GREEN ON A BUDGET

BY MICHAEL NICKLAS, FAIA

There are ways to be green without spending the green. Although many green building options have lower construction and operational costs than conventional approaches, the designers that pursue higher degrees of sustainability are challenged by initial costs. To achieve the highest level of sustainability within budget, begin the design by implementing strategies, systems, materials and products that have a lower initial cost.

Typically, the following strategies cost less than conventional, nonsustainable strategies. However, under certain circumstances, some may cost slightly more.

Community

For schools, design pedestrian walkways and bike paths so that they provide easy, safe access from the residential areas of the community to the campus. This allows students to walk or bike to school instead of riding the bus or being driven by parents. To facilitate this, analyze the surrounding neighborhoods within one mile from the school site, the necessary road crossings and the sidewalk system to better understand where key links can be made. If pedestrian access is improved, car-stacking lanes become less critical and the number of school buses can be reduced.

OPPOSITE The rain that falls on the roof at Heritage Middle School in Wake Forest, N.C., flows into a rainwater harvesting tank. The rainwater that lands on the balance of the site flows into a constructed wetland. The result is less storm water piping leaving the site and, in turn, less combined cost.

Site Design

Take advantage of the site by properly orienting the building to maximize the southern exposure and minimize east and west glazing.

Use existing trees, landscaping and natural berms. Vegetation and berms can serve to protect against winter winds. Trees can reduce unwanted solar gain and decrease cooling loads.

Incorporate or retain indigenous vegetation to minimize water needs. Xeriscape planting strategies initially cost less than nonnative plants and save on life-cycle water use.

Retain site features that can later serve as teaching tools and enhance experiential learning. For example, wooded areas can serve as interpretive spaces.

Locate the building on the higher part of the site to take advantage of natural slopes for drainage.

Keep parts of the site natural. Not planting grass saves on first costs and eliminates the need for continual mowing and watering.

Use on-site ground cover and mulch from existing vegetation for landscaping.

When using a prototype design, make sure it makes sense for the site, particularly in relationship to orientation and contours.

Use properly graded bioswales in lieu of storm water piping.

Balance cut and fill to reduce the need for trucks bringing fill in and out of the site. This is particularly beneficial with increasing fuel costs.

Use the pavement that is part of secondary fire lanes as hard-surface play areas such as basketball courts.

SMART TRADE-OFFS

Projects have many design trade-offs, which still will meet or exceed the owner's objectives without impacting quality. If designers begin the project with the belief that sustainability is an important component of the design, they will view potential trade-offs in different ways. The result likely will be the implementation of more sustainable concepts while staying within the overall project budget. By making smart trade-offs, firms can integrate sustainable design strategies and still keep projects an average of 5% under budget.

Under Budget Projects

Durant Road Middle School $3.6 million under budget, selected by the AIA as one of the most environmentally sensitive schools in the country.

Smith Middle School $750,000 under budget, incorporates extensive daylighting, a 1.2 million gallon per year rainwater catchment system, a solar hot water system and a photovoltaic system.

Heritage Middle School $1.4 million under budget, 150,000 ft^2, winner of SBIC's 2005 award for the most sustainable building in the United States.

The daylit **East Clayton Elementary School**, one of North Carolina's most energy-efficient schools, was $335,000 under budget.

Durant Road Middle School

Smith Middle School

High ceilings and an underfloor air-distribution system allow hot air to stratify and condition lower spaces in the room.

Daylighting and Windows

Editor's note: For more daylighting tips, see Part 1 in Spring 2008. View the issue online at www.HPBmagazine.org.

Daylighting has many benefits including saving energy, increasing productivity and improving health. These strategies have simple dollar paybacks ranging from two or three years to first-cost advantages. When selecting the most cost-effective strategies, choose air-conditioned spaces that are used frequently.

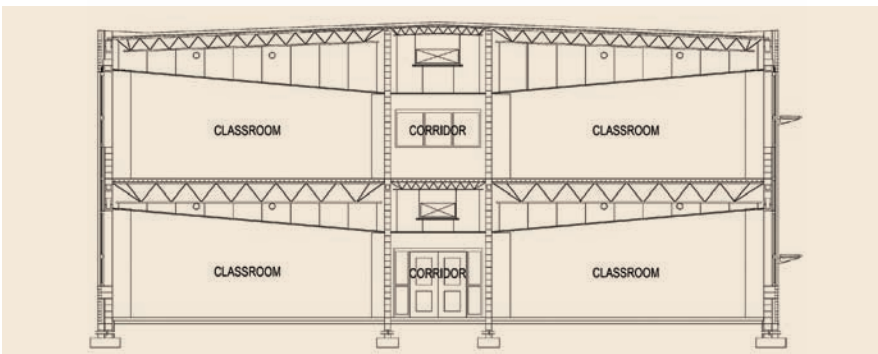


DIAGRAM 1 Sloped ceiling in classrooms bounce daylight to the back of the room and can reduce required glazing by 5%.

In rooms that are to be sidelit with assistance from lightshelves, slope the ceiling from the top of the window down to the interior corridor wall. This maximizes the high clerestory glass areas uniformly across the exterior wall and allows for mechanical system components close to the halls. The sloped ceiling approach increases daylighting performance and reduces glazing areas. It also can help eliminate the need to increase the floor-to-floor dimension in multistory buildings. *See Diagram 1.*

Use clear, double glazing in glass areas that are integral to the daylighting strategy to maximize visible light transmission. Even using low-e glass in roof monitor areas or clerestory areas will hurt daylighting performance and increase overall design cost.

Only use the minimum amount of glass necessary to achieve lighting level objectives during peak cooling times. Over glazing increases cost as well as peak cooling loads.

Eliminate east- and west-facing glass and only use view glass when there is a purpose other than to aesthetically balance the design elevation.

For required east- and west-facing windows, select low-e, tinted glazing to reduce peak cooling loads and reduce installed cooling equipment.

Building Shell

Use white roofing material. Ninety percent of heat gain from the roof is the result of radiant gains through the roof/ceiling assembly. A white single-ply roof, because it is smooth and less likely to capture dirt, retains a relatively high reflectivity.

Choose light-colored exterior wall materials to reflect solar gain. Use lighter paint colors. They typically have fewer VOCs.

To improve lighting inside rooms, paint interior walls light colors, select highly reflective ceiling materials and don't pick extremely dark floor finishes. The lighter the finishes, the fewer the number of lights that have to be installed and the size of daylighting apertures can be reduced.

Properly placed radiant barriers can reduce installed cooling equipment enough to offset the cost of the material. Added performance benefits can be realized by using the radiant barrier as a filtration barrier and placing the ductwork below the sealed barrier. *See Diagram 2.*

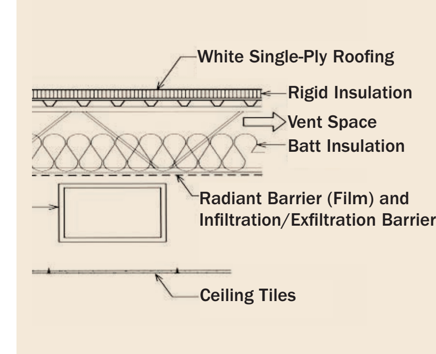


DIAGRAM 2 A sealed radiant barrier placed below trusses and insulation and above ductwork can keep ductwork in a semiconditioned space.

To reduce material waste and save time, develop the design based on even modules for materials.

Use building elements as experiential learning opportunities. A picture is worth a thousand words, but experiencing something in real life is better than reading the entire book.

Light colored walls, ceiling and floors improve daylighting performance.

Electrical Systems

Select U.S. Environmental Protection Agency (EPA) ENERGY STAR® labeled or other energy-efficient computers, vending machines, televisions, appliances and kitchen equipment. Because considerably less heat is generated, cooling equipment can be reduced to the point that initial cost savings are greater than the cost of the better plug load equipment.

Consider photovoltaic lighting for remote locations where conduit and trenching costs can exceed the cost of the photovoltaic system.

Limit exterior lighting to critical areas only.

Don't overlight hallways. Use automatic dimming or stepped lighting strategies that are tied to the energy management system to ensure peak load reductions. Although not appropriate in all applications, it makes sense for a gymnasium that can be dimmed by 5 or 10 footcandles during the highest peak cooling hours.

Using ganged-fluorescent light fixtures in daylit gymnasiums can cost less.

Install lighting in banks running parallel to the exterior wall that provides daylighting into the space.

Mechanical Systems

Analyze seasonal and hourly loads carefully to determine full-load conditions. This may allow for downsizing the chiller without significantly impacting comfort.

When selecting cooling equipment, accurately account for the benefits of daylighting in terms of cooling load reduction.

Minimize turns and reduce friction when laying out chilled and hot water lines and mechanical ductwork.

If the mechanical design provides for more than one space to be on the same zone, consider orientation and use patterns.

Optimize the mechanical system as a complete entity to allow for the interaction of various building system components. Don't oversize the equipment, particularly the cooling.

Use displacement/stratification strategies to condition occupied spaces. This benefit often can be used in daylit classrooms that have higher ceiling areas, media centers, multipurpose spaces and gymnasiums.

When sizing mechanical equipment, investigate unit sizes. It may make more sense to improve the energy efficiency of other design elements (insulation levels, etc.) to reduce the overall cooling load downward to match the next unit size. The net savings will include both the calculated tonnage difference and the cost associated with the difference between unit sizes.

If the next best option is to extend the city sewer line a half-mile or more to the school site, consider an environmentally sound, on-site waste treatment systems that can cost considerably less and help the environment.

A rainwater catchment system that provides 90% of the building's water needs can, in some cases, be supplemented with a low flow well, mostly for potable needs, to provide a less expensive solution than extending a city water line.

AVOID GREENWASHING

As in the 1970s when energy costs started to substantially rise and everything became "energy-efficient," everything today is becoming "green." As a result, it is critical for the environmentally concerned designer to engage in a deeper level of analysis.

Start with basic objectives such as saving energy and water, helping the environment, improving indoor environment quality and using resources efficiently. Judge the solutions based on impact. Considering the budget, determine what strategy or groups of strategies will make the most positive impact.

For example, a roof garden is a popular strategy being implemented by architects over another strategy that meets the same objectives with less cost and greater positive impact: a rainwater harvesting system that incorporates a white, single-ply roofing membrane.

Initially, roof gardens cost anywhere from an additional $9/ft^2$ to $20/ft^2$ when the soil depth is 2 in. or 3 in. They cost even more when the depth reaches 6 in. or 8 in. or more. But, the net cost for a white, single-ply roofing membrane and rainwater harvesting system that provides toilet flushing and ball field irrigation for a school is between $2/ft^2$ and $4/ft^2$.

From an energy perspective, a 2 in. deep roof garden, unlike many earth-sheltered buildings that incorporate 2 ft of earth, provides no lag-time benefits and likely increases peak load problems and provides little conductive benefits. Additionally, with shallow soil and darker surface colors, vegetation options are limited, shading benefits become minimal and nonvegetated areas absorb heat. Deeper soil improves performance, but it also increases costs.

From a storm water standpoint, roof gardens have some benefits in that 2 in. deep soil with 35% water retention can absorb up to 0.7 in. rainfall. Unfortunately, roof gardens often are watered and, in some cases, fertilized for a couple of years until vegetation is established. However, the rainwater/white roof strategies can save over 5% on the energy bill, 80% water and retain up to 2 in. of rainfall for a fraction of the cost.

Despite cost and environmental benefits of the rainwater/white roof strategy, what is implemented most often? Roof gardens.

Advertisement formerly in this space.

FORM FOLLOWS FUNCTION

A basic concept taught to every architectural student is that form follows function. When this concept is practiced, the result is almost always cost and resource savings. Unfortunately, designers often ignore this creed. Poor examples are everywhere. There are ramifications when functional benefits can only be rationalized after the architects created design elements based primarily on aesthetics.

The architect incorporated a shading device on the north-facing façade of this building. As a result, the expensive shading lattice provides no shading benefits and adds over $10/ft^2 to the total building cost. On the same building, the east-facing windows are completely unprotected.

Recycling and Sustainable Materials

During construction, require contractors to recycle construction materials that have a local market. There is a market for recycled materials, and contractors can make money while helping the environment.

With increased recycling efforts, it is possible to find recycled building products that cost less than traditional ones.

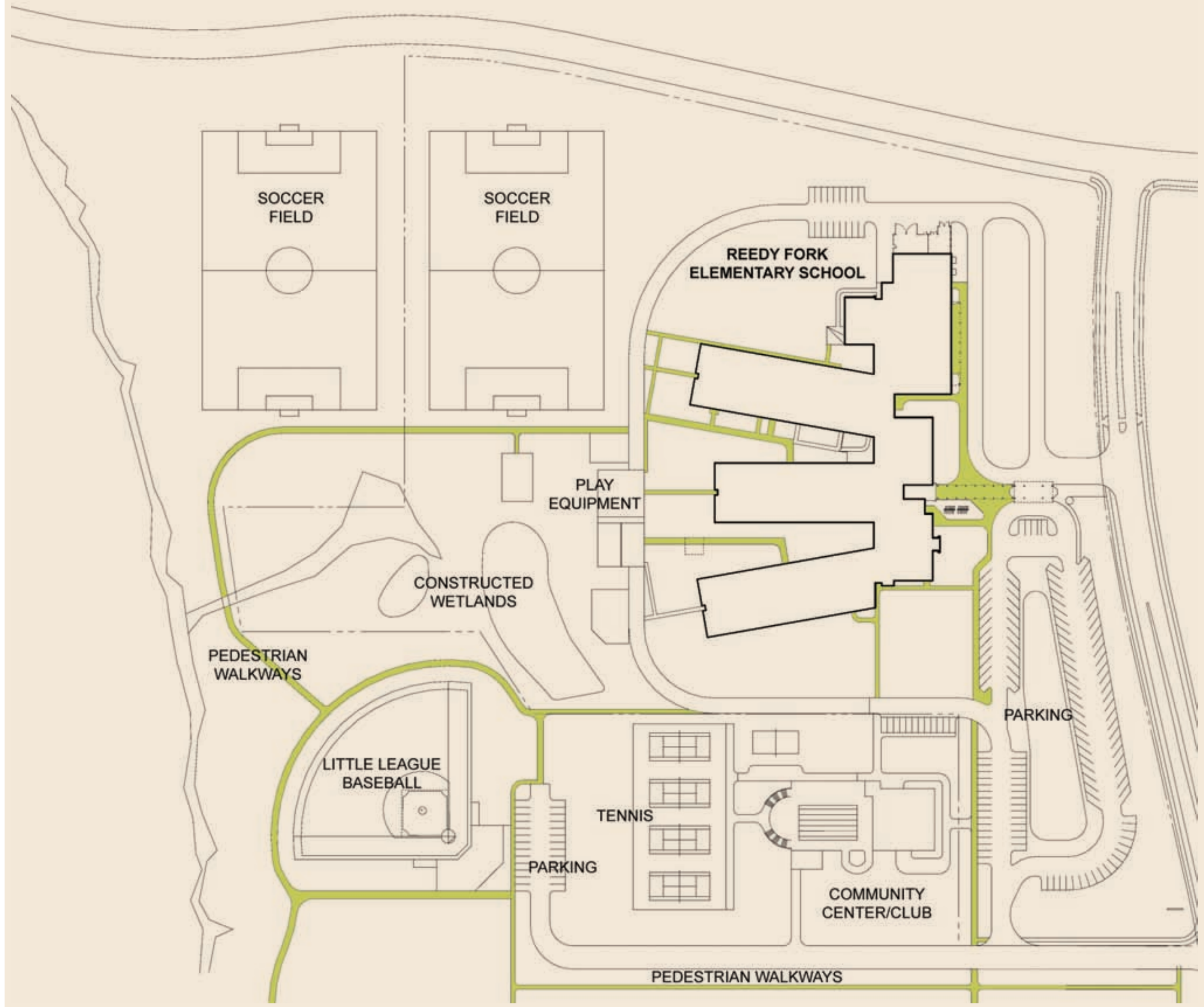
Buy local products, materials and equipment to help the local economy, reduce embodied energy associated with transportation and save money.

Complementary Strategies

Think whole building, not individual measures. Typically, a single green approach, by itself, will be more expensive than conventional approaches. But, in combination with other green elements, the overall impact may be significant enough to lower first cost and improve sustainability.

A rainwater harvesting system in conjunction with constructed wetlands and bioswales can save on upfront costs. By themselves, each green strategy costs more. However, they cost less when combined. Because there is no storm water being piped away from the building, civil costs associated with piping and trenching are reduced. Thus, the civil costs more than offset the rainwater harvesting and wetland costs.

DIAGRAM 3 REEDY FORK ELEMENTARY SCHOOL SITE PLAN



Within the Reedy Fork Civic Center Complex, the developer, elementary school, parks and recreation department, public library and community reduced costs and resources by jointly implementing and sharing:

A grading strategy that balanced the cut and fill over the entire complex;

A constructed wetland that provides for retention and water treatment for the majority of the complex site;

Parking spaces, recreation fields, play equipment, swimming pool, tennis courts and a community center that can be used for different groups at different times; and

A pedestrian walkway strategy that extends from residential areas to the complex site and reduces the need for additional stacking lanes at the school and car congestion throughout the community.

Dual Function Approaches

Whether designing building or site components, the more functions that can be served by one design element, the more resourceful and cost efficient the design.

Use smooth white, single-ply roof membranes to reflect radiation that negatively impacts cooling loads, bounce desired solar radiation into adjacent daylighting roof monitors and provide an ideal surface for rainwater harvesting.

Look for covered walkways or adjacent building shapes that can shade east or west glass.

Maximize community resources by analyzing facilities that can be shared by more than one group within the community. A church and a school can share parking. A town library system and a school can eliminate the need for space that otherwise would be duplicated. A single constructed wetland can be used by several surrounding neighbors to solve common erosion problems for less money. In addition, sharing recreational facilities provides an opportunity for significant cost savings and requires less land and resources. *See Diagram 3*.

Greatest Benefit to Initial Cost

A client may look at the investment in terms of what is the least costly way to provide the green benefit, the greatest benefit to initial cost. If the goal is to provide a healthy indoor environment, increase productivity or even provide the least costly way of ensuring low, long-term operational costs, the decision-making process in selecting the least costly avenue will certainly be different. For example, when education is the key driver, health and productivity often are a higher priority than operational savings associated with energy and water.

If the designer uses healthy building materials, clear benefits will result for the occupants, but dollar savings may never be realized by the owner.

Implementing good daylighting designs will provide significant energy savings. However, measuring productivity benefits in monetary terms is typically harder to consider upfront.

There is an extensive list of strategies implemented by designers that initially cost more but are good investments for the building owner. Strategies such as improved lighting and control options have paybacks within months; others like solar water heating and geothermal systems have longer returns. The options are many.

Sustainability Perspective

A client may choose to look at cost from a global sustainability perspective. For most clients, this viewpoint, while well appreciated by most, is beyond local financial capabilities to pursue. However, from a societal standpoint, this is precisely the perspective we must develop and somehow afford.

The Design Community's Challenge

Currently, skilled design teams can reduce energy consumption to 50% below current levels and still meet most reasonable construction budgets. Our immediate need from a sustainability standpoint is getting a greater part of the design community philosophically committed, increasing skill levels within the design community and better disseminating improved design tools.

Owners need to educate themselves about what can be accomplished with the budget and establish appropriate energy and water budgets. Architectural and engineering students should focus on more holistic system thinking and learning to analyze energy and water issues. Joint architectural and engineering classes will help make addressing engineering issues early in the design process the norm.

It is becoming more widely understood within our industry that buildings account for 48% of greenhouse gas emissions. The buildings we design today will be with us for 50 to 100 years. The cost to address environmental issues through better building design today is just a fraction of what it will cost society to deal with the ramifications of insufficient action. ●

ABOUT THE AUTHOR

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