School Housing Optimum Resource Efficiency

NCSSSMST Google Sketchup "Green" School Competition

High Technology High School

In building an environmentally-friendly school, numerous aspects must be considered. The location and structure of the school were some of the most important aspects, and the first to be decided. A school located near public fields would benefit the environment and the budget by taking advantage of existing community resources. A multistory school, by minimizing the building footprint, prevents plant destruction during the construction phase. Due to Monmouth County, New Jersey's suburban location and lack of a comprehensive public transportation, the best solution was to locate the school directly off of a major road to better handle the traffic flow of a large school. Thompson Park (40°20'N 74°09'W) met all of these criteria: it is located off of a major road (County Road 520), and it has ample open space.

School transportation is one of the most costly and environmentally destructive elements of running a school. However, hydrogen fuel for busses solves this problem. Hydrogen, nature's most abundant element comprises nearly 75% of the universe, making it a virtually renewable fuel source. Hydrogen can be easily produced through electrolysis of water as well as biologically with *Chlamydomonas reinhardtii* algae. Therefore, the design for our school includes a solar-powered electrolytic hydrogen production and fueling station. Also, the aforementioned algae biologically produce hydrogen in the greenhouse on top of the school. Because the fuel will be produced on-site, no transportation costs will be incurred. Aside from environmentally friendly production methods, the use of hydrogen fuel results in no harmful emissions. Each bus in the fleet will utilize hydrogen in a proton exchange membrane fuel cell, for which the only resulting emission is water. This is an improvement over much-touted biodiesel fuels. Biodiesel fuels produce emissions and require crops. Hydrogen is currently used by several bus fleets around the world. In fact, Iceland is working

towards a hydrogen based economy. Though expensive, this fuel is clearly feasible for our intended purposes, and will undoubtedly go down in price as time progresses. In order to further reduce pollution, the school would encourage students to ride their bikes to school and offer priority parking to those driving ultra low emission or hybrid vehicles.

The energy powering this hydrogen electrolysis will also be produced naturally. Energy for the school will be harnessed from arguably the most abundant and renewable resource – The sun. Solar panels composed of cadmium telluride thin film, rather than the more common and more expensive crystalline silicon, will be placed on the roof of the school. Cadmium telluride thin film technology results in a higher energy yield at a lower cost. A "solar parking lot" will also incorporate this Cadmium telluride film. This parking lot, unoccupied during the day, will allow solar panels embedded in the pavement to collect solar energy. The lot accommodates overflow parking during large after-school activities such as sporting events or plays. In addition, all south facing exterior windows will be constructed of photovoltaic glass. This new technology consists of solar cells that are embedded between two glass panes with a special resin filling the gap between the panes. While indiscernible from typical glass, the result can provide a significant portion of the school's power. All other windows will consist of two panes of glass, insulated with argon to save on heating and cooling costs.

This school will be constructed entirely out of recycled and renewable materials. For instance, cabinets will be constructed from recycled, biodegradable, premium-grade particleboard, and the different layers of the glass windows from recycled glass bottles. In addition, the present concrete production process results in carbon dioxide emissions. Current research at leading institutions, such as Drexel University, demonstrates that stronger concrete can be produced without the negative effects of carbon emissions. Also, this type of concrete has desirable thermal

properties as well as significant structural strength. Therefore, this new construction method will be utilized in the construction. It is a strong, dense, material, providing optimal thermal mass.

The school utilizes a passive solar model. By maximizing natural properties of heat exchange, the school will save considerably on heating and cooling costs. Thick, walls and floors constructed of dense concrete act as thermal mass stores by smoothing out temperature differences throughout the day, thus reducing heating and cooling needs. Societies have used this same principle for centuries, beginning with the adobe buildings of ancient civilizations. During the warmer months, closed blinds and the fan in each room will decrease the need for costly air conditioning. Trees placed along the window level of the school will provide a natural approach to reducing incoming heat in the summer by minimizing sunlight entering the building. In the winter, the leaves fall off and more sunlight passes through, heating the building during the coldest season. The advanced air recirculation and filtration system will filter the air and actively monitor it for hazards such as radon, carbon monoxide, excess carbon dioxide, and mold. Each room will be equipped with carbon dioxide sensors; the system can determine whether the room is occupied and provide appropriate climate control. Geothermal exchange heat pumps will also be installed to reduce heating needs by drawing up cool air when the air is warm, and vice-versa, using the ground temperature as a medium.

In order to reduce the environmental impact of the school, sections of the roof are covered in grass and biological carbon dioxide sinks. These will simultaneously act as a thermal mass store and benefit the surrounding area by filtering carbon dioxide out of the air. The school roof also incorporates a greenhouse at its center. Fruits and vegetables grown in the greenhouse will augment the food selection in the cafeteria with healthy, organically-grown foods.

Lights consume a large percentage of the total energy usage of any building, each room of the school will utilize LED light bars. These Light Emitting Diodes have a high initial cost, but pay

for themselves in the long run due to their massive lifespan and decreased energy consumption in relation to fluorescent and incandescent bulbs. LED bars can be bent and cut into different lengths, so they can be placed in the optimal location which will allow for the most efficient lighting. Fiber optic bundles will capture light from the outside and diffuse it inside as natural accent light in rooms without windows. Additionally, photoreceptors placed in each room will monitor lighting conditions and balance light provided by the sun and LEDs. Teachers will be able to override this system in the event that a room needs to be darkened for projector usage. Minimal outdoor lighting will also save on energy costs. Outdoor lights will only be placed where necessary for safety.

Since computers and lighting are the major uses of electricity in the school. Lighting accounts for approximately 20% of energy used, and computers are 80%. Taking into account that lights and computers will be on for about ten hours during the day, the total energy use will be close to 182 kWh per day. This number includes miscellaneous energy usage. Due to the LED lights and high efficiency laptop batteries, this school has relatively minimal power consumption. All necessary electricity will be produced by the solar panels on the roof. Considering the placement of 7000 panels at 170 watts each, a total output of 8400 kWh can be produced on sunny days. This far exceeds the energy requirement of the school, and excess energy can be sold back to the power grid.

It is important not only to conserve energy, but other resources as well. Schools consume large quantities of paper each year for textbooks, photocopied assignments, and note-taking. To reduce paper usage, the school will issue each student a digital tablet in place of their textbooks. Such digital tablets are already being used to replace books in more conventional schools. Unlike laptops, these tablets have sufficient power to operate all day. Providing students with tablets eliminates their large heavy textbooks reducing the loads students must carry. The majority of assignments will be composed and submitted in digital form in order to reduce paper waste. Also, to make more efficient use of space in the school, laptop carts will replace dedicated computer labs.

These portable labs, accommodated by a school-wide Wi-Fi network for internet access and file sharing, are more versatile and provide comparable performance to a conventional computer lab.

A terraced, constructed wetland lies behind the left wing of the school. The wetland is a closed system that recycles and treats water from bathrooms, the cafeteria, and other sources of grey-water, returning it to the building and bathrooms. The wetland is modeled after biological processes in nature; particularly those located in reed beds or natural wetlands that clean water. It will yield water clean enough to water plants without producing any odor. Organic waste from the kitchen will be moved to a compost heap, where it can decompose and later mulch plantings on the school campus. Less irrigation will be needed with the use of exterior planting more suited to an arid climate. Water needed for irrigation will be supplied by the wetland. Also, rainwater collection units will accumulate and store water for various purposes. Low-flow toilets and waterless urinals installed will cut down on unnecessary water usage, decreasing waste in the first place. The school will stress recycling, with receptacles placed throughout the building for batteries, glass, cardboard, paper, and plastic.

With such a wide range of resources available to the school's students, teachers will be encouraged to incorporate environmental concepts into their curriculum. Students, particularly in science classes, will observe and take part in the green operation of the school by maintaining the constructed wetland, tending to plants in the greenhouse, and numerous additional environmental pursuits. Graduates of the school will have a greater appreciation for the world around them and perhaps become major proponents of the "green" movement.