

A Student Perspective on Greening Schools

Analysis of an Austin, Texas High School as a Model for Rethinking in Green



By Michael Alexander Kats-Rubin

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Introduction

Global climate change, rising oil prices, increasing dependence on foreign energy as a matter of domestic security – all of these have moved to the top of America’s agenda and are now recognized as urgent national priorities. As more people have come to recognize the scope and severity of the energy problem, more people also have come to understand the importance of green building and sustainability. Energy conservation and reducing the electricity consumption are now known to be key components of solving our country’s energy crisis, and we understand that we cannot solve our problems without addressing the millions of existing building that account for 80 percent of electrical expenditures.¹

It is easy to focus attention, efforts and resources on new green building, which is more glamorous and certainly more cost effective than retrofits. If done well, green buildings can save 75 percent on energy bills,² reduce carbon dioxide emissions and stand as a monument to an organization’s commitment to the environment. Yet attention also must be paid to the green remodeling of at least some of the 5 million existing commercial buildings in the United States, of which 300,000 are schools,³

Unfortunately, as the shift to new green construction accelerates, green remodeling lags behind. The experience of Austin Energy illustrates why. The city utility gets six times more return on its investment in new green building than it does in green retrofitting. “For every \$1 million that Austin Energy puts into new green building, it puts \$18 million into green renovation, yet 30 percent of energy savings come from those new buildings,” says Austin Energy’s Richard Morgan.

New greener construction has captured the attention of the Austin Independent School District which opened two new elementary schools last year,⁴ Perez and Clayton, both built under green guidelines.⁵ While this is admirable, at the current rate it would take decades before AISD could replace its 116 existing schools with green ones.

AISD, like many school districts, has a great many old schools. Many Austin schools are more than 20 years old and the oldest opened its doors in 1876.⁶ Lyndon Baines Johnson High School, used as an example throughout this paper, was built in 1974 and has gone through a number of remodels and renovations. AISD has made an effort to switch to more efficient light bulbs at LBJ and had old boiler systems at the 34-year-old high school updated to newer, more energy efficient ones. Other changes at the school were supported by the cutting-edge rebate programs offered by Austin Energy and recognized nationally as setting standards for encouraging conservation.

Yet while these measures are a good place to begin, there is far more that AISD could do. This paper looks at several areas for potential green actions at LBJ, including one that would require no investment and could produced hundreds of thousands of dollars in potential, unrealized savings from energy conservation. (See “Computer Settings”)

New green construction alone will not solve our nation’s dependence on foreign energy, or solve climate change. We must also take a series of concrete steps to improve the efficiency of the older buildings that are part of our existing national infrastructure and in which we will continue to live, work and learn for decades to come. This paper looks at some ways to do this in schools.

Purpose of this Paper

To demonstrate the importance of green remodeling in energy conservation, and provide a resource for those interested in green renovations of schools through the example of Lyndon Baines Johnson High School in the Austin Independent School District.

To examine a set of specific, concrete actions that would produce significant savings for LBJ and the school district as an example of how school administrators and students need to start thinking cooperatively about conservation and green retrofits.

Barriers To Retrofitting Schools

On its surface, it seems like a relatively simple decision for the owners and operators of school buildings. Continue with the status quo, do nothing, and face increasing utility bills and waste, or invest a relatively small amount of money in retrofits and reap continuing savings. But a number of factors make decisions on green remodeling of schools more complicated.

There is a lack of access to capital, an absence of accountability, a variety of competing demands for limited resources and a simple lack of awareness. School districts set budgets for repair and maintenance, but not for upgrades, even if upgrades save money in repairs and maintenance. In the bureaucracy of a school system, there is also a lack of communications, a disconnect between the departments charged with paying utility bills and those charged with overseeing renovations and maintenance. Without ongoing, regular information on cost, it is hard to manage consumption and reduce waste. At the highest level, those managing school districts may simply be unaware of the huge potential savings that could be realized through a small investment in green renovation. Money is not made available to demonstrate savings, incentives are not given to encourage individual initiative in reducing waste and potential opportunities are neither identified nor known.⁷

Where to Go Green: Electricity

Every retrofit is unique. Each should be specific to the building and involve specific calculations and thorough research. What is valuable in one building may be a waste of money in another.

Many upgrades and actions work better when combined. For example, rather than pouring \$10,000 into upgrading the A/C system, a school could spend \$5,000 on upgrading the A/C, \$1,000 on increasing roof reflectivity and \$1,000 on adding overhangs to windows. The combined actions could produce greater returns with an expenditure of \$7,000 than would be realized through spending \$10,000.

While each building is different, there are some common categories of actions to consider in thinking about ways to save energy, although they may not all be applicable to every building. The following categories, examined in greater detail below, serve as a kind of checklist of potential actions for greening older buildings.

- HVAC Direct: The renovation of heating, ventilation and air conditioning systems to reduce energy consumption.
- HVAC Indirect: Actions to reduce the load on HVAC systems

- Lighting and Energy Use: Actions to increase lighting and appliance efficiency

In Austin, taxpayers approved a bond project in 2004 to support green renovations in the city's public schools. At LBJ, the bond money paid for five areas of retrofits and renovations. These included:

- Improving the insulation of the roof.
- Improving the solar reflectivity of the roof with a white membrane.
- Enhancing efficiency of light bulbs.
- Replacing five old boilers with more efficient ones and re-insulating hot water pipes.
- Adding automatic temperature controls in temporary classroom structures (portables).

While all these measures undoubtedly reduced the environmental impact of the school and saved the school district money, it is nearly impossible to know how much. It does not appear that the school district performed measurements prior to the work being done to set a baseline for gauging improvements, or performed evaluations afterward to determine savings and success. Without such evaluation, it is difficult to replicate success, avoid future pitfalls or generate support for additional green measures.

There were other problems associated with the worthy attempts by the school district to reduce energy consumption. For example, temperature control was given to teachers in the temporary structures. However, these teachers were not taught to use the controls effectively. As a result, many teachers leave the thermostat at an unnecessarily low temperature that wastes energy. The controls have been valuable in assuring that the HVAC systems are turned off during non-school hours, something that might otherwise be forgotten.

Sub-metering

Understanding the problem is half the battle. The most important part of an effective green retrofit is picking the right places to make your investment. Metering and sub-metering allow detailed information to be gathered on how much electricity is used and where it is being used. Metering and sub-metering also make it possible to evaluate the actual impact of a retrofit by comparing energy usage before and after the work. This can be important for making decisions on future upgrades. In school systems, such metering provides information that can be applied to other, similar school buildings. In addition to helping with decision making, sub-meter data made available to building operators, students and teachers raises awareness and encourages behavioral changes to enhance energy conservation. "Information is power," and it is also a way to reduce power consumption.

HVAC-Direct

HVAC accounts for 40 - 60 percent of the energy used in U.S. commercial and residential buildings.⁸ A large portion of green building and remodeling focuses on how to reduce the cost of HVAC. Building in the north should focus on reducing heating costs, while buildings in hotter, southern climates obviously would realize greater savings by focusing on their cooling systems.

Newer HVAC systems tend to be more efficient and help improve air quality. A large building of 50,000 square feet or more can save as much as \$150,000 a year by upgrading the system.⁹ For complete upgrades, rebates are often available through local, state and even federal authorities, including one offered by the U.S. Department of Energy.¹⁰ The largest savings can be obtained by reducing the size of

the HVAC system being installed, and this can be achieved by other actions that reduce the demand on the system.¹¹

Geothermal Heat Pumps

Regardless of the season and temperature, a few feet underground the earth maintains a fairly constant temperature of between 45 and 75 degrees Fahrenheit depending on location.¹² Geothermal heat pumps (GHPs) pull heat from usually over six feet into the ground into the building during the winter for pre-heating air and pump heat into the ground from the building in the summer. GHPs are one way to reduce the load on HVAC systems, especially during the peak hours of hot summer days. This helps both reduce the size of a heating system because the air that is drawn from the earth is already warmer than the ambient air. And, it reduces the load on cooling, by using the ground temperature to help cool the interior air.

Variable Frequency Drives (and Variable Speed Fans)

VFDs allow HVAC fans to be adjusted to run at the level needed rather than at a constant, full-power speed. VFDs also are often areas covered by rebates.¹³

Adjusting the Thermostat

Raising the temperature by as little as 1 degree during the summer can save 5 percent on cooling costs.¹⁴ A simple adjustment of the temperature may be one of the best ways to save money. The State of Illinois, under an administrative order issued by the governor, initiated the Winter Energy Conservation Plan that lowered the temperatures of nearly 2,000 state facilities from 72 to 68 degrees Fahrenheit during working hours and to 55 degrees when buildings were unoccupied.¹⁵ Last winter, this project saved the state nearly \$5 million, and by reducing overall demand helped keep energy prices down for Illinois residents.¹⁶ A similar plan during the summer was expected to raise the thermostat in the facilities by 2 to 6 degrees, for an estimated saving of \$1.2 million.¹⁷

HVAC-Indirect

In addition to improving HVAC efficiency through direct replacement, actions can also be taken to reduce the load the system has to bear. To decrease cooling cost, it is possible to take measures to prevent heat from coming in and to decrease the amount of heat being generated indoors. Of course, reducing the heat coming into or generated by a building will mean higher heating costs in the winter. But for a variety of reasons these are more than offset by the savings from cooling in the summer. This is true for most buildings in the United States.

Cool Roof

One way to reduce the heat of a building during hot summer days is to increase the solar reflective index (SRI) of the roof. SRI refers to how much sun a surface reflects. A black surface that absorbs heat, for example, would have a lower SRI than a white surface. A dark roof can increase the temperature of a rooftop by as much as 100 degrees Fahrenheit during hot summer days,¹⁸ and can drastically increase the interior temperature putting increased load on the A/C system.

Coating the roof with a more reflective or lighter color surface can be very effective in reducing energy demand and result in a speedy return on investment. Cool roofs also decrease thermal expansion and contraction which extends the life of a roof, reduces the cost of replacement and maintenance, and keeps the old roof out of landfills. Cool roof materials include sprays, sheets or a type of paint and the best

one to use depends on the type of building, and the Cool Roof Rating Council provides useful information for those researching Cool Roofs.¹⁹

Reducing the Heat Island Effect

The Heat Island Effect occurs when something that is dark gets hot and makes the things around it hotter. Areas covered in materials with a low SRI absorb heat. For most buildings, the direct energy savings from reducing the SRI are difficult to calculate, but buildings surrounded by large expanses of asphalt and those located in the middle of urban areas are likely candidates for the greatest savings by reducing the heat island effect. The heat island phenomenon can raise the temperature from 2-10 degrees Celsius in large cities or in suburban areas,²⁰ which also increases the demand on A/C systems. For every 1 degree increase in Fahrenheit the peak load increases by 2 percent.²¹

With the potential impact in mind, asphalt or dark surfaces needing periodic replacement can be replaced at a low or negligible additional cost with a surface that has a higher SRI. In addition to energy savings, such replacement will reduce smog and pollution and have a positive impact on health.²² In Phoenix, summer temperatures on asphalt have been recorded at 178 degrees, hot enough to burn skin in under a second of exposure.²³ Lower use driveways and roadways can also be paved with more porous asphalt²⁴ which can be installed at a lower initial cost, require less maintenance, generate less water runoff, absorb less heat and can be more attractive.

Insulation and Sealing

For any building undergoing a remodel, insulation may be one of the best investments that can be made, and it is one that can produce a high rate of return.²⁵ Insulation should be considered for any part of a building where protection would be useful from outside temperatures or in areas that generate their own heat or cold, such as boiler rooms. Adding insulation by itself can be prohibitively expensive unless it is part of a larger renovation effort. But it should always be considered anytime a wall or building section needs repair. Sealing, on the other hand, is reducing air flow and leakage around window, under doors and through other openings. And sealing is something that can be extremely beneficial at a much lower cost.

Planting

Trees and plants can be useful in reducing the need for HVAC costs in three ways. First, evaporation from the leaves on trees and plants help to cool down the air around them. Second, trees can serve as a windbreak and evergreens planted to block cold winter winds can help reduce heating costs by as much as 50 percent in residential buildings.²⁶ Third, and perhaps most obviously, they provide shade. Planting a few trees strategically around a home can reduce A/C energy usage by 30 percent.²⁷ On a large commercial building, trees will have less impact but can still make a difference. Deciduous trees planted to shade the south and west walls of buildings help block sun during the hottest parts of the day in the summer and drop their leaves in the winter to allow the sun to assist in heating the interior. Evergreen trees can be planted on the north side without reducing winter sun. Increasingly popular are green roofs planted with grasses, sedges and other vegetation which improve the reflectivity and insulation of the roof, decrease storm water runoff, and remove particulates and ozone precursors out of the air. Planting roofs, however, require a significant evaluation of the structural requirements and can be quite costly.

Windows and HVAC

Windows are another key consideration in reducing the load on an HVAC system. Like insulating walls, insulating windows help reduce the loss of both cold and warm air. Unlike walls, windows also can be tinted or shaded to reduce load on the AC .

Windows that are not properly insulated can account for 25 percent of a residential buildings total heating bill and 15 percent of a cooling bill.²⁸ According to the U.S. Department of Energy, poorly insulated windows account for 25 percent of all heating and cooling requirements in the United States at a cost of \$22 billion. To put this in perspective, this amounts to more than the annual sales of Shell Oil Company in 1993 and is equivalent to the amount of energy flowing through the Alaskan pipeline each year.”²⁹

For colder climates, windows can be made to keep light and warmth in while in warmer climates, windows can be tinted darker or have a higher solar reflective index to help reduce the impact of the sun. Likewise, shades or awnings can be added to help reduce the load on the AC.

Lighting and Electricity Use

The way a building handles the need for artificial illumination has a significant impact on energy use and the environment. Consequently, it is an area that requires early attention in any attempt to retrofit or renovate an existing school or commercial building. Lighting with traditional, incandescent bulbs uses far more energy than newer bulbs. Incandescent bulbs also generate more heat, creating additional load on an AC system. Finally, lights left on in empty room, which often happens in school buildings, wastes costly electricity for no purpose whatsoever.

Windows and Lighting

Windows diminish the need for artificial lighting. For older school buildings with few windows, light can be brought in through skylights or sun tunnels, although these can be difficult and costly to install and maintain. An alternative solution that increases the natural lighting in a room without increasing heat from the sun is the light shelf. Light shelves are installed about two thirds of the way up a window, sometimes replacing blinds. Incoming light bounces off this shelf and hits the ceiling, where it is more evenly and pervasively distributed through the room.³⁰ Natural lighting not only reduces the need for costly lamps and bulbs and reduces electricity use, but it also can improve the working environment of a building. Studies have shown that in schools, student test scores improve 5 percent in buildings with increased natural lighting.³¹ Schools throughout the country spend millions of dollars each year to gain even just a 2 percent improvement in test scores, so this kind of improvement from lighting is no small matter.

Bulb Types

A simple way to save energy is to upgrade the type of light bulb used. In residential buildings, that often means moving from an incandescent bulb to a compact fluorescent. This change reduces the energy use of lighting by 75 – 85 percent,³² and reduces the heat generated by lighting, reducing the load on the A/C system. Many commercial buildings already use T12 Fluorescent Lamps. But a newer model, the T8, along with an upgrade in the ballast can use 35 percent less energy.³³ A building that replaces 200 T12s could save more than \$5,000 each year, and reduce energy consumption enough to stop 63,000 pounds of CO₂ from entering the atmosphere.³⁴

At LBJ High School, even before the 2004 bond project, the school replaced T12 lights with T8s. No calculation was conducted to measure the savings from the switch to higher efficiency bulbs. No one counted the lights replaced. However, the school has 184 classrooms and portable classrooms and each of these rooms has an average of 26 light bulbs for a total in the classrooms of an estimated 4784 light bulbs. And this does not count the lighting in the extensive corridors between classrooms, cafeteria, bathrooms, kitchen, offices, gymnasium or theatre. If calculated, the savings from this change would prove substantial.

Dimmers

Most school spaces do not require full light all day long. Dimmers can help adjust the light to the actual need. Reducing the light generated by a light bulb by 10 percent is often imperceptible to the human eye yet can save 10 percent on energy use and double the life of the bulb.³⁵ Dimmers work well where large windows and skylights often make a full-powered light bulb unnecessary. At this point, dimmers are better suited to buildings using incandescent bulbs since compact fluorescents that are dimmable can be prohibitively expensive at \$3 to \$4 more per bulb.

Occupancy Sensors

Designed with the purpose of turning lights off when a room is empty, occupancy sensors can be very valuable in buildings, like schools, where lights are very often left on in empty rooms. In schools, people often feel they don't have the authority to turn off a light or believe it the janitor's responsibility. Occupancy sensors can reduce lighting energy use in frequently unused spaces by as much as 50 percent. Occupancy sensors also reduce the heating from lighting, reducing the load on the HVAC system. They are commonly either infrared or ultrasonic,³⁶ and work by detecting heat or movement.³⁷ They are most effective in rooms that are not continually occupied, such as conference rooms, bathrooms and teacher lounges.

At LBJ High School, a particularly useful place for such occupancy sensors would be the 18 bathrooms at the school, 14 for student and four for teachers and staff. Each of the student bathrooms are heavily used during the 5-minute period between classes. Students change classes on average six times per day, so the bathrooms are fully in use about 30 minutes out of each eight-hour school day. Nevertheless, while classes are in session and the bathrooms are largely unoccupied, they remain fully and constantly illuminated. The lights also stay on for an additional hour before school starts and two hours after the end of the school day, for a total of 11 hours each day.

A case study conducted by the EPA and the Rensselaer Polytechnic Institute, showed that restrooms were some of the most valuable places to install occupancy sensors, yielding savings of 40 percent to 45 percent in lighting.³⁸ Although this study included some schools, it focused mostly on office buildings where bathroom trips are more sporadic.

An estimate from a occupancy sensor company put the savings of electricity in a restroom for a K-12 school at around 53 percent.³⁹

If each restroom overhead light could be turned off for two-thirds of an 11-hour day, then the installation of occupancy sensors could save more than \$14 a week assuming 8 T8 bulbs per bathroom with each T8 using 32 watts per hour.⁴⁰

Watts Consumed Per Eleven Hour Day	kWh Saved Per Day	Amount Saved in School Week	Amount Saved in Calendar Year
<i>32 watts per hour for 112 T8 bulbs</i>	<i>2/3 use reduction</i>	<i>5 days, \$.1034 per kWh</i>	<i>36 school weeks</i>
39424	26	\$14	\$489.17

Occupancy sensors cost between \$30 and \$130 each, depending on the type, and the payback period on occupancy sensor retrofits usually range from 6 months to 5 years.⁴¹ And, this does not include any potential rebate that might be offered by Austin Energy.

Energy Star

Energy Star is a joint certification program by the Environmental Protection Agency and DOE to reduce energy use.⁴² Energy Star products are usually slightly more expensive than their non-certified counterparts, but they often also benefit from rebates and have a payback of less than one year. Anyone in charge of a school or office should require that all appliances or other electronic products purchased carry the Energy Star certification. The payback in energy savings from using such certified appliances or equipment occurs within the first half of the life cycle of a product. Additional savings continue to occur.

Vending Machines

Vending machines are often overlooked as a potential area for savings in a green remodel. Vending machines can draw up to 400 watts of electricity an hour,⁴³ making them worthy of consideration. Just turning out the lights within a vending machine alone can save 40 percent of the energy draw.⁴⁴ Other technology upgrades, such as more efficient vending machines or motion detectors can drive this energy demand down even farther.⁴⁵

Austin Energy offers to install on vending machines a variety of new energy-saving technologies. On non-refrigerated snack vending machines, they will install free of charge a SnackMiser which can reduce energy use by 80 percent, or 80-100 watts,⁴⁶ by turning off the machine when there is no motion detected nearby for 15 minutes. Other technologies exist for other sorts of vending machines, such as drink dispensers.

Reducing the Plug, or “Phantom,” Load

Lighting is only one of many needs for energy in a school. A variety of appliances and equipment also require power. Yet, even when we think that electronics are off, many continue to draw power. This is called “energy leak” or the “phantom load.” A desktop computer, for example, that has been turned off still draws 7 watts an hour while it is plugged into the wall.⁴⁷ Nationally, we spend \$3 billion a year paying for electricity drawn by electronics we think are off.⁴⁸ In a residence, phantom load can amount to as much as 23 percent of the total energy consumed.⁴⁹ For commercial buildings, office spaces and schools that have computers, photocopiers, and other electronics left plugged in the drain from a phantom load can be significant. But it can be reduced by using cheap and easy-to-use power strips that can be turned off to stop the needless flow of electricity to equipment. Such power strips produce nearly immediate return investment through energy savings. This paper explores below the specific savings to LBJ High School from shutting down computers and cutting the phantom load..

Computer Settings

Green retrofits and remodeling often begin by looking for the simple, easy changes that can reduce consumption and eliminate waste. But such savings are sometimes less about using new technologies and more about thinking in new ways. It is necessary to holistically consider the system in which technology is to be used in order to reap the most benefits.

An example of this lack of holistic thinking in schools are the changes LBJ High School has made in its computer system where new computer technology was purchased to reduce energy consumption, but other, simple changes in the way the school manages its computers could have realized significant, additional savings. And, unlike most actions to green a school, this one saves money and reduces environmental impact without the need to invest one penny.

LBJ could save about \$45,000 each year by just setting each of the school's 393 computer CPUs to hibernate when not in use. And, if each of the 16 high schools in the AISD has approximately the same number of computers, then the school district as a whole, could save more than \$700,000 each year in just its high schools.

Additional savings could be applied if similar actions were taken at the 20 middle schools and 81 elementary schools in the district. And even more savings could be found by eliminating the phantom load.

A few years ago, AISD switched to more energy efficient computer monitors. The E771mm Dell now used at LBJ High School is Energy Star certified and when on, uses 85 watts per hour⁵⁰ just over half of what a regular monitor uses.⁵¹ In hibernate mode, it uses only 2.2 watts of power. After 20 minutes of inactivity, the monitors shift to hibernate, using only 1/35th of the energy consumed when in use.

However, the school district did not change the settings to reduce energy use by the central processing unit, CPU. CPUs at LBJ use an average 160 watts per hour,⁵² better than average in terms of energy use but not set to realize additional, huge potential savings. Although the monitors are set to hibernate after 20 minutes, the CPUs are not set to ever hibernate at all.

Even if LBJ administrators wanted to change the settings on the CPUs, they couldn't, since the CPU settings are established and maintained centrally by district administrators.

When asked, AISD administrators explain that the machines are left on during nights and weekends to allow essential, centrally-managed software updates. However, such updates could be programmed to run at the time computers are turned on in early mornings or could be programmed to be left on one night each week for such updates. There are a variety of ways to address the need AND save energy.

Below are the calculations showing the savings that can be realized by setting the CPUs to hibernate when not in use.

Hibernate CPUs when not in use

These calculations assume 393 CPUs using 160 watts per hour when on and 15 watts per hour in hibernation⁵³ The 393 computers together use 63 kW per hour when on and 6 kW per hour when

hibernating.⁵⁴ By assuming computer use for half a school day, or 6 hours on a day running 7 a.m. to 7 p.m., and allowing them to hibernate following 20 minutes of inactivity and for the rest of the time, LBJ can save 7,866 kWh per school week.⁵⁵

In addition, allowing the computer CPUs to hibernate during school vacations would save another 9,576 kWh per week.⁵⁶ This results in a total savings per year of 436,392 kWh per school year.⁵⁷ With the current cost of kWh at 10.34 cents per kWh, energy savings at LBJ would total \$45,123 per year.⁵⁸

If similar savings could be realized by allowing computers at the all 16 AISD high schools to hibernate when not in use, **the school district would save \$721,968 each calendar year.**

Of course, some small sacrifice in convenience would be required. Students might have to wait a few seconds for the computers to come back to life. And AISD computer administrators might have to sacrifice some flexibility in favor of thinking through ahead of time and scheduling software updates. But the significant financial benefits justify such rethinking of old habits.

The data used in these calculations was compiled from a variety of sources and from what could be gathered in an unscientific but detailed survey of the school. Additional savings would very likely be found and greater accuracy in calculations achieved if additional data could be provided by the school district for analysis.

The problem of acquiring data from a school system is discussed in the section below, Broader Lessons and Recommendations.

Where to Go Green: Water Use Reduction

Water conservation and energy conservation go hand in hand. Conserving water reduces the need for electricity to pump and purify water, which contributes to bottom line savings on the utility bill. Conserving hot water means less energy needed to heat water, saving the cost of running a boiler, typically fueled by natural gas. Apart from energy saved, water conservation is an important goal on its own.

Low Flow- Faucets, Showers and Toilets

Installing low flow faucets and showerheads in homes can reduce both the amount of water used and the cost of heating water by 50 percent.⁵⁹ In a commercial building, low flow and/or automatic faucets that are turned on with motion sensors can save large amounts of water. Water flow is most often reduced by adding an aerator, which mixes air with the water to reduce water used while retaining water pressure.

In 1994 the government passed mandates requiring all toilets to use less than 1.6 gallons per flush. While better than earlier models, older post 1980 toilets use around 3.5 gallons,⁶⁰ meaning that replacing an older toilet with a new one will save 1.9 gallons of water per flush. Low flow toilets are especially valuable in school buildings where large student populations use and flush the toilets throughout the day.

Ultra low or no flow urinals use oil that floats above the urine, using no water. The waterless urinal eliminates the need to flush and also reduces odor, especially valuable in a school buildings where toilet usage is high and flushing is low.

At LBJ High School, for example, with nearly 1,600 students using the toilets an estimated three times each day, toilets are flushed about 4,800 times. With new toilets saving 1.9 gallons per flush,⁶¹ then 9,120 gallons of water per day could be saved by replacing toilets, or 45,600 gallons per week. With the cost of water at about \$5 per 1,000 gallons, depending on time of day, LBJ could save \$228 each week or \$8,208 per year. If each toilet costs \$200 to replace,⁶² or \$8,400 to replace all of them, three toilets in each of the 14 student bathrooms, then the ROI would be just over a year. That does not include the handsome rebates offered by the City of Austin for replacing older, wasteful toilets.

Times Toilets Used Per Day	Wasted Water Per Flush	Daily Wasted Water	Dollars Saved Per Year
<i>1600 students, 3 times a day</i>	<i>3.5 gallons to 1.6 gallons.</i>	<i>gallons per 5 day school week</i>	<i>36 weeks, at \$5 per 1000 gallons</i>
4800 flushes	1.9 gallons	45600 gallons	\$8208

Assuming a 15-year life span on a low-flow commode and an ROI of one year, then total savings to LBJ would be about \$114,000 – assuming that water costs do not rise. If these changes were replicated across Austin 15 other high schools of similar size, **AISD would save an additional \$1.7 million over the next 15 years** in water costs at current water rates.

Amount Saved in Year	Cost to Replace Toilets	Amount Saved Over Life of Toilets	Total over all AISD High Schools
<i>36 week year, \$5 per 1000 gallons</i>	<i>\$200 for each of the 42 toilets.</i>	<i>15 year life minus \$8400 to replace.</i>	<i>15 other high schools excluding LBJ</i>
\$8,208	\$8,400	\$113,520	\$1,702,800

This kind of calculation on the return on investment would help LBJ plan and prioritize investments in future green retrofit projects.

Rainwater Harvesting

For large buildings, especially those with irrigation needs, rainwater harvesting can save money. The return on investment also is often shortened through rebates offered in many cities. Austin, for example, offers up to \$40,000 for commercial water conservation projects.⁶³ Although rainwater can be used for flushing toilet, it requires levels of municipal bureaucratic approval. The more common use for the rainwater stored in a school’s cistern is for watering plants, which reduces the use of potable water for irrigation and reduces a school’s environmental footprint.

Future Value of Carbon Tax or Cap-and-Trade

When companies and individuals can save large sums of money by going green, then it stops being nice and starts being done. Green remodeling will pick up steam when the government creates a value for carbon emissions. A potential carbon emissions tax or a potential cap-and-trade program is likely to occur within the next several of years.

Without a value on carbon dioxide emission, savings are generally based upon the reduction in energy and the charges that appear on a utility bill.

Both presidential contenders Barrack Obama and John McCain have said they will seek to slice the United States’ carbon emissions. They have different ideas on how it should be done,⁶⁴ but the result will be some kind of value placed on carbon emissions.

A carbon emissions cap or tax⁶⁵ would likely target electric utilities and seek to drive up the price of energy generated by more polluting sources, making them less competitive and less commercially viable. An additional important benefit would be that higher energy costs would translate into a faster rate of return for investors in more efficient, green buildings. Such incentives should spur significant additional investment in green retrofits in the nation’s school systems.

For example, LBJ High School installed Energy Recovery Ventilators as part of the 2004 bond-funded renovations. ERVs reduce the electricity draw for HVAC systems. Using a reasonable estimate on just the savings LBJ may have had on the school’s energy bill, the return on investment for the ERVs was more than 5 years. But, if you calculate the return on investment with a \$35 per ton value on carbon emissions – less than the current European price – then the outcome changes dramatically.

The following chart shows the result of a carbon emissions value of \$35 per ton, which reduces the estimated rate of return on investment by 20 percent, from five years to four.

kWh	Estimated Cost to school	Amount saved on consumption reduction	ERR- Simple payback	Carbon Reduction	Value of CO2	ERR with Value to Carbon
Kilowatt hour reduction annually	Assuming the rebate is 50 percent of the total cost.	Texas average cost of 10.34 cents	Using only consumption reduction. Assuming the discount rate rises at the rate of electricity	CO2 reduction in tons	\$35 per ton	Estimated rate of return in years
6208	\$3,104	\$642	5	4	\$141	4

An Unexpected Lesson and a Recommendation on an Untapped Resource

I set out to learn about green retrofitting at LBJ and explore ways to save additional money and reduce environmental impact. While I learned something about the retrofits and found ways to save money, an unexpected lesson was learning how little schools tap a vast potential resource for improving the environmental footprint of a school – students.

A March 2007 nationwide survey of 767 teens 13 to 19 years of age by JWT and the non-profit ReLightNY found that 62 percent of teens care about what happens to the environment and 83 percent agreed that if someone showed them how they could help the environment, they would do it if it was easy. More and more, students are engaged environmentalists.

And this is important to note because many technologies are enlisted to make up for human failings in behavior. Occupancy sensors are needed because people don’t turn out the lights when they leave a

room. Many of the best and most valuable green retrofits tap into the people who use a space, getting them to cooperate and spread the message of conservation.

This is an especially useful idea for schools, where students spend a minimum of 40 hours a week over 12 years of their lives. They have a vested interest in making the school a better place, and many students also have a desire to give back to their communities. They feel a sense of school pride and a willingness to pitch in if asked to help. For many schools, students are or could be a huge and indispensable resource.

Students already are often taught about conservation and the environment, but enlisting their help at school could provide an opportunity to practice what they learn and gain a sense that their participation makes a difference. Information about energy use, future conservation plans and the current impact of the school, if made available to students, would support efforts to improve the environment. It would both give students a chance to learn real-world skills of building management and business while allowing an opportunity to apply their math, science and research skills to real-world problems.

Bright students familiar with the problems of the campus might help provide solutions by offering school administrators information for decision making. School administrators from central headquarters cannot know how many hours a day students spend in a particular room, but students know. School administrators cannot know which vending machines might be used more often if centrally located, but students know. School administrators cannot know if certain rooms are uncomfortably cold during certain hours and seasons, but students know because they use them and can report the experience to help adjust settings and conserve energy. Better strategies come from better information.

But the experience of gathering data for this paper indicates that, with all the best intentions, school administrators are just not set up or oriented toward working with students on matters of environmental issues or conservation.

Over the course of six months, administrators at AISD and with Austin Energy were uniformly kind and courteous. They tolerated my repeated phone calls and emails seeking information. But, in the end, they provided little useful data.

The fault lay principally with a complex bureaucratic system run by overworked employees where responsibility was ambiguous, accountability was difficult to determine, records were often inaccessible and plausible deniability was sometimes the order of the day. The net result was that, as a mere high school student, I did not have the information needed to complete the original and more ambitious project that I set for myself in the beginning.

Many people were generous with their time. However, I was unable to locate data on previous green renovations, their costs, savings, or impacts. It appeared that information often was not available – for example, calculations to determine the effectiveness or success of a project – because such calculations had not been done. No one seemed to have a handle or be responsible for future project. Questions on plans for future green retrofits could not be answered and no one seemed to know whether anyone else knew.

Despite this, and with the help of some very kind people and my own extensive outside research, I was able to find considerable savings from a couple of potential projects at LBJ that indicate much more could be found if the school district began more routine measurement, provided more information for analysis and engaged more effectively with committed, environmentally concerned students.

Conclusion

Saving money at LBJ

While there have been a number of valuable actions taken at LBJ to reduce consumption and save money, there are still a number of options worth considering. Making a change as simple as changing the settings on the computers could save the school district hundreds of thousands a year. Changing to more efficient toilets and exploring other options of conservation present a way for the school to save even more.

Carbon Emissions

The impending value to carbon emissions when it begins to approach European levels will have a noticeable impact on green remodeling as well as other conservation measures. Schools need to reevaluate retrofits and actions that may have previously been financially unattractive but with a price assigned to carbon emissions will become viable and valuable.

The Lack of Available Data

Lack of information or misinformation has been one of the biggest hindrances to conservation and green renovations. School administrators throughout the country should understand that students want to learn more, that many students care about the environment and that many students can be part of the solution. Instead of having the data being hidden, it should be made publicly available and accessible. To help increase available information, there should be sub-meters installed in the hallways so students can find out how much water and electricity is being used and what their impact is on CO₂ emissions.

Students should be encouraged to participate in gathering information, analyzing the data and helping find solutions. One of distinguishing features of many of the foremost universities in the world is that they are going green very fast and are actively encouraging their students to get involved in the process.

Therefore, AISD and school districts need to fundamentally change how they treat data and information about energy use and green retrofits.

After all, students and their families pay taxes to support schools. They pay taxes to cover energy and water bills. Most importantly, they suffer the health and environmental consequences of wasteful energy use. Students know they're part of the problem, want to be part of the solution and, if empowered by school districts, can be a powerful force for green.

Acknowledgements

This project began as a simple idea and evolved into a project more interesting and educational than any class I have ever taken. Yet it would not have been possible without the support, help and encouragement of many people. I would like to specifically thank a few of them.

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Endnotes

¹ The 2007 Energy Data Book located at <http://buildingsdatabook.eren.doe.gov/docs/2007-bedb-0921.pdf> is very useful for finding information about various subjects related to building in the US. A large portion is also dedicated to green building.

² Energy Efficiency and Renewable Energy Clearinghouse.

www.healthgoods.com/Education/Healthy_Home_Information/General_Energy_Efficiency/ee_and_renewable_energy.htm

³ Almost 5 million commercial buildings in 1995. Nearly 300,000 educational buildings.

<http://www.eia.doe.gov/emeu/cbecs/cb952a.html>

http://allcountries.org/uscensus/1227_commercial_buildings_number_and_size_by.html

⁴ 17 high schools, 21 middle schools, 78 elementary schools

www.austinisd.org/schools/campus.phtml?opt=bylevel&slevel=high

⁵ <http://www.austinisd.org/inside/2004bond/bond.phtml?opt=article&rid=1107>

⁶ 1876, Pease Elementary

<http://www.austin.k12.tx.us/newsmedia/releases/index.phtml?&more=0109>

⁷ An interesting paper evaluating the mental block that prevents green building can be found here, 'New Energy Finance'. Published by New Energy Finance of 2nd floor, New Penderel House, 283-288, High Holborn, London. WC1V 7HP

www.newenergyfinance.com

⁸ "Heating, Ventilating, and Air Conditioning" US DoE EERE. Last updated- 06/04/2008.

<http://www1.eere.energy.gov/buildings/commercial/hvac.html>

⁹ <http://sanantonio.bizjournals.com/sanantonio/stories/2005/04/18/editorial4.html>

¹⁰ Ibid

¹¹ www.rurdev.usda.gov/rbs/farbill/HVACpercent20systems.doc

¹² http://www.eere.energy.gov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12640 by the DOE and http://www.consumerenergycenter.org/home/heating_cooling/geothermal.html from the California Energy Commission.

¹³ For information about what Austin Energy offers for VFD rebates, visit

www.austinenergy.com/energypercent20efficiency/programs/rebates/Commercial/Commercialpercent20Energy/vfd.htm

- ¹⁴ <http://www.uesaz.com/business/EnergyEfficiency/EnergyTips/index.asp>
- ¹⁵ <http://www.illinois.gov/PressReleases/ShowPressRelease.cfm?RecNum=5052&SubjectID=4>
- ¹⁶ Ibid.
- ¹⁷ Ibid
- ¹⁸ <http://www.consumerenergycenter.org/coolroof/>
- ¹⁹ Their basic website is located at <http://www.coolroofs.org/>. Aside from a database with the SRI of many different types of covers listed, the CRRC is also active on environmental issues.
- ²⁰ <http://www.epa.gov/hiri/>
- ²¹ <http://www.epa.gov/hiri/about/energysavings.html>
- ²² <http://www.epa.gov/hiri/about/healthenv.html>
- ²³ http://www.pavements4life.com/QDs/Environment_1HeatIsland.asp
- ²⁴ An example of porous pavement can be found here- http://www.stormcon.com/sw_0305_porous.html more information can be found here- http://www.hotmix.org/view_article.php?ID=533
- ²⁵ The DOE is pretty good on the basic information that you need to know to add insulation. http://www.eere.energy.gov/consumer/your_home/insulation_airsealing/index.cfm/mytopic=11320
- ²⁶ <http://www.dnr.state.md.us/forests/publications/urban5.html>
- ²⁷ Ibid.
- ²⁸ <http://www1.eere.energy.gov/consumer/tips/windows.html>
- ²⁹ Based on the DOE report. www.healthgoods.com/Education/Healthy_Home_Information/General_Energy_Efficiency/ee_and_renewable_energy.htm
- ³⁰ For a more in depth explanation livebuilding.queensu.ca/green_features/smart_lighting/light_shelves
- ³¹ http://www.huffingtonpost.com/a-siegel/keeping-students-awake-an_b_97603.html
- ³² <http://www.washingtonpost.com/wp-dyn/content/article/2007/10/05/AR2007100501100.html>
- http://www.healthgoods.com/Education/Healthy_Home_Information/General_Energy_Efficiency/ee_and_renewable_energy.htm. A good resource for choosing bulbs for a residential building is <http://www.edf.org/page.cfm?tagID=632>
- ³³ <http://ge.ecomagination.com/site/products/t5t8.html>
- ³⁴ Ibid
- ³⁵ http://www.sprags.com/advantages_of_dimmers.html
- ³⁶ <http://www.p2pays.org/ref/32/31316.pdf>
- ³⁷ Harvard recently launched a program where they installed 81 occupancy sensors, with a return on investment of 2.2 years. <http://www.greencampus.harvard.edu/gclf/documents/GCLFCaseStudy-100-35HRESSFPOccupancySensors.pdf>
- ³⁸ <http://www.lrc.rpi.edu/resources/pdf/dorene2.pdf>
- ³⁹ <http://www.novitas.com/sensorSolutions.cfm?page=education>
- ⁴⁰ http://www.anaheim.net/utilities/ea/PA_11.html
- ⁴¹ <http://www.p2pays.org/ref/32/31316.pdf>
- ⁴² http://www.energystar.gov/index.cfm?c=about.ab_index
- ⁴³ <http://lists.p2pays.org/ref/32/31320.pdf>
- ⁴⁴ A&M evaluation of vending machines. <http://txspace.tamu.edu/bitstream/handle/1969.1/2006/ESL-TR-00-11-01.pdf;jsessionid=FD6237B1B0DDAC919ED23FF471132715?sequence=1>
- ⁴⁵ Some of the best occupancy sensors for vending machines are Energy Misers, some information can be found at <http://lists.p2pays.org/ref/32/31320.pdf> , An example of a more efficient vending machine can be found here- http://www.energystar.gov/index.cfm?c=vending_machines.pr_vending_machines.
- ⁴⁶ <http://www.austinenergy.com/Energypercent20Efficiency/Programs/Energypercent20Miser/index.htm> A recent article about the support for carbon tax on Capital Hill. <http://www.carbontax.org/issues/carbon-taxes-vs-cap-and-trade/> Why some people believe that a carbon tax would be better than a cap and trade program.
- ⁴⁷ Harvard provides an amusing and informative 1 page pdf on the phantom load with examples of electronics that continue to draw power after being turned off. <http://www.greencampus.harvard.edu/cerp/documents/version2Januarytip.pdf>
- ⁴⁸ An extremely useful page done by the Redwood Coast Energy Authority on phantom loads. <http://www.redwoodenergy.org/ContentPage.asp?ContentID=374>
- ⁴⁹ Ibid
- ⁵⁰ www.dell.com/downloads/global/corporate/environ/E771mm.pdf
- ⁵¹ www.oru.com/energyandsafety/energyefficiency/calculatingenergyuse.html
- ⁵² http://www.dell.com/downloads/us/products/optix/gx260_spec.pdf
- ⁵³ CPUs 160 watts per hour on http://www.dell.com/downloads/us/products/optix/gx260_spec.pdf
- 15 watts per hour when asleep <http://www.trentu.ca/admin/eab/computerenergy.shtml>

⁵⁴ Method of Calculation:

kW used per hour when on

$(393 \text{ Number of computers} * 160 \text{ watts used per hour}) / 1000 \text{ watts per kW} = 63 \text{ kW per hour}$

kW used per hour when asleep

$(393 \text{ Number of computers} * 15 \text{ watts used per hour}) / 1000 \text{ watts per kW} = 6 \text{ kW per hour}$

⁵⁵ kWh savable in a school week

$(63 \text{ kW used when on per hour} - 6 \text{ kW used per hour when asleep}) * [(6 \text{ hours during the school day} + 12 \text{ hours at night}) * 5 \text{ days a week} + 48 \text{ hours in a weekend}] \text{ the number of hours the CPUs could be asleep instead of on} = 7866 \text{ kWh per school week}$

⁵⁶ kWh savable in a summer or vacation week

$(63 \text{ kW used when on per hour} - 6 \text{ kW used per hour when asleep}) * (24 \text{ hours a day} * 7 \text{ days a week}) = 9576 \text{ kWh per vacation week}$

⁵⁷ kWh savable in a year

$(7866 \text{ kWh per school week} * 36 \text{ school weeks per year}) + (9576 \text{ kWh per vacation week} * 16 \text{ weeks of vacation}) = 436392$

kWh per school year

⁵⁸ Savings

$436392 \text{ kWh per school year} * \$.1034 \text{ per kWh} = \$45,123 \text{ a year}$

price of electricity- <http://www.eia.doe.gov/cneaf/electricity/epa/fig7p4.html>

⁵⁹ http://www.eartheasy.com/live_lowflow_aerators.htm for more information about low flow, visit

http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=13050

⁶⁰ <http://www.mwra.state.ma.us/publications/ulftoilets.pdf> and

http://www.nesc.wvu.edu/nsfc/Articles/SFQ/SFQ_sp04_PDF/Close_Thought_AltToilet.pdf

⁶¹ <http://www.sanjoseca.gov/esd/natural-energy-resources/PDFs/Green-It-Yourself-091305.pdf>

⁶² <http://www.ci.austin.tx.us/watercon/ctoilet.htm>

⁶³ <http://www.ci.austin.tx.us/watercon/downloads/icispecialapp.pdf>

⁶⁴ <http://www.washingtonpost.com/wp-dyn/content/article/2007/03/31/AR2007033101040.html>

⁶⁵ <http://www.washingtonpost.com/wp-dyn/content/article/2007/03/31/AR2007033101040.html>