work to be in accordance with prevailing industry practice, state, and local codes.

Building List and UV-C Systems Count

Facility/Location	UV-C Systems Count
5th-7th Grade	6
8th Grade	11
9th Grade	7
10th-12th Grade	6
Totals	54

Pathogen Eradication Rates at URV-13 Design

Common Name	Pathogenic name	Known, Published UVC value for pathogen reduction		FILTER EFFICIENCY		UVC-only Pathogen reduction	Pathogen reduction UVC + filtration
		UVGI K m²/J	μw/cm²	MERV 8	MERV 10	URV 13 2000μJ/cm²	MERV 13 + URV 13
Pneumonia	Pseudomonus aeruginosa	0.5721	0.005721	14	15	99.99	99.99
TB / Tuberculosis	Mycobacterium tuberculosis	0.4721	0.004721	19	21	99.99	99.99
Corona Virus	COVID-19	0.3770	0.00377	18	20	99.99	99.997
Legionella	Legionella pneumophila	0.1930	0.00193	15	16	99	99.79
Acinetobactor	Acinetobacter baumannii	0.1280	0.00128	42	44	97	99.79
Flu	Influenza A & B	0.1190	0.00119	30	31	96	99.47
Staph / MRSA	Staphylococcus aureus	0.1130	0.00113	28	30	95	99
Avian Flu	Avian Influenza Virus	0.1060	0.00106	12	13	94	97
Measles	Measles	0.1051	0.001051	10	9	94	97
Chicken Pox	Varicella Zoster	0.105	0.00105	10	9	94	97
Strep	Streptococcus pyogenes	0.8110	0.00811	29	31	92	99

Demolition, Removal and Onsite Prep Work

Onsite Prep

- Clear debris in area identified for installation of new pads.
- Inspect AHUs for continued integrity after installation of equipment.

New Installation Work

Electrical

- Furnish and install new electrical disconnect.
- Furnish and install I-beam aluminum unistrut support inside each unit sized to support up to 2000 lb/in2.
- Furnish and install wind-chill corrected lamps (for improved performance in moving air and reducing number of lamps).
- All electrical quick connects to be waterproof.
- All racks to be slide-out style for ease of lamp replacement.
- Furnish and install proximity door and lockout switches.
- All systems are EPA approved.
- Provide labor, conduit, fittings breakers, insulation, etc.

ECM 17 – Solar Photovoltaic System

Reason for Exclusion

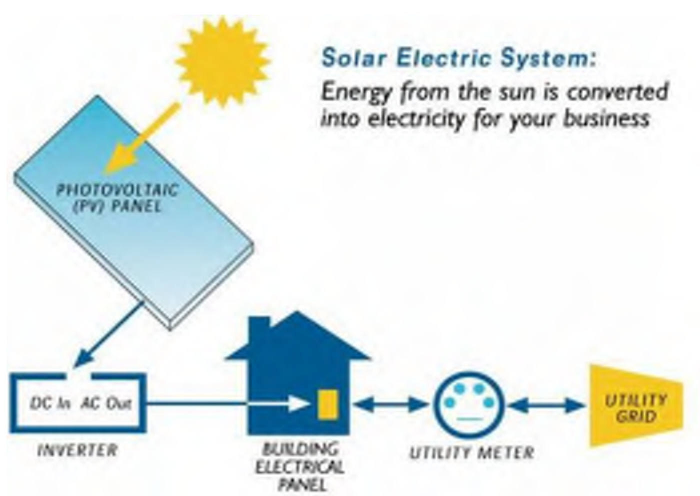
A high payback made this ECM uneconomical.

General

Electricity generated from solar photovoltaic (PV) panels will reduce the quantity of power purchased from the local utility. The generation of an excess power from the solar system can be transferred back to the gird via net-metering. Many factors affect the size of the solar PV installation, including onsite consumption load, suitable roof space or open space.

Solar electrical energy is generated when the sun's energy strikes the solar PV panel. A series of PV panels are combined in a PV array. Electrical energy, in Direct Current (DC), is sent from the array to an inverter, which converts the electricity to Alternating Current (AC) power. The AC electrical output from the inverter is integrated into the building's electrical system.

JCI has included a solar PPA as part of our proposal. A solar PPA is a financial agreement where a developer (third-party PPA provider) arranges for the design, permitting, financing and installation of a solar energy system. The developer sells the power generated to the school district at a fixed rate that is typically lower than the baseline utility rate. This lower electricity price serves to offset the school district's purchase of electricity from the grid while the developer receives the income from these sales of electricity as well as any tax credits and other incentives generated from the system. The developer remains responsible for the operation and maintenance of the system for the duration of the agreement. Typically at the end of the PPA contract term, a customer may be able to extend the PPA, have the developer remove the system or choose to buy the solar energy system from the developer.



All three sites were evaluated for the potential to install rooftop PV solar panels for power generation. The amount of available roof area determines how large of a solar array can be installed on any given location.

This ECM will reduce the quantity of purchased power at a lower utility rate resulting in good financial benefits for both electric and fossil fuels.

Scope of Work

JCI recommends that the Stafford County Public Schools enter into a PPA agreement to source electric energy through a photovoltaic electrical generation system that will inter-connect with the existing electrical distribution system. By installing a photovoltaic system you will receive the following benefits:

- Save money every month by lowering your electric bills
- Use free energy from the sun to reduce the effect of utility rate increases
- Enjoy energy independence by becoming your own power producer
- Protect the environment by using clean, renewable energy in your school
- Provide a valuable teaching program to instill environmental awareness and responsibility

Sample PV Layout

Detailed layouts for all buildings are provided as part of Appendix F.

ECM 18 – AHU Refurbishment

Reason for Exclusion

High payback and low priority. Though the impact of this measure extends the life of the equipment, the energy savings component is minimum, and the measure is cost prohibitive for the target size of the overall project.

General

The following general requirements are associated with the recommissioning of existing mechanical equipment, including AHUs, as listed in the table below. Makeup air units and energy recovery ventilators have been included in the AHU counts. Units identified for recommissioning are generally in good shape and have more remaining useful life.

The general intent of this ECM is to extend the useful life of the listed equipment through a deep recommission. To some extend replacing/repairing failed or failing control valves and other components will address overheating/cooling and simultaneous heating/cooling. Both electric and thermal savings will be achieved through implementation of this work.

All work to be in accordance with prevailing industry practice, state, and local codes.

Equipment Recommissioning List

Facility/Location	Type of Unit
Evans ES	AHU (3) and associated Variable Air Volume (VAV) boxes (varies)
Limerick ES	AHU (3) and associated VAV Boxes (varies), UVs (35), Chiller (1)
Oaks ES	AHU (3) and associated VAV Boxes (varies), UVs (45), Chiller (1)
Royersford ES	AHU (6) and associated VAV Boxes (varies), UVs (35)
Spring City ES	AHU (1) and associated duct controls, UVs (16), Chiller (1)
Upper Providence ES	AHU (2), HPs (79), VAV Boxes
5-7th Grade Center	AHU (6), HPs (243), VAV Boxes
8th Grade Center	AHU (11) and associated VAV Boxes (varies), Chiller (2)
9th Grade Center	AHU (7), HPs (133), VAV Boxes
Spring-Ford Area HS	AHU (41), HPs (11), VAV Boxes, UV (65), CT (1)

Demolition, Removal and Onsite Prep Work

Electrical

- Safely disconnect all components/wiring to be disposed of.

Other Onsite Prep

- Clear debris and clean surfaces inside and outside the unit(s).

New Work

Electrical

- Reconnect new components to existing electrical power wiring as applicable.
- Reconnect new components to existing BAS as applicable.
- Provide labor, conduit, fittings, gauges, insulation, etc.

Mechanical

- Replace failed dampers, linkages, valves, belts and sheaves.
- Lubricate per manufacturer’s specifications all bearings, dampers and linkages to ensure proper functioning.
- Verify and adjust fan belt tension to manufacturer’s specifications.
- Clean coil face of all AHUs to remove dirt.
- Where insulation is damaged or missing, replace.
- Repair and restore functionality to economizers.
- Retrieve existing heat wheels cassettes from the unit(s) and clean (dry and wet) per manufacturer’s specifications to remove all grease and dirt build-up on the heat wheels.
- Ensure proper alignment of heat wheels and inspect for gaps in air seals.
- Verify refrigerant charge matches manufacturer’s specifications for units listed in the table above..
- Confirm or repair functionality of all sensors within the unit(s), supply air dampers, return air dampers and outdoor air modulating dampers.
- Reinsulate all damaged ductwork insulation, consistent with best practices.
- Ensure lockout of re-heat coils during winter season.
- Perform air-balancing of all associated air-systems to ensure proper functioning as designed.

General

- Obtain all licenses, permits and required inspections.
- Startup and checkout of units to be performed by a factory authorized representative and shall follow manufacturer’s startup and checkout procedures. Checkout shall include part-load and full load operations. Performance report to be provided by JCI.

ECM 19 – AHU Replacement

Reason for Exclusion

High payback

General

The following general requirements are associated with the replacement of existing AHUs with new high efficiency units (York or equal) as listed in the table below. The existing AHUs are constant volume. These units will be converted to VAV systems to maximize energy savings. The general intent of this ECM is to create energy savings through reset strategies and installation of more efficient units. Electric and thermal savings will be achieved through implementation of this work. All work to be in accordance with prevailing industry practice, state, and local codes.

AHUs Replacement List

Facility/Location	Unit #	Area Served
Brooke ES	AHU-1	Admin Area
	AHU-2	Cafeteria
	AHU-3	Multi-Purpose
	AHU-4	Music Room
	AHU-5	Library

Demolition, Removal and Onsite Prep Work

Electrical

- Safely disconnect existing units.
- Remove existing electrical disconnect.
- Remove existing thermostat and/or BAS connections.
- Properly disconnect and isolate smoke alarms and other life safety devices connected to the unit.

Mechanical

- Temporarily seal or cap all disconnected utilities.
- Remove existing units and dispose of properly.

Other Onsite Prep

- Clear debris and clean any newly exposed surfaces.
- Inspect support structures, beams and pads holding equipment and pipes for continued integrity. Replace as needed.

New Installation Work

Electrical

- Furnish and install new electrical disconnect and VFDs for each unit.
- Location of new electrical disconnects shall be per state and local code requirements.
- After completion of work, reconnect equipment to existing electrical power wiring.
- Reconnect equipment to existing BAS. Ensure sequencing controls are setup within the BAS.
- Provide labor, conduit, fittings, gauges, insulation, etc.

Mechanical

- Furnish and Install new high efficiency AHUs (York or equal) according to the table above..
- Installation to be performed in accordance with mechanical, electrical, fire, local, state, and national installation and operational codes.
- Reconnect equipment to existing condensate drain piping (as applicable). Verify for proper drainage.
- Reconnect equipment to existing distribution piping/ductwork as required.
- Furnish and install appropriate number of VAV boxes (with hot water/electric reheats) for each of the spaces served by the AHUs.
- Furnish and install pressure transducers at appropriate locations within the ductwork.
- Ensure lockout of re-heat coils during winter season.
- Perform air-balancing and functional testing of all associated air-systems to ensure proper functioning as designed.
- Inspect and verify continued structural integrity of frames, mechanical curbs, hangers supporting replaced units.

Controls

- JCI to connect the AHUs and VAV boxes to the building's BAS.

General

- Include all required cranes and rigging.
- Obtain all licenses, permits and required inspections.
- Startup and checkout to be performed by a factory authorized representative and shall follow manufacturer's startup and checkout procedures. Checkout shall include part-load and full load operations. Performance report to be provided by the contractor.
- Submit O&M documentation in Adobe Acrobat® format.

ECM 20 – Unit Ventilator Replacement

Reason for Exclusion

High payback and capital-intensive project

General

The following general requirements are associated with the replacement of existing unit ventilators with new high efficiency units (Daikin or equal) as listed in the table below. Units identified for replacement show signs of damage including corrosion, are nearing the end of its ASHRAE rated useful life or are district requested upgrades. Newly installed unit ventilators shall have dehumidification capability. The general intent of this ECM is to create energy savings through reset strategies and address operational deficiencies that may exist, i.e., overheating/overcooling, humidity issues, scheduling, etc. Both electric and thermal savings will be achieved through implementation of this work. All work to be in accordance with prevailing industry practice, state, and local codes.

Unit Ventilator Replacement List

Facility/Location	Count	Manufacturer	Existing Controls
Limerick ES	35	Magic Aire	Electric
Royersford ES	35	Trane	Pneumatic
Spring City ES	12	Nesbitt	Pneumatic
8th Grade Center	29	Trane	Pneumatic

Demolition, Removal and Onsite Prep Work

Electrical

- Safely disconnect existing units.
- Remove existing electrical disconnect.
- Remove existing thermostat and/or BAS connections.
- Properly disconnect and isolate smoke alarms and other life safety devices connected to the unit.

Mechanical

- Remove existing units and dispose of properly.
- Safety disconnect equipment from existing refrigerant lines.
- Temporarily seal or cap all disconnected utilities.

Other Onsite Prep

- Clear debris and clean any newly exposed surfaces and fresh air intake vents.

- Inspect and verify continued integrity of floor area holding equipment and connecting pipes near unit ventilators.

New Installation Work

Electrical

- Location of new electrical disconnects shall be per state and local code requirements.
- After completion of work reconnect equipment to existing electrical power wiring.
- Reconnect equipment to existing BAS. Ensure sequencing controls are setup within the BAS.
- Provide labor, conduit, fittings, gauges, insulation, etc.

Mechanical

- Furnish and install new high efficiency unit ventilators (Daikin or equal) according to the table above.
- Installation to be performed in accordance with mechanical, electrical, fire, local, state, and national installation and operational codes.
- Assemble and install curb adapters as required. All work will be performed in a neat and workmanlike manner.
- Reconnect equipment to existing condensate drain piping (as applicable). Verify for proper drainage.
- Reconnect equipment to existing distribution piping/ductwork as required.
- Furnish and install all flashing and ensure a watertight seal around the unit ventilator.
- JCI to include all safety devices necessary for the proper operation of the unit ventilators and shall meet codes set in place by AHJ.
- Work shall meet acceptable industry standards.

General

- Obtain all licenses, permits, and required inspections.
- Startup and checkout to be performed by a factory authorized representative and shall follow manufacturer's startup and checkout procedures. Checkout shall include part-load and full load operations. Performance report to be provided by JCI.
- Submit O&M documentation in Adobe Acrobat® format.

ECM 21 – Motor Replacements

Reason for Exclusion

High payback

General

The following general requirements are associated with the replacement of existing Open Drip Proof (ODP) enclosure motors with Totally Enclosed Fan Cooled (TEFC) enclosure motors with like performance ratings for locations listed in the table below. The general intent of this ECM is to create energy savings by ensuring high efficiency ratings continue to be maintained during a motor's lifecycle. The existing motors have high efficiency ratings but are located in spaces that result in moderate dust and grease build-up. This dust and grease eventually settle on motors and in an ODP enclosure within the motor winding itself thereby reducing overall efficiency. Electric savings will be achieved through implementation of this work. All work to be in accordance with prevailing industry practice, state, and local codes.

Pumps/Motor Replacement List

Facility/Location	Type	HP
Brooke ES	CHWP	7.5
	CHWP	7.5
Upper Providence ES	Cir Pump	60
	Cir Pump	60
	ERVS-P1	20
	ERVR-P1	20
	ERVS-P2	20
	ERVR-P2	20
5th-7th Grade Center	Cir Pump	125
	Cir Pump	125
8th Grade Center	P1	20
	P2	20
	P3	20
	P4	20
9th Grade Center	Cir Pump	125
	Cir Pump	125

Demolition, Removal and Onsite Prep Work

Electrical

- Safely disconnect existing units.
- Existing motor starter is to remain if serviceable.
- Disconnect and secure electrical connections to the motor(s).
- Remove and dispose of properly pumps, motors, shafts and piping no longer necessary in the operation of associated system.

Other Onsite Prep

- Clear debris on newly exposed pads/support structures.
- Inspect pads, support structures, pumps and pads holding motor(s) in place for continued integrity. Replace as necessary.

New Installation Work

Electrical

- Furnish and install new premium efficiency TEFC enclosure motors according to the table above.
- For pump replacement, install new pumps, high efficiency motors and drive shafts.
- Installation of units to include leveling and alignment.
- Reconnect motor to existing electrical power wiring, reusing motor starter (where applicable).
- Verify new motor rotation.
- Provide labor, conduit, fittings, gauges, insulation, etc.
- Reconnect equipment to existing BAS. Ensure sequencing controls are setup within the BAS.
- Include all required rigging.
- Obtain all licenses, permits and required inspections.
- Startup and checkout to be performed by a factory authorized representative and shall follow manufacturer's startup and checkout procedures. Checkout shall include part-load and full load operations. Performance report will be provided by JCI.
- Submit O&M documentation in Adobe Acrobat® format.

Close-Out

- Prior to final acceptance, JCI shall submit new set of as-builts (two hard copies, software copy) reflecting work as completed.
- Startup and testing will be performed per manufacturer's guidelines and a report will be provided.

- Submit O&M documentation.
- Provide all warranties associated with the work.

Housekeeping

In addition, JCI shall have its contractors commit to the following:

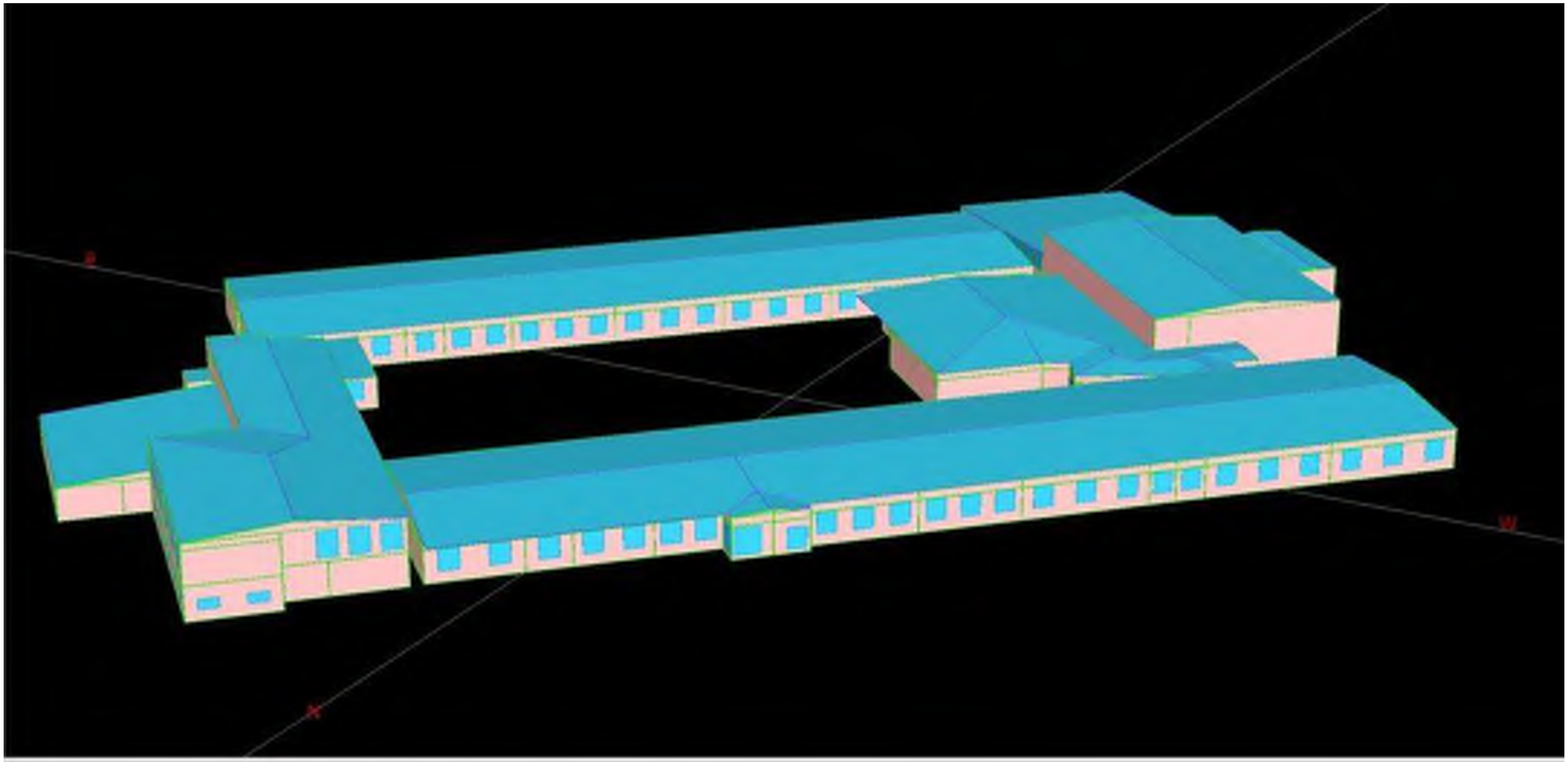
- The contractor is responsible for daily cleanup before leaving the site. Prior to close-out, the contractor shall clean all impacted areas to a condition equal to or better than original condition.
- Contractor is responsible for proper disposal of all debris related to the Work.
- Contractor tools and equipment shall be secured properly when not in use and at the end of each workday.
- Contractor to take appropriate picture documentation as evidence of proper housekeeping.
- Prior to final acceptance, the contractor shall submit new set of as-builts (two hard copies, software copy) reflecting work as completed.

Appendix E: eQUEST Model Overview

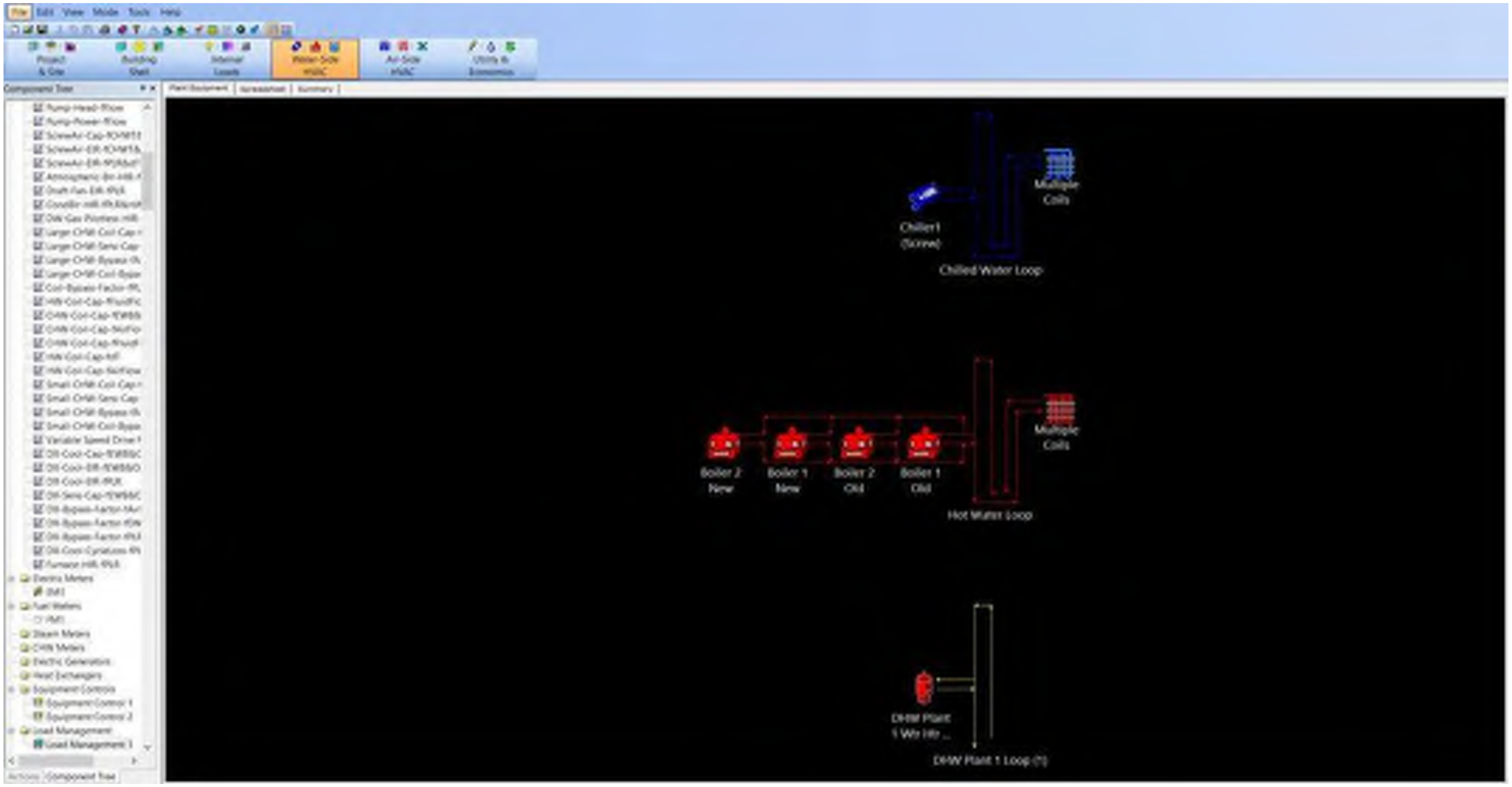
eQUEST is a popular and commonly used building energy modeling program. eQUEST building energy performance modeling tool is built on the Department of Energy's DOE 2 engine.

With eQUEST, JCI is able to model a building's geometry and simulate energy performance pre and post construction to determine energy savings. JCI used eQUEST to model the performance of Limerick ES and Royersford ES.

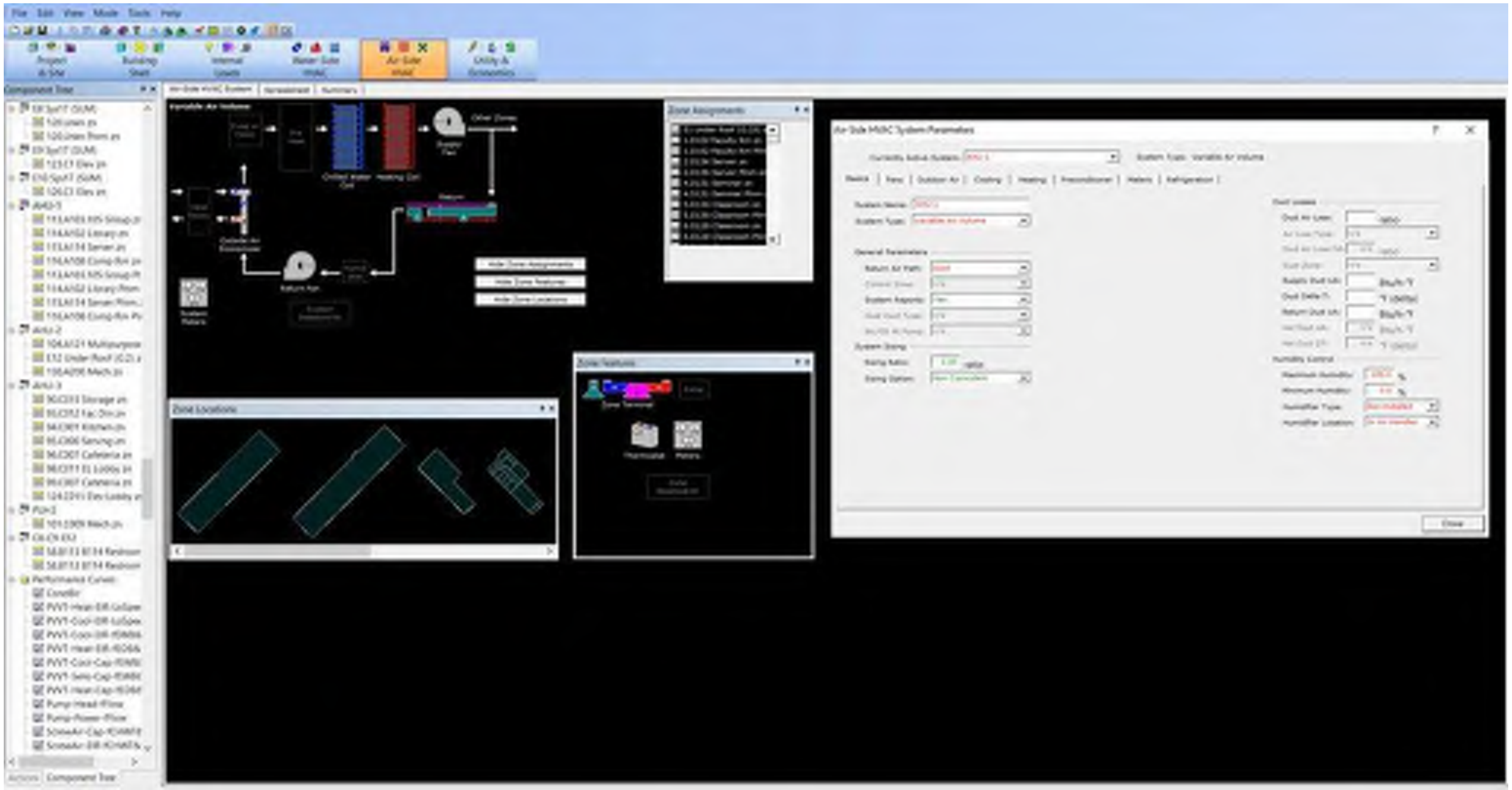
Limerick ES



The above image shows the 3D image of the building shell to factor various physical attributes of the building.

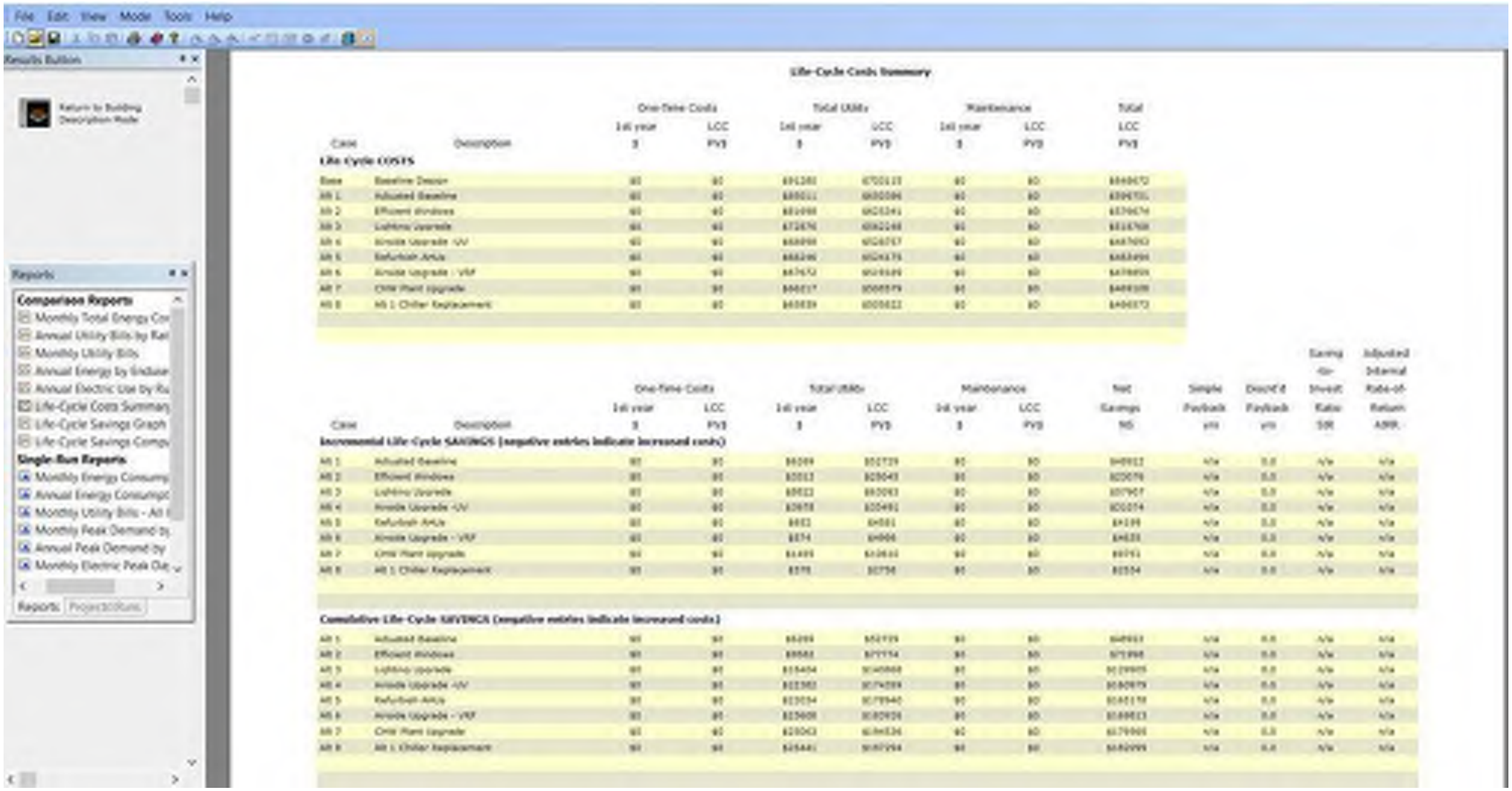


Limerick ES Boilers and Chillers are modeled into the eQuest simulator to account for energy usage.

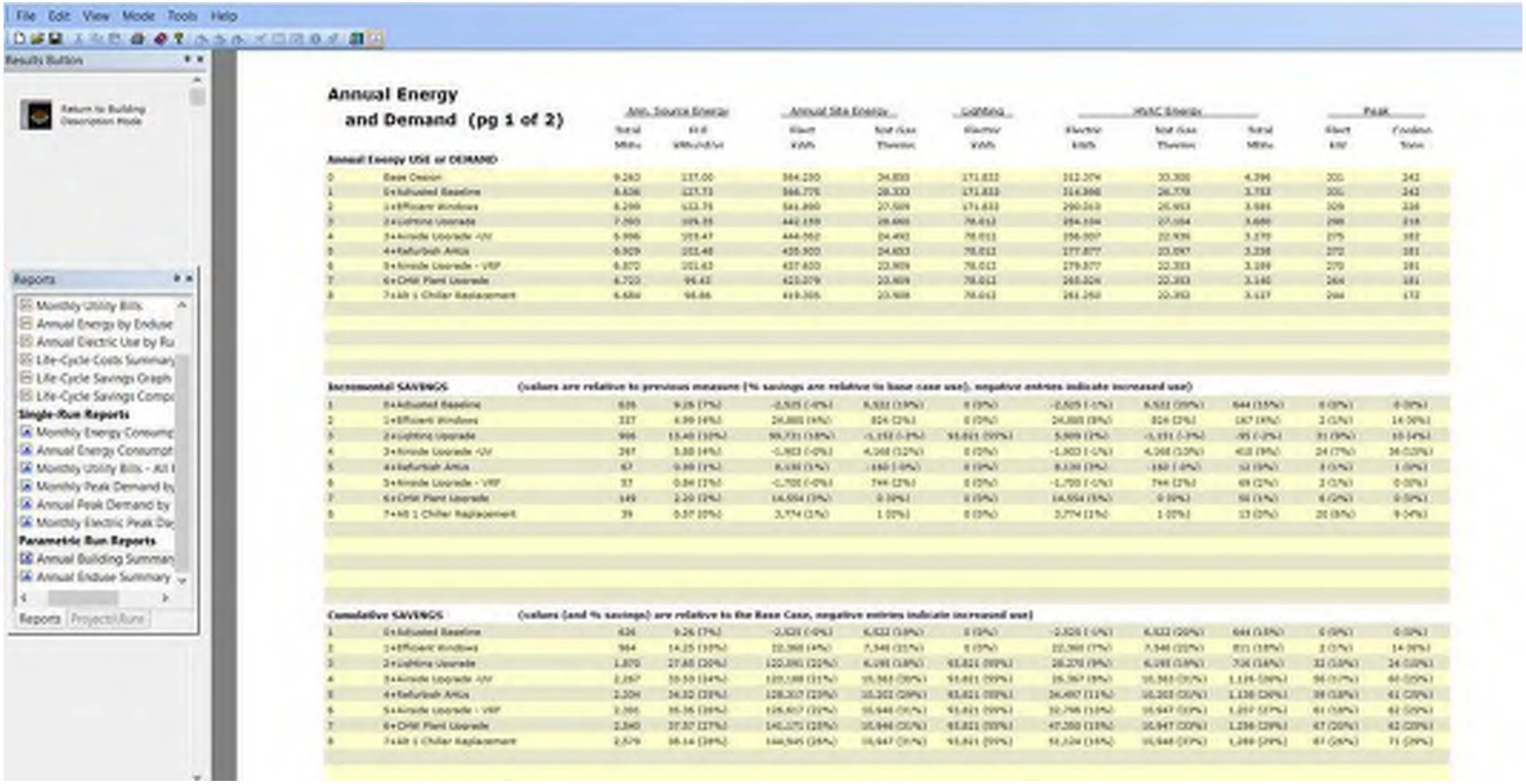


Limerick ES HVAC equipment is modeled into the eQuest simulator to account for energy usage.

Results:

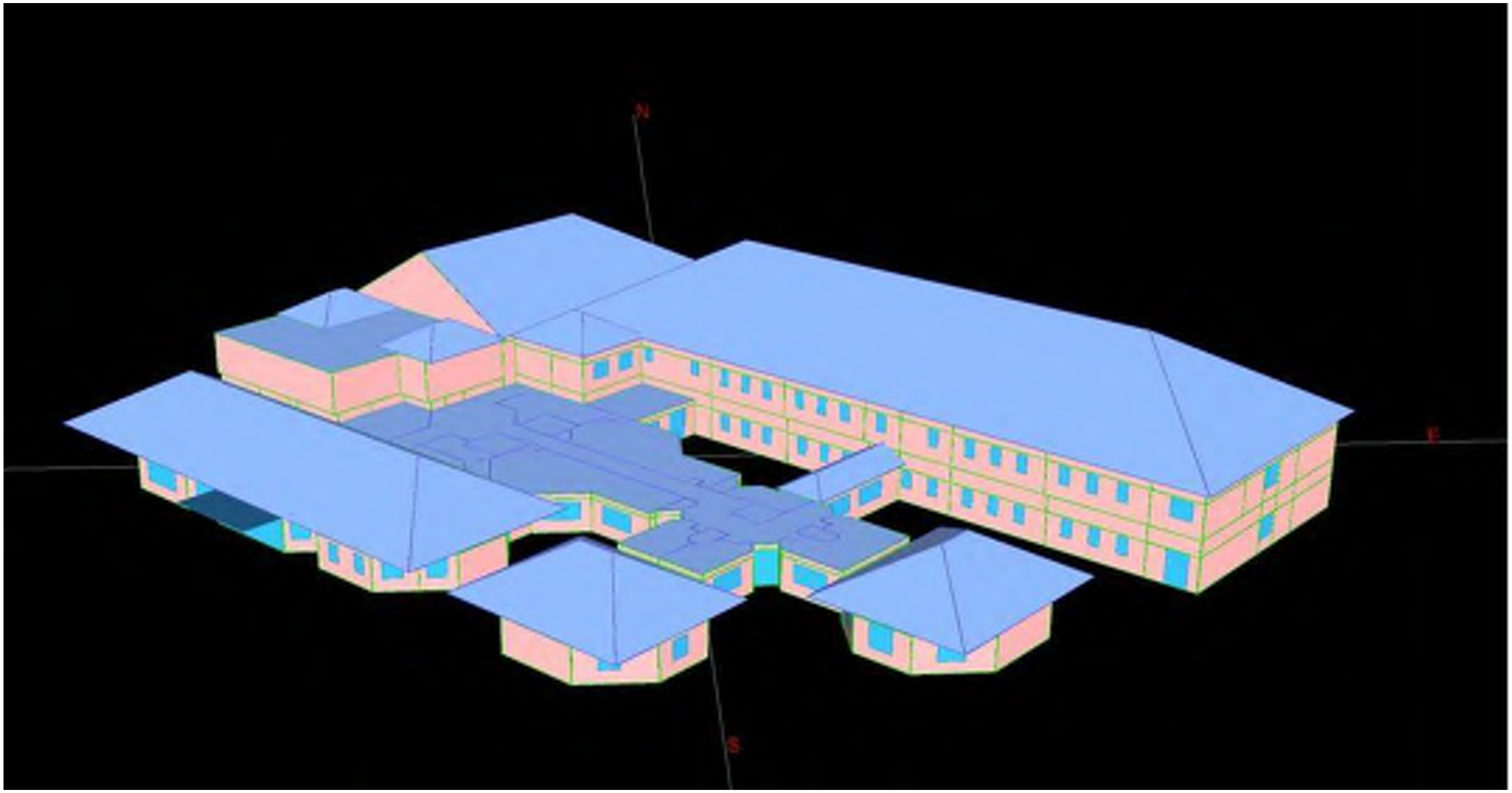


eQUEST model output results after performing parametric run with proposed equipment factored.

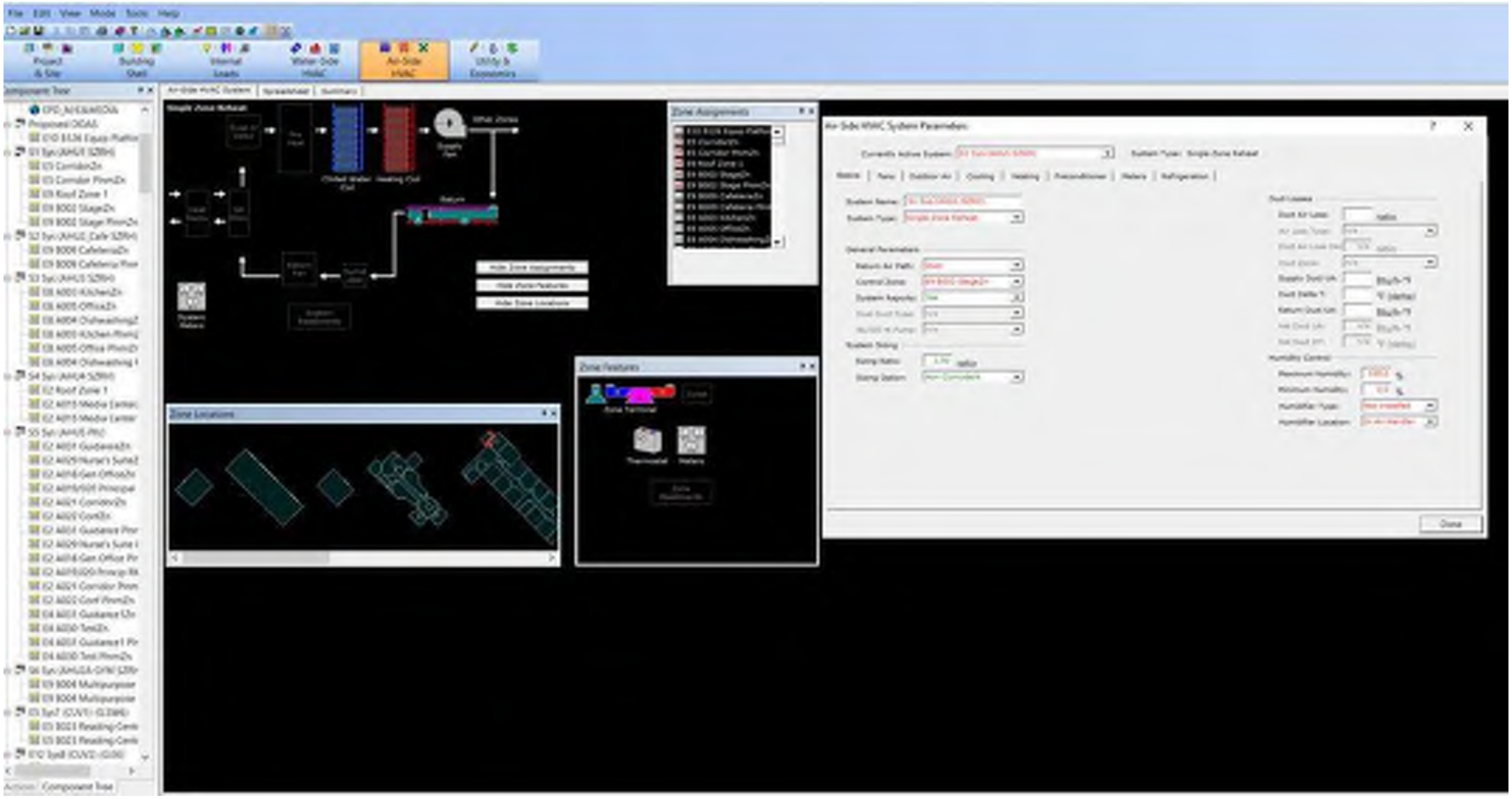


eQUEST model output results after performing parametric run with proposed equipment factored.

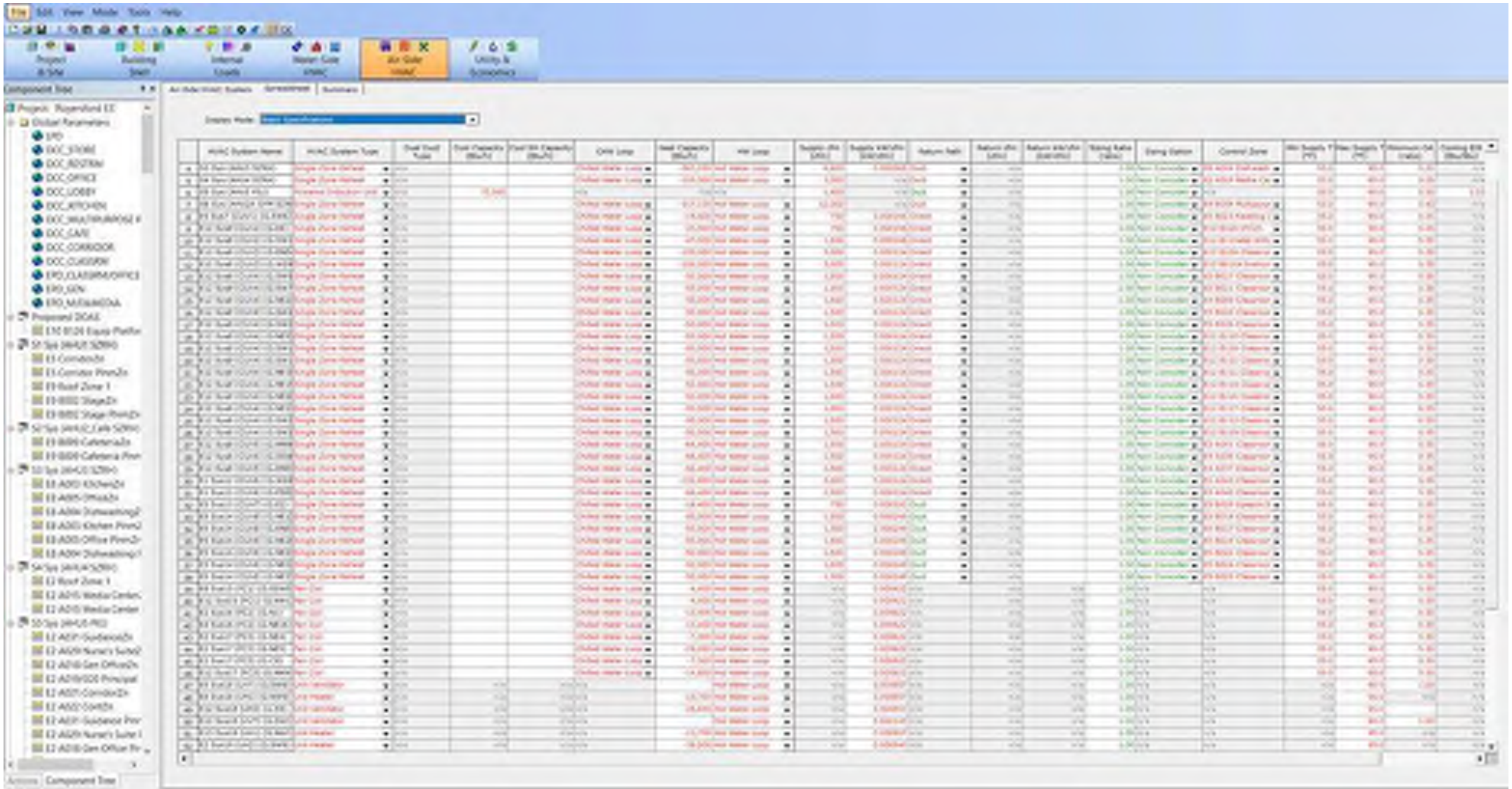
Royersford ES:



The above image shows the 3D image of the building shell to factor various physical attributes of the building.

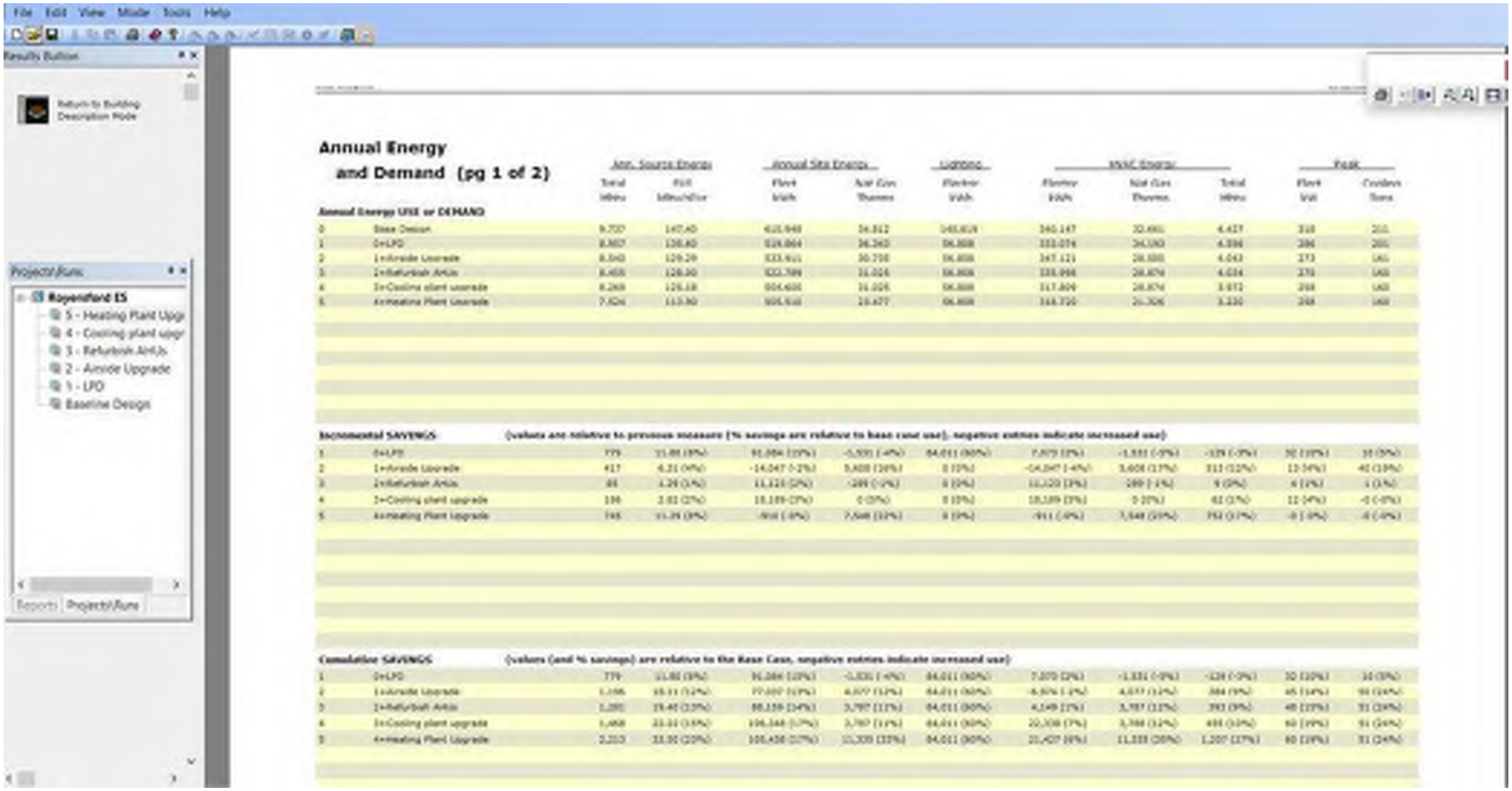


Royersford ES HVAC equipment is modeled into the eQUEST simulator to account for energy usage.

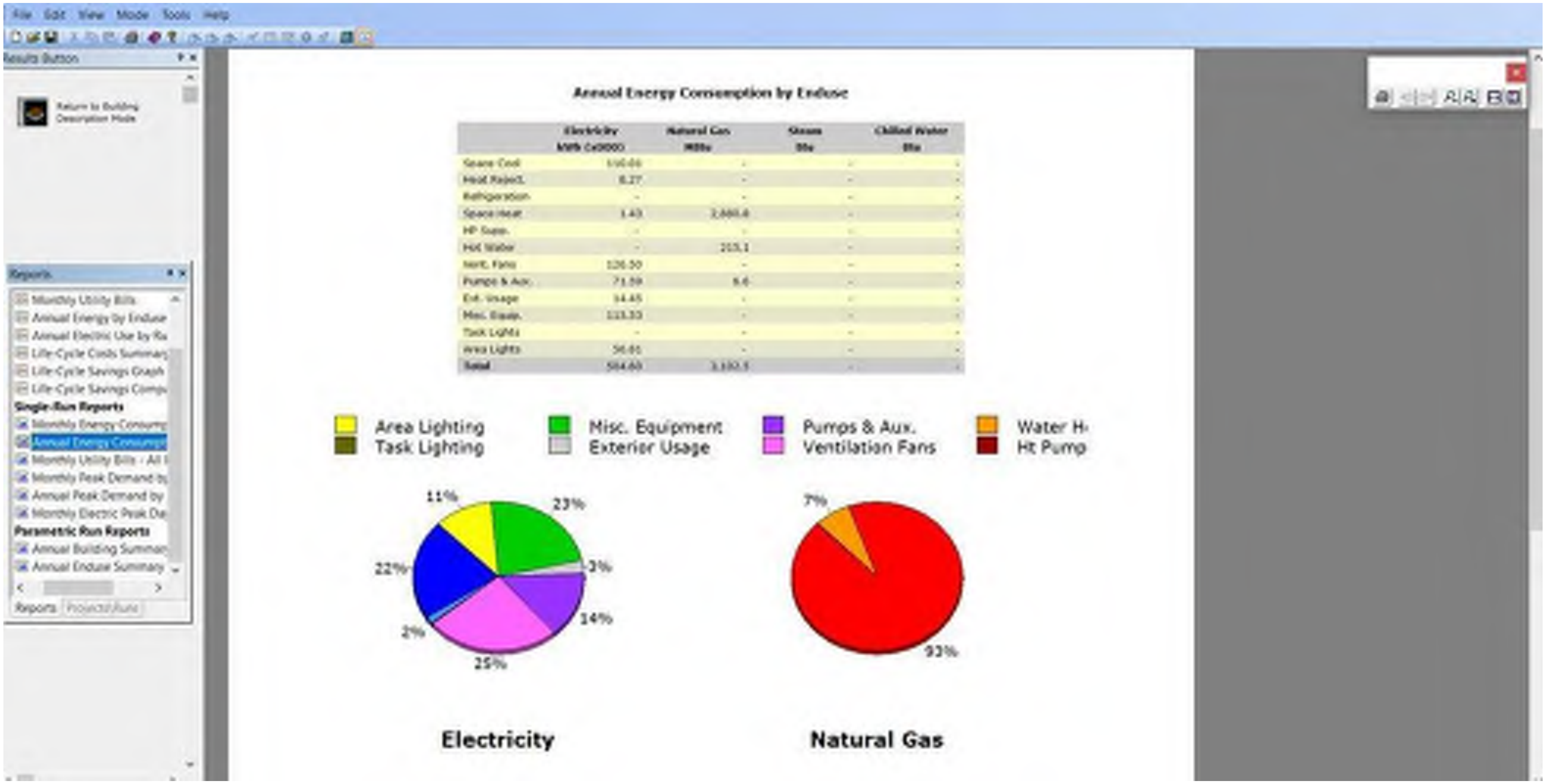


Royersford ES HVAC equipment is modeled into the eQUEST simulator in detail.

Results



eQUEST model output results after performing parametric run with proposed equipment factored.



eQUEST model output results after performing parametric run with proposed equipment factored.

Appendix F: Solar Photovoltaic Layouts

Appendix G: Equipment Specifications

This section provides specifications representative equipment to be installed as part of this project. Note specifications are subject to change as part of final design.