KEEPS Assessment Report
PHASE II
On-Site Opportunities

Prepared for:
Southgate Elementary School
Southgate, KY

October 22, 2010

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KPPC
Kentucky's Resource Center for Environmental Sustainability

KEEPS
Kentucky Energy Efficiency Program for Schools

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For questions, please call KPPC at (502) 852-0965.

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EXECUTIVE SUMMARY

On October 8th, 2010, KEEPS - Kentucky Energy Efficiency Program for Schools - conducted a Phase II Energy Efficiency Assessment of Southgate Elementary School (SES) in the Southgate Independent School District. The school is located in Southgate, KY and serves 240 students. The school consists of three buildings tied together with corridors with the buildings built in 1903, 1930 and 1995. They have a combined footprint of 27,783 ft^2. SES consumed 969 MMBtu of electricity costing $28,591 and 1,909 MMBtu of natural gas costing $17,440 during the 2009-2010 billing cycle.

The purpose of the assessment was to evaluate existing energy-consuming systems and help identify opportunities for the school to become more energy efficient. The assessment includes an analysis of the following: utility rates, energy intensity benchmarking, retro-commissioning opportunities, operations and maintenance, heating, ventilation and air conditioning (HVAC) system and controls, lighting, plug load, computer power management, water heating and water consumption. **Table 1** summarizes the identified energy management opportunities (EMO).

Table 1: Energy Management Opportunities (EMO) Summary

EMO Description	Estimated Cost	Estimated Savings/Yr	Est. MMBtu Savings/Yr	Est. Simple Payback
Retro-commission	Not estimated	Not estimated	N/a	N/a
Implement O&M program	Not estimated	Not estimated	N/a	N/a
Modify thermostat settings	FREE	$589	55.7	INSTANT
Install ENERGY STAR® computer power management software	FREE	$3,820	129.5	INSTANT
Replace water heaters with condensing gas on-demand tankless system when necessary	$3,400	$669	73	5.1 years
Unplug refrigerators during summer	FREE	$513	17.4	INSTANT
Install low-flow faucet aerators	$47	$895	43	0.1 year
Total[1]	**$3,447**	**$6,486**	**318.6**	**0.5 year**

The savings in **Table 1** equate to the following reductions:

- $4,450 annual reduction in electricity costs[2]
- $1,534 annual reduction in natural gas costs[2]
- 44.2 MWh annual reduction of electricity consumption
- 0.16 MMcf annual reduction in natural gas consumption
- 0.0003 metric tons of Carbon Monoxide (CO)[3]
- 49.9 metric tons of Carbon Dioxide (CO_2) equivalent greenhouse gases[3]
- 0.055 metric tons of Nitrogen Dioxide (NO_2)[3]
- 0.0006 metric tons of Particulate Matter (PM)[3]
- 0.206 metric tons of Sulfur Dioxide (SO_2)[3]
- 0.00003 metric tons of Volatile Organic Compounds (VOC)[3]
- $0.23/ft
- 1,327 kBtu/student
- 11.5 kBtu/ft^2
- $27.03/student

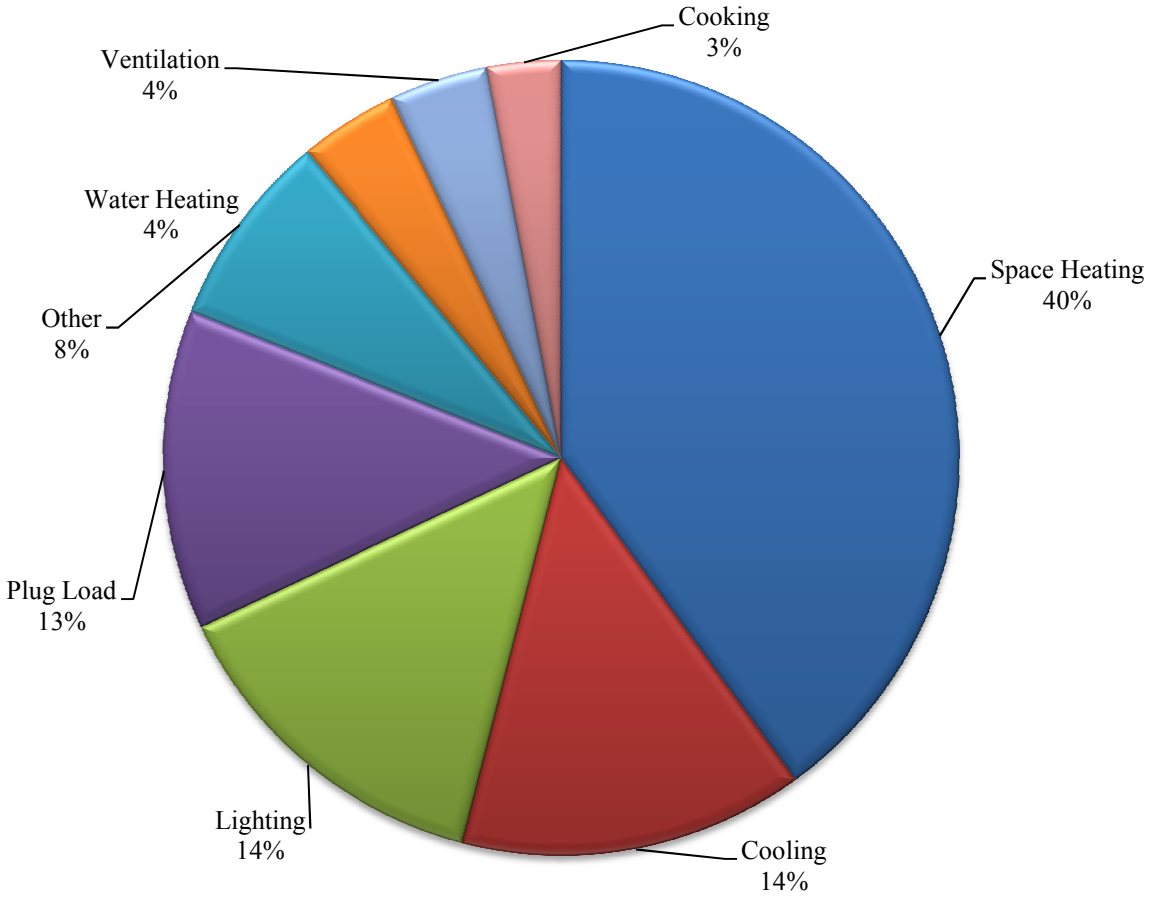
[1] The totals in Table 1 do not include estimated savings from retro-commissioning and implementing an effective O&M program because of their difficulty to estimate. Because HVAC consumes more than 50% of a typical school's energy, savings from both of these EMOs are significant and therefore prioritizing them cannot be emphasized enough.
[2] Assumes retro-commissioning savings to be proportional to CBECS average k-12 school heating (40%) and cooling (14%) energy consumption
[3] Source: KY Division of Air Quality and U.S. Department of Energy (DEDI Calculator)

1.0 UTILITY BILL AND ENERGY USE ANALYSIS

Southgate Elementary School's electricity and natural gas is supplied by Duke Energy and paid on the Distribution Service (DS01) and General Service (GS) rate schedule respectively. After reviewing 12 months of gas and electric bills, it appears SES's main building is on the best available rate. In fact, according to Duke Energy's available electric rates Southgate Elementary is on the only available rate the school qualifies for.

Figure 1 shows the energy use profile for a typical K-12 school[4]. **Figures 2, 3, 4** and **5** shows how the energy (MMBtu) and costs at SES are distributed over the course of a year. The energy usage increases with an increase in Heating Degree Days (HDD) and Cooling Degree Days (CDD).

Figure 1: Typical Energy Use Profile, K-12 School



[4] Commercial Buildings Energy Consumption Survey (CBECS)

Figure 2: Energy Usage and Degree Days

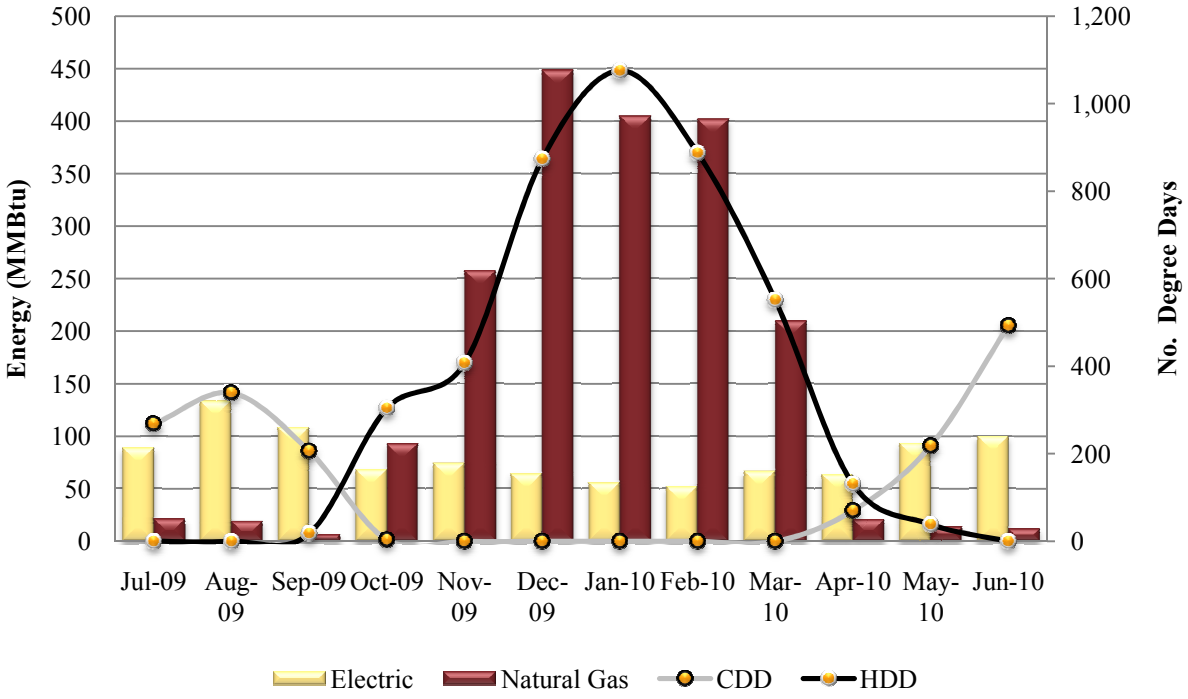


Figure 3: Energy Cost and Degree Days

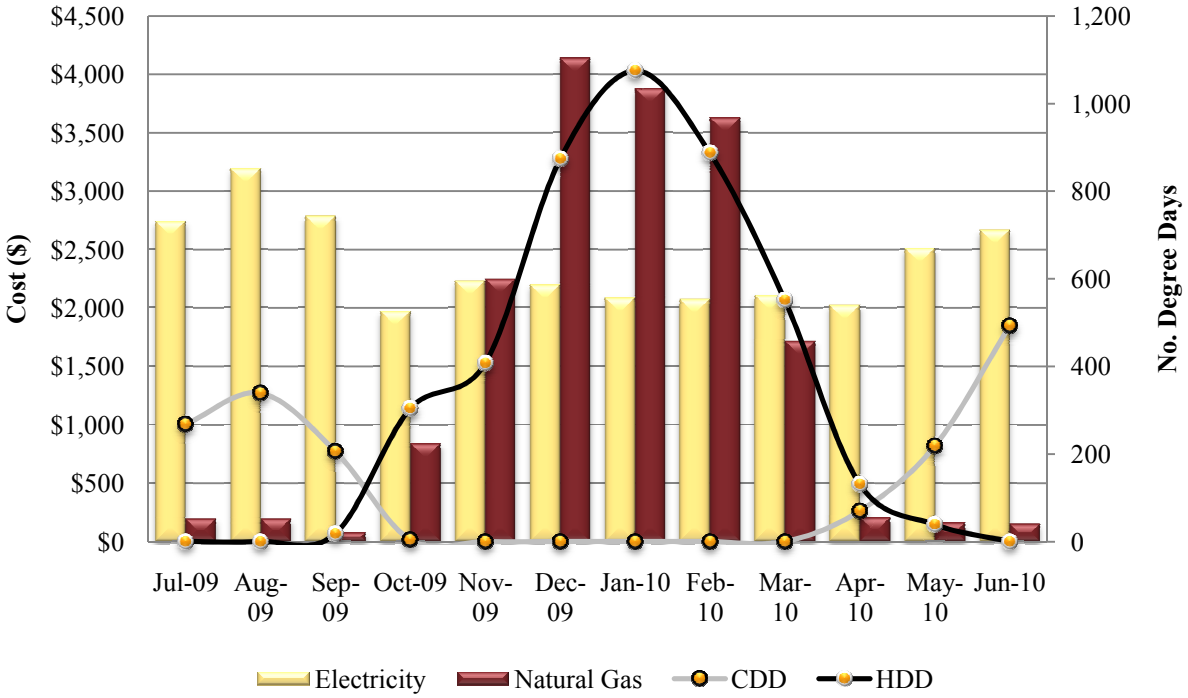
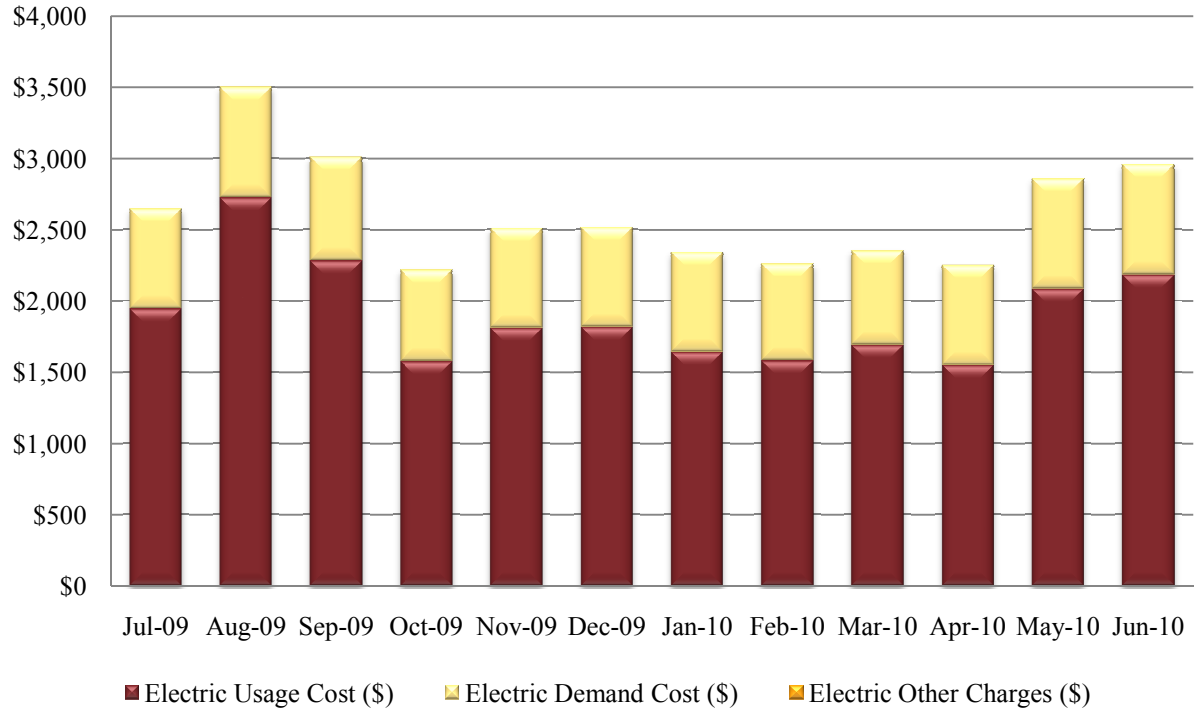
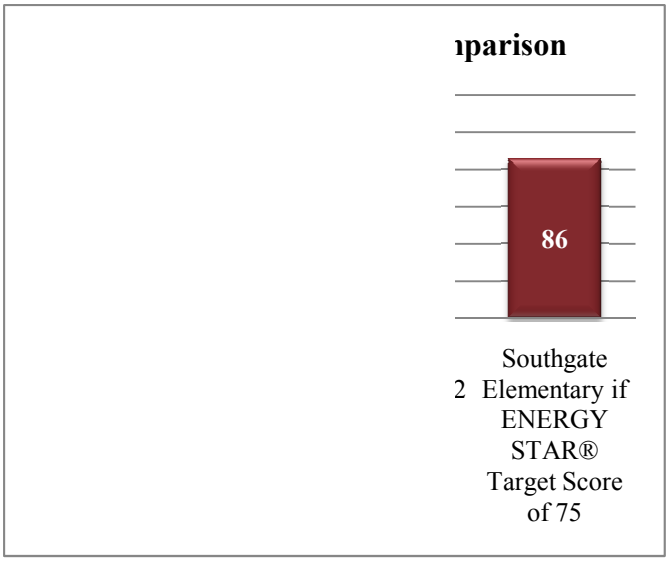


Figure 4: Electric Cost Breakdown



2.0 ENERGY USE COMPARISON

Comparing similar buildings is a useful exercise in energy management. It gives the building a "score" so an energy manager can prioritize his/her efforts. ENERGY STAR® has created a system of comparing buildings of the same size, use profile (cooking, open on weekends, number of computers, etc.), and climate. The original data was compiled from Commercial Building Energy Consumption Survey (CBECS). ENERGY STAR Portfolio Manager® and ENERGY STAR Target Finder® both have the capability to benchmark the energy intensity of your school[5].



Southgate Elementary's energy intensity is 103 kBtu/ft^2/year, which is higher than the average intensity for a school of the same size, climate and use profile, 110 kBtu/ft^2/year. This is partly due to a lighting retrofit and summer thermostat setups. An energy intensity of 86 kBtu/ft^2/year would assist Southgate Elementary in earning ENERGY STAR® certification (see **Figure 5**).

[5] http://www.energystar.gov/index.cfm?c=new_bldg_design.bus_target_finder

3.0 ENERGY MANAGEMENT OPPORTUNITIES

This section identifies specific energy conservation opportunities for Southgate Elementary School. Potential costs and savings are estimated based upon information provided by the school, external sources such as vendors and observations made during the on-site visit. Engineering assumptions are made when necessary information is not readily available. Although many recommendations will include retrofits or equipment replacements, staff and student behavior and commitment to conserve energy are the necessary prerequisites for energy and related cost reduction. The following practices are already in place to help lower the facility's energy consumption and should be continued:

- There are some thermostat setups during night hours and weekends
- Lights are turned OFF during unoccupied times
- All of the T12 lighting fixtures have been replaced with T8s and electronic ballasts

3.1 Retro-Commissioning

Building commissioning is the systematic process of ensuring a building performs according to the design's intent and the owner's operational needs. Commissioning can be done on new or existing buildings (referred to as retro-commissioning). Retro-commissioning identifies the almost inevitable "drift" from where things should be and puts the building back on course. Retro-commissioning goes beyond evaluating individual components to ensure the entire system of components is operating as efficiently as possible. The results are compelling. According to ENERGY STAR® Building Upgrade Manual,[6] "Retro-commissioning is the first stage in the building upgrade process".

Commissioning costs can vary considerably from project to project. Actual costs depend on the size and complexity of the project as well as the extent and rigor of the commissioning specified. However, a 2009 meta-analysis by Lawrence Berkeley National Laboratories (LBNL) observed a median cost of $\$0.30/ft^2$ of 561 retro-commissioned buildings. The report also specifically found school buildings to have an average 3.3 year simple payback which equates to approximate annual saving of $\$0.09/ft^2$ (see **Appendix B**). Of consideration, a majority of the commissioned buildings studied resided in mild climates requiring less energy to condition buildings. Since Kentucky's climate requires more energy for building conditioning, the above savings are conservative.

Commissioning may include some of the following services:

- Functional testing of heating and cooling equipment
- Verify and calibrate dampers, sensors, economizers, outside air intake flow
- Work with staff so they understand the building and how to keep it in optimal condition

Because commissioning costs vary widely, potential costs and savings for Southgate Elementary School have not been included. Instead, it is recommended to contact commissioning agencies for free on-site estimates. From the assessment, Southgate Elementary would benefit from being retro-commissioned. However, due to the cost of retro-commissioning and financial constraints if the school, consider implementing the lower-cost recommendations identified later in this report in the meantime.

[6] http://www.energystar.gov/index.cfm?c=business.EPA_BUM_CH5_RetroComm

3.2 Operations and Maintenance Program

According to CBECS survey of K-12 schools, (see **Figure 1**), 58% of a typical school's energy is consumed by the HVAC system. Approximately 67% of Southgate Elementary School's energy usage is consumed by HVAC systems. This is largely due to the current HVAC system setup and because the system must maintain at least 69°F to prevent pipes from freezing in the 1930 building farthest from the boiler room. Typically HVAC systems present the largest opportunity for savings because they consume the most energy. Effective O&M is one of the most cost-effective methods for ensuring reliability, safety, and energy efficiency of the HVAC system. Studies have shown nearly one-third of the energy consumed in the average U.S. school is wasted[7]. O&M programs targeting energy efficiency can save 5% to 20% on energy bills without a significant capital investment[8]. Successful O&M have the support from upper management and proper funds are made available. A summary of HVAC benefits and maintenance actions can be found below[9].

Regular maintenance of the HVAC system has a number of benefits:

- Energy savings
- Extension of equipment life to avoid premature replacement and reduce life-cycle cost
- Enhanced indoor air quality and ventilation
- Elimination of contaminant sources, increased occupant comfort improved reliability and reduction in emergency equipment issues
- Avoidance of classroom disruptions with equipment operating at maximum efficiency
- Integration into pest management through cleaning procedures
- Empowerment of maintenance staff to take charge through demonstrated energy savings.

Summary of low cost or no cost energy-savings maintenance actions:

- Ensure systems run only during occupied periods
- Clean burners and air conditioner coils
- Replace and clean air filters and keep economizer dampers clean
- Check ducts for leaks at joints and flexible connections
- Check hot and cold duct and pipe insulation and seals for inadequate insulation
- Fix faulty equipment
- Verify and adjust refrigerant charge on packaged air conditioning systems
- Check, adjust, calibrate, and repair all controls, such as thermostat controllers and valve and damper operations. Monitor, calibrate and repair enthalpy controls and mixed-air controls to maintain efficient operation
- Repair or replace all defective dampers
- Check, adjust, or replace fan belts
- Lubricate all bearings and other friction points, such as damper joints
- Inspect fan wheels and blades for dirt accumulation and clean them as required
- Adjust or repair packing glands and seals on valve stems and pumps
- Ensure that no oil or water enters the main air supply for the control systems

[7] http://apps1.eere.energy.gov/buildings/publications/pdfs/energysmartschools/ess_o-and-m-guide.pdf
[8] http://www1.eere.energy.gov/femp/pdfs/omguide_complete.pdf
[9] http://chps.net/manual/index.htm#BPM

3.3 HVAC & Controls

Southgate Elementary School is heated alternately by two 1983 Weil McLain boilers that are 81% AFUE efficient. The individual rooms are cooled and ventilated by univents. At the time of the assessment, the superintendent mentioned that the system is setup in the summer to 85°F, but can only setback to 69°F during the heating season. Any lower setback causes the pipes to freeze in the building addition furthest from the boiler room. Studies have shown average thermostat savings to be 1% (of the annual heating and cooling cost) per degree setback for eight hours/day[10]. The inset below provides potential savings if the thermostat settings (HVAC controls) were adjusted as outlined in **Appendix B**.

Estimated cost to adjust HVAC controls……...……FREE
Estimated annual cost savings……..……..……$589/year
Estimated simple payback……...……...INSTANT

Because greater savings would result from greater system-wide winter setbacks, it may be cost-effective to disconnect the 1930 addition's HVAC piping from the main boiler system and install a separate smaller heating system for the addition. As this is beyond the scope of KEEPS technical service, consult HVAC contractors and architects for prices and design.

3.4 Lighting

The lighting system during the 2009 – 2010 billing period consumed 4% of the total energy used at Southgate Elementary. A typical school's lighting uses 14% of the total energy. The percentage difference is due to hours of usage and the efficiency of the lighting lamps. The existing lighting system consists of an estimated 163 fixtures with T8 lamps and electronic ballasts with an estimated annual operating cost of $3,659. Because all of the lighting fixtures have been upgraded to T8s with appropriate ballasts, there are no further lighting recommendations except to continue to turn OFF lights when areas are unoccupied.

3.5 Computer Power Management

According to CBECS, plug load consumes an estimated 13% of a schools energy use (see **Figure 1**). At Southgate Elementary, 18% of the total energy is consumed by plug load. This is largely due to computers and refrigeration energy consumption. Computers are the largest consumer of energy within the plug load category. See **Appendix B** for details on the energy consumed by other school appliances and electronics.

Even if computers are shut down at nights and on weekends, at least half the energy consumed by computers may be wasted because they are on continuously through the school day. The ENERGY STAR Power Management® program[11] provides free software that can automatically place active monitors and computers into a low-power sleep mode through a local area network.

[10] http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12720
[11] www.energystar.gov/index.cfm?c=power_mgt.pr_power_management (EZ Wizard tool or EZ GPO tool)

Southgate Elementary School has approximately 44 computers. In addition to enabling "sleep" mode which causes the computers to power down after 15 minutes of non-use, it is recommended to download and install the ENERGY STAR Power Management® program (EZ Wizard tool or EZ GPO tool) which "wakes-up" the computers for scheduled updates and then powers them back down afterwards. The inset below provides annual savings if the above two recommendations are implemented. See **Appendix B** for details.

Estimated cost for computer management……..……..……...FREE
Estimated annual savings…..…….$3,820/year
Estimated simple payback…..……..……INSTANT

3.6 Water Heating

Southgate Elementary School uses about 198 MMBtu of natural gas (7% of the total energy) to heat water costing $1,810 annually. A low-cost maintenance measure to improve the efficiency of the water heaters is periodic flushing, which removes sediments from the system and increases heat transfer efficiency. Energy is wasted if the water heater temperatures are set higher than appropriate for end use. ENERGY STAR® recommends a water temperature of 120° F for general use.

Water heaters have an expected life of 15 years. At Southgate Elementary, both water heaters utilize natural gas; the water heater serving the bathrooms is 10 years old and the heater serving the kitchen is one year old. Although the water heaters are still within their expected lifespan, upon necessary replacement consider a 0.96 EF on-demand, tankless condensing gas water heater system. The estimated savings below to replace the existing system are supported by calculations in **Appendix B**. Available Kentucky appliance rebates[12] range from $300-$400.

Estimated installed cost for gas condensing tankless water heating system……..…$4,000
Kentucky appliance rebate (if funding persists)……..…$600
Estimated annual savings……....…$669/year
Estimated simple payback…….……..…….…5.1 years

In addition, solar water heating may be another retrofit option. According to Kentucky Solar Partnership,[13] a solar water heating system retrofit for a standard Kentucky school of 500 students with "in-school" cooking and dishwashing and using the existing storage tanks can cost approximately $9,000, offer savings of $480 per year with a 12 year simple payback. Because every school is different, exact cost and annual savings will vary and an installation company should be contacted for exact figures. Although not necessarily cost-effective, solar water heating does utilize renewable energy and provides an educational tool for teachers.

[12] http://www.kyappliancerebates.com/
[13] www.kysolar.org

3.7 Refrigeration

Refrigeration is the next largest consumer of energy within plug load after computers. It is recommended to unplug the refrigerators during the summer break which accounts for 20% of the school year. If some food items must remain, it is recommended to consolidate into one unit and unplug the remaining empty units. See **Appendix B** for annual refrigerator energy usage and cost.

Estimated cost of unplugging refrigerators……FREE
Estimated annual cost savings……$513/year
Estimated simple payback……INSTANT

4.0 ADDITIONAL MANAGEMENT OPPORTUNITIES

(Range Hoods)
It is also important to turn the kitchen exhaust hood OFF when there is no cooking. Exhaust hoods can be an energy penalty in three ways: the energy cost of the fan motor, the energy cost of exhausting conditioned air, and the energy cost of pre-conditioning the make-up air.

(Water)
Water usage is a cost often overlooked, but should be considered as a commodity to be conserved. **Appendix B** gives annual savings if low-flow fixtures/appliances are installed. Savings encompass gallons of water, costs (at tap and sewer) and energy from reduced hot water demand. Considering cost-effectiveness, install low-flow faucet aerators (0.5 gpm) now for immediate payback. Although the initial cost for high-efficiency toilets (1.28 gpf or less) and waterless urinals (0.0 gpf) is expensive and the payback drawn out, it is important to remember that these appliances' expected lifespan greatly exceeds the payback.

Estimated cost of installing low-flow faucet aerators……$47
Estimated annual cost savings……$895/year
Estimated simple payback……0.1 year

Water utility companies typically assume that the amount of water discharged into the sewer drain is equal to the amount consumed at the tap. What is not usually accounted for is water used for irrigation and evaporated by a cooling cooler all that which is not discharged to the sewer. Deduct meters measure this difference and cost in the range of $175 - $300 per meter installed. Because sewer charges are typically equal to or more than water charges, cost savings are significant along with a quick payback on the installed meter(s).

5.0 CONCLUSION

The following energy savings opportunities have been identified (**Table 2**). In addition, it is critical to implement an O&M program to keep the building in optimal condition.

Table 2: Energy Management Opportunities (EMO) Summary

EMO Description	Estimated Cost	Estimated Savings/Yr	Est. MMBtu Savings/Yr	Est. Simple Payback
Retro-commission	Not estimated	Not estimated	N/a	N/a
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Total[14]	**$3,447**	**$6,486**	**318.6**	**0.5 year**

Thank you for your participation with KEEPS. Please contact KPPC—KEEPS with any questions or for additional assistance.

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[14] The totals in Table 2 do not include estimated savings from retro-commissioning and implementing an effective O&M program because of their difficulty to estimate. Because HVAC consumes more than 50% of a typical school's energy, savings from both of these EMOs are significant and therefore prioritizing them cannot be emphasized enough.