Greenfield High School
Lighting System Analysis

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Presentation Overview

- Introduction to energy management.
- Graph of GHS total electric power consumption.
- GHS energy intensity compared to a Vermont benchmark.
- Lighting energy consumption and cost estimates for the school auditorium, and east corridor hallway.
- Energy and cost savings estimates of proposed retrofits.
- Light intensity measurements compared to recommended standards.
- Light quality: color temperature.
- Conclusions
- Next steps

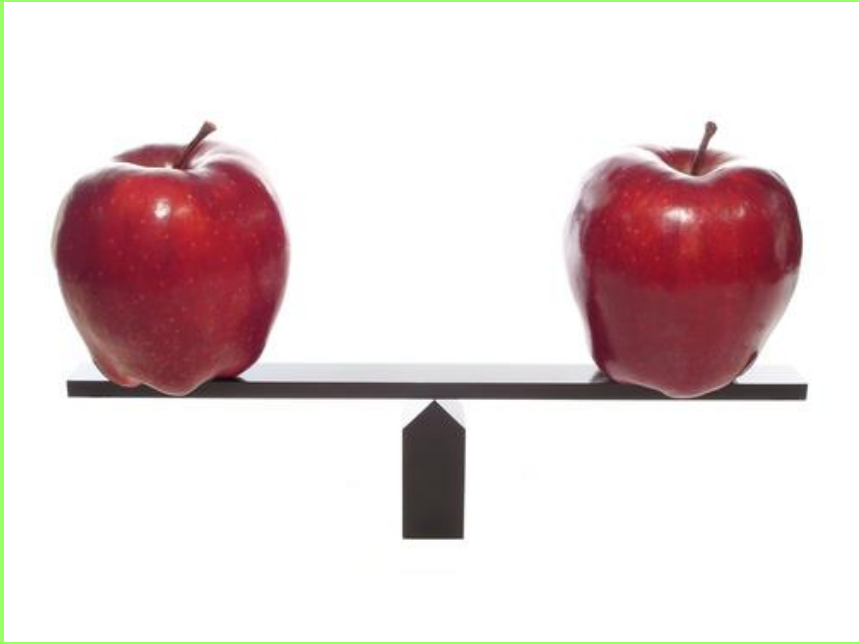
How Important is Energy Conservation and Efficiency?

- Nationwide, schools spend $6-$8 Billion dollars annually on energy.
- More is spent on energy than on textbooks and computers combined!
- In fact, after salaries, energy is usually a school district's single largest expense. It is the most significant *manageable* cost.
- With a more energy efficient school, GHS could invest more money into class supplies, field trips, and other improvements to the educational experience.
- More efficient energy usage also helps schools become environmentally responsible, setting an example for all to learn from.

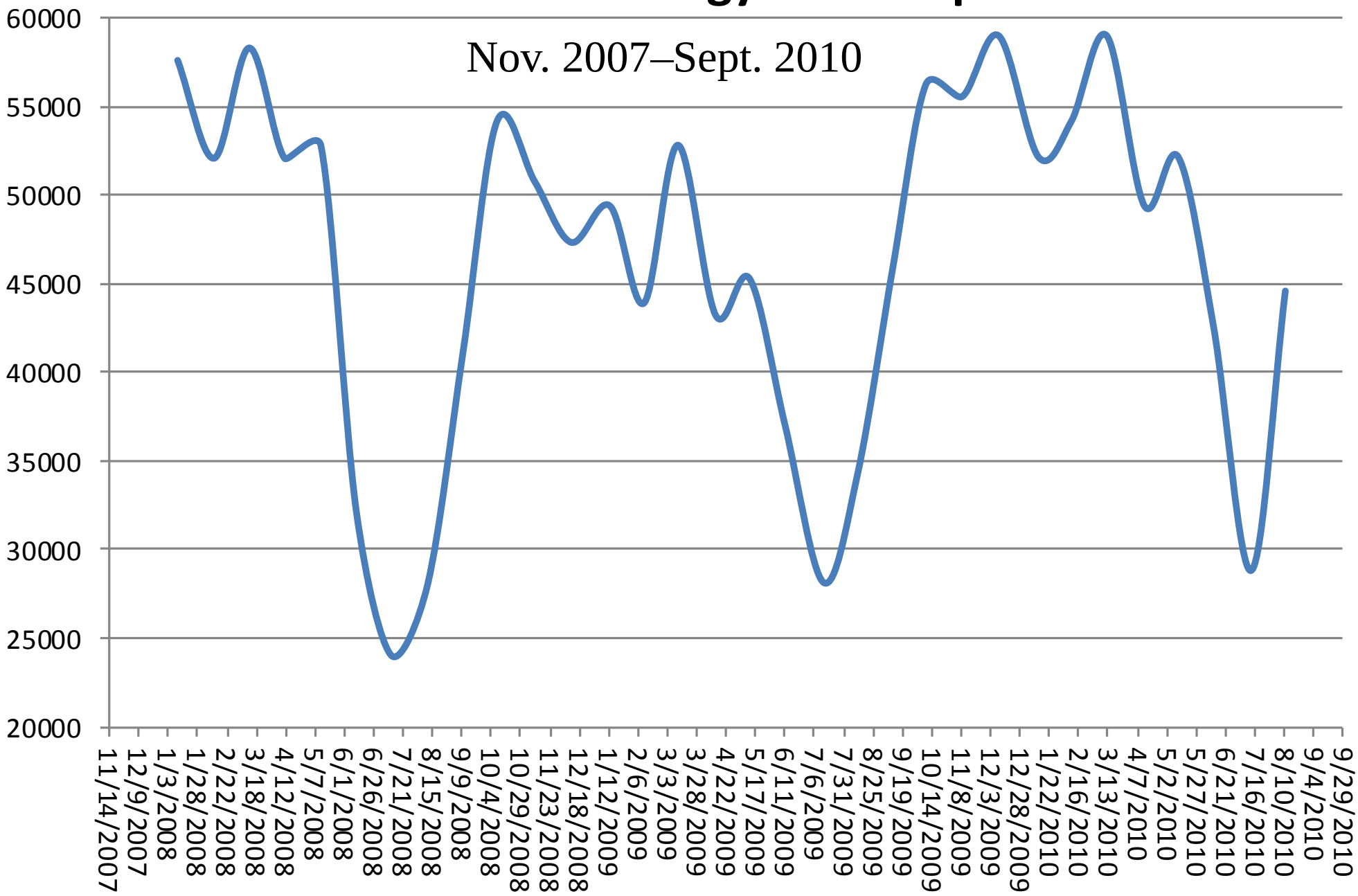
Energy Audits and Benchmarking

- An energy audit is a study done by an energy specialist to determine the best way to improve the energy efficiency of a building.
- Energy benchmarking is a valuable first step towards performing an audit on your school.
- Benchmarking means comparing energy consumption for a particular building with that of similar buildings to determine a rating, usually a scale of zero to 100%.

- In a benchmarking study, building energy use is divided by area (square feet), which allows large and small buildings to be compared.



GHS Electric Energy Consumption



GHS Annual Energy Intensity (KWH/SqFt) and Cost ($/SqFt)

KWH/yr	553032
$/yr	$89,504.00
Square Feet	160587
Energy Intensity (KWH/SqFt)	**3.4**
Cost ($/SqFt)	**0.56**

How GHS Compares to a Sample of Vermont Schools

GHS Annual Energy Intensity: 3.4 KWH/SqFt
GHS Annual Energy Cost: $0.56/SqFt

Vermont Schools Average Annual Energy Intensity (KWH/sqft) and Cost ($/sqft).

Electricity Benchmark Data	KWH/sq.ft. 2-year average ('03/04 and '04/05)	$/sq.ft. 2-year average ('03/04 and '04/05)
SAMPLE SIZE	27.00	26.00
Lowest Value (Most Efficient)	2.56	0.32
25th Percentile (first quartile—low energy use)	4.71	0.60
50th Percentile (median)	6.12	0.77
75th Percentile (third quartile—high energy use)	7.45	0.90
Highest Value (Least Efficient)	15.49	1.86
Standard Deviation	2.66	0.32
MEAN	6.27	0.80

What can students and staff do to save energy?

- In a walkthrough of the school we found 47 vacant rooms. Of these, 53% (25 rooms) had their lights left on.

- Shut the lights off in rooms that are vacant.
- If it’s a bright sunny day and there's plenty of daylight, don’t turn your lights on.
- Make sure lights in closets and bathrooms are turned off when not in use.

Motion Sensors

- Every day energy is wasted from lights being left on in unoccupied rooms!
- An easy way to resolve this problem would be to add motion sensors to specific areas of the building.
- These sensors can be adjusted from 30 seconds to 15 minutes until they shut off.
- Rooms that would benefit most if motion sensors were installed are bathrooms, the locker rooms, and storage space.

Greenfield High School Auditorium Energy and Cost Estimates

Row 1: Existing Incandescent Lamps
Row 2: Proposed CFL retrofit

# of lamps	watts	Total Watts (J/sec)	J/hr	KWH/hr	J/ day	KWH/day	J/year	KWH/ yr	$/yr
265	90	23850	85860000	24	686880000	191	123638400000	34344	4464
265	23	6095	21942000	6	175536000	49	31596480000	8777	1140

Assumptions:

- The auditorium lamps are on for 12 hours/day, 180 days/year.
- The cost of electricity is $0.13/KWH

Conversion factor:

1 KWH = 3,600,000 J

Auditorium CFL Retrofit Benefits

- By retrofitting the incandescent lamps to CFLs, our school will save:

$4464.72-$1140.98 = **$3,324 per year**

- At $10.99/ lamp, the cost of purchasing the CFL's is:

265 x $10.99 = **$2907**

- Despite the upfront costs of the retrofit, GHS would realize a **$417** savings during the first year, and **3,324/yr** annually after that!

Greenfield High School
East Corridor Energy and Cost Estimates

Row 1: Existing Incandescent Lamps
Row 2: Proposed CFL retrofit

# of lamps	watts	Total Watts (J/sec)	J/hr	KWH/hr	J/day	KWH/day	J/year	KWH/yr	$/yr
19	75	1425	5130000	1.425	61560000	17.1	11080800000	3078	$400.14
19	15	285	1026000	0.285	12312000	3.42	2216160000	615.6	$80.03

Assumptions:

- The auditorium lamps are on for 12 hours/day, 180 days/year.
- The cost of electricity is $0.13/KWH

Conversion factor:
1 KWH = 3,600,000 J

East Hallway Retrofit

- The school currently spends $400 yearly on track flood lights used to illuminate the wall.
- By retrofitting the flood lights to 15 watt fluorescent lamps, the school would be saving $320/year!
- Assuming a unit cost of $9.00/lamp, the price of the retrofit would be:

  19 X $9.00= $171.00
- Even with paying for the retrofit, GHS will save at least $150 in the first year.

GHS Illumination Levels Compared to Recommended Standards*

Building Area	Recommended Illumination (LUX)	GHS Illumination (LUX)
Gymnasiums	538-1600	376
Cooridors	53-107	135
Cafeteria	107-538	350
Locker Rooms	53-65	29.4

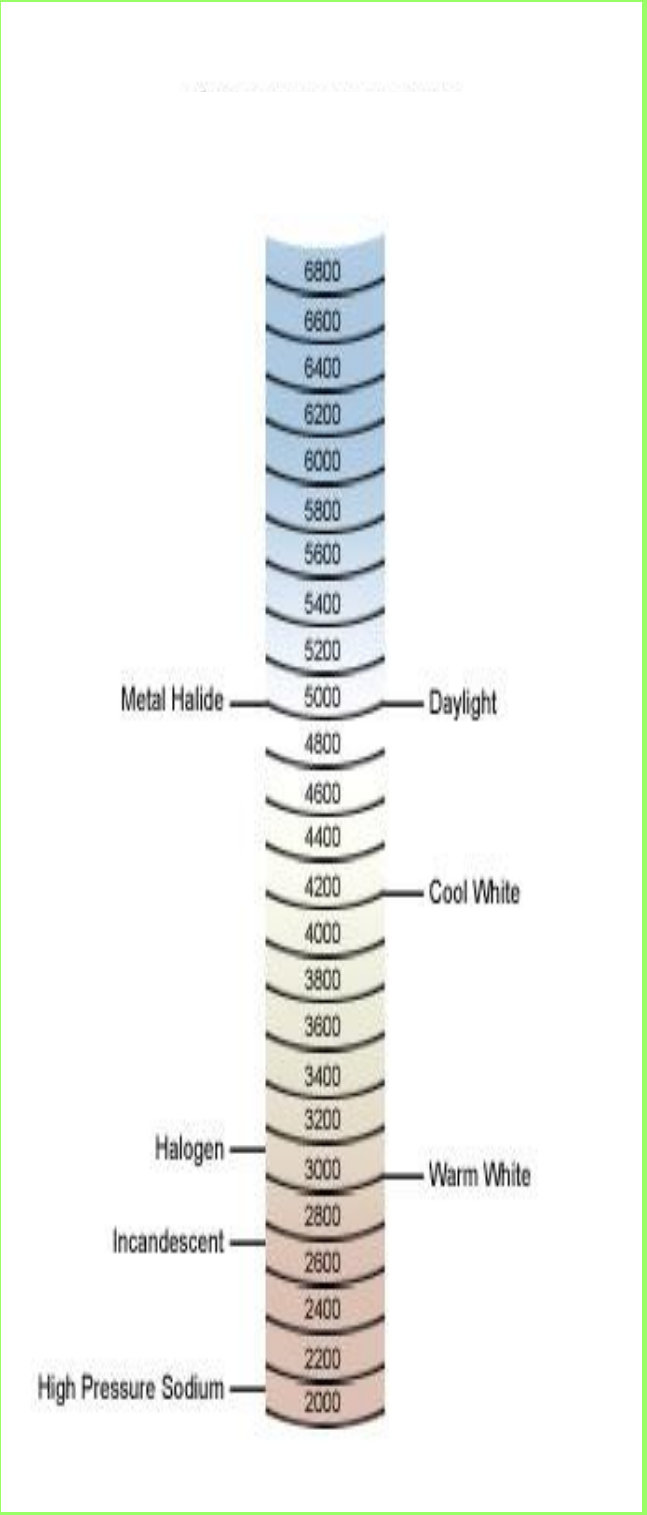
*Based on Illumination Engineering Society of North America guidelines.

Incandescent vs. Fluorescent--how does color temperature effect you?

- In spite of their higher efficiency, fluorescent lamps are not always popular among building occupants.
- A common misconception is the belief that fluorescent lamps cannot emit the same *warm* (red-white) light that incandescent lamps emit.
- However advances in technology now allow fluorescent lamps to emit light in a variety of color temperatures, including the same *warm* light typical of an incandescent lamp.

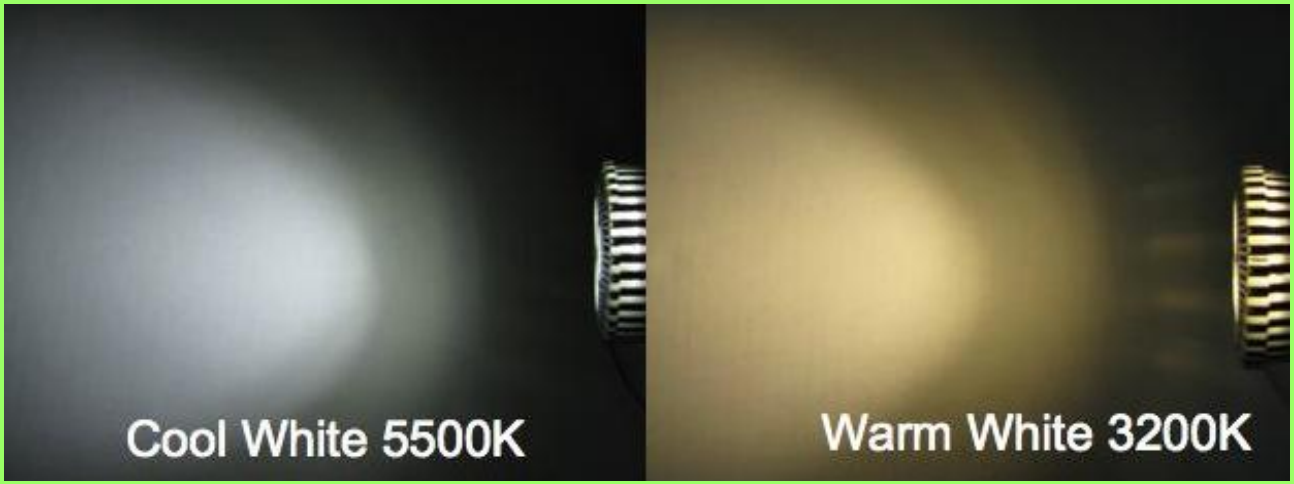
Color Temperature

- Used to describe light quality (measured in Kelvin’s—a unit of temperature).
- White light is a mix of red, yellow, and blue wavelengths, but not necessarily all equally represented.
- Low color temperature lamps emit proportionally more red wavelengths.
- High color temperature lamps emit more blue wavelengths.
- *Incandescent and halogen lamps have a fixed color temperature 2700 and 3200 K.*
- *Fluorescent lamps can be designed to mimic a variety of color temperatures, from "warm" (red-white 3000 K) to "cool" (blue-white 6000 K).*

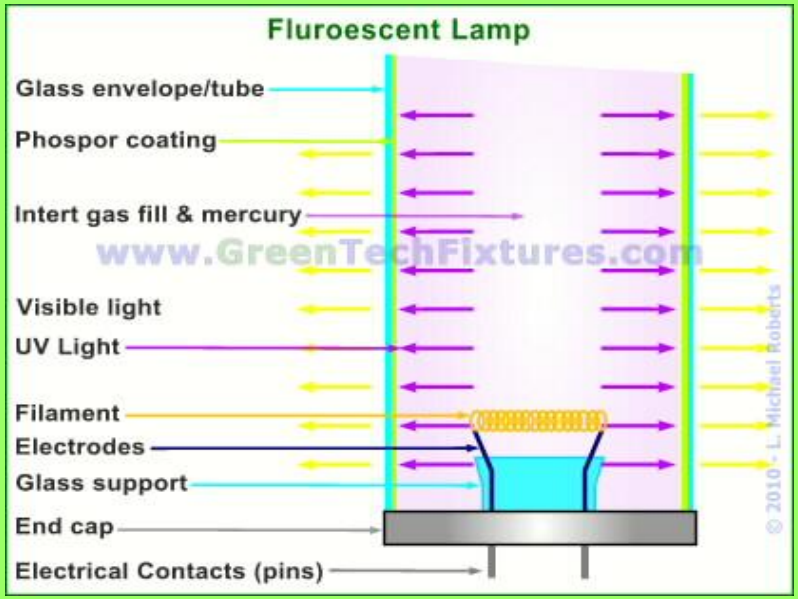


How Versatile are Fluorescent Lamps?

- Fluorescent lamps can be chosen to best fit the specific requirements of a given illuminated space.
- For example, high color temperature "cool" white light is a good choice in areas the require sharp color contrasts, the ability to see fine detail, and a heightened sense of alertness, such as arts and crafts work spaces, shops, kitchens, and gymnasiums.
- Lower color temperature "warm" white light is a good choice in areas that do not require sharp contrasts, and benefit from a sense of calm, such as hallways, eating areas, theaters, and nurses and guidance offices.
- Classrooms are well served by medium color temperature (4500 K) lamps.



What's more efficient?



Incandescent lamps use electric current to heat a high resistance tungsten filament, which emits low color temperature (2700 K), "warm“ light (proportionally more red).

–90% of the energy emitted is *infra-red*, invisible to the human eye. This represents wasted radiant heat.

Fluorescent lamps are gas discharge tubes. An electric current excites mercury vapor to emit ultra-violet light. A phosphor coating on the glass absorbs the UV and re-radiates the energy as visible wavelengths.

–Far less energy is converted to wasted radiant heat. Fluorescent lamps consume about 75% less electricity to produce an equal amount of light as an incandescent lamp. The energy savings translates into a cost savings as well.

Summary Conclusions

- GHS electric power usage ranks highly (upper 25th percentile), compared to benchmark data from schools in a similar climate zone.
- Careful selection of appropriate color temperature fluorescent lamps can improve light quality in different building areas. This in turn could improve student and teacher performance.
- Despite relatively high electrical efficiency, there is still room for improvement.
  - GHS could save almost $4,000/year by replacing incandescent lamps in the auditorium and hallways.
  - Better education of students and staff could help save energy. Empty rooms are left with lights on approximately 50% of the time!
  - Investment in motion sensors for appropriate building areas, such as bathrooms, locker rooms, and storage spaces, could also pay for itself by saving energy.

Next Steps

- Analyze other electrical loads, such as smartboards/computers, and cafeteria electric appliances.
- Perform a similar analysis of heating, ventilation, and air conditioning systems.
- Analyze transportation fuel system (Buses).