Sustainable Roofs for Buffalo Schools

Andrew Zemrac
University at Buffalo Law School
Green Cities
Fall 2007

Executive Summary

The Buffalo public school system, currently in the midst of a ten year, 1.1 billion dollar reconstruction project, has a unique opportunity to create sustainable, high performance schools. Instead, the Joint Schools Construction Board has apparently decided to take a more conservative approach to the renovation plan, incorporating commendable but limited initiatives such as updates to windows, lighting systems, heating systems, and exterior weatherization improvements.

This myopic agenda is a serious mistake. It bars the schools from reaching their full potential as centers of education for the children and the community. It fails to take advantage of readily-available techniques that reduce pollution and produce important, long-term savings on energy costs.

There are many possible enhancements that would increase the sustainability of the schools. One promising area is the use of the schools' roofs. Often forgotten wastelands, school roofs could be turned into valuable resources.

First, school roofs can be treated with various mediums to help lessen the impact of the sun's heat during the warmer months of the year. Referred to as cools roofs, these systems create a more comfortable learning environment for children in buildings that lack air conditioning systems. Cool roofs also make if more feasible to use schools year round, giving the surrounding community a meeting place, entertainment venue, and sporting event facility.

Second, rainwater from the roofs can be harvested and reused for various functions around the school. From watering athletic fields and foliage around the campus to supplying the medium for toilet flushing, rainwater has potential value for schools. Harvesting rainwater also has many benefits. Schools may save money by reducing their water bill. Less storm water runoff will find its way into Buffalo's combined sewer system, decreasing the likelihood of polluting combined sewer overflows. Starting rainwater collection and reuse efforts now may also be an important first step toward addressing the potentially severe effects that climate change will have on our local water supply.

Third, school roofs can be transformed from barren and unused surfaces into greenroofs. This change involves the planting of gardens with various types of foliage, depending on such factors as the purpose of the garden and load bearing capacity of the school's roof. There are many benefits associated with greenroofs. The school roof's life is extended as it is protected from the effects of weather. The building obtains an extra layer of insulation, keeping in heat during the cold months and lowering energy bills. Also, storm water is captured by the garden, diminishing the amount of runoff.

Finally, alternative energy sources such as solar panel systems can be installed on school roofs. Harnessing the sun's energy not only lowers the electricity bill, but also creates a valuable learning tool for children regarding sustainable living practices.

The Joint Schools Construction board should reconsider its conservative approach to incorporating sustainable initiatives into the reconstruction project of Buffalo's schools. Failure to do so now may result in a missed opportunity to provide the best learning environments for community children, maximum protection of the environment, an environmental standard to be emulated and further economic savings to the Buffalo school district.

Introduction

The Buffalo Public School District is renovating most of its schools. Buffalo schools are some of the oldest in the nation; more than 60 percent were built before 1930. The renovation project is one of the City's several substantial initiatives to stabilize itself after years of economic decline and population loss.

The project includes changes to school programs and curricula in addition to physical reconstruction and is expected to require more than one billion dollars in funding. Approximately ninety-four percent will come in the form of reimbursement payments from the State Education Department of New York. The remaining share – roughly 62.7 million dollars – will come from local sources. Such an overdue infusion of economic aid aims to improve the city schools' facility quality as compared to their suburban counterparts. These funds will also help to save money for the school district in the long term by increasing the energy efficiency of district buildings.

The Strategic Plan Recommendations of 2004, used as the guiding principles and goals by project management company LP Ciminelli during reconstruction design, contain several goals to be implemented among five construction phases. Each phase includes measures to improve school operational efficiencies, incorporate feedback from the schools' immediate communities, and address funding considerations. Such measures are certainly admirable and necessary for a successful project. Yet they fall short of requiring sustainable building practices during the reconstruction process that will help mitigate the impact city schools have on their surrounding environments over the long term. This myopic agenda in current school reconstruction plans is a serious mistake.

The Problem

The current reconstruction project calls for deficient sustainability measures, thus potentially defeating its two most important purposes:

First, the schools will have lost an important opportunity to realize their full potential as learning centers and community standards. Most of the schools being reconditioned are situated in our city's poorest neighborhoods. Such neighborhoods experience a high degree of urban blight in the form of vacant houses, decaying sidewalks, graffiti, inadequate or nonexistent green space, and garbage-strewn empty lots. Schools currently under or slated for reconstruction are in a unique but temporary position to develop into shining examples of the educational and societal standards to which their communities can aspire.

Such a beacon should not be limited to the aesthetic, or even the efficient, effects of new windows, lighting, heating systems, remodeled classrooms, and exterior cosmetic and weatherizing enhancements as proposed by the existing project plan. Rather, strategic construction plans should capitalize on this rapidly fading opportunity to incorporate more extensive projects that promote sustainability. Today's schools should be modern learning centers that incorporate environmental responsibility and sustainable practices such as sustainable building construction into their curricula, using themselves as their most illustrative examples. Schools should not only be a source of pride for struggling families in struggling neighborhoods, but also the guiding standards that surrounding neighborhoods strive to emulate.

Second, incorporating sustainable building practices could further increase the long-term savings already associated with the various updates being made to heating systems, lighting, and building envelopes.

Unfortunately, what is seen first when sustainable building practices are considered is a higher cost of construction. The response to this objection comes in two forms: First, the district is already using calculated energy savings from planned improvements involving up front costs to help finance its local share of the project. What is stopping the process from continuing when savings from sustainable building practices are considered? Second, we are not the first school district to consider these sustainable upgrades to local schools. Scientific studies and other communities around the nation, around the world, serve as sources of evidence to prove that in the long run, higher up front costs will be repaid over the life span of the sustainable initiatives. Often the repayment period is much sooner.

Money saved over the long term can create greater financial flexibility for the Buffalo school district. It was only five years ago that the district laid-off hundreds of employees because of repeated budget deficits. An increase in savings on energy costs would ease the financial strain experienced by the district.

Possible Aspect of the Solution

One area of the schools that could be targeted for sustainable projects is their roofs. Often considered vast wastelands never seen by the surrounding neighborhoods or even the individuals they help protect from nature's elements, these areas of schools can serve as important sources of energy savings, water conservation, and environmental protection.

This proposal describes several options that the Joint Schools Construction Board should consider for school roofs going forward with the reconstruction process.[i] These alternative roof enhancements may be used in combination with one another. Some of these suggestions also depend on the actual physical structure of the existing roof. For example, size, load capacity, and existing insulation may affect the attractiveness of some of the following alternatives. The natural lifecycle of existing roofs is also an important factor to consider. For instance, if any of the district's school roofs have recently been redone using standard techniques, it probably wouldn't make economic sense to upgrade them so early in their life cycle. However, the Joint Schools Construction Board should seize this opportunity to create schools that have roofs that provide the greatest benefit to the children, the district, and the community.

Cool Roofs

To be considered cool, a roof must reflect a substantial amount of the sun's light and radiate solar energy away from the building.

Typically, large roofs are covered with a standard layer of tar as a sealant against inclement weather. This method of roof protection is very common in buildings with a high square footage of roof space, such as the Buffalo schools, because of its relatively low, up-front cost. However, tar sealed roofs experience high rates of heat absorption because the low reflective rate of its dark color. This concept should seem quite familiar to anyone who has planned a wardrobe for an active day outside in the sun. In such a case one might choose a lighter color over a darker one because of the tendency of the lighter color to reflect some of the sun's rays and heat, keeping the body cooler.

How much of a difference can raising the reflective level of school roofs make in helping keep schools cooler during the hotter months? It is difficult to know the extent that current tar roofs increase the temperature of school buildings throughout the district. There are many variables in each school's construction that affect indoor temperatures, such as heat transfer and air circulation. The New York-Collaborative for High Performance Schools (NY-CHPS), a manual of planning standards for school construction in the state, suggests that schools should conduct energy modeling to help predict which facilities would benefit the most from having a cool roof.

However, tar roofs do experience high temperatures and transfer heat to the building below.[ii] By contrast, the exceptional reflectivity and heat release capabilities of a cool roof combine to significantly lower roof temperatures and decrease temperatures inside the buildings. When a roof reflective rating of 0.24 (0 being the least reflective and 1 being the most) is raised to 0.60, the roof temperature on a hot, sunny day can decrease by as much as 55 degrees.[iii]

In most other similar school renovation projects, the aim of cool roof construction has been to improve the efficiency of buildings' HVAC systems. Buffalo schools do not air conditioning, so the district does not stand to save money on air conditioning costs. However, a cool roof makes a cooler building, resulting in higher overall comfort levels with or without air conditioning.[iv] One of the underlying goals of rebuilding Buffalo's schools is to create comfortable learning environments for the children. An increased building temperature because of tar roofs during the warmer months of the recently extended school year does not contribute to this goal.

District schools may also be used for various community activities during the summer months when school is not in session. From community meetings to the use of the gymnasium and auditorium for various events, Buffalo schools should be constructed and used as year round resources for surrounding neighborhoods. Having cooler buildings due to higher performing roofs that reflect the suns heat enhances the comfort and feasibility for using the schools for these various functions.

Current tar roofs also contribute to an increased heat island effect surrounding the school. An analysis undertaken by the Lawrence Berkeley National Laboratory (a U.S. Department of Energy research facility), the U.S. Environmental Protection Agency, and NASA's Global Hydrology and Climate Center experts shows that since the 1930s, peak summer temperatures in Los Angeles have increased by about 8°F due to the replacement of natural vegetation by commercial buildings, pavement and homes.[v] In other words, oxygen-generating and cool moisture-producing plant life has been replaced by vast expanses of heat-absorbing black tar surfaces.

Cost can be a chief concern when considering the installation of a cool roof. For reference, a 30,000 square foots roof cost $23,900 to coat with a durable reflective substance in 1998. Included in the cost were materials, at $15,100, and labor, at $8,800. These numbers must to be adjusted for inflation to have a true sense of 2007 values.

Also, inflation adjustment would be offset by a lower price for materials as economies of scale due to increased demand take effect.

There are many different types of roofing systems to choose from to help lower the temperature of the city's school roofs. The higher performing systems can all be expected to have a reflective rate of around 0.70. Some systems require a coating of a durable substance that expands during the summer as it is warmed and returns to its original shape when it cools. Other systems come in more tangible form of pre-fabricated sheets, such as vinyl. Whatever form is chosen, several questions of prospective installation contractors should be asked. Some of these questions include:

- What type of coating materials will you use, based on your expert opinion?
- What is the reflective rate of the material?
- What is the cost of the coating material per gallon?
- How many coats need to be applied?
- What is the guaranteed lifetime of the coating?
- What are the labor costs per hour?
- What is the time and cost of preparatory work?
- What are your experiences and references in coating work?

Rainwater Collection and Reuse

The collection and reuse of rainwater from school roofs serves as a water conservation effort in the face of potentially diminishing resources. Rain harvesting also eases the burden placed on Buffalo's combined sewer system. On average, 68 combined sewer overflows occur annually as the result of rain and melting snow.[vi] When overflows occur, storm water and sewage are discharged into local waterways, polluting them.

At this point, rainwater collection and reuse efforts are more commonly occurring in arid states such as Texas. Roy Lee Walker Elementary School in McKinney, Texas, a new build school which finished construction in 2000, is an example of a school designed with sustainability as a primary goal. Construction plans incorporated water conservation initiatives to help offset the arid conditions that the school found itself. Rainwater was collected from the school's roof to water the native grasses and plants found around the school grounds.

With Buffalo's proximity to a portion of the largest sources of fresh water in the world, we do not always view conservation of water as a pressing issue. This might not be a luxury we enjoy for long, though. Climate change due to global warming is becoming harder to dispute as evidence continues to support its existence. For example, a report by the Union of Concerned Scientists estimates that due to climate change attributable to greenhouse gas emissions, by the end of the century, Buffalo may experience an average of 14 days per year where the temperature exceeds 100 degrees and 50 days per year where the temperature exceeds 90 degrees. Summer may be extended by an additional 26 days per year. An increase in frequency of short and medium length droughts is associated with these higher temperatures and longer warm periods of the year. Finally, the frequency of intense rainfall events, where two inches or more of precipitation falls over a 48 hour period, is estimated to increase by 12 to 13 percent by the end of the century.[vii]

A 17 million dollar, five year study is being conducted by the International Joint Commission, an entity that advises the United States and Canada on water resources, to determine if recent shrinking of the Great Lakes is attributable to the recent seasonal water cycle or climate change. This study should be completed in 2012.

Measures should be taken now to mitigate the extent of the looming water crisis our area will face over the next century. One alternative Buffalo schools could use is cisterns. These large retention drums are commonly used in rainwater harvesting systems. Cisterns can be buried underground or remain above ground and be incorporated into the design of the building, as seen in the above image of the Roy Lee Walker Elementary School.

The cost of rainwater collection systems can vary, depending on the uses planned for the captured water. For instance, if the water is going to be used as graywater for toilet flushing purposes, extra components are needed to first treat the water, driving up the cost of the project. To avoid this cost, Roy Lee Walker Elementary School chose not to use captured water for flushing toilets. Instead, the school reuses captured rainwater to hydrate natural grasses and plants located on school grounds. Several sources have indicated that one dollar per gallon of cistern tank used is a good rule of thumb to estimate system costs. Local experts could provide a more precise estimate on costs.

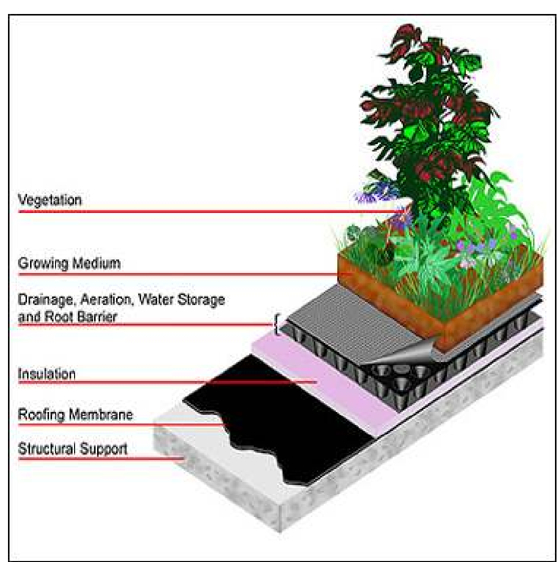
While rainwater collection from school roofs cannot be the sole solution to water conservation and Buffalo's combined sewer overflow problem, it would be foolish to ignore the chance currently present in the schools reconstruction project to incorporate a forward thinking roof alternative that mitigates the extent of these two water related problems. To act now would put Buffalo at the forefront of rainwater collection efforts in the United States and help develop a city image of being environmentally friendly.

Roof Top Gardens

Another exciting alternative for school roofs is the development of greenroofs. These are quickly becoming mainstream additions to buildings striving to become sustainable and environmentally friendly. They provide several benefits to the buildings that house them. First, water trapped by the foliage helps mitigate storm water runoff that would otherwise find its way into the combined sewer system of Buffalo. Fifty to seventy percent of annual precipitation can be captured by a greenroof.[viii] Second, roof top gardens extend the life of existing roofs by protecting them from the harmful affects of the sun and inclement weather. Third, the garden's soil acts as an insulating agent for the building during the cold winter months. Finally, roof top gardens help lessen overall noise associated with urban settings by creating a sound absorbing surface.

Greenroofs have yet to be incorporated into a sizeable number of buildings in the United States but have been used around the world for centuries. The Hanging Gardens of Babylon, built around 500 B.C., are an early example of this sustainable practice. More recently, Europe has led the way in the use of greenroofs. It is estimated that 14% of all flat roofs in Germany are green.[ix]

The number of layers incorporated into a green roof to protect the existing roof



varies from system to system. As seen in the image to the right, typical greenroof gardens have the following layers: waterproofing or roofing membrane; drainage; growth medium; and vegetation. Flat roofs with a pitch less than five degrees often have an extra layer to drain excess water. Types of vegetation are dependent on the locality of the garden and the depth of the growing medium, or soil.

There are two main types of green roofs. “Extensive” greenroofs are not designed for public use. Instead, their function is primarily an environmental one. They typically have a soil depth of 1-7 inches and exert 15 pounds per square foot on the underlying roof. Vegetation associated with these types of roofs is of the hardier variety that can withstand extreme weather conditions and require a low amount of maintenance.

The second type of greenroof, “intensive”, is designed for public use. Gardens that fall into this category often have trees, shrubs, various flowers, walkable paths, and benches. Intensive garden soil depth ranges from eight inches to four feet and pounds per square foot exerted on the underlying roof can range from 80-150. These types of gardens are considerably more labor intensive in their upkeep.

The cost of to install a rooftop garden can vary based on type of garden, size of garden, and type of foliage chosen for the garden. However, costs for all types are estimated to average between 15-20 dollars per square foot.[x] As with some other sustainable initiatives, the up front cost to install a garden can seem daunting. Monetary benefits stemming from easing of strain on the sewer system, lowering of energy consumption, and improved air quality can be difficult to quantify and may fluctuate due to unforeseen circumstances. It has been estimated though that greenroofs with a lifespan of 40 years return the investment put into them in 20 years.[xi]

There are already examples of school districts within New York State installing greenroofs. The Calhoun School, located in New York City, opened its Green Roof Learning Center in May 2005. Benefits attributed to the semi-intensive garden include mitigating storm water runoff (reportedly by 40 percent), insulating the school during cold months of the year, improving air quality, providing a learning environment for biology and math for the students of the school, and supplying herbs grown in the garden to food service employees. This does not even take into account the example it sets for the students and members of the community of the importance of incorporating sustainable practices into our daily lives.

Due to their costly nature, greenroofs cannot be the alternative of choice for every school in the district. The load bearing capacity of district schools may also limit eligibility. However, because of the many benefits and the cost effectiveness of greenroofs over the long term, the Joint School Construction Board should at least consider this alternative.

Installation of Solar Panels

The final proposal that should be considered for use of the Buffalo school district's roofs is the installation of solar power systems as an alternative energy source. These systems could help alleviate the burden that schools put on the local energy grid, especially during daytime peak hours when overall demand can increase the service rate.

The State of New York has realized the benefits of linking schools with solar power; it recently offered a *School Power…..Naturally* program through the New York State Energy Research and Development Authority (NYSERDA). This 2.1 million dollar program picked 50 schools from an open application process to receive small solar energy and data collection systems worth about $24,000. Each system provided the school with 2 kilowatts worth of energy. The data collection system was included to link the solar system with a course curriculum in the classroom regarding alternative energy and sustainability. Unfortunately this demonstration project ended in 2006.

The difficulty in incorporating the installation of PV systems into the Buffalo schools reconstruction project is the cost effectiveness of the system. The NY-CHPS High Performance School Guidelines depict two cases studies of schools that installed PV systems. The first school's kilowatt output was 56, 54 higher than that offered in the NYSERDA *School Power.....Naturally* program. The 56 kilowatts only accounted for 9.9% of the school's energy needs. The second school's kilowatt output was 34, 32 higher than offered in the NYSERDA *School Power.....Naturally* program. The 34 kilowatts only accounted for 2.3% of the school's energy needs.

These two instances illustrate that the percentage of energy needs met remained relatively low. With a reconstruction project that is heavily dependent on recouping energy costs to make up the bulk of the local share, PV system installation may not make economic sense without state subsidies. Fortunately, NYSERDA funding of up to 70% for PV systems is currently available.[xii]. PV systems can also meet the goals of educating the schoolchildren and the local community about sustainable building practices, a goal that the Joint Schools Reconstruction Board should be incorporating into this project.

Conclusion

The Joint Schools Reconstruction Board has an obligation to ensure that energy efficiency and sustainability efforts are maximized. Using the roofs of the schools for such creative initiatives as cool roofs, rainwater harvesting and reuse, greenroofs, and renewable energy system installation would help the Board meet this obligation.

The alternatives mentioned in this proposal should not be considered an exhaustive list of possibilities of what could be done with school roofs. These alternatives might not each be the perfect fit for the existing structures. But perhaps the Board can look at these alternatives as a catalyst for a reassessment regarding its efforts to make the Buffalo schools as energy efficient and sustainable as affordably possible.

Endnotes

---

[i] It must be pointed out that efforts to construct sustainable schools should not stop at roofs. There are many other initiatives that can be undertaken to produce sustainable schools that serve as a standard to be admired, learned from, and emulated for cost reduction.

[ii] See, for example, "Cool Roofs," the U.S. E.P.A., October 2007, available at http://www.epa.gov/heatisld/strategies/coolroofs.html. See also, "Third Party Evaluation of 'Cool Roof' Technologies," the Texas State Energy Conservation Office, February 2007, available at http://www.seco.cpa.state.tx.us/zzz_sa/sa_coolroof-report2007.pdf.

[iii] Konopacki, S., L Garland, H. Akbari, and L. Rainer. Demonstration of Energy Savings of School Roofs. Ernest Orlando Lawrence Berkeley National Laboratory. June 1998.

[iv] National Coatings Corporation, Cool Roof Systems Overview, at http://www.nationalcoatings.com/cr-overview.shtml.

[v] Lawrence Berkeley National Laboratory Report LBL-28308, 1990.

[vi] *Buffalo Comprehensive Plan 2003-2004*. Published by the City of Buffalo.

[vii] Frumhof, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. *Confronting Climate Change in the U.S. Northeast: Science, Impact, and Solutions*. Synthesis report of the Northeast Climate Impacts Assessnment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS). 2007.

[viii] Clark, Corrie, Peter Adriaens, and F. Brian Talbot. *Green Roof Evaluation: A Probabilistic Economic Analysis of Environmental Benefits*. University of Michigan. 2006.

[ix] Getter, Kristen L. and D. Bradley Rowe. *The Role of Extensive Green Roofs in Sustainable Development*. HortScience 41 (5): 1276-1285. 2006.

[x] Scholz-Barth, K. *Green Roofs, Stormwater Management From the Top Down*. Environmental Design and Construction. 2001.

[xi] Clark, Corrie, Peter Adriaens, and F. Brian Talbot. *Green Roof Evaluation: A Probabilistic Economic Analysis of Environmental Benefits*. University of Michigan. 2006.

[xi] http://www.powernaturally.org/Programs/Solar/incentives.asp

Acknowledgements

I would like to thank several people in the creation of this proposal. First, Buffalo Schools Board of Education member Lou Petrucci for being generous with his valuable time to discuss what sustainable initiatives are being incorporated into reconstructions plans for the schools. Second, University at Buffalo professor Sam Magavern for his timely advice and suggestions that kept this project moving forward. Finally, my student colleagues that took part in the Green Cities class. Their feedback and excellent questions lead to some necessary alterations to this proposal.