WRATT WASTE REDUCTION AND TECHNOLOGY TRANSFER FOUNDATION

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Waste Reduction and Energy Conservation in Schools

The WRATT Foundation has conducted waste reduction and energy use assessments for over 500 pre-k through college educational facilities in Alabama, Michigan, Minnesota, and other states. Based on work in these schools, a wide variety of commonly encountered problems and missed opportunities have been identified. This brochure is a product of that experience and presents a number of recommendations which schools and similar institutions may find helpful in reducing energy usage, waste generation and handling problems, and operating costs.

General Policy and Educational Matters

- Consider a school-level, rather than a central office-level, approach to utility bill paying and energy conservation. Under this type of program, funds are allocated to individual schools for energy use. Each school is expected to pay its own utility bills from these funds and may retain any unused money for other school uses. This approach has been extremely successful in increasing principal and teacher interest in and commitment to energy management issues.

- Consideration should be given to forming a Waste Reduction (WR) Team or Committee. Such an organization could consist of the school principal, custodians or maintenance persons, and representatives from the teaching staff and student body selected to serve for specified terms. The Waste Reduction Team would provide leadership and guidance by suggesting and implementing ideas to reduce waste, energy, and operating costs in the school. The committee should consider both source reduction and recycling approaches and should be given the freedom to propose or facilitate a variety of operational or educational projects.

- Waste reduction and educational opportunities can often be combined in the school environment. California's Integrated Waste Management Board has compiled a number of school-specific waste prevention ideas and projects at <http://www.ciwmb.ca.gov/Schools/WasteReduce/Prevention/> This list is a good example of the types of input that a school-level WR Team can provide. School level waste audits can also provide educational as well as WR opportunities. These types of audits are invaluable for determining exactly how much, and what kind of, waste is actually generated in a specific school. This information can serve as a necessary benchmark for future improvements. A good procedure for conducting such an audit is shown at <http://www.ijams.org/Pages/ef_audit.htm>

- Consideration should be given to including waste reduction issues in the educational curriculum of the school. Classroom exercises of the types shown at <http://www.ciwmb.ca.gov/publications/Schools/32200014.pdf> will involve and educate students in the concepts and practices of waste reduction, and make the goal of school waste reduction more easily attainable. Also, the National Science Teacher's Association has designed a middle level science curriculum on source reduction that can also prove helpful; it is available at <http://cygnus-group.com/NSTA.html>.

- Recommendations for reducing energy usage will be more readily accepted and implemented if decision-makers are given the proper background information. Local Boards of Education should schedule training for school principals (and other appropriate staff) in the areas of energy management and conservation appropriate to a school environment. This type of training is available from local utility companies and from major heating and air conditioning manufacturers.

Electricity Usage

Monthly electrical bills usually consist of two principal components. The first is a dollar charge for the total amount of electrical energy a customer uses and is

expressed in kilowatt-hours (kWh). The second is a dollar charge based on the rate at which electricity is used. This is normally based on the highest average amount (peak) of kilowatts required over a specified period (15 minutes, 30 minutes, etc.) during the billing period. This is referred to as the "billed demand" and is expressed in kilowatts (kW).

Reduction in Electrical Demand Charges

- To help reduce demand, a specific individual should be assigned to calculate and track the monthly demand charges accruing to the school, and to suggest and implement options for reducing electrical demand. Billed demand is usually itemized on the monthly electrical bills.
- Demand can be reduced by sequencing the start-up of equipment, especially HVAC, building lighting, kitchen appliances, and shop equipment such as welding machines, so that they do not all start at the same time.
- Where possible, try to shift electrical loads from occurring at the same time in the day to different times throughout the day (i.e., schedule shop classes in the afternoon after the kitchen equipment is no longer being used).
- Although many demand billing approaches measure peak demand over say, a 30 minute period of time, simply staggering equipment startups every 30 minutes may not actually help reduce demand. Most electrical heating and air conditioning equipment, after startup, will use peak power for a longer period than 30 minutes before the building or room temperature comes to equilibrium and the unit(s) begin to require less power. Exactly how to stagger the startup of specific pieces of equipment will depend on the characteristics of the equipment involved, the type of service the equipment is expected to deliver to the school, and the time period the utility company uses to determine billed demand.
- Significant savings in demand can also be realized by reducing energy usage.

Reduction in Electrical Use Charges

Opportunities for reducing electricity usage occur primarily in lighting, HVAC, and building envelope design and maintenance, and are discussed in he following sections.

Lighting

A substantial amount of electricity can be saved by changing the equipment and approaches used in lighting school facilities, because lighting can account for over 40% of a building's total electrical load.

- In general, all incandescent lighting should be replaced with some type of fluorescent or high intensity discharge lighting.
- Replace all older T-12 fluorescent lamps and magnetic ballasts with newer, more energy efficient T-8 lamps and electronic ballasts. With proper selection of fixtures and the use of 50% delamping, this upgrade can produce the same amount of light as the older approach, but can reduce affected lighting costs by as much as two thirds.
- When renovating lighting systems, specific attention should be given to lighting levels recommended by the Illumination Engineering Society of North America (IESNA). For example, simply replacing T-12 fluorescent lamps and magnetic ballast systems with newer T-8 fluorescent lamps and electronic ballast systems on a one for one basis will reduce electrical usage but will likely produce lighting levels much higher than necessary and at an unnecessarily high lighting power density (see below). In many cases, replacing T-12 systems with T-8 systems and delamping 50% will still maintain the appropriate lighting levels.
- When renovating lighting systems, try to attain lighting power densities of between 0.8 (using natural day lighting) and 1.2 connected watts per square foot, to save on electrical usage and reduce demand. This will require careful attention to the type of lighting and fixtures used, as well as the placement of these fixtures.
- When replacing incandescent bulbs with compact fluorescent lamps (CFLs), ensure that the fixtures into which the CFLs will be placed do not allow the buildup of heat (many recessed, enclosed, or inverted fixtures). Excessive heat buildup around CFLs will reduce both their lumen output and their lifetime (sometimes dramatically).
- Where possible, particularly with new installations, consider a combination of natural daylighting and automatic dimming controls. Under optimum conditions, these can reduce affected lighting costs by 35-70%. It is imperative that these systems be installed, and each installation specifically tuned, by qualified professionals.
- Another lighting issue that should receive attention during renovations is switching. Older systems usually use a combination of 2 and 4 lamp, 4- and 8-foot T-12 fixtures, usually con-

trolled with one wall switch; i.e., all lighting in the room is either "on" or "off.") A very effective, efficient, and popular alternative is to replace existing 2 or 4 lamp T-12 fixtures with 3 lamp, 4-foot T-8 fixtures, switched so that either 1, 2, or all 3 lamps in each fixtures can be powered. This arrangement gives teachers and staff more flexibility and control of room lighting.

- Where it is not practical to immediately switch to T-8 fluorescent lamps and electronic ballasts, consider: (1) replacing T-12 40-watt lamps with T-12 34-watt lamps , and (2) initiating or expanding an intentional delamping program for existing fluorescent fixtures, particularly in hallways, near natural light sources (windows), and in infrequently occupied storage areas. When delamping fluorescent fixtures, be sure to disconnect unused magnetic ballasts. If only the fluorescent lamps are removed, the ballast will still continue to draw power, reducing the benefit of delamping.

- All fluorescent lamps contain mercury, so WRATT suggests that school systems adopt a policy of purchasing reduced mercury lamps. The lamps are usually identified by green end caps, or green lettering on the lamp tube. Philips Alto®, General Electric Ecolux®, and Sylvania Ecologic® are examples of this type of product.

- For large area, high-ceilinged rooms, such as auditoriums, gymnasiums, and multipurpose rooms currently lit by incandescent or older mercury vapor lighting, consider switching to a newer form of specially designed high-bay fluorescent fixtures using high-output T-5 lamps. These systems may be equipped with occupancy sensors and multi-level sensing to take advantage of outside lighting such as skylights. Not only is this combination of fixture and lamp much more efficient than incandescent or mercury vapor lighting, but because it is fluorescent, it is also 'instant-on" and does not require lengthy restrike times.

- As practical, replace incandescent EXIT signs with LED (light emitting diode) EXIT signs. While more expensive to purchase than the more traditional incandescent or fluorescent signs, LED exit signs draw only 2-5 watts and have a life expectancy of 25-80 years.

- Consider using crank-timers or motion sensor switches for lighting in rooms or areas that are infrequently occupied (i.e., restrooms, locker rooms, storage areas, and mechanical equipment rooms). This will eliminate the possibility of lighting being left on when no one is in the area. Selection and installation of motion sensors with fluorescent lighting should be done only by professionals.

- Switch from timer-controlled security lighting to photosensor-controlled security lighting. These sensors do not have to be continually reset or adjusted as sunset and sunrise times change during the year. Try to install photosensors where birds or wasps will be unlikely to build nests over them. If manual controls must be used, assign a specific individual to ensure that lights do not remain on during the daytime.

- Establish and maintain an effective schedule for cleaning dirty diffusers or replacing badly yellowed or discolored diffusers on fluorescent fixtures; these can easily absorb more than 30% of the fixture's light output. Replace small para-cube louvers (that have gridwork or cells less than one inch) with louvers that have a larger, more open grid pattern. This will provide more light output for the same energy usage.

- Where open top fluorescent fixtures have been intentionally selected to provide indirect lighting by allowing light to escape from the top of the fixtures and be reflected from the ceilings, make sure the ceilings are painted a light reflective color and are less than two feet from the top of the fixture. Otherwise, the light exiting the top of the fixture will be effectively lost. If this is impractical, consider installing relatively cheap reflectors in these fixtures which will direct the light downward where it can be used.

- Where schools leave building lighting on as security lighting at night , a specific individual should be assigned to turn this lighting off during school hours. If the school does not have separate security lighting, determine if only a portion of the building lighting can be isolated for security lighting.

HVAC Systems

Heating, ventilation, and air conditioning equipment and operations are major users of electricity, gas, or both. The following recommendations will be helpful.

- Establish a specified temperature range for heating and cooling and a procedure for adjusting the thermostat to achieve this range. Example: Temperature setting - heating season - 68°F; cooling season - 76°F. Limit thermostat adjustment to $\pm$2° to achieve this range.

- A building energy management systems, properly installed and operated, can reduce both electrical use and demand.

- Establishing and adhering to a schedule for treating boiler water will add years to the boiler's effective life and reduce maintenance costs.

- Heating in high bay areas, such as gymnasiums, can be improved by installing fans or air handling units at the ceiling to force heated air down to floor level.

- Gas radiant heaters may be used in the gymnasiums. The general concept of heating people (with radiant heaters) instead of trying to heat all the air (forced air heaters) may be a more practical solution where open doors and substantial air exchange is necessary during cold weather.

- Consideration should also be given to newer forms of HVAC equipment, particularly ground source (or geothermal) heat pumps. This type of equipment has yielded energy cost savings of 50 percent or greater in some school systems.

- On an annual basis, refrigerant levels should be verified, and heat transfer fins cleaned. Low refrigerant levels and dirty fins will reduce equipment efficiency and increase utility costs, and can also increase maintenance costs and shorten equipment life.

- Use the waste heat from the kitchen refrigerator and freezer compressors for heating, especially during cold weather operation.

- Review the adequacy of insulation on boilers.

- Establish and adhere to a schedule for cleaning or replacing air handling filters to decrease utility costs and maintenance, and to increase equipment lifetimes.

- Proper operation of economizers, which supply ventilation and potential free cooling or heating, should be checked annually. The economizers may be upgraded to include dual enthalpy sensing; sensing both outside and return total heat content to determine the optimum air source

- When planning renovations, consider performance contracting as an approach which will allow HVAC upgrades with no capital or other up-front costs for the school system. Contractors are paid through utility bill savings after equipment upgrades and school renovations are completed. A thorough energy audit of school operations is required to correctly identify practical energy saving approaches, and the school system should insist on a total life-cycle cost analysis of all proposed options.

- Beware of oversized cooling systems. Whether by design, or because of building remodeling subsequent to the installation of the equipment, oversized air conditioners will 'short-cycle', contributing to high humidity, the growth of mold, and other indoor air quality problems.

Building Envelope

Temperature and humidity problems that result from building envelope issues can have a serious impact on comfort, building lifetime, and utility costs.

- To reduce solar heat loading in the summer and building heat loss in the winter, use double-pane windows with energy efficient framing (vinyl, aluminum with thermal breaks, or wood).

- Effective window treatments (blinds, shades, etc.), storm windows over regular single pane windows, or various types of solar screening or reflective films on the outside of the windows will also reduce energy costs. This is particularly important on the southern and western exposures to buildings.

- Properly designed doors (with vestibules or airlocks) should be installed. Make sure that weather-stripping, sweeps, and caulking around and under exterior doors and windows are in good repair and that the doors seal properly when closed. While these individual air leaks may seem small, throughout an entire building they can have the same aggregate effect on heating/cooling as leaving a window open 24 hours per day, seven days per week.

- School should adopt a policy of shutting exterior doors during cooler and warmer weather to reduce heating and cooling costs.

- Classroom ceilings should be no higher than necessary to reduce cooling and heating requirements.

- Check attic spaces for insulation. Add enough insulation to the R-level appropriate to your locality to reduce heat loss during colder months. Consider adding a thermal barrier to minimize solar heating during warmer months.

- Consider the use of reflective roof materials or coatings to reduce heating costs

- Install foot paths on gravel roofs to avoid damage to roof liners under the gravel.

Other Improvements

- Establish a system-wide policy regarding unplugging drink machines or water fountains during periods of non-use (summer, Christmas break, etc.).

- For schools with swimming pool facilities, periodically review the efficiency of pool heaters, filters, and pumping equipment.

- Make sure new computers and office equipment are EPA Energy Star®–compatible (i.e., they have energy management software) and make sure the energy management software is enabled. This allows the monitors, hard drives, and processors to power down (and thereby draw much less electrical power) after a pre-set period of inactivity. This feature also allows the equipment to "wake up" in seconds when a student or staff member touches a mouse or the keyboard. The EPA has estimated that anywhere from $7 to $52 per year per computer may be saved by using Energy Star® equipment.

- Establish a periodic maintenance program for compressed air systems in school shops. At a minimum, check for air leaks, excessive pressure, and excessive pressure dorp across the system.

Water Use Efficiency

Water use and sewage treatment costs are commonly much higher than necessary.

- Consider use of self-closing water faucets in restrooms, particularly hot water faucets. These can be adjusted to deliver a set amount of water and then automatically turn off. This will eliminate the possibility of water faucets being left on, wasting water and/or the electricity or gas it took to heat that water. This type of faucet can save as much as $700 in water and heating costs over the estimated 10-year lifetime of the faucet.

- Consider the use of devices to automatically flush the fixtures in the bathrooms.

- Consider the use of flow restrictors in faucets and shower heads.

- To avoid unnecessary sewage treatment charges, make sure that irrigation water supplies (for athletic fields, for instance) are metered separately from main building water supplies that are discharged into city sewer systems.

- Guard against too-high building water pressure. Water-using appliances and equipment are generally designed to expect system water pressure of about 60 psi. Very high water pressure will waste water and can harm equipment. Studies have shown that reducing water pressure form 80 psi to 50 psi can save 30% in water use costs.

Recycling

Recycling programs can provide good opportunities to satisfy both educational and cost reduction goals.

- Schools should develop recycling programs for aluminum cans, glass containers, plastic, paper, and cardboard. Large steel food cans (from the kitchen) can also be recycled. If the volume of some materials is too small to allow recycling, collaboration with other schools or nearby businesses may increase the volume of the materials to the point where recycling becomes practical.

- Evaluate the refuse currently put into dumpsters for items which can be recycled. Wastes from janitorial supplies, from the wood shop, and from the kitchen are possibilities. Excess food can sometimes be given to local food shelves or sold to hog farmers, local laws permitting.

- Schools with larger campuses may wish to consider composting of kitchen and other organic wastes. Substantial savings of waste handling costs can be realized.

- Laser and Ink-jet printer cartridges can be mailed free for recycling. Pre-addressed labels for recycling ink-jet cartridges may be available at your local post office.

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