

Angevine Middle School  
Lighting and Personal Appliance Audit  
Findings and Recommendations

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January 2011



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## Summary of Recommendations

The following table outlines the major recommendations for Angevine Middle School. For more information about these recommendations, as well as estimated cost savings, see later sections of the Audit Report.

Recommendation	Responsible Party
Educate staff and students about the importance of energy use, conservation and efficiency.	District, School Administration, Staff, Student Groups
Encourage staff to turn off lights at the end of the day instead of relying on motion sensors.	School Administration and Staff
Improve signage about energy conservation, including “Turn me off when not in use” stickers for light switches.	Student Groups
Replace all incandescent bulbs with compact fluorescent bulbs.	Staff
Unplug personal appliances when not in use. Plug appliances into power strips for easy on/off.	Staff
Retire personal appliances, such as mini-fridges and microwaves.	Staff
Encourage use of natural lighting, when possible, to reduce electrical lighting demand.	School Administration and Staff
De-lamp fixtures in over-lit areas or in areas with ample natural lighting.	Custodial Staff
Decrease the lag time between when a room becomes unoccupied and the motion sensors switch off lights.	District and Custodial Staff
Ensure exterior lights are only on when necessitated by ambient light levels.	Custodial Staff
Switch to LED exterior lights. Switch to hi-bay fluorescent gymnasium lights.	District and School Administration
Replace conventional appliances with Energy Star rated counterparts.	District and School Administration
Install motion sensors or switches in bathrooms.	District and School Administration

## Summary of Cost Savings

The following table summarizes the cost savings associated with some recommendations. These values serve to illustrate the **magnitude** of savings associated with implementation, but will **vary based upon degree of implementation and accuracy of assumptions**. See Estimated Cost Saving sections later in the Audit Report for more information.

Recommendation		kWh Saved in 10 Years	\$ Saved in 10 Years	
No or Low Cost	Immediate Payback	Conversion to 28W T8s	180,420	\$15,100
		Motion Sensors	52,500	\$4,395
		Increase Natural Lighting	39,000	\$3,390
		De-Lamping in South-Facing Classrooms	23,330	\$1,950
		Bathroom Lighting	8,210	\$690
		Retire 75% of Mini-Fridges	157,680	\$13,200
		Computer Monitors Off	16,500	\$1,380
		Power Strip and Unplug	67,450	\$5,650
		Retire 75% of Microwaves	13,000	\$1,090
		Retire 75% of Other Kitchen Appliances	14,980	\$1,255
Moderate to High Capital Investment	Payback in 1-5 years	Conversion of Metal Halide to Fluorescent	162,000	\$13,560
		Upgrade Exterior Lights	141,910	\$11,880
		Conversion of Incandescent to CFL	5,800	\$485

## **Goals of the Audit**

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The audit is designed to identify no- and low-cost improvements for reducing energy that can be undertaken by individual schools by encouraging behavior changes and awareness. In 2008, Boulder Valley School District created the Sustainability Management System (SMS). The SMS provides goals and strategies that help move the District towards sustainability. The Lighting and Appliance Audit falls under SMS Compliance and is supported by Board of Education policy. Lighting in commercial buildings, such as schools, can often account for over 20% of electrical use, while personal appliances can account for another 10% (EIA, 2003). These contributions can often be reduced through conservation and efficiency measures. Conservation refers to reducing overall use, while efficiency is related to using technologies that provide the same output with reduced energy inputs.

The Angevine Middle School Audit was conducted on October 28, October 29 and November 1. Students in Mrs. Linda Arroyo's Publication Class assisted with gathering data. Information was gathered by walking through all rooms within the school building. The number and types of lights were recorded for each room, as well as notes about how lights are controlled. A light meter was used to record the illumination levels provided by electric lights. The number and types of appliances in each room were also recorded.

Data collected during the audit was then processed to provide estimates for yearly contributions of lighting and personal appliances to overall electrical use. These calculations relied on several assumptions, which will be detailed later in the Audit Report. These calculations, along with observations made during the audit, provide the basis for recommendations.

## Background Information

Angevine Middle School was identified for the audit because of its high electrical use. In 2009, Angevine had the highest electrical demand of all middle schools (with complete electrical data) in the District (see Figure 1). Angevine has the second largest building, and the second highest enrollment rate, both of which can contribute to higher energy use. However, as shown in Figures 2 and 3, Angevine still has a higher energy use when these factors are controlled.

Between August 2007 and June 2010, Angevine Middle had an annual average electrical use of 1,095,931 kWh. Angevine Middle spent an average of \$91,700 per year on electricity during the same time period. The average cost of electricity is \$0.0837/kWh.



*Figure 1. Overall Electrical Use (MWh) in 2009 at Boulder Valley School District Middle Schools. Angevine had the highest overall electrical usage in 2009.*

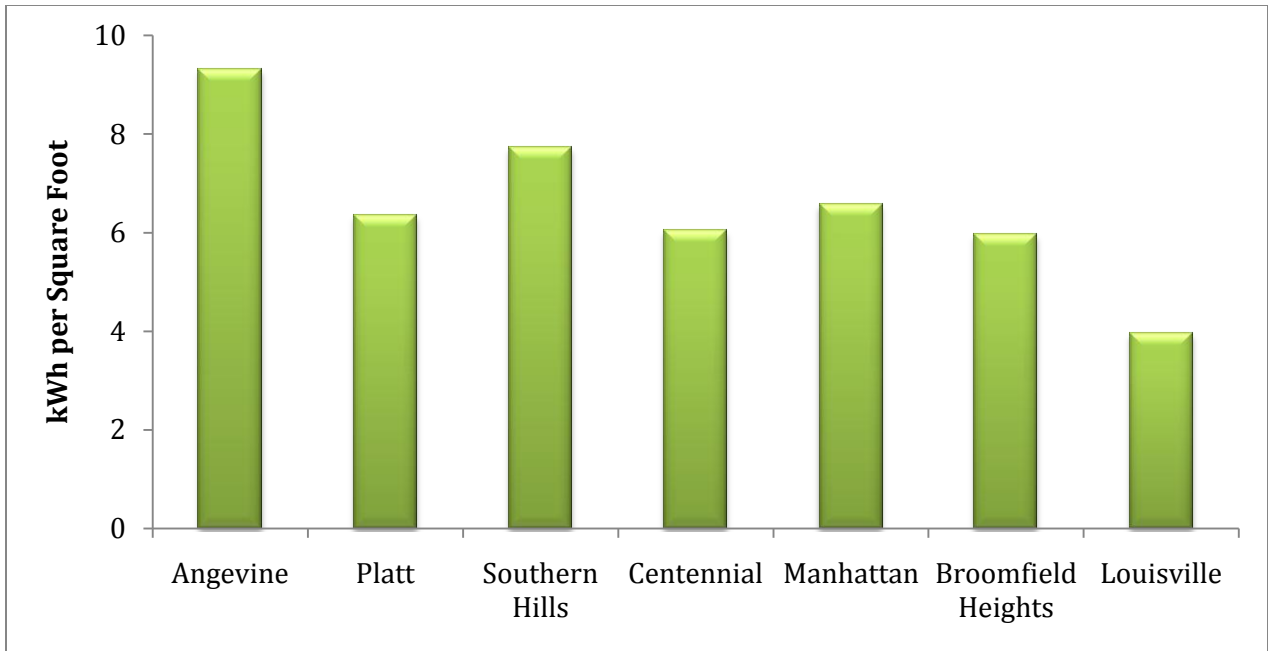


Figure 2. Electrical use is often correlated with building size. Angevine Middle was the largest user of electricity per square foot in 2009.

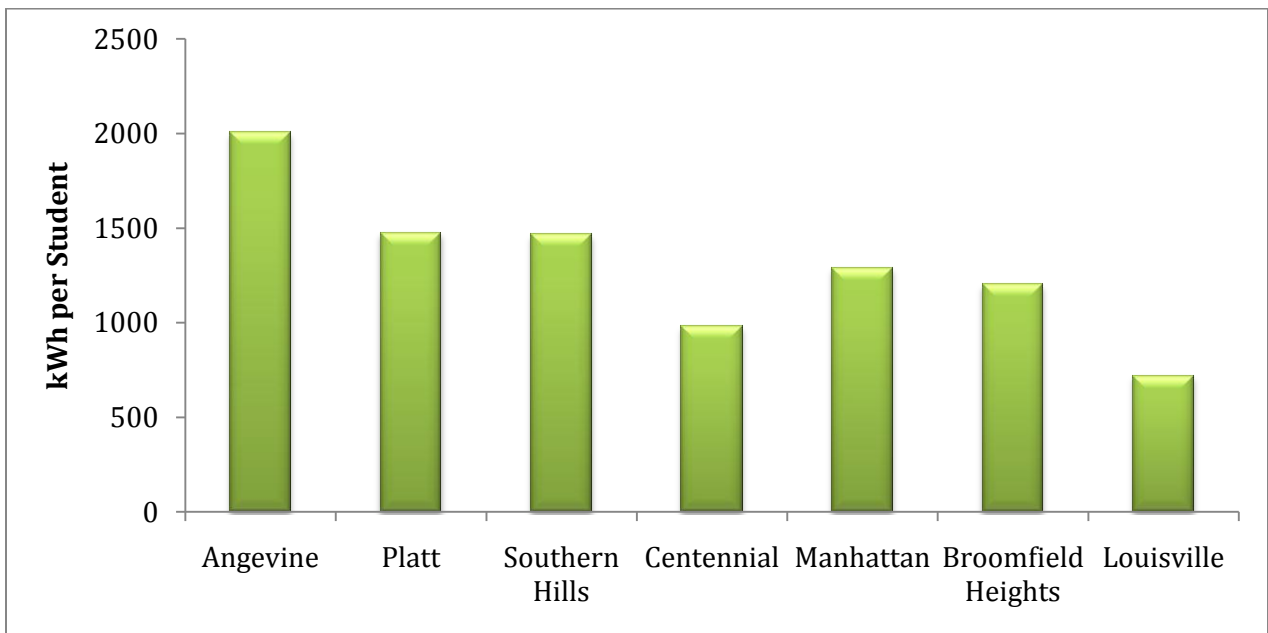
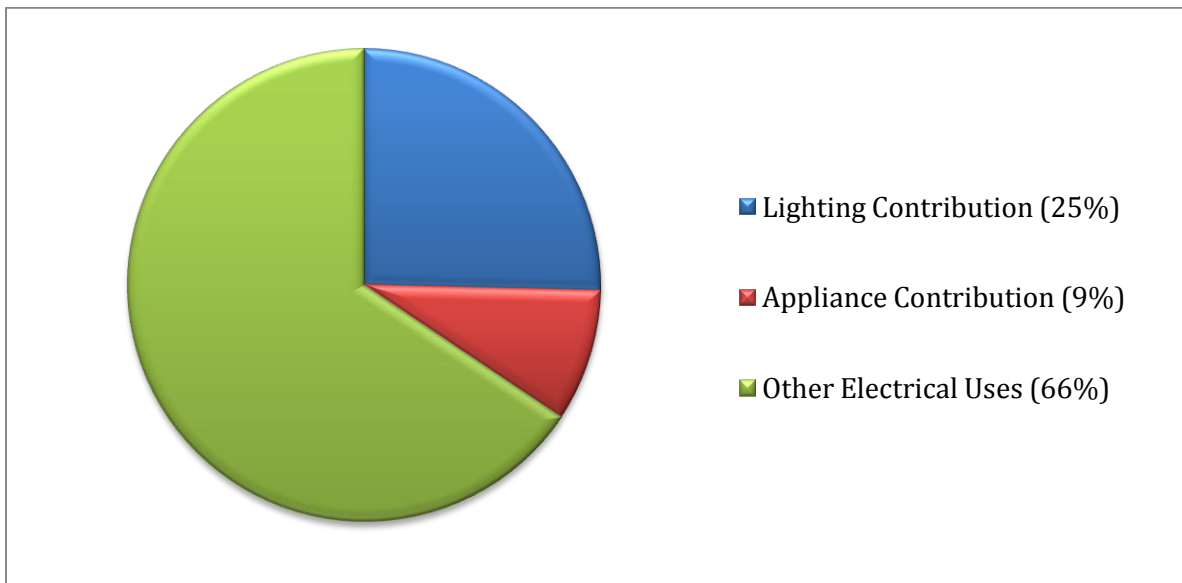


Figure 3. Electrical use is often correlated with number of building users. Angevine Middle was the largest user of electricity per student in 2009.

## Overall Findings

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The average electrical use at Angevine is assumed to be 1,095,931 kWh per year. This value represents a three year average, spanning from August 2007-June 2010. Lighting accounts for approximately 25% of total electrical demand, while personal appliances contribute approximately 9% (see Figure 4). The remaining 66% were not identified in this audit, but include other uses such as heating, cooling, and larger appliances. In terms of cost, lighting the building costs approximately \$23,270 per year, and personal appliances another \$8,250.



*Figure 4. Contribution of lighting and personal appliances to overall electrical use at Angevine Middle School. The total annual electrical use is assumed to be 1,095,931 kWh, which represents a 3-year average.*

## Lighting Data

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Total Number of Lights: 3,442

4' T8 Fluorescent Tubes (32 W): 2,174

2' T8 Fluorescent Tubes (17 W): 704

Incandescent Bulbs (45-100 W): 28

Compact Fluorescent Bulbs (15 W): 2

Exterior Lights (70-250 W): 53

Tubular Fluorescent Spot Lights (18 W): 139

Metal Halide (400 W): 40

Other: 302

Assumptions about Usage:

Lights in Hallways on for 12 hours per day

Lights in Classrooms, Library, Gym, Computer Rooms and Offices on for 9 hrs/day

Lights in Bathrooms on for 10 hours per day

Individual Bulbs on for 5 hours per week

The above usage values correspond to the 180 day school year. However, school buildings are still in use, in one form or another, throughout the year. To capture this additional usage, it is assumed that lights are on as listed above for an additional 45 days (1/4 of total use for remaining days of the years). See Appendix A for more detailed information about usage and wattage assumptions.

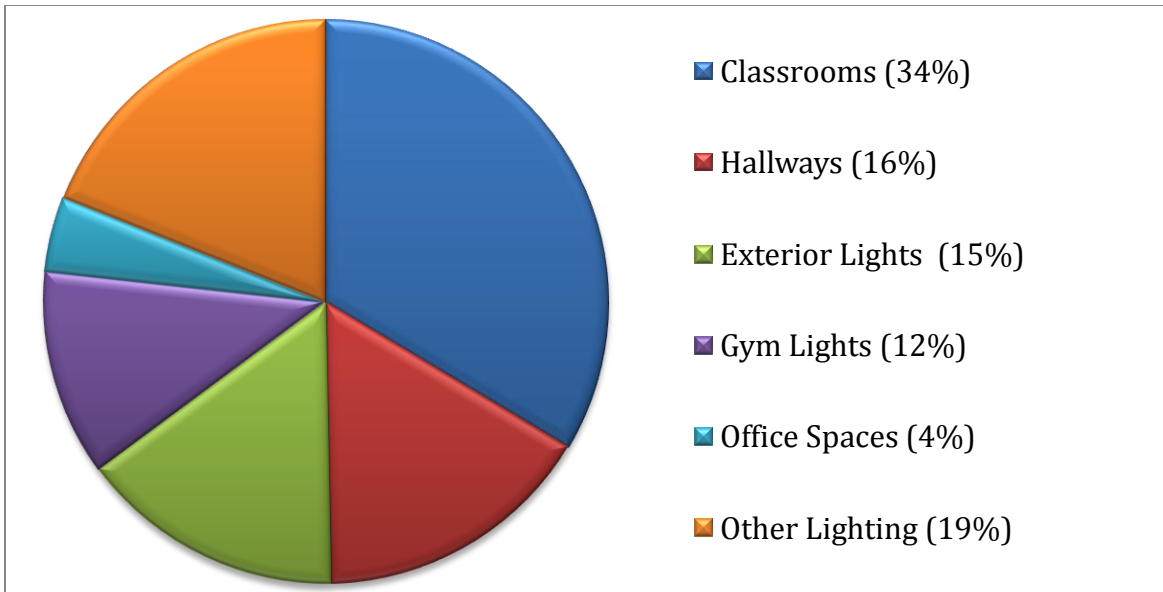


Figure 5. Contribution of building spaces to overall lighting demand (277,998 kWh/yr).

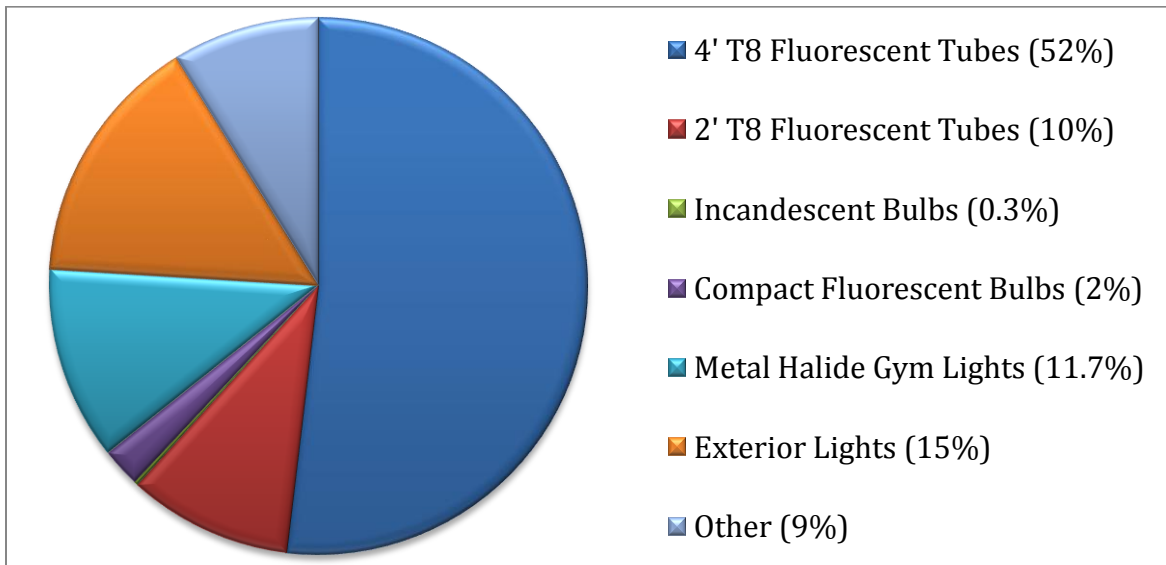


Figure 6. Contribution of different lighting fixture types to overall lighting demand (277,998 kWh/yr)

## **Lighting Observations**

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(1) At the time of the audit, there were at least 10 unoccupied rooms with all the lights on. Two of these spaces (room 112, 218) were storage closets which are controlled by light switches only.

(2) Twelve classrooms have light fixtures located in the skylight structure. Seven of these classrooms had these lights on, even though the other electric lights plus natural lighting supplied more than enough illumination.

(3) Motion sensors were installed in schools throughout the district, in part, to reduce energy waste. Many teachers rely on the motion sensors to turn off the lights at the end of the day, or when they leave the room for an extended period of time. The motion sensors have a 12-15 minute delay. This is 12-15 minutes of extra electricity use for unnecessary lighting. Some motion sensors are also tripped by moving objects in the room. These movements are often created by air flow from the HVAC system and can result in lights being switched on unnecessarily.

(4) There were 28 incandescent bulbs in classrooms and office spaces throughout the building. Some were used for illuminating individual reading areas, some for providing lights to classroom pets, and some for aesthetics.

(5) Much of the hallway spaces receive a great deal of natural lighting from skylights and clerestories. These areas are also illuminated with various types of lighting fixtures during the school day and after-school hours.

(6) Some spaces lacked visible light switches (bathrooms, Room 502). While administration may wish to control the lighting in these spaces, the lack of easily accessible switches results in these rooms being illuminated longer than required.

(7) Many classrooms with windows had their blinds partially or fully drawn. While natural lighting can cause glare, it can also reduce the load placed on electrical lighting demand.

(8) In the main office, several of the light fixtures were not filled to capacity with bulbs.

(9) The cafeteria was surveyed during the final period of the school day. This space was unoccupied but all lights were on. This space also has great natural lighting from clerestories along the eastern side.

(10) Most rooms had adequate light level readings (approximately 30-40 foot-candles). Classroom 804 had light level readings above 50 foot-candles, reaching as high as 125 foot-candles near the window.

(11) The lights in the gymnasium are metal halide bulbs. These bulbs use a tremendous amount of energy (400 W).

(12) Several teachers indicated that they don't use certain lights, or that they don't use lights during certain times of the day. Actions like these help to conserve electrical energy!

## **Lighting Recommendations**

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(1) Teachers, staff members and students need to have a conversation about the importance of energy conservation and efficiency at the school, and discuss ways in which they can have an impact.

(a) Learning about energy conservation and efficiency can be easily incorporated into classroom discussion. Students should be encouraged to think about ways in which they can help improve energy use in their classroom, as well as at home. Student groups can get involved with promoting energy conservation at their school by making stickers and posters about energy-related topics, such as “Turn Me Off When Not in Use” stickers for light switches.

(b) Teachers and staff should be encouraged to use manual light switches at the end of the school day, to ensure lights are off for the evening. This will not only save 12-15 minutes per room of extra lighting, but will prevent non-human moving objects from tripping the sensors during the course of the night.

(c) Teachers and staff should be encouraged to swap out their incandescent bulbs for compact fluorescent bulbs. Incentives can be provided for making this switch, or bulbs can be made available for teachers to use.

(d) The custodial staff should also be involved in these conversations, as they are major users of the building after-hours. Custodians should only turn on the lights in whatever area of the building they are currently servicing. Light switches should be used to ensure lights are out, instead of relying on motion sensors. Custodians should also report rooms where motion sensors appear to be mal-functioning, or rooms in which lights were left on by teachers or staff members.

(2) Natural lighting has the potential to replace a portion of electric lighting demand at Angevine Middle School, especially in spaces with south-facing windows. This method of lighting should be embraced where possible.

(a) Teachers with windows should be encouraged to use natural lighting when possible. In some classrooms, this will require removing posters and art work from windows, or merely opening the blinds. In addition to providing natural light, windows provide a connection for students to the outside world. Some researchers suggest that access to nature, even just visually, can improve students’ performance in the classroom and mitigate behavioral issues, such as attention deficit hypersensitivity disorder (Louv, 2008).

(b) Teachers with lighting fixtures located inside skylight structures should be encouraged to only use these light sources on cloudy days, as they do not contribute

significantly to overall classroom illumination. Light switches for these fixtures can be painted a different color to make teachers more aware of which lights they are turning on when they enter their classroom.

(c) Natural lighting can also be relied on more heavily in common areas, including hallways and the cafeteria. The school could consider hosting “Lights Out” lunches as both an energy saving method and an education/awareness tool. Lights in entranceways could be switched off during the daytime hours when light entering through glass doorways are sufficient to light these sparsely used spaces.

(3) Motion sensors provide an important energy saving service, when used correctly. However, there are ways to improve their use.

(a) Teachers should be encouraged to use their manual switches when leaving rooms at the end of the day, or for longer periods during the day. Each time a light is switched off, instead of relying on the motion sensor, 12-15 minutes of extra lighting is conserved.

(b) A survey should be conducted to determine which rooms have motion sensors that are being tripped by non-human moving objects (flags, hanging artwork, etc.). Objects can be relocated so as to be out of the motion sensor’s view path.

(c) The school can work with District electricians to reduce the lag time between un-occupancy and lights off for all motion sensors within the building.

(4) De-lamping is the process by which fixtures are dismantled so as to prevent the operation of a bulb. It is a useful conservation technique that can be employed in over-lit places. Xcel Energy has a rebate program for de-lamping.

(a) In the office, many fixtures were not filled to capacity with bulbs. Removal of bulbs is the first step in the de-lamping process. The next step involves physically dismantling the fixture so that a bulb cannot function even if one is added in the future. The full de-lamping process should be undertaken in the main office space, as well as in any other areas where bulbs have already been removed.

(b) De-lamping is also an option for fixtures directly in front of windows. Removing a single lamp from such fixtures will not significantly reduce light levels during cloudy days, but will prevent over-lighting spaces when natural light is abundant. A single classroom can be chosen for a trial-run of this de-lamping process. Room 804 would make an ideal candidate for this trial-run, as it has south facing windows and had the highest light level readings of all rooms in the school building.

(5) Bathrooms are not equipped with motion sensors, and often the light switches were not located near the entrance.

(a) Installing motion sensors in bathrooms can help reduce this lighting load significantly. Currently, bathroom lights are on all day and into the after-school hours. As the majority of bathrooms in the school open directly into the hallway, it will be important to locate sensors so that hallway movement does not trigger lights on.

(b) It is worth investigating why light switches are not currently located in convenient locations for easy on/off. If it is due to inadequate wiring, the BVSD electrician can be contacted to install switches in more convenient locations. Stickers promoting conservation (“Turn me off when not in use”) will be affixed below each new switch. If, however, it is due to safety issues (ie. prankers turning off lights on other students), then this may not be a feasible option.

(c) If neither of the options above are feasible, the staff should be responsible for ensuring bathroom lights are switched off at the conclusion of the school day, especially in areas unoccupied by students involved in after-school activities. On the day of the audit, a gate restricted access to the majority of the school building (south of the main entrance), yet bathroom lights were still on. Assigning a responsible party for ensuring these lights are switched off could save 1-2 hours of extra electrical use.

(6) Ensure exterior lights are only on when ambient light levels have reached a certain level.

(a) Light sensors can be installed on exterior lights to prevent unnecessary lighting during daylight hours.

(b) Exterior lights can be placed on a timer. However, the turn on and shut off times should change throughout the school year, depending on the season.

(c) The District currently requires school buildings to be lit at night. It might be time to have another conversation about the efficiency of this policy. Recent research suggests that lighting campuses at night is not effective at reducing instances of vandalism; it is more suspicious and noticeable if an individual is on school grounds with a flashlight. Exterior lights are some of the larger energy users, and revising this “lights on” policy has the potential to significantly reduce use and costs.

(7) The school should consider upgrading to more efficient lights in the gymnasium and in exterior light fixtures.

(a) LED light technology for exterior lighting has advanced significantly over the past years. While these lights have much higher up-front costs, the lifetime savings will outweigh the cost differential. The Sustainability Intern can provide more information about technologies and associated cost savings, if desired. The school should consider LED exterior lights in future budget conversations.

(b) Metal halide lights have the highest wattage requirement of all lights located on the school property (400 W). Other schools in the District, including Boulder High, have already made the switch to more efficient fluorescent lighting for gymnasiums. Again, these lights have higher up-front costs, but will reduce lifetime energy usage and also illustrate the school's commitment to sustainability. Hi-bay fluorescent gymnasium fixtures should be considered in future budget conversations.

## Estimated Cost Savings Associated with Lighting Recommendations

Deciding which recommendations to pursue first can be a difficult task. Some recommendations require increased communication and education of electricity users, while others will require time and monetary investments. The table below outlines estimated savings (excluding upfront investment costs) associated with each recommendation category. These estimates are meant to show the magnitude of savings associated with each response, but will vary depending on actual implementation. See Appendix C for calculations.

<b>Recommendation</b>	<b>kWh Saved in 10 Years</b>	<b>\$ Saved in 10 Years</b>
(1) Increase Natural Lighting Use*	39,000	\$3,390
(2) De-Lamping in South-Facing Classrooms <sup>\$</sup>	23,330	\$1,950
(3) Motion Sensors* <sup>,\$</sup>	52,500	\$4,395
(4) Bathroom Lighting* <sup>,\$</sup>	8,210	\$690
(5) Exterior Lighting <sup>,\$\$</sup>	141,910	\$11,880
(6) Incandescent to CFL <sup>\$</sup>	5,800	\$485
(7) Conversion to 28W T8s*	180,420	\$15,100
(8) Metal Halide to Fluorescent <sup>,\$\$</sup>	162,000	\$13,560
<b>Total Savings</b>		

\* = no associated costs, \$ = moderate costs associated with labor inputs, \$\$ = high upfront capital investment

### Assumptions:

(1) Rely on natural lighting in classrooms (600,603, 604, 700, 703, 704, 800, 803,804) (0.5 hrs/day; 4 hrs/day in skylight structures), cafeteria (2 hrs/day), and entranceways (4 hrs/day).

(2) 4 bulbs are removed from the following south-facing classrooms (600, 603, 604, 700, 703, 704, 800, 803, 804).

(3) Upgrades to motion sensors are two-fold. Assume lag time is reduced by 5 minutes, and that sensors turn off lights twice every day (total of 10 saved minutes). Assume lights are manually switched off at the end of the day (total of 15 minutes saved). Motion sensor use is assumed in classrooms, computer rooms and office spaces.

(4) Assume bathroom lighting load is reduced by 2 hours/day by either installation of motion sensors, or switching off completely at the end of the day. Motion sensor installation will obviously result in a higher upfront cost, as designated in the table above. The no-cost solution would be to ensure lights are physically switched off when spaces are not in use.

(5) Exterior lights are upgraded to LED equivalents.

(6) Assume all incandescent bulbs are replaced with 15 W compact fluorescent bulbs.

(7) The District plans to begin stocking 28W 4' T8 bulbs instead of the 32W model. These will be swapped in as existing bulbs reach the end of their life. As this is a District-level purchase, the cost of this upgrade will not be incurred by the school.

(8) Assume all metal halide gymnasium lights are replaced with hi-bay fluorescent fixtures.

## Personal Appliance Data

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### Major Appliances:

Desktop Computers (130 W/1.3 W): 193

Full-Size Fridges (600 W): 2

Microwaves (1,200 W/3W): 28

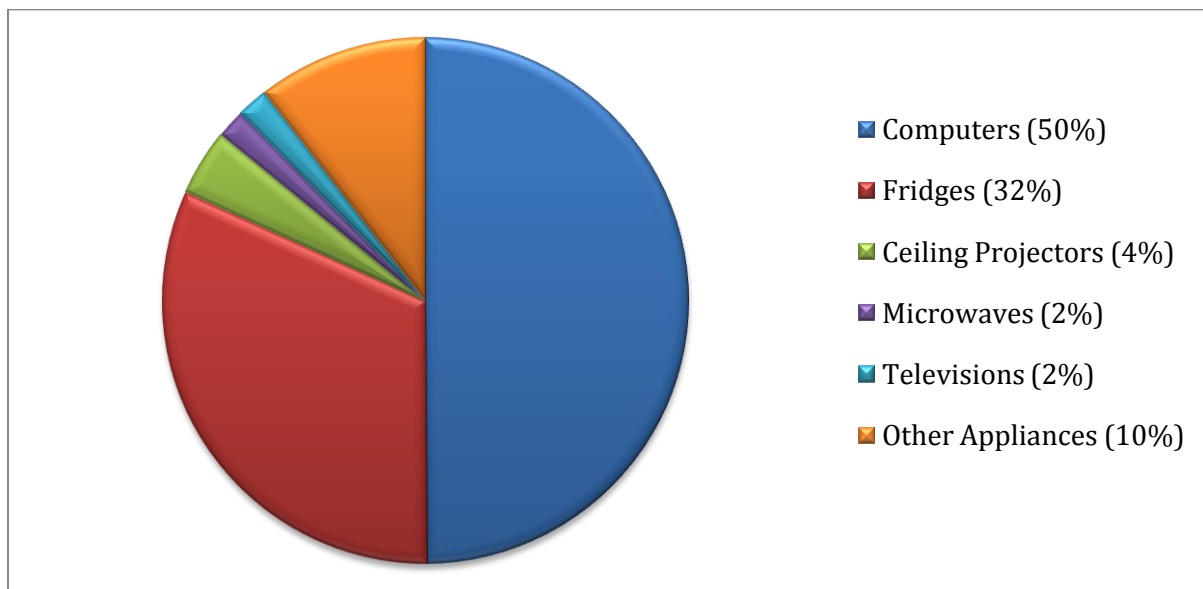
Mini-Fridges (100 W): 24

Projectors (340 W/5W): 33

Televisions (95 W/3W): 52

Other Appliances (wattages vary, see Appendix B for specifics): 174

Wattage values (on/standby) are based on data collected by Monarch K-8 and the Lawrence Berkeley National Lab. See Appendix B for more detailed information about usage and wattage assumptions.



*Figure 4. Contribution of different appliances to overall appliance electrical demand. Annual appliance electrical use is estimated to be 98,846 kWh.*

## **Personal Appliance Observations**

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(1) Computers are the largest users of electricity in the personal appliance category. The majority of computers in the school were Energy Star rated.

(2) A large number of teachers have food-related personal appliances in their classrooms (mini-fridges, microwaves, toasters, coffee makers). These items are also made available in the Teachers' Lounge.

*Rooms with Microwaves: 301, 501, 600, 602(x2), 603, 604, 605, 607, 619, 700, 704, 706, 709, 717, 801, 803, 804, 805, 810*

*Rooms with Mini-Fridges: 217, 227, 501, 602, 603, 604, 610, 700, 701, 703, 705, 708, 709, 710, 717, 800, 801, 803, 804, 805(x2), 810*

*Rooms with Other Kitchen Appliances: 218, 600, 605, 607, 700, 705, 710, 717, 804, 810*

(3) The Home Economics classroom also contains a number of food-related personal appliances. At the time of the audit, many of the smaller appliances were unplugged. Actions like this help to conserve energy!

(4) There were several unoccupied classrooms that had ceiling-mounted projectors or document cameras still on at the end of the school day (Classroom 702, 709).

(5) All classrooms surveyed were equipped with televisions. Televisions are primarily used for morning announcements. Televisions were plugged in.

(6) Many teachers had personal printers in their classrooms and offices. Printers are also available in more common spaces where they can be used by all.

*Rooms with Personal Printers: 106, 130, 209, 212, 306, 602, 607, 701, 703, 708, 916*

(7) In the majority of classrooms, smaller appliances (fans, pencil sharpeners, stereos) were plugged in. Some were plugged into power strips, but many were not. There were also cases (Classroom 610) where a power strip was plugged into the wall, but had nothing plugged into it.

## **Personal Appliance Recommendations**

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(1) Teachers and staff should be encouraged to unplug all appliances when not in use.

(a) Educate staff and students about why unplugging is an important component of energy conservation. Many appliances, especially those with clocks or lit components, are always drawing energy when plugged in. These energy losses are referred to as “phantom” or “vampire” energy losses. Exploring these energy vampires can be incorporated into classroom curriculum. It seems that unplugging appliances may be an important concept taught in Home Economics. These efforts should be continued and expanded.

(b) Televisions are primarily used in classrooms for morning announcements. Teachers should be encouraged to unplug televisions when announcements are finished. Teachers can even designate a student to be responsible for unplugging this energy vampire. To take this idea even further, an “Energy Saver” position can be rotated among the students in the class. Their role as “Energy Saver” is to identify and unplug all energy vampires in the classroom.

(c) Appliances, especially those utilized by students, should be plugged into power strips. Power strips not only allow the user to quickly turn off several units at once, but they mitigate the dangers associated with electrical outlets. Power strips do still draw small amounts of energy and, therefore, are most effective when several appliances are plugged in (replacing many vampire energy sources with just one).

(d) At the end of the school year, all teachers and staff should be required to unplug appliances that will not be in use over the summer. Only unplugging mini-fridges during the summer months can have a significant impact on energy demand. The custodial staff can do a final sweep to ensure there are no unnecessary energy draws during the summer months.

(e) Ceiling-mounted projectors are always plugged in. These technologies are always drawing unnecessary energy. However, as these projectors are plugged into the ceiling, it becomes difficult to unplug them in between uses. Some method needs to be developed to reduce this unnecessary energy load, whether it is just fully turning off projectors using a remote, or re-wiring so that a switch can cut all power to projectors. At the very least, projectors should be unplugged at the conclusion of the school year to prevent unnecessary energy losses during the summer months.

(2) Reduce energy use by computers.

(a) The District has recently begun to use a computer management software tool which remotely powers computers down to a very low level (~1.3 W). This software will help reduce energy losses while computers are not in use. This step has already been taken by the District and will require no additional effort on behalf of individual schools.

(b) While the District requires computers to remain on at all times so that ITS can provide remote support, individuals can still switch off their computer monitors. Turning off the monitors can save small amounts of energy that will add up over time. Individual teachers, as well as computer room staff, should be encouraged to turn off their monitors when not in use.

(3) Personal appliances should be retired, when possible.

(a) There are an overwhelming number of kitchen-related personal appliances in classrooms and office spaces. Larger versions of these appliances are available for common use in areas like the Teachers Lounge. Teachers should be encouraged to retire their personal appliances in favor of these common resources. A kitchen area could be established in each of the Family Clusters for teachers who don't wish to make the trip to the main office.

(b) There were a number of dishwashers (Rooms 605, 705, 805) that do not appear to still be in use. If it is determined that these appliances are in fact no longer used, they should be removed, or at the very least unplugged.

(4) Consider energy conservation and efficiency in future purchasing.

(a) Replace electric appliances with manual ones, where possible. In the future, the school should choose to purchase manual appliances (pencil sharpeners, staplers, hole-punchers) instead of ones that use energy.

(b) The majority of desktop and laptop computers are Energy-Star rated. Any remaining computers should be replaced, budget allowing.

(c) Other appliances should be swapped for Energy Star equivalents, when possible.

(d) Decorative water fountains seem to be quite popular among teachers and staff at Angevine Middle School. Depending on their intended benefit, staff may consider decorating with a non-energy user instead.

## Estimated Cost Savings Associated with Appliance Recommendations

Deciding which recommendations to pursue first can be a difficult task. Some recommendations require increased communication and education of electricity users, while others will require time and monetary investments. The table below outlines estimated savings associated with each recommendation category. These estimates are meant to show the magnitude of savings associated with each response, but will vary depending on actual implementation. See Appendix D for calculations.

<b>Recommendation</b>	<b>kWh Saved in 10 Years</b>	<b>\$ Saved in 10 Years</b>
(1) Power Strip and Unplug*	67,450	\$5,650
(2) Computer Monitors Off*	16,500	\$1,380
(3) Retire 75% of Mini-Fridges*	157,680	\$13,200
(4) Retire 75% of Microwaves*	13,000	\$1,090
(5) Retire 75% of Other Kitchen Appliances*	14,980	\$1,255
<b>Total Savings</b>	<b>269,610</b>	<b>\$22,575</b>

\* = no associated costs

### Assumptions:

- (1) Assume no stand-by power is needed for appliances which are unplugged or placed on a power strip.
- (2) Assume all monitors are turned off when computers are in stand-by mode (18 hrs/day). Assume turning monitors off reduces energy demand by 1.3 W during non-use times.
- (3-5) Assume 75% of personal kitchen appliances are retired and staff begins to utilize common resources.

## **Conclusions**

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Angevine Middle School was chosen for the lighting and personal appliance audit because it is the highest electrical energy user among Boulder Valley School District Middle Schools. This audit has identified areas for improvement in regards to both lighting and personal appliance use. These recommendations fall under the general categories of energy conservation and energy efficiency. Many of these recommendations can be implemented merely through education of students, teachers and staff members (turning off lights, unplugging appliances). Other recommendations will require to the school to work with BVSD personnel (removal of dishwashers, upgrading exterior lights). Some of these recommendations are low or no-cost, while others will require the school to invest a portion of their budget. Each upgrade will reduce overall electricity use, saving the District money. Most importantly, each upgrade or behavioral change can be used as a learning opportunity for students, helping to create sustainable, conscientious global citizens.

Special Thanks to Mrs. Linda Arroyo's Publication Class for help with gathering data and developing recommendations!

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## Appendix A: Lighting Data

Room Type	Fixture Type	#	W	hrs/d	days/yr	kWh/yr
Band Room	4' T8	116	32	8	225	6681.6
	2' T8	6	17	8	225	183.6
Bathroom	4' T8	57	32	10	225	4104
	Tube	2	18	10	225	81
Cafeteria	4' T8	116	32	6	225	5011.2
	Bay Lights	6	100	6	225	810
Classroom	4' T8	1124	32	9	225	72835.2
	2' T8	531	17	9	225	18279.68
	Incandescent	13	60	1	225	175.5
	Incandescent	1	75	1	225	16.875
	CFL	2	15	1	225	6.75
	Spotlights	12	100	6	225	1620
Closet	Tube	12	18	9	225	437.4
	4' T8	24	32	0.5	225	86.4
	4' T8	9	32	2	225	129.6
Computer Room	Incandescent	1	60	1	225	13.5
	4' T8	154	32	9	225	9979.2
	2' T8	21	17	9	225	722.925
Conference Room	4' T8	18	32	1	60	34.56
Copy Room	4' T8	16	32	9	225	1036.8
Exit Lights	LED	103	1	24	365	902.28
Exterior Lights	Wall Pack	20	70	12	365	30642.48
	Parking Lot	33	250	12	365	6132
Gym	Metal Halide	40	400	9	225	36135
	4' T8	7	32	9	225	453.6
Hallway	4' T8	184	32	12	225	15897.6
	2' T8	71	17	12	225	3258.9
	Tube	113	18	12	225	5491.8
	Philips	11	60	12	225	1782
	Up Lights	59	100	12	225	15930
	Circle Lights	9	100	12	225	2430
Library	4' T8	138	32	9	225	8942.4
	2' T8	36	32	9	225	2332.8
	Tube	12	18	9	225	437.4
	Spotlights	4	100	9	225	810
Locker Room	4' T8	112	32	10.5	225	8467.2
Office	4' T8	137	32	9	225	8877.6
	2' T8	75	17	9	225	2581.875

<b>Room Type</b>	<b>Fixture Type</b>	<b>#</b>	<b>W</b>	<b>hrs/day</b>	<b>days/yr</b>	<b>kWh/yr</b>
Office	Incandescent	4	60	1	225	54
	Incandescent	1	40	1	225	9
	Incandescent	5	100	3	225	337.5
	Incandescent	3	60	3	225	121.5
Stage Area	Spotlights	21	100	2	10	42
	4' T8	34	32	2	10	21.76
	Heavy Duty Spotlights	5	750	2	10	75
	Bar Spotlights	72	100	2	10	144
Teachers Lounge	4' T8	8	32	9	225	518.4
Tool Room	4' T8	18	32	9	225	1166.4

## Appendix B: Appliance Data

Appliance	Wattage (on/standby)	Hours (on/standby)	Days (on/standby)	kWh/yr
10 C Coffee Maker	825/3	0.25/23.75	150/365	342
14 C Coffee Maker	900/3	0.25/23.75	150/365	120
2 C Coffee Maker	500/3	0.25/23.75	150/365	90
2' Mini-Fridge	100	24	365	9,636
3' Mini-Fridge	100	24	365	11,388
Clock Radio	10/2	1/23	50/365	138
Computers	90/1.3	10/14	225/365	40,365
Computer Monitors	28/1.3	6/18	225/365	8,944
Dishwasher	1800	1	40	360
Document Camera	220	1	225	1,485
Dryer	3500	1	40	140
DVD/VCR	25/7.5	2/22	10/365	1,154
Electric Tea Kettle	1000/3	0.25/23.75	150/365	191
Fans	660	4	60	2,534
Full Fridge	600	24	365	10,512
Laptop	65/5	4/2	225/225	182
Laser Jet Printer	575/5	0.5/23.5	225/365	2,152
Microwave	1200/3	0.25/23.75	120/365	1,736
Mini-Freezer	65	24	365	569
Mini-Heater	1500	6	60	540
Paper Shredder	17	0.25/23.75	20/365	0.26
Projector	340/5	2/22	120/365	4,018
Sharpener	20	0.02	100	0.92
Stapler	100	0.01	50	0.20
Stereo	400/4	1/23	50/365	268
Television	95/3	0.5/23.5	225/365	1,894
Toaster	1050	0.01	50	1.05
Toaster Oven	1200	0.5	120	72
Washer	400	1	40	16

Wattage values (on/standby) are based on data collected by Monarch K-8 and the Lawrence Berkeley National Lab.

## Appendix C: Lighting Recommendations Cost Calculations

### (1) Increased Natural Lighting

Space	# of Bulbs	Wattage	Hours Reduced/Day	Days/Year	kWh/Year
Classroom	240	32	0.5	225	864
Classroom	87	17	0.5	225	166
Cafeteria	62	32	2	225	893
Skylights	48	32	4	225	1,382
Entranceways	11	60	4	225	594
<b>Total</b>					<b>3,900</b>

### (2) De-Lamping

Space	# of Bulbs	Wattage	Hours Reduced/Day	Days/Year	kWh/Year
Classroom 600	4	32	9	225	259
Classroom 603	4	32	9	225	259
Classroom 604	4	32	9	225	259
Classroom 700	4	32	9	225	259
Classroom 703	4	32	9	225	259
Classroom 704	4	32	9	225	259
Classroom 800	4	32	9	225	259
Classroom 803	4	32	9	225	259
Classroom 804	4	32	9	225	259
<b>Total</b>					<b>2,333</b>

### (3) Motion Sensors

Part A: Reduced Lag Time Decreases Lighting by 10 Minutes

Space	# of Bulbs	Wattage	Hours Reduced/Day	Days/Year	kWh/Year
Classroom	1124	32	0.167	225	1,351
Classroom	531	17	0.167	225	339
Computer Rm	154	32	0.167	225	185
Computer Rm	21	17	0.167	225	13
Office	137	32	0.167	225	165
Office	75	17	0.167	225	48
<b>Total</b>					<b>2,102</b>

Part B: Lights Switched Off at End of Day Decreases Lighting by 15 Minutes

Space	# of Bulbs	Wattage	Hours Reduced/Day	Days/Year	kWh/Year
Classroom	1124	32	0.25	225	2,023
Classroom	531	17	0.25	225	508
Computer Rm	154	32	0.25	225	277
Computer Rm	21	17	0.25	225	20
Office	137	32	0.25	225	247
Office	75	17	0.25	225	72
<b>Total</b>					<b>3,147</b>

<b>Total of Part A and B</b>	<b>5,248</b>
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*(4) Bathrooms*

Space	# of Bulbs	Wattage	Hours Reduced/Day	Days/Year	kWh/Year
Bathrooms	57	32	2	225	821

*(5) Exterior Lighting*

# of Bulbs	Current Wattage	LED Wattage	Hours/Day	Days/Year	kWh/Year
20	70	40	12	365	2,628
33	250	170	12	365	11,563
<b>Total</b>					<b>14,191</b>

*(6) Incandescent Bulbs Converted to CFL*

# of Bulbs	Incandescent Wattage	CFL Wattage	Hours/Day	Days/Year	kWh/Year
18	60	15	1	225	182
1	75	15	1	225	14
1	40	15	1	225	6
5	100	15	3	225	287
3	60	15	3	225	91
<b>Total</b>					<b>579</b>

**(7) Upgrade to 28W T8s**

<b># of Bulbs</b>	<b>Initial Wattage</b>	<b>New Wattage</b>	<b>Hours/Day</b>	<b>Days/Year</b>	<b>kWh/Year</b>
116	32	28	8	225	835
57	32	28	10	225	513
116	32	28	6	225	626
1602	32	28	9	225	12,976
24	32	28	0.5	225	11
9	32	28	2	225	16
18	32	28	1	225	16
184	32	28	12	225	1,987
112	32	28	10.5	225	1,058
34	32	28	2	10	3
<b>Total</b>					<b>18,042</b>

**(8) Metal Halide**

<b># of Bulbs</b>	<b>Initial Wattage</b>	<b>New Wattage</b>	<b>Hours/Day</b>	<b>Days/Year</b>	<b>kWh/Year</b>
40	400	200	9	225	<b>16,200</b>

## Appendix D: Appliance Recommendations Cost Calculations

### *(1) Unplug and Power Strip*

Appliance	Number	Stand-by Wattage	Stand-by Hours Reduced	Days/Year	kWh/Year
Coffee Maker	10	3	23.75	365	260
Stereos	13	2	23	365	218
DVD/VCR	19	7.5	22	365	1,144
Kettles	3	3	23.75	365	78
Microwaves	28	3	23.75	365	728
Projectors	33	5	22	365	1,325
TVs	23	2	23.75	365	399
Mini-Fridges	24	100	24	30	1,728
Full-Size Fridges	2	600	24	30	864
<b>Total</b>					<b>6,745</b>

### *(2) Computer Monitors Off*

Appliance	Number	Wattage Reduced	Hours/Day	Days/Year	kWh/Year
Computers	193	1.3	18	365	<b>1,648</b>

### *(3) Retire 75% of Kitchen Appliances*

Appliance	Current Number	Current kWh/Year	Number Retired	Saved kWh/Year
Coffee Makers	10	552	8	442
Mini-Fridges	24	21,024	18	15,768
Dishwashers	5	360	4	288
Kettles	3	191	2	127
Microwaves	28	1,736	21	1,300
Mini-Freezer	1	569	1	569
Toaster Oven	1	72	1	72
<b>Total</b>				<b>18,566</b>