



Photo: Innovative Design

## Northern Guilford Middle School Greensboro, North Carolina

### A Holistic Approach to Sustainability

Guilford County Schools (GCS) has made a strong commitment to sustainability and is leading the way for schools in North Carolina and the United States to build green. Through its green design specifications, the *G3-Guilford Green Guide* ([www.gcsnc.com/depts/facilities/G3.pdf](http://www.gcsnc.com/depts/facilities/G3.pdf)), GCS has become the first North Carolina district to outline sustainability standards for its schools. Because of these efforts, GCS received a Sustainable Energy Leadership Award for helping the state achieve its energy efficiency, renewable energy, and sustainability goals.

GCS understands a whole-building design approach is necessary to build a truly sustainable EnergySmart school. It asked its design team to develop holistic and innovative green schools with well-integrated systems. For Northern Guilford Middle School, this meant planning for daylighting, heating, cooling, and air distribution early in the design process to identify and address energy requirements. By determining how these systems interact and by sizing them appropriately, schools can meet energy goals at the same first costs as traditional schools. It also ensures that the school becomes a living

laboratory where students and the community can learn about energy and resource conservation.

### Goals

GCS has definite and aggressive goals for its new school projects:

- Reduce operating costs
- Protect the environment
- Design buildings that teach
- Improve academic performance
- Optimize health, safety, and comfort.

To achieve these goals in Northern Guilford Middle School and other projects, GCS takes an active role in the process. The GCS Facilities and Construction Department manages design and construction. Each project has a Building Advisory Team composed of the design team, school principal, school staff representatives, parents, and board of education members. At the high school level, GCS asks students to participate. The board of education also appoints a Construction Advisory Team, composed of board of education members, an architect from a local university, construction executives, and local business leaders, to offer input into the process.

“Northern Guilford Middle School demonstrates that you can build a school that provides a better learning environment, reduces long-term operating costs, and lessens the impact on the planet without spending more money up front. Our planning incorporated a holistic approach that focused on daylighting and other green strategies. Even with these features, construction costs for Northern Guilford Middle School were the same as for a comparably sized school built without sustainable and energy-efficient features. The cost of building a school like this is not an issue.”

—Joe Hill, Guilford County Schools  
Facilities Consultant

### Project Details

**Building:** Single story, 140,000 square feet

**Completed:** January 2007

**Financing:** General Obligation Bonds

**Cost:** \$20.7 million; \$148 per square foot;  
\$21,789 per student

**Capacity:** 950 students

**Energy performance and savings:**

43% below a comparably sized school based on ENERGY STAR® data; \$77,097 annual reduction in energy cost

**Energy costs:** \$0.65 per square foot per year and approximately 45,000 Btu per square foot annually

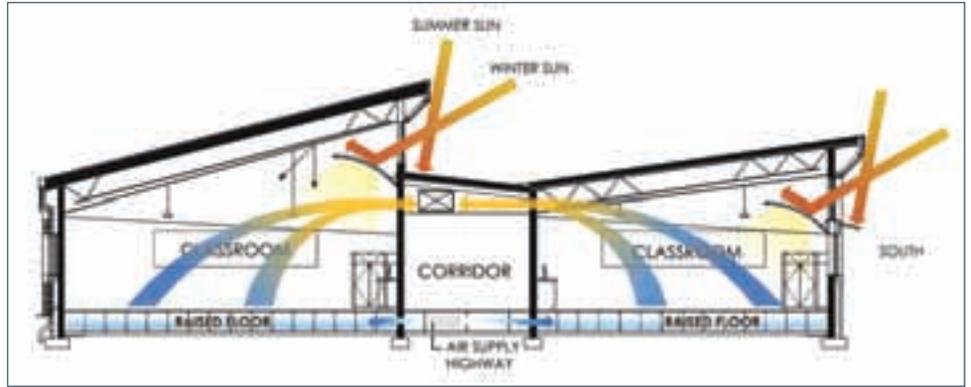
**Guilford County School District:**

- 111 schools
- 71,237 students

One of the key goals for the team was to design Northern Guilford Middle School to be a three-dimensional educational experience. Students get a hands-on look at conservation and renewable energy through all the features at the school, including a wetland ecosystem. The learning opportunities at Northern Guilford will increase awareness of energy use and environmental issues for future generations.

**Resources**

GCS developed the *G3-Guilford Green Guide* to outline the key steps to achieve an energy-efficient and sustainable school. GCS also follows energy saving recommendations from the *Advanced Energy Design Guide for K-12 School Buildings* (available at [www.ashrae.org/aedg](http://www.ashrae.org/aedg)), which was developed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the American Institute of Architects, the Illuminating Engineering Society of North America, the U.S. Green Building Council, and the U.S. Department of Energy. The *Advanced Energy Design Guide* provides prescriptive methods, by climate zone, to build a school that uses 30 percent less energy than the ASHRAE 90.1-1999 standard. GCS plans for its schools to save at least 30 percent but sets an ultimate target of 50 percent reduction in energy use. Because of this, the GCS design team relies on additional energy-saving measures determined through energy modeling.



Graphic: Innovative Design

Schematic section of classrooms showing daylight strategies

**Energy Modeling and Trade-Offs**

The design team used the eQUEST (Quick Energy Simulation Tool) interface to the DOE-2 simulation program to perform extensive energy modeling. The modeling, conducted throughout the design and construction phases, helped balance the heating and cooling needs based on all the systems, including lighting, the under-floor air distribution system, and the variable air volume system. Understanding the interactions of these systems is critical to sizing the heating and cooling systems accurately and reducing construction costs.

The energy modeling was especially important because of unique systems in Northern Guilford Middle School. First, the lead architect on the project, Innovative Design, developed a new daylighting design. Northern Guilford uses south-facing clerestories with curved, interior, translucent light shelves that produce more

diffused light throughout the classroom. Northern Guilford also incorporates an under-floor air distribution system in the classrooms, media center, and administrative offices, which eliminates ductwork in the ceiling that can interfere with daylighting. The new light shelf design and the unobstructed ceiling mean less glazing is needed to reach the desired daylighting level, which translates into lower cooling loads. Clearly, every design decision influences other decisions, so optimizing all the systems concurrently helps develop the most efficient school at the least cost.

**Financing**

Funding for Northern Guilford Middle School was provided through the sale of General Obligation Bonds authorized by the voters of Guilford County. Local property taxes provide the primary source of debt service funding for the bonds.

Northern Guilford Middle School Energy-Related Goals	
Goal	Project Outcome
Decrease energy use to about half that of a typical school. Based on ENERGY STAR® data, a typical school uses about 79,500 Btu per square foot annually.	Northern Guilford Middle School currently uses about 45,000 Btu per square foot annually, which is 50% to 60% of the energy used by a similar school in this climate.
Reach an optimal level of daylighting to improve student and faculty performance and maximize energy savings.	Natural light is the primary source of lighting for all educational and administrative spaces during two-thirds of the daylight hours. This level of daylighting minimizes the fenestration-to-wall area ratio and eliminates heat gain from extra glazing.
Reduce the size of the school's heating and air-conditioning system.	The central boiler/chiller is 20% smaller than a typical system for a school this size.
Lessen water consumption significantly.	By collecting rainwater for use in toilets and implementing a plant-based treatment strategy, called a Living Machine™, to purify wastewater for irrigation, the school saves roughly 9 million gallons of water per year.

## Results

Northern Guilford Middle School requires about half the energy of typical schools. The integration of daylighting, a highly insulated building envelope, and an under-floor air distribution system enabled the size of the air-conditioning system to be reduced by 75 tons.

DOE-2 energy simulations indicate the daylighting strategy reduces lighting energy use by 50 percent, peak load by 11 percent, and overall energy use by 19 percent compared to the ASHRAE 90.1-2001 base model.

All this was accomplished at the same cost of a similar, nongreen school. And the school is expected to save more than \$70,000 annually in energy costs, or about \$0.50 per square foot, bringing the lifetime cost of the building below that of a standard school. Planning and a whole-building approach make these energy-saving features possible at no additional cost.

“Studies show that students perform better with natural light. In addition to educational benefits, daylighting offers significant energy and money savings. The school is not paying for electricity for artificial lights. The school also does not need to pay for cooling as a result of the heat from the lights. All these dollars saved can be directed toward the teachers and students—where the money should be going.”

—Michael Nicklas, President, Cofounder, Design Principal at Innovative Design in Raleigh, North Carolina, and Lead Architect for Northern Guilford Middle School

### Northern Guilford Middle School—EnergySmart Choices

Feature	Benefit
Solar power	A drainback solar thermal system comprised of 10 compound parabolic collector panels provides 75% of the school's hot water. The school also features three photovoltaic (PV) systems totaling 1.5 kW that are used for the school sign and the wetland's aerators. They are also used as an educational tool. Using PV for these remote energy needs was less expensive than running electrical lines from the main building.
Building envelope	The school features thermal mass walls made of concrete masonry units (CMUs). Mass walls with exterior insulation help keep the building comfortable in the summer and winter. The CMUs have a 4¾-in. cavity filled with foam-in-place insulation, made of amnio-plast resin and a catalyst foaming agent surfactant. The result is an R-37 rating for the entire wall assembly. The two roofing systems used, a thermoplastic membrane and an insulated metal roof, are rated at least R-30. These materials have a high reflectance that reduces heat gain and cooling load. Overall, the envelope is more insulated than standard practice; the wall insulation is 3 times code and the roof levels exceed code by double.
Site orientation and design	The school is oriented on an east-west axis to take advantage of southern exposure for applications such as daylighting, solar hot water, and PV. The surrounding landscape was disturbed as little as possible during construction.
Daylighting	Extensive daylighting is used, including revolutionary curved, translucent interior light shelves. These, in combination with highly reflective ceiling tiles, reduce the square footage of glazing by 40%. This design provides uniform light with less glare. The gymnasium and dining areas feature south-facing roof monitors with translucent fabric baffles in the light wells to diffuse the light through the space. Overhangs on the monitors protect the space from direct light and reduce cooling loads. Natural light is the primary source for all educational and administrative spaces during two-thirds of the daylight hours. Daylighting produces half the heat and the same amount of light as fluorescent fixtures.
Windows	Clerestory windows for daylighting use clear double glazing to minimize glass area. Lower-view windows facing south and north have clear, low-emissivity (low-e) double glazing. Windows facing east and west have tinted, low-e double glazing. Choosing windows specific to each use optimizes the natural light and decreases costs.
Lighting	Dimmable, indirect, fluorescent lighting is installed throughout the school. Occupancy and photocell sensors help to minimize the use of artificial light. The foot-candle setpoint for the classrooms is 60.
Heating, ventilating, and air conditioning (HVAC)	The under-floor air distribution system enhances comfort, air quality, flexibility, and energy efficiency. This system distributes heated and cooled air, provided by the central boiler/chiller, evenly throughout the space. This system requires considerably less ductwork than a standard HVAC system, which helped reduce construction costs. Because of daylighting and other efficiency strategies, the school's heating and air-conditioning system is 20% smaller than is typical for a school this size.
Water	Northern Guilford Middle School committed to reducing water use by promoting a water cycle approach: rainwater to toilet flushing to a cleansing wetland to underground irrigation and finally to the aquifer. A 360,000-gallon tank collects rainwater from the school and from an adjacent high school. This water is used primarily for toilets and saves 4 million gallons annually. The next step is to funnel the wastewater from the toilets and urinals to a wetland with a plant-based cleansing strategy that treats up to 30,500 gallons per day. This water then goes to a subsurface irrigation system, or drip system, for the fields, which uses 40% less water than sprinklers because of reduced evaporation. By using the water twice, the school saves a total of 9 million gallons per year. In addition to the money saved by recycling water, the school avoided spending several million dollars to extend the city waste lines.
Materials	Following the <i>G3-Guilford Green Guide</i> , the carpeting, metal roofing, and acoustical ceiling tiles contain recycled content. The design team also chose locally manufactured masonry products and certified wood. Almost 60% of total construction waste was recycled. Also, the school implemented a recycling program.
Indoor environmental air quality	Northern Guilford did much to improve the indoor air quality, including using low volatile organic compound (VOC) paints and adhesives, increased ventilation with outdoor air, high-efficiency filters, and urea-formaldehyde-free casework. The <i>G3-Guilford Green Guide</i> provides detailed specifications to ensure occupants are protected from indoor air contamination.
Monitoring	The solar water heating, PV, daylighting, rainwater harvesting, and wetland systems are monitored in real time. The monitoring systems and data are readily available to faculty, students, and visitors and are part of the school's curriculum.

## Importance of Monitoring the Facility

A key lesson learned from Northern Guilford Middle School is that the work is not complete once classes start. When Northern Guilford first opened, it was performing at an unexpected rate of 85,166 Btu per square foot annually. The design team, led by Michael Nicklas of Innovative Design, studied the building carefully to identify reasons for the higher energy use and discovered a natural gas leak. Mainly by addressing the leak and making some initial control and balancing modifications, consumption dropped to 65,195 Btu per square foot annually. The team continued to analyze the building and also found that many controls were either not set properly or were not functioning correctly. An important finding was that the carbon dioxide monitor was malfunctioning and pulling in 100 percent more outside air than necessary. Addressing these issues resulted in additional savings and this year's predicted consumption is around 45,000 Btu per square foot annually.

The performance of this school has improved dramatically since it first opened because the design team:

- Set specific energy goals and did extensive modeling to predict performance
- Took the time to follow through after the school was complete to compare actual and predicted performance
- Easily identified that the building was not initially performing as planned because of the modeling
- Persisted in contacting utilities, manufacturers, and others responsible for problems.

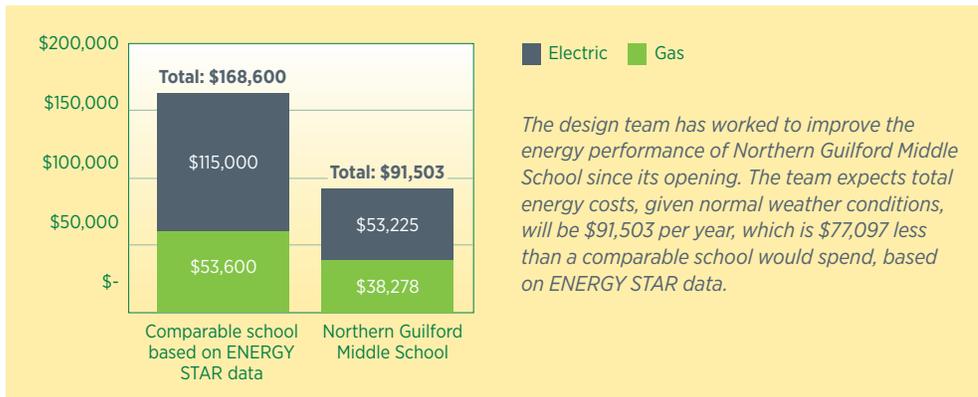
Mr. Nicklas cannot stress enough the importance of continuing to monitor the building and work on performance once construction is complete. Utility bills must be monitored to see if energy use matches projections. All the controls must be examined to confirm they are programmed correctly and operating as planned. Design teams need to plan for resources to do this critical work after construction. GCS realizes the importance of post-occupancy monitoring and is now establishing a

district-wide energy monitoring program to gather the data needed to verify the effectiveness of energy efficiency measures.

The school is very close to operating as planned and achieving the projected energy savings—using only about half of the energy of a typical school. And, the school was built at no additional cost compared to a typical school. If you ask any of the school administrators or GCS staff, they would all agree Northern Guilford Middle School is a resounding success.

## Lessons Learned

- Plan carefully at the beginning of the design process and sustainable, energy-efficient schools do not cost more.
- Do the right analysis to understand the trade-offs with various technologies.
- Follow a commissioning process to achieve peak performance and efficiency.
- Concentrate on the controls, as these pose the biggest problem in achieving high levels of energy efficiency if not set properly and monitored.
- Design the daylighting so that teachers and students do not need to be actively involved in managing it.
- Supplement daylighting with indirect lighting because it has a similar look.
- More work is needed in humid climates where moisture must be removed from the air but the air does not necessarily need to be cooled.
- Provide good training and orientation for the building staff.



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