Smartenergy.illinois.edu
800.214.7954
sedac-info@illnois.edu

Facility Energy Assessment Report

Smart Energy Design Assistance Center (SEDAC)

Putnam County Primary School

Published:	December 22, 2022
SEDAC Building Energy Specialist:	Robert Schlorff, SEDAC
Facility Location:	400 E Silverspoon Ave, Granville, IL 61326
Site Visit:	October 11, 2022

This report was prepared as the result of work by a member of the staff of the Smart Energy Design Assistance Center (SEDAC). It does not necessarily represent the views of the University of Illinois, its employees, or the State of Illinois. SEDAC, the State of Illinois, its employees, contractors and subcontractors make no warrant, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the uses of this information will not infringe upon privately owned rights. Reference to brand names is for identification purposes only and does not constitute an endorsement. All numerical data are order of magnitude estimates and the number of digits shown is an artifact of the calculation procedure; they are not meant to imply greater accuracy or precision. SEDAC is an applied research program at the University of Illinois at Urbana-Champaign. SEDAC works in collaboration with the 360 Energy Group.

Contact Information

Facility Contact:	Tracy Reaska District Maintenance Supervisor Putnam County School District 815.882.2800 reaskat@pcschools535.org
	Clayton Theisinger Superintendent Putnam County School District 815.882.2800 ext. 5 theisingerc@pcschools535.org
SEDAC:	Robert Schlorff Energy Engineer 217.333.6928 schlorf2@illinois.edu

Table of Contents

Acknowledgements

The Smart Energy Design Assistance Center (SEDAC) would like to thank Tracy Reaska, of the Putnam County School District, for participating in the Public Sector Design Assistance Program and for providing access to information necessary to develop this report. Robert Schlorff, of SEDAC, was the engineer responsible for the analysis and is the primary author of this report. Additional assistance in report preparation by Ryan Siegel and Shawn Maurer are greatly appreciated. Other contributors to this report of SEDAC are also gratefully acknowledged.

Executive Summary

The Putnam County Primary School building is owned by the Putnam County School District and is located in Granville, Illinois. The facility is used as a primary school for students from pre-K through 2nd grade and has approximately 39,000 sq. ft. of usable space. The primary school building is used by 200 students and 20 staff members and is fully occupied during the school year with minimal occupancy for summer school and maintenance during the summer months.

This report identifies 5 potential energy cost reduction measures for implementation. After a thorough evaluation of each measure, 4 of the measures are recommended based upon their feasibility for implementation and strong return on investment.

Recommended Package of Energy Efficiency Measures			
Simple payback (before incentives)	4.1 years	**Incentives Available**	$94,600
Annual Utility Cost Savings	$39,100	**Percent Annual Cost Savings Reduction**	72%
kWh Reduced/yr	170,000	**Percentage kWh Reduction**	48%
therms Reduced/yr	16,100	**Percentage therms Reduction**	87%

The recommendations in this report are designed to allow the facility to create an effective and financially prudent implementation plan to be used to help the building become more energy efficient. The report should be used as a tool to facilitate budgetary planning and obtaining funding/financing. Eligible public-sector incentives are described in this report as well as other opportunities for need-based grants and other funding sources. All information is current at the time of the assessment; for up-to-date information on funding or incentives, contact SEDAC any time at 800.214.7954. Alternatively, you may contact your utility. Implementing the recommendations in this report will reduce energy consumption, help improve occupant comfort, and reduce vulnerability to fluctuations in future energy costs. This report can also help towards obtaining LEED® and ENERGY STAR building certification.

Each of the 5 Measures is discussed in detail in this report. Recommendations on HVAC and lighting improvements are included along with suggestions for additional cost reduction measures. Table E1 presents the facility's utility information, as obtained from Ameren Illinois documentation. Table E2 presents the results of the analysis performed on each measure.

Table E1: Utility Information for October 2021 through September 2022

Fuel	Utility	Rate Class	Peak Demand (kW)	Annual Consumption		Annual Cost ($/yr)	Annual Cost (%)	Unit Cost*	
Electricity	Ameren IL	DS-3	190	352, 690	kWh	$35,269	68%	$0.10	$/kWh
Natural Gas	Ameren IL	GDS-2	N/A	18,492	therm	$17,198	32%	$0.93	$/therm
Floor Area	39,000 sf		Totals	3,052,578	kBtu	$52,467	100%		
			Site Energy Use Intensity	78	kBtu/sf/yr		Energy Cost Intensity	$1.35	$/sf/yr
			Electricity Use Intensity	9	kWh/sf/yr		Natural Gas Use Intensity	0.47	therms/sf/yr

***Note: Unit Costs are blended averages which include all taxes and demand charges.**

Table E2: Energy Cost Reduction Measure Analysis

Measures #	Description	Potential Energy Savings				Estimated Project Cost	Potential Incentive	SPB w/o &w/ Incentive (yrs)[2]	IRR (%)	NPV ($)
		kW	kWh	Therm	$					
1	Lighting Upgrades	16.1	22,800	(200)	$2,100	$16,800	$12,300	8	4%	($624)
								2.2	45%	$11,600
2[1]	Implement Demand Controlled Ventilation	0	7,600	4,100	$4,600	$7,200	$5,850	1.6	63%	$28,100
								0.3	N/A	$34,000
3[1]	Exhaust Fan Control	0	13,300	3,800	$4,800	$3,000	$10,700	0.6	N/A	$34,400
								-1.6	N/A	$45,100
4[4]	High Efficiency Ventilation System (HEVS)	0	139,600	16,100	$28,900	$134,200[2]	$65,700	4.6	17%	$89,200
								2.4	41%	$154,900
5[5]	Condensing Boilers	0	0	1,300	$1,200	$105,000	$0	85.7	(27%)	($95,500)
								85.7	(27%)	($95,500)
PKG 1[3]	All Measures	16.1	170,000	16,100	$41,600	$266,200	$94,500	6.4	9%	$55,500
								4.1	21%	$150,000
PKG 2[3]	Recommended Measures (ECRM-1-4)	16.1	170,000	16,100	$39,100	$161,200	$94,500	4.1	21%	$140,800
								1.7	58%	$235,300

Notes:

1) Savings from this measure are decreased due to the existing oversized system. With proper-sized units or the implementation of measure 4 savings would be greater.
2) Costs for this measure are incremental costs. Incremental costs are the costs of High Efficiency equipment, as described in measure 4, beyond the cost of standard replacement equipment.
3) Savings reflect overlapping measures. Heat pump units implemented in Measure 4 eliminate natural gas usage for space conditioning.
4) Measure 4 assumes the implementation of DCV and exhaust fan controls as part of the work included in implementing the HEVS. Savings for DCV and exhaust fan controls included in this measure have been adjusted to reflect proper-sized units.
5) Measure 5 is redundant if Measure 4 is implemented.
6) “SPB” Refers to Simple Payback, or the amount of time that the projected energy savings will exceed the first cost of the project.
7) IRR (%) refers to Internal Rate of Return.
8) NPV ($) refers to Net Present Value.

1 Introduction

The Public-Sector Design Assistance Program is an energy efficiency program that provides millions of dollars in rebates to public facilities that make large-scale equipment improvements to their electric and natural gas systems. SEDAC supports the Public-Sector Design Assistance Program in advocating the efficient and effective use of energy by businesses and public buildings throughout Illinois. The objective of SEDAC is to encourage communities, building owners and operators, design professionals, and building contractors to incorporate energy efficiency practices and renewable energy systems. SEDAC is managed by the University of Illinois at Urbana-Champaign, in collaboration with 360 Energy Group.

The Smart Energy Design Assistance Center (SEDAC) has performed an energy savings and cost analysis for various energy cost reduction measures (Measures) applied to the Putnam County Primary School, located in Granville, Illinois. The analysis is based on a site inspection conducted on October 11th, 2022, engineering calculations, and typical industry assumptions. This report presents the results of the analysis along with the methods and assumptions used.

Engaging in energy-efficiency strategies to control costs is more critical than ever as organizations face the lingering recession and budget challenges. Organizations that take a systematic and strategic approach toward energy management will acquire a broad array of tangible and intangible benefits of interest to themselves and the public at large.

The elevation of energy management to critical importance is a result of many factors, including an increasingly complex and volatile energy marketplace, a growing awareness about the realities of climate change, recognition of the rising importance of intangibles in calculating market value, and an expanding awareness of the importance to restrict the carbon footprint of organizations. According to the U.S Green Building Council, most commercial buildings use 10 to 30 percent more energy than necessary and have ample opportunities to reduce their energy consumption levels.

Public entities known for aggressive and proactive environmental policies stand to reap many intangible benefits including improved community relations, an enhanced reputation as a socially responsible entity, and improved productivity/morale. Energy management practices also help to ensure the reliability of equipment, which reduce the risks and costs associated with equipment failures and downtime.

2 Building Description

2.1 General

The analysis of the building was based on engineering calculations, rule of thumb assumptions, and experience of the engineer. The sections which follow describe details of each building and important input parameters of the calculations.

2.2 Site Conditions and Building Details

The building operates as a primary school for students from pre-K through 2nd grade and has approximately 39,000 sq. ft. of usable space. The facility is used by 200 students and 20 staff members and is fully occupied by students and faculty during the school year from 7:45am to 3:00pm, Monday through Friday. Maintenance staff occupy the building from 5am-5pm, Monday through Friday, year-round. The building also serves as a summer school location for 1 month per summer for a handful of classes.

2.3 Building Envelope

Roof:

The roof is approximately 13 years old and consist of a built-up ballasted system with above deck insulation and an EPDM membrane. The estimated R-value of the roof areas is R-20, based on the Illinois Energy Conservation Code at the time of construction.

Exterior Walls:

The building's exterior walls are multi-wythe masonry consisting of CMU with an exterior brick veneer. These exterior masonry walls are assumed to have an R-value of R-7.6.

Windows and Doors:

The windows of this building are double-pane aluminum-framed windows installed when the building was built in 2009. The typical window unit within classrooms and offices has one fixed sash above one or two operable sashes. All observed windows appeared to be in good condition with glazing gaskets in place, perimeter air sealing in good condition, and operable sashes working as intended.

There are 5 sets of insulated, double pane, aluminum framed doors leading in and out of the building. These doors appeared to be in good condition with glazing gaskets and bottom sweeps in place, as well as weather stripping and/or a center post between the doors.

There are also three sets of insulated metal doors leading out of the boiler room and gymnasium and 1 additional insulated metal door leading out from the kitchen. All insulated metal doors were observed in good condition with perimeter weather stripping in place and bottom sweeps installed. The two pairs of insulated metal doors leading out from the gymnasium also have center posts installed along with weather stripping.

2.4 HVAC Systems

Heating:

Heating is provided to the building with two non-condensing gas-fired boilers. These units were manufactured by Sellers and have a nameplate thermal efficiency of 80%. Both boiler units were manufactured in 2008 and have an input capacity of 1255 MBH each and an output capacity of 1004 MBH each. The boilers are set to 180-degree supply temperature and maintain that 24/7 all year. Given the boilers are non-condensing, the return water temperature needs to be maintained above 140°F to avoid condensing which is corrosive for boilers not designed for it.

Two circulating pumps distribute hot water throughout the building. These motors were manufactured by Baldor and are rated at 5 HP each. Both circulating pumps have VFDs installed. One operates at a time and the other serves as a backup in case of failure.

Eight gas-fired RTUs also provide some heating capacity and are generally used as heat sources during morning startup with the boiler reheat system taking over once the building has recovered to occupied setpoints. It was noted that turning the boilers off during the summer results in very high interior humidity. This is typically a sign that the existing equipment is improperly sized and may have been based on a far larger occupancy than the building currently serves. This appears to be confirmed by the occupancy values listed on the building prints. Based on those prints, occupancy for the building is calculated at 839 occupants. This figure does not include the multi-purpose room and kitchen area on the east end of the building which is listed for an additional 848 occupants. Current estimated building occupancy is 220 occupants, which is ¼ of the designed occupancy.

Cooling:

Cooling is provided to the building by eight RTUs which were all manufactured by Aaon in 2008. The largest RTU has a rated cooling capacity of 40 tons. This large unit serves the front offices, administrative spaces, and a few classrooms. The second RTU has a rated cooling capacity of 30 tons and serves the media center and remaining classrooms on the south wing. The third and fourth RTUs have rated cooling capacities of 25 tons each and serve the remainder of the classrooms, computer lab, and restrooms in the north wing of the building. One smaller RTU serves the connecting corridor between the gymnasium and the rest of the school. This unit has a rated cooling capacity of 2 tons. Two RTUs serve the gymnasium, which can be split in half for different uses with one RTU per space. These units have a rated cooling capacity of 20 tons each. Both of these units above the gymnasium were installed with heat recovery wheels. During our site visit one recovery wheel was stationary and the other was rotating unusually quickly at roughly 60rpm as compared to the typical value of around 20rpm. The last RTU serves the kitchen and storage space adjacent to the gymnasium. This unit was not directly observed during our visit but is assumed to have a rated cooling capacity of 2 tons. All existing RTUs have VSDs installed.

The building IT closet has a dedicated AC system with the temperature set point at 70 degrees.

Ventilation:

Ventilation is provided by the RTUs through a VAV system and is oversized given the occupancy designs stated earlier.

Control System:

The building's VAV system utilizes IX Controls and is monitored by a Building Automation System (BAS) linking all four Putnam County Schools.

Kitchen:

The kitchen space within the building is limited, which necessitates the transport of food back and forth between other school buildings. The limited kitchen equipment within this building includes: an electric double oven with exhaust hood, one electric hot plate, one microwave, and a small commercial dishwasher with exhaust hood. The dishwasher was set to 159 degrees and utilizes a high temperature sanitizing rinse.

Beyond cooking equipment there are 4 standing double-door reach-in coolers/freezers as well as 2 chest style coolers to store food before meals.

2.5 Lighting and Internal Loads

Indoor Lighting:

Interior lighting throughout the building is provided primarily by fluorescent fixtures. The classroom spaces, offices, restrooms, and corridors all utilize 3 lamp, 32W, T8 fixtures. Supplementary lighting in the corridors and restrooms is provided by 18W 4-pin CFL can lights. The gymnasium is lit with 150W LED fixtures. The boiler room and electrical rooms are lit with 2 lamp, 32 W, T8 industrial fixtures.

The building is equipped throughout with ceiling mounted and wall mounted occupancy sensors along with manual switches for lighting control.

Outdoor Lighting:

The building's exterior lighting was upgraded in 2016 to LED wall packs. Parking lot lighting was also upgraded to LED fixtures at that time. Exterior lighting is on a set schedule with all lights on from dusk to 10pm, reducing to half of the lights on from 10pm to dawn.

Internal Loads:

Typical internal loads within the building include:
- Computers
- Monitors
- Printers
- Personal Space Heaters, fans, microwaves, refrigerators
- Other office equipment

2.6 Domestic Hot Water

Domestic hot water is supplied by a conventional gas fired, 250,000 Btu, 100-gallon capacity unit from Lochinvar, manufactured in 2008. This unit is installed with a recirculation system and all pipes are insulated.

3 Energy Consumption Analysis

3.1 Electric and Natural Gas Utility Data Analysis

The building's energy consumption was obtained from utility bills provided by the Putnam County School District. Utility bills were analyzed for a twelve-month timeframe from October 2021 to September 2022. Electricity and natural gas are delivered by Ameren Illinois.

The facility paid a total of $35,269 for electricity in this time frame and $17,198 for natural gas. The total utility cost for the facility from October 2021 to September 2022 was $52,467.

Table 1: Utility Information for October 2021 through September 2022

Fuel	Utility	Rate Class	Peak Demand (kW)	Annual Consumption		Annual Cost ($/yr)	Annual Cost (%)	Unit Cost*	
Electricity	Ameren IL	DS-3	190	352,690	kWh	$35,269	68%	$0.10	$/kWh
Natural Gas	Ameren IL	GDS-2	N/A	18,492	therm	$17,198	32%	$0.93	$/therm
Floor Area	39,000 sf		Totals	3,052,578	kBtu	$52,467	100%		
			Site Energy Use Intensity	78	kBtu/sf/yr	Energy Cost Intensity		$1.35	$/sf/yr
			Electricity Use Intensity	9	kWh/sf/yr	Natural Gas Use Intensity		0.47	therms/ sf/yr

*Note: Unit Costs are blended averages which include all taxes and demand charges.

Figure 1 represents the comparison of electricity consumption (kWh) and annual cooling degree days (CDD). A degree day compares the outdoor temperature to a standard indoor temperature of 65 degrees Fahrenheit. The more extreme the outdoor temperature, the higher the degree day number. Therefore, degree-day measurements can be related to the amount of energy needed for space heating and cooling as compared to the outdoor temperature.

Utility data provided shows a relatively good relationship between outdoor temperature and electrical usage within the building. It also appears that the building HVAC equipment operated for the whole summer in 2021 despite the building being minimally occupied for most of the summer. The lower usage seen in the summer of 2022 is assumed to be from lower activity and no summer school classes.

The existing above ground electrical supply lines were noted to be slack with the ability to sway and move considerably. During strong weather this situation can cause the building to lose 1 of 3 electrical phases. This necessitates a call to the electric company as well as the need to quickly shut down equipment manually within the building in order to prevent damage.

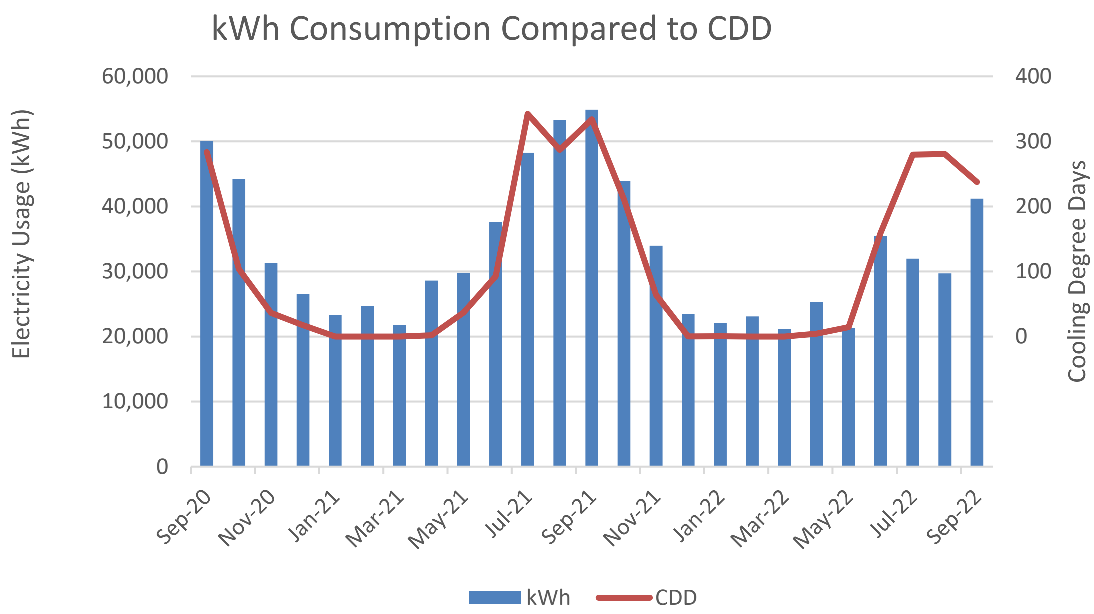


Figure 1: Comparison of Regional Cooling Degree Days versus kWh

Figure 2 represents the comparison of natural gas consumption (therms) and annual heating degree days (HDD). The primary sources of natural gas usage in the building are the gas fired boilers, DWH, and RTU heaters. The utility data provided shows a relatively good relationship between natural gas usage and outdoor temperature. However, there is substantial gas used during the summer for reheat to offset the oversized cooling equipment. 2022 appeared to have better control than 2021, but still a fair bit of gas was used.

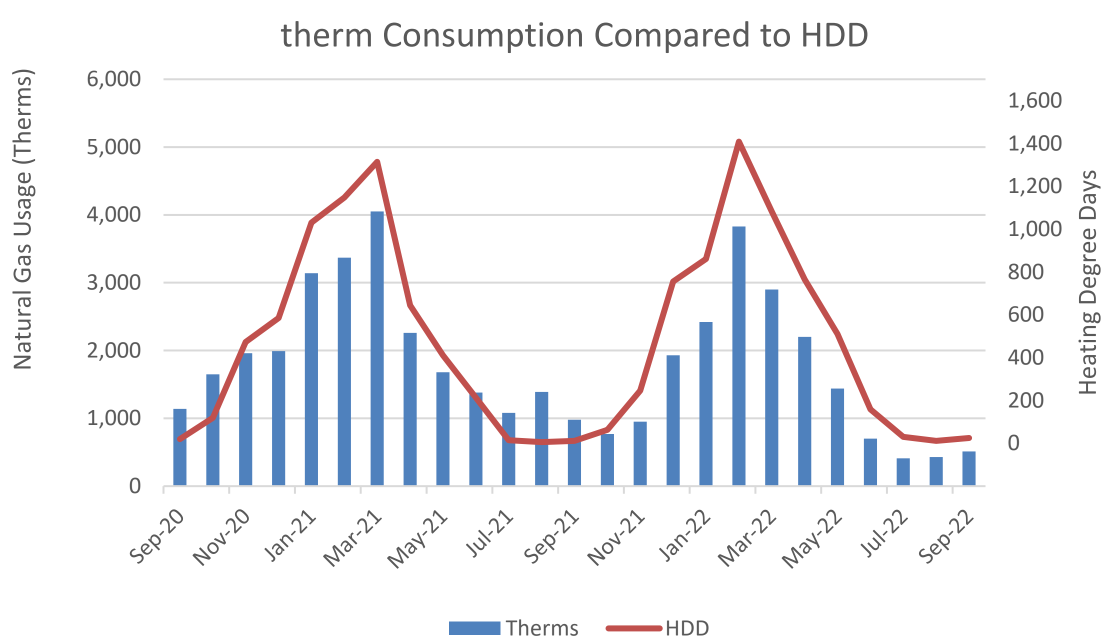


Figure 2: Comparison of Regional Heating Degree Days versus therms

3.2 Benchmarking

Benchmarking is a valuable tool for gauging energy usage relative to similarly classed facilities. Using the ENERGY STAR Portfolio Manager or Target Finder application, the facility's energy consumption can be compared to other facilities of similar size and use. Table 1 below shows the annual site energy consumption of a school building compared to the national average of a similar type facility, as well as a facility with an ENERGY STAR score of 75, which is the minimum requirement to apply for certification. The results indicate that the Putnam County Primary School has well below average performance. With a rating of 28, the primary school is not eligible to apply for the ENERGY STAR. Implementation of the recommended measures will help Putnam County School District improve the building's ENERGY STAR score and possibly qualify to become ENERGY STAR certified.

Table 2: ENERGY STAR Target Results

ENERGY STAR Portfolio Manager	Site Energy ($kBtu/ft^2/yr$)	Total Annual Energy Costs ($)	ENERGY STAR Score
Putnam County Primary School	**78**	**$52,467**	**27**
National Average	61.9	$41,514	50
ENERGY STAR Rated	46.8	$31,394	75

3.3 Breakdown of Energy Consumption

Determining where and in what quantities energy is used throughout the building helps to prioritize energy improvement efforts to maximum effectiveness. SEDAC also estimated how energy is used throughout the primary school and how much it costs for each function. Figure 3 shows all building energy use, both electric and natural gas, presented in terms of the proportional energy use for each function. Figure 4 shows the energy cost for each of these functions. The proportions are different between the two graphs because the per-unit cost of natural gas is less than the cost of electricity.

Figures 3 and 4 help visualize energy and money flows and give an indication of possible areas for improvement. The buildings energy use is dominated by building heat which makes up 55% of yearly energy. Building cooling, interior & exterior lighting, and domestic water heating combined make up another 42% of yearly energy. The last 3% of ‘Other’ energy represents plug load items such as computers, TVs, printers, personal space heaters, personal fans, and other miscellaneous electrical equipment. Improving the efficiency and operations of these areas can provide abundant savings. Measures address these areas later in this report.

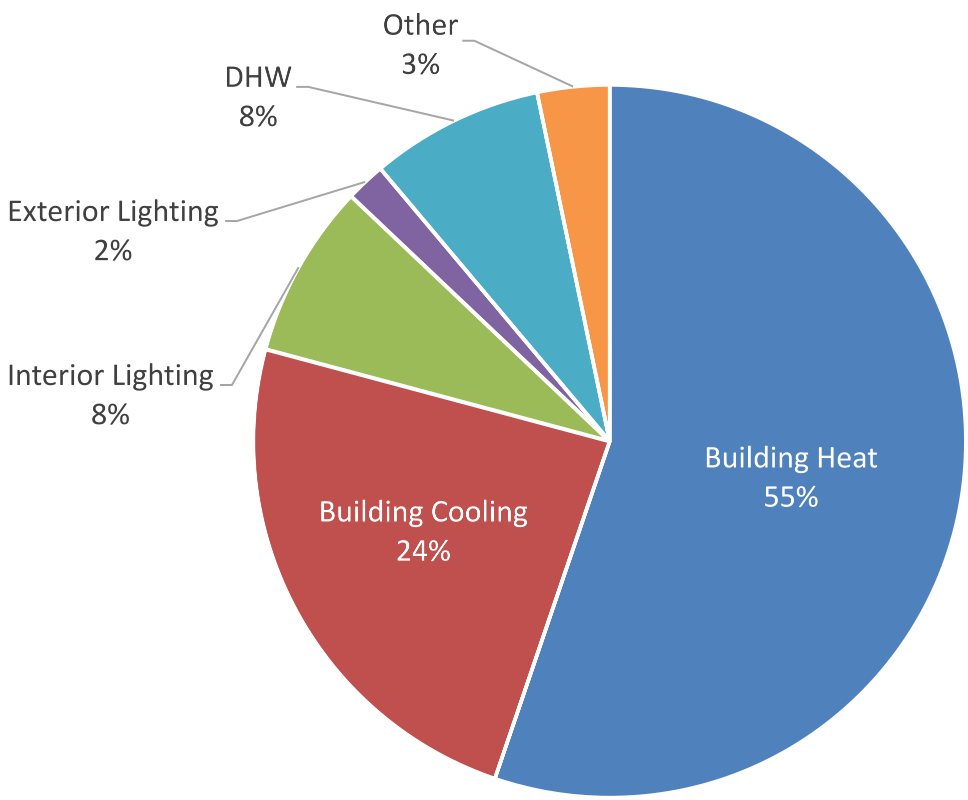


Figure 3: Energy Use Breakdown

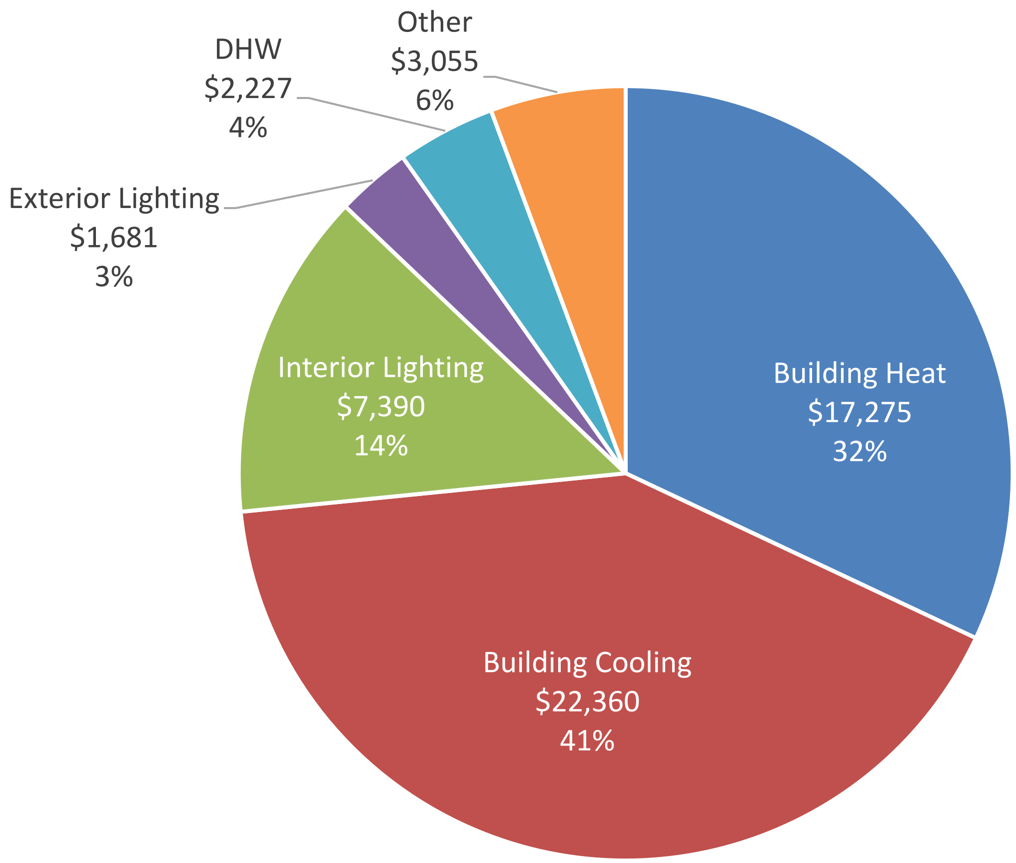


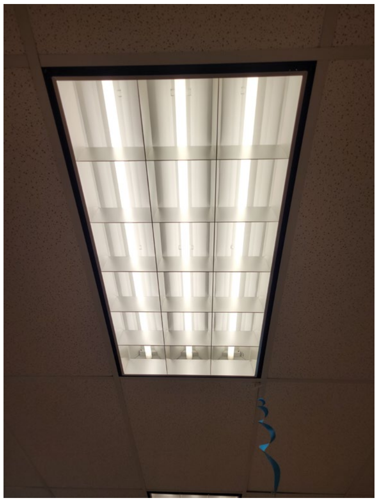
Figure 4: Energy Cost Breakdown

4 Energy Cost Reduction Measures

4.1 Measure–1 Lighting Upgrades

Issues and Observations:

Interior lighting throughout the building is provided primarily by fluorescent fixtures. The classroom spaces, offices, restrooms, and corridors all utilize 3 lamp, 32W, T8 fixtures. Supplementary lighting in the corridors and restrooms is provided by 18W 4-pin CFL can lights. The boiler room and electrical rooms are lit with 2 lamp, 32 W, T8 industrial fixtures.



Recommendations:

It is recommended that the current florescent fixtures, throughout the building, be upgraded to LED lamps. Calculations for this measure were based on tubular (TLED) replacement lamps which can be used within existing fixtures. It is anticipated that these new lamps would consume 17 watts each as compared with the current lamps of 32 watts each. Lower wattage high performance lamps are also available.

Type B ballast bypass TLED lamps offer the lowest cost of ownership when compared to Type A ballast compatible TLED lamps and are therefore recommended. Type B lamps will require some rewiring to supply line voltage directly to the sockets, bypassing and eliminating the need for a ballast, but avoid the ballast compatibility issues of the Type A lamps. It also avoids future maintenance on the ballasts, which will fail before the TLEDs.

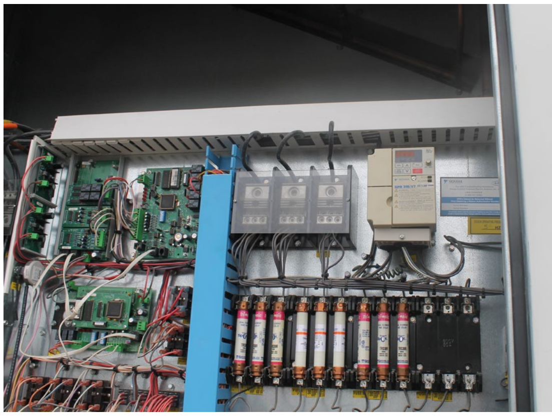
The can lights should be upgraded, using canless recessed lighting kits which are a round flat panel that is installed inside an existing can housing or in place of the can light in the same round opening where the can light was previously. It is best practice to ensure recessed fixtures are air sealed when installed. This prevents air movement up into or out of the ceiling space, improving indoor air quality and saving energy used to condition the interior spaces. Some LED retrofit kits include air-sealing gaskets.

Selection of new lamps should be coordinated with existing fixture outputs in order to ensure spaces are not over-lit by new LED fixtures. Ameren's Small Business Direct Installation program provides substantial incentives and may cover most of the cost of the project. It also includes the installation labor which could be beneficial given the district's present maintenance staffing level and summer project needs.

Based on the economics, this measure is recommended.

4.2 Measure–2 Implement Demand Controlled Ventilation

Issues and Observations:



The HVAC systems presently operate in a constant ventilation mode. This leads to the system operating at its full ventilation output regardless of the actual occupant load. This brings in moisture-laden outdoor air which requires cooling and dehumidification, which then requires the building reheat system to compensate. During our site visit it was noted that turning the boilers off during the summer results in very high interior humidity. This is typically a sign that the existing equipment is improperly sized and may have been based on far larger occupancy and loading than the building currently serves as mentioned earlier.

It is conceivable this building was designed to accommodate a portion of the local population in times of natural disasters or significant weather, as it is common for school buildings to serve as local storm shelters. This may have led to the existing HVAC system being sized such that it could accommodate nearly 1600 occupants, or 50% of the entire city population, based on occupancy figures from building plans. Since the current occupancy of the school, including students and staff, is only roughly 220 occupants the HVAC system is working far more than the actual occupancy demand would require. The system is providing ventilation based on the design occupancy figures which are nearly 8x the actual occupancy figures.

Recommendations:

It is recommended that the existing HVAC system be upgraded in order to implement demand-controlled ventilation (DCV). This will provide some staging capability such that the HVAC system can operate at a lower capacity matched to actual occupancy. If and when needed, the system will still have the capability to run at full capacity if the demand exists.

Implementing this measure will require the following work:

- The installation of pressure sensors
- Installation of CO2 sensors either in the return air ducts or in the various rooms
- Reprogramming of current Building Automation System

Calculations for this measure assume the existing, oversized HVAC system is left in place. Savings from this measure are included within measure 4 and adjusted for a proper-sized system.

Based on the economics, this measure is recommended.

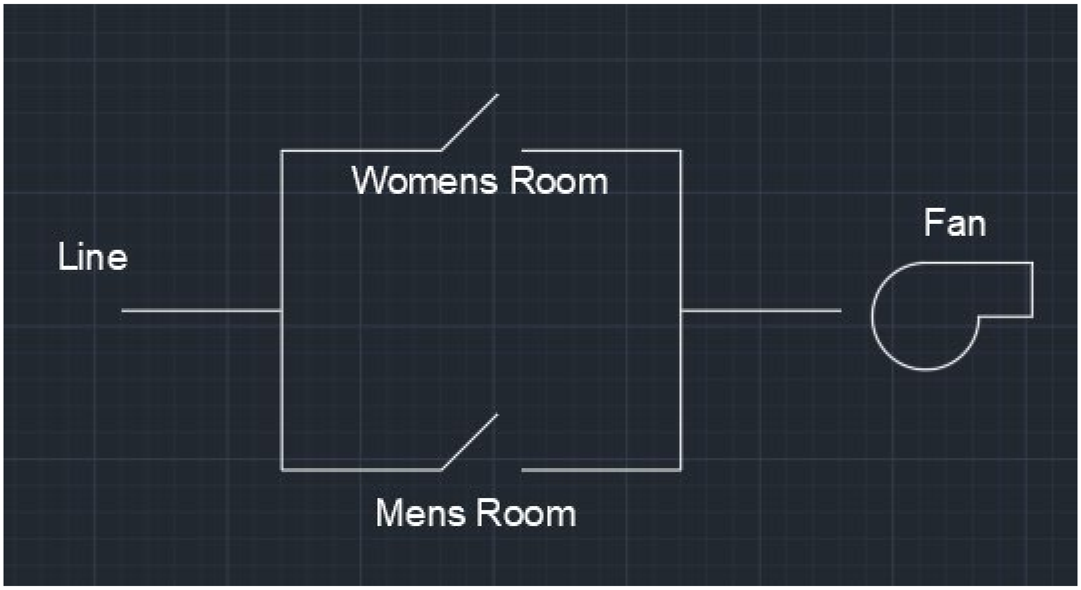
4.3 Measure–3 Exhaust Fan Control

Issues and Observations:

Presently, the bathroom exhaust fans operate 24 hours per day regardless of building occupancy. The 6 restroom exhaust fans combined are estimated to move roughly 5,000 cubic feet per minute. This air must be made up through leaks or from the rooftop units bringing in moisture-laden outdoor air.

Recommendations:

It is recommended to install occupancy sensors within each restroom to control the exhaust fans. Connecting the sensors in parallel as shown below would allow the fan to operate any time either bathroom is occupied and for a period of time after it is vacated. Alternatively, if the existing lighting occupancy sensors have auxiliary output contacts, these can be used to control the exhaust fan.



Calculations for this measure assume the existing, oversized HVAC system is left in place. Savings from this measure are included within measure 4 and adjusted for a proper-sized system.

Based on the economics, this measure is recommended.

4.4 Measure–4 High Efficiency Ventilation System

Issues and Observations:

It is important to ensure right-sizing of equipment for any future unit replacements and new school district projects. As discussed previously in this report the existing HVAC system units installed in this building appear to have been significantly over-sized.

Based on the information available we evaluated occupancy figures within two spaces of the primary school.

Classroom 113			1,000 sf (scaled estimate)
Building Plans	50 occupants		
International Building Code (Table 1004.5 Maximum floor area allowances per occupant)	Educational	20 net square feet per occupant	50 occupants
	Classroom area		
International Mechanical Code (Table 403.3.1.1 Minimum Ventilation Rates)	Education	25 occupants per 1000 sf	25 occupants
	Classrooms (ages 5-8)		

Gymnasium 126			6,200 sf (scaled estimate)
Building Plans	840 occupants		
International Building Code (Table 1004.5 Maximum floor area allowances per occupant)	Exercise rooms	50 gross square feet per occupant	124 occupants (entire gymnasium)
	Assembly without fixed seats – Unconcentrated (tables and chairs)	15 net square feet per occupant	414 occupants (entire gymnasium)
International Mechanical Code (Table 403.3.1.1 Minimum Ventilation Rates)	Sports and amusement – Gym, stadium, arena	7 occupants per 1000 sf	44 occupants (entire gymnasium)
	Education – Auditorium	150 occupants per 1000 sf	930 occupants (entire gymnasium)
	Education – Multiuse assembly	100 occupants per 1000 sf	620 occupants (entire gymnasium)

The tables above represent the differences between emergency egress occupancy figures and ventilation occupancy figures. From this analysis it appears the classrooms may have been designed with at least 2x the ventilation required. Gymnasium spaces are more complicated in terms of occupancy due to the variety of possible activities within the space. Given the analysis above it appears the gymnasium may have been designed with ventilation appropriate for an educational auditorium space. However, the gymnasium is currently not used as such a space. Half is used for physical education and sports practice for the students, which would equate to roughly 22 occupants per the ventilation requirements for “Sports and amusement – Gym, stadium, arena” spaces. The other half of the gymnasium is used as the school cafeteria and is set up with tables which would equate to roughly 310 occupants per the ventilation requirements for “Education – Multiuse assembly” spaces. These ventilation occupancy figures would equal 332 occupants for the entire gymnasium under normal conditions, roughly 40% of the given occupancy values from the building plans.

When considering the design of any new construction or additions to school district buildings it is recommended to ensure HVAC design capacities are not based solely on egress occupancy figures. HVAC design capacities should be based on actual, expected occupancy within the building to limit the potential for oversizing and associated problems. The district should provide or work with the design team to develop expected occupancy values rather than relying on code minimum/maximum values. Egress occupancy figures are defined by the Building Code and represent the highest occupancy possible given a specific space type. This occupancy figure is primarily used to determine the required egress width of doorways and corridors. This ensures all occupants are able to leave the building safely in the event of an emergency. However, egress occupancy figures will rarely, if ever, represent actual occupancy in school buildings.

If the building is being designed to serve as a storm shelter, we recommend the HVAC system be designed with supplemental capacity for that extraordinary need. This allows the primary system to operate within its expected design window while allowing extra capacity when required. This ultimately lowers energy consumption as well as limiting wear and tear on equipment. In this case egress occupancy figures could be used to determine maximum capacity including supplemental systems, while minimum ventilation rates based on expected occupancy could be used to determine the primary system capacities. Implementing demand controlled ventilation as described in measure 2 helps reduce loads when the building is at occupancy levels below the expected occupancy.

Load Sizing

SEDAC performed a regression analysis to get a sense of the actual building load. Understanding that the building has 2 million Btu of heating capacity and 164 tons of cooling puts into scale the degree of oversizing. The envelope has an estimated heating load of 325,000 Btu and a cooling load of 8 tons plus solar gain. Ventilation is typically the majority of the heating and cooling load, which is why using high efficiency energy recovery ventilators is important. This would indicate that a new variable refrigerant flow (VRF) system, as described below, would need a total capacity of around 600,000 Btu or 50 tons combined across all the different systems. A more accurate load calculation is required, but this analysis provides a sense of the overall load.

Considerations:

Separate Ventilation from Building Conditioning

In order to ensure efficient operations and realize the full savings potential of the measures within this report, we recommend the existing system be modified and downsized as follows. The existing oversized RTU units would be removed and replaced with high efficiency rooftop energy recovery ventilators (ERV). These units are manufactured to fit directly over existing supply and return ducts with minimal modifications. These units would handle the ventilation loads within each zone of the building. Since these units are designed to recover energy from outgoing exhaust air using energy recovery wheels, they are capable of saving up to 85% of the total energy, and associated costs, that are otherwise lost via exhaust. This then allows for substantially smaller sizing of the heating and cooling equipment required. Ventilation commands can be tied into planned or new sensors in order to implement DCV.

Heating and cooling would be provided to the building by two or more cold climate variable refrigerant flow (VRF) units. VRF units operate similar to mini-split or heat pump units but are capable of conditioning larger spaces and multiple zones with similar efficiencies. This solution has the added benefit of eliminating the existing boilers and piping and their associated natural gas usage, as the VRF units would be capable of providing the required heating. Cold climate models can provide heating down to -18F or colder.

VRF systems come in standard and heat recovery versions. Heat recovery systems would be recommended rather than standard systems. While heat recovery systems are more expensive, they allow for the system to transfer heat from warm zones to cool zones rather than just heating or cooling all zones at once. Standard systems can only make heating or cooling available to all zones at one time which is likely to lead to comfort issues.

While this is a different building conditioning methodology than traditional RTU systems that combine conditioning and ventilation in one unit, this provides conditioning and ventilation at much higher efficiencies and much lower operating costs.

Saving calculations for this measure assume the implementation of DCV and exhaust fan controls as a part of the new High Efficiency Ventilation System. Savings for DCV and exhaust fan controls were adjusted to reflect a proper-sized system.

Based on the economics, this measure is recommended.

4.5 Measure–5 Condensing Boilers

Issues and Observations:

Heating is provided to the building with two non-condensing gas-fired boilers. These units were manufactured by Sellers and have a thermal efficiency of 80%. Both boiler units were manufactured in 2008 and have an input capacity of 1255 MBH each and an output of 1004 MBH each. The boilers are set to 180-degree supply temperature and operate 24/7 all year. Given the boilers are non-condensing, the return water temperature needs to be maintained above 140°F.

Considerations:

Modern modular condensing boilers offer improved efficiencies over the existing boilers. Minimal changes would be required to the HVAC system beyond replacing the boiler units themselves. They also use dedicated intake and exhaust piping often made of PVC due to operating at much lower temperatures. These units are much smaller and often run exhaust and inlet flues out the wall of the boiler room to reduce the number of roof penetrations which are more likely to leak in the future. This measure would increase boiler thermal efficiency from the existing 80% to roughly 92%.

Based on the economics this measure is not recommended until it is time to replace the existing boilers.

This measure becomes redundant if measure 4 is implemented. Measure 4 includes the removal of the existing boilers as part of the new High Efficiency Ventilation System.

4.6 Potential Measures Not Quantified

Heat Pump Water Heater

Installing a heat pump water heater would reduce the energy consumed to provide domestic hot water. Instead of using electricity to heat water it uses around ¼ of the electricity to move heat from the surroundings into the water. This has some side effects, including providing some cooling to the surrounding space and some nominal dehumidification. Given the relatively low water use of the facility, it would be wise to install a heat pump water heater when the time comes to replace the existing water heater. They also avoid the potential for carbon monoxide poisoning from incomplete combustion that the present gas-fired water heater would have.

Eliminate Extra Transformer

Eliminating the extra transformer located within the building's north data and electrical room would help to reduce ambient temperature within that space. It was observed during our site visit that the transformers in this room were putting out a significant amount of heat. Given these transformers are just for a portion of the plug loads, the remaining 45 kVa transformer would still be more than needed. Removing the additional source of heat from this space would help to lengthen equipment life as well as reduce cooling loads.

5 Incentives

Listed below are various additional opportunities to consider. Please note that the incentive information provided is current at the time the assessment is completed. For up-to-date information on available incentives, contact SEDAC any time at 800.214.7954. Alternatively, you may contact or your utility.

5.1.1 Utility Incentive Offerings

Ameren has several incentives to encourage installation of energy efficient equipment. Incentives change frequently and SEDAC recommends checking with Ameren for the latest incentive offerings. More information may be found at: https://amerenillinoissavings.com/

The Small Business Direct Installation (SBDI) Program is available through registered trade allies and avoids the paperwork of standard and custom incentives. SBDI services include a lighting assessment and project quote, including installation. The SBDI program has higher incentive levels than standard incentives; the incentives may cover up to 100% of the material and labor costs: https://amerenillinoissavings.com/business/industry-solutions/small-business/

Table 3: 2022 Ameren Incentives

Ameren Offerings	Information
Linear T-8 LED 4’ Tube	$10/lamp (SBDI)
LED Fixture Replacing T-8 lamps	$0.70/watt reduced (SBDI) $0.50/watt reduced (Standard)
LED Exit sign replacing incandescent sign	$23/sign (SBDI)
Demand Controlled Ventilation	$0.15/square foot controlled
Custom	$0.24/kWh saved $2.00/therm saved

5.1.2 Contractors and Installers

Visit the Ameren Illinois Energy Efficiency Program Allies website for a list of mechanical and lighting contractors, engineers, architects, energy service companies, wholesalers, distributors, and retailers that can help get your energy efficiency project implemented.
https://amerenillinoissavings.com/business/business-contractors/

6 Conclusion

This report by the Smart Energy Design Assistance Center evaluated 5 Measures for potential application by the Putnam county primary school to reduce electrical and natural gas consumption and thereby save on utility costs. After thorough evaluation, 4 of the measures are recommended for implementation based on their effective rates of return.

The facility management and operators should be commended for their ongoing efforts to reduce energy consumption. As noted in Section 3 – Energy Consumption Analysis, the primary school's site energy use of 78 kBtu/ft2 is above the Energy Star U.S. National Median Reference Value. By also participating in a Smart Energy Design Assistance Center Program energy audit, the facility is exhibiting a sharpened focus as an organization dedicated to energy management practices. Undergoing an energy audit analysis sends a very strong message to one's community of a solid commitment to energy efficiency and sustainable business practices. SEDAC recommends that the energy savings initiatives identified in this report be implemented to decrease the building's overall energy consumption. A total reduction of 170,000 kWh and 16,100 therms is possible through the implementation of the suggested Measures shown in Tables E2. This represents an approximate 72% utility cost savings and 48% energy savings. SEDAC recommends implementing this measure package, which includes:

- Measure-1: Lighting Upgrades
- Measure-2: Implement Demand Controlled Ventilation
- Measure-3: Exhaust Fan Control
- Measure-4: High Efficiency Ventilation System (HEVS)

The suggested measures will significantly reduce the electrical and natural gas consumption of the facility while providing an estimated annual total gas and electric utility savings of $39,100 (at current costs).

The items included in this report are the primary elements of creating and managing a sustainable building; they are to serve as guides to implementation.

To demonstrate its effectiveness to the State of Illinois, SEDAC is asked to compile quarterly reports that document implementation of energy efficiency measures. We ask that you keep us apprised of all work towards implementation of our recommendations; this information will allow us to accurately reflect subsequent savings. We will also contact you periodically to discuss, answer questions, and review status.

Thank you for the opportunity to be of service. Please do not hesitate to contact us if we may be of further assistance.

7 Customer Interest Form

Below is a selection form that will allow SEDAC to gauge the interest of the client in implementing each individual measure. Please fill this out and return to SEDAC.

Measure ##	Measure Description	Interest in Implementing?		Estimated Completion Date
		YES	NO	
1	Lighting Upgrades			
2	Implement Demand Controlled Ventilation			
3	Exhaust Fan Control			
4	High Efficiency Ventilation System (HEVS)			
5	Condensing Boilers			
6				
7				